APPENDIX 15-6

AVIATION ASSESSMENT SUMMARY REPORT

Report

Knockshanvo Wind Farm

Aviation Summary Report

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Abbreviations

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

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1. Introduction

This report has been prepared in support of a planning application for Knockshanvo Wind Farm and examines the potential impact on aviation services. At the feasibility stage in 2020, the preliminary design for the project was for an 18-turbine site (at this time the project was known as Violet Hill). AI Bridges were appointed at that time to act in a Project Management role to manage the Aviation Safeguarding Assessments for the proposed Violet Hill development. AI Bridges conducted desktop aviation assessments and sought engagement with the Irish Aviation Authority (IAA) through a series of consultations in 2021 and 2022. In addition, AI Bridges engaged with IAA-approved aviation specialists to conduct detailed technical assessments. (Cyrrus Limited and FCSL Limited) on behalf of the Applicant. Following engagements with the IAA and other key stakeholders the project design evolved over time into the current 9 turbine project layout. Several turbines were removed from the original layout to mitigate impacts on identified constraints which was in part informed by impacts on aviation infrastructure.

During the engagements with IAA summarized in Section 1.1 below, specific concerns were raised in relation to aviation and requests were made for more detailed assessments. AI Bridges have prepared this report to summarise the extensive Aviation Safeguarding Assessments that have been completed in accordance with IAA requests. The full detailed technical assessments are included as appendices to this report.

1.1 Statement Of Authority

Ai Bridges Limited:

Ai Bridges Limited has been a contributor to this report to manage the aviation assessments and conduct aviation statement reviews in respect of the proposed Knockshanvo Project. Ai Bridges has been supplying telecommunications and aviation assessment solutions to the wind farm industry throughout the Republic of Ireland, Northern Ireland and the UK since 2007. The Ai Bridges Engineering Department has more than 170-man years of experience in the delivery of Aviation, Telecommunications, Broadcast & EMI\EMC Impact Assessments for the Wind Farm industry.

The Engineering Team at Ai Bridges takes the role of Project Manager responsible for overseeing project progress and deliverables for the Telecommunications and Aviation Impact Assessments. This role takes responsibility, along with other team members, for day-to-day running of the projects including co-ordination of project team, sub-contractors and achieving agreed milestones.

The team responsible has extensive experience in the areas of software modelling of communications networks. This includes extensive working knowledge of software modelling and of telecommunications and aviation networks and systems. This role also includes the ongoing development of 3D modelling software techniques used to predict wind farm impacts on aviation safeguarding surfaces and infrastructure.

Cyrrus Limited:

Cyrrus Limited were contracted by Ai Bridges on behalf of the Applicant to address the IAA request for detailed technical IFP and Radar Assessments. Cyrrus Limited is an IAA Approved Procedure Designer Organisation. Cyrrus provides specialized Radar Engineering & Consultancy Services and IFP Assessments and IFP Procedure Design Services. Cyrrus have relevant experience in the areas of UUK Civil Aviation and MoD Radar Assessments.

Shaun Gouvera conducted the IFP Assessments and Kevin Sissons completed the Radar Assessments. Kevin Sissons conducted the Radar Assessment Studies.

1.2 IAA Consultations

In advance of an initial engagement with IAA in relation to the original 18 turbine layout, AI Bridges completed a desktop assessment which included:

- All of the Communications, Navigations and Surveillance surfaces, sensors and equipment at Shannon Airport and Woodcock Hill Radar facilities.
- A review of the Flight Inspection procedures which investigated any effects that the proposed turbines would have on the bi-annual ILS Flight Inspection procedures.
- A Radar Surveillance Desktop Review.

Following these studies potential impacts to the Instrument Flight Procedures (IFP) for Shannon Airport, the Radar Surveillance equipment at Shannon Airport and Woodcock Hill and as well as potential impacts to the Navigational Aids at Shannon Airport used for annual flight calibrations, were noted.

An initial consultation was sent to IAA with the details of the Proposed Development for their review. The IAA noted the following in their consultation response in November 2021.

- Surveillance: Woodcock Hill MSSR could be affected by the turbines and filtering out this issue, although possible, may be prohibitively expensive
- NAVAIDs: For flight calibration activity, the turbines could impact this activity
- Instrument flight procedures (IFP’s): Surveillance minima as well as Instrument flight procedures could have some impact dependent on the wind turbine elevations

On receiving this information, AI Bridges recommended that detailed technical assessments be conducted by certified Procedure Designers and Radar Engineering Consultants. Cyrus Limited were commissioned to undertake both Instrument Flight Procedures (IFP) Safeguarding Assessment in August 2021, an Assessment of the ILS Flight Inspection procedures and Radar Assessments in September 2021 for the original 18 turbine layout. (Other than where specifically relevant, these have not been attached as they relate to the original layout design, they are being mentioned here primarily in the context of describing the engagement process). These technical assessment reports were provided to the IAA for review. Following this, detailed consultations and engagement, via email and telephone conference calls with the IAA took place. They highlighted their concerns in relation to the Air Traffic Control Surveillance Minimum Altitude Chart (ATCSMAC) used for vectoring of aircraft onto the approach runway at Shannon Airport. AI Bridges then commissioned Cyrrus to conduct a Conceptual Design Report which included mitigation measure options to address the concerns in relation to any effects on ATCSMAC. Following these engagements a number of wind farm design changes occurred which ultimately resulted in the site reducing in scale from 18 turbines to the final proposed 9 turbine layout for which permission is being sought.

The detailed consultations with the IAA, from November 2021 to April 2022, are shown in Appendix 1.1.

On 23 January 2023 the Environmental Consultants MKO sent a consultation, on behalf of the Applicant, to the Shannon Airport Authority in relation to the final proposed 9 turbine Knockshanvo Wind Farm development.

> *" Please find attached a scoping document for FuturEnergy Irelands (FEI) proposed construction of a wind energy development at Knockshanvo, approximately 3km south of Broadford, Co. Clare. The proposed site covers an area of approximately 931 hectares. At this scale the site has the potential to accommodate a wind energy development in excess of 50 Megawatts. The number and layout of turbines will be defined during the upcoming project design stages.*
>
> *The following application will be seeking determination from An Bord Pleanala in relation to the developments Strategic Infrastructure Development Status. If the Proposed Development does not fall under Section 182A of the Planning and Development Act 2000, an application for planning permission for any relevant works will be made to Clare County Council.*
>
> *As part of the scoping exercise for the Proposed Development, we would welcome any comments in relation to the proposed project."*

On 03 February 2023 the IAA sent a response to the Environmental Consultants, in relation to the proposed Knockshanvo Wind Farm development as follows:

> *"Correspondence below and attached refer, with thanks to Paul Hennessy for passing on this.*
> *From an IAA Air Navigation Service Provider (ANSP) perspective, there are areas where we would need more analysis:*

- ***Instrument Flight Procedures (IFPs) Shannon Airport:***
  - *The Grids displayed represent the Max Above Mean Sea Level elevation of any new obstacles, above which, an IFP Assessment is needed.*
  - *In the area around Knockshanvo as per the attached report, there are a range of grid values from 361m to 401m. I understand that the proposed blade-tip heights are c.170m. This equates to a c.370m AMSL elevation based on a general site elevation of 200m. Added to this any potential cranage used during construction will need a full IFP Assessment.*
- ***Woodcock Hill Radar:*** *Surveillance effect (IAA ANSP Surveillance Domain copied). Generally any significant obstacle within 16km of this facility may have impact. In the case of this proposed Wind farm, this is highly likely and will need to be assessed with mitigations proposed. Please note that previous experience has shown that mitigations suggested for similar developments have been prohibitively costly for the ANSP and ultimately don't guarantee that the surveillance service is not affected. Third*

attachment is the EUROCNTROL Guidelines on How to Assess the Potential Impact of Wind Turbines Surveillance Sensors

- ***Navigation Aids (NAVAIDS):*** *This will need to be considered by my NAVAID colleagues (copied), although generally there should not be an impact. There is however another aspect to this. On a 6-monthly basis, these NAVAIDs have to be flight calibrated. The calibration aircraft flies in this area at low altitudes to achieve this and a report from this company (FCSL) may be required also. "*

On receipt of this feedback, a final suite of technical assessments was commissioned and completed. In addition to the specific concerns raised by IAA, the consultants also considered potential impacts on:

- **Potential impacts on Primary and Secondary radar facilities at Shannon Airport**
- **En-route radar facilities at Woodcock Hill**

This report provides a summary of the key findings of these assessments with details included in referenced appendices.

1.3 Regulatory Context

The International Civil Aviation Organization (ICAO) published their Global Air Navigation Plan 2013 – 2018 which sets out the introduction of Performance Based Navigation (PBN) in order to achieve a transition to a more modern navigation system from the traditional navigation infrastructure. In response to this EU Regulation 2018 / 1048[1] was brought into force and lays down airspace usage requirements concerning Performance Based Navigation (PBN IR). In turn, the IAA has developed the PBN Transition plan[2] applicable to all airspace users as required under EU regulations. This is to ensure a transition and rationalization of the ground-based navigation infrastructure so that there is a smooth and safe transition to the provision of the Air Traffic Management and Air Navigation services using performance-based navigation and the eventual rationalization of the ground-based navigation infrastructure.

The current legacy navigation infrastructure that has been in use by pilots and air traffic controllers and involves two types of aircraft approaches i.e. precision approaches (ILS) or non-precision approaches (VOR). As part of the State PBN implementation plan mixed mode approaches will be phased out and navigation infrastructure rationalized by 06 June 2030.

This information is of relevance as several of the potential issues identified in the detailed assessments below will no longer be relevant when this new PBN system is introduced i.e. the current navigation systems will be progressively replaced by a framework that allows PBN routes to RNAV1 or where required by operational considerations to RNP 1 specification, so as to allow aircraft to operate PBN from take-off to landing.

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[1] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32018R1048

[2] https://www.iaa.ie/commercial-aviation/airspace/airspace---pbn-ta-acp-fua#:~:text=Performance%20Based%20Navigation&text=Volume%20II%20contains%20a%20number,based%20to%20performance%2Dbased%20navigation.

1.4 Methodology

The proposed methodologies used for the Ai Bridges Limited Aviation Assessments are outlined below. This methodology has been adopted for the aviation review statement included in Appendix 10.

The proposed methodology approach to address the scope of aviation assessments has been supplemented with additional detailed technical assessments and references to demonstrate evidence-based support of the mitigations measure proposals.

1.4.1 Aviation Assessment Methodology

There are four stages in preparing and compiling an aviation review of the study area which as shown below:

- Consultation with relevant aviation authorities and aviation stakeholders.
- Undertaking field survey and desktop screening of the receiving aviation & aeronautical environment
- Undertake desktop network modelling and software screening analysis of all aviation & aeronautical surfaces with reference to all legislation and ICAO and EASA Guidelines.
- Aviation Impact Assessment Report

1.4.2 Aviation Consultations

Consultations are commenced with relevant statutory consultees, aviation & aerodrome operators, Air Navigation Service Providers (ANSP), Aviation Authority Safety Regulation Divisions as well as Air Corp and Emergency Service Response Units who are requested to raise any concerns they have regarding the impact of the proposed wind farm development on critical surfaces (Aeronautical Surfaces, Instrument Flight Procedures, Navigational Aids, Communications and Radar Surveillance networks).

1.4.3 Aviation Surveys

Desktop surveys of the critical aeronautical infrastructure & aerodromes sites are undertaken to assess aviation communications, navigation and surveillance infrastructure. This is to ensure that all aeronautical activities in the controlled Class C and uncontrolled Class G (including private air strips) airspace have been identified for review at the desktop network analysis and modelling stage. The survey process is used to assist in identifying aeronautical infrastructure that could be impacted by the proposed wind farm development to ensure aviation safeguarding. (e.g. identification of Primary and Secondary radar surveillance for low coverage and enroute navigation, Navigational & Communication Aids including ILS landing system).

1.4.4 Aviation Desktop Network Analysis & Modelling

Desktop network analysis & modelling are carried out against relevant aviation & aeronautical infrastructure identified during the desktop survey process. Software based communications and radio planning tools are used to construct a 3D model of the wind farm morphology that can be layered on a topography layer and shown relative to the Proposed Development layout. The radio planning tool uses GIS and terrain mapping databases to enable accurate 3D modelling, and the aviation & aeronautical surfaces can then be layered on the proposed wind farm topology an assessment is carried out to determine if there will be any impacts on aviation & aeronautical safeguarding surfaces including Navigational Aids, Instrument Flight Procedures communication of critical networks due to the Proposed Development. The impacts are screened as per the matrix shown in Table 1. This matrix is completed as shown in the Aviation Review Statement in Appendix 10.

All assessment work at this stage would assist in establishing a baseline environment. Any cumulative effects of the proposed wind farm development is then considered and included for analysis at this stage.

Aeronautical Aid \ System	Residual Impact	Impact Summary	Mitigation Measure
Annex 14 - Obstacle Limitation Surfaces (OLS)	Take-off :		
	Approach		
Annex 15 - Aerodrome Surfaces			
Minimum Sector Altitudes (MSA)			
Instrument Flight Procedures: Departures, Approaches and ATCSMAC charts			
Communication and Navigation Systems			
Radar Surveillance Systems Safeguarding			
Enroute Radar Surveillance			
Flight Inspection and Calibration			
Aeronautical Obstacle Warning Light Scheme			
Irish Air Corps Policy on Wind Farms			
Garda Air Support Unit			

Table 1. Screening Matrix

1.4.5 Aviation Impact Assessment Report

Following the network analysis & modelling screening assessment the findings and outcomes are documented in a screening matrix showing all aeronautical surfaces and aids \ infrastructure with reference to residual impacts with high level Mitigation Measure Strategies. The report would also include detailed recommendations and considerations, where required, for further consultation with the Aviation Authorities appointed approved Designer & Vendors. A detailed scope for further technical assessment by approved design and vendor specialists would be included and managed to provide implementable mitigation measure strategies to bring to the wind farm planning application stage.

2. Aviation Assessment

2.1 Instrument Flight Procedures (IFP’s) and Air Traffic Control Surveillance Minimum Altitude Charts - Shannon Airport

In October 2023 AI Bridges engaged Cyrrus Limited to conduct a detailed technical Instrument Flight Procedure Safeguarding Assessment.

The findings presented by Cyrrus in their IFP Safeguarding Assessment (shown in Appendix 12) in March 2024 concludes that the Proposed Development would have an impact to the following the Instrument procedures for Shannon Airport:

- Standard Instrument Departure (SID) RWY06 Procedures
- VOR Instrument Approach RWY24
- Air Traffic Control (ATC) Surveillance Minimum Altitude Chart

As noted in Section 1.1 above, there were extensive engagements with the IAA between 2021 – 2022 in relation to the 18-turbine design layout. During the consultation process, the IAA highlighted that the impacts to the SID RWY06 and VOR Approach RWY24 procedures could be mitigated, and it was agreed at that time that of the impacted IFP’s, the primary concern of the IAA was the ATCSMAC.

2.1.1 Mitigation Options:

Cyrrus present mitigation options in Section 3 of their IFP Safeguarding Assessment (attached in Appendix 12) to mitigate the impacts to the Instrument Flight Procedures at Shannon Airport. Cyrrus also present additional design options in section A.2 which offer viable mitigation measures to remove the impacts on the flight procedures and ATCSMAC Charts.

The mitigation options presented by Cyrrus draw reference to an increase in Procedure Design Gradient Required Navigation Performance (RNP) as set out in Section 1.2 above. Taking these in turn:

- <u>Standard Instrument Departure (SID) RWY06 Procedures</u>
  During the engagements with the IAA in 2022 they state that Instrument Flight Procedure designs were planned for Shannon Airport in 2022 and that this would enable the mitigation of the impact in relation to the Standard Instrument Departure (SID) i.e. the IAA agreed in principle that increasing the Procedure Design Gradient for the SID departure would be incorporated in updated IFP designs by late 2022 as shown in their consultation response below:

  > *“ Increasing of PDG from 3.5% to 4.0% for affected SIDs: Agreed in principle and can be incorporated in updated IFP designs planned for late 2022. This is also consistent with non-SID departure instructions increased PDG ”*

- VOR Instrument Approach RWY24

  The IFP Safeguarding Assessment completed by Cyrrus in December 2023 in Appendix 12 highlights that the Instrument Flight Procedures for approach onto Runway 24 and Instrument Departure from Runway 06 for Shannon Airport will be impacted. The IAA have stated (Appendix 1.4 – "IAA Email to Ai Bridges Ltd 22 February 2022") that the VOR Approach procedure is due for withdrawal by 06 June 2030 according to the State PBN Plan:

  > *" VOR RWY 24 IAP: Impact noted and mitigations understood. These are not however consistent with our requirements for SDF etc. If the development goes ahead, I would recommend withdrawal of the VOR IAP on the basis that this would be in line with the State PBN plan and that RNP IAPs are planned for Shannon during 2022 "*

  Also as referenced in the State PBN Plan (section 11 in Appendix 14) the Shannon Airport currently has approach runways are inline for RNP approaches by 25 January 2024:

  > *"the runway ends that currently have precision approaches, RNP approaches (LNAV & LNAV/VNAV & LPV Minima) shall be established at the same time as the PCP Airports, by 25 January 2024 (phase2).*

  This issue can therefore be mitigated through a pre-construction planning condition requiring the Applicant to provide appropriate evidence to the relevant planning authority that this new navigation system has been implemented. A specific condition is proposed in Section 6 below.

- Air Traffic Control (ATC) Surveillance Minimum Altitude Chart

  In their IFP Safeguarding Assessment Cyrrus identify that there will be an impact to the existing ATCSMAC Charts for Shannon Airport. As part of the ATCSMAC mitigation options presented by Cyrrus, four feasible design options are presented in Annex A of the IFP Safeguarding Report in Appendix 12 that would mitigate the impacts to the ATCSMAC Charts. All of the four mitigation options allow for safe vectoring onto the Instrument Approach procedures, which includes an option for a shortened ILS on an RNP approach. Should Shannon Airport the IAA \ AirNav have any further technical queries in relation to the assessments carried out or the mitigations proposed, the Applicant would be pleased to address these through a "request for further information".

2.1.2 IFP's summary

In the concluding statement of IFP Safeguarding Assessment in Appendix 12 Cyruss confirm what while there are impacts from the proposed Knockshanvo development to the Flight Procedures and ATCSMAC Charts at Shannon Airport there are viable mitigation options. In section 5 below the Applicant confirms its willingness to contribute its share of the cost of implementing these mitigations.

2.2 Radar Safeguarding Assessment

In their consultation response in February 2023 the IAA stated that any significant obstacle within 16km of the Woodcock Hill Radar may have an impact. They also state that in the case of the proposed Knockshanvo Wind farm that, Radar impacts would be highly likely and would need to be assessed with mitigations proposed.

The IAA also stated that their previous experience has shown that mitigations suggested for "similar developments" have been prohibitively costly for the ANSP and ultimately don't guarantee that the surveillance service is not affected. The IAA have requested that any further detailed Radar Safeguarding Assessments should comply with the "EUROCONTROL Guidelines on How to Assess the Potential Impact of Wind Turbines Surveillance Sensors."

The IAA only highlighted concerns in relation to the possible effects of the Proposed Development on the Woodcock Hill Surveillance Radar. Based on information in the public domain in relation to IAA feedback on neighbouring windfarms, it was decided that the detailed technical Radar Safeguarding Assessment should also include a due-diligence assessment of the En-route Radar facilities at Woodcock Hill. For completeness, this Radar Mitigations Options study also considers the Primary & Secondary radar facilities at Shannon Airport.

Ai Bridges engaged with Cyrrus to review the impacts of the proposed wind farm on the Radar Surveillance equipment at Woodcock Hill. The review was carried out against EUROCONTROL GUIDELINES as requested by the IAA.

Taking these assessments in turn:

- **Woodcock Hill Secondary Surveillance Radar**

It was reported by Cyrrus that while there would be impacts on the Secondary Radar (MSSR), these impacts would be operationally tolerable. In relation to the common issues relating to wind farm impacts on Radar Surveillance Systems, they note the following:

  - Reflections

  The radar at Woodcock Hill is a Thales RSM970 MSSR and is sited 5.6 km from the nearest wind turbine. The Thales radar utilizes a two-stage system to prevent both temporary (Dynamic) and permanent (Static) reflections being displayed. It also has inbuilt adaptive reflection processing. This is referenced in The Thales RSM970 MSSR Technical Description Document [Appendix 11.2]. To prevent possible reflection issues, some minor optimization may be required. This is usually carried out as part of the scheduled maintenance of the equipment.

- Deflections

The Thales RSM970 MSSR uses a well-established processing system to remove any False Replies Unsynchronized In Time (FRUIT). This process removes the issue of deflections from the system. No additional optimization is required as a DEFRUITER is part of the standard MSSR processing on the Thales system.

- Shadowing

In their Radar Mitigations Options Study, Cyrrus Limited have conducted a detailed technical assessment with detailed calculations and analysis showing there would be no radar shadowing effect caused by the Proposed Development on the Woodcock Hill Secondary Radar. Cyrrus also reference the Radar Assessment that they conducted in 2021 (as shown in **Appendix 7** – "Violet Hill Wind Farm Radar Assessment") against previous 18-turbine design and state that this turbine design did not cause any significant adverse shadowing affect and that the shadowing effect of the reduced 9-turbine design would be no worse.

- **Shannon Airport Primary & Secondary Radar:**

Though not requested by AirNav Ireland, a due-diligence assessment of the Shannon Airport Primary and Secondary Surveillance Radar shows that the proposed wind farm is within the instrumented range of the wind farm. It has been noted in the Mitigation Options Study Report that an impact mitigation strategy can be provided, that includes a suite of optimization and upgrade packages, if required.

- **En-route Radar Facilities at Woodcock Hill:**

This En-route Radar facility was assessed on the basis that IAA\AirNav raised this as a concern to two other Wind Farms (Ballycar Wind Farm and Oatfield Wind Farm) located in East Clare and currently in the planning process. The Cyruss assessment in Appendix 11 shows that there will be no shadowing impact to Woodcock Hill Radar Surveillance of En-route aircraft at heights of 10,000 to 35,000ft as the shadow regions beyond the proposed turbines are considered sufficiently small to be operationally tolerable.

To support this assessment a reference has been included to field trials that have taken place in the UK to address the minimal shadow region impacts on En-route Radar facilities. This is supported by reference to the UK Civil Aviation Authority (CAA) Safety Policy (extract shown in Appendix 13 in section "Appendix A to SUR 13: Guidance on Wind Farm Mitigation Techniques - Part 3: Impact of Wind Turbine Interference Effects on Surveillance Performance Parameters") which addresses the precedent of shadowing and low-level coverage impacts caused by the physical obstruction of wind turbines.

> *"SUR13A.68 Trials have indicated that wind turbines also create a shadow beyond the wind farm so that low flying aircraft flying within this shadow go undetected. The magnified shadows of the turbine blades and the moving rotors are visible on the radar screens of weather and ATC radars. However recent trial measurements have indicated that the shadow region behind the wind turbines would last only a few hundred meters and would hide only very small objects.* "

"SUR13A.85 Existence of a shadow region means the radar's ability to detect targets directly behind the wind turbines can be affected. Since a shadow region is thought to exist only a few kilometers behind a wind farm and the size is believed to be defined by a straightforward geometric relationship between the radar and the wind turbine farm, only the low level coverage is affected."

2.2.1 Mitigation Measures

Cyrrus have conducted their assessment in accordance with the EUROCONTROL Guidelines as requested by the IAA. Based on the detailed technical assessments, the only potential mitigation required to address any concerns in relation to radar facilities relates to the Woodcock Hill Secondary Surveillance Radar. To prevent possible reflection issues, some minor optimization of the existing radar system may be required. Cyrrus state that the erection of the 9-turbines would have no operational impact on the Woodcock Hill MSSR system. And should the Woodcock Hill Radar require optimization this would be completed one channel at aa time and allow the system and allow the system to remain operational throughout. Cyrrus also recommend an asset condition survey of the Woodcock Hill Radar system be undertaken by Thales (the manufacturer and Design Authority of the radar system). If upgrades or optimization are required to the Woodcock Hill Radar system transitional arrangements can be managed to ensure minimal operational disruption occurs.

Should the IAA have any further technical queries in relation to the assessments carried out or the mitigations proposed, the Applicant would be pleased to address these through a "request for further information".

2.2.2 International & National Precedence

The Cyrrus Radar Mitigation Options Study Report, carried out in December 2023, refers to the rationale behind the EUROCONTROL assessment to show:

- that any operational impact caused by the proposed Knockshanvo Project would be operationally acceptable.
- that a suitable mitigation, if required, can be put in place to ensure continued compliance.

Newcastle Airport: Based on these EUROCONTROL Guidelines the Mitigation Scheme in operational use at Newcastle Airport (reference attached in **Appendix 16**) would appear to demonstrate that wind farm mitigations can be implemented on the current facility at Woodcock Hill. By reference to the published Aeronautical Informational Procedure (AIP) for Newcastle Airport, it can be seen that there are several wind farms located within the radar's operating volume. The radar is operational and is used to control aircraft within the control airspace. Some of the wind farms are closer to Newcastle Airport than the proposed Knockshanvo Project is to Woodcock Hill.

Project Marshall: The reference to the Project Marshall Radar Upgrade in the UK is a reference to an FOI Request by the UK Wind Industry in relation to the MOD Radar Upgrade Program for Air Traffic Control. The UK Military of Defense (MOD) deployed an upgrade program that incorporated Windfarm Mitigation Filters to their existing radars some of which were the same model and age of the Woodcock Hill Radar. The upgrade list can be seen in **Appendix 17**. This list shows that a number of radars upgraded were the Thales RSM970S which is the same model as the Woodcock Hill Secondary Radar.

These references demonstrate that the Woodcock Hill Secondary Radar can be upgraded, subject to a conditions survey. Cyrrus state in Section 9 of their Radar Mitigations Options Study in **Appendix 11** that:

> *" An asset condition survey of the Shannon Airport and Woodcock Hill radar systems should be undertaken by Thales. This will include the current build state.*
>
> *As the manufacturer and Design Authority of both radar systems, Thales will be able to assess the type of mitigation package required (if any). They will confirm costs and timescales based on their scope of work."*

2.2.2.1 UK Aviation Plan – Wind Turbines and Aviation Radar

The Newcastle Airport reference site (as attached in **Appendix 16**) demonstrates how the Radar facilities, same model as is used at Woodcock Hill, was upgraded as part of the implementation of a viable wind farm mitigation solution. Newcastle Airport has a Thales STAR2000 with a co-mounted Thales RSM970 Secondary Radar, the same Secondary Surveillance Radar model that is used at Woodcock Hill.

The Project Marshall reference (as attached in **Appendix 17**), undertaken by the Military of Defense (MOD) is an example of a Radar Facilities project that included an upgrade and deployment to the Thales RSM970S radars, the same model of the Rader at Woodcock Hill. The Marshall Project consists of over forty Military of Defense (MOD) Radar installations.

From 2005 until 2011 Newcastle airport received over 250 consultations for on and off-shore wind farm developments from across the UH North-East region, all aiming to meet government-set targets for renewable energy. Many of the developments had the potential to affect the daily operations of Newcastle Airport's Air Traffic Control since wind turbines in operation can appear on the airport radar with similar markings to a moving aircraft.

In the absence of a solution, in the past, Newcastle Airport had no alternative but to object to proposed wind farm developments where an unacceptable impact was predicted. However, a technological solution was found in the form of Radar Blanking software, which involved updating the airport's radar system. The software places a 'patch' to cover the potential wind farm sites, thereby preventing turbines appearing, so they cannot be mistaken for moving aircraft.

In the UK, Renewable UK has been working with the Ministry of Defense, Department for Transport, Department for Business, Energy and Industrial Strategy (BEIS), the Scottish Government, the Civil Aviation Authority, NATS, the Airport Operators Association, the General Aviation Awareness Council, and The Crown Estate for many years.

In 2008 in the UK, the DECC, the Dept for Transport, Military Of Deference, Renewable UK, Civil Aviation Authority and National Air Traffic Services signed a Memo Of Understanding which committed them to work together to identify mitigation solutions and drive forward progress on projects as part of an "Aviation Plan" (as attached in **Appendix 15**). This Plan was endorsed by representatives from the relevant stakeholders within the Aviation Sector.

2.3 NAVAIDS – Flight Inspection Procedures

Flight checks are conducted annually at Shannon Airport to ensure that flight procedures and associated navigational aids are safe and accurate. These flight checks are carried out by the IAA approved service provider, Flight Inspection Service Provider Limited (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.

In June 2023, Ai Bridges conducted reviews of the Navigational Aids (NAVAIDS) for possible wind farm impacts to Flight Inspection Procedures. This involved a review of the actual recordings of the bi-annual Inspection Flights conducted by FCSL, on 12 June 2023 and 28 July 2023. The sections 2.8.2 to 2.8.3 within the Aviation Review Statement prepared by Ai Bridges (attached in **Appendix 10**) provides evidence of the actual radial flight paths showing that the flight inspection paths avoid the Proposed Development and as shown in Figures 1 to 3 below.

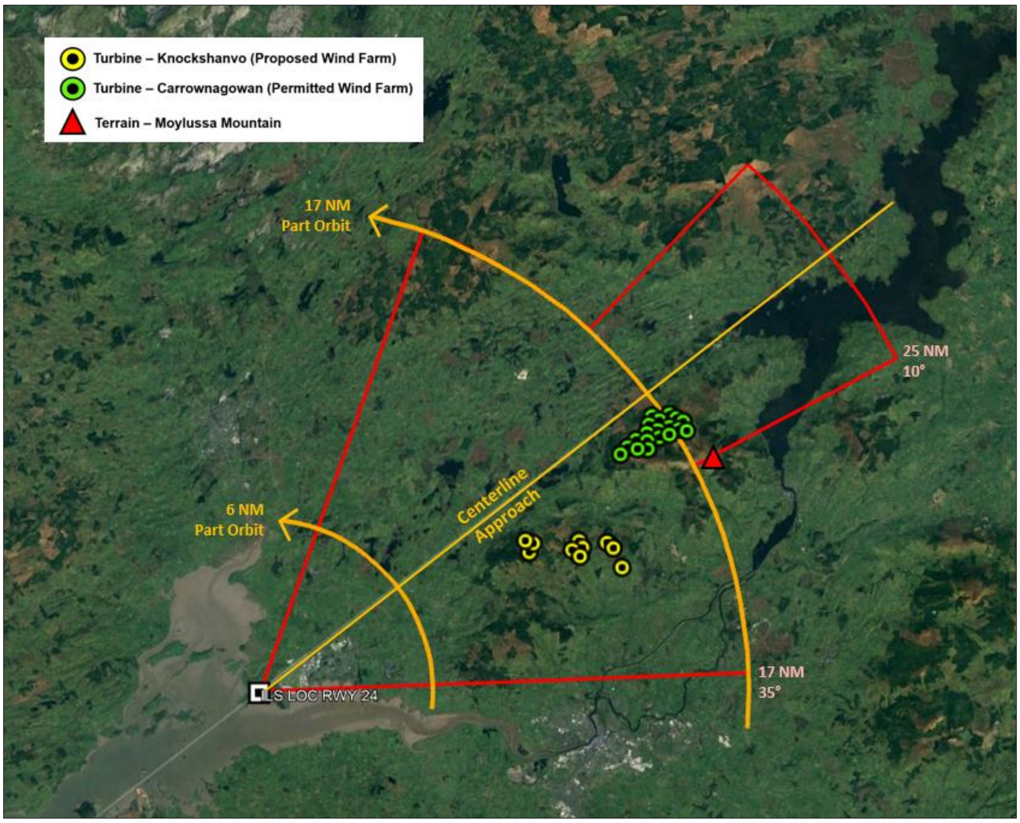


Figure 1. Flight Inspection and Calibration Test Procedures should account for Existing Obstacles (i.e. existing/permitted wind farms and terrain

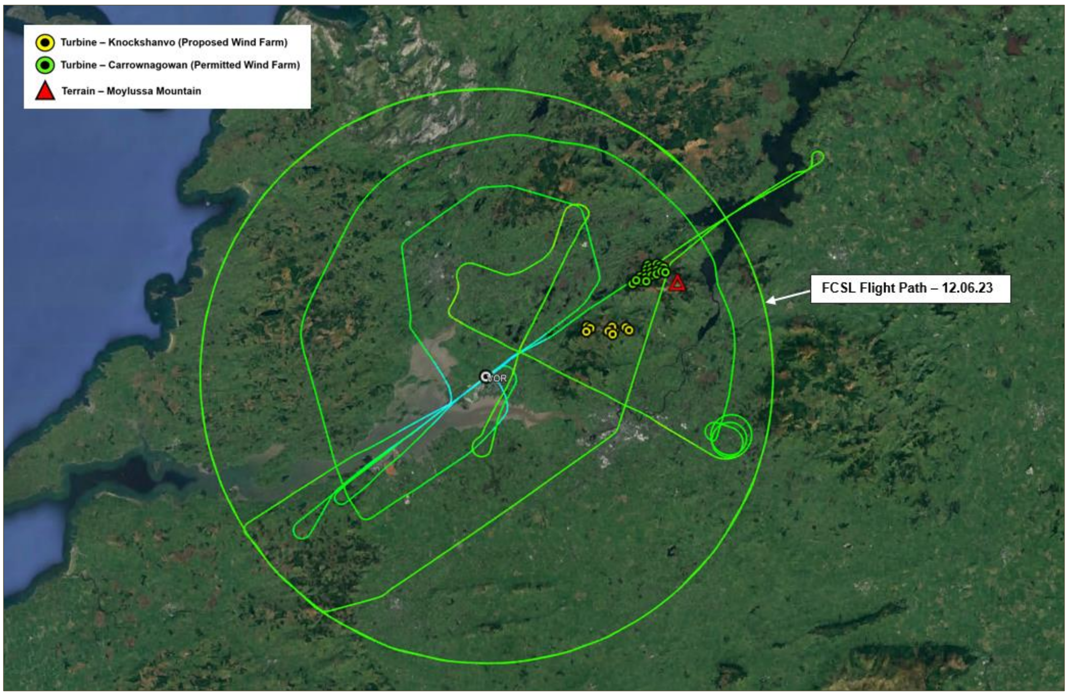


Figure 2. FCSL Flight Route - 12th June 2023

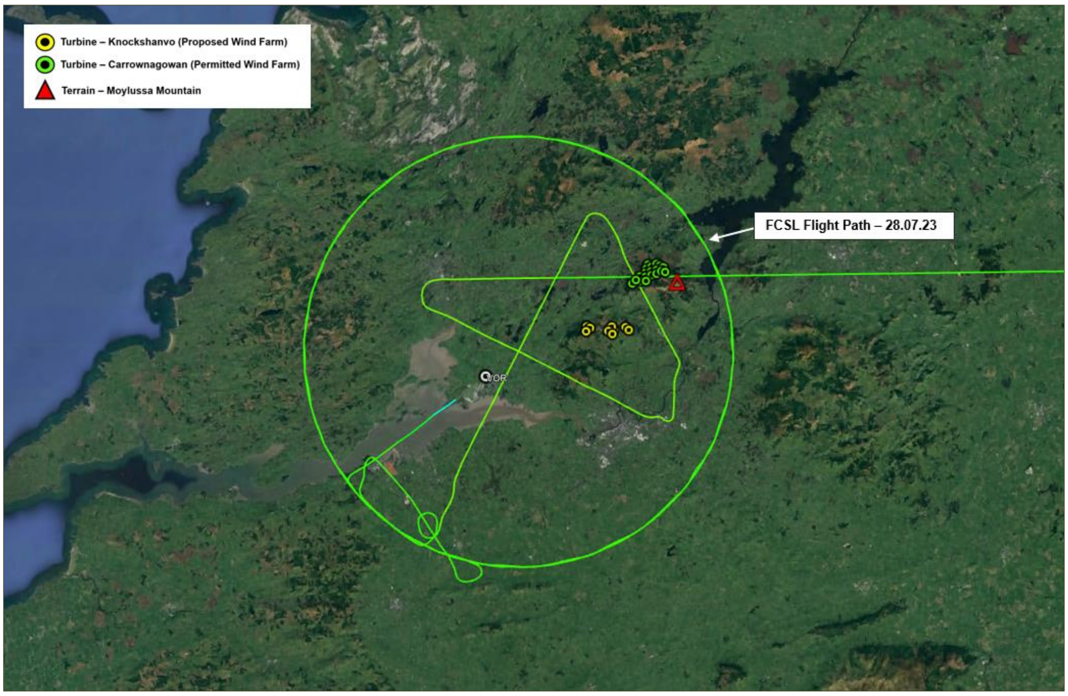


Figure 3. FCSL Flight Route - 28th July 2023

Figure 4 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 1000 ft higher than the highest of the proposed turbines.

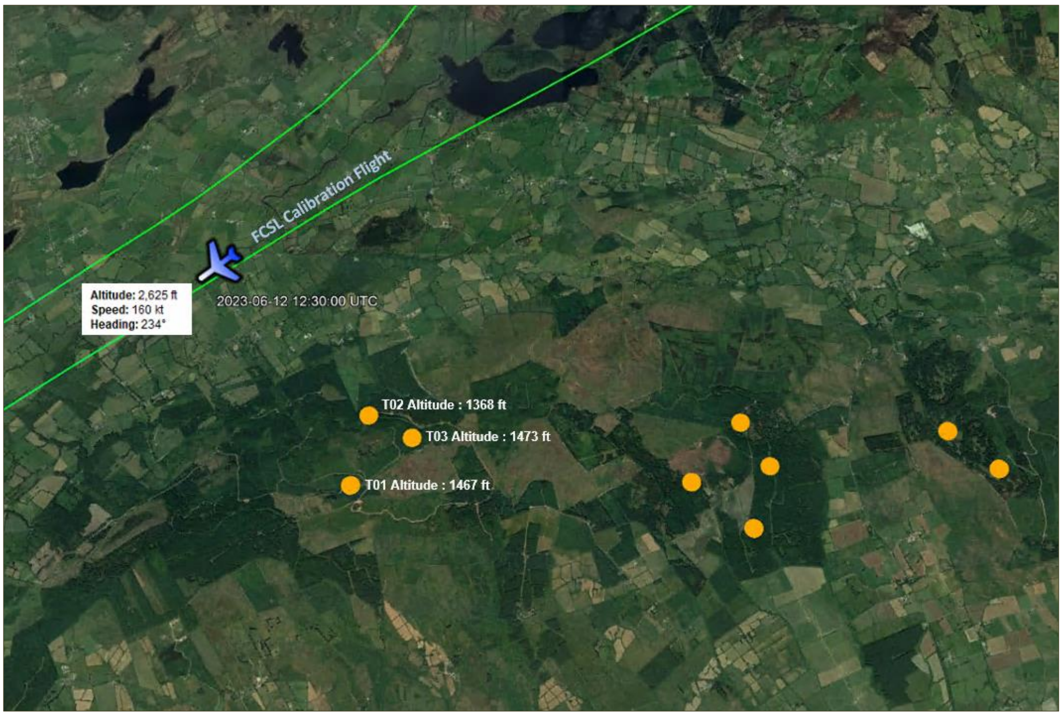


Figure 4. Close-up View of FCSL Flight Route - 12th June 2023

As part of the 18-turbine design layout (formerly referred to as Violet Hill), Ai Bridges commissioned FCSL in 2022 to conduct an assessment of the Flight Check Procedures for Shannon Airport against the potential for wind farm impacts. To further investigate the potential impact on the Flight Check Procedures Ai Bridges engaged with FCSL; to undertake an additional technical study (both of these reports are attached in **Appendix 6** and **Appendix 9.1**).

At that rime FCSL concluded

- *Flight inspection aircraft flying centreline, part orbit and bottom edge flight profiles associated with the Shannon Airport Runway 24 ILS would remain sufficiently clear of the proposed Wind Farm Site.*

  This means that if ILS flight inspection operations are conducted in IMC, the flight inspection level runs can be flown at 2,600 ft and the proposed Violet Hill wind farm will therefore not have any adverse effect on Runway 24 ILS flight inspection procedures and flight profiles.

The proposed Knockshanvo Project and the Violet Hill proposed development are on the same site and the findings of the FCSL Assessment in 2022 are relevant to the current assessment of potential impacts. All of the detailed consultations with FCSL in 2022 are attached in **Appendix 9.2.**

2.3.1 Mitigation Options:

The review of the bi-annual calibration flights conducted in 2023 shows no impact to NAVAID Flight Inspection Services and thus no mitigations are required.

2.3.2 NAVAIDS Summary

As the test aircraft flies over 1000 ft above the proposed turbines and does not fly directly over the Proposed Development, there would be no adverse effects on the Flight Inspection Services.

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 9 turbines at Knockshanvo.

3. Cumulative Impacts

There are a number of wind farms in East Clare at various stages in the planning process, some of which have been consented. In their consultation response in January 2023 the IAA did raise concerns in relation to similar developments. To assess the potential cumulative impacts of the Knockshanvo Project, it can be highlighted that the combined effect of wind farms can be difficult to mitigate, and it is possible that objections can be made to any further wind farm developments in areas where previously proposed wind farms have been consented.

In their consultation response in January 2023 the IAA refer to "previous experience" in relation to "similar developments". The details of the previous developments that have been reviewed for the same site at the proposed Knockshanvo Project have been included below.

- Brookfield Renewable pre-planning development in 2018.
- Coillte pre-planning development at the Violet Hill site in 2020 – 2022.

There was extensive stakeholder engagement to discuss the outcomes of the above projects, both of which have informed the baseline assessment of the Knockshanvo Project. The stakeholders involved were the IAA, Shannon Airport Authority, the wind farm developers and several aviation specialists contracted by the developers.

An overview of the consented wind farms and wind farms in the Planning Process in East Clare have also been included.

3.1 2018 Wind Farm Pre-Planning Consultation:

In 2018 a wind farm development was previously proposed by Brookfield Renewables (hereafter referred to as "Broopkfield") for 26 turbines which went through a pre-planning cycle. This development was proposed at the same location as the proposed Knockshanvo Project.

The initial consultation with the IAA for this previous development was in 2008 regarding a meteorological mast. At that time the IAA stated that an objection would be raised against any future wind farm planned for the site.

Brookfield engaged with the IAA from 2016 – 2018 and several detailed technical assessments were carried out at the request of the IAA. Brookfield contracted aviation specialists to conduct specialist Instrument Flight Procedures and Radar Assessments respectively. In 2018 Brookfield also contracted the National Air Traffic Services (NATS) to conduct a Technical Safeguarding Summary against said assessments. (NATS is UK's principal air navigation services provider which provides air traffic management services to aircraft within UK airspace). On the matter of the Woodcock Hill Radar assessment, NATS noted that the Radar Assessment, derived from EUROCONTROL GUIDELINES, was very similar to the process that NATS themselves use to safeguard their own Secondary Radars across the UK. NATS also noted they were unable to comment on the conclusion in the Radar Assessment that "aircraft would be unlikely to fly within the shadow" without input from the IAA or Shannon Airport Authority but that the conclusion does not seem unrealistic given the low altitudes of shadow regions indicated in the report.

3.2 2020-2022 Violet Hill Wind Farm Pre-Planning Consultation & Aviation Assessments:

This is a reference to the proposed 18-turbine Violet Hill development by Coillte that was considered for the same site as the Knockshanvo Project from 2020 to 2022. The engagements with the IAA are included in the following appendices **Appendix 1** – **Appendix 9.2.**

3.3 Consented Wind Farms Developments in East Clare:

The Planning References for the Wind Farm(s) in the vicinity of the proposed Knockshanvo Project are shown in Table 1 below. These wind farms are depicted in Figure 1 which shows the wind farm developments in relation to the Monopulse Secondary Surveillance Radar (MSSR) facilities at Shannon Airport and Woodcock Hill that are in the vicinity of the proposed Knockshanvo Project.

Both the **Carrownagowan** and **Fahybeg** wind farms have been permitted. Both wind farm developments are within 16km of the Woodcock Hill Secondary Surveillance Radar at Woodcock Hill. The IAA, in their consultation response in relation to the Knockshanvo Project in February 2023, state that any significant obstacle within 16km of the Woodcock Hill Radar may have an impact. There were no amendments or re-design of Instrument Flight Procedures for Shannon Airport required for either Carrownagowan or Fahybeg and there were no adverse impacts to En-route Secondary Surveillance Radar facilities at Woodcock Hill. The Radar Safeguarding Assessments for both projects were conducted according to Eurocontrol guidelines and the IAA deemed there to be no adverse impact to the Woodcock Hill Radar. An IFP Safeguarding Assessment for both wind farms also showed no adverse impacts minimum surveillance vectoring altitudes.

The **Lackareagh** wind farm development has been submitted for planning and no impacts on Instrument Flight Procedures or ATC SMAC Charts for Shannon Airport were reported and there are no adverse impacts to En-route Secondary Surveillance Radar facilities at Woodcock Hill.

The **Ballycar** wind farm is in the planning process. The IAA\AirNav have not raised any concerns in relation to Instrument Flight Procedures against the Ballycar wind farm. There is no combined effect of the Ballycar Wind Farms that needs to be considered in relation to the Aviation Impact Assessment for this project. While the IAA have raised a concern in relation to En-route Radar facilities at Woodcock Hill against Ballycar Wind Farm there would be no combined wind turbine effect on En-route Radar facilities.

The **Oatfield** wind farm is currently in the planning process and is in the vicinity of this project. From the perspective of IFP Safeguarding each wind turbine is assessed independently of every other turbine in terms of penetration of protected aviation surfaces. The IFP Assessment carried out against the Oatfield Wind Farm showed an impact to the Instrument Approach and Standard Departure procedures at Shannon Airport however mitigation measures have been proposed by the Applicant that would ensure that the effect of the Proposed Development would not have an effect on the Instrument Flight Procedures at Shannon Airport.

Wind Farm	Planning Status	Planning Reference	Wind Farm Description
Carrownagowan	Consented	Planning Application: 229000 (Clare County Council) https://www.eplanning.ie/ClareCC/AppFileRefDetails/229000/0	Permitted 19-Turbine Wind Farm (No Impacts on Instrument Flight Procedures or Radar Surveillance Facilities)
Fahy Beg	Consented	https://www.pleanala.ie/en-ie/case/317227	Permitted Wind Farm
Lackareagh	Submitted for Planning	https://www.eplanning.ie/ClareCC/AppFileRefDetails/2360219/0	Proposed 7-Turbine Wind Farm (No Impacts on Instrument Flight Procedures or Radar Surveillance Facilities)
Oatfield	Submitted for Planning	https://www.pleanala.ie/en-ie/case/318782	Proposed 1-Turbine Wind Farm In Planning
Ballycar	Submitted for Planning		Proposed 12-Turbine Wind Farm In Planning

Table 1 East Clare Wind Farm Planning Reference

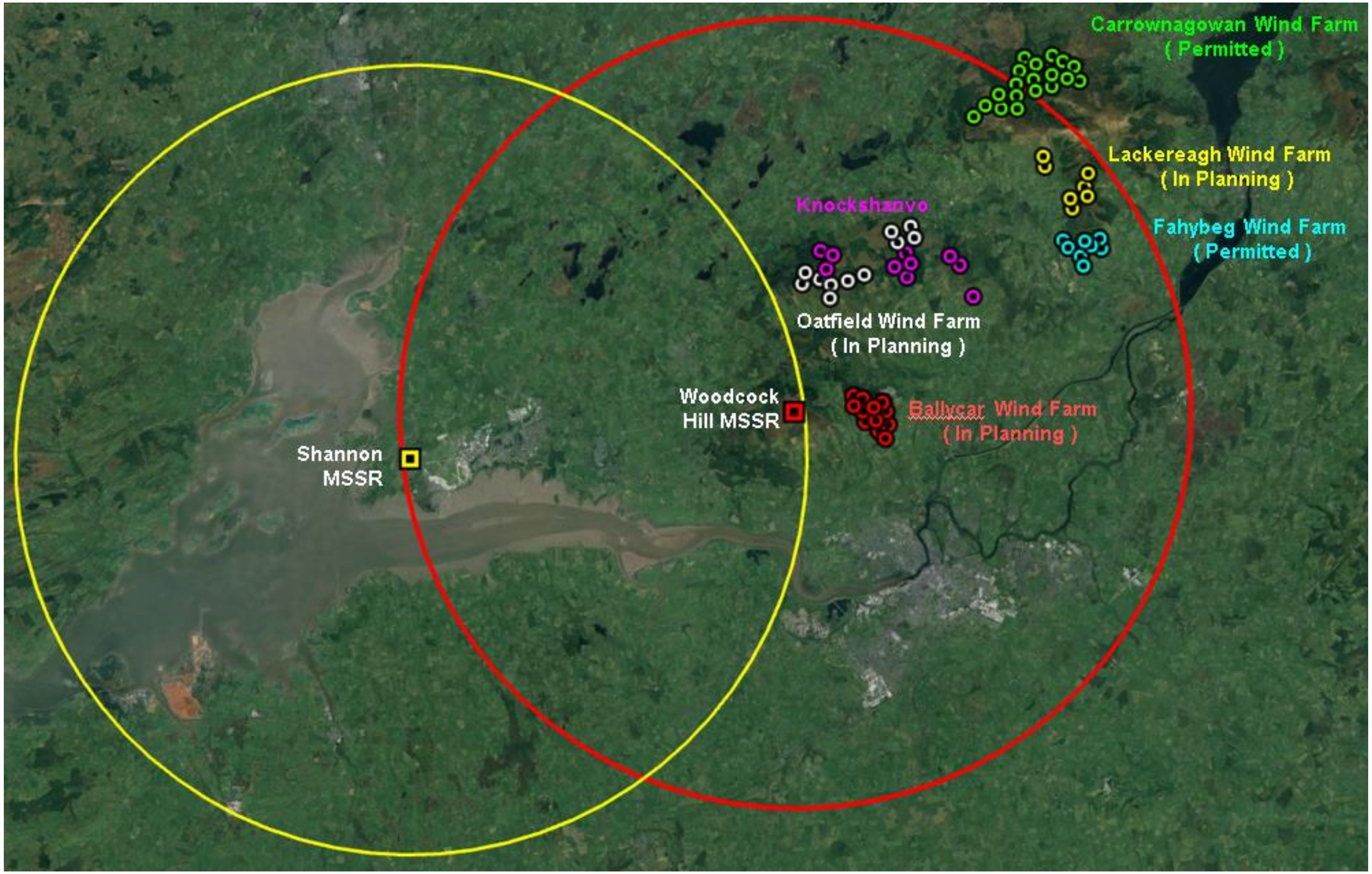


Figure 1 East Clare Wind Farm Developments

4. Residual Impacts

The implementation of the State PBN Plan by 06 June 2030 will allow for mitigation of the reduction of impacts of the proposed Knockshanvo Project on the Standard Instrument Departures (SID) and Standard Arrival (STAR) procedures at Shannon Airport.

Following consultations with the IAA in 2022 the impacts to the VOR RWY 24 Instrument Approach Procedure were noted and mitigations understood. The IAA note that should a development go ahead at the same site of the proposed Knockshanvo Project then the withdrawal of the VOR Instrument Approach Procedure would be recommended on the basis that this would be in line with the State PBN plan and that RNP IAPs are planned for Shannon during 2022. This would ensure that proposed project would not have any significant residual impact on the operations of the Instrument Approach Procedure.

During the engagements with the IAA in 2022 they state that Instrument Flight Procedure designs were planned for Shannon Airport in 2022 and that this would enable the mitigation of the impact in relation to the Standard Instrument Departure (SID) i.e. the IAA agreed in principle that increasing the Procedure Design Gradient for the SID departure would be incorporated in updated IFP designs by late 2022. This would ensure that proposed project would not have any significant residual impact on the operations of the Standard Instrument Departure Procedures.

It has been identified that there will be an impact to the existing ATCSMAC Charts for Shannon Airport. As part of the ATCSMAC mitigation options presented, four feasible design options are presented to mitigate the impacts. All of the four mitigation options allow for safe vectoring onto the Instrument Approach procedures, which includes an option for a shortened ILS on an RNP approach. The Applicant acknowledges that the proposed project, prior to a mitigation design option, would have an impact of the vectoring of flights by Air Traffic Controllers at Shannon Airport. The Applicant further acknowledges that additional consultation and additional design iteration may have to be undertaken to address any concerns that may be raised by the IAA, to ensure that the effect of the proposed project on the ATCSMAC on Shannon Airport ATC services are no significant

The introduction of the State PBN plan by 06 June 2030 will ensure that that the effect of the proposed project on Shannon Airport IFP’s and ATCSMAC charts will not be significant. And will not have a residual impact on ATC services at Shannon Airport.

The Radar Assessment carried out by Cyrrus shows that there will be no impact on the Woodcock Hill Radar according to the industry standard Eurocontrol Guidelines adopted by the IAA thus ensuring that the effect of the proposed project is not significant.

5. Mitigation Costs

The Applicant is accepting of the need for financial support the funding of additional resources that may be required by the IAA \ AirNav to conduct further flight procedure designs and radar upgrades as part of their PBN rationalisation plan and scheduled Radar Facility upgrades in the coming years. The Applicant also accepts that the expectations of the IAA\AirNav and Shannon ATC expectations in relation to safe operations, would need to be met i.e. any mitigation measure solution would be safe and ensure an efficient air traffic flow.

The Applicant would be willing to contribute its share of the costs associated with any implementable and viable mitigation measure solution, as required, on a pro-rata basis with any of the listed projects that are granted a planning consent. During the engagements with the IAA in 2022 they stated.

> *“ Aside for the costs in production of further assessments as referenced, system upgrades for filtering, flight procedures changes, ATC changes to support the mitigate for the new obstacles, as well as continuing additional costs associated with more flight check activity on an bi-annual basis, has the potential to cost the ANSP in the region of €200,000.00+, should planning be granted as proposed. “*

6. Conclusions

A concluding statement for each of the issues identified by the IAA as areas for further analysis including Assessment Outcomes and Mitigations is provided below.

- Instrument Flight Procedures and ATCSMAC at Shannon Airport
- Secondary Surveillance Radar (MSSR) at Woodcock Hill
- Navigational Aids at Shannon Airport.

Issues	Areas for Further Analysis	Assessment Outcomes \ Mitigations	Residual Impact
IFP's \ ATCSMAC Charts Shannon Airport	IFP's	The impacted IFP's will be withdrawn in line with the State PBN Plan for Ireland on 06 June 2030 after which time there will no longer be an impact to the impacted IFP's. The IAA agreed in principle that increasing the Procedure Design Gradient for the SID departure would be incorporated in updated IFP designs by late 2022. The IAA recommends withdrawal of the VOR IAP on the basis that this would be in line with the State PBN plan and that RNP IAPs are planned for Shannon during 2022. Also as referenced in the State PBN Plan (section 11 in Appendix 14) the Shannon Airport currently has approach runways are inline for RNP approaches by 25 January 2024:	None
	ATCSMAC Chart	The IFP Assessment shows that there are four mitigation options that allows for safe vectoring onto the Instrument Approach procedures, which includes an option for a shortened ILS on an RNP approach. The ATCSMAC can be re-designed on the basis of an Airspace Redesign Concept i.e. a RNP Instrument Approach Procedure (IAP) on a shortened ILS as a possible mitigation, and which would be operationally feasible for Shannon ATC.	
MSSR at Woodcock Hill	Reflections	The Thales RSM970 MSSR Sited at Woodcock Hill is 5.6 km from the nearest wind turbine. The Thales radar utilizes a two-stage system to prevent both temporary (Dynamic) and permanent (Static) reflections being displayed. It also has inbuilt adaptive reflection processing. This is referenced in The Thales RSM970 MSSR Technical Description Document [**Appendix 11.2**].To prevent possible reflection issues, some minor optimisations may be required. This is usually carried out as part of the scheduled maintenance of the equipment. The IAA\AirNav have scheduled an upgrade in the next two to five years of all the radar surveillance equipment in the state and these upgrades will likely include updates to the two-stage system within MSSR to prevent reflections being displayed. This would be conformed as part of an asset conductions survey by the Radar Manufacturer (Thales)	None

Issues	Areas for Further Analysis	Assessment Outcomes \ Mitigations	Residual Impact
	Deflections	The Thales RSM970 MSSR uses a well-established processing system to remove any False Replies Unsynchronised In Time (FRUIT). This process removes the issue of deflections from the system. No additional optimisation is required as a DEFRUITER is part of the standard MSSR processing on the Thales system.	
	Shadowing	Due to the close proximity of the Turbines to the Woodcock Hill radar, some shadowing will occur. A detailed previous assessment was completed by Cyrrus on the previous 18-turbine design. It was considered any shadowing would be minimal and be operationally tolerable. With the reduction in turbines to 9, it is assumed the shadowing would be no worse than the previous assessment and so remain operationally tolerable.	
NAVAIDS at Shannon Airport.	Flight Inspection Procedures	The proposed Knockshanvo Project will have no adverse effect on the Flight Inspection Procedures and procedures associated with the Runway 24 Instrument Landing Systems at Shannon Airport	None

The Applicant would welcome the opportunity to engage with AirNav Ireland to discuss the mitigation solutions that have been presented in the Safeguarding Assessments for Instrument Flight Procedures and Radar Assessments.

The Applicant is accepting of the need for financial support the funding of additional resources that may be required by the IAA\AirNav to conduct further flight procedure designs and radar upgrades as part of their PBN rationalisation plan and scheduled Radar Facility upgrades in the coming years. The Applicant also accepts that the expectations of the IAA\AirNav and Shannon ATC expectations in relation to safe operations, would need to be met i.e. any mitigation measure solution would be safe and ensure an efficient air traffic flow.

The implementation of the State PBN Plan by 06th June 2030 is welcomed. What this means in the context of building out the Proposed Wind Farm is that several of the potential issues identified in the detailed assessments noted earlier will no longer be relevant. As such, proposed turbines T01, T02 and T03 of the Proposed Wind Farm currently noted as penetrating the departure and approach obstacle protection areas at Shannon Airport. Under the new navigation measures, proposed turbines T01, T02 and T03 could be erected, albeit not until the 07th June 2030 when the new measures are rolled out.

As such, the Applicant here confirms that should An Bord Pleanála deem it appropriate, a planning condition attached to any grant of planning permission issued requiring that turbines T01, T02 and T03 will not be erected until the measures are in force, is acceptable. Suggested wording is set out below:

Turbines T01, T02 and T03 *as identified on the plans and particulars accompanying the planning application shall not be erected until such time as the IFP measures relating to Shannon Airport are in force.*

Reason: in the interests of aviation safeguarding

The ATCSMAC at Shannon Airport consists of four sectors. The impact of the turbines on the ATCSMAC Chart on Sector 1 and Sector 2 can be addressed by four proposed redesign options which enable an evaluation of the potential ways to remove the impact to the ATCSMAC. These redesign options would need to be evaluated by Shannon Airport and the IAA to determine if the proposed designs would allow for safe and effective vectoring of aircraft.

The Applicant would be willing to contribute its share of the costs associated with any implementable and viable mitigation measure solution, as required, on a pro-rata basis with any of the listed projects that are granted a planning consent. During the engagements with the IAA in 2022 they stated.

" Aside for the costs in production of further assessments as referenced, system upgrades for filtering, flight procedures changes, ATC changes to support the mitigate for the new obstacles, as well as continuing additional costs associated with more flight check activity on an bi-annual basis, has the potential to cost the ANSP in the region of €200,000.00+, should planning be granted as proposed."

Appendix 1.1

Violet Hill Wind Farm 2020-2022 Pre-planning Consultations :

Violet Hill Wind Farm 2020 - 2022 Pre-Planning Consultations

This summary appendix includes reference to the pre-planning Aviation assessments and consultations that were commenced in 2020 in relation to the proposed the Violet Hill development, comprising of 18 turbines. At that time Coillte commissioned Ai Bridges to engage with the Irish Aviation Authority (IAA) and aviation authorities and other Aviation Stakeholders to conduct an aviation desktop screening of the potential wind farm impacts. Ai Bridges completed a desktop assessment, (as attached in Appendix 1) which assessed all of the Communications, Navigations and Surveillance surfaces , sensors and equipment at Shannon Airport and Woodcock Hill Radar facilities. Ai Bridges also conducted a specific assessment review of the Flight Inspection procedures (as attached in Appendix 2) which investigated any effects that the proposed turbines would have on the bi-annual ILS Flight Inspection procedures. Ai Bridges also completed a Radar Surveillance Desktop Review (as shown in Appendix 3)

Ai Bridges noted potential impacts to the Instrument Flight Procedures (IFP) for Shannon Airport, the Radar Surveillance equipment at Shannon Airport and Woodcock Hill and as well as potential impacts to the Navigational Aids at Shannon Airport used for annual flight calibrations.

An initial consultation was sent to IAA with the details of the proposed development for their review. The IAA noted the following in their consultation response in November 2021.The detailed consultations with the IAA, from November 2021 to April 2022, are shown in Appendix 4.

> *Surveillance: Woodcock Hill MSSR could be affected by the turbines and filtering out this issue, although possible may be prohibitively expensive*
>
> *NAVAIDs: For flight calibration activity, the turbines could impact this activity*
>
> *IFPs: Surveillance minima as well as Instrument flight procedures could have some impact dependent on the wind turbine elevations*

Ai Bridges recommended that detailed technical assessments be conducted by certified Procedure Designers and Radar Engineering Consultants. Cyrus Limited were commissioned to undertake both Instrument Flight Procedures (IFP) Safeguarding Assessment in August 2021 (as attached in Appendix 5) , an Assessment of the ILS Flight Inspection procedures (as attached in Appendix 6) and Radar Assessments in September 2021 (as attached in Appendix 7) for the proposed Violet Hill Wind Farm comprising of 18 turbines.

These technical assessment reports were provided to the IAA for review.

There was detailed consultations and engagement, via email and telephone conference calls with the IAA, where they highlighted their concerns in relation to the Air Traffic Control Surveillance Minimum Altitude Chart (ATCSMAC) used for vectoring of aircraft onto the approach runway at Shannon Airport. AI Bridges then commissioned Cyrrus to conduct a

Conceptual Design Report which included mitigation measure options to address the concerns in relation to any effects on ATCSMAC (as shown in Appendix 8)

On a telephone conference call in January 2022 the IAA provided an overview of the main concerns that the IAA Flight Procedure Designers had in relation to Violet Hill. Some of the points addressed on the call included

- *An overview of IAA Roadmap in relation to Flight Procedures. IAA are moving to Performance Based Navigation with the current Instrument Landing Systems (ILS) being used as a back-up . VHF Omnidirectional Range (VOR) will be phased out and relates to the approach procedures which is currently impacted by the proposed turbines.*

- *A reference the ongoing re-design of the Standard Instrument Departures (SID) to achieve shorter segments and transition routes. There is a rationalization for the cardinal N, S, E and W routes with earlier transition as the current SID's are legacy n nature and also noting that all ATS routes are now gone outside 30NM*

- *A consideration of the ATC Surveillance Minimum Altitude Clearances (ASMAC) i.e. altitudes based on obstacles on the close in segments for vectoring of aircraft based on the ASMAC Charts*

In a further written consultation response on 4th February 2022 the IAA acknowledged the proactive engagement by Ai Bridges and the involvement of Cyrrus with the various assessments received. The IAA then went on to state the following in relation to the Radar Assessment following review :

> *"Methodology of this assessment has been accepted in principle"*
>
> *"While the content of the Radar Assessment is appreciated, the likely costs, operational impacts and timeline deliverables of the proposed wind farm will be need to be further assessed by the ANSP and also in the context of Regulatory requirements."*

Following their review of the assessment carried out for Navigational Aids and the Flight Inspection Procedures at Shannon Airport, the IAA stated :

> *"Conclusions of the report are noted potential delays to flight calibration activity resulting from the Wind Farm development as constructed, are not acceptable. This is because the ANSP is regulatory required to complete NAVAIDs flight calibration twice yearly. If schedule is affected or missed, this could result in (temporary) withdrawal of ILS systems, in turn adversely affecting airport arrival operations to RWY 24"*

In their concerns regarding Instrument Flight Procedures the IAA highlight their concerns while also referencing the State PBN Implementation Plan as to possible ways to address the impacts on the conventional VOR Runway 24 IAP. The IAA also refers to the Required Navigational Performance (RNP) approaches in combination with the ILS-based final approaches as part of the State PBN plan. The IAA allow for the possible withdrawal of the conventional VOR approach on the basis of the State PBN plan :

> *"Increasing of PDG from 3.5% to 4.0% for affected SIDs: Agreed in principle and can be incorporated in updated IFP designs planned for late 2022. This is also consistent with non-SID departure instructions increased PDG"*

“VOR RWY 24 IAP: Impact noted and mitigations understood. These are not however consistent with our requirements for SDF etc. If the development goes ahead, I would recommend withdrawal of the VOR IAP on the basis that this would be in line with the State PBN plan and that RNP IAPs are planned for Shannon during 2022”

The IAA also raised operational aspects in the application of Surveillance Minimum Altitude Chart minima with two major ATC concerns.

“Vectoring of traffic for short finals, amended SMAC minima has the potential to increase ATCO workload in vectoring traffic with less flexible minima on shorter finals for RWY 24”
“For aircraft operations the potential false capture of the GP with more constrained altitudes is of concern particularly as RWY 24 is the CAT II ILS approach for Shannon Airport”
“Lastly, there is a likelihood that the 3° Glide Slope might need to be increased to cater for these new obstacles, which is not acceptable operationally

Following the engagements Ai Bridges commissioned FCSL Ltd in April 2022 another for additional assessment were conducted including an additional ILS Glide Path flight. The report, as shown in Appendix 9.1, concluded that adequate RF signal levels were received at the higher altitudes of 2,600ft and 3,000ft and the proposed Violet Hill development would not have any adverse effect on the Runway 24 ILS flight inspection procedures. The consultations with FCSL Ltd are documented, as shown in Appendix 9.2. In a correspondence on 30th April 2022 FCSL conclude

The proposed Violet Hill wind farm will not have any adverse effect on Runway 24 – Special Flight Ins[pection procedures and flight profiles

The final consultation response received from the IAA sent in April 2022 stated :

“ I can only once again apologise for the tardy response and again acknowledge the proactive engagement from you. I have a clear understanding of your position in guiding Coillte that you require an assessment on magnitude of costs.

I would be of the strong opinion that it doesn’t make sense to add to your burden of costs if potentially the project won’t get planning.

In the thread below, I made reference to like assessments and a burden of cost on the IAA ANSP, across NAVAIDs, Surveillance and ATC Procedures/ Instrument Flight Procedures.

Aside for the costs in production of further assessments as referenced, system upgrades for filtering, flight procedures changes, ATC changes to support the mitigate for the new obstacles, as well as continuing additional costs associated with more flight check activity on an bi-annual basis, has the potential to cost the ANSP in the region of €200,000.00+, should planning be granted as proposed.

Attached once again are the various reports as commented on by me below.

While I am very aware of the strategic importance of this project in relation to the National Gird, being even more pertinent in these times, I’m afraid to say, that the IAA cannot offer its full support, unless the project could consider lowering the elevations of the turbines at this time. There are simply too many open questions as outlined below.

Could I genuinely compliment you on your work and the understanding of the multiple working parts of the IAA ANSP that you have demonstrated in our interactions?

> *Noting that you had planned a May 2022 date for having a clear roadmap towards the planning application process, I can only suggest you proceed with the application and we will accordingly engage at that point, via Clare Co.Co"*

In 2022 the IAA acknowledged the level of engagement and the understanding of the position taken by the developer to assess the magnitude of mitigation measure costs. The IAA provided indicative costs of €200,000 and above for implementation of mitigation measure costs should planning be granted for the proposed Violet Hill Wind Farm 18-turbine layout.

The IAA also stated that they would engage in the planning application via Clare County Council Planning Authority in the case that the proposed Violet Hill Wind Farm development be submitted through the planning application process.

Appendix 1.2

Violet Hill Wind Farm Aviation Review

Violet Hill Wind Farm Aviation Assessment

Ai Bridges Ltd.	
Document Title: Ai Bridges Aviation Studies	Date: 19.04.21
Document Number: AICYTRA001	Revision: 0.1

Aviation Assessment Overview

Review of the following obstacle assessment surfaces, protected surfaces for flight procedure including rules and regulations for aviation safeguarding

1. Wind Farm Development Overview
2. Shannon Airport Overview
3. Oatfiled and Violet Hill Wind Turbines Overview
4. Annex 14 - Obstacle Limitation Surfaces (OLS)
5. Annex 15 – Aerodrome Surfaces
6. Minimum Sector Altitudes (MSA)
7. Instrument Flight Procedures
8. Communications, Navigation Safeguarding
9. Aeronautical Obstacle Warning Light Scheme
10. Flight Calibration Checks
11. Radar Surveillance Systems Safeguarding

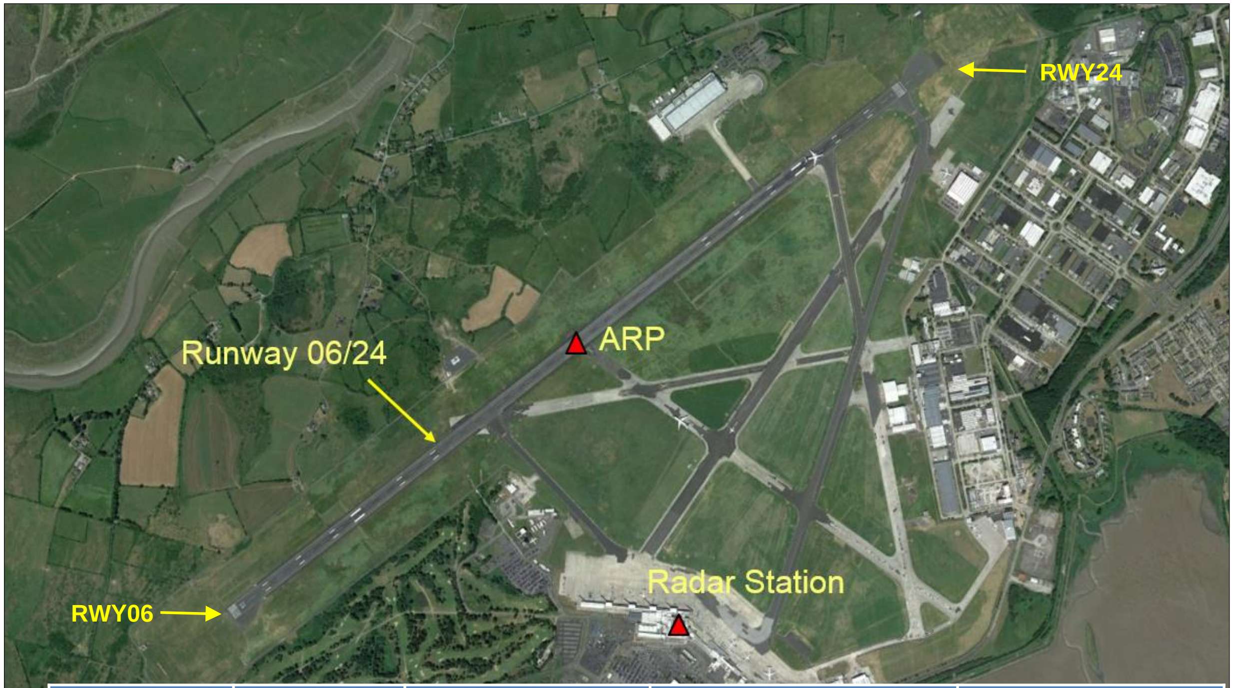
1. Wind Farm Development Overview

- The location of the proposed wind farm development is shown in Figure 1.
- The proposed development consists of 16 turbines.
- The turbine dimensions are provided in the table opposite.

Wind Farm	Number of Turbines	Turbine Tip Height	Turbine Rotor Diameter
Violet Hill	16	185m	155m

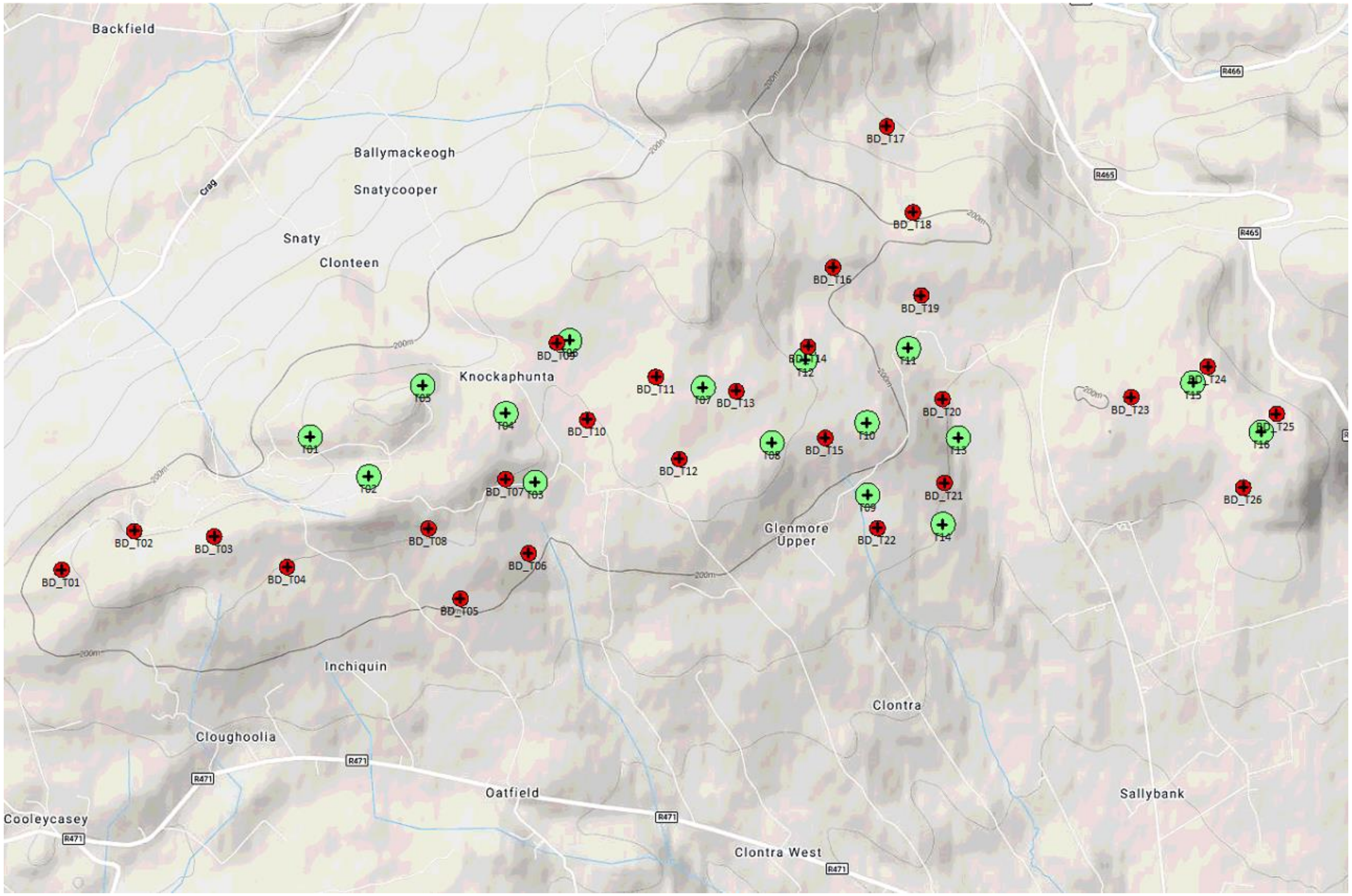
2. Shannon Airport Overview

- Airport Reference Point (ARP), - 17.4 km from Violet Hill
- One single runway surface with two Runways – 06 and 24
- There are departures and approaches on both Runways 06 and 24
- Violet Hill review takes into account Approaches on Runway 24 and Approaches on Runway 06



Location	Installation	Description	Airport Ref. Point ARP	Distance to Proposed Wind Farm
Shannon, Co Clare	International Airport	Single Asphalt Runway Airspace: Class C	52 42 07 N 008 55 29 W (Mid-point of Runway 06/24).	17.6 km

3. Oatfield & Violet Hill Wind Turbine Overview



Violet Hill Turbines

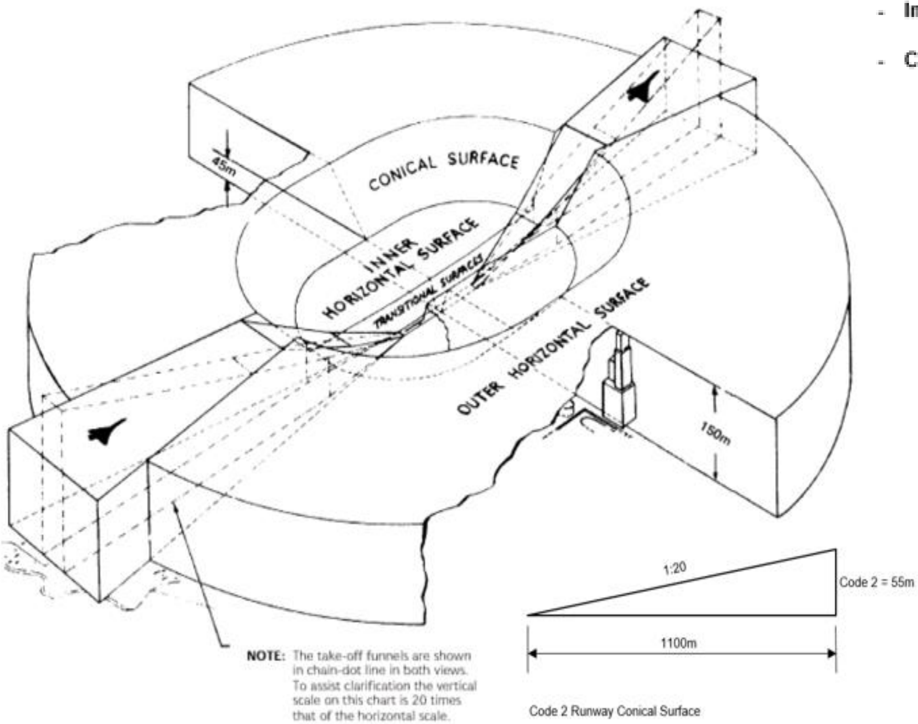
Oatfield 2018 Turbines

Wind Farm	No. of Turbines	Tip Height	Rotor Diameter	Bearing	Distance NM	Distance Km
Violet Hill	16	185m	155m	NE	9.5	17.6
Oatfield	26	150m	100m	NE	7	12.964

4. Annex 14 -Obstacle Limitation Surfaces (1)

The IAA Aerodrome Licensing Manual specifies that for a Non-Instrument runway the following obstacle limitation surfaces should be established:

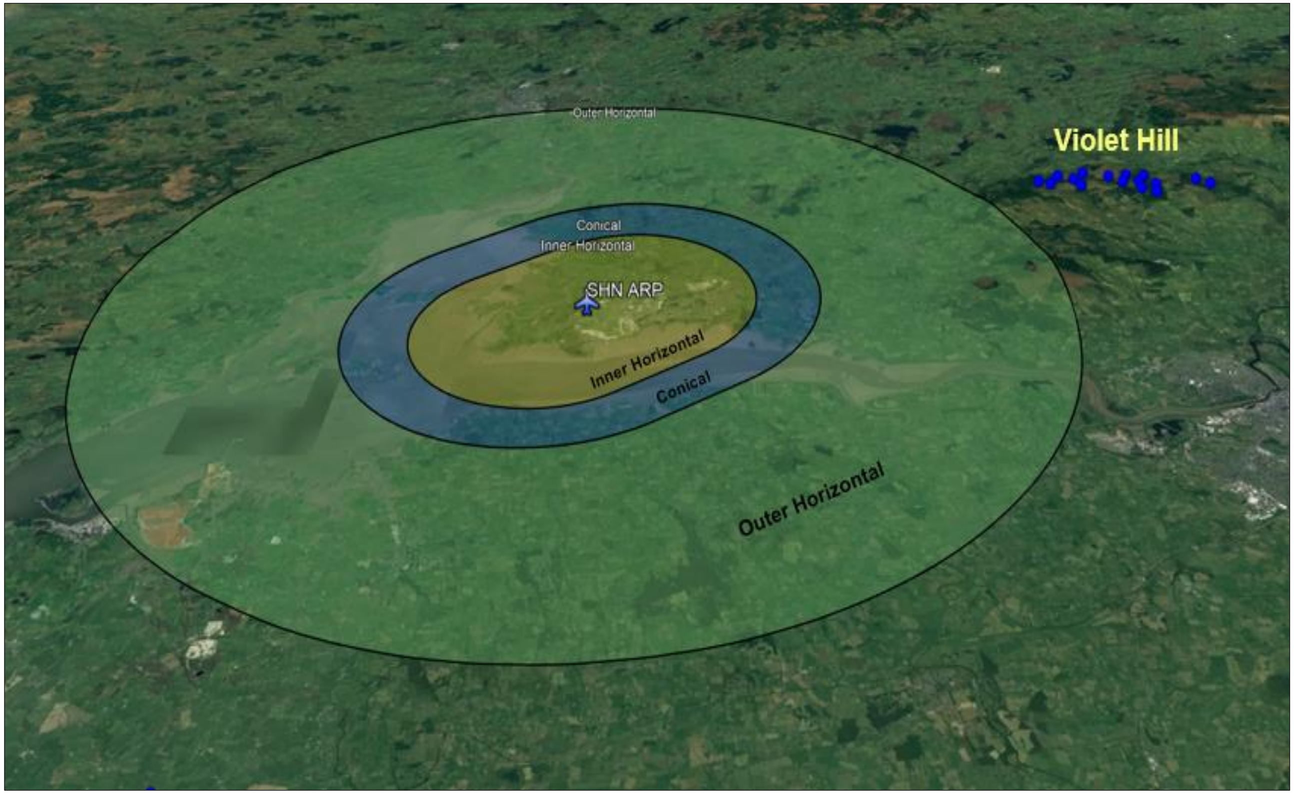
- **Approach Surfaces:** Long wedge-shapes, leading to the end(s) of each runway.
- **Take-Off Climb Surfaces:** Also at the end(s) of each runway, and usually (but not always) narrower than the Approach Surface.
- **Transitions Surfaces:** To both sides of each runway, mostly contained within the aerodrome itself.
- **Inner Horizontal Surface:** A large race-track-shaped or circular area above an aerodrome.
- **Conical Surface:** A large rising 'rim' area just outside the Inner Horizontal Surface



Obstacle Limitation Surfaces (OLS)

- Outer Horizontal Surfaces out to 15km are not penetrated
- IAA Flight Procedure designers may need to assess the turbines as obstacles within the containment area of the instrument flight procedures i.e.

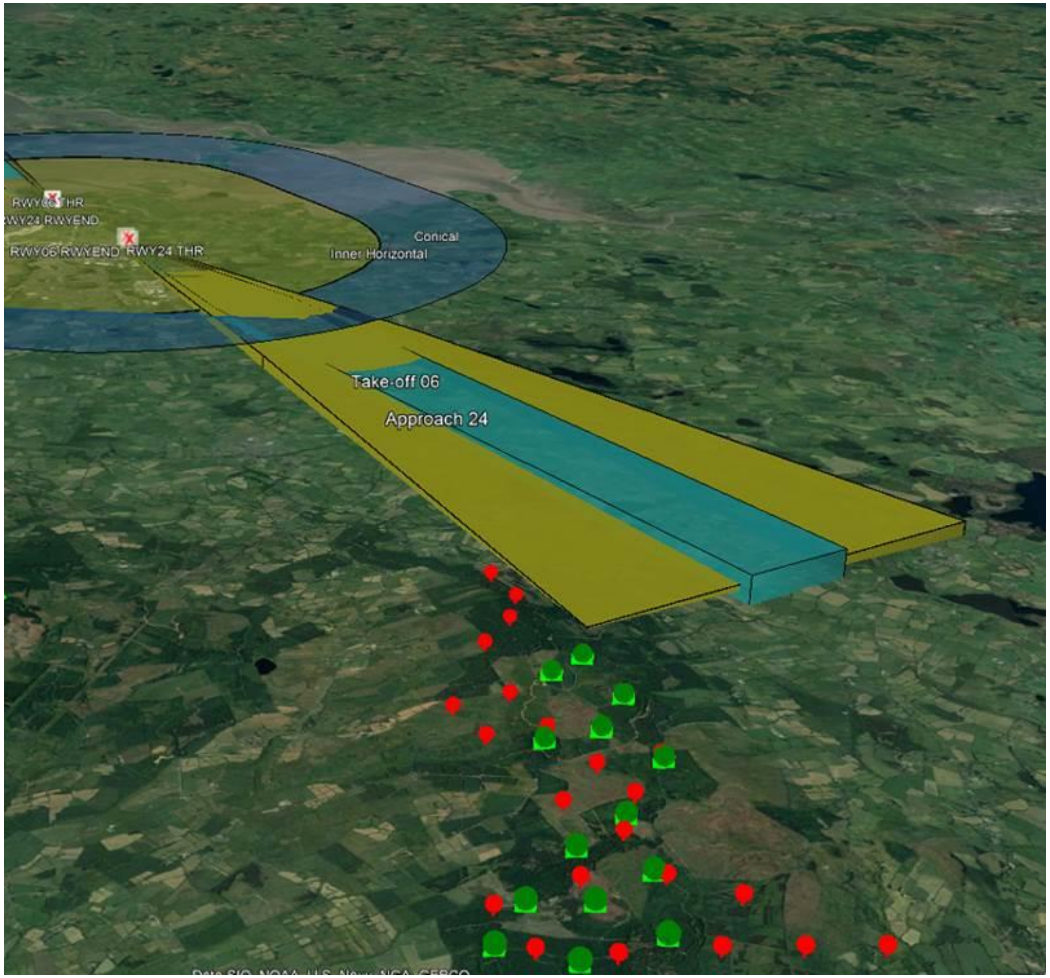
4. Annex 14 - Obstacle Limitation Surfaces (2)



- Outer Horizontal Surfaces out to 15km are not penetrated

- IAA Flight Procedure designers may need to assess the turbines as obstacles within the containment area of the instrument flight procedures i.e. ***Take-Off and Approach Surfaces***

4. Annex 14 -Obstacle Limitation Surfaces (3)

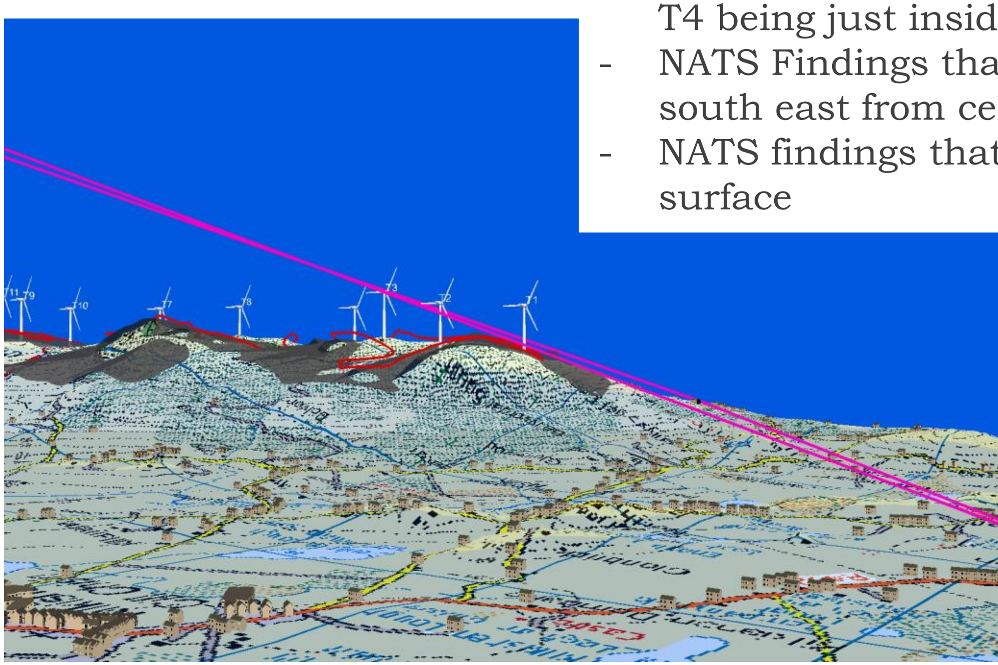


3D Model of Take-Off Approach Surfaces

- Violet Hill Turbines do not penetrate the Take-off or Approach Surfaces
- This is indicative that the flight procedures for all precision approach flights into Runway 24 will not be impacted i.e. based on instrument landing systems (ILS) flights

4. Annex 14 - Oatfield Wind Farm OLS (4)

Oatfield Wind Farm Aviation Assessment Findings :
- Pink line: Obstacle limitation surface
- In 2D dimension WTG 1, 2, 3 can be seen clearly penetrating the Obstacle Limitation Surface (OLS), with T4 being just inside the Obstacle Limitation Surface.
- NATS Findings that 4 turbines to be dropped or relocated south east from centre line of runway
- NATS findings that T8 also penetrates the protection surface



Observations :
1. Appears to be reference to Instrument Flight Procedure Surface
2. Also Pink Line surface appears to be a flight approach \ take-off gradient and not an OLS surface
3. Not an accurate plan view

5. Annex 15 – Aerodrome Surfaces (1)

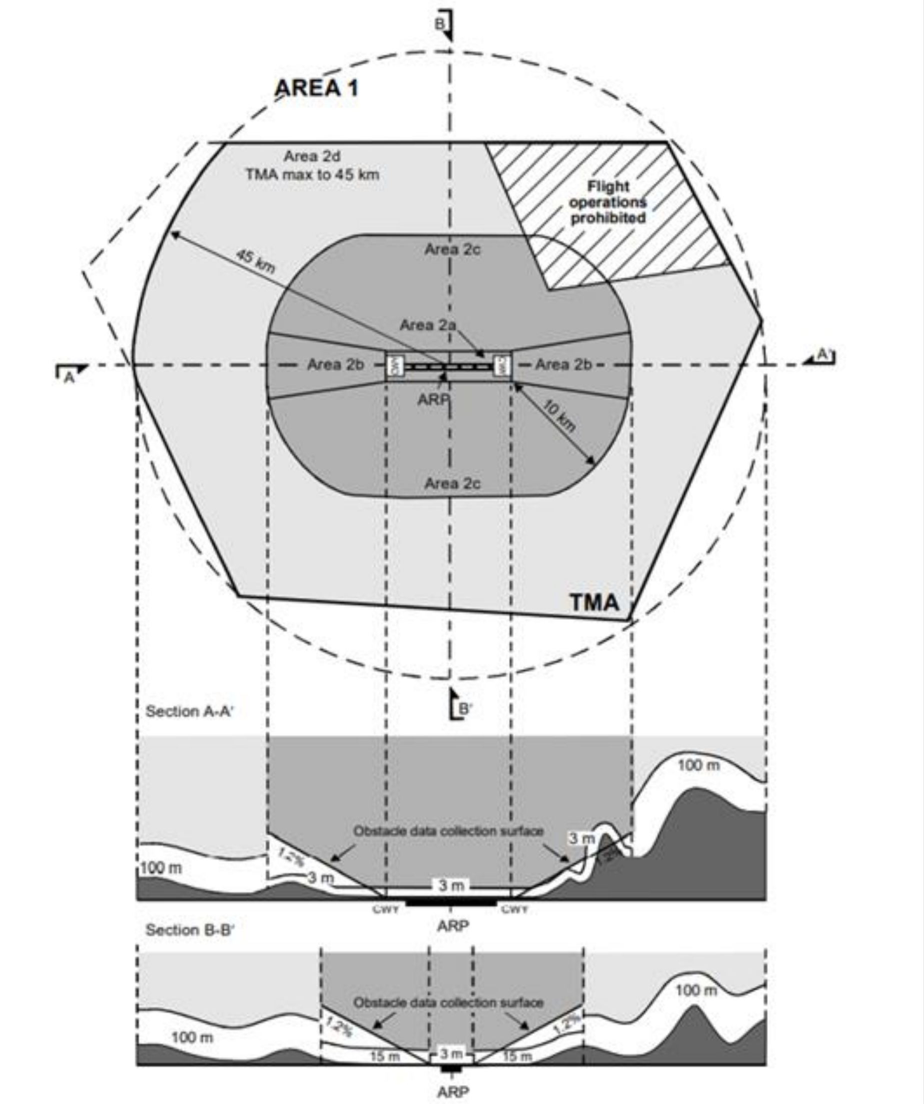
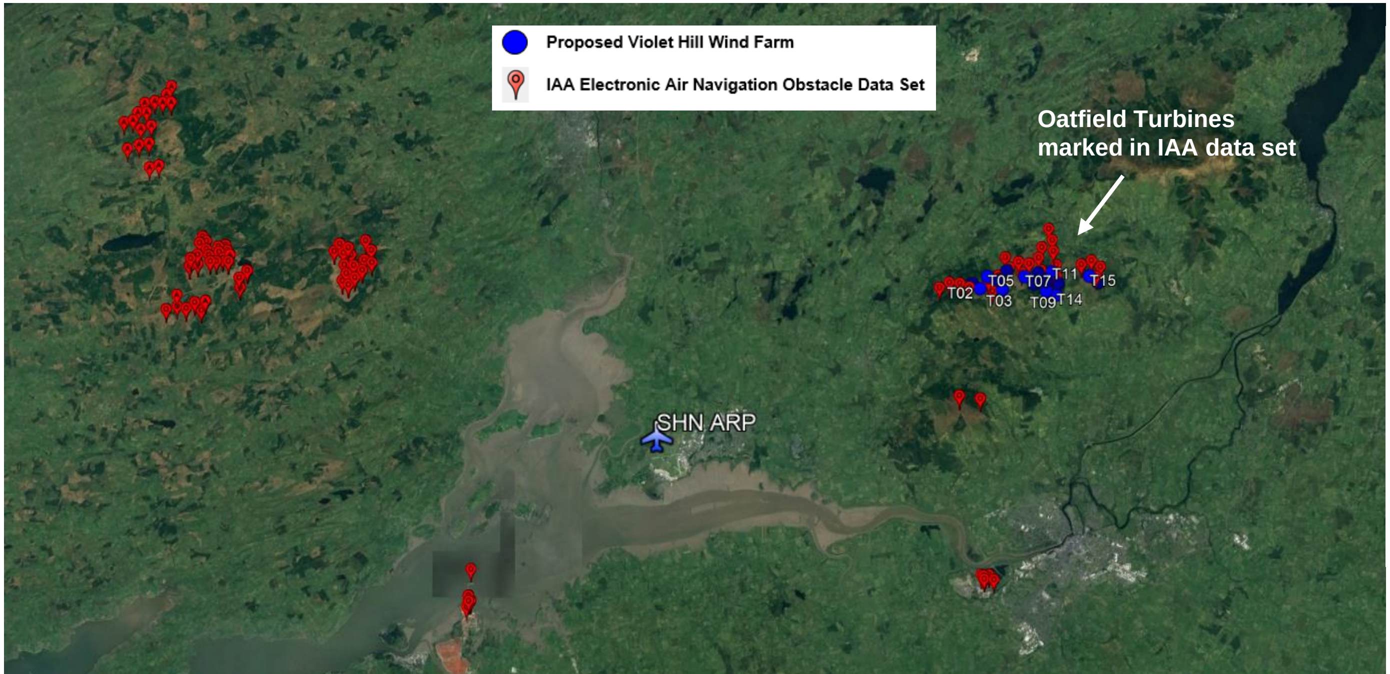


Figure A8-2. Obstacle data collection surfaces — Area 1 and Area 2

- This Annex 15 Aerodrome Surface defines an obstacle data collection surface which follows the terrain out to a boundary at 45km from the Shannon Airport ARP.
- All obstacles, if they are more than 100 meters above terrain for a distance of 45km from Shannon Airport, need to be registered in the IAA Air Navigation Obstacle Data Set.
- Area 1 known as TMA i.e. Total Maneuvering Area used for en-route circling and maneuvering.
- Violet Hill turbines would penetrate this surface.
- However the turbines are proposed on the Clare Hills, which are already dominant obstacles
- In the event of an emergency for take-off the contingency would be to fly left and away for the Clare Hills

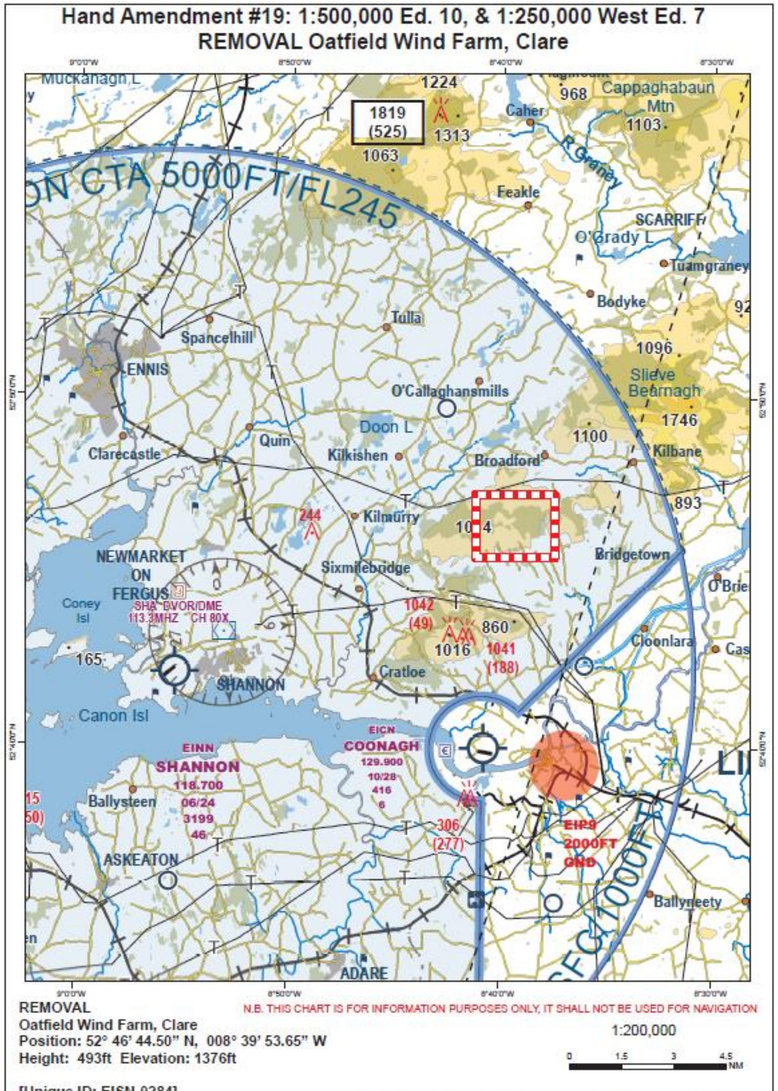
5. Annex 15 – Oatfield Aerodrome Surfaces (2)



- IAA Chart Obstacle Data Set April 2020 list the Oatfield turbines
- Removed in June 2020 (see overleaf)

Data source identifier Mandatory	Obstacle_identifier Mandatory	Horizontal_position Mandatory LAT_DMS	LONG_DMS	LAT_DD	LONG_DD	ING_E	ING_N	Elevation Mandatory (ft)	Height Optional (ft)	Obstacle_type Mandatory	Operations Optional	County	Obstacle ID_Name_Design	Obstacle_Group	Structure_Numbers	Date_ Constructed
Irish Aviation Authority (IAA)	EISN-0284	52° 46' 44.50"N	008° 39' 53.65"W	52.779028	-8.664904	155180.72	169944.57	1376	493	Wind Farm	Completed	Clare	Oatfield Wind Farm	Yes	26	01/01/2017
Irish Aviation Authority (IAA)	EISN-0284.001	52° 46' 04.55"N	008° 43' 17.12"W	52.767929	-8.721423	151354.35	168746.24	1248	493	Wind Farm	Completed	Clare	Oatfield Wind Farm	Yes	26	01/01/2017
Irish Aviation Authority (IAA)	EISN-0284.002	52° 46' 12.55"N	008° 42' 52.31"W	52.770152	-8.714531	151822.01	168989.00	1281	493	Wind Farm	Completed	Clare	Oatfield Wind Farm	Yes	26	01/01/2017
Irish Aviation Authority (IAA)	EISN-0284.003	52° 46' 11.43"N	008° 42' 24.92"W	52.769841	-8.706921	152335.30	168949.31	1373	493	Wind Farm	Completed	Clare	Oatfield Wind Farm	Yes	26	01/01/2017
Irish Aviation Authority (IAA)	EISN-0284.004	52° 46' 05.07"N	008° 41' 59.98"W	52.768075	-8.699994	152800.97	168748.22	1274	493	Wind Farm	Completed	Clare	Oatfield Wind Farm	Yes	26	01/01/2017
Irish Aviation Authority (IAA)	EISN-0284.005	52° 45' 58.57"N	008° 41' 00.61"W	52.766270	-8.683502	153912.22	168536.56	1182	493	Wind Farm	Completed	Clare	Oatfield Wind Farm	Yes	26	01/01/2017
Irish Aviation Authority (IAA)	EISN-0284.006	52° 46' 07.95"N	008° 40' 37.33"W	52.768874	-8.677036	154351.43	168822.31	1189	493	Wind Farm	Completed	Clare	Oatfield Wind Farm	Yes	26	01/01/2017
Irish Aviation Authority (IAA)	EISN-0284.007	52° 46' 23.31"N	008° 40' 45.19"W	52.773142	-8.679219	154208.55	169298.56	1281	493	Wind Farm	Completed	Clare	Oatfield Wind Farm	Yes	26	01/01/2017
Irish Aviation Authority (IAA)	EISN-0284.008	52° 46' 13.06"N	008° 41' 11.56"W	52.770294	-8.686544	153711.13	168986.35	1291	493	Wind Farm	Completed	Clare	Oatfield Wind Farm	Yes	26	01/01/2017
Irish Aviation Authority (IAA)	EISN-0284.009	52° 46' 51.48"N	008° 40' 27.47"W	52.780967	-8.674299	154548.77	170166.29	1330	493	Wind Farm	Completed	Clare	Oatfield Wind Farm	Yes	26	01/01/2017
Irish Aviation Authority (IAA)	EISN-0284.010	52° 46' 35.66"N	008° 40' 17.09"W	52.776572	-8.671414	154738.87	169675.36	1278	493	Wind Farm	Completed	Clare	Oatfield Wind Farm	Yes	26	01/01/2017
Irish Aviation Authority (IAA)	EISN-0284.011	52° 46' 44.50"N	008° 39' 53.65"W	52.779028	-8.664904	155180.72	169944.57	1376	493	Wind Farm	Completed	Clare	Oatfield Wind Farm	Yes	26	01/01/2017
Irish Aviation Authority (IAA)	EISN-0284.012	52° 46' 27.59"N	008° 39' 45.74"W	52.774330	-8.662705	155324.26	169420.43	1314	493	Wind Farm	Completed	Clare	Oatfield Wind Farm	Yes	26	01/01/2017
Irish Aviation Authority (IAA)	EISN-0284.013	52° 46' 41.56"N	008° 39' 26.23"W	52.778212	-8.657285	155694.02	169849.06	1350	493	Wind Farm	Completed	Clare	Oatfield Wind Farm	Yes	26	01/01/2017
Irish Aviation Authority (IAA)	EISN-0284.014	52° 46' 50.79"N	008° 39' 01.59"W	52.780776	-8.650442	156158.36	170130.18	1215	493	Wind Farm	Completed	Clare	Oatfield Wind Farm	Yes	26	01/01/2017
Irish Aviation Authority (IAA)	EISN-0284.015	52° 46' 31.80"N	008° 38' 55.70"W	52.775500	-8.648805	156263.53	169542.14	1238	493	Wind Farm	Completed	Clare	Oatfield Wind Farm	Yes	26	01/01/2017
Irish Aviation Authority (IAA)	EISN-0284.016	52° 47' 07.14"N	008° 38' 53.19"W	52.785318	-8.648108	156320.42	170634.21	1189	493	Wind Farm	Completed	Clare	Oatfield Wind Farm	Yes	26	01/01/2017
Irish Aviation Authority (IAA)	EISN-0284.017	52° 47' 36.37"N	008° 38' 34.67"W	52.793435	-8.642963	156675.62	171534.46	920	493	Wind Farm	Completed	Clare	Oatfield Wind Farm	Yes	26	01/01/2017
Irish Aviation Authority (IAA)	EISN-0284.018	52° 47' 18.62"N	008° 38' 25.81"W	52.788506	-8.640502	156836.77	170984.45	1150	493	Wind Farm	Completed	Clare	Oatfield Wind Farm	Yes	26	01/01/2017
Irish Aviation Authority (IAA)	EISN-0284.019	52° 47' 01.35"N	008° 38' 22.87"W	52.783708	-8.639686	156887.04	170449.99	1091	493	Wind Farm	Completed	Clare	Oatfield Wind Farm	Yes	26	01/01/2017
Irish Aviation Authority (IAA)	EISN-0284.020	52° 46' 39.82"N	008° 38' 15.64"W	52.777727	-8.637678	157016.68	169783.24	1022	493	Wind Farm	Completed	Clare	Oatfield Wind Farm	Yes	26	01/01/2017
Irish Aviation Authority (IAA)	EISN-0284.021	52° 46' 22.53"N	008° 38' 14.96"W	52.772926	-8.637490	157024.62	169248.78	1018	493	Wind Farm	Completed	Clare	Oatfield Wind Farm	Yes	26	01/01/2017
Irish Aviation Authority (IAA)	EISN-0284.022	52° 46' 13.16"N	008° 38' 37.97"W	52.770323	-8.643881	156590.70	168963.03	1077	493	Wind Farm	Completed	Clare	Oatfield Wind Farm	Yes	26	01/01/2017
Irish Aviation Authority (IAA)	EISN-0284.023	52° 46' 40.25"N	008° 37' 11.00"W	52.777846	-8.619722	158228.48	169785.89	1137	493	Wind Farm	Completed	Clare	Oatfield Wind Farm	Yes	26	01/01/2017
Irish Aviation Authority (IAA)	EISN-0284.024	52° 46' 46.63"N	008° 36' 44.84"W	52.779619	-8.612455	158720.60	169979.03	1058	493	Wind Farm	Completed	Clare	Oatfield Wind Farm	Yes	26	01/01/2017
Irish Aviation Authority (IAA)	EISN-0284.025	52° 46' 36.82"N	008° 36' 21.27"W	52.776895	-8.605908	159159.81	169672.12	1045	493	Wind Farm	Completed	Clare	Oatfield Wind Farm	Yes	26	01/01/2017
Irish Aviation Authority (IAA)	EISN-0284.026	52° 46' 21.53"N	008° 36' 32.63"W	52.772647	-8.609064	158942.85	169201.16	1114	493	Wind Farm	Completed	Clare	Oatfield Wind Farm	Yes	26	01/01/2017

5. Annex 15 – Oatfield Aerodrome Surfaces (3)



Hand Amendments/Changes to VFR Charts
1:500,000 edition 10 & 1:250,000 edition 7:

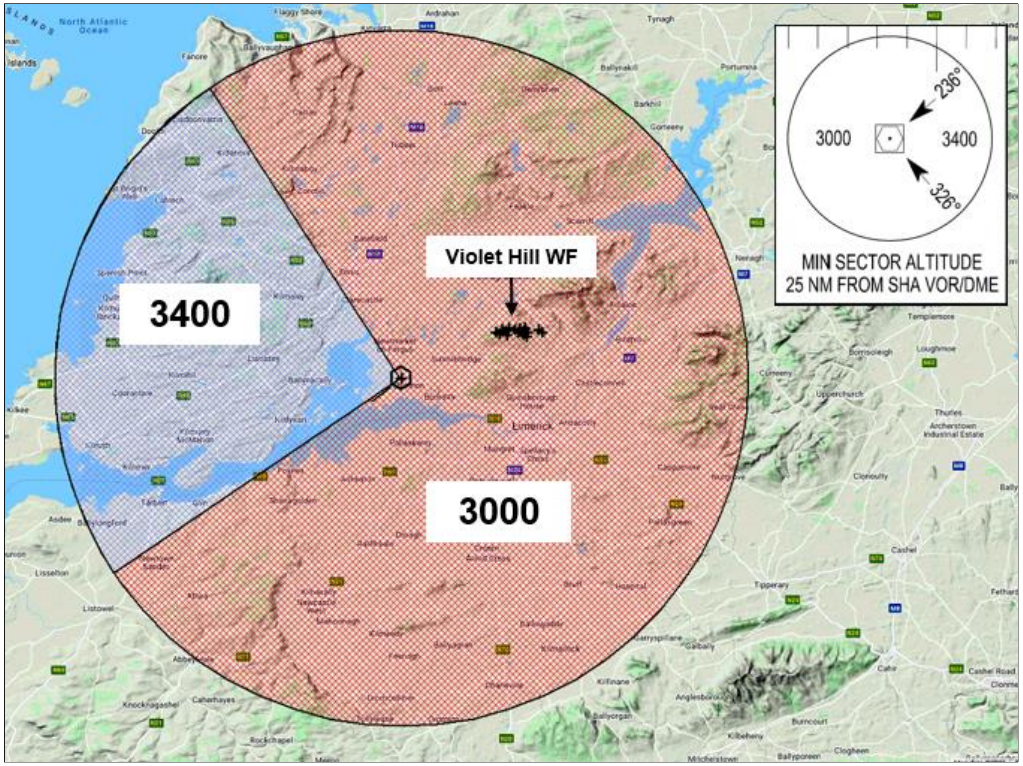
HA #19-EISN-0284-REMOVAL Oatfield Wind Farm, Clare

Jul 5, 2020, 10:24 AM by James O'Sullivan

- Removal of Oatfield from IAA Charts (June 2020) under an Amendment.

6. Minimum Sector Altitudes (MSA)

- A review of the Minimum Sector Altitudes (MSA) shows that the proposed wind turbines are within 25 nautical miles from the Non Directional Beacon at Shannon Airport.
- The MSA provides a minimum obstacle clearance of 1000 ft above the highest obstacle within specified quadrants
- The turbines are located within the main quadrant (MSA 3000 ft)
- According to the turbine locations, the maximum construction height for the site would be 2000 ft/609.6m AMSL (3000 ft MVA minus 1000 ft) which is greater than the maximum tip of the proposed turbine elevation of 1524.4 ft AMSL (highest turbine T05).
- No impact \ infringement on the published MSA altitude figures.



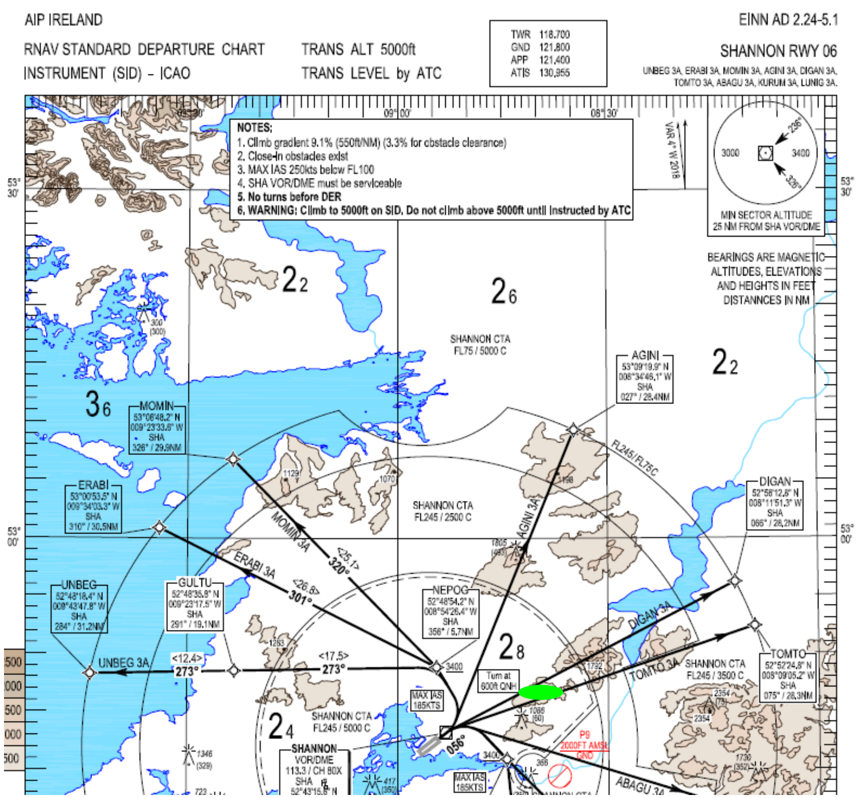
7. Flight Procedures – Oatfield Wind Farm (1)

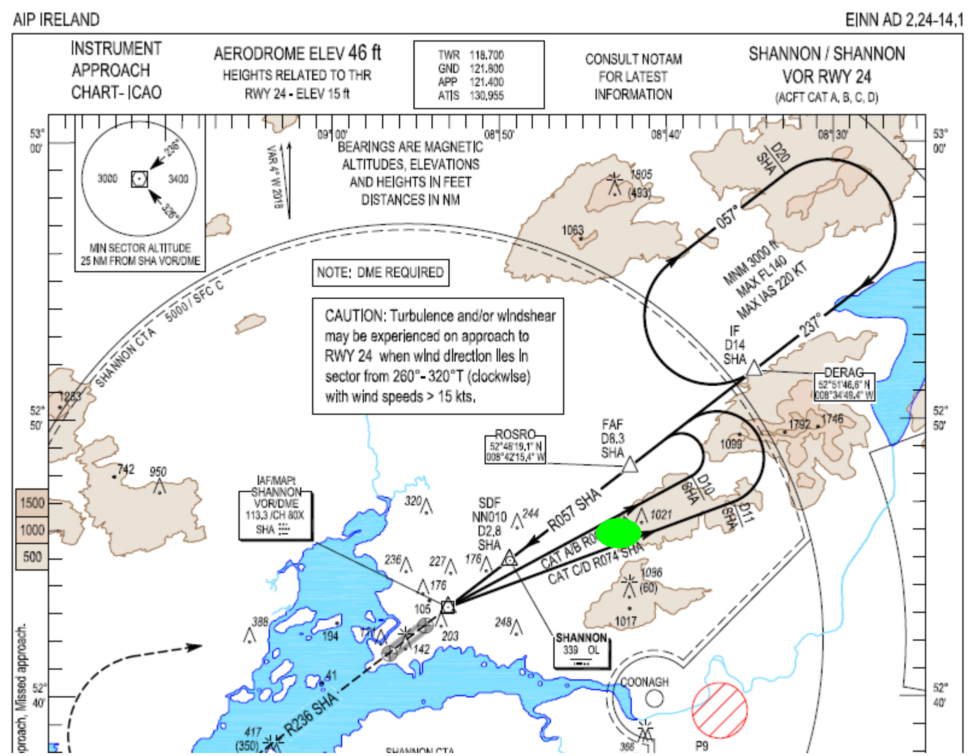
- Based on the NATS 2018 Report for Oatfield they found that two of the Flight procedures would be impacted
  Instrument Approach Procedure (VOR Runway 24)
  Standard Instrument Departure Procedure (RNAV Runway 06)
- There was no infringement on the other flight procedures

Instrument Flight Procedure - NATS IFP Analysis (Oatfield Wind Farm -2018)			
No	Procedure	Infringement	Description
1	Minimum Sector Altitudes (MSA) 25 NM	No	-
2	Visual Manoeuvring (VM)	No	-
3	RNAV Standard Arrival Routes RWY 06	No	-
4	RNAV Standard Arrival Routes RWY 24	No	-
5	VOR RWY 06	No	-
6	ILS or LOC RWY 06	No	-
7	Instrument Approach Procedure VOR RWY24	Yes	There are 9 WTGs lcoated inside the secondary area of the Final Approach (FAF-SDF)
8	Instrument Approach Procedure ILS or LOC RWY24	No	-
9	RNAV Standard Instrument Departure RWY06	No*	The WTGs do not impact the 9.1 % climb gradient. The obstacle identification surface (OIS) related to the 3.3% obstacle clearance is penetrated.
10	RNAV Standard Instrument Departure RWY24	No	-

7. Flight Procedures (2)

- Standard Instrument Departure Procedure : RNAV Runway 06 will be infringed
- Instrument Approach Procedure VOR RWY24 will infringe secondary area of the final approach fix





7. Flight Procedures – Approach Surfaces (3)

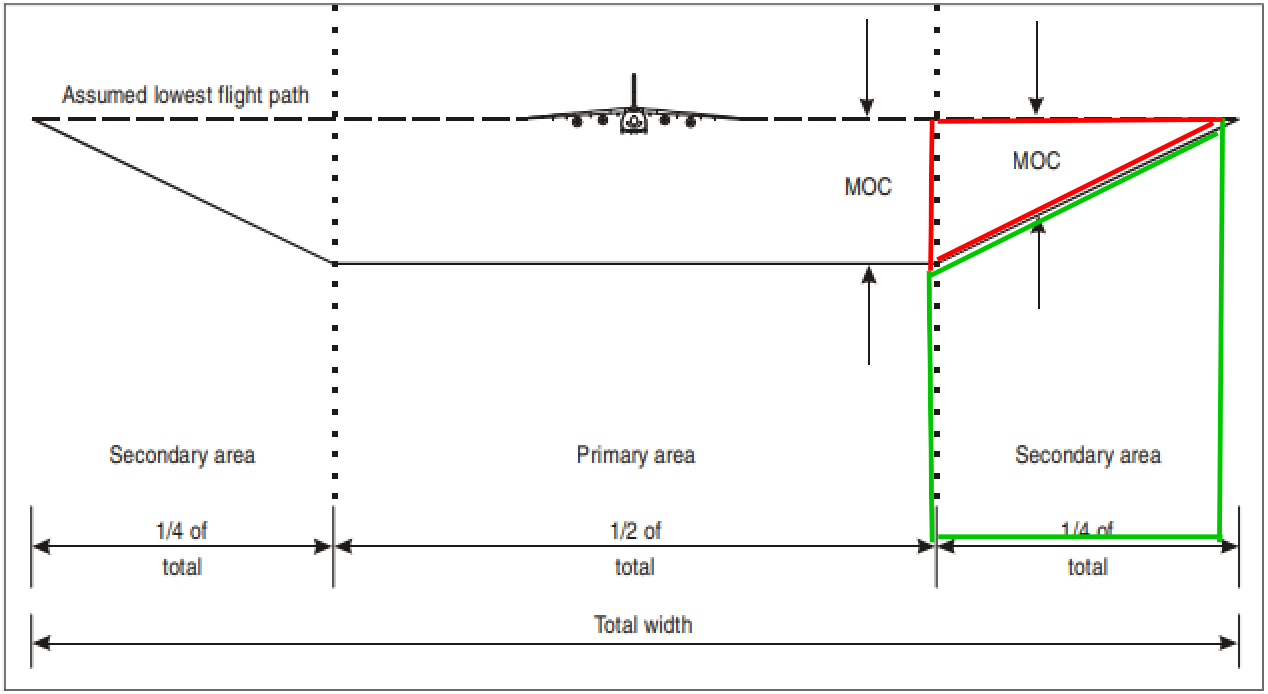
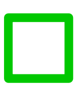
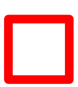


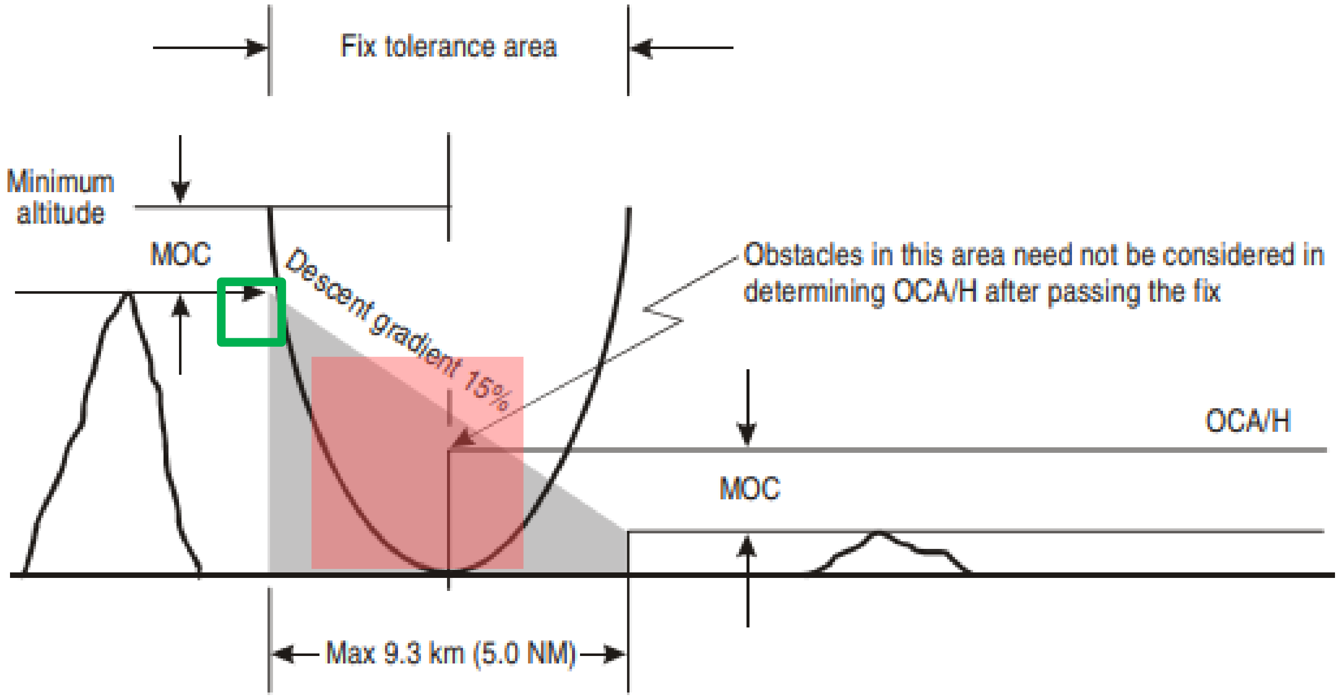
Figure I-2-1-2. Relationship of minimum obstacle clearances in primary and secondary areas in cross-section

- MOC = Minimum Obstacle Clearance of 1000ft

 - Violet Hill Wind Farm turbines in this area do not penetrate protected surface

 - Violet Hill Wind Farm turbines in this area penetrate protected surface

7. Flight Procedures– Approach Surface* (4)

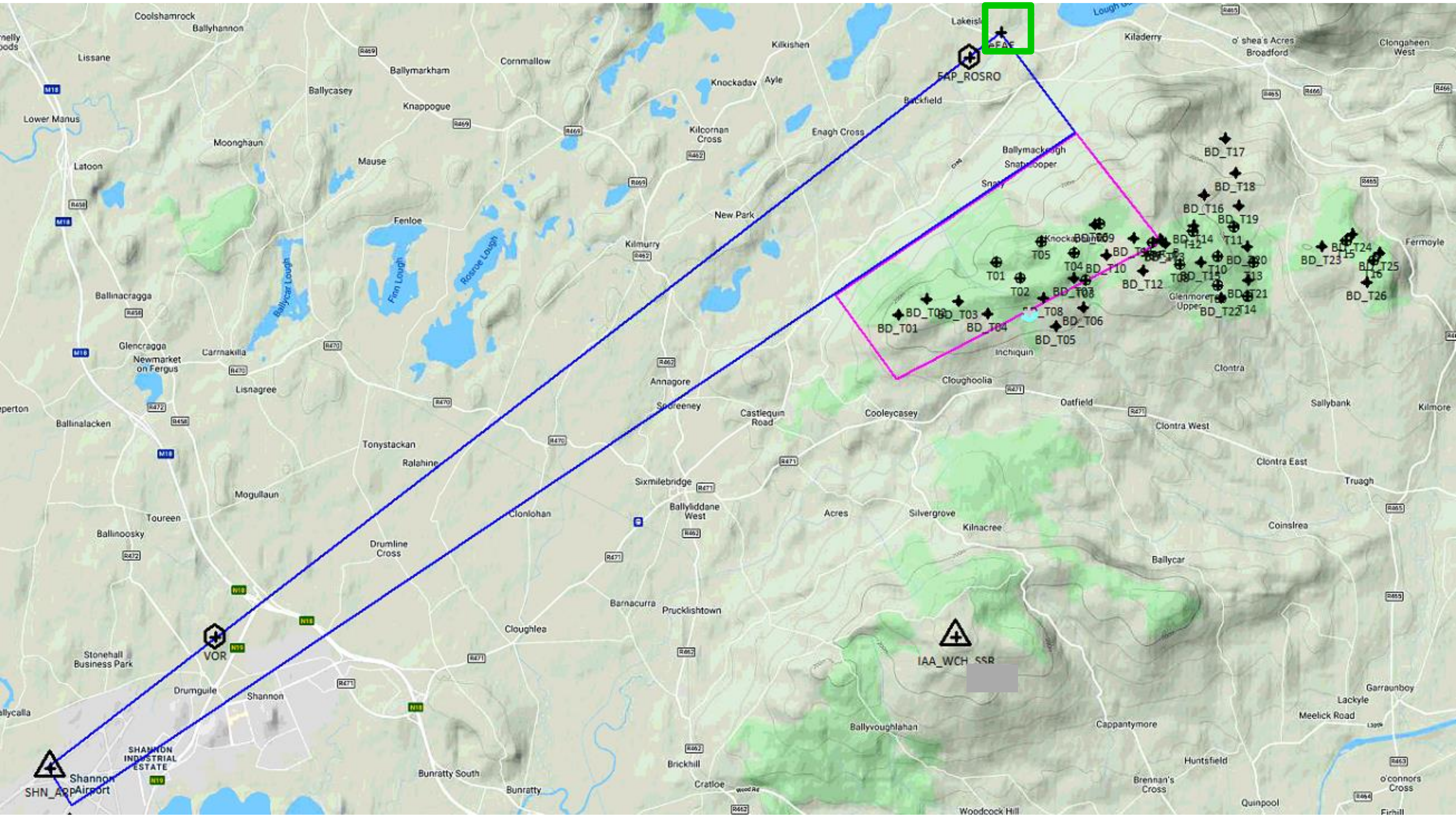


- Final Approach Fix – where aircraft start descent from 3,000ft

- Turbines in this area

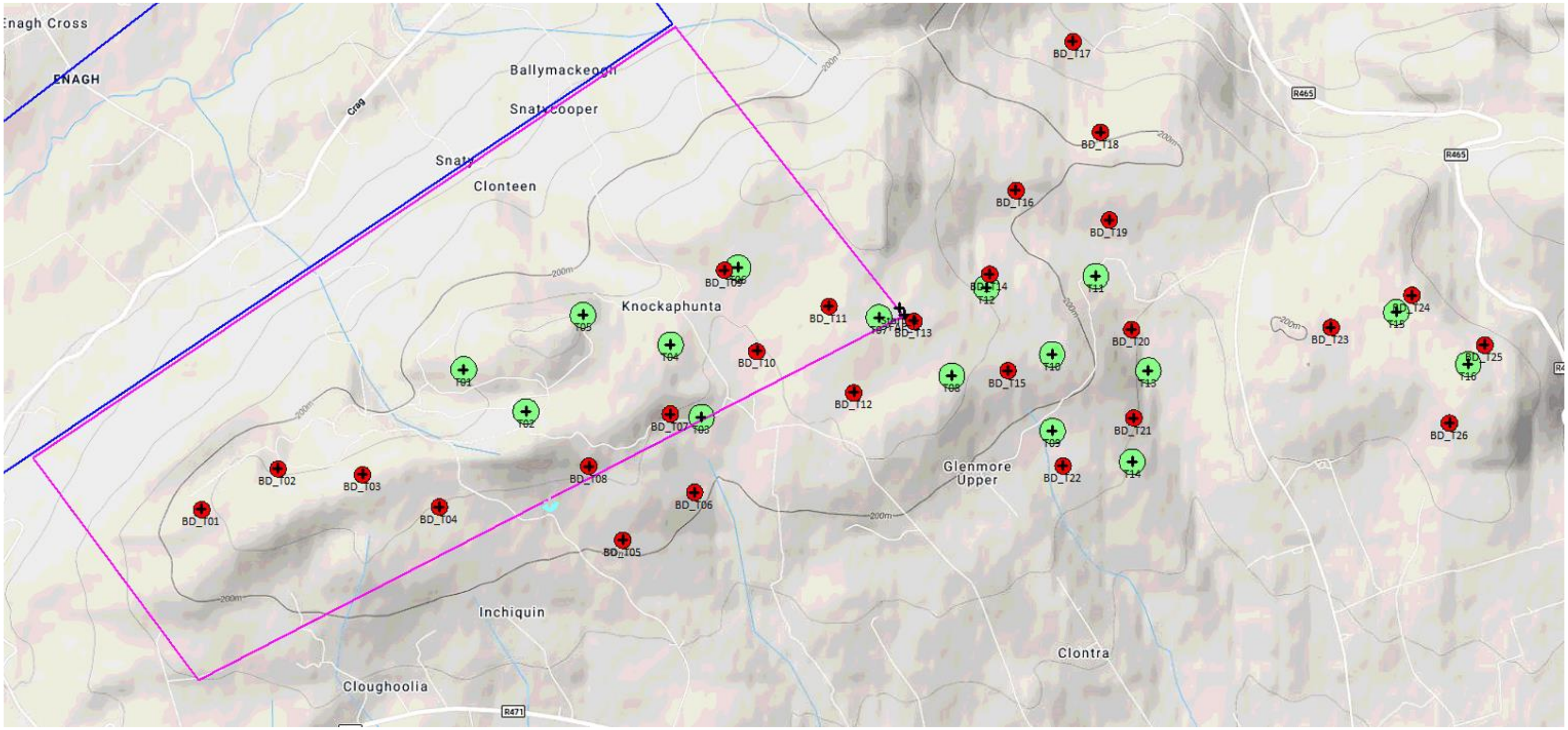
* Taken from ICAO 8168 PANS-OPS

7. Flight Procedures – Approach Surfaces(5)



Final Approach Fix **Primary Approach Area** **Secondary Approach Area**

7. Flight Procedures - Approach Surfaces (6)



Oatfield Wind Farm

- NATS identified that 9 turbines in the secondary area
  WTG 01, 02, 03, 04, 07, 08, 09, 10 and 11
- WTG 01, 02, 03,04 and 08 penetrated the secondary approach surfaces with NATS recommendation that these turbines be dropped or re-located

Violet Hill Wind Farm

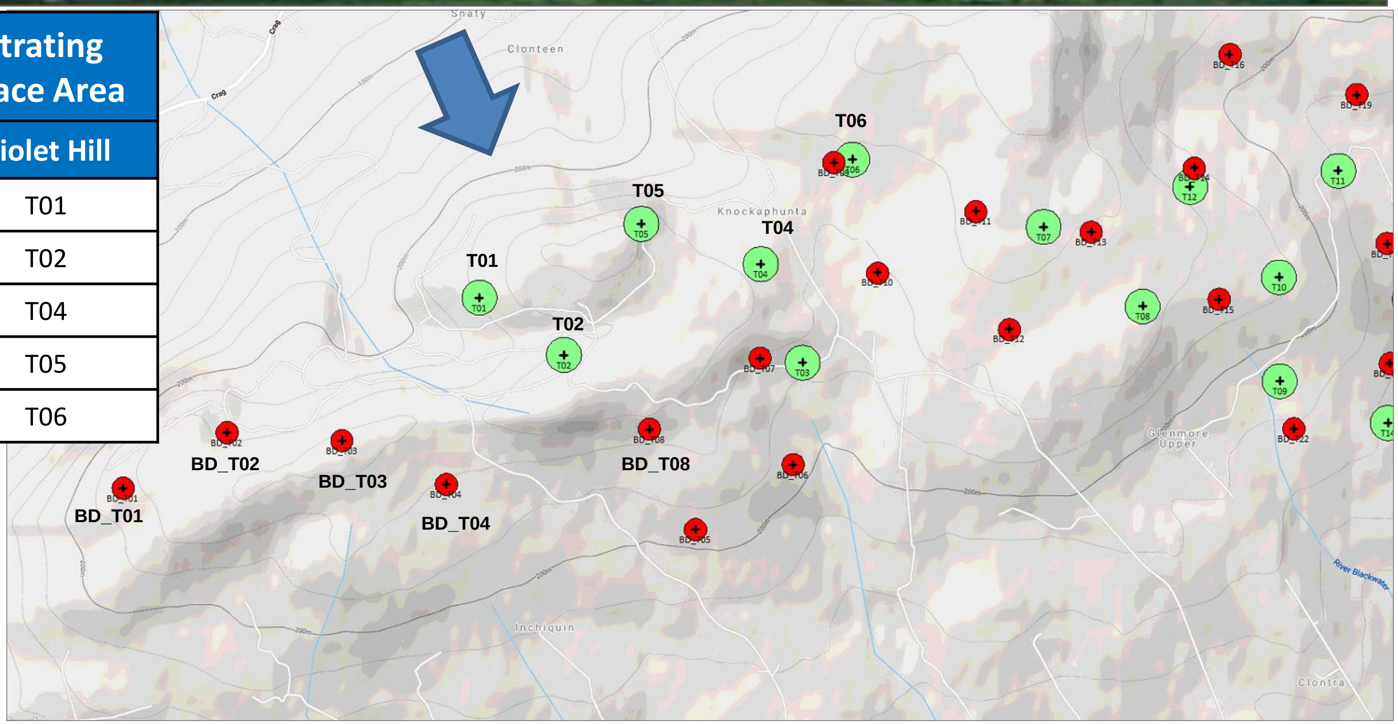
- Review shows that 7 turbines in secondary area (Lateral Surface)

7. Flight Procedures - Approach Surfaces (7)

3D Visualization of Protected Approach Surface showing

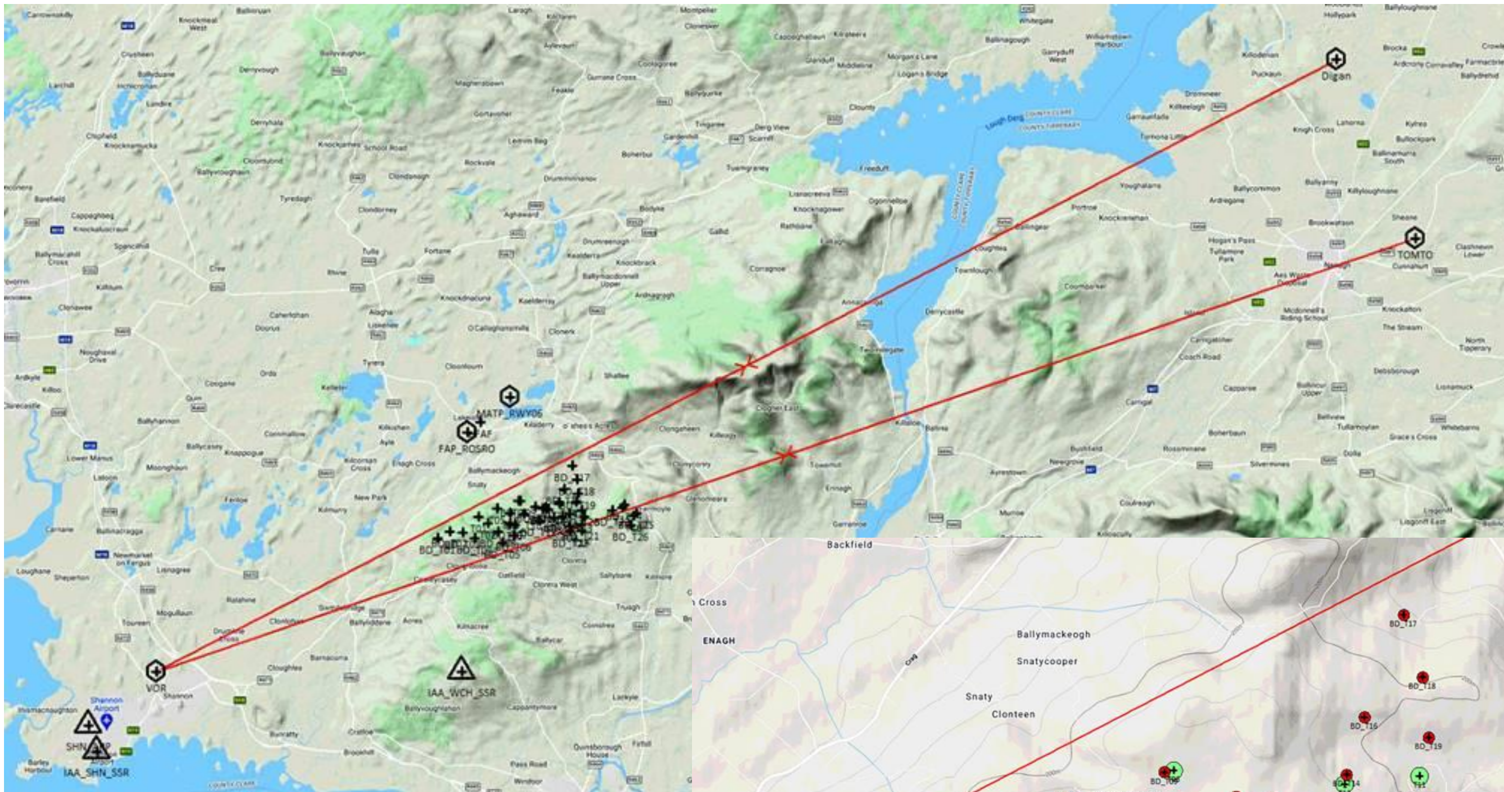
- Penetration by 5 turbines under Oatfield Wind Farm Application (Horizontal Surface)
- Penetration by 5 turbines under proposed Violet Hill Wind Farm (Horizontal Surface)

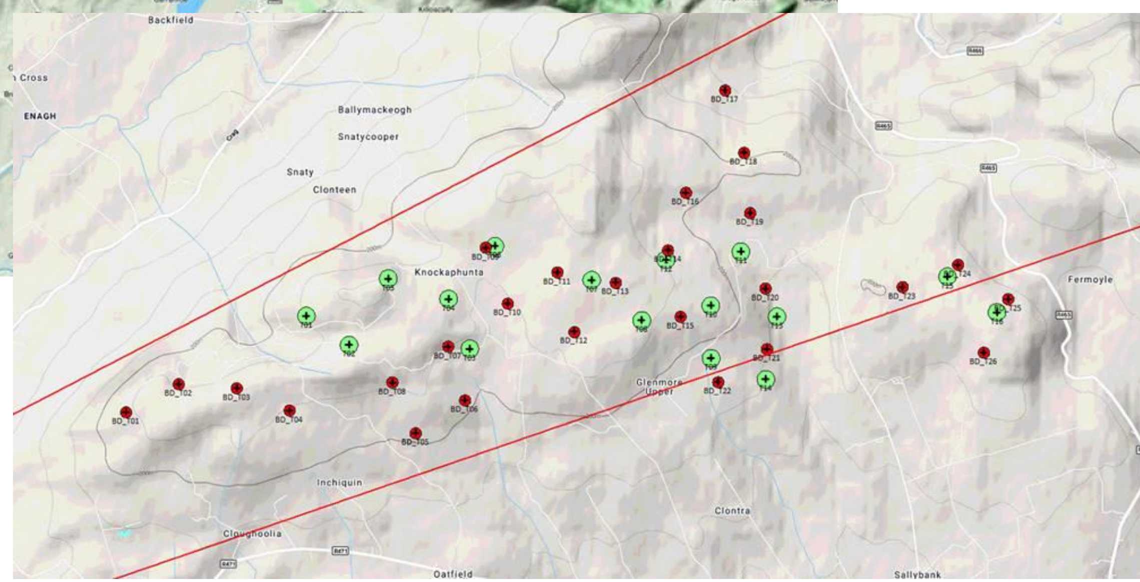
Turbines Penetrating Protection Surface Area	
Oatfield	**Violet Hill**
BD_T01	T01
BD_T02	T02
BD_T03	T04
BD_T04	T05
BD_T08	T06



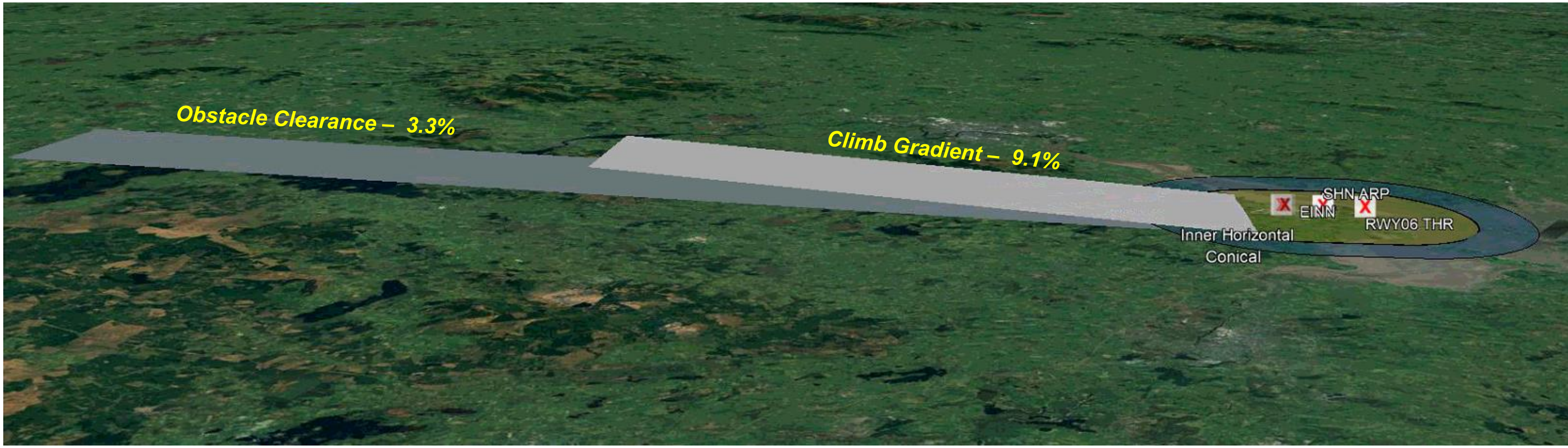
7. Flight Procedures - Departure Surfaces (8)

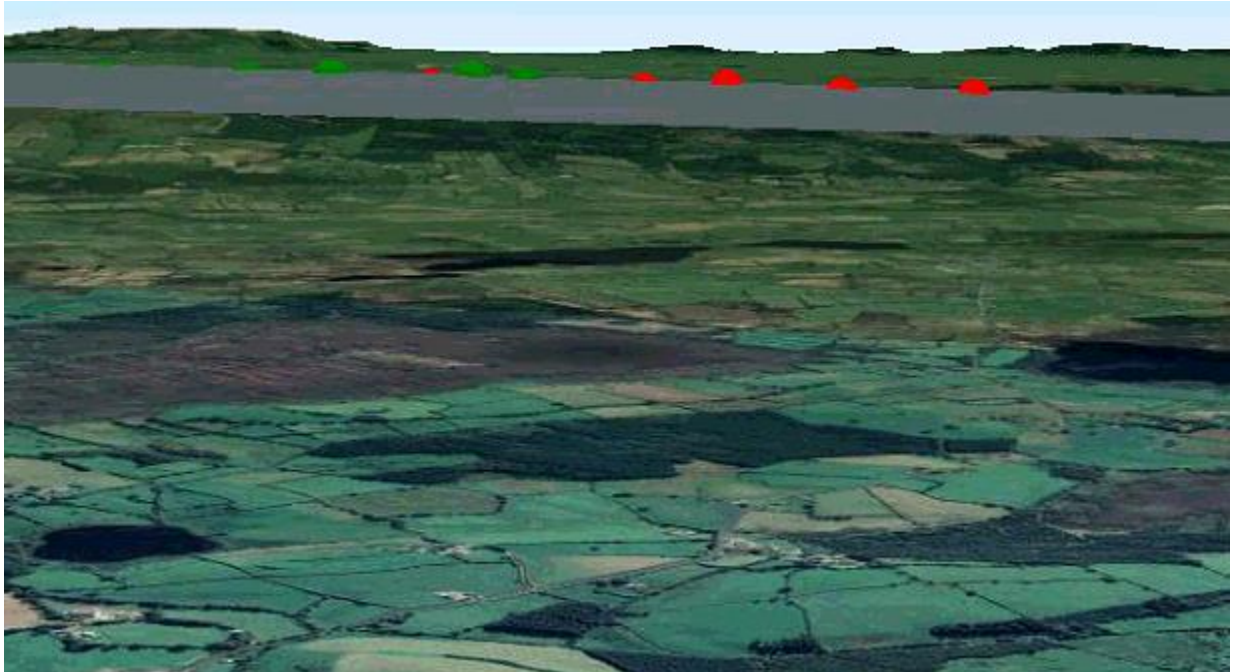
- There are two departure routes that will be impacted by the turbines (markers at DIGAN and TOMTO)





7. Flight Procedures - Departure Surfaces (9)





Violet Hill Turbine

Oatfield 2018 Turbine

9.1% Climb Gradient – Clear

3.3% Obstacle Clearance - Penetration

10. Oatfield Flight Calibration (1)

18. Flight Calibration

18.1. General

The IAA expressed the following concern about the calibration of flight procedures:

"The precision and non-precision instrument flight procedures (IFPs) need to be flight calibrated twice yearly. This means that for RWY 24 a calibration flight will be flying below published altitude minima for this function. So, even if the IFPs are not impacted by the proposed Wind Farm, calibration of flight procedures may become an issue."

18.2. Assumptions

- This assessment takes into account the twenty-six WTGs and does not account for any other obstacle.
- Flight calibration aircraft do not require procedures that meet PANS-OPS obstacle clearance criteria.
- All procedures requiring Flight Calibration are PANS-OPS compliant. It should be noted that the proposed WTGs would dictate some change to IAP VOR 24 which has been detailed in the relevant section*.

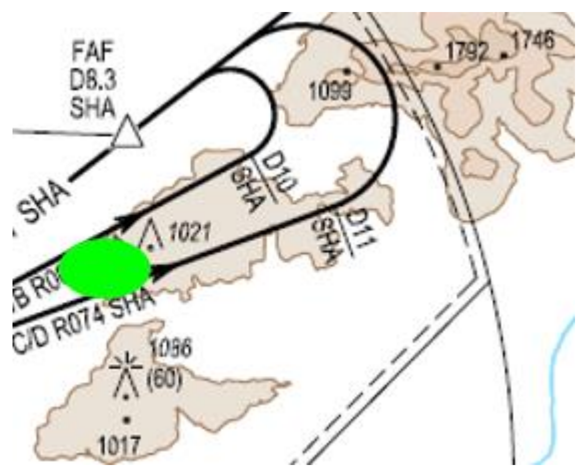
18.3. Assessment

The WTGs have been assessed against the precision and non-precision approaches to RWY 24. The table below shows the PANS-OPS minimum obstacle clearance (MOC) applied to each procedure segment the WTGs encompass laterally. The MOC required to be PANS-OPS compliant would enable a flight calibration aircraft to execute procedures 100ft below the procedure altitude for the approaches to RWY 24:

Procedure	Segment	(MOC)	Procedure Altitude
VOR RWY24	Hold	300m (984ft)	3000ft
	Base Turn	300m (984ft)	3000ft
	Intermediate	150m (492ft)	3000ft
	Final (FAF-SDF)	75m (246ft)	Requires Change*
ILS or LOC RWY24	Hold	300m (984ft)	3000ft
	Base Turn	300m (984ft)	3000ft
	Intermediate	150m (492ft)	3000ft

*See assumption 3 and Section IAP VOR 24.

- NATS reported that a change is required for annual Flight Calibration Checks
- Flight Calibration checks are conducted at lower heights that the ICAO PANS-OPS rules and regulations
- Flights are conducted at 100ft below the standard flight procedure altitudes
- Inspection Flights are operated 1000 ft above ground terrain
- IAA may require an assessment of the Flight Calibration routes with respect to DME \VOR inspection



11. Radar Surveillance Systems – Shannon Airport (1)

Figure 3. PSR and SSR at Shannon Airport

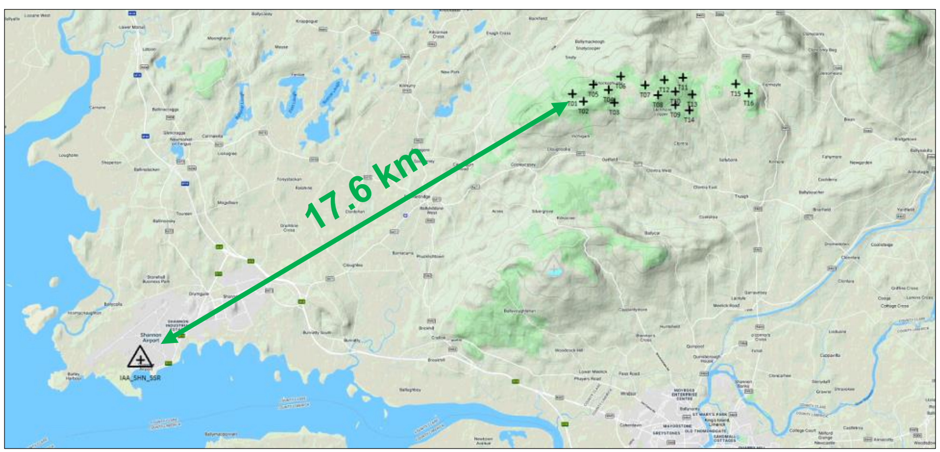


Figure 4. Shannon PSR/SSR relative to proposed turbines

- At Shannon Airport the IAA have a Primary Surveillance Radar (PSR) and a Secondary Surveillance Radar (SSR) System.

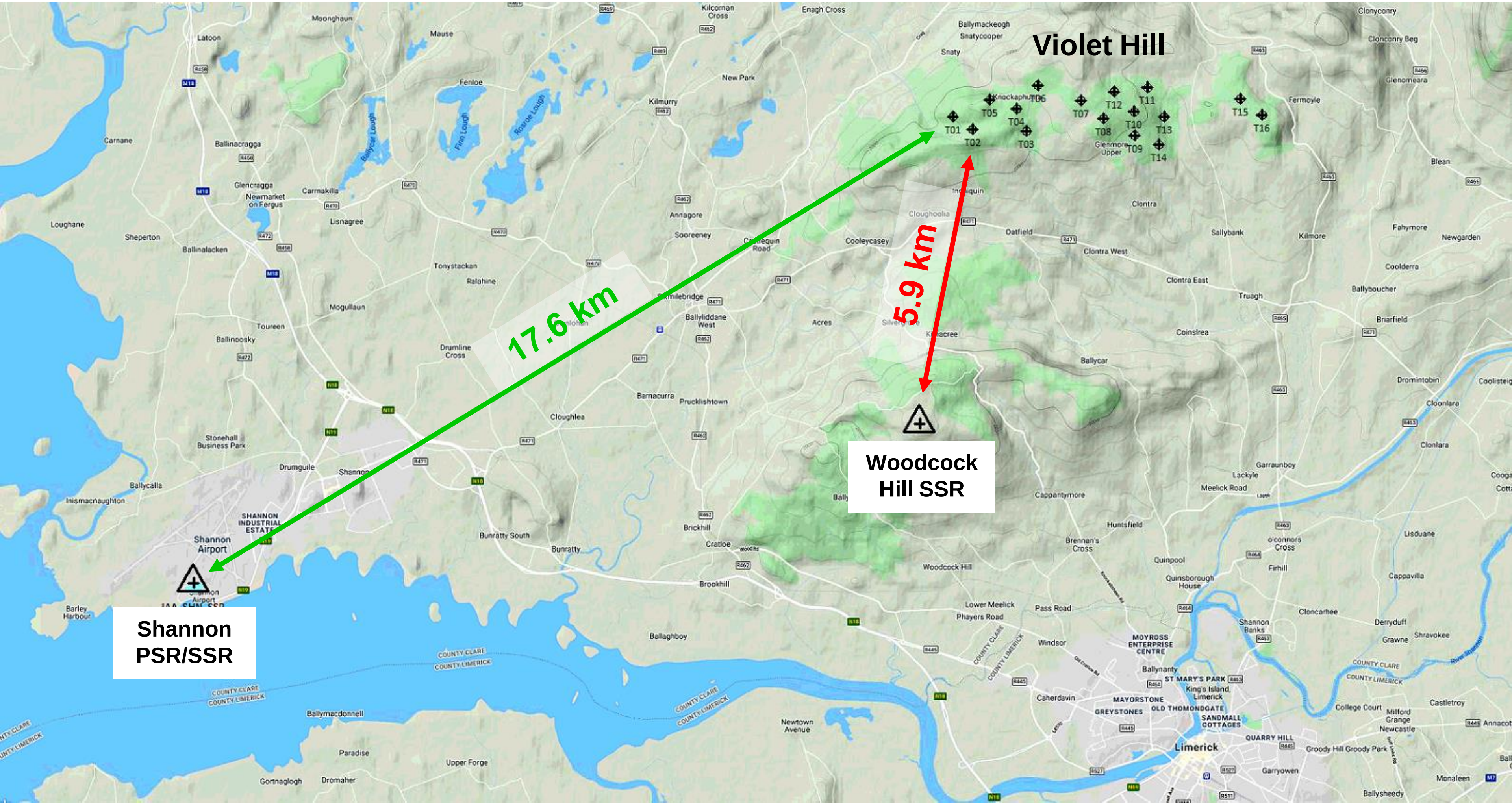
- Both radar systems are enclosed in the domes structure a s shown in Figure 3.

- Shannon airport is 17.6 km from the proposed wind arm development.

11. Radar Surveillance Systems (2)

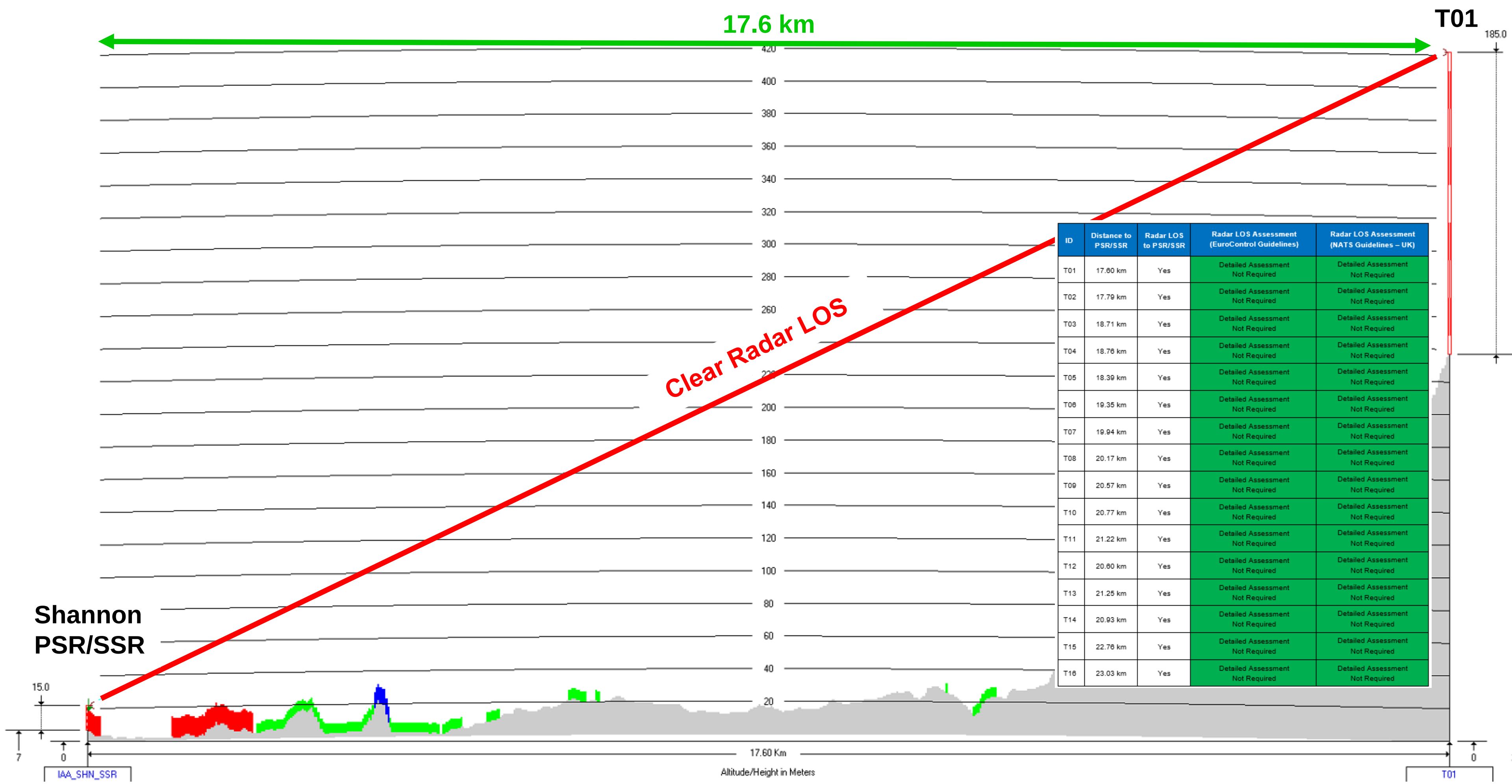
- The Shannon Primary \ Secondary Radars will not be impacted

- A detailed radar assessment required for Woodcock Hill Secondary Radar



11. Radar Surveillance Systems – Shannon Airport Radar LOS (3)

Detailed Radar Assessment NOT Required (Eurocontrol/NATS Guidelines)



ID	Distance to PSR/SSR	Radar LOS to PSR/SSR	Radar LOS Assessment (EuroControl Guidelines)	Radar LOS Assessment (NATS Guidelines – UK)
T01	17.60 km	Yes	Detailed Assessment Not Required	Detailed Assessment Not Required
T02	17.79 km	Yes	Detailed Assessment Not Required	Detailed Assessment Not Required
T03	18.71 km	Yes	Detailed Assessment Not Required	Detailed Assessment Not Required
T04	18.76 km	Yes	Detailed Assessment Not Required	Detailed Assessment Not Required
T05	18.39 km	Yes	Detailed Assessment Not Required	Detailed Assessment Not Required
T06	19.35 km	Yes	Detailed Assessment Not Required	Detailed Assessment Not Required
T07	19.94 km	Yes	Detailed Assessment Not Required	Detailed Assessment Not Required
T08	20.17 km	Yes	Detailed Assessment Not Required	Detailed Assessment Not Required
T09	20.57 km	Yes	Detailed Assessment Not Required	Detailed Assessment Not Required
T10	20.77 km	Yes	Detailed Assessment Not Required	Detailed Assessment Not Required
T11	21.22 km	Yes	Detailed Assessment Not Required	Detailed Assessment Not Required
T12	20.60 km	Yes	Detailed Assessment Not Required	Detailed Assessment Not Required
T13	21.25 km	Yes	Detailed Assessment Not Required	Detailed Assessment Not Required
T14	20.93 km	Yes	Detailed Assessment Not Required	Detailed Assessment Not Required
T15	22.76 km	Yes	Detailed Assessment Not Required	Detailed Assessment Not Required
T16	23.03 km	Yes	Detailed Assessment Not Required	Detailed Assessment Not Required

Figure 5. SSR at Woodcock Hill

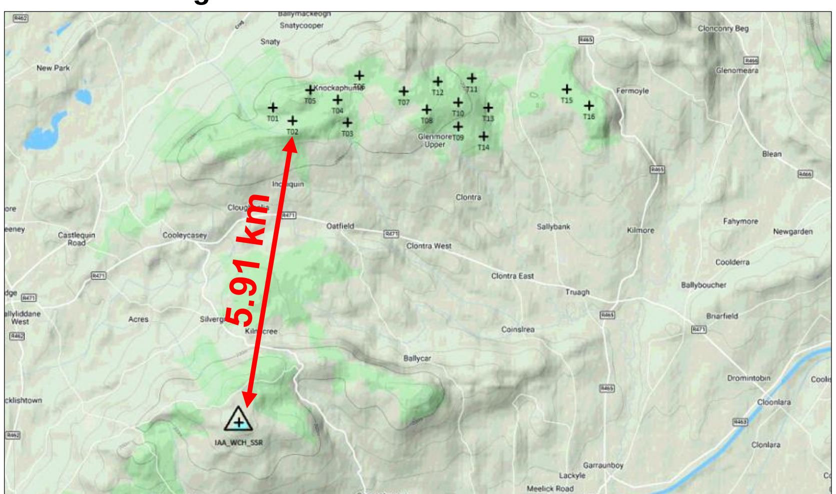
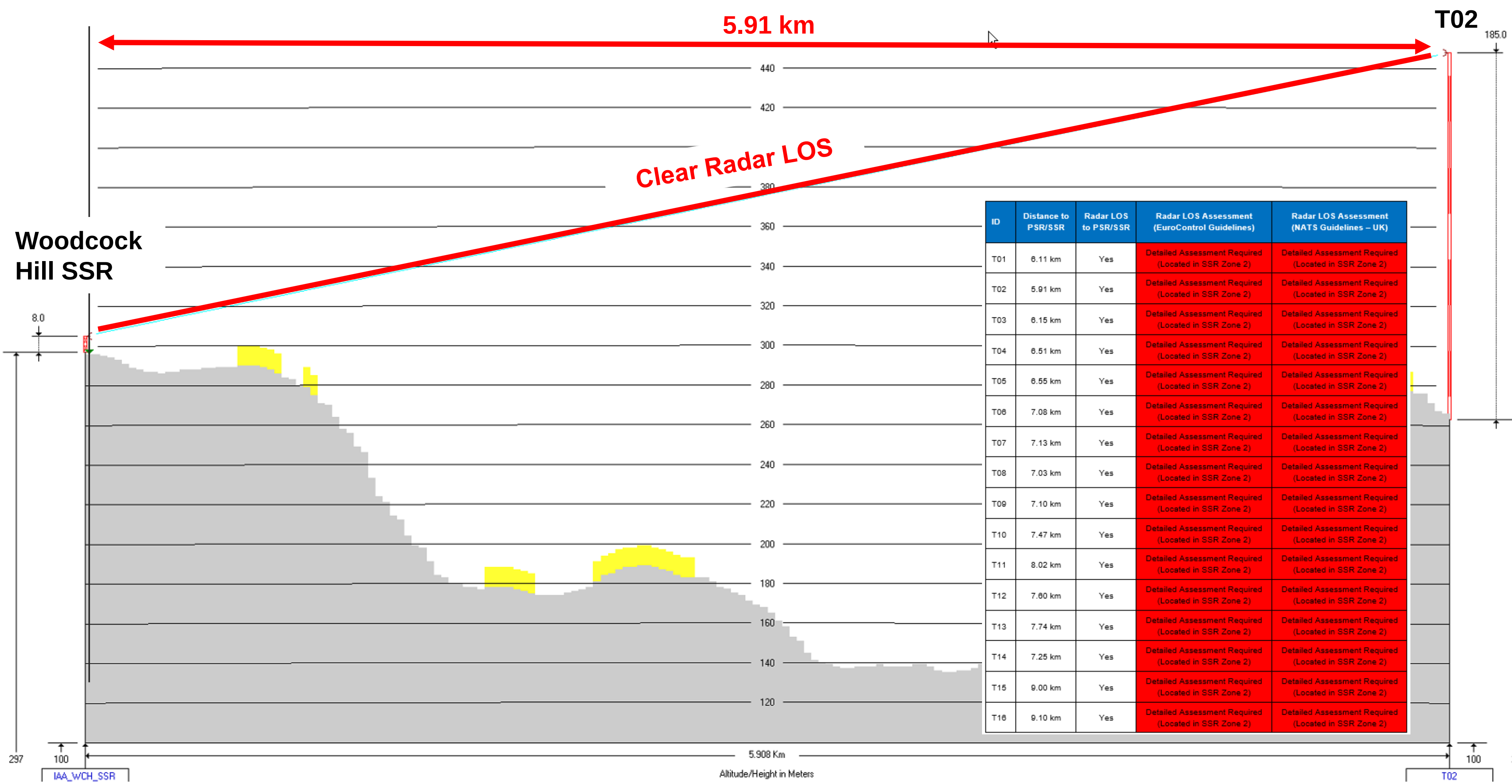


Figure 6. SSR at Woodcock Hill

- At Woodcock Hill the IAA have a Secondary Surveillance Radar (SSR) System.
- The radar system is enclosed in the dome shaped structure as shown in Figure 5.
- The SSR is just 5.91 km from the proposed wind farm development.

11. Radar Surveillance Systems – Woodcock Hill Radar LOS (5)

Detailed Radar Assessment Required (Eurocontrol/NATS Guidelines)



ID	Distance to PSR/SSR	Radar LOS to PSR/SSR	Radar LOS Assessment (EuroControl Guidelines)	Radar LOS Assessment (NATS Guidelines – UK)
T01	6.11 km	Yes	Detailed Assessment Required (Located in SSR Zone 2)	Detailed Assessment Required (Located in SSR Zone 2)
T02	5.91 km	Yes	Detailed Assessment Required (Located in SSR Zone 2)	Detailed Assessment Required (Located in SSR Zone 2)
T03	6.15 km	Yes	Detailed Assessment Required (Located in SSR Zone 2)	Detailed Assessment Required (Located in SSR Zone 2)
T04	6.51 km	Yes	Detailed Assessment Required (Located in SSR Zone 2)	Detailed Assessment Required (Located in SSR Zone 2)
T05	6.55 km	Yes	Detailed Assessment Required (Located in SSR Zone 2)	Detailed Assessment Required (Located in SSR Zone 2)
T06	7.08 km	Yes	Detailed Assessment Required (Located in SSR Zone 2)	Detailed Assessment Required (Located in SSR Zone 2)
T07	7.13 km	Yes	Detailed Assessment Required (Located in SSR Zone 2)	Detailed Assessment Required (Located in SSR Zone 2)
T08	7.03 km	Yes	Detailed Assessment Required (Located in SSR Zone 2)	Detailed Assessment Required (Located in SSR Zone 2)
T09	7.10 km	Yes	Detailed Assessment Required (Located in SSR Zone 2)	Detailed Assessment Required (Located in SSR Zone 2)
T10	7.47 km	Yes	Detailed Assessment Required (Located in SSR Zone 2)	Detailed Assessment Required (Located in SSR Zone 2)
T11	8.02 km	Yes	Detailed Assessment Required (Located in SSR Zone 2)	Detailed Assessment Required (Located in SSR Zone 2)
T12	7.60 km	Yes	Detailed Assessment Required (Located in SSR Zone 2)	Detailed Assessment Required (Located in SSR Zone 2)
T13	7.74 km	Yes	Detailed Assessment Required (Located in SSR Zone 2)	Detailed Assessment Required (Located in SSR Zone 2)
T14	7.25 km	Yes	Detailed Assessment Required (Located in SSR Zone 2)	Detailed Assessment Required (Located in SSR Zone 2)
T15	9.00 km	Yes	Detailed Assessment Required (Located in SSR Zone 2)	Detailed Assessment Required (Located in SSR Zone 2)
T16	9.10 km	Yes	Detailed Assessment Required (Located in SSR Zone 2)	Detailed Assessment Required (Located in SSR Zone 2)

Summary

Violet Hill Aviation Review		
Surface \ Procedure \ Safeguaring Assessment Review	**Impact**	**Further assessment**
Annex 14 Obstacle Limitation Surfaces	None	Not required
Annex 15 Aerodrome Surfaces	Yes	Unlikely
Minimum Sector Altitudes	None	Not Required
Instrument Flight Procedures	Yes	Required by Approved Designer
Communication, Navigation	None	Not Required
Flight Calibration Inspection	TBC	Ongoing review , completion WEEK 20
Radar Surveillance (Shannon Airport)	None	Not Required
Radar Surveillance (Woodcock Hill)	Yes	Required

Appendix 2

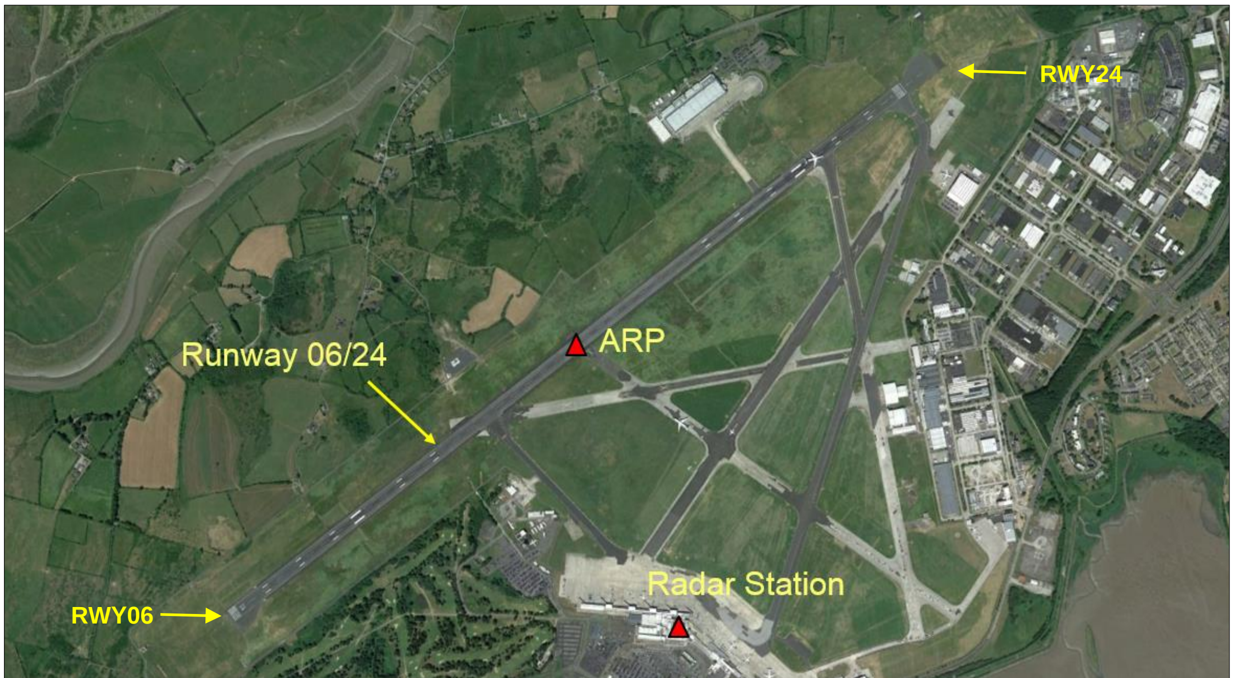
Violet Hill Wind Farm – Flight Inspection Check Assessment

Violet Hill Wind Farm Flight Inspection Check Assessment

Ai Bridges Ltd.	
Document Title: Aviation DTS	Date: 23.07.21
Document Number: AICYTRA001	Revision: 0.1

Shannon Airport Overview

- Airport Reference Point (ARP), - 17.4 km from Violet Hill
- One single runway surface with two Runways – 06 and 24
- There are departures and approaches on both Runways 06 and 24
- Violet Hill review takes into account Approaches on Runway 24 and Approaches on Runway 06



Location	Installation	Description	Airport Ref. Point ARP	Distance to Proposed Wind Farm
Shannon, Co Clare	International Airport	Single Asphalt Runway Airspace: Class C	52 42 07 N 008 55 29 W (Mid-point of Runway 06/24).	17.6 km

Flight Inspection Check Procedures (1)

EINN AD 2.19 RADIO NAVIGATION AND LANDING AIDS

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
DVOR/DME 4º W 2017	SHA	113.300 MHz	H24	524315.6N 0085306.8W	200ft		Designated Operational Coverage 300 NM/70,000ft 180ºTrue BRG to 360º True BRG. Designated Operational Coverage 100 NM/50,000ft.

Shannon Airport DME

- Flight Calibration and Flight Inspection Data is obtained during Orbital and Radial Flights by a flight inspection aircraft .

- Flight Calibration procedures are governed by Standards and Recommended Practices (SARPs) for Flight Navigational Aids and are published by the ICAO.

- Guidance material on flight testing of DME transponders is published in ICAO Doc 8071 Volume 1.

- Distance Measuring Equipment (DME) is a navigation beacon, usually coupled with a VHF Omnidirectional Range (VOR) beacon, to enable aircraft to measure their position relative to that beacon.

- The DME at Shannon Airport is located at 52 43 15.6 N 08 53 06.8 W (approximately 1.9km NE of RWY06)

Flight Calibration – Orbital Flight (1)

- To verify adequate signal level coverage from the DME, ICAO Doc 8071 Volume 1 recommends that a circular orbit is flown around the DME transponder at an altitude corresponding to an elevation angle of approx. 0.5° to 3.6° above the DME antenna site, **or 300m (1000 ft) above intervening terrain**, whichever is higher. If there is no associated airport\terminal , the orbit may be made at any radius greater than 18.5km (10NM).

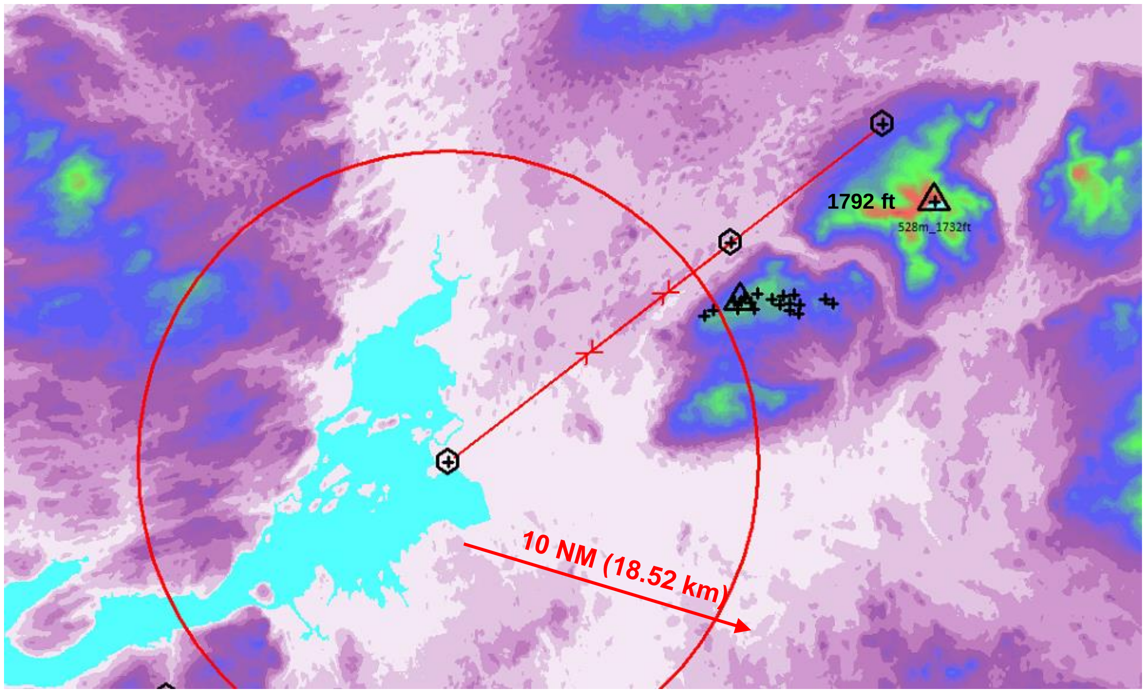
- For the DME orbit flight profile, heights and distances are decided by the Flight Inspector in conjunction with the pilots to ensure correct and sufficient data is recorded while taking into account local terrain and obstacle clearance requirements.

- Turbine T01 is the highest of the proposed wind turbines at Violet Hill and would have to be considered in any orbital flight inspection over the proposed wind farm.

Violet Hill Wind Farm (Updated Turbine Layout (June 25 2021))

Turbine ID	Co-ordinates (ITM)		Max Turbine Tip Height	Turbine Base (AMSL) (m)	Max Tip Height (AMSL)	
	Easting	Northing			Meters (m)	Feet (ft)
T01	553159	669794	185	276	461	1512.5
T02	553332	669350	185	269	454	1489.6
T03	554359	669318	185	227	412	1351.8
T04	554176	669759	185	255	440	1443.6
T05	553781	669968	185	255	440	1443.6
T06	554589	670222	185	255	440	1443.6
T07	555442	669913	185	265	450	1476.5
T08	555881	669555	185	247	432	1417.4
T09	556491	669215	185	188	373	1223.8
T10	556477	669664	185	225	410	1345.2
T11	556762	670152	185	181	366	1200.8
T12	556098	670086	185	233	418	1371.5
T13	557076	669576	185	153	338	1109.0
T14	556971	669020	185	157	342	1122.1
T15	558585	669916	185	184	369	1210.7
T16	559020	669597	185	190	375	1230.4
T17	551911	669321	185	203	388	1273.0
T18	551370	668955	185	234	419	1374.7

Flight Calibration – Orbital Flight (2)



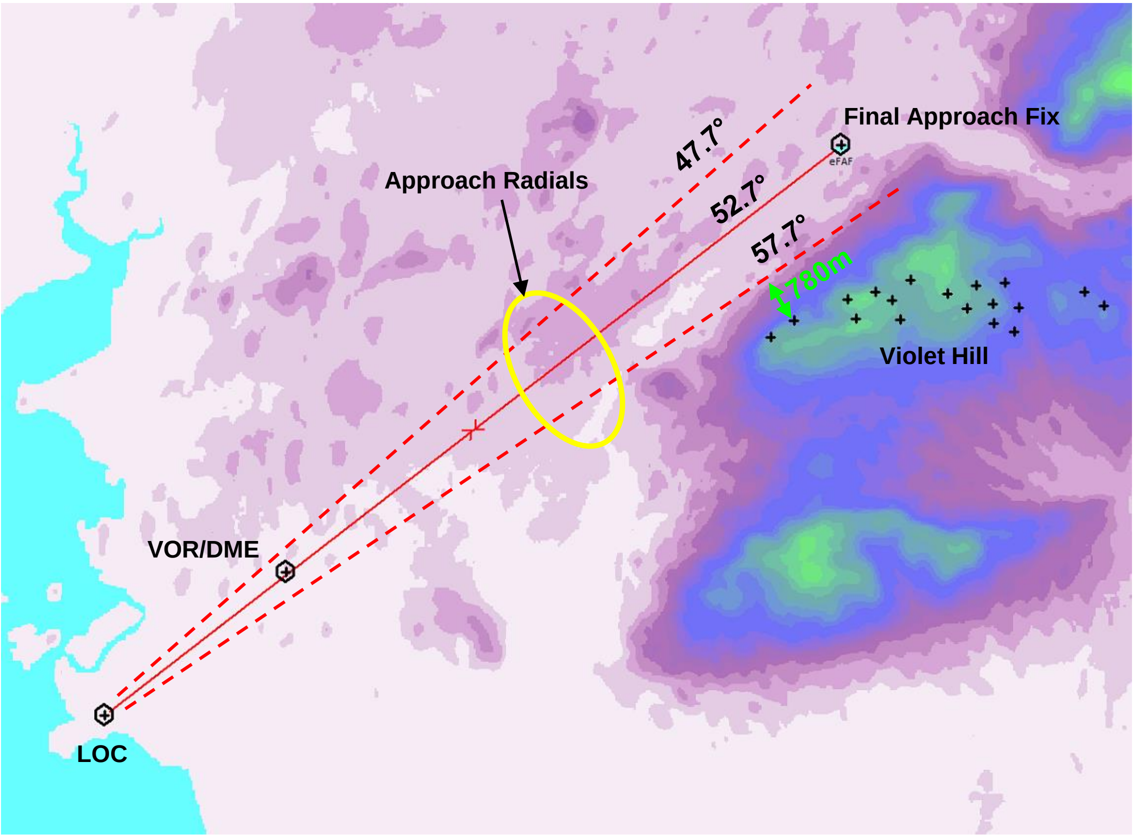
- The highest terrain in the vicinity of Violet Hill is 961ft AMSL. Existing rules would indicate that Orbital DME Calibration flights should fly at least 1961ft AMSL in this region
- Conducting an orbital flight within a radius of 5 to 8NM would mean that the proposed Violet Hill would not have any impacts on line of sight from the aircraft to localiser antenna in the vicinity of Shannon Airport
- Any circular orbit flights in the vicinity of Violet Hill would need to consider the existing terrain noting that the proposed turbines are all located outside 10NM

Off-course clearance

4.3.21 The localizer clearance is checked to determine that the transmitted signals will provide the user with the proper off-course indication and that there are no false courses. Conduct an orbital flight with a radius of 9 to 15 km (5 to 8 NM) from the facility and approximately 460 m (1 500 ft) above the antenna. Where terrain is a factor, the height will be adjusted to provide line-of-sight between the aircraft and the antenna.

4.3.22 Clearance should be checked within the promulgated angular limits of coverage provided on either side of the front course (typically 35 degrees), unless the back course is used for approaches. In such cases, clearances will also be checked to the angular coverage limits of the back course. Outside of the promulgated coverage, there may be false courses due to antenna pattern characteristics or environmental conditions.

Flight Calibration – Radial Flights (1)



- Terminal Radials (Approach, Missed Approach, Standard Instrument Departure SID)) – should be flown 30m (100 ft) below specified altitudes. Site and commissioning inspections require two additional radials 5 degrees either side of the approach radial.

- The figure opposite indicates that the proposed turbines at Violet Hill should have no impact on the Approach Radial test flights.

2.3.36 Approach radials should be evaluated at a distance that includes the procedure turn, holding pattern and missed approach on commissioning inspections. The approach radial should be flown 30 m (100 ft) below specified altitudes. Site and commissioning inspections require two additional radials 5° either side of the approach radial to be flown and analysed with the same criteria as the approach radial. This needs only to be performed if the approach radial shows performance near the set accuracy requirement. Radials used to support SID procedures should be evaluated to the extent to which they are used.

10. Flight Calibration – Radial Flights (2)

The localizer coverage sector is specified as follows (Annex 10, Volume I, 3.1.3.3.1), or as promulgated by the State:

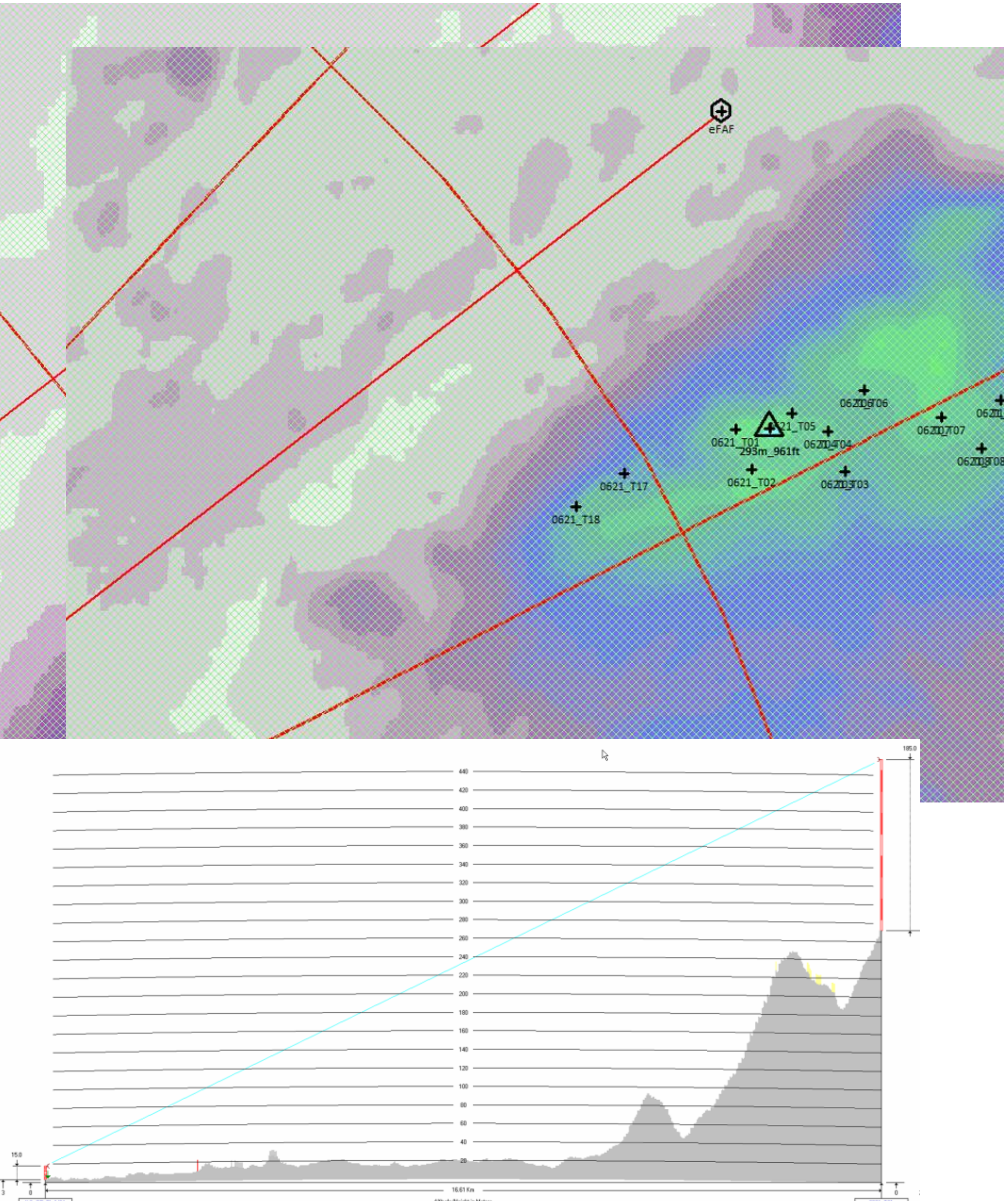
"3.1.3.3.1 […] The localizer coverage sector shall extend from the centre of the localizer antenna system to distances of:

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; and
18.5 km (10 NM) outside of plus or minus 35 degrees from the front course line if coverage is provided;

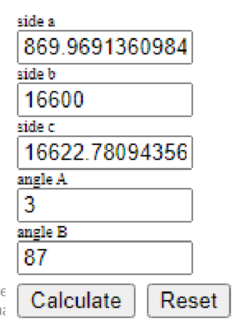
except that, where topographical features dictate or operational requirements permit, the limits may be reduced down to 33.3 km (18 NM) within the plus or minus 10-degree sector and 18.5 km (10 NM) within the remainder of the coverage when alternative navigational means provide satisfactory coverage within the intermediate approach area. The localizer signals shall be receivable at the distances specified at and above a height of 600 m (2 000 ft) above the elevation of the threshold, or 300 m (1 000 ft) above the elevation of the highest point within the intermediate and final approach areas, whichever is the higher; except that, where needed to protect ILS performance and if operational requirements permit, the lower limit of coverage at angles beyond 15 degrees from the front course line shall be raised linearly from its height at 15 degrees to as high as 1 350 m (4 500 ft) above the elevation of the threshold at 35 degrees from the front course line. Such signals shall be receivable, to the distances specified, up to a surface extending outward from the localizer antenna and inclined at 7 degrees above the horizontal.

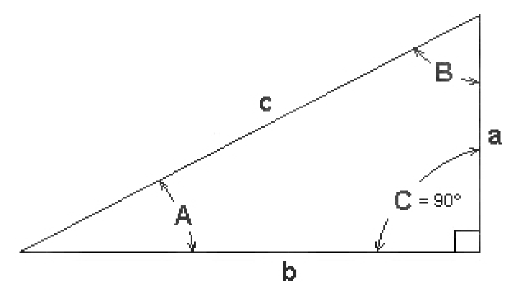
Terminal Radials (Approach, Missed Approach, Standard

Flight Calibration – Radial Flights (3)

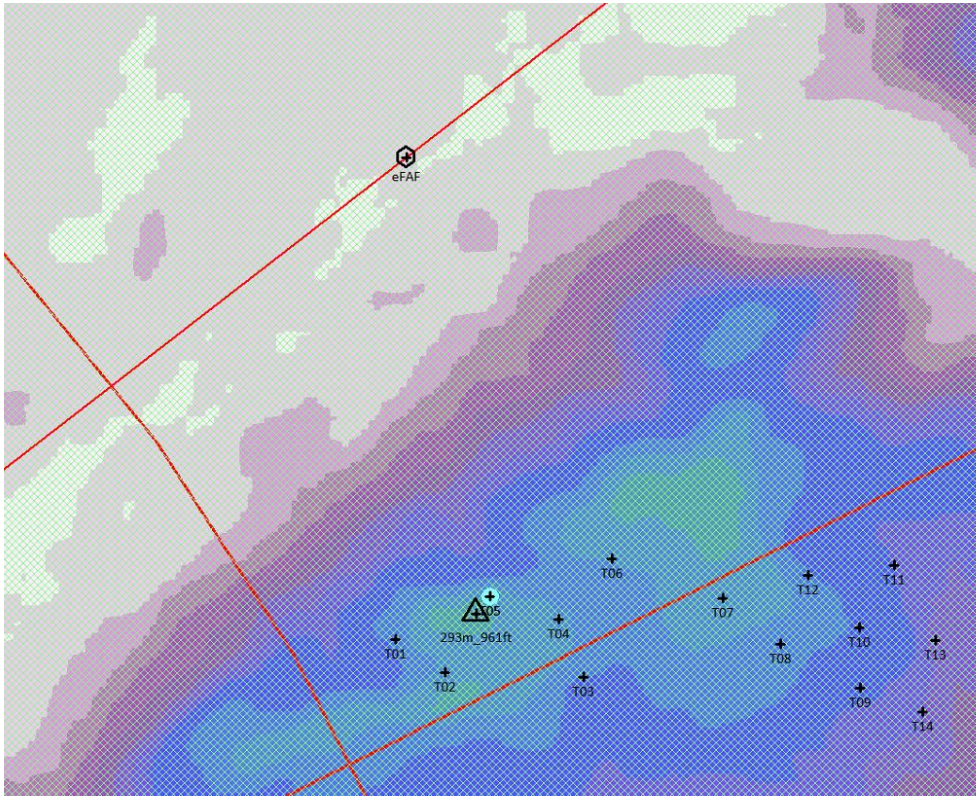


- <u>En-route Radials</u> – should be flown along their entire length from the Airport terminal at a minimum altitude as published. The minimum altitude for flying en-route radials, predicated on terminal facilities is 300m **(1000 ft) above the highest terrain or obstruction** along the radial to a distance of 46.3 km 25 (NM).
- RWY24 localizer antenna to T1 is 16.6km
- Based on an antenna height of 14m the calculations of the height of the aircraft at 16.6km along the flight radial would be 1,388ft AMSL.
- As the flight aircraft will be flying below published minima by 100ft this would mean that the aircraft altitude would be 1,288 ft at 16.6km and would still be above T1 by 1,000ft
- Thus T1 would have no impact on radio flight calibration checks



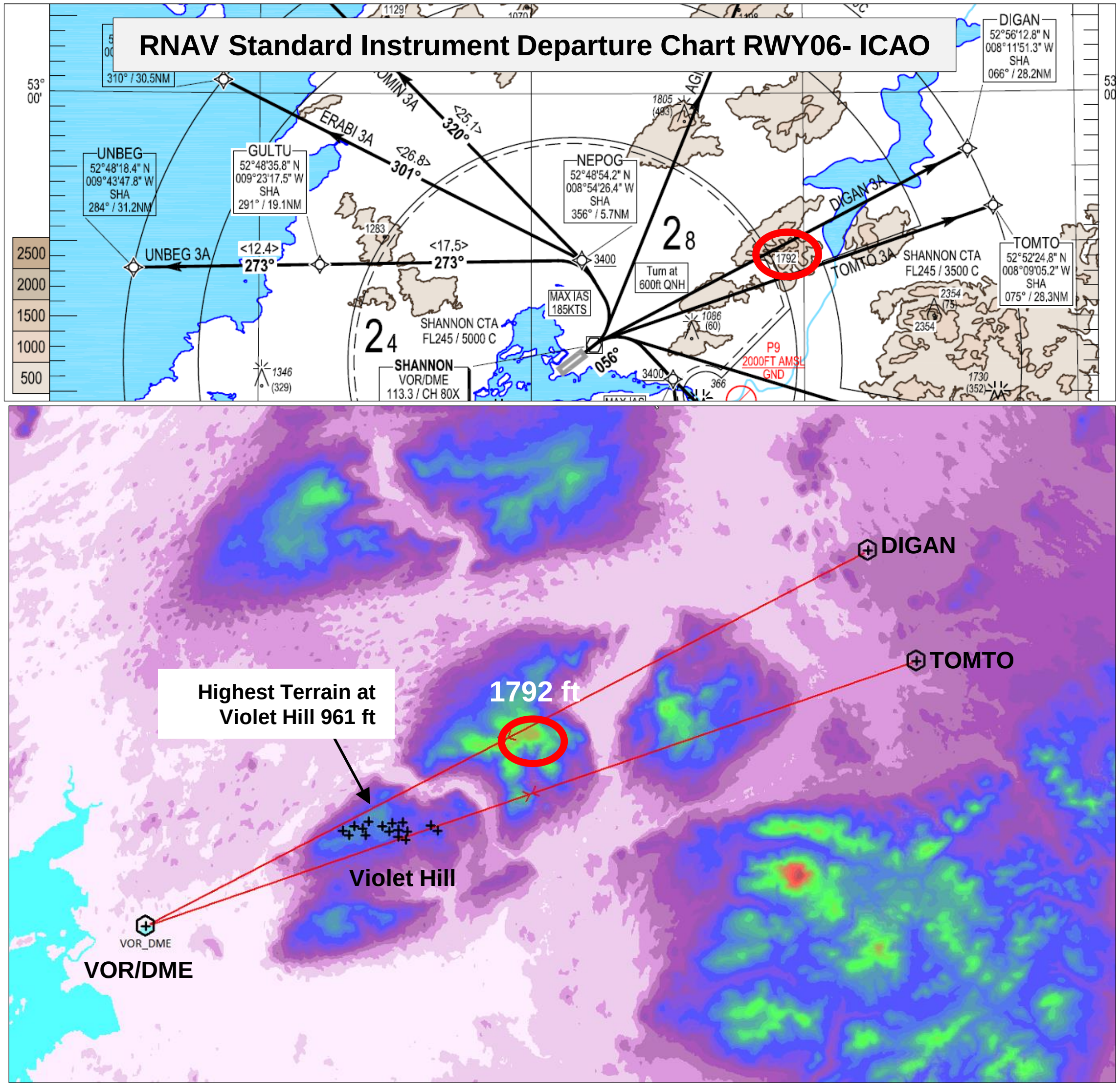


Flight Calibration – Radial Flights (4)



- En-route Radials – should be flown along their entire length from the facility (Airport) at a minimum altitude as published. The minimum altitude for flying en-route radials, predicated on terminal facilities is 300m **(1000 ft) above the highest terrain or obstruction** along the radial to a distance of 46.3 km 25 (NM).

Flight Calibration – Radial Flights (5)



Departure Radials

- There are two Departure Radials that pass over the proposed wind farm: DIGAN and TOMTO

- The highest mountain peak along the radials is 1792 ft and is marked on the IAA SID chart for RWY06. The minimum flight altitude along this radial would be 2792 ft.

- Turbine T01 is the highest of the proposed wind turbines at Violet Hill. The max tip-height for T01 is 1512.5 ft AMSL indicating that the proposed development should have no impact Flight Calibration Inspections on these Departure Radials.

Appendix 3

Violet Hill Wind Farm Radar Surveillance Desktop Review

Violet Hill Wind Farm
Radar Surveillance Desktop Review

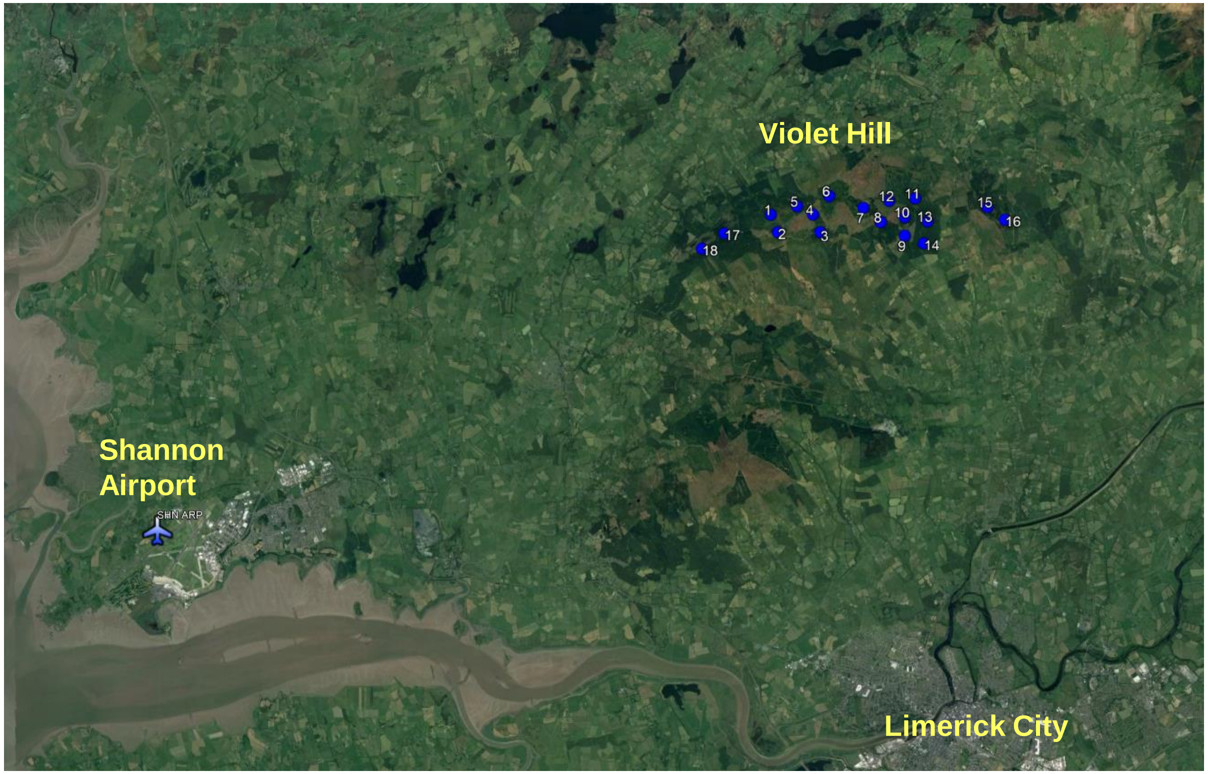
Ai Bridges Ltd.	
Document Title: Radar Surveillance Desktop Review	Date: 19.07.21
Document Number: AB-CEVHRSA-001	Revision: 1.0

1. Assessment Overview (1)

- Coillte is proposing a new wind farm development at Violet Hill on the Clare Hills in the West Of Ireland. The proposed wind farm consists of 18 turbines. The proposed site in 9NM north east of Shannon Airport

- Coillte have commissioned Ai Bridges Ltd to conduct an initial desktop assessment of the potential impacts to radar surveillance sensors in the vicinity of the wind farm. A desktop assessment of the PSR\SSR radars at Shannon Airport and Woodcock Hill has been carried out based on Eurocontrol Guidelines. The findings in relation to the desktop assessment of Violet Hill are presented herein.

2. Wind Farm Development - Overview (1)



- The location of the proposed wind farm development is shown
- The proposed development consists of 18 turbines situated circa 9NM (18km) north east of Shannon Airport

Wind Farm	No. of Turbines	Tip Height	Rotor Diameter	Bearing	Distance NM	Distance Km
Violet Hill	18	185m	155m	NE	9.5	17.6

2. Wind Farm Development – Turbine Co-ordinates (2)

Violet Hill Wind Farm - Turbine Co-ordinate Details						
Turbine ID	Co-ordinates (ITM)		Max Turbine Tip Height (AGL) (m)	Turbine Base (AMSL) (m)	Max Tip Height (AMSL)	
	Easting	Northing			Meters (m)	Feet (ft)
T01	553159	669794	185	276	461	1512.5
T02	553332	669350	185	269	454	1489.6
T03	554359	669318	185	227	412	1351.8
T04	554176	669759	185	255	440	1443.6
T05	553781	669968	185	255	440	1443.6
T06	554589	670222	185	255	440	1443.6
T07	555442	669913	185	265	450	1476.5
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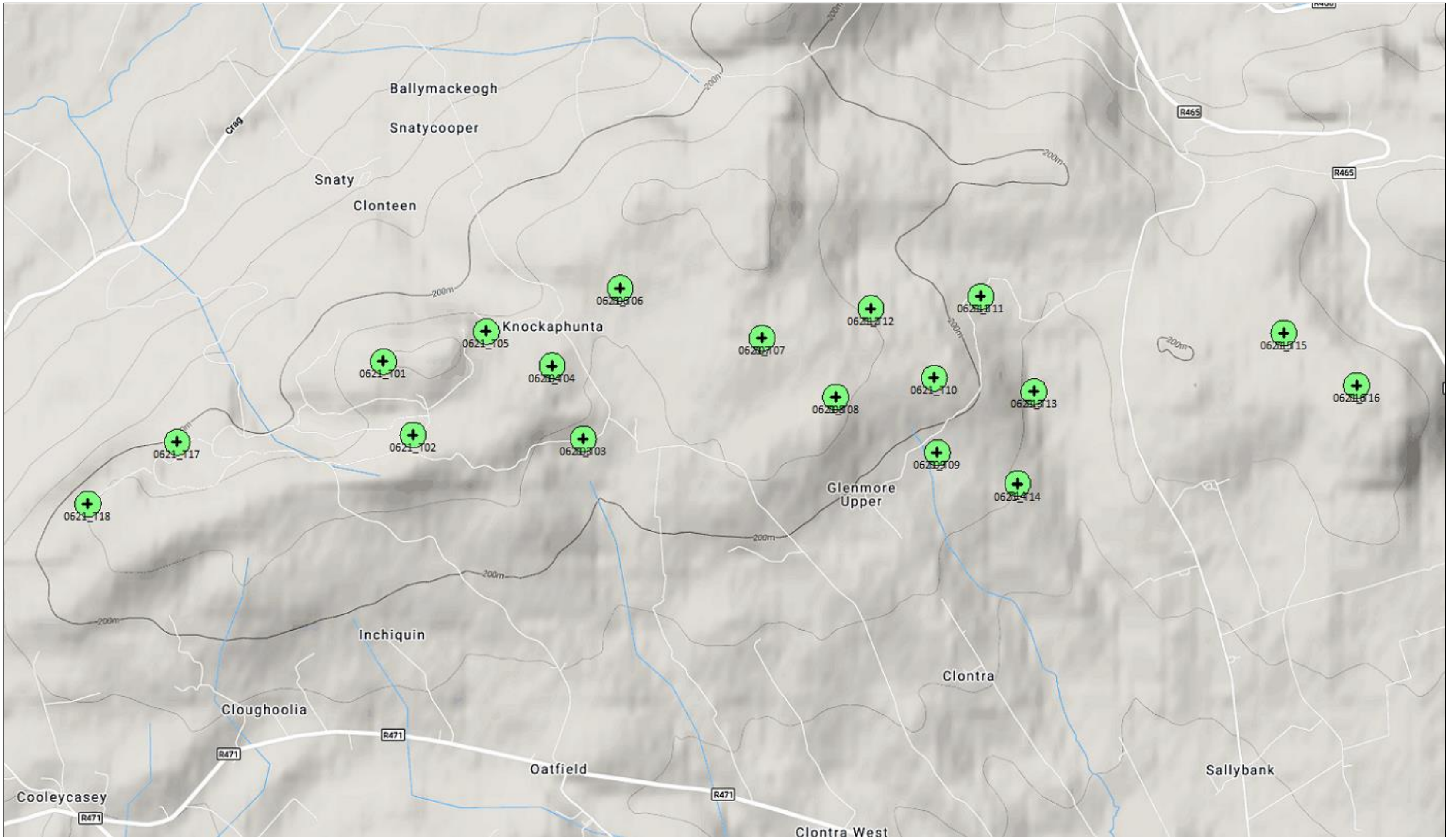
T12	556098	670086	185	233	418	1371.5
T13	557076	669576	185	153	338	1109.0
T14	556971	669020	185	157	342	1122.1
T15	558585	669916	185	184	369	1210.7
T16	559020	669597	185	190	375	1230.4
T17	551911	669321	185	203	388	1273.0
T18	551370	668955	185	234	419	1374.7

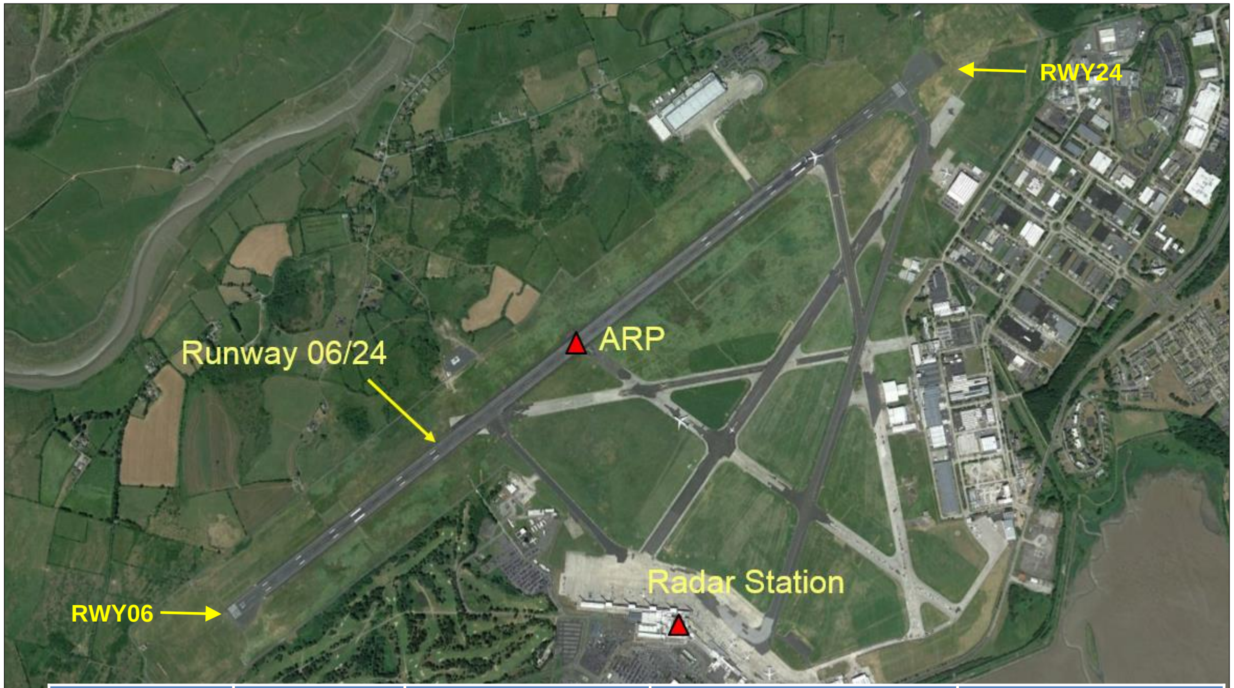
2. Wind Farm Development - Wind Turbine Layout (3)



Wind Farm	No. of Turbines	Tip Height	Rotor Diameter	Bearing	Distance NM	Distance Km
Violet Hill	18	185m	155m	NE	9.5	17.6

3. Shannon Airport - Overview (1)

- Airport Reference Point (ARP), - 17.4 km from Violet Hill
- One single runway surface with two Runways – 06 and 24
- There are departures and approaches on both Runways 06 and 24
- This desktop assessment takes into account Approaches on Runway 24 and Approaches on Runway 06



Location	Installation	Description	Airport Ref. Point ARP	Distance to Proposed Wind Farm
Shannon, Co Clare	International Airport	Single Asphalt Runway Airspace: Class C	52 42 07 N 008 55 29 W (Mid-point of Runway 06/24).	17.6 km

4. Radar Surveillance Systems – Overview (1)

- The EUROCONTROL Guidelines require a 16km safe distance for a “Zone 4 - No Assessment” condition and detailed assessments are required for any proposed wind fsrm 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.”

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 and in radar line of sight	Simple Assessment
Zone 4	Not in radar line of sight	No Assessment

Table 3. 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 4. SSR Zone Arrangements

4. Radar Surveillance Systems – Shannon Airport (2)

Figure 3. PSR and SSR at Shannon Airport

- At Shannon Airport the IAA have a Primary Surveillance Radar (PSR) and a Secondary Surveillance Radar (SSR) System.

- Both radar systems are enclosed in the domes structure a s shown in Figure 3.

- Shannon airport is 17.6 km from the proposed wind arm development.

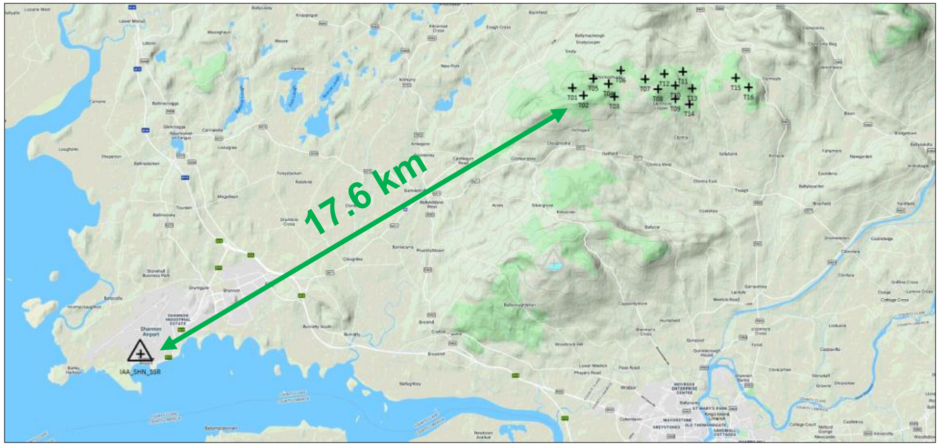
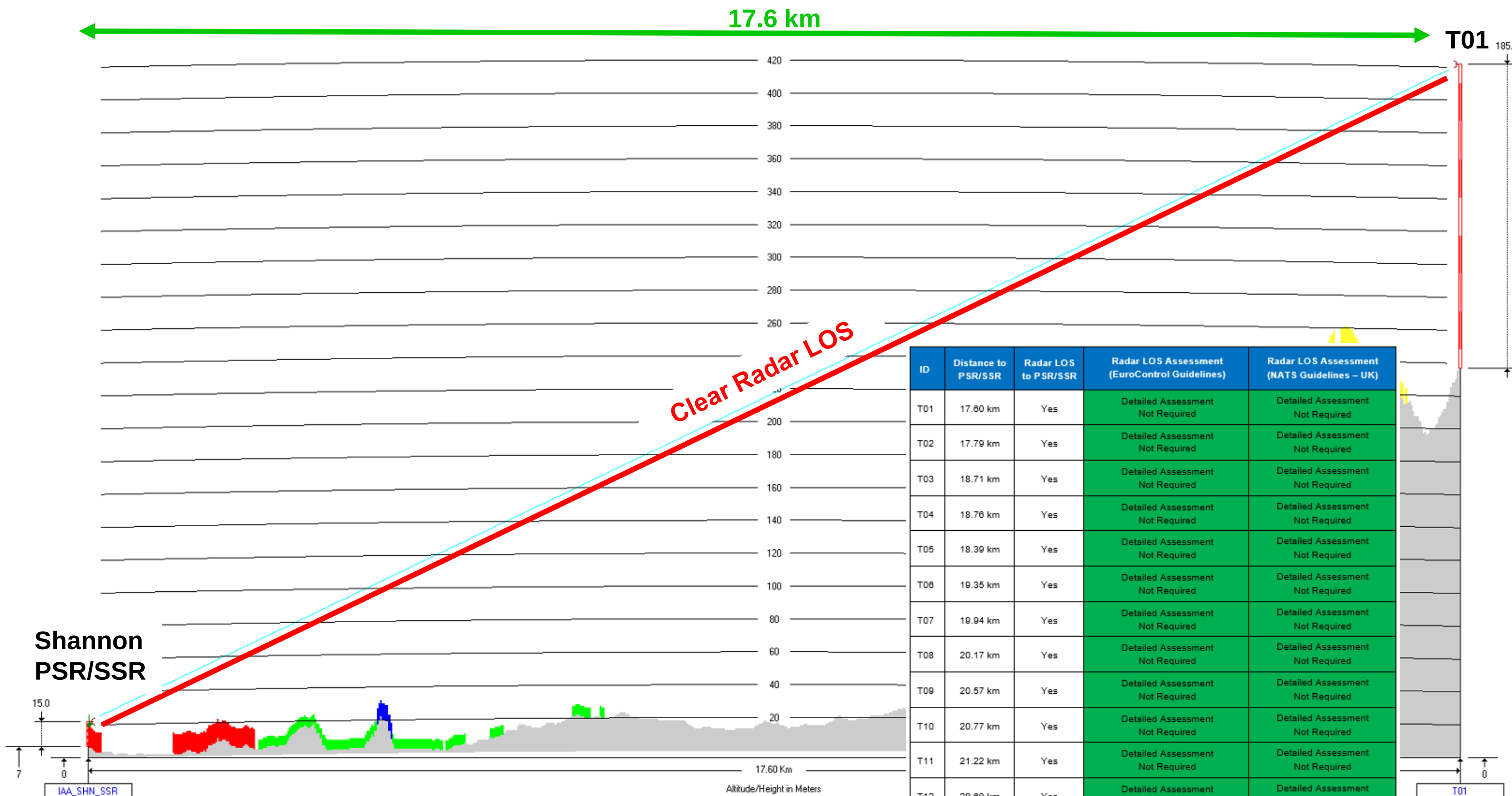


Figure 4. Shannon PSR/SSR relative to proposed turbines

4. Radar Surveillance Systems – Shannon Airport Radar LOS (3)



ID	Distance to PSR/SSR	Radar LOS to PSR/SSR	Radar LOS Assessment (EuroControl Guidelines)	Radar LOS Assessment (NATS Guidelines – UK)
T01	17.60 km	Yes	Detailed Assessment Not Required	Detailed Assessment Not Required
T02	17.79 km	Yes	Detailed Assessment Not Required	Detailed Assessment Not Required
T03	18.71 km	Yes	Detailed Assessment Not Required	Detailed Assessment Not Required
T04	18.76 km	Yes	Detailed Assessment Not Required	Detailed Assessment Not Required
T05	18.39 km	Yes	Detailed Assessment Not Required	Detailed Assessment Not Required
T06	19.35 km	Yes	Detailed Assessment Not Required	Detailed Assessment Not Required
T07	19.94 km	Yes	Detailed Assessment Not Required	Detailed Assessment Not Required
T08	20.17 km	Yes	Detailed Assessment Not Required	Detailed Assessment Not Required
T09	20.57 km	Yes	Detailed Assessment Not Required	Detailed Assessment Not Required
T10	20.77 km	Yes	Detailed Assessment Not Required	Detailed Assessment Not Required
T11	21.22 km	Yes	Detailed Assessment Not Required	Detailed Assessment Not Required
T12	20.60 km	Yes	Detailed Assessment Not Required	Detailed Assessment Not Required
T13	21.25 km	Yes	Detailed Assessment Not Required	Detailed Assessment Not Required
T14	20.93 km	Yes	Detailed Assessment Not Required	Detailed Assessment Not Required
T15	22.76 km	Yes	Detailed Assessment Not Required	Detailed Assessment Not Required
T16	23.03 km	Yes	Detailed Assessment Not Required	Detailed Assessment Not Required

4. Radar Surveillance Systems – Woodcock Hill (4)

Figure 5. SSR at Woodcock Hill

- At Woodcock Hill the IAA have a Secondary Surveillance Radar (SSR) System.

- The radar system is enclosed in the dome shaped structure as shown in Figure 5.

- The SSR is just 5.91 km from the proposed wind farm development.

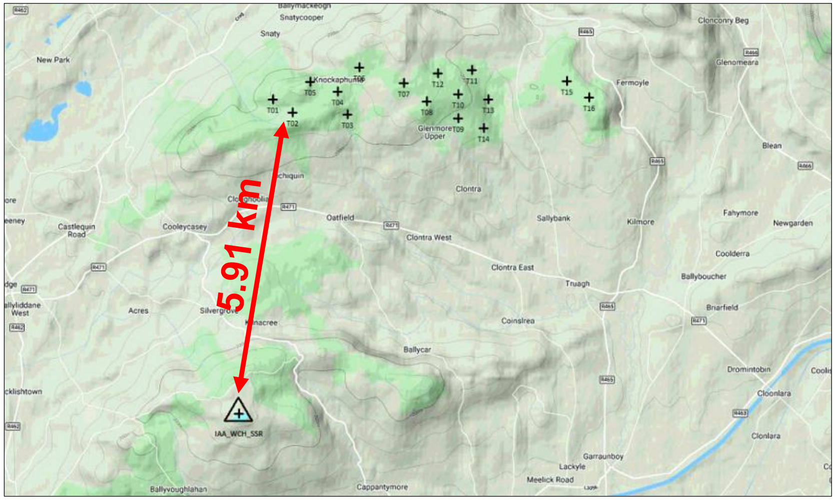
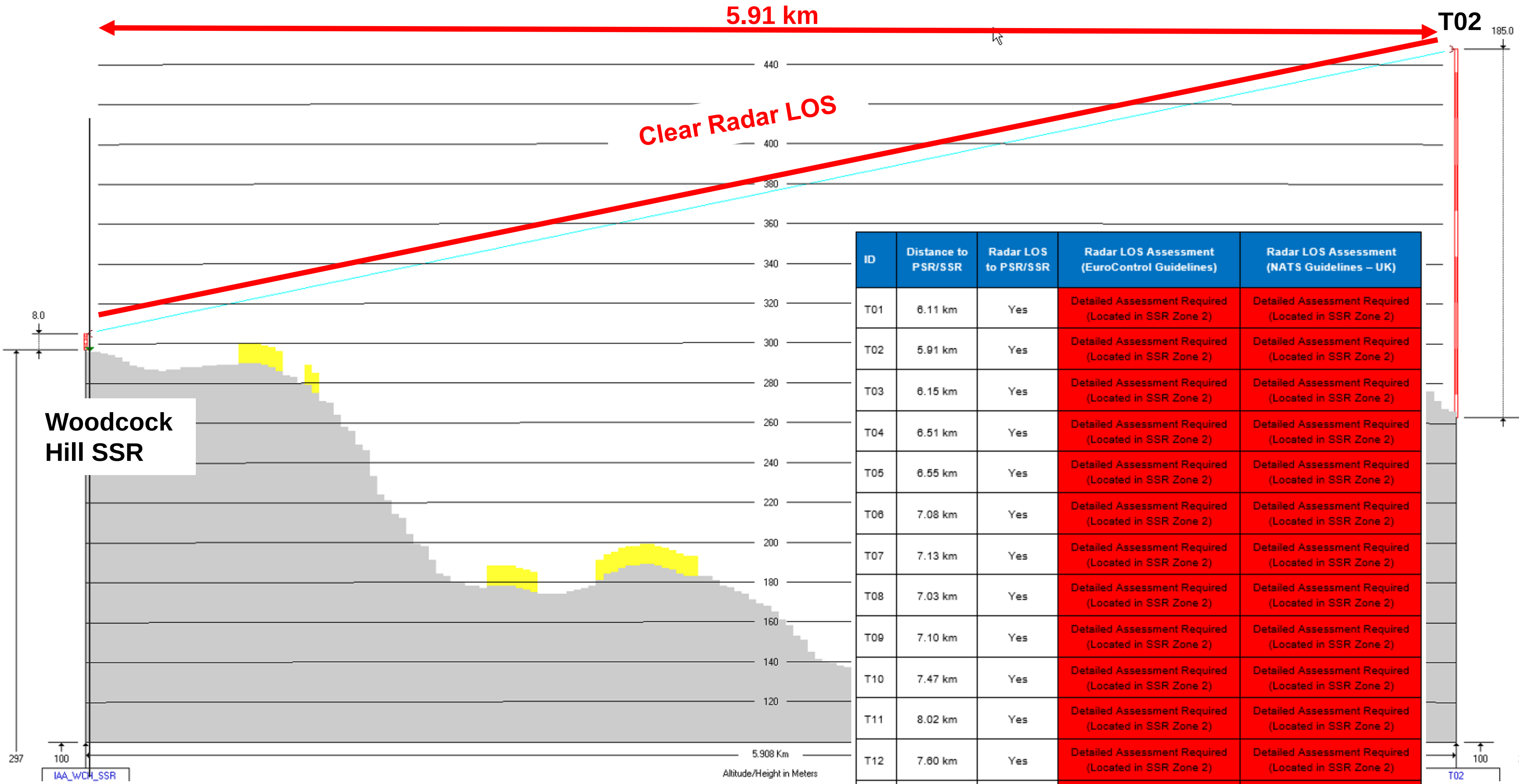


Figure 6. SSR at Woodcock Hill

4. Radar Surveillance Systems – Woodcock Hill Radar LOS (5)

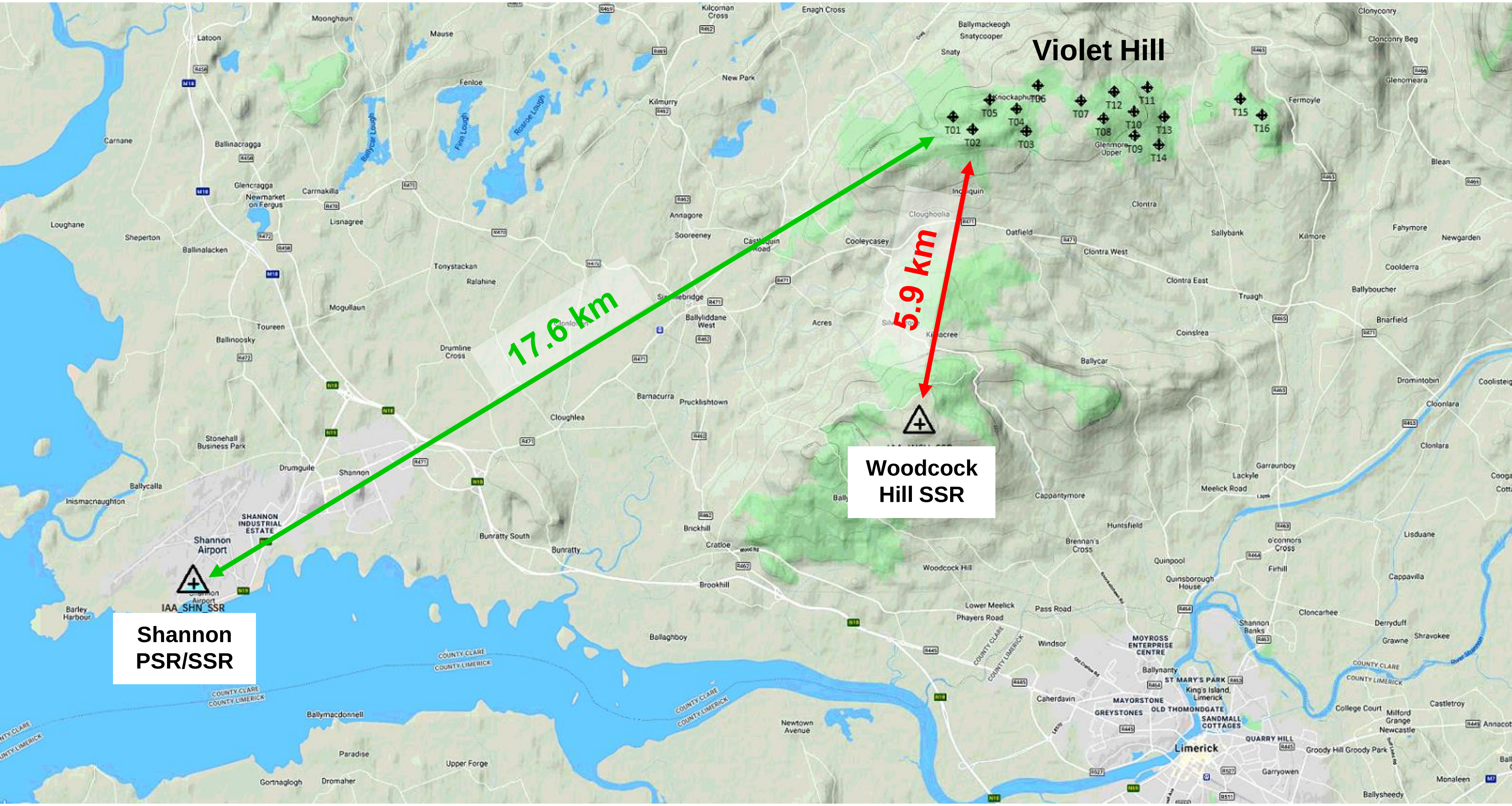


ID	Distance to PSR/SSR	Radar LOS to PSR/SSR	Radar LOS Assessment (EuroControl Guidelines)	Radar LOS Assessment (NATS Guidelines – UK)
T01	6.11 km	Yes	Detailed Assessment Required (Located in SSR Zone 2)	Detailed Assessment Required (Located in SSR Zone 2)
T02	5.91 km	Yes	Detailed Assessment Required (Located in SSR Zone 2)	Detailed Assessment Required (Located in SSR Zone 2)
T03	6.15 km	Yes	Detailed Assessment Required (Located in SSR Zone 2)	Detailed Assessment Required (Located in SSR Zone 2)
T04	6.51 km	Yes	Detailed Assessment Required (Located in SSR Zone 2)	Detailed Assessment Required (Located in SSR Zone 2)
T05	6.55 km	Yes	Detailed Assessment Required (Located in SSR Zone 2)	Detailed Assessment Required (Located in SSR Zone 2)
T06	7.08 km	Yes	Detailed Assessment Required (Located in SSR Zone 2)	Detailed Assessment Required (Located in SSR Zone 2)
T07	7.13 km	Yes	Detailed Assessment Required (Located in SSR Zone 2)	Detailed Assessment Required (Located in SSR Zone 2)
T08	7.03 km	Yes	Detailed Assessment Required (Located in SSR Zone 2)	Detailed Assessment Required (Located in SSR Zone 2)
T09	7.10 km	Yes	Detailed Assessment Required (Located in SSR Zone 2)	Detailed Assessment Required (Located in SSR Zone 2)
T10	7.47 km	Yes	Detailed Assessment Required (Located in SSR Zone 2)	Detailed Assessment Required (Located in SSR Zone 2)
T11	8.02 km	Yes	Detailed Assessment Required (Located in SSR Zone 2)	Detailed Assessment Required (Located in SSR Zone 2)
T12	7.60 km	Yes	Detailed Assessment Required (Located in SSR Zone 2)	Detailed Assessment Required (Located in SSR Zone 2)
T13	7.74 km	Yes	Detailed Assessment Required (Located in SSR Zone 2)	Detailed Assessment Required (Located in SSR Zone 2)
T14	7.25 km	Yes	Detailed Assessment Required (Located in SSR Zone 2)	Detailed Assessment Required (Located in SSR Zone 2)
T15	9.00 km	Yes	Detailed Assessment Required (Located in SSR Zone 2)	Detailed Assessment Required (Located in SSR Zone 2)
T16	9.10 km	Yes	Detailed Assessment Required (Located in SSR Zone 2)	Detailed Assessment Required (Located in SSR Zone 2)

4. Radar Surveillance Systems (7)

- The Shannon Primary \ Secondary Radars will not be impacted and a detailed radar assessment will not be required

- A detailed radar assessment required for Woodcock Hill Secondary Radar will be required



4. Radar Surveillance Assessment - Conclusions (8)

- There are two aviation surveillance radar sites in the vicinity of the proposed Violet Hill wind farm. The surveillance radar sites are located at Shannon Airport and at Woodcock Hill.

- Desktop survey analysis shows that the proposed wind farm development is located outside the Assessment Zone 2 of the IAA Assessment Zone 2 of the Secondary Surveillance Radar (SSR) At Shannon Airport

- Desktop survey analysis shows that the proposed wind farm development is located within Assessment Zone 2 of the IAA Secondary Surveillance Radar (SSR) at Woodcock Hill.

- As the development is located within Assessment Zone 2, the IAA is likely to object to the wind farm unless a detailed technical assessment is provided by the applicant and the results of which are found to be acceptable to IAA.

- For a detailed technical assessment, the IAA have referred 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 and mitigation measure proposals has been provided in the Appendices in the document "Violet Hill Wind Farm Radar Surveillance Assessment Guidelines & Mitigation Measures"

4. Radar Surveillance Assessment - Recommendations (9)

- Ai Bridges recommend that a detailed technical assessment should be conducted

- The SSR service degradation should be predicted to determine the impact on operational service in the airspace of the proposed wind farm

- The findings of the technical and operational review should inform any discussion on proposed mitigation measures including the possibility for an additional more robust surveillance radar that can cope with wind farm interference

Appendix 4

Violet Wind Farm - IAA Consultations

Report

Violet Hill Wind Farm

IAA Consultations

Document Number: 001/KO/202202

Author: PT\DMG

Approved for Release: Rev 1.0 KH **Date:** 24/05/2022

Document Filename: *Violet Wind Farm – IAA Consultations*

1.1 IAA Consultations

The consultations between Ai Bridges Ltd and the Irish Aviation Authority (IAA) in relation to proposed Violet Hill wind farm are presented below.

IAA email to Ai Bridges Ltd - 23 November 2021

From: MACCRIOSTAIL Cathal <Cathal.MacCriostail@IAA.ie>
Sent: 23 November 2021 12:41
Subject: 211123 Coillte Windfarm Proposal East Clare Ref. 19107/ABP30879920

Dear Kevin,

As discussed earlier and reflecting your involvement on this referenced project along with your interaction with Cyrrus, please see below the detail we have on the proposed East Clare Wind farm:

Category: *19107/ABP30879920*
Applicant Name: *Coillte CGA*
Local Authority: *Malachy Walsh And Partners*
Description: *This project has been the subject of a Pre-application Stage consultation for Strategic Infrastructure with An Bord Pleanala (An Bord Pleanala Reference. 303105-18). An Bord Pleanala has determined that this proposed project falls within the Strategic Infrastructure Development consent process. In confirming that this project is a Strategic Infrastructure Development project it has identified 16*
prescribed bodies that have to be notified in relation to this planning application. Accordingly, we are notifying you that the application has been lodged with An Bord Pleanala on Monday 30th of November 2020.
The following sets out the description of the proposed development:
• Nineteen (19) No. Wind Turbines (blade tip height up to 169m.)
• Nineteen (19) No. Wind Turbine foundations and associated Hardstand areas.
• One (1) No. Permanent Meteorological Mast (100m height) and associated foundation and hardstand area.
• One (1) No. Substation (llOkV) including associated ancillary buildings (electrical building including control, switchgear and metering rooms, and the operational building including welfare facilities, workshop and office), security fencing and all associate d works.
• Upgraded Site Entrance.
• New and upgraded internal site service roads (8.4km of existing tracks to be upgraded and 11.4km of new service roads to be constructed).
• Provision of an on-site Visitor cabin and parking. • Underground electrical collection and SCADA system linking each wind turbine lo the proposed on-site substation.
• Construction of new roadways and localised widening along turbine delivery route.
• Two (2) No. Temporary construction site compounds.
• Three (3) No. Borrow Pits to be used as a source o f stone material during construction.
• Three (3) No. Peat and Spoil deposition areas (at borrow pit location s).
• Associated surface water management systems.
• Tree felling for wind farm infrastructure.
• All associated site development works.
Site Location: The townlands of Ballydonaghan, Caherhurley, Coumnagun, Carrownagowan, Inchalughoge, Killokennedy, Kilbane, Coolready and Drummod Co. Clare.
Observations:

Eng Obs letter sent 21/12/2020
Surveillance Obs letter 21/12/2020
Receipt of obs 08/01/2020
Further Info 25/02/2021
Obs letter sent 03/02/2021
Obs sent via email 18/03/2021

As also discussed, the proposed location is an area that has been presented for Windfarm development in a number of different guises in recent years including as you referenced, Brookfield Renewables (Oatfield Windfarm). The location is challenging for the IAA ANSP on a number of fronts:

1. **Surveillance**: Woodcock Hill MSSR could be affected by the turbines and filtering out this issue, although possible may be prohibitively expensive
2. **NAVAIDs:** For flight calibration activity, the turbines could impact this activity
3. **IFPs:** Surveillance minima as well as Instrument flight procedures could have some impact dependent on the wind turbine elevations

I've copied colleagues for the relevant sections for their information as well as the SAA. As this progresses and Cyrrus provide more information, you're welcome to use me as a focal point for engagement with the project leads/Coillte.

Best regards,

Cathal
Cathal Mac Criostail

Ai Bridges Ltd email to IAA – 24 November 2021

From: Kevin Hayes
Sent: 24 November 2021 17:32
To: MACCRIOSTAIL Cathal <Cathal.MacCriostail@IAA.ie>
Subject: Coillte Windfarm Proposal East Clare - Violet Hill Wind Farm

Dear Cathal,

I am just following up from your email below yesterday following our call in relation to the proposed Wind Farm Development in East Clare.

The proposed wind farm that we are have been engaging with Coille on is located at Violet Hill , approximately 4km northeast of Sixmilebridge, Co Clare. There has been no planning application submitted for this proposed development to-date. We have been engaged by Coillte to carry our desk-top assessments for the Telecommunications & Aviation networks in the vicinity of this proposed wind farm.

Just to confirm from our call that the project reference is "Violet Hill" and this may have been confused with the active planning application at "Carrownagowan Wind Farm " which you have referenced in your email below.

Just to confirm that the proposed wind turbine layout for the Violet Hill Wind Farm development has been informed by the previous "Oatfield Wind Farm" proposal dating back to 2018 and the developer at this time was Brookfield Renewables.

The proposed Oatfield Wind Farm was located in an IAA-ANSP operational zone inside the Zone 2 Detailed Assessment area. This project was the subject of two technical assessments by third party aviation consultants which in turn were both subject to a Safeguarding Summary Report by NATS at that time. It was identified that a detailed technical assessment for the SSR and the PSR at Shannon Airport should be undertaken. This wind farm project never progressed.

Thus in this case of the proposed Violet Hill Wind Farm, Coillte has taken the previous Oatfield development into consideration and has located the proposed development in a Zone 3 Simple Assessment Area (PSR Only) i.e. outside the 15km area of a Zone 2 Assessment area. This has been done in order to facilitate a Radar Impact Assessment for Shannon Airport PSR where mitigation measure solution options may be available for consideration

Ai Bridges have been engaging directly with Cyrrus who have completed a full Radar Assessment of the PSR\MSSR and Shannon Airport and the MSSR at Woodcock Hill. The Assessment Report is attached for your reference

As discussed yesterday I would be grateful if you could make yourself available for a call \ online meeting to discuss.

We have been in contact with Cyrrus and that would have availability to join a call on Monday next in the afternoon. Also Coillte have confirmed their availability to join this call, I understand that you may have engaged with the Coillte PM, Charles Langley, previously in relation to Carrownagowan Wind Farm

Would you and your colleagues be available for a Teams Meeting between 15:00 – 16:00 on Monday 29th Dec next week for an initial discussion on this proposed development at Violet Hill ?

I am happy to have a call with you tomorrow morning to discuss.
Best Regards,
Kevin Hayes,

CL-5693-RPT-002 V1.0 Violet Hill Wind Farm Radar Assessment.pdf
.pdf File

Ai Bridges Ltd email to IAA – 29 November 2021

From: Kevin Hayes
Sent: 29 November 2021 19:07
To: MACCRIOSTAIL Cathal <Cathal.MacCriostail@IAA.ie>
Subject: RE: Coillte Windfarm Proposal East Clare - Violet Hill Wind Farm

Cathal,

Thank you to both you and colleagues for making yourselves available for today's meeting and for co-ordinating same. It was a very productive call.

As discussed please find attached copies for your review of the IFP Safeguarding Assessment Report from Cyrrus and the Impact Assessment on ILS Flight Inspections from FCSL.

I am available to discuss with you on Friday this week.

Best Regards,

Kevin Hayes,

CL-5682-RPT-003 V1.0 Violet Hill Windfarm IFP Safeguarding (signed).pdf
.pdf File

FCSL 0138.pdf
.pdf File

Ai Bridges Ltd email to IAA - 20 January 2022

From: Kevin Hayes
Sent: 20 January 2022 16:45
To: 'MACCRIOSTAIL Cathal' <Cathal.MacCriostail@IAA.ie>
Subject: RE: Coillte Windfarm Proposal East Clare - Violet Hill Wind Farm

Hello Cathal,

I hope that you had an enjoyable break over the holiday period.

I am just following up from our last call in relation to the IFP Assessment Report by Cyrrus. We have discussed your concerns with them and

Would you be available for a call next week with Cyrrus to discuss, would you have any availability in any of the time slots below, 1 hour should suffice

- Tue 25th Jan , 2:00PM - 5:00PM
- Wed 26th Jan, 2:00PM – 5:00PM
- Thur 27th Jan, 9:30AM – 1:00PM

Also do you have any update from your Technical Services Team in relation to their review of the Radar Impact Assessment Report

Best Regards,
Kevin Hayes,

Ai Bridges Ltd email to IAA - 24 January 2022

From: Kevin Hayes
Sent: 24 January 2022 15:20
To: 'MACCRIOSTAIL Cathal' <Cathal.MacCriostail@IAA.ie>
Subject: RE: Coillte Windfarm Proposal East Clare - Violet Hill Wind Farm

Hello Cathal,

I am just following up from the email that I sent out on Thursday last week and the voicemail that I left for your earlier.

Would you be available for a call with your colleague on any of the dates below this week for a call with Cyrrus to discuss the concerns that you raised on our last call so that we could review possible mitigations.

We are also just looking to discuss any updates that you have received from your Technical Services in relation to the Radar and Flight Calibration Assessment Reports

Would you be available for a brief call later today just to discuss your schedule availability ?

Best Regards,
Kevin Hayes,

Ai Bridges Ltd email to IAA - 15 February 2022

From: Kevin Hayes
Sent: 15 February 2022 11:33
To: 'cathal.maccriostal@IAA.ie' <cathal.maccriostal@IAA.ie>
Subject: RE: Coillte Windfarm Proposal East Clare - Violet Hill Wind Farm

Cathal,

I am just following up from our call earlier this morning.

As discussed we hope to have the Report of the ATC SMAC mitigation options with you by later today for your own internal review

Would you be able to provide an update from your Technical Services in relation to the Radar Surveillance Reports as I overlooked raising on this mornings meeting.

I look forward to hearing from you

Best Regards,
Kevin Hayes,

Ai Bridges Ltd email to IAA - 15 February 2022

From: Kevin Hayes <khayes@aibridges.ie>
Sent: 15 February 2022 19:53
To: 'Cathal.MacCriostail@IAA.ie' <Cathal.MacCriostail@IAA.ie>
Subject: Re: Coillte Windfarm Proposal East Clare - Violet Hill Wind Farm

Cathal,

As per our call earlier today please find attached the Concept Design ATC SMAC Report prepared by Cyrrus for your review

Best Regards,
Kevin Hayes.

PDF CL-CYB1434-Q-001 1.0 ATCSMAC Options.pdf
.pdf File

IAA email to Ai Bridges Ltd - 22 February 2022

From: MACCRIOSTAIL Cathal <Cathal.MacCriostail@IAA.ie>
Sent: 22 February 2022 16:59
To: Kevin Hayes <khayes@aibridges.ie>
Subject: 220222 Coillte Windfarm Proposal East Clare - Violet Hill Wind Farm ANSP Update

Dear Kevin and all,

Later than promised with my apologies, I'm trying to collate all reports and confirm the IAA ANSP position in relation to Coillte Violet Hill Wind Farm development as detailed in the attached reports, each of which I'll address from an ANSP perspective below.

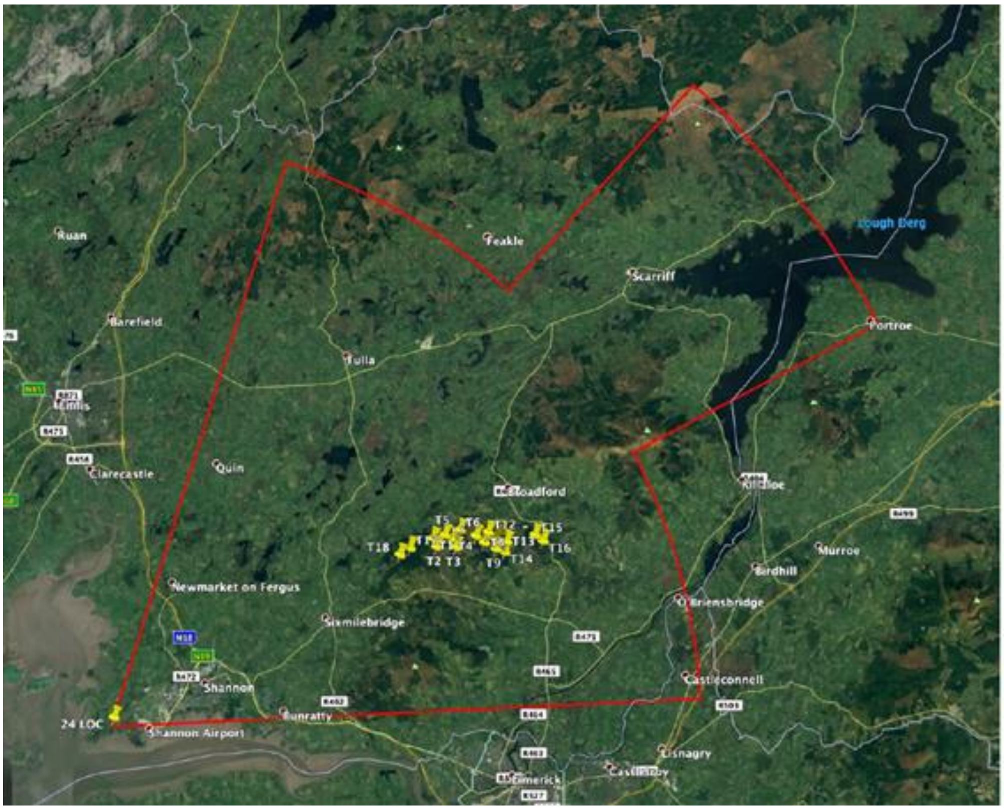
At the outset, I acknowledge that we as an ANSP do need to make every effort to support such development as being part of the national power supply strategy. I equally appreciate your proactive engagement with us in recent months and for the involvement of Cyrrus with the various assessments received. I also acknowledge that Coillte plan to submit a planning application by May 2022 and the process we are involved in is informing the planning process itself.

To address each assessment/report:

1. **Radar Assessment: (Attachment 1)** Charlie O'Loughlin and his team copied for the ANSP Surveillance Domain
   Comments:
   - Methodology of this assessment has been accepted in principle
   - "4.9.4. No mitigation measures are considered necessary for either Shannon MSSR or Woodcock Hill MSSR." This is to be assessed and confirmed by the ANSP Surveillance Domain
   - "5. Shannon PSR Mitigation": Content noted and will need to be considered by the ANSP Surveillance Domain for workload and costs associated with this approach

   Overall IAA ANSP Position for this Item: While the content of the Radar Assessment is appreciated, the likely costs, operational impacts and timeline deliverables of the proposed wind farm will be need to be further assessed by the ANSP and also in the context of Regulatory requirements.

2. NAVAIDs Potential Issues (Attachment 2: FCSL Report) Fergal Arthurs and his team copied for NAVAIDs Domain
   Comments:
   - Once again the level of detail and effort here is appreciated
   - Correctly the main area of concern is for ILS coverage areas as depicted in the report:



- The main conclusion noted from this report is: "The flight inspection Glide Path left slice 8° profile (level run) will have to be raised to an altitude of 2,600ft in IMC to provide the flight inspection aircraft adequate coverage over the proposed wind turbines. This will result in increased flight inspection costs for the extended Glide Path level runs. If there is insufficient Glide Path RF signal for the extended level run at 2,600 ft then it may not be possible to conduct this flight inspection in conditions of bad visibility. This may result in additional cost if the flight inspection aircraft is delayed while waiting for VFR conditions.

Overall IAA ANSP Position for this Item: Conclusions of the report are noted potential delays to flight calibration activity resulting from the Wind Farm development as constructed, are not acceptable. This is because the ANSP is regulatory required to complete NAVAIDs flight calibration twice yearly. If schedule is affected or missed, this could result in (temporary) withdrawal of ILS systems, in turn adversely affecting airport arrival operations to RWY 24.

3. **IFP Safeguarding Assessment Report (Attachment 3 Cyrrus Report):** My domain

3. Mitigation

Assessed Procedure	IFP Mitigation	Turbine Mitigation
TOMTO 3A SID RWY06	T18, T01, T02, T05, T17, T04 penetrate the turn area for TOMTO 3A which results in a higher PDG of 3.5-4.0%.	The max turbine height permissible: T18: 124m, T01: 122m, T02: 136m, T05: 166m, T17: 171m, T04: 171m.
ABAGU 3A SID RWY06	T18, T01, T02, T05, T17, T04 penetrate the turn area for ABAGU3A which results in a higher PDG of 3.5-4.0%.	The max turbine height permissible: T18: 124m, T01: 122m, T02: 136m, T05: 166m, T17: 171m, T04: 171m.
VOR RWY24	(Final Approach) T01, T02, T05, T06, T18, T04, T17 penetrate the secondary area of the Final approach and raises the currently published MOCA by 400ft from 1270ft to 1670t. It also affects the gradient from the SDF to MAPt. A re-design is recommended to; • determine if the current step-down fix can be repositioned to prevent an increase to the gradient, or • if an additional step-down fix is to be added to the design.	The max turbine height permissible: T:01 64m, T02: 99m, T05: 99m, T06: 106m, T18: 107m, T04: 113m, T17: 136m.
ATC Surveillance Minimum Chart	T01, T02, T07, T04, T05, T06, T08, T18, T12, T03, T17, T09 penetrate Sector 1 and raises the published minima by 300ft from 2300ft to 2600ft	The max turbine height permissible: T:01 116m, T02: 132m, T07: 135m, T04: 143m, T05: 144m, T06: 144m, T08: 152m, T18: 167m, T12: 168m, T03: 124m, T17: n/a, T09: n/a

Table 42: Mitigation

Comments:

- Increasing of PDG from 3.5% to 4.0% for affected SIDs: Agreed in principle and can be incorporated in updated IFP designs planned for late 2022. This is also consistent with non-SID departure instructions increased PDG
- VOR RWY 24 IAP: Impact noted and mitigations understood. These are not however consistent with our requirements for SDF etc. If the development goes ahead, *I would recommend withdrawal of the VOR IAP* on the basis that this would be in line with the State PBN plan and that RNP IAPs are planned for Shannon during 2022
- Surveillance Minimum Altitude Chart (see also attachment 4) - Below is a snip from the IFP assessment that shows the SMAC Sector 1 with the proposed turbines included

- The operational aspects in the application of SMAC minima is the key sticking point for me in this regard as reflected in our recent meeting with amendments to the SMAC proposed by Cyrrus. I have given this very close consideration. There are 2 major ATC operational concerns for me:
    - Vectoring of traffic for short finals: amended SMAC minima has the potential to increase ATCO workload in vectoring traffic with less flexible minima on shorter finals for RWY 24
    - For aircraft operations the potential false capture of the GP with more constrained altitudes is of concern particularly as RWY 24 is the CAT II ILS approach for Shannon Airport
    - Lastly, there is a likelihood that the 3° Glide Slope might need to be increased to cater for these new obstacles, which is not acceptable operationally
    (ATC operations team copied)

Summary:

Once again, I do appreciate the level of effort gone to in trying to square the impacts of the proposed wind farm. There are some recommendations from the IFP assessment, in lowering some of the turbines, that could result in no impact to current operations which I'd ask should be considered.

Ultimately the siting of turbines in the western portion of the development are affecting the primary Instrument Approach to Shannon Airport (copied) in both the procedure and in ATC operational delivery.

I cannot ask you to stop the planning application going ahead but there may be significant issues for the ANSP in both cost and operational mitigations, which are not desirable in my view.

I will add as we discussed that we are in the process of developing new IFP designs for Shannon, for planned submission later this year, so there is an opportunity to incorporate design elements that could support the project overall with some restrictions on elevations.

I'll ask those copied from the ANSP and Shannon Airport to consider that attachments and my comments and add to these as they see fit.

I'll be also happy to arrange further meetings if required.

Best regards,

Cathal
Cathal Mac Criostail

FCSL 0138.pdf
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CL-CYB1434-Q-001 1.0 ATCSMAC Options.pdf
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Ai Bridges Ltd email to IAA - 04 April 2022

From: Kevin Hayes
Sent: 04 April 2022 14:25
To: 'MACCRIOSTAIL Cathal' <Cathal.MacCriostail@IAA.ie>
Subject: RE: 220222 Coillte Windfarm Proposal East Clare - Violet Hill Wind Farm ANSP Update

Hello Cathal,

I am following up in relation to your email below.

Can you please give an indication of

1. The likely costs for the further assessment required by the ANSP in relation to Radar Assessment in point 1 below

In relation to the NAVAIDS issues, the ILS Flight Inspection Impact Assessment Report highlights the remediation proposals by FCSL. We have requested associated costs from FCSL along with a request for their availability to discuss with yourself and the ANSP.

1. Additional flight trials should be conducted at the next routine ILS flight inspection to assess the RF signal levels for an extended level Glide Path run at an altitude of 2,600 ft.
2. It is recommended that computer simulations be performed to assess the levels of potential interference to the Runway 24 ILS Localiser guidance signal.

In relation to the IFP Assessment can you give an indication of the following, also we have discussed your response below with Cyrrus and they are available to discuss with you and the ANSP Team

1. Operational mitigations and associated costs .

If you require any further information please do not hesitate to contact me.

Would it be possible to schedule a call with yourself and the relevant Divisional stakeholders with the IAA and ANSP in the coming weeks ?

Best Regards,
Kevin Hayes,

Ai Bridges Ltd email to IAA - 12 April 2022

From: Kevin Hayes <khayes@aibridges.ie>
Sent: Tuesday 12 April 2022 10:47
To: MACCRIOSTAIL Cathal <Cathal.MacCriostail@IAA.ie>
Subject: RE: 220222 Coillte Windfarm Proposal East Clare - Violet Hill Wind Farm ANSP Update

Hello Cathal,

I am just following up from our call earlier in relation to the email correspondence below.
As discussed we would be grateful if you could reach out to the various stakeholders in relation to their response on the points below and any feedback they have regards same.

The wind farm developer is very keen to get an overview of the areas that they can co-operate with the IAA and various stakeholders in preparation for submission of their planning application.

Also just to conform that we have been in contact with FCSL and they have confirmed their availability to run an additional flight as they have outlined in their report and as highlighted in the email below

Would you be able to confirm availability in the coming 1 – 2 weeks to schedule a Team call with the relevant stakeholders to discuss the points below and we can follow up with both Cyrrus and FCSL to confirm their availability.
We look forward to hearing from you.

Best Regards,
Kevin Hayes,

IAA email to Ai Bridges Ltd - 27 April 2022

From: MACCRIOSTAIL Cathal <Cathal.MacCriostail@IAA.ie>
Sent: 27 April 2022 15:14
Subject: 220427 Coillte Windfarm Proposal East Clare - Violet Hill Wind Farm ANSP Update

Dear Kevin,

I can only once again apologise for the tardy response and again acknowledge the proactive engagement from you. I have a clear understanding of your position in guiding Coillte that you require an assessment on magnitude of costs.

I would be of the strong opinion that it doesn't make sense to add to your burden of costs if potentially the project won't get planning.

In the thread below, I made reference to like assessments and a burden of cost on the IAA ANSP, across NAVAIDs, Surveillance and ATC Procedures/ Instrument Flight Procedures.

Aside for the costs in production of further assessments as referenced, system upgrades for filtering, flight procedures changes, ATC changes to support the mitigate for the new obstacles, as well as continuing additional costs associated with more flight check activity on an bi-annual basis, has the potential to cost the ANSP in the region of €200,000.00+, should planning be granted as proposed.

Attached once again are the various reports as commented on by me below.

While I am very aware of the strategic importance of this project in relation to the National Gird, being even more pertinent in these times, I'm afraid to say, that the IAA cannot offer its full support, unless the project could consider lowering the elevations of the turbines at this time. There are simply too many open questions as outlined below.

Could I genuinely compliment you on your work and the understanding of the multiple working parts of the IAA ANSP that you have demonstrated in our interactions?

Noting that you had planned a May 2022 date for having a clear roadmap towards the planning application process, I can only suggest you proceed with the application and we will accordingly engage at that point, via Clare Co.Co.

I regret that we can go no further for now and this I'm afraid reflects the heavy workload for all copied for the IAA ANSP in work at Dublin Airport for the new runway and ongoing woks at Shannon Airport.

Regards,
Cathal

Cathal Mac Criostail
Údarás Eitlíochta na hÉireann / Irish Aviation Authority
The Times Building, 11-12 D'Olier Street, Dublin 2, D02 T449, Ireland
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+353 (0)86 0527130
www.iaa.ie

CL-5693-RPT-002 V1.0 Violet Hill Wind Farm Radar Assessment.pdf
.pdf File

CL-5682-RPT-003 V1.0 Violet Hill Windfarm IFP Safeguarding (signed).pdf
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FCSL 0138.pdf
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CL-CYB1434-Q-001 1.0 ATCSMAC Options.pdf
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Appendix 5

IFP Safeguarding Assessment – Violet Hill Wind Farm

IFP Safeguarding Assessment

Violet Hill Wind Farm

Shannon Airport

09 September 2021

CL-5682-RPT-003 V1.0

www.cyrrus.co.uk

info@cyrrus.co.uk

Executive Summary

Ai Bridges Limited (hereafter referred to as the Client) has requested an Instrument Flight Procedure (IFP) Safeguarding Assessment for a proposed windfarm development (Violet Hill) near Shannon Airport.

The proposed development is approximately 8NM north-east of Shannon Airport, 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 does impact to the current published IFPs for Shannon Airport.

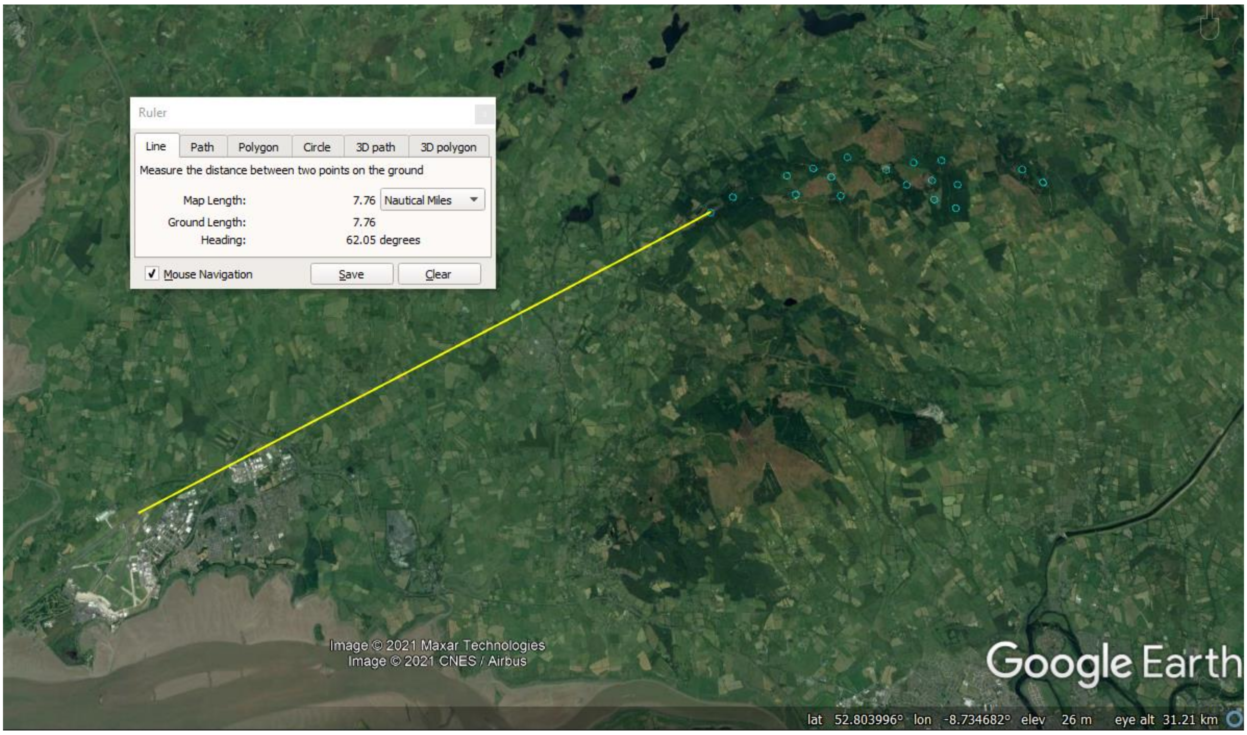

Figure 1: Position and Location of Crane relative to the RWY 24 Centreline

[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.

Design and Verification

This Safeguarding Assessment has been undertaken under the Cyrrus Procedure Design Manual (PDM) as approved by the Irish Aviation Authority (IAA).

The assessment has been undertaken by a newly employed IFP Designer who is undergoing induction training. The training is fully supervised by an Approved Procedure Designer with the final assessment and report verified by an independent IFP Designer.

Name	Designation	Signature	Date
Ferlicia Matloha	IFP Designer (IAA Induction)	Matloha	24 August 2021
Mitchell Nunes	IFP Designer (Instructor)	[illegible]	24 August 2021
Shaun Gouvea	IFP Designer (Verifying Designer)	S Gouvea	09 September 2021
John van Hoogstraten	Accountable Manager	John van Hoogstraten	09 September 2021

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)

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1. Introduction

1.1. General

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 Shannon contained in the Ireland AIP, reference EINN AD Section 2.

The following data was used for the assessment:

- Irish AIP – AIRAC 07/2021 effective 15 July 2021.

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 "FW_AI Bridges Ltd – Violet Hill Wind Farm – Request for Quaotation.msg"

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

The max tip height of 185m Above Ground Level (AGL) and rotor diameter of 155m was used.

Turbine No	Easting (ITM)	Northing (ITM)	Lat (X)	Long (Y)	Ground Level (m AMSL)	Max Tip Elevation (m AMSL)
1	553159	669794	520624.4	5847523.29	276	461
2	553332	669350	520803.51	5847081.85	269	454
3	554359	669318	521830.61	5847064.13	227	412
4	554176	669759	521641.54	5847502.43	255	440
5	553781	669968	521243.77	5847705.88	255	440
6	554589	670222	522047.97	5847971.02	255	440
7	555442	669913	522904.98	5847673.97	265	450
8	555881	669555	523348.8	5847322.19	247	432

Turbine No	Easting (ITM)	Northing (ITM)	Lat (X)	Long (Y)	Ground Level (m AMSL)	Max Tip Elevation (m AMSL)
9	556491	669215	523963.32	5846990.78	188	373
10	556477	669664	523943.09	5847439.44	225	410
11	556762	670152	524221.21	5847931.23	181	366
12	556098	670086	523558.35	5847856.03	233	418
13	557076	669576	524543.11	5847359.79	153	338
14	556971	669020	524445.87	5846802.51	157	342
15	558585	669916	526046.89	5847720.64	184	369
16	559020	669597	526486.18	5847407.79	190	375
17	551911	669321	519383.39	5847033.11	203	388
18	551370	668955	518847.66	5846659.72	234	419

Table 1: Extracted and Converted Wind Farm data

1.2. Baseline Criteria

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 and Assumptions

The ground elevations provided was compared to the Ordnance Survey Ireland 10m DTM and differences were observed. It is noted in Table 4 that there are elevation difference ranging from approximately 1 to 9m and the higher reported ground elevation (rounded up where applicable) was used for the assessment.

Turbine ID	GND Elevation provided (m)	Ordnance Survey 10m DTM	Difference (m)	GND used (m)
T01	276	284.766	8.766	**285**
T02	269	263.049	-5.951	**269**
T03	227	226.662	-0.338	**227**
T04	255	258.002	3.002	**258**
T05	255	256.866	1.866	**257**
T06	255	257.081	2.081	**257**
T07	265	266.393	1.393	**266**
T08	247	248.838	1.838	**249**
T09	188	189.128	1.128	**189**
T10	225	222.737	-2.263	**225**
T11	181	179.363	-1.637	**181**
T12	233	228.996	-4.004	**233**
T13	153	148.249	-4.751	**153**
T14	157	155.541	-1.459	**157**
T15	184	178.715	-5.285	**184**
T16	190	188.673	-1.327	**190**
T17	203	201.202	-1.798	**203**
T18	234	232.362	-1.638	**234**

Table 4: Ground Elevation Data Check

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

<table>
<tr><th>Assessed Procedure</th><th>RWY</th><th>Impact</th><th>Comments</th></tr>
<tr><td>MSA</td><td>Both</td><td>No</td><td>Nil</td></tr>
<tr><td>ILS or LOC</td><td rowspan="5">06</td><td>No</td><td>Nil</td></tr>
<tr><td>VOR</td><td>No</td><td>Nil</td></tr>
<tr><td>RNAV STARs</td><td>No</td><td>Outside Protection Areas</td></tr>
<tr><td>RNAV SIDs</td><td>Yes</td><td>T18, T01, T02, T05, T17, T04 penetrates the turn area for TOMTO 3A which results in a higher PDG than the standard obstacle clearance PDG of 3.3%.

T18, T01, T02, T05, T17, T04 penetrate the turn area for ABAGU 3A which results in a higher PDG than the standard obstacle clearance PDG of 3.3%.</td></tr>
<tr><td>ILS CAT I & II or LOC</td><td rowspan="4">24</td><td>No</td><td>Nil</td></tr>
<tr><td>VOR</td><td>Yes</td><td>T01, T02, T05, T06, T18, T04, T17 penetrate the secondary area of the Final approach and raises the currently published MOCA by 400ft from 1270ft to 1670t. It also affects the gradient from the SDF to MAPt.</td></tr>
<tr><td>RNAV STARs</td><td>No</td><td>Outside Protection Areas</td></tr>
<tr><td>RNAV SIDs</td><td>No</td><td>Outside Protection Areas</td></tr>
<tr><td>ATCSMAC</td><td>Both</td><td>Yes</td><td>T01, T02, T07, T04, T05, T06, T08, T18, T12, T03, T17, T09 penetrate Sector 1 and raises the published minima by 300ft from 2300ft to 2600ft</td></tr>
</table>

[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.

Table 5: 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
Sector 1	
From	056° M
To	146° M
Calculated Minimum	2700 ft
Number of Checked Obstacles	18
Sector 2	
From	146° M
To	056° M
Calculated Minimum	2600ft
Number of Checked Obstacles	18

Table 6: MSA - VOR/DME SHA

Name	Latitude	Longitude	Alt. (m)	MOC applied (m)	OCA (ft)
T01	52°46'37.70"N	008°41'39.30"W	470.0	300.0	2526.3
T02	52°46'23.39"N	008°41'29.85"W	454.0	300.0	2473.8
T07	52°46'42.24"N	008°39'37.56"W	451.0	300.0	2464.0
T04	52°46'36.88"N	008°40'45.03"W	443.0	300.0	2437.7
T05	52°46'43.52"N	008°41'06.21"W	442.0	300.0	2434.4
T06	52°46'51.99"N	008°40'23.22"W	442.0	300.0	2434.4
T08	52°46'30.79"N	008°39'13.96"W	434.0	300.0	2408.2
T18	52°46'09.98"N	008°43'14.30"W	419.0	300.0	2359.0
T12	52°46'48.03"N	008°39'02.64"W	418.0	300.0	2355.7
T03	52°46'22.67"N	008°40'35.04"W	412.0	300.0	2336.0

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

Name	Latitude	Longitude	Alt. (m)	MOC applied (m)	OCA (ft)
T01	52°46'37.70"N	008°41'39.30"W	470.0	300.0	2526.3
T02	52°46'23.39"N	008°41'29.85"W	454.0	300.0	2473.8
T07	52°46'42.24"N	008°39'37.56"W	451.0	300.0	2464.0
T04	52°46'36.88"N	008°40'45.03"W	443.0	300.0	2437.7
T05	52°46'43.52"N	008°41'06.21"W	442.0	300.0	2434.4
T06	52°46'51.99"N	008°40'23.22"W	442.0	300.0	2434.4
T08	52°46'30.79"N	008°39'13.96"W	434.0	300.0	2408.2
T18	52°46'09.98"N	008°43'14.30"W	419.0	300.0	2359.0

T12	52°46'48.03"N	008°39'02.64"W	418.0	300.0	2355.7
T03	52°46'22.67"N	008°40'35.04"W	412.0	300.0	2336.0

Table 8: MSA - VOR/DME SHA - Checked Obstacles - 146° M - 056° M

As indicated in Table 7 and Table 8 there is no impact to the MSA.

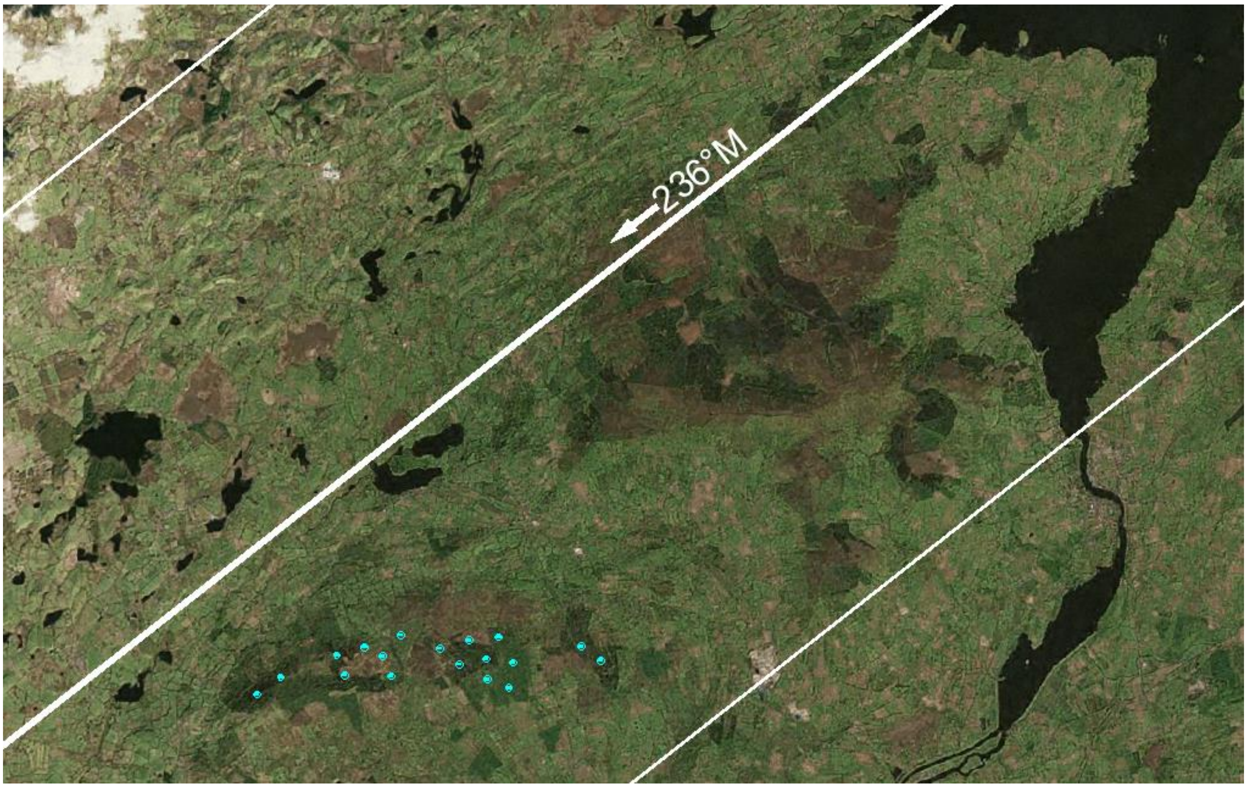

Figure 2: MSA VOR/DME SHA

2.2. DERAG HOLD (Conv)

The turbines fall into the buffer areas (1-2NM and 2-3NM) of 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	232.25 °
Turns	Right
Obstacles	
Number of Checked Obstacles	18

Table 9: DERAG HOLD (Conv)

Name	Latitude	Longitude	Alt. (m)	Area	MOC applied (m)	MOCA (ft)
T07	52°46'42.24"N	008°39'37.56"W	451.0	Buffer (1 nm - 2 nm)	150.0	1971.8
T05	52°46'43.52"N	008°41'06.21"W	442.0	Buffer (1 nm - 2 nm)	150.0	1942.3
T06	52°46'51.99"N	008°40'23.22"W	442.0	Buffer (1 nm - 2 nm)	150.0	1942.3
T01	52°46'37.70"N	008°41'39.30"W	470.0	Buffer (2 nm - 3 nm)	120.0	1935.7
T02	52°46'23.39"N	008°41'29.85"W	454.0	Buffer (2 nm - 3 nm)	120.0	1883.3
T12	52°46'48.03"N	008°39'02.64"W	418.0	Buffer (1 nm - 2 nm)	150.0	1863.6
T04	52°46'36.88"N	008°40'45.03"W	443.0	Buffer (2 nm - 3 nm)	120.0	1847.2
T10	52°46'34.49"N	008°38'42.22"W	410.0	Buffer (1 nm - 2 nm)	150.0	1837.3
T08	52°46'30.79"N	008°39'13.96"W	434.0	Buffer (2 nm - 3 nm)	120.0	1817.6
T18	52°46'09.98"N	008°43'14.30"W	419.0	Buffer (2 nm - 3 nm)	120.0	1768.4
T03	52°46'22.67"N	008°40'35.04"W	412.0	Buffer (2 nm - 3 nm)	120.0	1745.5
T16	52°46'33.04"N	008°36'26.51"W	375.0	Buffer (1 nm - 2 nm)	150.0	1722.5
T15	52°46'43.24"N	008°36'49.86"W	369.0	Buffer (1 nm - 2 nm)	150.0	1702.8
T11	52°46'50.36"N	008°38'27.24"W	366.0	Buffer (1 nm - 2 nm)	150.0	1693.0
T17	52°46'22.00"N	008°42'45.64"W	388.0	Buffer (2 nm - 3 nm)	120.0	1666.7
T09	52°46'19.97"N	008°38'41.25"W	374.0	Buffer (2 nm - 3 nm)	120.0	1620.8
T13	52°46'31.82"N	008°38'10.22"W	338.0	Buffer (1 nm - 2 nm)	150.0	1601.1
T14	52°46'13.80"N	008°38'15.55"W	342.0	Buffer (2 nm - 3 nm)	120.0	1515.8

Table 10: DERAG HOLD Conv – Checked Obstacles

As indicated in Table 10, no turbines impact the Hold.

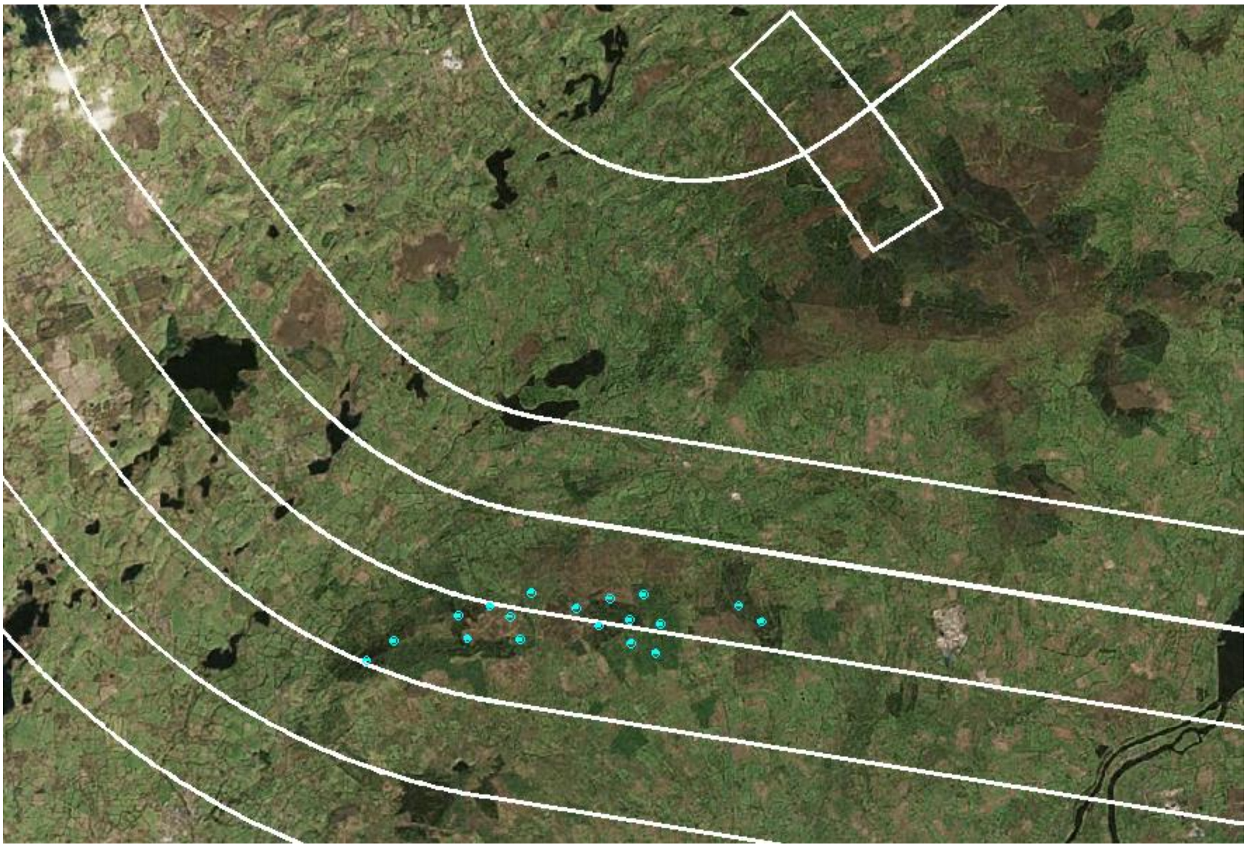

Figure 3: DERAG Conventional HOLD - Wind farm Location

2.3. DERAG HOLD (RNAV)

The turbines fall withing the primary area of the HOLD.

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	Time
IAS	220 kts
TAS	280.6 kts
Altitude	14000 ft
ISA	15 °C
Time	1 min
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	232.18 °
Turns	Right
Obstacles	
Number of Checked Obstacles	18

Table 11: DERAG HOLD (RNAV)

Name	Latitude	Longitude	Alt. (m)	Surface	MOC (m)	MOCA (ft)	Ctrl?
T01	52°46'37.70"N	008°41'39.30"W	470.0	Primary Area	300.0	2526.3	No
T02	52°46'23.39"N	008°41'29.85"W	454.0	Primary Area	300.0	2473.8	No
T07	52°46'42.24"N	008°39'37.56"W	451.0	Primary Area	300.0	2464.0	No
T04	52°46'36.88"N	008°40'45.03"W	443.0	Primary Area	300.0	2437.7	No
T05	52°46'43.52"N	008°41'06.21"W	442.0	Primary Area	300.0	2434.4	No
T06	52°46'51.99"N	008°40'23.22"W	442.0	Primary Area	300.0	2434.4	No
T08	52°46'30.79"N	008°39'13.96"W	434.0	Primary Area	300.0	2408.2	No
T18	52°46'09.98"N	008°43'14.30"W	419.0	Primary Area	300.0	2359.0	No
T12	52°46'48.03"N	008°39'02.64"W	418.0	Primary Area	300.0	2355.7	No
T03	52°46'22.67"N	008°40'35.04"W	412.0	Primary Area	300.0	2336.0	No
T10	52°46'34.49"N	008°38'42.22"W	410.0	Primary Area	300.0	2329.4	No
T17	52°46'22.00"N	008°42'45.64"W	388.0	Primary Area	300.0	2257.3	No
T16	52°46'33.04"N	008°36'26.51"W	375.0	Primary Area	300.0	2214.6	No
T09	52°46'19.97"N	008°38'41.25"W	374.0	Primary Area	300.0	2211.3	No
T15	52°46'43.24"N	008°36'49.86"W	369.0	Primary Area	300.0	2194.9	No
T11	52°46'50.36"N	008°38'27.24"W	366.0	Primary Area	300.0	2185.1	No
T14	52°46'13.80"N	008°38'15.55"W	342.0	Primary Area	300.0	2106.3	No
T13	52°46'31.82"N	008°38'10.22"W	338.0	Primary Area	300.0	2093.2	No

Table 12: DERAG HOLD (RNAV) - Checked Obstacles

As indicated in Table 12, no turbines impact the HOLD.

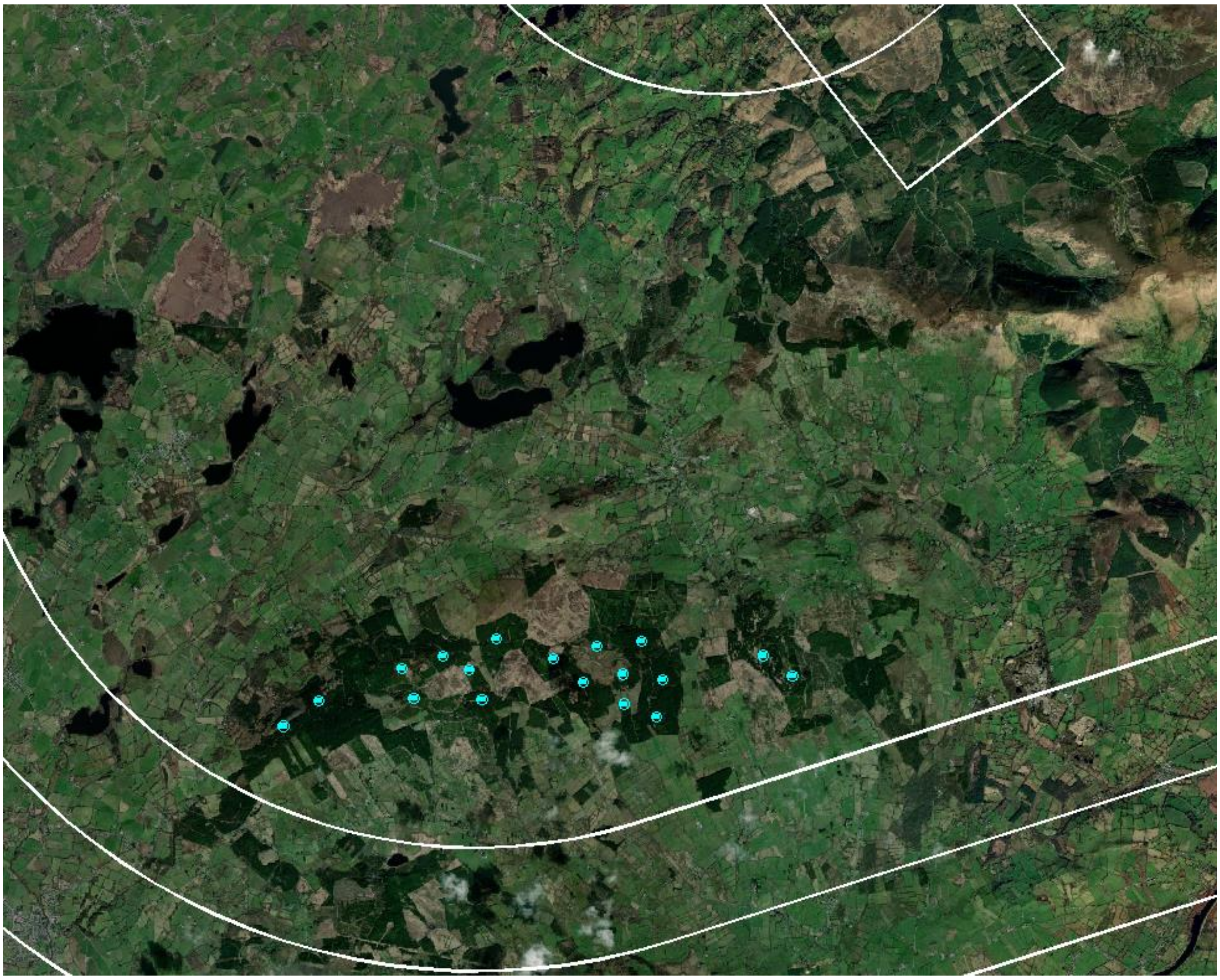

Figure 4: DERAG HOLD (RNAV) - Wind farm Location

2.4. IAP – ILS Runway 06

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

Parameters	
SOC Position	
ID	SOC
Latitude	52°41'51.51"N
Longitude	008°56'02.51"W
Altitude	18.67 m (61.24 ft)
Track	052.17 °
MOC [int./fin.]	30 m / 50 m
MACG	2.5 %
Obstacles	
Number of Checked Obstacles	14

Table 13: ILS RWY 06 - CAT A-D - Missed Approach

Name	Latitude	Longitude	Alt. (m)	Area	Do (m)	MOC (m)	Ac. alt. (ft)	Alt. req. (ft)	MACG (%)	Ctrl?
T18	52°46'09.98"N	008°43'14.30"W	419.0	Primary	18140.4	0.0	1549.1	1542.0	2.5	No
T01	52°46'37.70"N	008°41'39.30"W	470.0	Primary	16207.4	0.0	1390.6	1374.7	2.5	No
T02	52°46'23.39"N	008°41'29.85"W	454.0	Primary	18011.1	0.0	1538.5	1489.5	2.5	No
T05	52°46'43.52"N	008°41'06.21"W	442.0	Primary	18741.6	0.0	1598.4	1450.1	2.3	No
T04	52°46'36.88"N	008°40'45.03"W	443.0	Primary	18931.0	0.0	1614.0	1453.4	2.3	No
T17	52°46'22.00"N	008°42'45.64"W	388.0	Primary	16859.6	0.0	1444.1	1273.0	2.2	No
T06	52°46'51.99"N	008°40'23.22"W	442.0	Primary	19539.4	0.0	1663.9	1450.1	2.2	No
T07	52°46'42.24"N	008°39'37.56"W	451.0	Primary	20034.1	0.0	1704.5	1479.7	2.2	No
T03	52°46'22.67"N	008°40'35.04"W	412.0	Primary	18811.5	0.0	1604.2	1351.7	2.1	No
T08	52°46'30.79"N	008°39'13.96"W	434.0	Primary	20168.8	0.0	1715.5	1423.9	2.1	No
T12	52°46'48.03"N	008°39'02.64"W	418.0	Primary	20661.8	0.0	1755.9	1371.4	2.0	No
T10	52°46'34.49"N	008°38'42.22"W	410.0	Primary	20710.1	0.0	1759.9	1345.1	1.9	No

Table 14: ILS RWY 06 - CAT A-D - Missed Approach Intermediate Phase - Checked Obstacles

Name	Latitude	Longitude	Alt. (m)	Area	Do (m)	MOC (m)	Ac. alt. (ft)	Alt. req. (ft)	MACG (%)	Ctrl?
T11	52°46'50.36"N	008°38'27.24"W	366.0	Primary	188.6	50.0	1802.7	1364.8	1.9	No
T13	52°46'31.82"N	008°38'10.22"W	338.0	Primary	92.4	50.0	1794.8	1273.0	1.8	No

Table 15: ILS RWY 06 - CAT A-D Missed Approach Final Phase - Checked Obstacles

As indicated in Table 14, the turbines do not impact to the procedure.

Figure 5: ILS RWY 06 – Intermediate Missed Approach – Windfarm Location

2.5. IAP – LOC Runway 06

The Turbines fall into the Intermediate and Final Missed Approach segment 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 [int./fin.]	30 m / 50 m
MACG	2.5 %
Obstacles	
Number of Checked Obstacles	12

Table 16: LOC RWY 06 - Missed Approach

Name	Latitude	Longitude	Alt. (m)	Area	Dz (m)	Do (m)	MOC req. (m)	Ac. alt. (ft)	Alt. req. (ft)	MACG (%)	Ctrl?
T01	52°46'37.70"N	008°41'39.30"W	470.0	Primary	N/A	18452.7	30.0	1863.5	1640.4	2.2	No
T18	52°46'09.98"N	008°43'14.30"W	419.0	Primary	N/A	16519.7	30.0	1705.0	1473.1	2.1	No
T02	52°46'23.39"N	008°41'29.85"W	454.0	Primary	N/A	18323.4	30.0	1852.9	1587.9	2.1	No
T05	52°46'43.52"N	008°41'06.21"W	442.0	Primary	N/A	19053.9	30.0	1912.8	1548.6	2.0	No
T04	52°46'36.88"N	008°40'45.03"W	443.0	Primary	N/A	19243.3	30.0	1928.4	1551.8	2.0	No
T06	52°46'51.99"N	008°40'23.22"W	442.0	Primary	N/A	19851.7	30.0	1978.3	1548.6	1.9	No
T07	52°46'42.24"N	008°39'37.56"W	451.0	Primary	N/A	20346.4	30.0	2018.8	1578.1	1.9	No
T17	52°46'22.00"N	008°42'45.64"W	388.0	Primary	N/A	17171.9	30.0	1758.5	1371.4	1.9	No
T03	52°46'22.67"N	008°40'35.04"W	412.0	Primary	N/A	19123.8	30.0	1918.6	1450.1	1.8	No
T08	52°46'30.79"N	008°39'13.96"W	434.0	Primary	N/A	20481.2	30.0	2029.9	1522.3	1.8	No
T12	52°46'48.03"N	008°39'02.64"W	418.0	Primary	N/A	20974.1	30.0	2070.3	1469.8	1.7	No
T10	52°46'34.49"N	008°38'42.22"W	410.0	Primary	N/A	21022.5	30.0	2074.3	1443.6	1.6	No

Table 17: LOC RWY 06 - Missed Approach – Intermediate Phase - Checked Obstacles

As indicated in Table 17, the LOC procedure is not impacted.

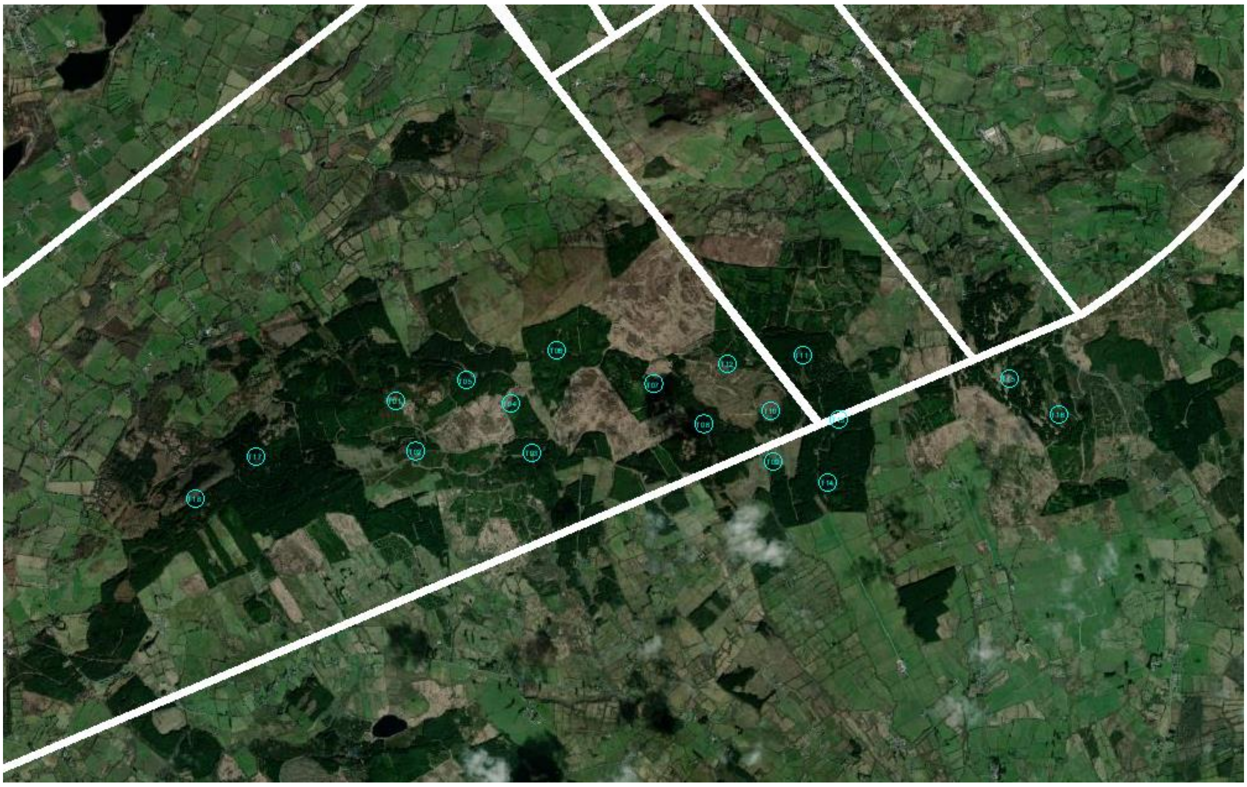

Figure 6: LOC RWY 06 - Missed Approach – Windfarm Location

2.6. IAP – VOR Runway 06

The turbines fall in the Intermediate Missed Approach segment of the procedure.

Parameters	
SOC Position	
ID	SOC
Latitude	52°41'47.65"N
Longitude	008°56'13.21"W
Altitude	360 m (1181.1 ft)
Track	052.09 °
MOC [int./fin.]	30 m / 50 m
MACG	2.5 %
Obstacles	
Number of Checked Obstacles	7

Table 18: VOR RWY 06 - CAT A-D - Missed Approach

Name	Latitude	Longitude	Alt. (m)	Area	Do (m)	MOC req. (m)	Ac. alt. (ft)	Alt. req. (ft)	MACG (%)	Ctrl
T01	52°46'37.70"N	008°41'39.30"W	470.0	Secondary	18368.0	14.3	2687.7	1588.8	0.7	No
T02	52°46'23.39"N	008°41'29.85"W	454.0	Secondary	18238.1	6.7	2677.0	1511.6	0.6	No
T05	52°46'43.52"N	008°41'06.21"W	442.0	Secondary	18968.9	11.6	2736.9	1488.1	0.5	No
T18	52°46'09.98"N	008°43'14.30"W	419.0	Secondary	16435.6	17.8	2529.2	1433.2	0.5	No
T04	52°46'36.88"N	008°40'45.03"W	443.0	Secondary	19157.7	5.6	2752.4	1471.9	0.5	No
T06	52°46'51.99"N	008°40'23.22"W	442.0	Secondary	19766.3	8.6	2802.4	1478.3	0.5	No
T17	52°46'22.00"N	008°42'45.64"W	388.0	Secondary	17087.7	18.3	2582.7	1333.0	0.3	No

Table 19: VOR RWY 06 - CAT A-D – Intermediate Missed Approach Phase - Checked Obstacles

As indicated in Table 19, there is no impact to the procedure.

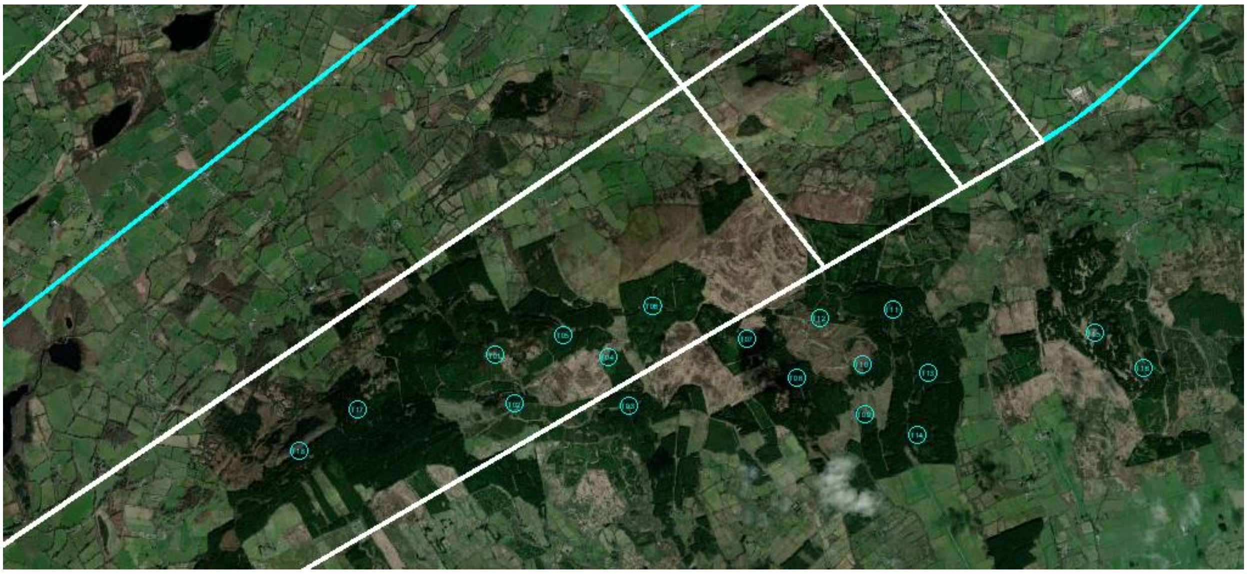

Figure 7: VOR RWY 06 – Intermediate Missed Approach – Windfarm Location

2.7. RNAV SID (DIGAN 3A) RWY 06

DER	
Latitude	52°42'37.24"N
Longitude	008°54'25.30"W
Altitude	4.57 m (14.99 ft)
Parameters	
Track	052.2 °
MOC	Greater of 0.8 % or 75 m
PDG	3.3 %
Turning Altitude	600 ft
Number of Checked Obstacles	18

Table 20: SID - RWY 06 - DIGAN3A

Name	Latitude	Longitude	Alt. (m)	Area	Do (m)	MOC req. (m)	Ac. alt. (ft)	Alt. req. (ft)	PDG (%)	Ctrl?	Close-in
T01	52°46'37.70"N	008°41'39.30"W	470.0	Primary	14105.2	128.1	2127.1	1962.2	3.0	No	No
T18	52°46'09.98"N	008°43'14.30"W	419.0	Primary	12132.5	112.3	1913.6	1743.1	2.9	No	No
T02	52°46'23.39"N	008°41'29.85"W	454.0	Primary	14057.8	127.7	2122.0	1908.5	2.9	No	No
T05	52°46'43.52"N	008°41'06.21"W	442.0	Primary	14736.7	133.1	2195.5	1886.9	2.7	No	No
T04	52°46'36.88"N	008°40'45.03"W	443.0	Primary	14995.4	135.2	2223.5	1897.0	2.7	No	No
T06	52°46'51.99"N	008°40'23.22"W	442.0	Primary	15571.4	139.8	2285.9	1908.8	2.6	No	No
T07	52°46'42.24"N	008°39'37.56"W	451.0	Primary	16205.7	144.9	2354.6	1955.0	2.6	No	No
T17	52°46'22.00"N	008°42'45.64"W	388.0	Primary	12782.5	117.5	1983.9	1658.5	2.6	No	No
T03	52°46'22.67"N	008°40'35.04"W	412.0	Primary	14973.9	135.0	2221.2	1794.7	2.5	No	No
T08	52°46'30.79"N	008°39'13.96"W	434.0	Primary	16463.9	147.0	2382.5	1906.0	2.5	No	No
T12	52°46'48.03"N	008°39'02.64"W	418.0	Primary	16874.5	150.2	2427.0	1864.3	2.3	No	No
T10	52°46'34.49"N	008°38'42.22"W	410.0	Primary	17055.9	151.7	2446.6	1842.8	2.3	No	No
T11	52°46'50.36"N	008°38'27.24"W	366.0	Primary	17508.4	155.3	2495.6	1710.3	2.0	No	No
T09	52°46'19.97"N	008°38'41.25"W	374.0	Secondary	16903.3	134.1	2430.1	1666.9	2.0	No	No
T13	52°46'31.82"N	008°38'10.22"W	338.0	Secondary	17579.0	143.1	2503.2	1578.4	1.7	No	No
T15	52°46'43.24"N	008°36'49.86"W	369.0	Secondary	19109.2	118.4	2668.9	1599.2	1.6	No	No
T14	52°46'13.80"N	008°38'15.55"W	342.0	Secondary	17285.3	104.1	2471.4	1463.6	1.6	No	No
T16	52°46'33.04"N	008°36'26.51"W	375.0	Secondary	19408.8	75.6	2701.3	1478.3	1.4	No	No

Table 21: SID - RWY 06 - DIGAN3A - Turn Area - Obstacle Assessment - Checked Obstacles

As indicated in Table 21, no turbines impact the procedure.

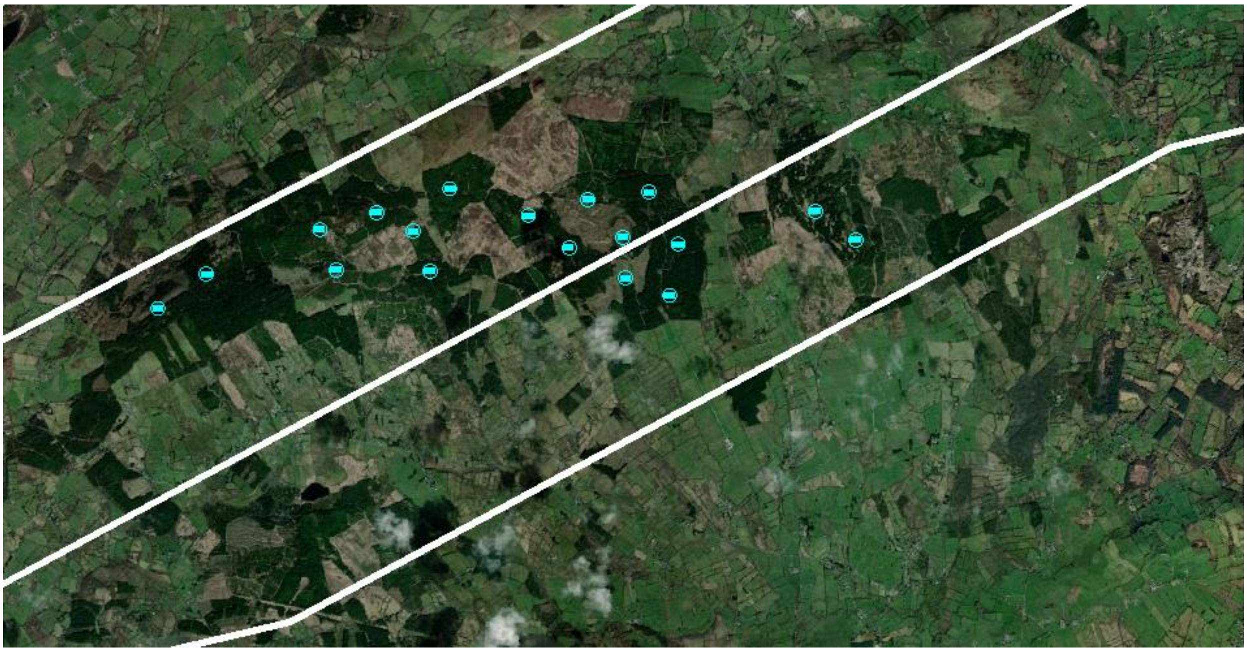

Figure 8: SID - DIGAN3A – Windfarm Location

2.8. RNAV SID (TOMTO 3A) RWY 06

DER	
Latitude	52°42'37.24"N
Longitude	008°54'25.30"W
Altitude	4.57 m (14.99 ft)
Parameters	
Track	052.2 °
MOC	Greater of 0.8 % or 75 m
PDG	3.3 %
Turning Altitude	600 ft
Number of Checked Obstacles	18

Table 22: SID - RWY 06 - TOMTO3A

Name	Latitude	Longitude	Alt. (m)	Area	Do (m)	MOC req. (m)	Ac. alt. (ft)	Alt. req. (ft)	PDG (%)	Ctrl?	Close-in
T18	52°46'09.98"N	008°43'14.30"W	419.0	Primary	8696.4	111.6	1541.5	1740.8	4.0	Yes	No
T01	52°46'37.70"N	008°41'39.30"W	470.0	Primary	10663.7	127.3	1754.5	1959.8	3.9	Yes	No
T02	52°46'23.39"N	008°41'29.85"W	454.0	Primary	10603.0	126.9	1748.0	1905.7	3.8	Yes	No
T05	52°46'43.52"N	008°41'06.21"W	442.0	Primary	11290.7	132.4	1822.4	1884.4	3.5	Yes	No
T17	52°46'22.00"N	008°42'45.64"W	388.0	Primary	9348.5	116.8	1612.1	1656.2	3.5	Yes	No
T04	52°46'36.88"N	008°40'45.03"W	443.0	Primary	11540.4	134.4	1849.4	1894.2	3.5	Yes	No
T06	52°46'51.99"N	008°40'23.22"W	442.0	Primary	12121.3	139.0	1912.3	1906.2	3.3	No	No
T07	52°46'42.24"N	008°39'37.56"W	451.0	Primary	12744.0	144.0	1979.8	1952.0	3.3	No	No
T03	52°46'22.67"N	008°40'35.04"W	412.0	Primary	11511.2	134.1	1846.3	1791.7	3.2	No	No
T08	52°46'30.79"N	008°39'13.96"W	434.0	Primary	12998.3	146.0	2007.3	1902.9	3.1	No	No
T12	52°46'48.03"N	008°39'02.64"W	418.0	Primary	13411.5	149.3	2052.0	1861.3	2.9	No	No
T10	52°46'34.49"N	008°38'42.22"W	410.0	Primary	13590.0	150.8	2071.4	1839.7	2.8	No	No
T09	52°46'19.97"N	008°38'41.25"W	374.0	Primary	13438.1	149.5	2054.9	1717.6	2.6	No	No
T11	52°46'50.36"N	008°38'27.24"W	366.0	Primary	14043.8	154.4	2120.5	1707.3	2.5	No	No
T16	52°46'33.04"N	008°36'26.51"W	375.0	Primary	15947.5	169.6	2326.6	1786.8	2.3	No	No
T15	52°46'43.24"N	008°36'49.86"W	369.0	Primary	15644.4	167.2	2293.8	1759.1	2.3	No	No
T14	52°46'13.80"N	008°38'15.55"W	342.0	Primary	13822.7	152.6	2096.6	1622.7	2.3	No	No
T13	52°46'31.82"N	008°38'10.22"W	338.0	Primary	14113.3	154.9	2128.0	1617.2	2.2	No	No

Table 23: SID - RWY 06 - TOMTO3A - Turn Area - Obstacle Assessment - Checked Obstacles

As indicated in Table 23, the turbines have an impact on the procedure, which results in a higher PDG than the standard obstacle clearance PDG of 3.3%

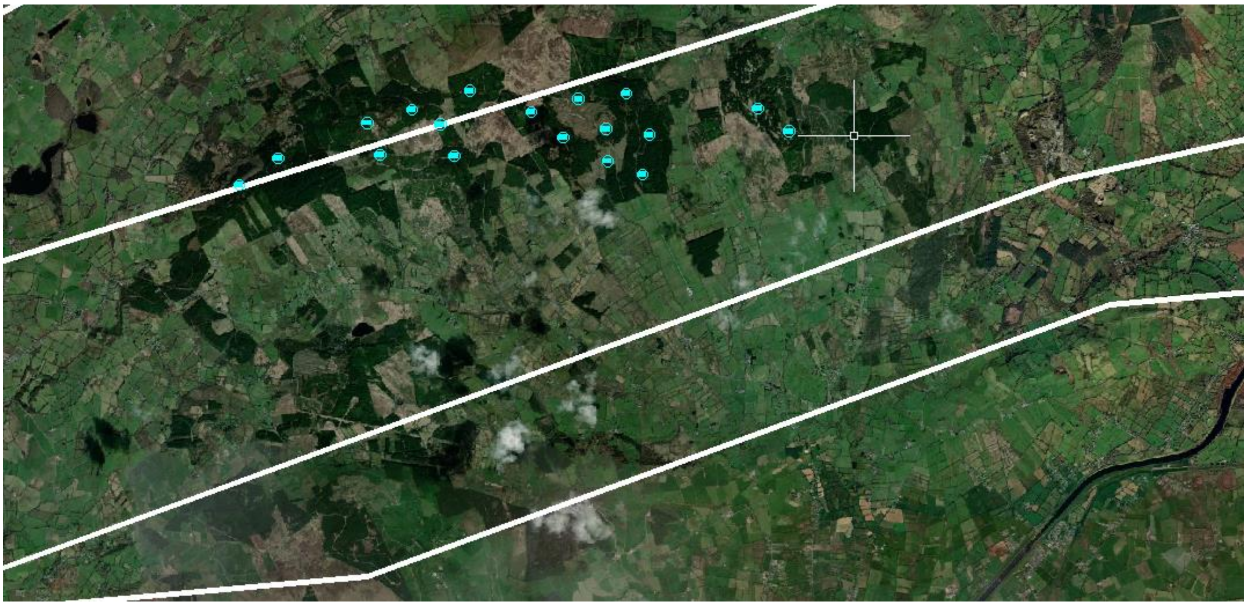

Figure 9: SID TOMTO3A

2.9. RNAV SID (ABAGU 3A) RWY 06

DER	
Latitude	52°42'37.24"N
Longitude	008°54'25.30"W
Altitude	4.57 m (14.99 ft)
Parameters	
Track	052.2 °
MOC	Greater of 0.8 % or 75 m
PDG	3.3 %
Turning Altitude	600 ft
Number of Checked Obstacles	16

Table 24: SID - RWY 06 - ABAGU3A

Name	Latitude	Longitude	Alt. (m)	Area	Do (m)	MOC req. (m)	Ac. alt. (ft)	Alt. req. (ft)	PDG (%)	Ctrl?	Close-in
T18	52°46'09.98"N	008°43'14.30"W	419.0	Primary	8696.5	111.6	1541.5	1740.8	4.0	Yes	No
T01	52°46'37.70"N	008°41'39.30"W	470.0	Primary	10663.7	127.3	1754.5	1959.7	3.9	Yes	No
T02	52°46'23.39"N	008°41'29.85"W	454.0	Primary	10603.0	126.8	1748.0	1905.6	3.8	Yes	No
T05	52°46'43.52"N	008°41'06.21"W	442.0	Primary	11290.7	132.3	1822.4	1884.3	3.5	Yes	No
T17	52°46'22.00"N	008°42'45.64"W	388.0	Primary	9348.5	116.8	1612.1	1656.2	3.5	Yes	No
T04	52°46'36.88"N	008°40'45.03"W	443.0	Primary	11540.4	134.3	1849.5	1894.2	3.5	Yes	No
T06	52°46'51.99"N	008°40'23.22"W	442.0	Primary	12121.3	139.0	1912.3	1906.1	3.3	No	No
T07	52°46'42.24"N	008°39'37.56"W	451.0	Primary	12744.0	144.0	1979.8	1952.0	3.3	No	No
T03	52°46'22.67"N	008°40'35.04"W	412.0	Primary	11511.2	134.1	1846.3	1791.7	3.2	No	No
T08	52°46'30.79"N	008°39'13.96"W	434.0	Primary	12998.3	146.0	2007.3	1902.9	3.1	No	No
T12	52°46'48.03"N	008°39'02.64"W	418.0	Primary	13411.5	149.3	2052.0	1861.2	2.9	No	No
T10	52°46'34.49"N	008°38'42.22"W	410.0	Primary	13590.0	150.7	2071.4	1839.7	2.8	No	No
T09	52°46'19.97"N	008°38'41.25"W	374.0	Primary	13438.1	149.5	2054.9	1717.6	2.6	No	No
T16	52°46'33.04"N	008°36'26.51"W	375.0	Primary	15947.6	169.6	2326.6	1786.7	2.3	No	No
T14	52°46'13.80"N	008°38'15.55"W	342.0	Primary	13822.8	152.6	2096.6	1622.7	2.3	No	No
T13	52°46'31.82"N	008°38'10.22"W	338.0	Primary	14113.3	154.9	2128.0	1617.2	2.2	No	No

Table 25: SID - RWY 06 - ABAGU3A - Turn Area - Checked Obstacles

As indicated in Table 25, the turbines have an impact on the procedure, which results in a higher PDG than the standard obstacle clearance PDG of 3.3%.

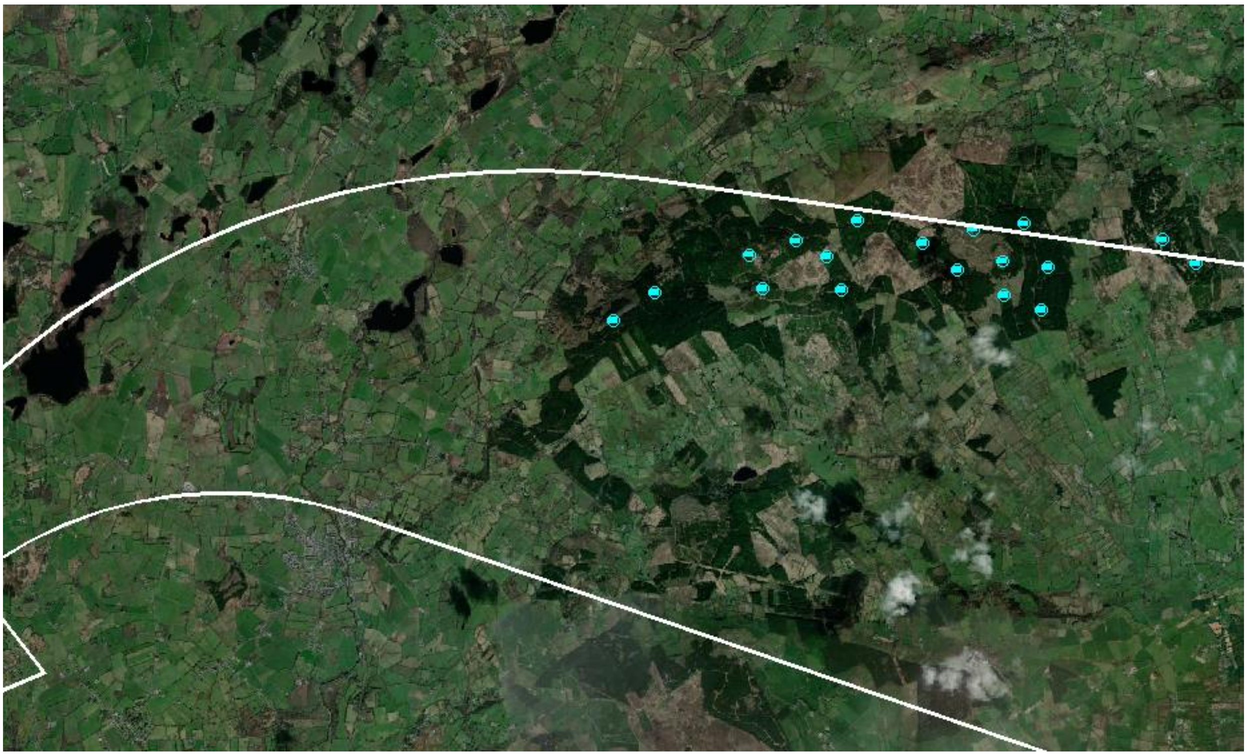

Figure 10: SID - ABAGU3A

2.10. IAP – ILS Runway 24

The turbines fall within the Initial approach (Base turn).

General	
Primary MOC	300 m
Obstacles	
Number of Checked Obstacles	18

Table 26: ILS CAT I & II RWY 24 - Base Turn CAT A/B

Name	Latitude	Longitude	Alt. (m)	Area	Dist. in (m)	MOC applied (m)	MOCA (ft)
T01	52°46'37.70"N	008°41'39.30"W	470.0	Pri.	N/A	300.0	2526.3
T02	52°46'23.39"N	008°41'29.85"W	454.0	Pri.	N/A	300.0	2473.8
T07	52°46'42.24"N	008°39'37.56"W	451.0	Pri.	N/A	300.0	2464.0
T04	52°46'36.88"N	008°40'45.03"W	443.0	Pri.	N/A	300.0	2437.7
T05	52°46'43.52"N	008°41'06.21"W	442.0	Pri.	N/A	300.0	2434.4
T06	52°46'51.99"N	008°40'23.22"W	442.0	Pri.	N/A	300.0	2434.4
T08	52°46'30.79"N	008°39'13.96"W	434.0	Sec.	122.4	292.2	2382.5
T18	52°46'09.98"N	008°43'14.30"W	419.0	Pri.	N/A	300.0	2359.0
T12	52°46'48.03"N	008°39'02.64"W	418.0	Pri.	N/A	300.0	2355.7
T03	52°46'22.67"N	008°40'35.04"W	412.0	Pri.	N/A	300.0	2336.0
T10	52°46'34.49"N	008°38'42.22"W	410.0	Sec.	309.3	280.2	2264.5
T17	52°46'22.00"N	008°42'45.64"W	388.0	Pri.	N/A	300.0	2257.3
T11	52°46'50.36"N	008°38'27.24"W	366.0	Sec.	9.6	299.4	2183.1
T09	52°46'19.97"N	008°38'41.25"W	374.0	Sec.	716.7	254.1	2060.8
T15	52°46'43.24"N	008°36'49.86"W	369.0	Sec.	1089.5	230.3	1966.1
T13	52°46'31.82"N	008°38'10.22"W	338.0	Sec.	673.4	256.9	1951.8
T16	52°46'33.04"N	008°36'26.51"W	375.0	Sec.	1581.7	198.7	1882.4
T14	52°46'13.80"N	008°38'15.55"W	342.0	Sec.	1119.6	228.3	1871.2

Table 27: ILS CAT I & II RWY 24 - Base Turn CAT A/B - Checked Obstacles

As indicated in Table 27, the turbines have no impact on the procedure.

Figure 11: RWY 24 - Base Turn CAT AB – Windfarm Location

General	
Primary MOC	300 m
Obstacles	
Number of Checked Obstacles	18

Table 28: ILS CAT I & II RWY 24 - Base Turn CAT CD

Name	Latitude	Longitude	Alt. (m)	Area	Dist. in (m)	MOC applied (m)	MOCA (ft)
T01	52°46'37.70"N	008°41'39.30"W	470.0	Primary	N/A	300	2526.3
T02	52°46'23.39"N	008°41'29.85"W	454.0	Primary	N/A	300	2473.8
T07	52°46'42.24"N	008°39'37.56"W	451.0	Primary	N/A	300	2464.0
T04	52°46'36.88"N	008°40'45.03"W	443.0	Primary	N/A	300	2437.7
T05	52°46'43.52"N	008°41'06.21"W	442.0	Primary	N/A	300	2434.4
T06	52°46'51.99"N	008°40'23.22"W	442.0	Primary	N/A	300	2434.4
T08	52°46'30.79"N	008°39'13.96"W	434.0	Primary	N/A	300	2408.2
T18	52°46'09.98"N	008°43'14.30"W	419.0	Primary	N/A	300	2359.0
T12	52°46'48.03"N	008°39'02.64"W	418.0	Primary	N/A	300	2355.7
T03	52°46'22.67"N	008°40'35.04"W	412.0	Primary	N/A	300	2336.0
T10	52°46'34.49"N	008°38'42.22"W	410.0	Primary	N/A	300	2329.4
T17	52°46'22.00"N	008°42'45.64"W	388.0	Primary	N/A	300	2257.3
T16	52°46'33.04"N	008°36'26.51"W	375.0	Primary	N/A	300	2214.6
T09	52°46'19.97"N	008°38'41.25"W	374.0	Primary	N/A	300	2211.3
T15	52°46'43.24"N	008°36'49.86"W	369.0	Primary	N/A	300	2194.9
T11	52°46'50.36"N	008°38'27.24"W	366.0	Primary	N/A	300	2185.1
T14	52°46'13.80"N	008°38'15.55"W	342.0	Primary	N/A	300	2106.3
T13	52°46'31.82"N	008°38'10.22"W	338.0	Primary	N/A	300	2093.2

Table 29: ILS CAT I & II RWY 24 - Base Turn CAT CD - Checked Obstacles

In indicated in Table 29 the turbines have no impact on the procedure.

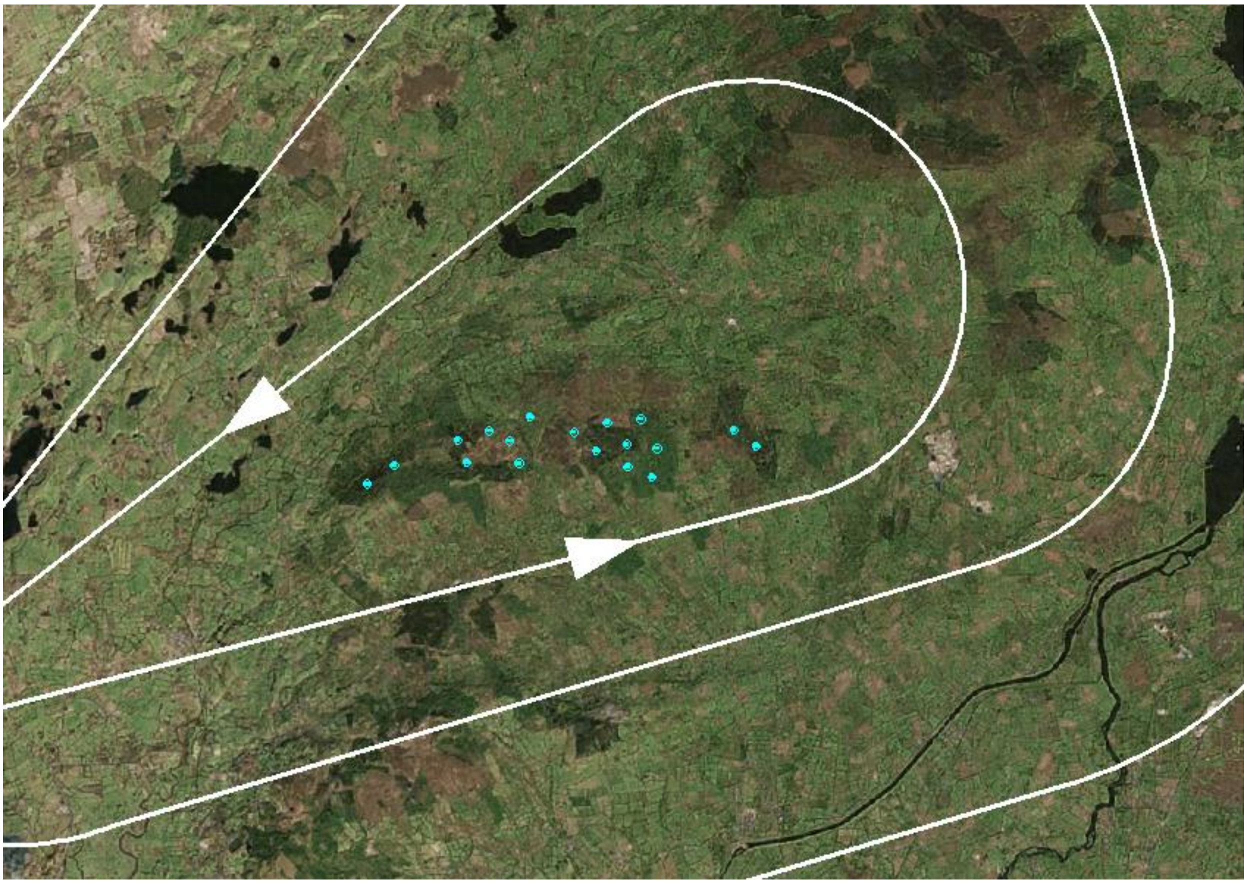

Figure 12: RWY 24 - Base Turn CAT CD – Windfarm Location

2.11. IAP – LOC Runway 24

The turbines fall within the Initial approach for the procedure. The Initial approach via base turn is common to the ILS RWY 24 procedure and is reported on in section 2.10 above.

2.12. IAP – VOR Runway 24

The Turbines fall within the Initial (base turn) for CAT A/B and C/D, intermediate and the final approach segment for the procedure.

General	
Primary MOC	300 m
Obstacles	
Number of Checked Obstacles	18

Table 30: VOR RWY 24 - Base Turn CAT AB

Name	Latitude	Longitude	Alt. (m)	Area	Dist. in (m)	MOC applied (m)	MOCA (ft)
T01	52°46'37.70"N	008°41'39.30"W	470.0	Primary	N/A	300.0	2526.3
T02	52°46'23.39"N	008°41'29.85"W	454.0	Primary	N/A	300.0	2473.8
T07	52°46'42.24"N	008°39'37.56"W	451.0	Primary	N/A	300.0	2464.0

T04	52°46'36.88"N	008°40'45.03"W	443.0	Primary	N/A	300.0	2437.7
T05	52°46'43.52"N	008°41'06.21"W	442.0	Primary	N/A	300.0	2434.4
T06	52°46'51.99"N	008°40'23.22"W	442.0	Primary	N/A	300.0	2434.4
T08	52°46'30.79"N	008°39'13.96"W	434.0	Secondary	120.0	292.2	2382.7
T18	52°46'09.98"N	008°43'14.30"W	419.0	Primary	N/A	300.0	2359.0
T12	52°46'48.03"N	008°39'02.64"W	418.0	Primary	N/A	300.0	2355.7
T03	52°46'22.67"N	008°40'35.04"W	412.0	Primary	N/A	300.0	2336.0
T10	52°46'34.49"N	008°38'42.22"W	410.0	Secondary	304.6	280.3	2264.7
T17	52°46'22.00"N	008°42'45.64"W	388.0	Primary	N/A	300.0	2257.3
T11	52°46'50.36"N	008°38'27.24"W	366.0	Secondary	8.6	299.4	2183.3
T09	52°46'19.97"N	008°38'41.25"W	374.0	Secondary	707.2	254.2	2061.0
T15	52°46'43.24"N	008°36'49.86"W	369.0	Secondary	1075.5	230.3	1966.3
T13	52°46'31.82"N	008°38'10.22"W	338.0	Secondary	664.4	256.9	1952.0
T16	52°46'33.04"N	008°36'26.51"W	375.0	Secondary	1561.8	198.8	1882.6
T14	52°46'13.80"N	008°38'15.55"W	342.0	Secondary	1105.3	228.4	1871.4

Table 31: VOR RWY 24 - Base Turn CAT AB - Checked Obstacles

As indicated in Table 31, the turbines have no impact on the procedure.

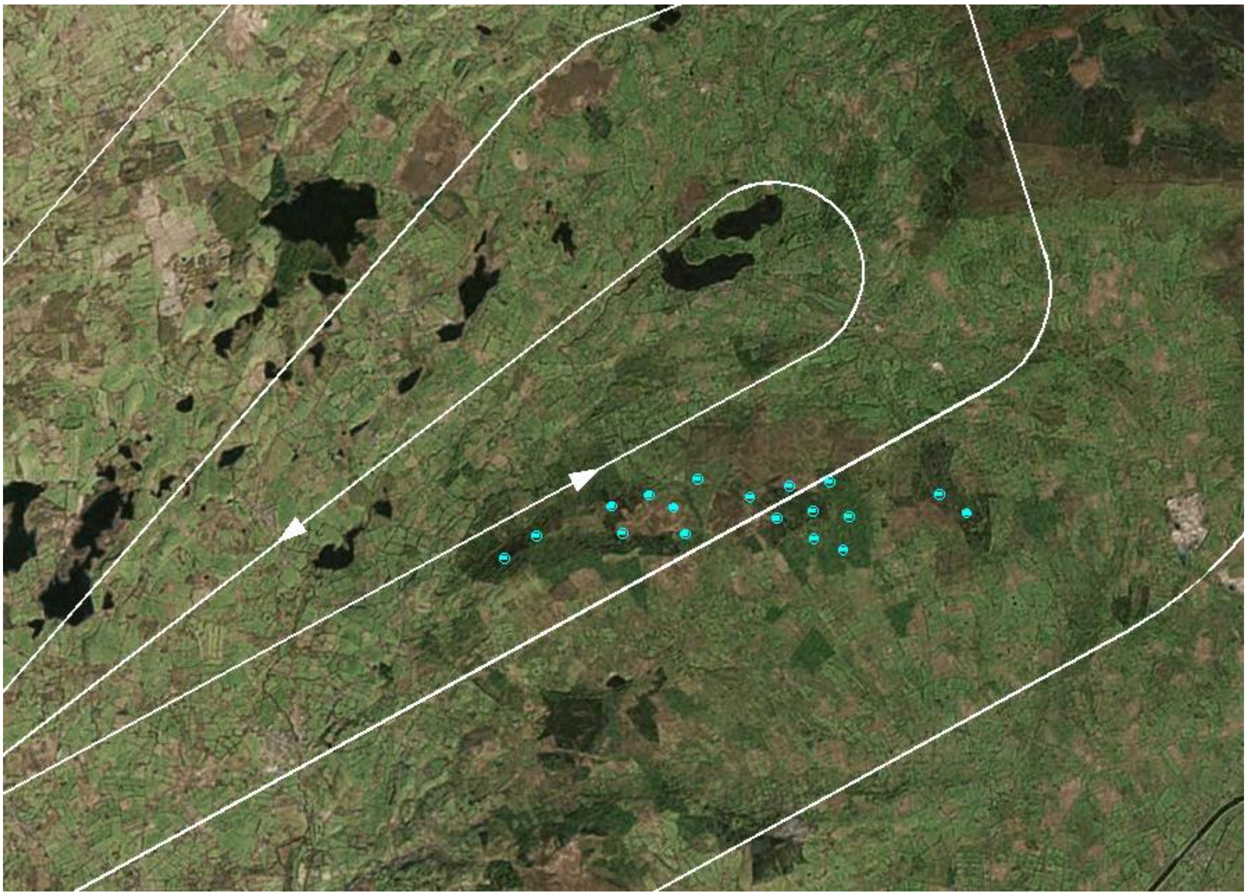

Figure 13: RWY 24 - Base Turn CAT AB Windfarm Location

General	
Primary MOC	300 m
Obstacles	
Number of Checked Obstacles	18

Table 32: VOR RWY 24 - Base Turn CAT CD - General

Name	Latitude	Longitude	Alt. (m)	Area	Dist. in (m)	MOC applied (m)	MOCA (ft)
T01	52°46'37.70"N	008°41'39.30"W	470.0	Primary	N/A	300.0	2526.3
T02	52°46'23.39"N	008°41'29.85"W	454.0	Primary	N/A	300.0	2473.8
T07	52°46'42.24"N	008°39'37.56"W	451.0	Primary	N/A	300.0	2464.0
T04	52°46'36.88"N	008°40'45.03"W	443.0	Primary	N/A	300.0	2437.7
T05	52°46'43.52"N	008°41'06.21"W	442.0	Primary	N/A	300.0	2434.4
T06	52°46'51.99"N	008°40'23.22"W	442.0	Primary	N/A	300.0	2434.4
T08	52°46'30.79"N	008°39'13.96"W	434.0	Primary	N/A	300.0	2408.2
T18	52°46'09.98"N	008°43'14.30"W	419.0	Primary	N/A	300.0	2359.0
T12	52°46'48.03"N	008°39'02.64"W	418.0	Primary	N/A	300.0	2355.7
T03	52°46'22.67"N	008°40'35.04"W	412.0	Primary	N/A	300.0	2336.0
T10	52°46'34.49"N	008°38'42.22"W	410.0	Primary	N/A	300.0	2329.4
T17	52°46'22.00"N	008°42'45.64"W	388.0	Primary	N/A	300.0	2257.3
T16	52°46'33.04"N	008°36'26.51"W	375.0	Primary	N/A	300.0	2214.6
T09	52°46'19.97"N	008°38'41.25"W	374.0	Primary	N/A	300.0	2211.3
T15	52°46'43.24"N	008°36'49.86"W	369.0	Primary	N/A	300.0	2194.9
T11	52°46'50.36"N	008°38'27.24"W	366.0	Primary	N/A	300.0	2185.1
T14	52°46'13.80"N	008°38'15.55"W	342.0	Primary	N/A	300.0	2106.3
T13	52°46'31.82"N	008°38'10.22"W	338.0	Primary	N/A	300.0	2093.2

Table 33: VOR RWY 24 - Base Turn CAT CD - Checked Obstacles

As indicated in Table 33, the turbines have no impact on the procedure.

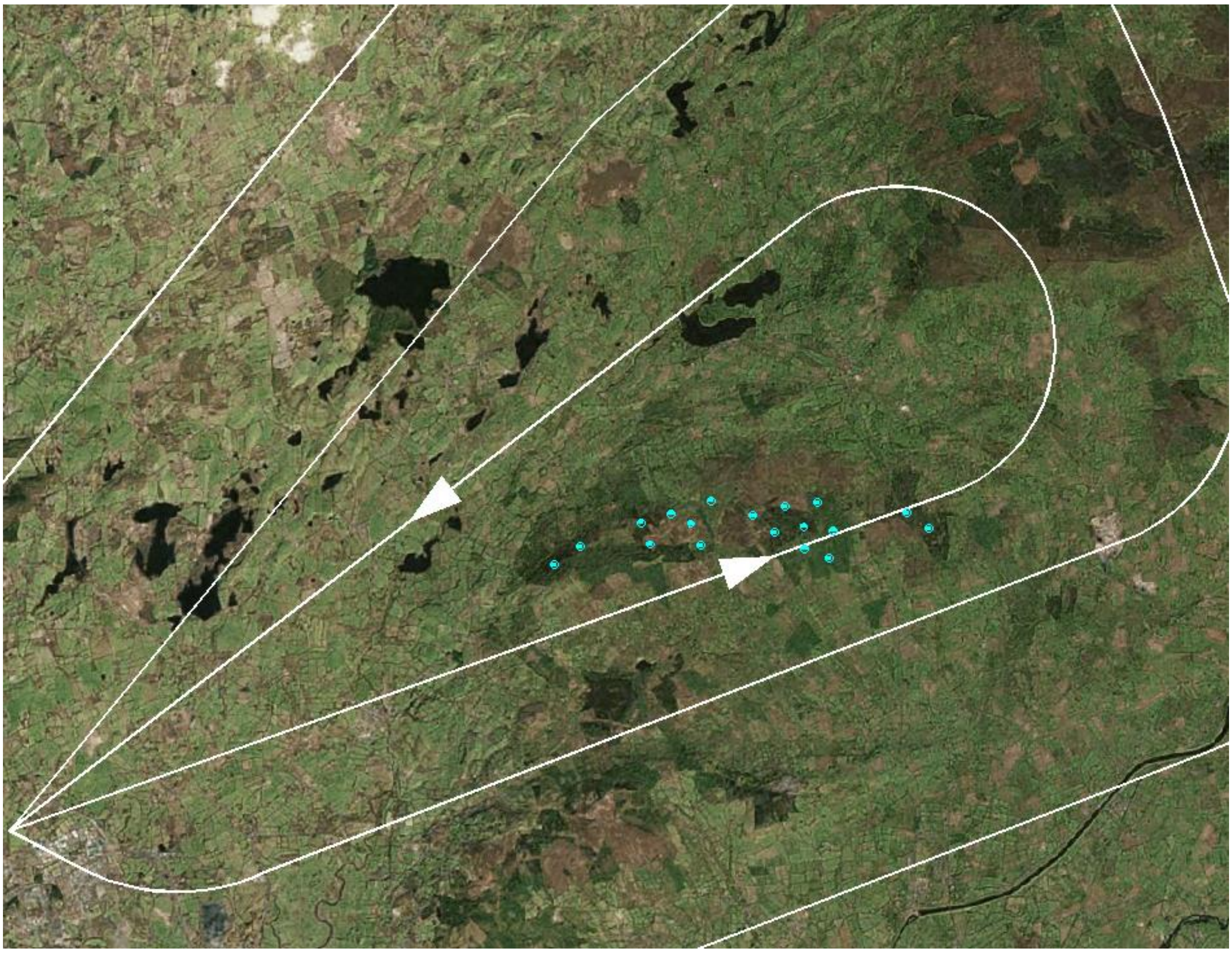

Figure 14: RWY 24 - Base Turn CAT CD – Windfarm Location

General	
Primary MOC	150 m
Obstacles	
Number of Checked Obstacles	4

Table 34: VOR RWY 24 - Intermediate Approach

Name	Latitude	Longitude	Alt. (m)	Area	MOC applied (m)	MOCA (ft)
T06	52°46'51.99"N	008°40'23.22"W	442.0	Secondary	45.7	1600.1
T07	52°46'42.24"N	008°39'37.56"W	451.0	Secondary	5.3	1497.0
T12	52°46'48.03"N	008°39'02.64"W	418.0	Secondary	5.8	1390.4

Table 35: VOR RWY 24 - Intermediate Approach - Checked Obstacles

As indicated in Table 35 there is no impact to the Intermediate Approach.

Figure 15: VOR RWY 24 - Intermediate Approach – Windfarm Location

General	
Primary MOC	75 m
Obstacles	
Number of Checked Obstacles	7

Table 36: VOR RWY 24 - Final Approach

Name	Latitude	Longitude	Alt. (m)	Area	MOC applied (m)	MOCA (ft)
T01	52°46'37.70"N	008°41'39.30"W	470.0	Secondary	37.3	1664.4
T02	52°46'23.39"N	008°41'29.85"W	454.0	Secondary	30.6	1550.4
T05	52°46'43.52"N	008°41'06.21"W	442.0	Secondary	18.5	1550.1
T06	52°46'51.99"N	008°40'23.22"W	442.0	Secondary	23.2	1526.2
T18	52°46'09.98"N	008°43'14.30"W	419.0	Secondary	46.1	1525.9
T04	52°46'36.88"N	008°40'45.03"W	443.0	Secondary	15.8	1505.2
T17	52°46'22.00"N	008°42'45.64"W	388.0	Secondary	47.3	1428.2

Table 37: VOR RWY 24 - Final Approach - Checked Obstacles

As indicated in Table 37, the turbines have an impact on the procedure and raises the currently published MOCA by 400ft from 1270ft to **1670t.**

Figure 16: VOR RWY 24 - Final Approach – Windfarm Location

2.13. Unassessed Procedures

The turbines lie outside the protection areas of the following procedures.

- RNAV STARs RWY 06
- RNAV STARs RWY 24
- RNAV SIDs RWY 24
- The Visual Approach Chart

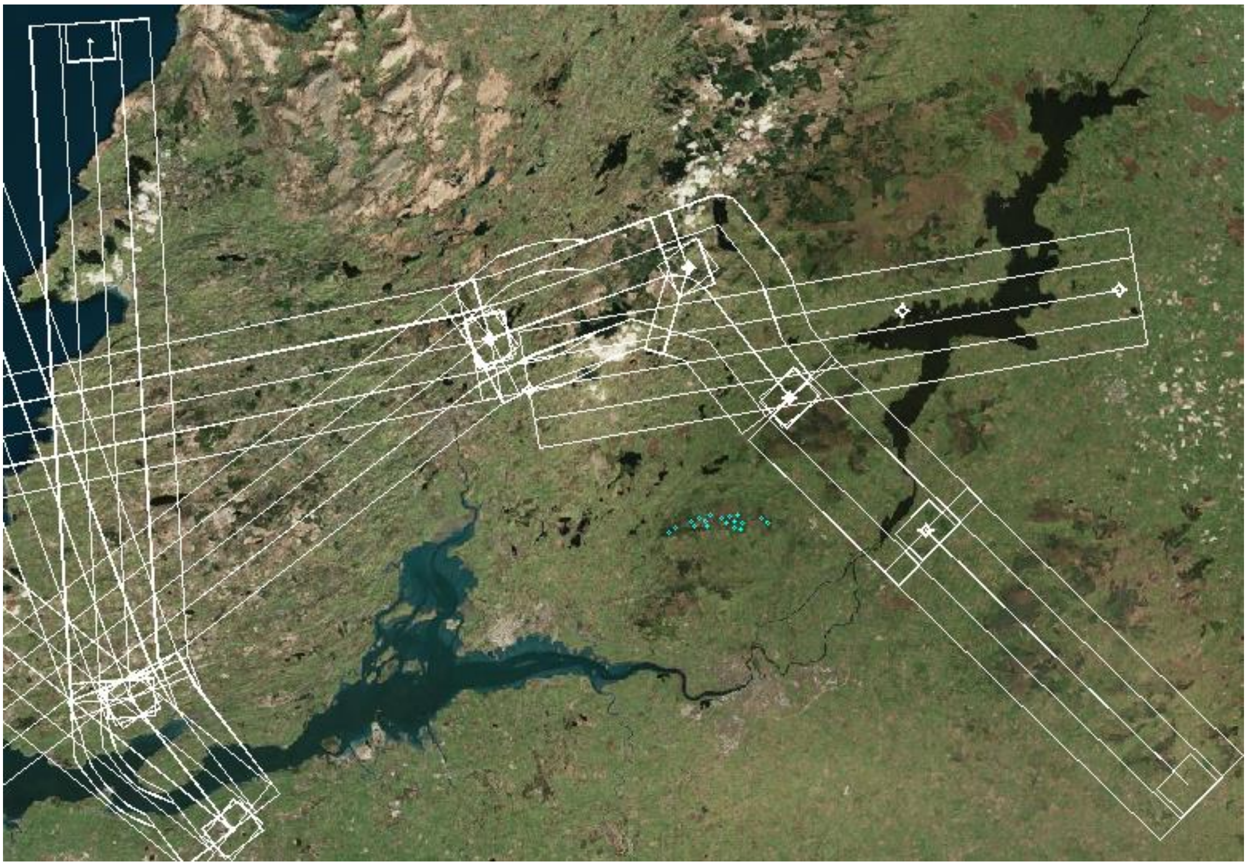

Figure 17: STAR RWY 06/24

Figure 18: RNAV SIDs RWY24

2.14. ATC Surveillance Minimum Altitude Chart

The ATC Surveillance Minimum Chart consists of four sectors. The turbines fall within Sector 1 **(2300ft)** and Sector 2 **(3000ft)** areas of the ATCSMAC.

General	
Primary MOC	300 m
Obstacles	
Number of Checked Obstacles	11

Table 38: ATCSMAC Sector 1

Name	Latitude	Longitude	Alt. (m)	Area	MOC applied (m)	MOCA (ft)
T01	52°46'37.70"N	008°41'39.30"W	470.0	Sector 1	300.0	2526.3
T02	52°46'23.39"N	008°41'29.85"W	454.0	Sector 1	300.0	2473.8
T07	52°46'42.24"N	008°39'37.56"W	451.0	Sector 1	300.0	2464.0
T04	52°46'36.88"N	008°40'45.03"W	443.0	Sector 1	300.0	2437.7
T05	52°46'43.52"N	008°41'06.21"W	442.0	Sector 1	300.0	2434.4
T06	52°46'51.99"N	008°40'23.22"W	442.0	Sector 1	300.0	2434.4
T08	52°46'30.79"N	008°39'13.96"W	434.0	Sector 1	300.0	2408.2
T18	52°46'09.98"N	008°43'14.30"W	419.0	Sector 1	300.0	2359.0
T12	52°46'48.03"N	008°39'02.64"W	418.0	Sector 1	300.0	2355.7
T03	52°46'22.67"N	008°40'35.04"W	412.0	Sector 1	300.0	2336.0
T17	52°46'22.00"N	008°42'45.64"W	388.0	Sector 1	300.0	2257.3

Table 39: ATCSMAC Sector 1 - Checked Obstacles

As indicated in Table 39, the turbines have an impact on the procedure and raises the published minima for Sector 1 by 300ft from 2300ft to **2600ft.**

General	
Primary MOC	300 m
Obstacles	
Number of Checked Obstacles	8

Table 40: ATCSMAC Sector 2

Name	Latitude	Longitude	Alt. (m)	Area	MOC applied (m)	MOCA (ft)
T12	52°46'48.03"N	008°39'02.64"W	418.0	Sector 2	300.0	2355.7
T10	52°46'34.49"N	008°38'42.22"W	410.0	Sector 2	300.0	2329.4
T16	52°46'33.04"N	008°36'26.51"W	375.0	Sector 2	300.0	2214.6
T09	52°46'19.97"N	008°38'41.25"W	374.0	Sector 2	300.0	2211.3
T15	52°46'43.24"N	008°36'49.86"W	369.0	Sector 2	300.0	2194.9
T11	52°46'50.36"N	008°38'27.24"W	366.0	Sector 2	300.0	2185.1
T14	52°46'13.80"N	008°38'15.55"W	342.0	Sector 2	300.0	2106.3
T13	52°46'31.82"N	008°38'10.22"W	338.0	Sector 2	300.0	2093.2

Table 41: ATCSMAC Sector 2 - Checked Obstacles

As indicated in Table 41, the turbines have no impact on the procedure.

Figure 19: ATC Surveillance Minimum Altitude Chart - Windfarm Location

3. Mitigation

Assessed Procedure	IFP Mitigation	Turbine Mitigation
TOMTO 3A SID RWY06	T18, T01, T02, T05, T17, T04 penetrate the turn area for TOMTO 3A which results in a higher PDG of **3.5-4.0%.**	The max turbine height permissible: T18: 124m, T01: 122m, T02: 136m, T05: 166m, T17: 171m, T04: 171m.
ABAGU 3A SID RWY06	T18, T01, T02, T05, T17, T04 penetrate the turn area for ABAGU3A which results in a higher PDG of **3.5-4.0%.**	The max turbine height permissible: T18: 124m, T01: 122m, T02: 136m, T05: 166m, T17: 171m, T04: 171m.
VOR RWY24	(Final Approach) T01, T02, T05, T06, T18, T04, T17 penetrate the secondary area of the Final approach and raises the currently published MOCA by 400ft from 1270ft to **1670t**. It also affects the gradient from the SDF to MAPt. A re-design is recommended to; • determine if the current step-down fix can be repositioned to prevent an increase to the gradient, or • if an additional step-down fix is to be added to the design.	The max turbine height permissible: T:01 64m, T02: 99m, T05: 99m, T06: 106m, T18: 107m, T04: 113m, T17: 136m.
ATC Surveillance Minimum Chart	T01, T02, T07, T04, T05, T06, T08, T18, T12, T03, T17, T09 penetrate Sector 1 and raises the published minima by 300ft from 2300ft to **2600ft**	The max turbine height permissible: T:01 116m, T02: 132m, T07: 135m, T04: 143m, T05: 144m, T06: 144m, T08: 152m, T18: 167m, T12: 168m, T03: 124m, T17: n/a, T09: n/a

Table 42: Mitigation

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Appendix 6

Violet Hill Wind Farm Impact on ILS Flight Inspection

FLIGHT CALIBRATION SERVICES LTD

VIOLET HILL WIND FARM

IMPACT ON ILS FLIGHT INSPECTION

Prepared For:	Ai Bridges Ltd
Author:	John Wilson
Reviewed by:	David Bartlett
Reference:	FCSL 0138
Issue:	1
Date:	27 August 2021

VIOLET HILL 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
ICAO	International Civil Aviation Organization
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
ITM	Irish Transverse Mercator
LOC	Localiser
NM	Nautical Mile
RF	Radio Frequency
VMC	Visual Meteorological Conditions
WGS	World Geodetic System

1 INTRODUCTION

Violet Hill Wind Farm is a proposed renewable energy project in County Clare located approximately 9 NM north east of Shannon Airport.

The wind farm developer 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 Violet Hill Wind Farm comprises 18 wind turbines and associated infrastructure including turbine foundations, access tracks, an electricity substation and underground cabling located in an area of approximately 650 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 coordinates are shown in Table 2.1 below.

The maximum height of the proposed wind turbines (to blade tip) is 185 m (607 ft) above ground level. Ground height at the highest turbine (T1) is 276 m (906 ft) AMSL.

The height of the highest turbine (to blade tip) is therefore 461 m (1,512 ft) AMSL.

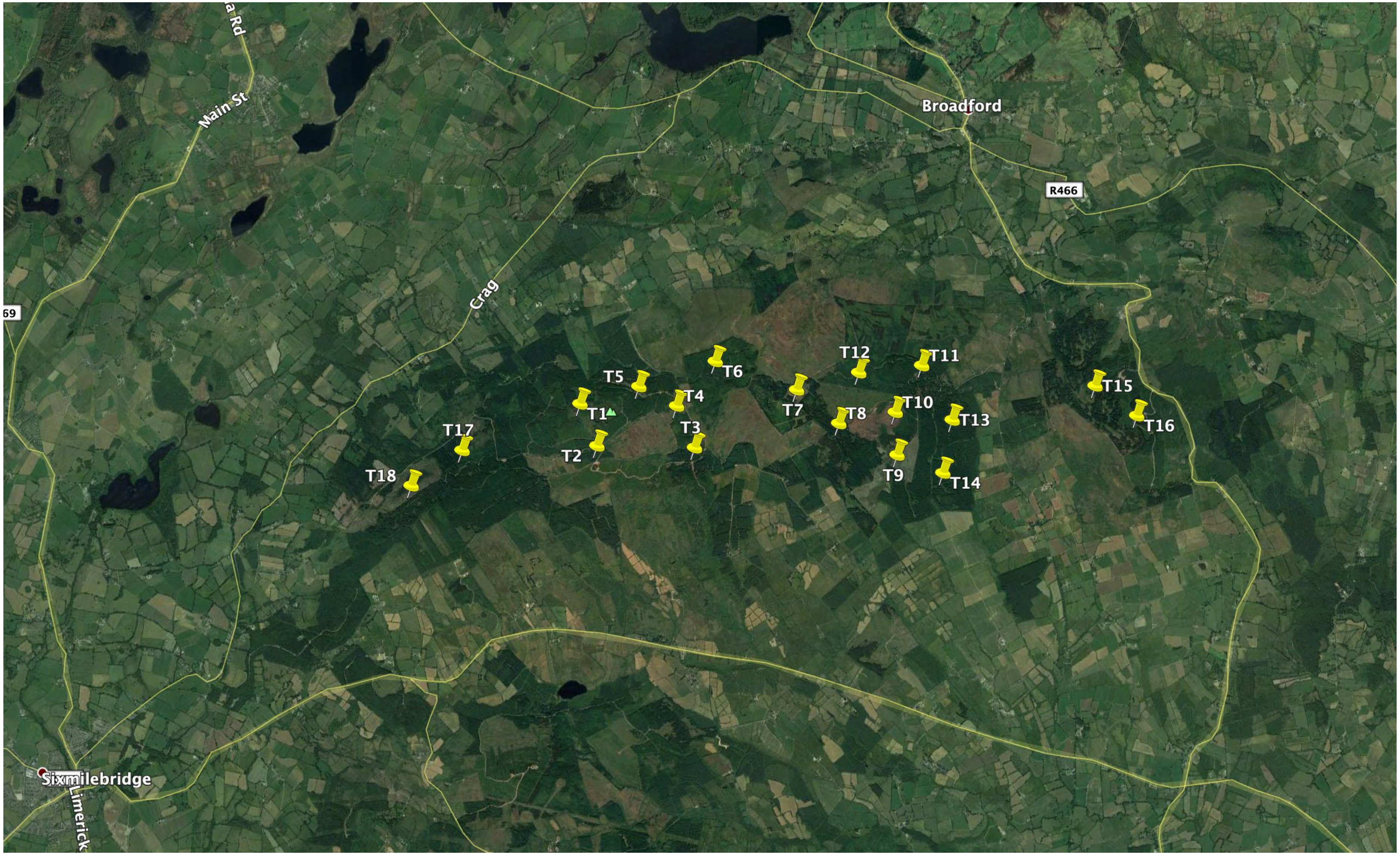


Figure 2.1 - Proposed Violet Hill Wind Farm Site Layout

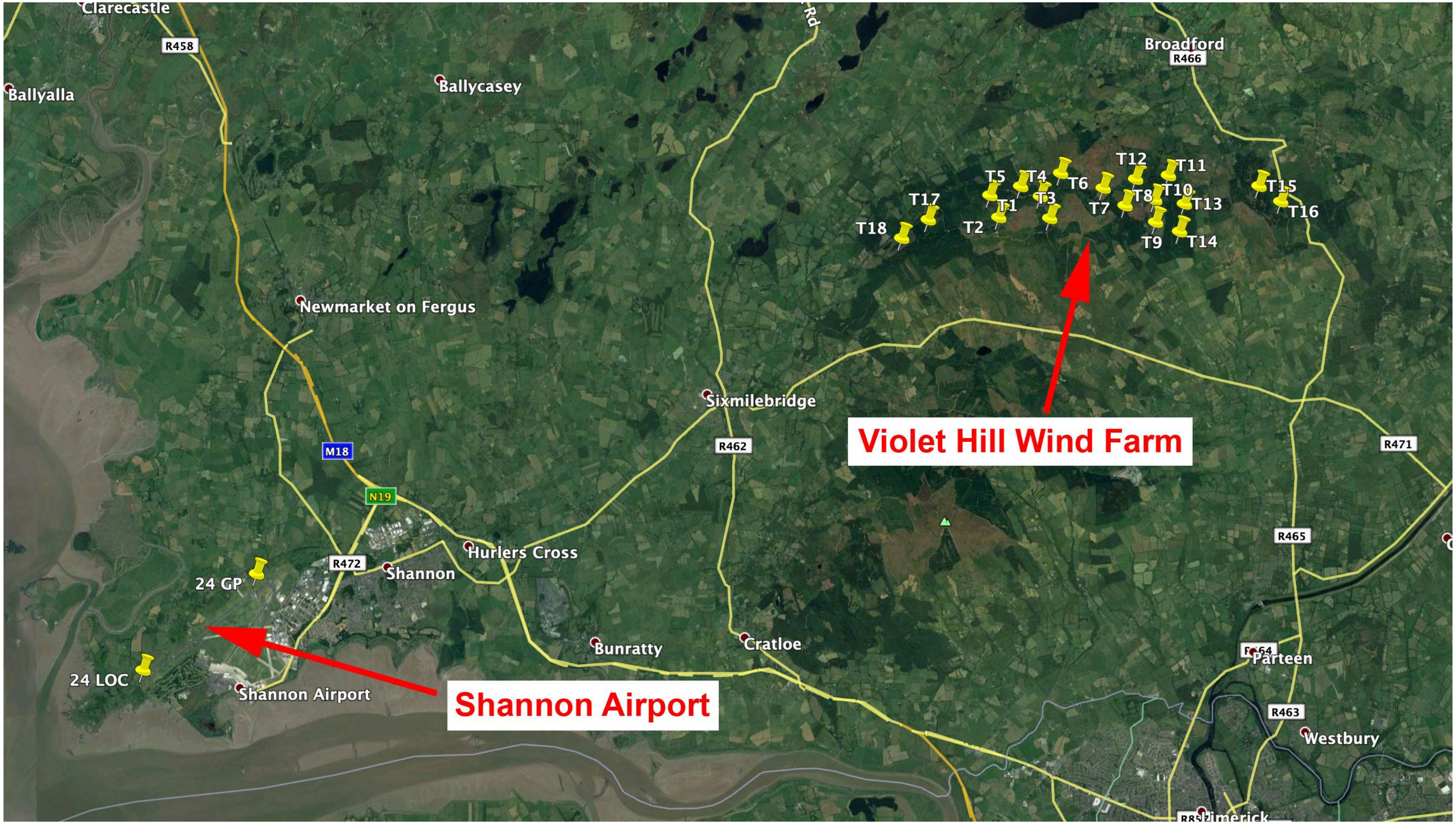


Figure 2.2 – Location of Proposed Violet Hill Wind Farm and Shannon Airport

Turbine	ITM Coordinates		WGS-84 Coordinates		Ground Level AMSL (m)
	Easting	Northing	Latitude	Longitude	
1	553159	669794	52.777138	-8.694251	276
2	553332	669350	52.773163	-8.691624	269
3	554359	669318	52.772963	-8.676400	227
4	554176	669759	52.776911	-8.679174	255
5	553781	669968	52.778756	-8.685057	255
6	554589	670222	52.781107	-8.673117	255
7	555442	669913	52.778401	-8.660432	265
8	555881	669555	52.775220	-8.653878	247
9	556491	669215	52.772213	-8.644793	188
10	556477	669664	52.776248	-8.645060	225
11	556762	670152	52.780656	-8.640900	181
12	556098	670086	52.780009	-8.650733	233
13	557076	669576	52.775505	-8.636171	153
14	556971	669020	52.770499	-8.637654	157
15	558585	669916	52.778678	-8.613851	184
16	559020	669597	52.775844	-8.607364	190
17	551911	669321	52.772778	-8.712677	203
18	551370	668955	52.769440	-8.720640	234

Table 2.1 - Proposed Turbine 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 Violet Hill 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).

ICAO Annex 10 Volume I states that ILS Glide Path coverage shall extend 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 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 Violet Hill Wind Farm.

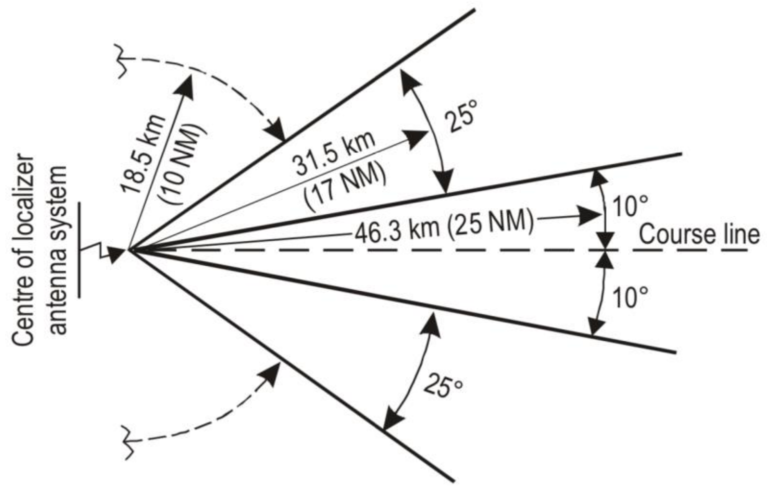
3.2.3 DME Coverage

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

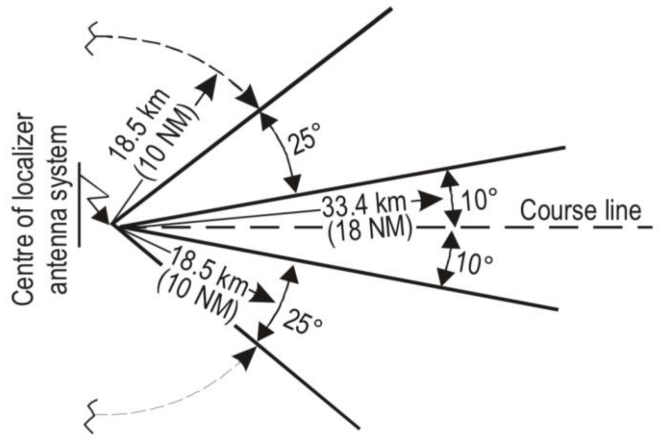
AIP IRELAND **EINN AD 2 - 9**
10 SEP 2020

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 4° 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

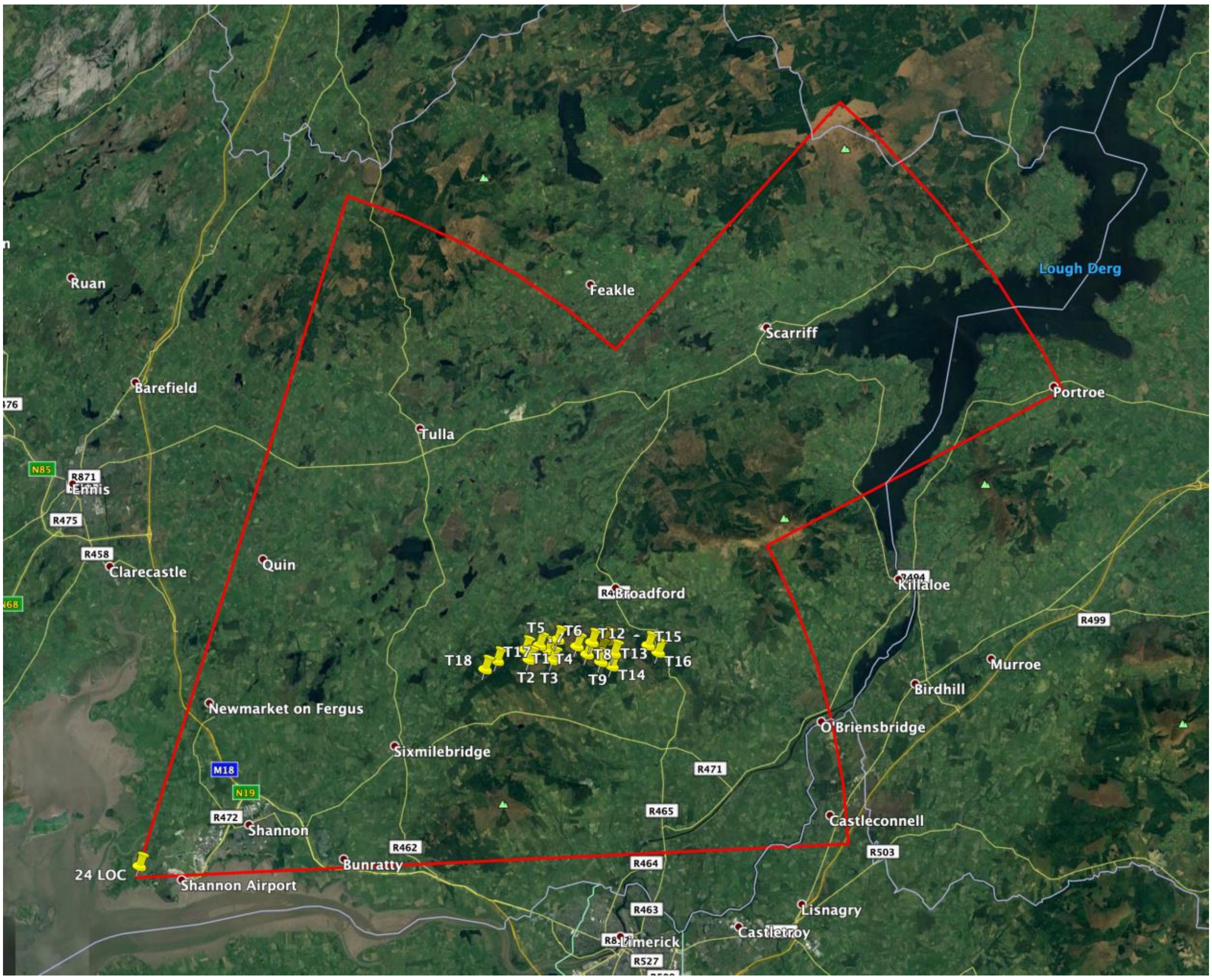


Figure 3.3 - Runway 24 ILS Localiser Lateral Coverage Sector

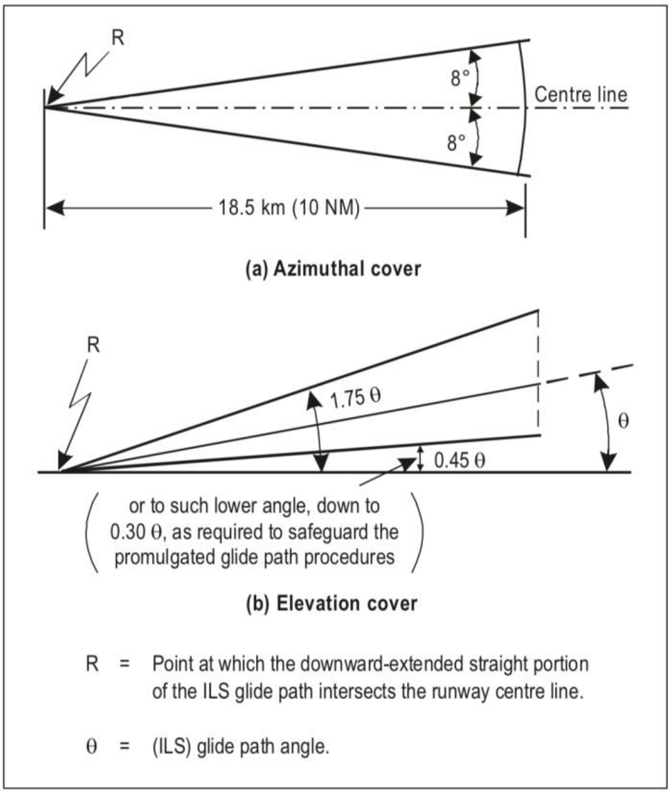


Figure 3.4 - ILS Glide Path Coverage

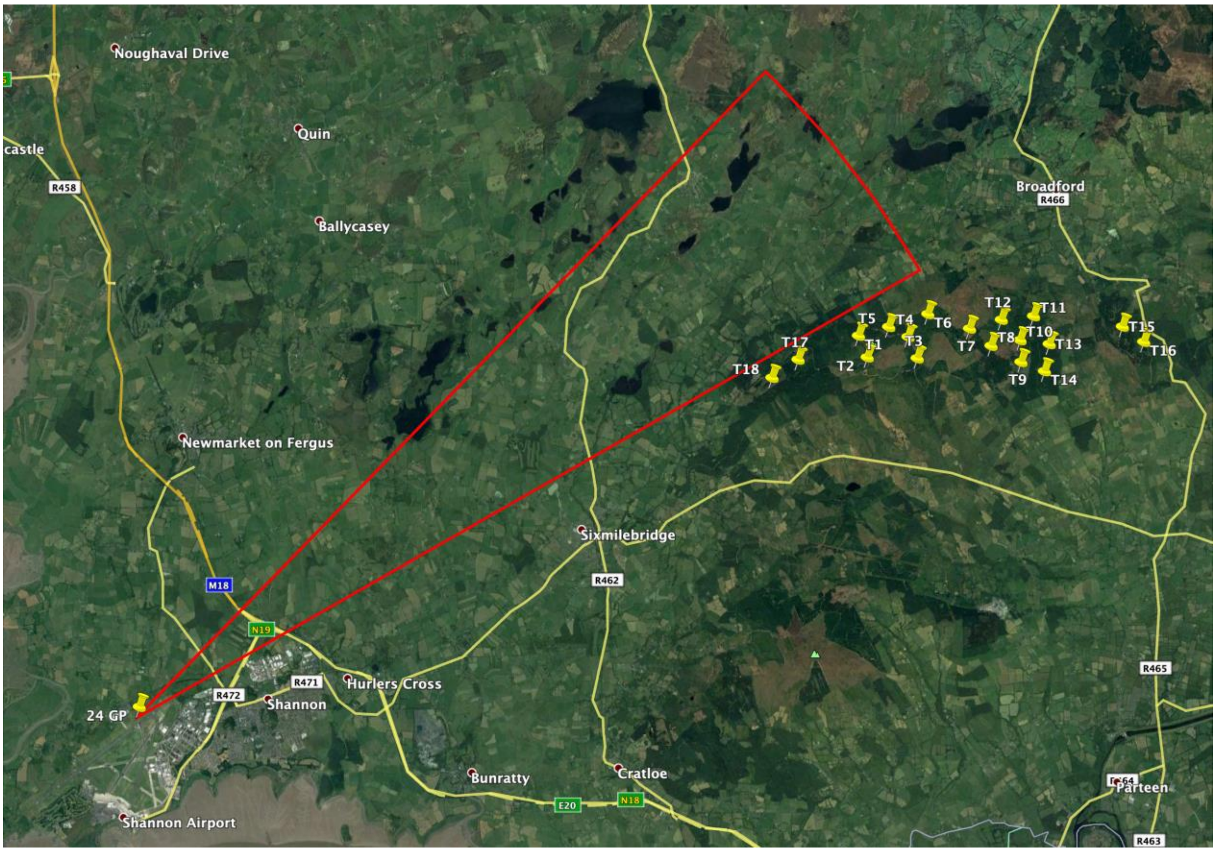


Figure 3.5 - Runway 24 ILS Glide Path Lateral Coverage Sector

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.

To verify Glide Path displacement sensitivity, ICAO Doc 8071 recommends that approaches be made on centreline, 0.12θ below and 0.12θ above the nominal glide path angle (θ), where aircraft should receive 50% full-scale fly up (below path) and 50% full-scale fly down (above path) guidance indications.

The clearance of the Glide Path sector is verified by flying towards the facility on centreline at a constant height (level run) starting at a distance corresponding to an angle of 0.3θ (where θ is the nominal glide path angle) continuing to a point where twice the glide path angle (2θ) has been passed. Glide Path RF signal level is also measured during the level run to ensure the received signal level meets ICAO minimum requirements at the limits of coverage.

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 the following flight profiles are flown as defined in FCSL Form 102 (Flight Profile Chart):

Profile No	Profile Description	See Figure
01	Centreline Approach	5.1
04	Part Orbit	5.2
12	Top Edge	5.3
13	Bottom Edge	5.4
14	Slice (Level run)	5.5
15	Left Slice 8° (Level run)	5.6
16	Right Slice 8° (Level run)	5.7

Figures 5.1 to 5.7 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.

Glide Path flight inspection procedures include checks below the Glide Path sector to assure a safe flight path area between the bottom edge of the Glide Path sector and any obstacles on the approach path. The Glide Path slice and left slice 8° (level runs) flight profiles must therefore ensure that the flight inspection aircraft clears obstacles by at least 500 ft in VMC and by at least 1,000 ft in IMC.

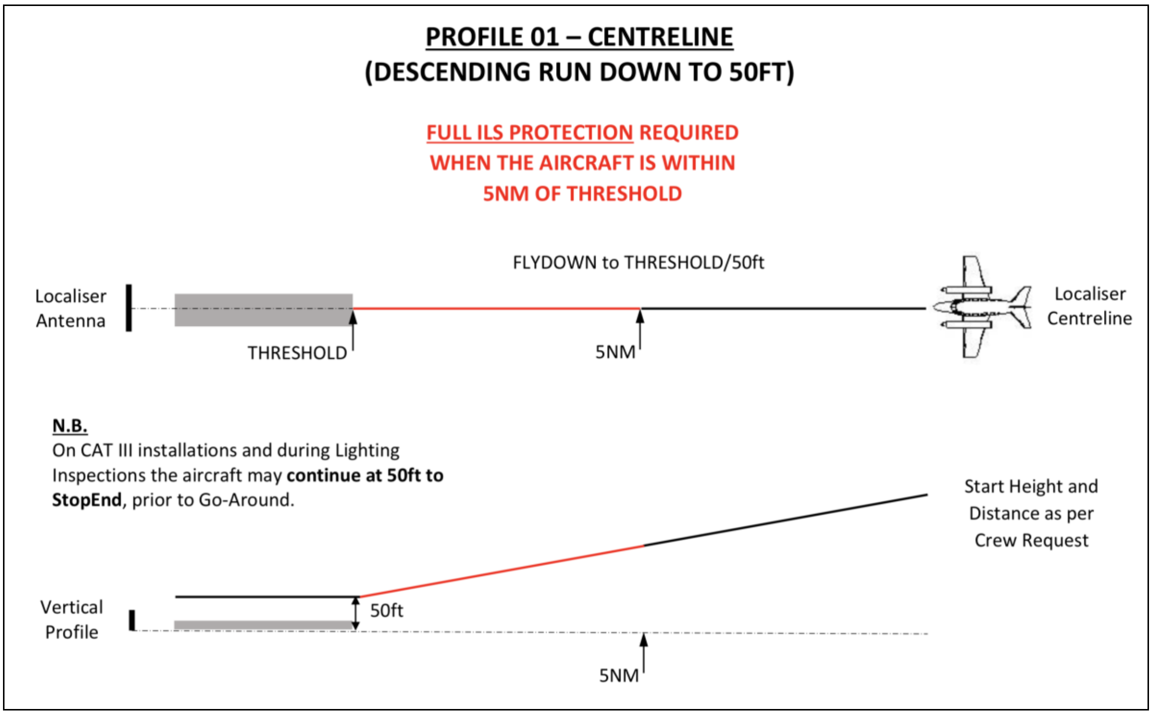


Figure 5.1 - Centreline Approach Flight Profile

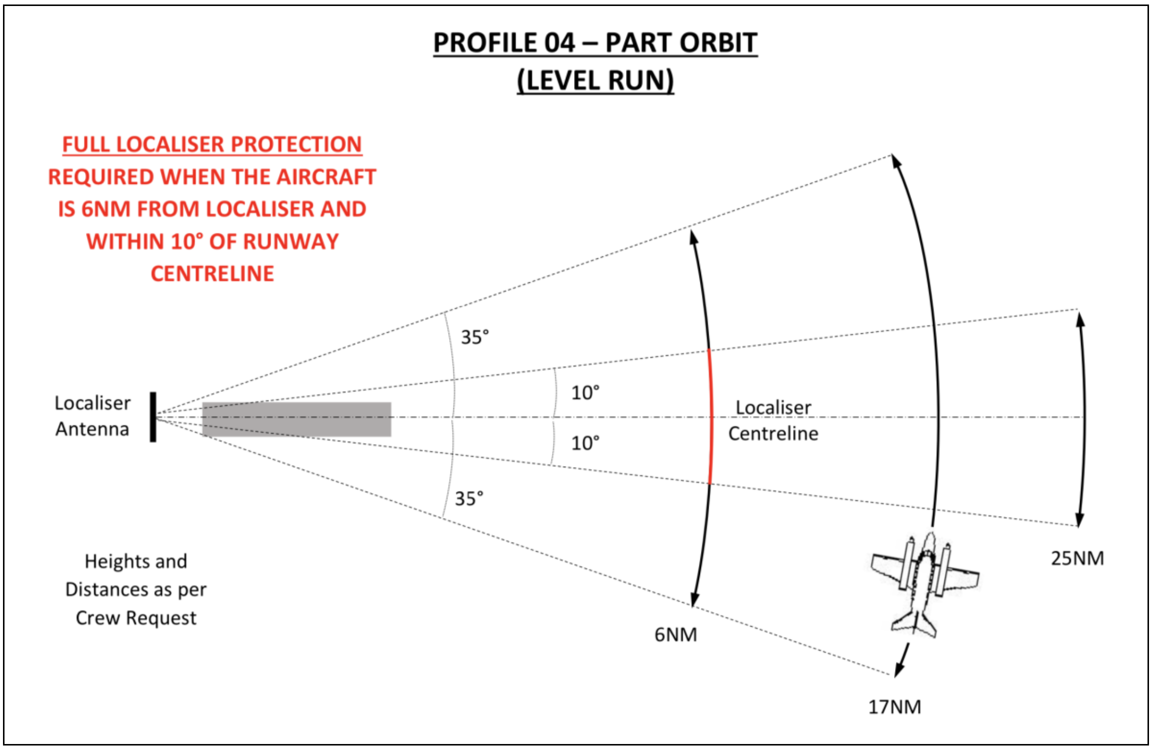


Figure 5.2 – Part Orbit Flight Profile

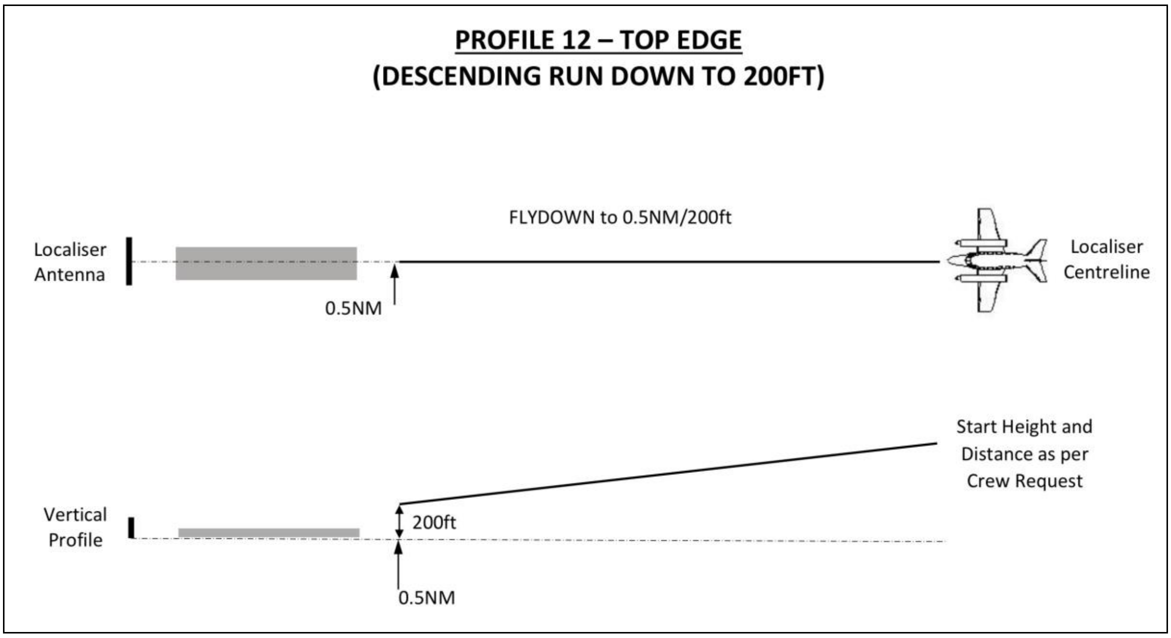


Figure 5.3 – Top Edge Flight Profile

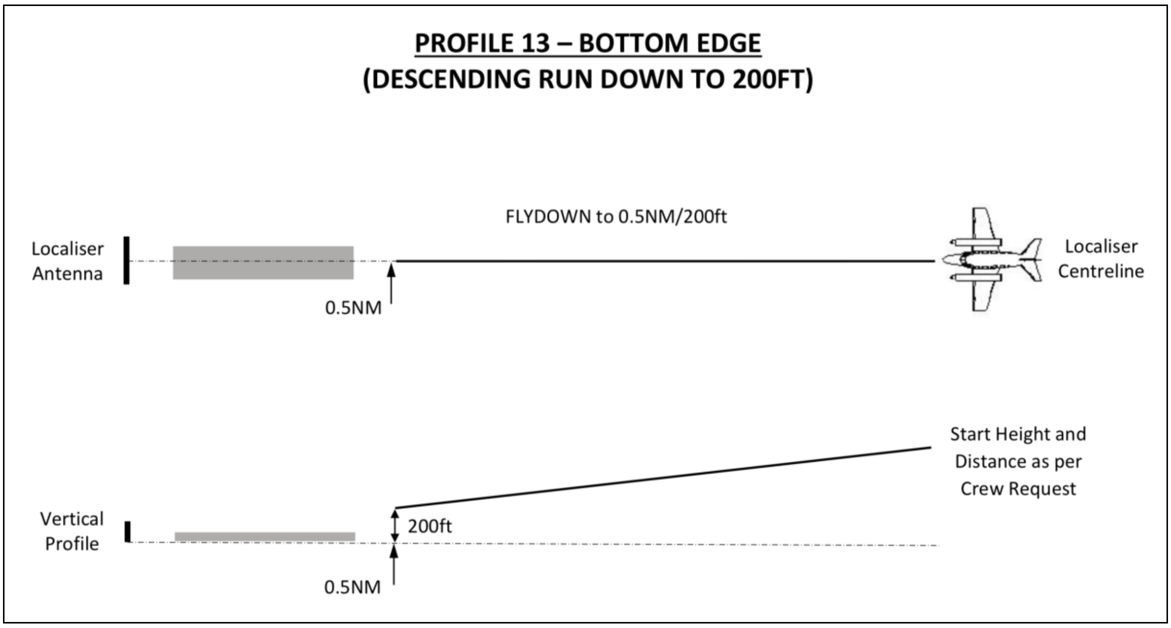


Figure 5.4 – Bottom Edge Flight Profile

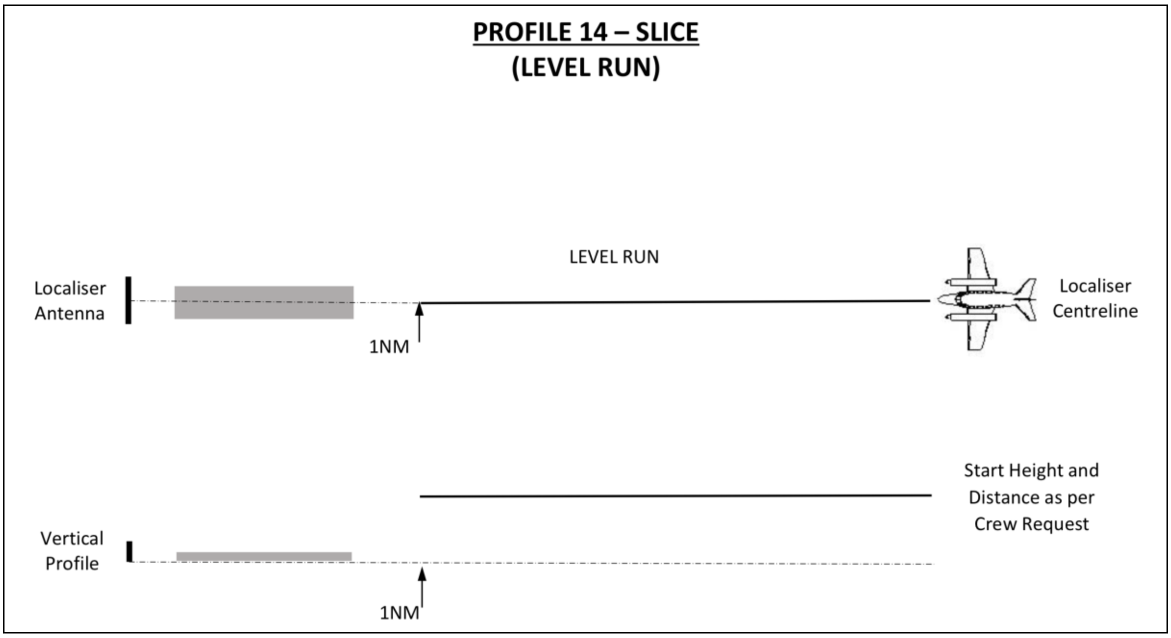


Figure 5.5 – Slice Flight Profile

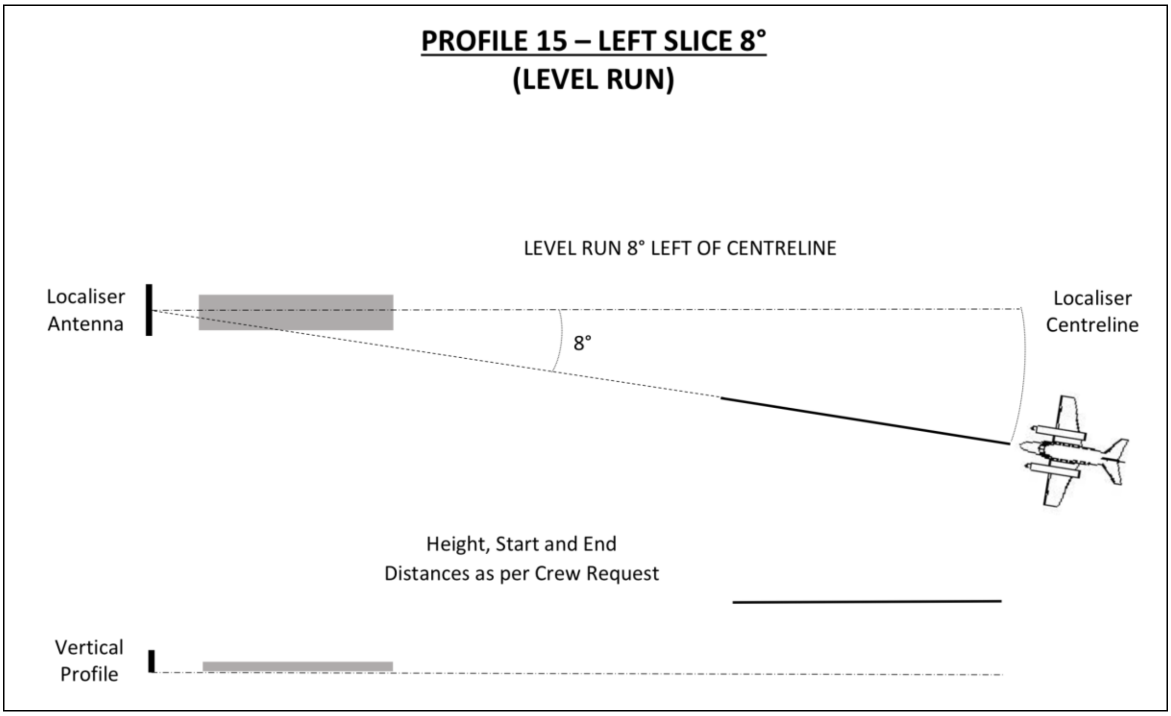


Figure 5.6 – Left Slice 8° Flight Profile

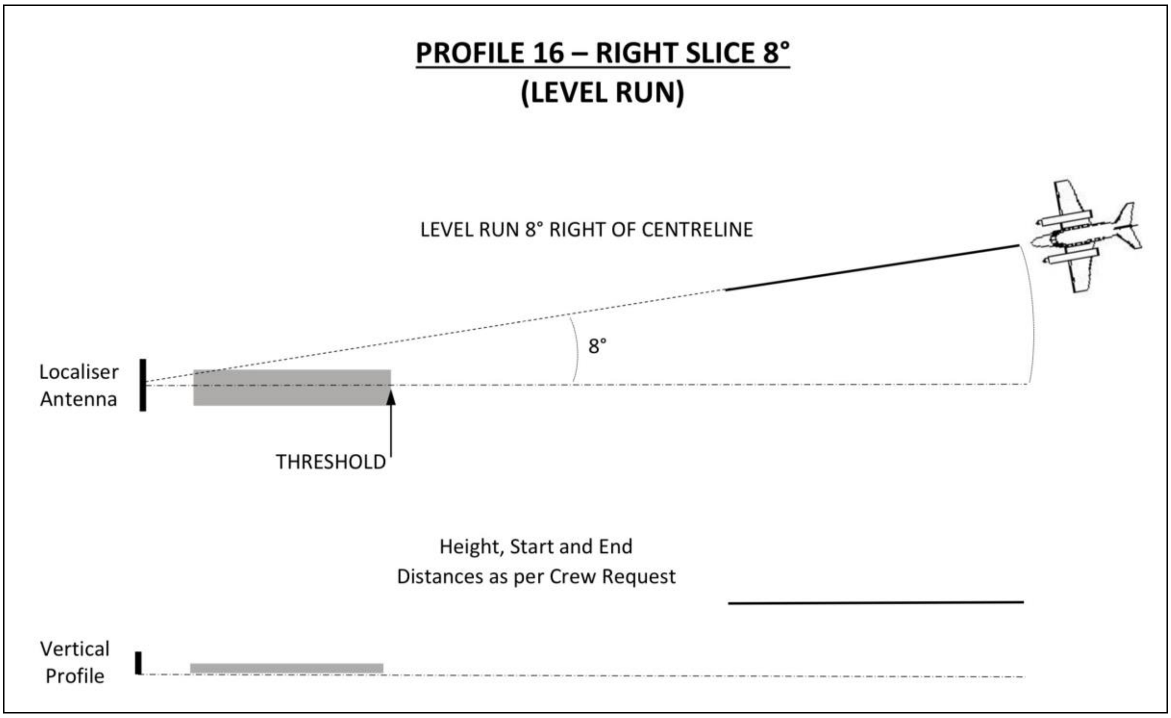


Figure 5.7 – Right Slice 8° Flight Profile

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 1.3 NM laterally from the nearest wind turbine (T18) 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 in IMC, 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 above, but 1.3 NM laterally distant from, the proposed Violet Hill Wind Farm site. The flight inspection aircraft vertical clearance above the highest turbine (T1) can be estimated as follows (see Figure 6.1):

Horizontal distance from 24 Glide Path antenna (on boresight) to Turbine T1

= 16,349 m

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

Clearance (h) above highest turbine (T1)

$= (16{,}349 \text{ m} \times \tan 3.0°) - (276 \text{ m} - 14 \text{ m}) - 185 \text{ m} = 410 \text{ m} = 1{,}345 \text{ ft}$

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 3.5 NM from the nearest wind turbine (T18) at a point on the part orbit track closest to the wind farm site. This distance is less than the minimum clearance required from any object in IMC, as defined in FIP 23.

For a 17 NM part orbit flight profile, the flight inspection aircraft will be at least 3.6 NM from the nearest wind turbine (T16) at a point on the part orbit track closest to the wind farm site. This distance is less than the minimum clearance required from any object in IMC, as defined in FIP 23.

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 below 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 (T1) can be estimated as:

Ground height + maximum turbine height = 276 m + 185 m = 461 m (1,512 ft).

For an orbit height of 2,745 ft AMSL, a flight inspection aircraft will therefore have a clearance of 1,233 ft above the highest wind turbine. This height exceeds the minimum clearance required above terrain and obstacles in IMC.

6.3 ILS Bottom Edge Flight Profile

6.3.1 Horizontal Obstacle Clearances

For the bottom edge flight profile (flown on centreline), the flight inspection aircraft will be approximately 1.3 NM laterally from the nearest wind turbine (T18) 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 in IMC, as defined in FIP 23.

6.3.2 Vertical Obstacle Clearances

For the bottom edge flight profile (flown on centreline), the flight inspection aircraft is flown at a glide path angle 0.12θ below the nominal glide path angle (θ).

Bottom edge glide path angle = $\theta - 0.12\theta = 3° - 0.36° = 2.64°$.

The flight inspection aircraft will pass above, but 1.3 NM laterally distant from, the proposed Violet Hill Wind Farm site. The flight inspection aircraft vertical clearance above the highest turbine (T1) can be estimated as follows:

Horizontal distance from 24 Glide Path antenna (on boresight) to Turbine T1

= 16,349 m

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

Clearance (h) above highest turbine (T1)

$= (16{,}349\ m \times \tan 2.64°) - (276\ m - 14\ m) - 185\ m = 307\ m = 1{,}007\ ft$

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

6.4 ILS Slice Flight Profile

6.4.1 Horizontal Obstacle Clearances

For the slice flight profile (flown on centreline), the flight inspection aircraft will be approximately 1.3 NM laterally from the nearest wind turbine (T18) 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 in IMC, as defined in FIP 23.

6.4.2 Vertical Obstacle Clearances

Figure 6.4 below shows the track of the ILS slice flight profile. The slice profile is normally flown at a height of 1,000 ft AMSL.

Figure 6.5 below shows the terrain elevation profile for the slice flight profile. The highest terrain on the slice profile from a range of 11 NM (12.7 miles) is approximately 150 ft AMSL. The 1,000 ft slice flight profile must therefore be flown within sight of the surface and not flown in IMC.

Figure 6.5 below shows that for a Runway 24 ILS Glide Path flight inspection slice profile (level run) at an altitude of 1,000 ft, clearance above the highest terrain will be adequate at approximately 850 ft. However, in IMC, Glide Path level runs will need to be flown at an altitude of at least 2,512 ft to remain 1,000 ft above the highest wind turbine. The altitude will be rounded up to the nearest 100 ft, so the ILS Glide Path slice profile will therefore have to be flown at 2,600 ft in IMC.

6.5 ILS Left Slice 8° Flight Profile

6.5.1 Horizontal Obstacle Clearances

For the left slice 8° flight profile (flown at an angle of 8° left of centreline with respect to the Localiser antenna), the flight inspection aircraft will pass directly overhead the proposed wind farm site at a distance of approximately 11 NM (12.7 miles) from the Localiser antenna.

6.5.2 Vertical Obstacle Clearances

Figure 6.4 below shows the track of the ILS left slice 8° flight profile. The slice profile is normally flown at a height of 1,000 ft AMSL.

Figure 6.6 below shows the terrain elevation profile for the left slice 8° flight profile.

The highest terrain on the left slice 8° profile from a range of 11 NM (12.7 miles) is approximately 900 ft AMSL. The 1,000 ft left slice 8° flight profile must therefore be flown within sight of the surface and not flown in IMC.

Figure 6.6 below shows that for a Runway 24 ILS Glide Path flight inspection level run (left slice 8°) at an altitude of 1,000 ft, clearance above the highest wind turbine will not be adequate. However, in IMC, Glide Path level runs will need to be flown at an altitude of at least 2,512 ft to remain 1,000 ft above the highest wind turbine. The altitude will be rounded up to the nearest 100 ft, so the ILS Glide Path left slice 8° (level run) will therefore have to be flown at 2,600 ft in IMC.

6.6 Analysis

If Glide Path flight inspection level runs (slice profiles) are to be flown at higher altitudes to provide sufficient clearance above obstacles, the length and duration of the runs, and distance from the runway will increase correspondingly. This could result in some increased flight inspection costs.

In addition, at increased ranges, there may not be sufficient Glide Path RF signal to ensure correct ILS receiver operation. It is therefore recommended that flight trials are conducted (at the next routine ILS flight inspection) to ensure correct ILS receiver operation at increased ranges.

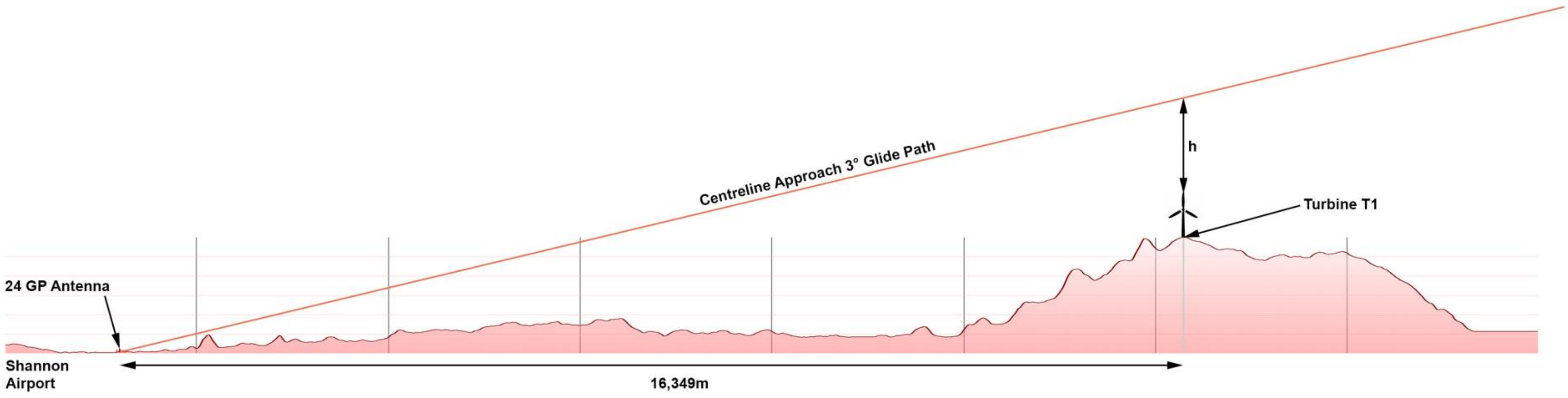


Figure 6.1 – ILS Centreline Approach Profile

(Not to scale)

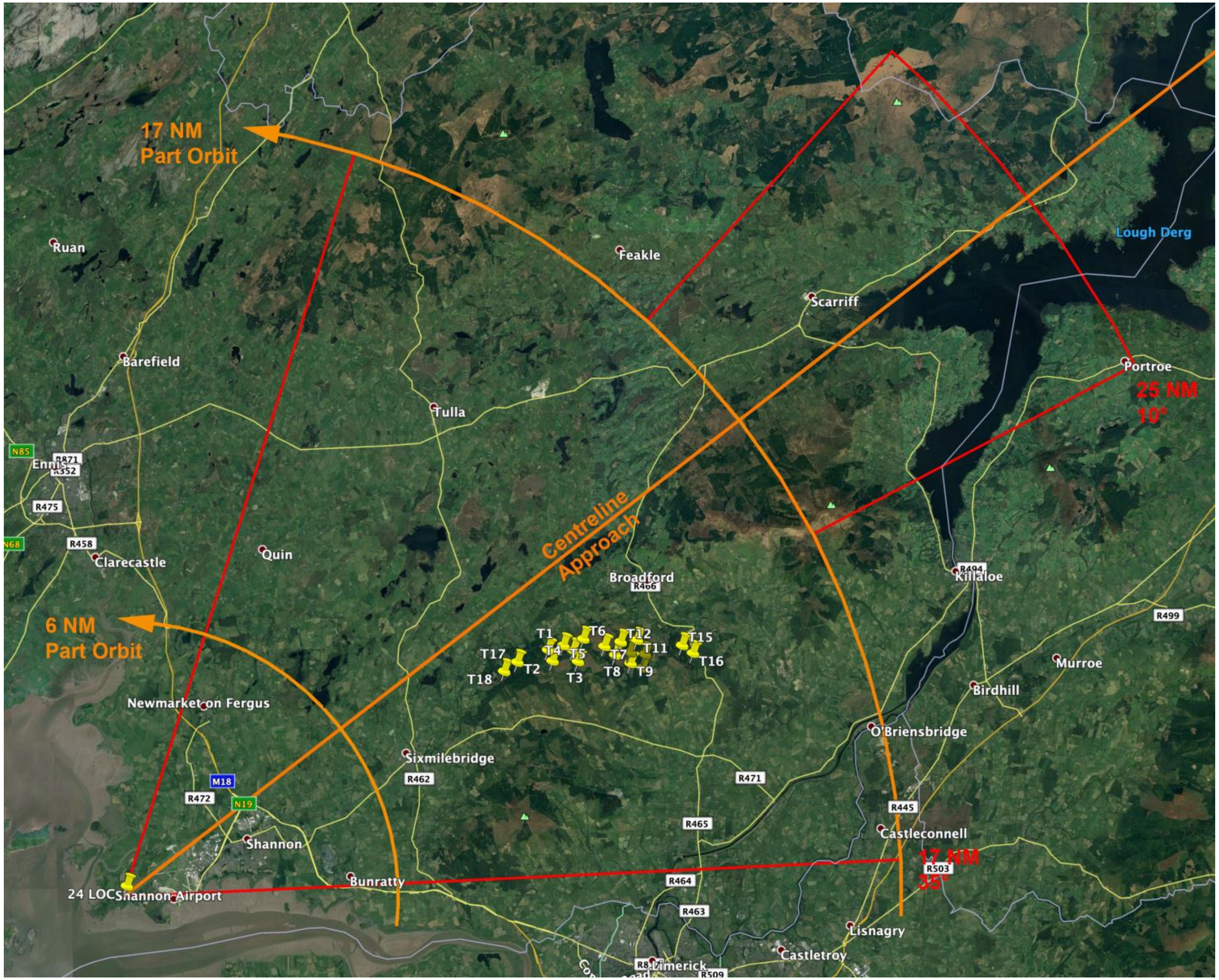


Figure 6.2 – ILS Centreline Approach and Part Orbit Tracks

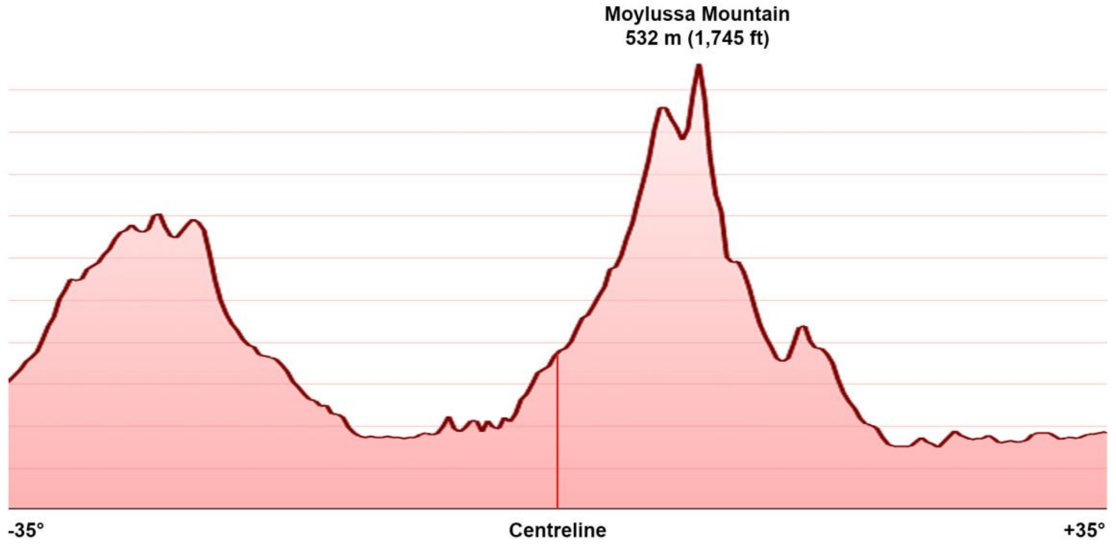


Figure 6.3 – 17 NM Part Orbit Terrain Elevation Profile

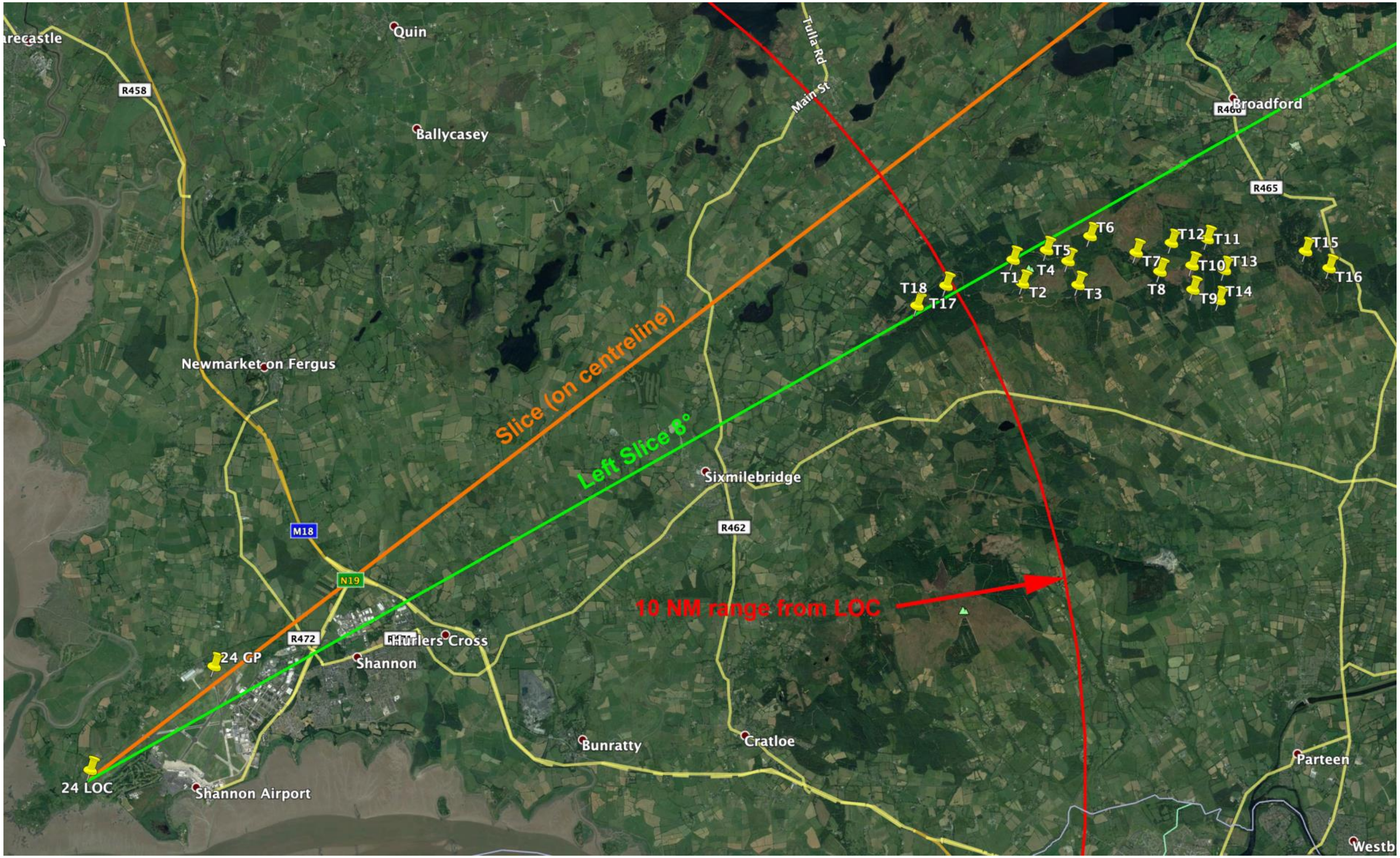


Figure 6.4 – Slice and Left Slice 8° Tracks

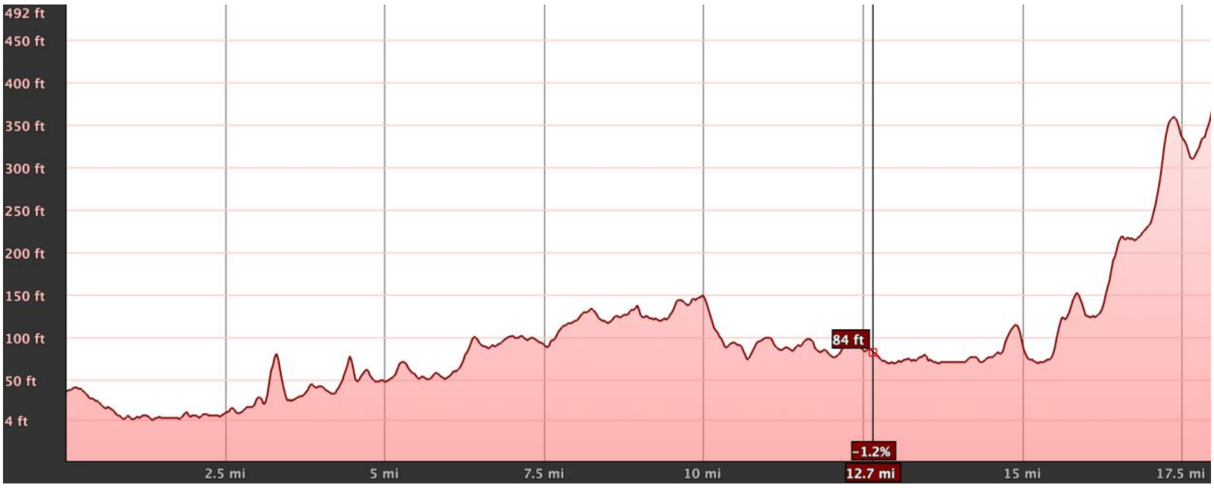


Figure 6.5 – Slice Terrain Elevation Profile

Figure 6.6 – Left Slice 8° Terrain Elevation Profile

7 RECOMMENDATIONS

7.1 Flight Trials

Additional flight trials should be conducted at the next routine ILS flight inspection to assess the RF signal levels for an extended level Glide Path run at an altitude of 2,600 ft.

7.2 ILS Computer Simulations

The proposed Violet Hill Wind Farm site is within the Shannon Runway 24 Localiser lateral coverage sector (see Figure 3.3 above).

As the proposed Violet Hill Wind Farm site is within 8° azimuth and 1.3° 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 10 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.

8 CONCLUSIONS

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

However, for the slice and left slice 8° profiles, the proposed wind farm will require that these profiles are flown at higher altitudes to provide sufficient clearance above the proposed wind turbines.

The flight inspection Glide Path left slice 8° profile (level run) will have to be raised to an altitude of 2,600ft in IMC to provide the flight inspection aircraft adequate coverage over the proposed wind turbines.

This will result in increased flight inspection costs for the extended Glide Path level runs. If there is insufficient Glide Path RF signal for the extended level run at 2,600 ft then it may not be possible to conduct this flight inspection in conditions of bad visibility. This may result in additional cost if the flight inspection aircraft is delayed while waiting for VFR conditions.

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 7

Violet Hill Wind Farm Radar Assessment

Violet Hill Wind Farm Radar Assessment

Ai Bridges Limited

01 September 2021

CL-5693-RPT-002 V1.0

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Executive Summary

Cyrrus Limited has been engaged by Ai Bridges Limited to provide guidance on aviation issues arising from the planned development of Violet Hill Wind Farm in County Clare in the West of Ireland. The proposed wind farm comprises 18 turbines with maximum tip heights of 185m.

Detailed radar modelling of the indicative layout against the combined Primary Surveillance Radar/Monopulse Secondary Surveillance Radar (PSR/MSSR) facility at Shannon Airport shows the following:

- Radar Line of Sight (RLoS) exists between Shannon PSR and all 18 proposed turbines;
- There is a high probability that Shannon PSR will detect all of the Violet Hill turbines, leading to turbine-induced clutter and false targets, and track seduction of aircraft targets;
- Mitigation for Shannon PSR may be required;
- The proposed turbine sites are outside the Eurocontrol recommended 16km turbine assessment zone for Shannon MSSR, therefore an impact assessment for the facility was not required;
- No mitigation measures are considered necessary for Shannon MSSR.

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

- RLoS exists between Woodcock Hill MSSR and all 18 proposed turbine towers;
- Bistatic reflections from these turbine towers 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.

Possible mitigation solutions for Shannon PSR include blanking of PSR transmissions over the wind farm. This can be combined with the application of a Transponder Mandatory Zone in the affected airspace, or with in-fill data from a remote radar source.

Existing remote PSR data can be used as in-fill provided it has suitable airspace coverage and does not have visibility of the turbines. This relies on suitable terrain screening and can be problematic in terms of synchronisation and slant range errors.

In-fill mitigation can be provided using a dedicated 2D radar from a company such as Terma. The mitigation radar must be located in close proximity to the airport PSR and be synchronised with it. Terma radars filter out turbines while continuing to track aircraft.

The Aveillant Holographic Radar™ offers a 3D radar mitigation solution that can discriminate turbines from aircraft without the need for masking. It does not require locating close to the airport PSR and its target output can be coordinate transformed to the PSR origin without slant range errors.

Abbreviations

AGL	Above Ground Level
AMSL	Above Mean Sea Level
ATCO	Air Traffic Control Officer
CFAR	Constant False Alarm Rate
DOC	Designated Operational Coverage
DTM	Digital Terrain Model
MSSR	Monopulse Secondary Surveillance Radar
MTZ	Mandatory Transponder Zone
NM	Nautical Miles
PD	Probability of Detection
PSR	Primary Surveillance Radar
RCS	Radar Cross Section
RLoS	Radar Line of Sight
RPM	Revolutions Per Minute
VPD	Vertical Polar Diagram

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1. Introduction

1.1. Background

1.1.1. A new wind farm development, Violet Hill Wind Farm, is being proposed in County Clare in the West of Ireland. The proposed development is planned to comprise 18 wind turbines with a maximum tip height of up to 185m Above Ground Level (AGL).

1.2. Aviation Assessment

1.2.1. Cyrrus Limited has been engaged by Ai Bridges Limited to provide guidance on aviation issues arising from the planned development of Violet Hill Wind Farm.

1.2.2. Specifically, this report is concerned with the possible impacts the turbines may have on the combined Primary Surveillance Radar/Monopulse Secondary Surveillance Radar (PSR/MSSR) facility at Shannon Airport and the MSSR facility at Woodcock Hill. Radar Line of Sight (RLoS) assessments will determine the degree of visibility of the proposed turbines to each of the radars and detailed Probability of Detection (PD) calculations will assess the likelihood of an impact on radar caused by signal reflections from the turbine blades and towers.

2. Evaluation Tools Used

2.1. Software

- ATDI HTZ communications v23.3.4 x64;
- Global Mapper v21.1;
- ZWCAD+ 2015 SP1 Pro v2014.11.27(26199).

2.2. Terrain Data

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

2.3. Data Provided by the Client

- AB 25.06.21 Violet Hill Wind Farm Aviation Consultation Review.pdf;
- AB 16.07.21 Violet Hill Wind Farm - Radar Surveillance Desktop Review (....pdf;
- AB 19.07.21 Violet Hill Wind Farm Radar Technical Assessment Requirement....pdf.

3. Development

3.1. Location

3.1.1. The indicative 18 turbine layout used for the modelling is shown in Figure 1.

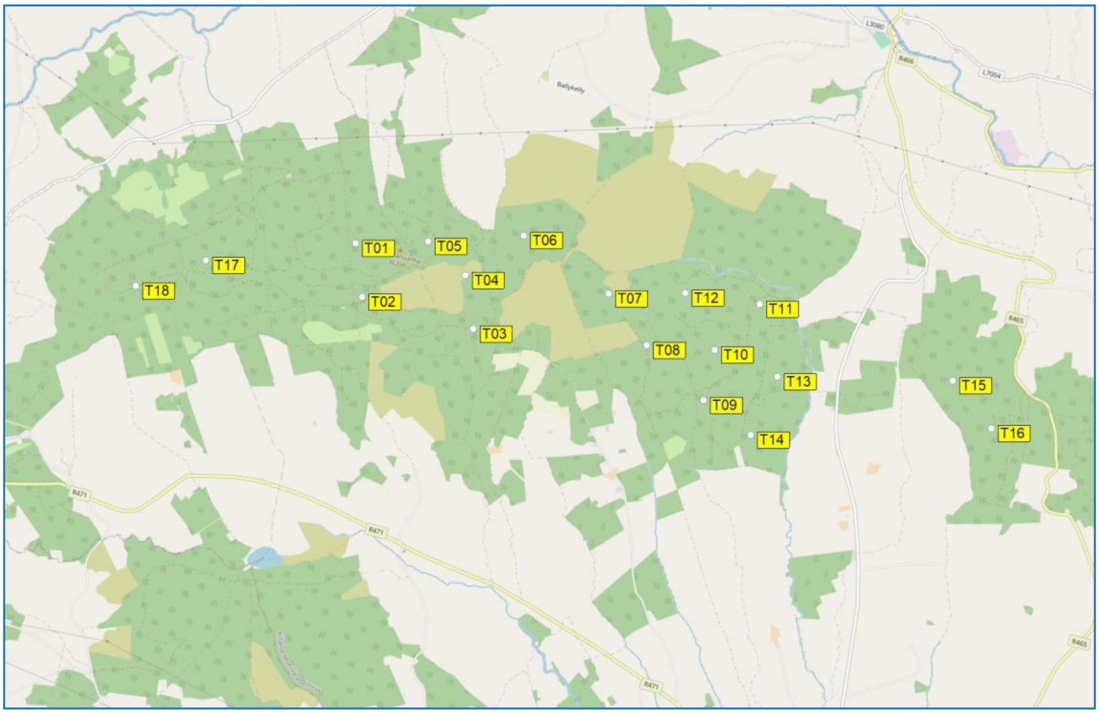

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Figure 1: Indicative turbine layout

3.2. Turbine Data

3.2.1. Each turbine has a planned tip height of 185m AGL and a rotor diameter of 155m. Turbine blade length is thus 77.5m and hub height is 107.5m AGL.

3.2.2. The locations of the 18 proposed turbines were supplied by the Client. The Irish Transverse Mercator grid coordinates for each turbine are presented in Table 1.

Turbine ID	Easting	Northing
T01	553159	669794
T02	553332	669350
T03	554359	669318
T04	554176	669759
T05	553781	669968
T06	554589	670222
T07	555442	669913

Turbine ID	Easting	Northing
T08	555881	669555
T09	556491	669215
T10	556477	669664
T11	556762	670152
T12	556098	670086
T13	557076	669576
T14	556971	669020
T15	558585	669916
T16	559020	669597
T17	551911	669321
T18	551370	668955

Table 1: Turbine coordinates

4. Radar Assessment

4.1. Potential Impact of Wind Turbines on PSR

4.1.1. A PSR transmits pulses of energy that are reflected back to the radar's receiver by objects that are within RLoS. Wind turbines can act as reflectors presenting a static target to the radar system. This phenomenon is no different to any other reflection received from ground obstacles (buildings, electricity pylons etc) except that each turbine structure reflects an amount of energy several orders of magnitude larger than that caused by an aircraft. This has the potential effect of causing a shadow behind the obstacle rendering the receiver blind to wanted targets in the immediate area beyond the turbine. It is thus not possible to reduce the gain of the radar in this range cell and still see the wanted targets.

4.1.2. PSRs will 'see' any reflecting object that the radar energy illuminates. To discriminate wanted targets (aircraft) from the unwanted clutter, the radar ignores static objects and only displays moving targets. The rotating blades of a wind turbine impart a Doppler frequency shift to the reflected radar pulse, which the radar receiver 'sees' as a moving target; these targets are then presented on the Air Traffic Control Officers (ATCOs) radar display as primary radar returns, indistinguishable from those returns originating from aircraft. This is not a steady effect but has dependency on the axis of rotation of the turbine in relation to the radar. Such unwanted radar returns are known as 'clutter'.

4.1.3. PSRs are usually designed to manage the amount of clutter within defined cells using Constant False Alarm Rate (CFAR) algorithms. In areas of high clutter returns, as experienced from wind turbines, the CFAR action is to reduce the sensitivity of the receiver. Whilst this has the positive benefit of keeping the displayed data usable by the ATCOs rather than being totally swamped with clutter returns, it does have the adverse effect of reducing the PD of aircraft within the affected cells.

4.1.4. A consequence of these effects is that the tracking mechanism in the radar processing is no longer able to reliably report the aircraft's passage in the vicinity of the turbines. The aircraft's track is liable to either be lost or 'seduced' by the turbine returns to create an erratic course.

4.1.5. If the radar cannot distinguish a wanted target (aircraft) amongst the returns originated by the turbines it can result in an undecipherable data display to the ATCO. In the worst case, the presence of a real aircraft, possibly in confliction with another aircraft under control, may be hidden by turbine-induced clutter or a desensitized receiver thereby increasing the risk of collision. Furthermore, false targets when presented on the ATCO's radar screen may appear as conflicting traffic to other real aircraft, resulting in the issuance of unnecessary avoiding action. In addition, the establishment by the ATCO of aircraft identity may be delayed or subsequently lost altogether in the vicinity of a wind farm.

4.2. Potential Impact of Wind Turbines on MSSR

4.2.1. Unlike PSR, 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. Range and azimuth information is derived in the same way as PSR, but 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.

4.2.2. 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.

4.2.3. 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 2: Direct interrogation and reply pulses

4.2.4. In Figure 2, 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.

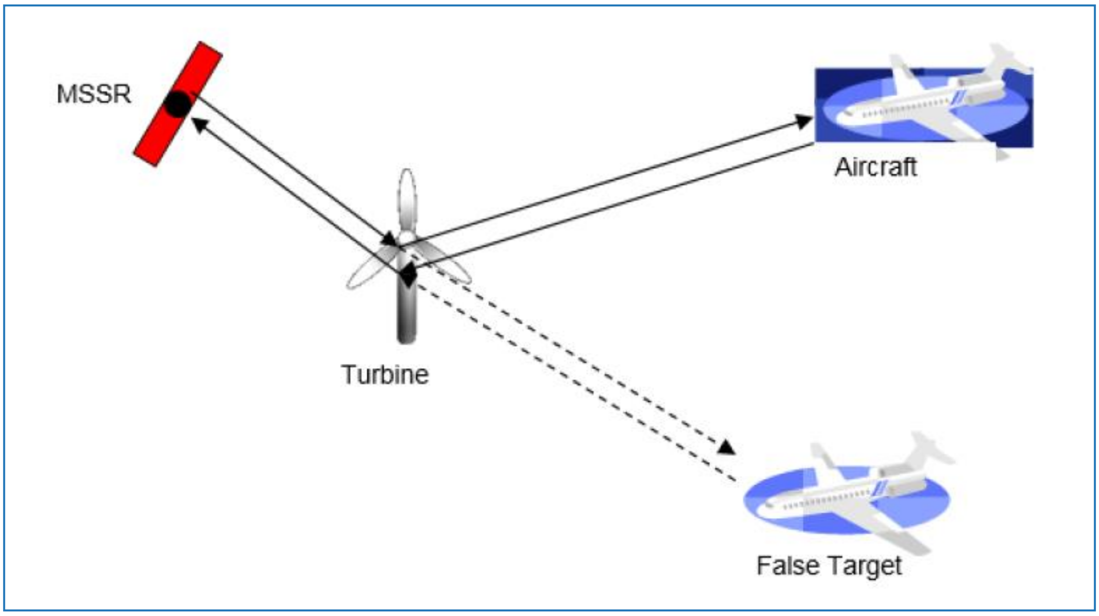

Figure 3: Reflected interrogation and reply pulse

4.2.5. In Figure 3, 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.

4.2.6. Objects can produce a radar shadow in the airspace behind the object. As a wind turbine is narrow compared to the radar beam width, assuming the turbine is >2km 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 tower, 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 where the turbine is in the direct RLoS between the radar and the aircraft target.

4.3. Shannon Airport Radar

4.3.1. The radar at Shannon Airport is a combined head with co-mounted PSR and MSSR antennas.

4.3.2. The PSR model is a Thales Star 2000, operating in the S-Band frequency, turning at 15 Revolutions Per Minute (RPM) and with an instrumented range of 60 Nautical Miles (NM). As with all PSRs of this type, it is vulnerable to the adverse effects of wind turbines, however, Thales claim to have newer processing capabilities which are more turbine tolerant.

4.3.3. The MSSR model is a Thales RSM 970 S. It meets the current standard of MSSR capability to the European Mode S Functional Specification[1] and has an instrumented range of 256NM.

Image © 2021 Google © 2021 Europa Technologies

Figure 4: Shannon PSR/MSSR

4.3.4. The WGS84 coordinates for the radar are: 52° 42' 05.03'' N, 08° 56' 11.74'' W

4.3.5. The PSR antenna height is 16m AGL, the MSSR antenna height is 18m AGL.

4.3.6. The location of Shannon PSR/MSSR is shown in Figure 5.

[1] EUROCONTROL European Mode S Station Functional Specification v3.11, May 2005

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Figure 5: Location of Shannon PSR/MSSR

4.4. Woodcock Hill Radar

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

Image © 2021 Google

Figure 6: Woodcock Hill MSSR

4.4.2. The WGS84 coordinates for the radar are: 52° 43' 15.77'' N, 08° 42' 26.78'' W

4.4.3. The MSSR antenna height is 10m AGL.

4.4.4. The location of Woodcock Hill MSSR is shown in Figure 7.

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Figure 7: Location of Woodcock Hill MSSR

4.5. Locations of Turbines and Radars

4.5.1. The relative locations of the proposed turbines and the radars at Shannon Airport and Woodcock Hill are shown in Figure 8.

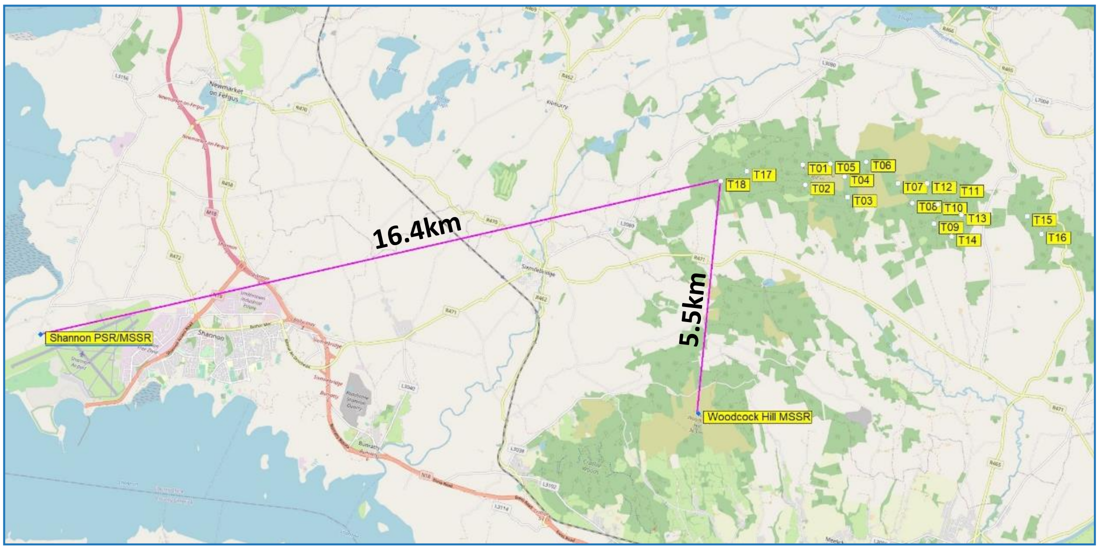

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Figure 8: Locations of radars and proposed turbines

4.5.2. The closest proposed turbine within Violet Hill Wind Farm (T18) is 16.4km from the Shannon PSR/MSSR, and 5.5km from Woodcock Hill MSSR.

4.5.3. In accordance with Eurocontrol Guidelines[2], the wind turbine assessment zone for MSSR facilities extends to 16km. Beyond this range the impact of a wind turbine is considered to be tolerable. Therefore, an assessment of the impact on the Shannon MSSR is not required.

4.6. Radar Line of Sight Modelling

4.6.1. RLoS is determined from a radar propagation model (ATDI HTZ communications) using 3D DTM data with a 25m horizontal resolution. Radar data is entered into the model and RLoS to the turbines from the radars is calculated.

4.6.2. 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, the RLoS assessments are worst-case results.

4.6.3. For PSR, the principal sources of adverse wind farm effects are the turbine blades, so for Shannon PSR RLoS is calculated for the maximum tip height of the turbines, i.e. 185m AGL.

4.6.4. In the case of MSSR, adverse effects are generated by the turbine towers, so for Woodcock Hill MSSR RLoS is calculated for the maximum hub height of the turbines, i.e. 107.5m AGL.

4.6.5. A 3D view of the turbines and the terrain model, as viewed from Shannon PSR/MSSR, is shown in Figure 9.

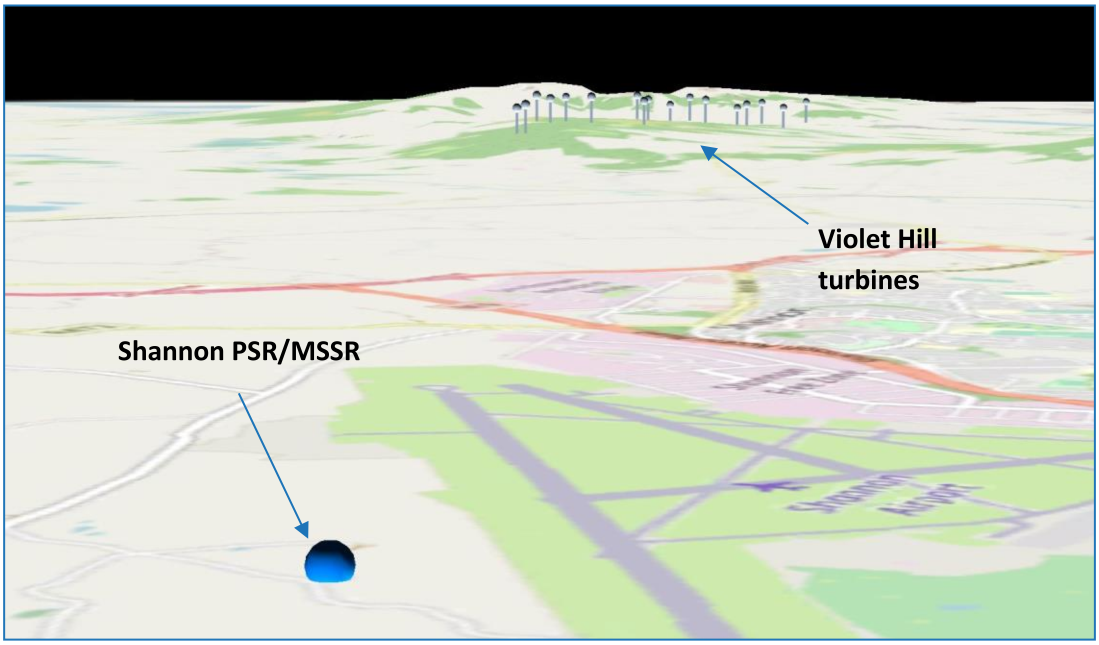

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Figure 9: 3D view from Shannon PSR/MSSR towards turbines

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

4.6.6. The magenta shading in Figure 10 illustrates the RLoS coverage from Shannon PSR to turbines with a blade tip height of 185m AGL.

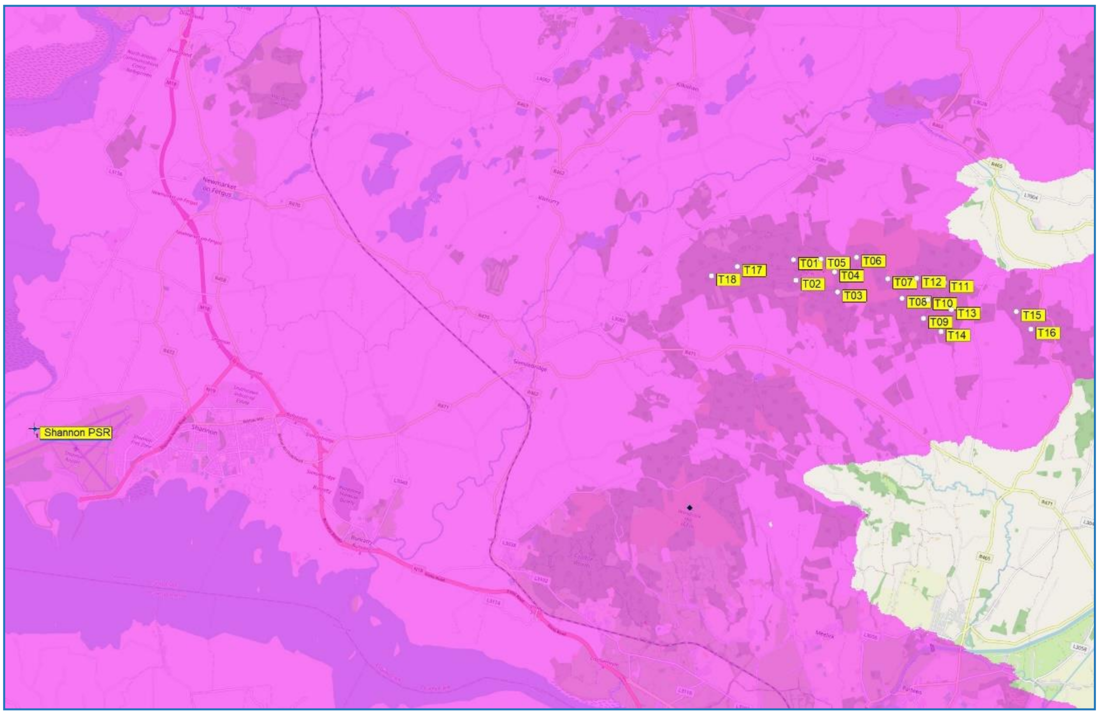

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Figure 10: Shannon PSR RLoS to 185m AGL

4.6.7. RLoS exists between Shannon PSR and all of the turbines in the indicative layout.

4.6.8. A 3D view of the turbines and the terrain model, as viewed from Woodcock Hill MSSR, is shown in Figure 11.

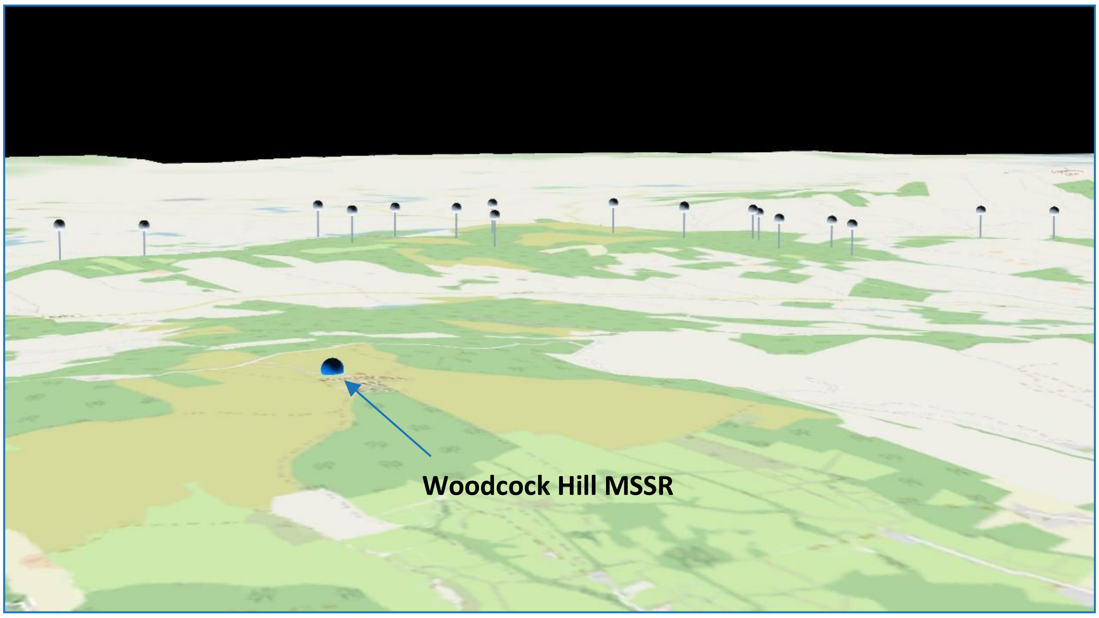

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Figure 11: 3D view from Woodcock Hill MSSR towards turbines

4.6.9. The magenta shading in Figure 12 illustrates the RLoS coverage from Woodcock Hill MSSR to turbines with a tower hub height of 107.5m AGL.

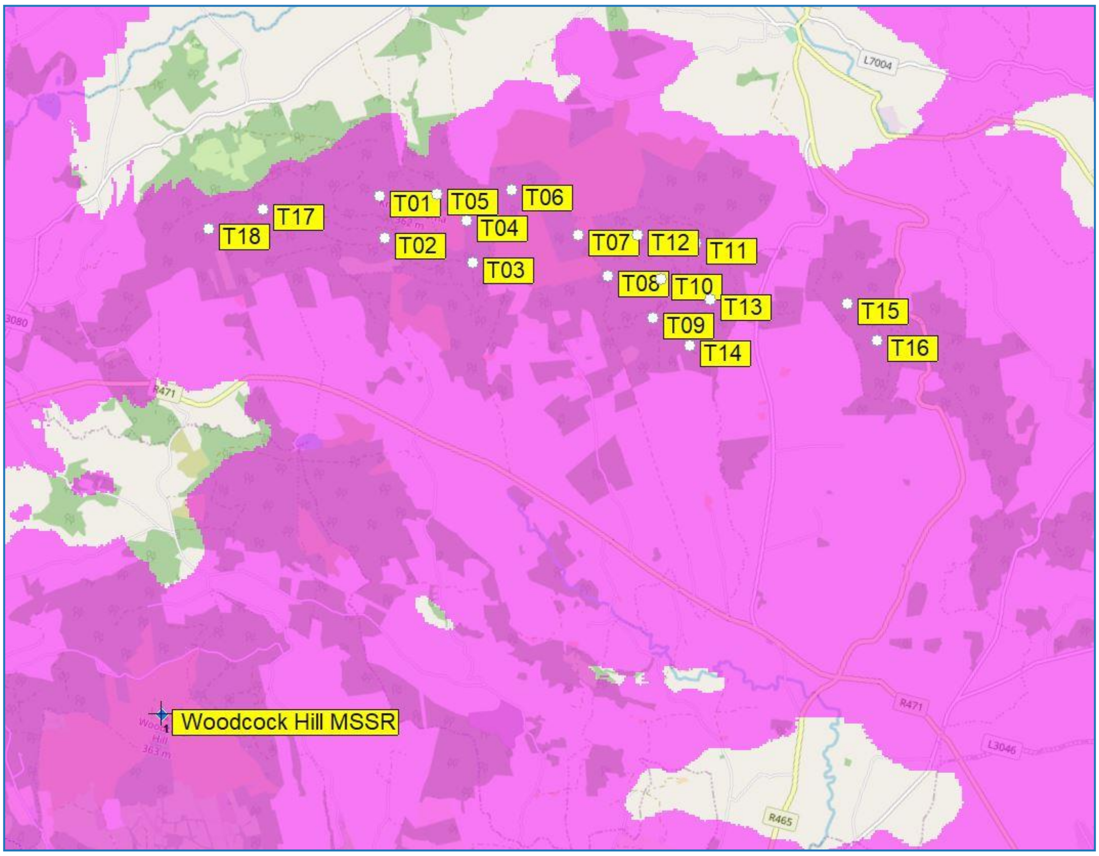

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Figure 12: Woodcock Hill MSSR RLoS to 107.5m AGL

4.6.10. RLoS exists between Woodcock Hill MSSR and all of the turbines in the indicative layout.

4.7. Shannon PSR Path Loss and Probability of Detection

4.7.1. Using the radar propagation model the actual path loss between Shannon PSR and various parts of each turbine can be determined.

4.7.2. An illustration of the path loss profile between Shannon PSR and turbine T01 is shown in Figure 13. As with all the other Violet Hill turbines, Shannon PSR has uninterrupted RLoS to the turbine tip.

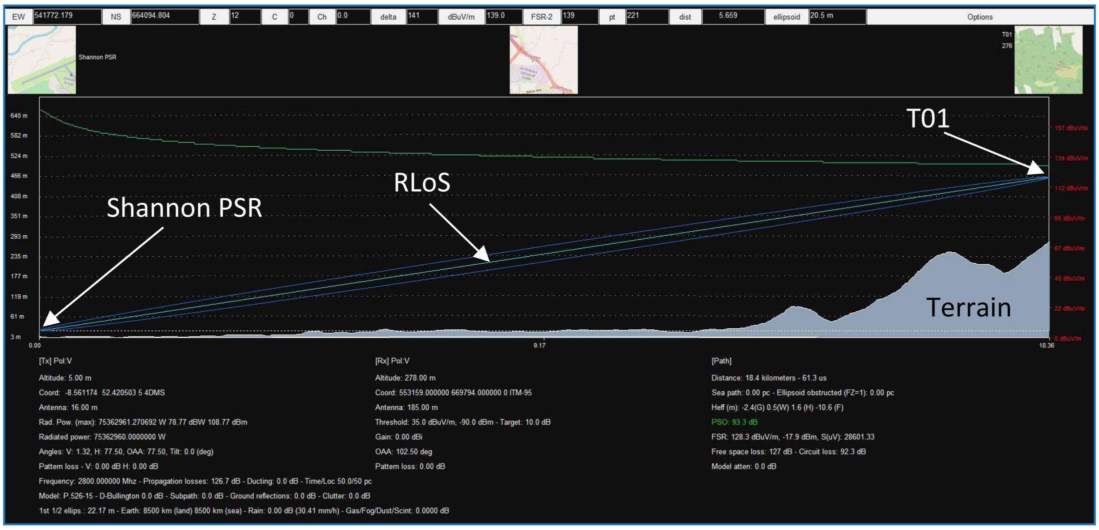


Figure 13: Path loss profile between Shannon PSR and tip of turbine T01

4.7.3. All of the path profiles between Shannon PSR and the 18 Violet Hill turbines are shown in Annex A of this report.

4.7.4. Even with no intervening terrain between the PSR and the turbines, the probability that a turbine will be detected by the radar is still dependant on several factors including the radar's power, the angle of antenna tilt and distance to the turbine.

4.7.5. The radar propagation model can determine the actual path loss between the PSR and various parts of the turbine. By knowing the PSR transmitter power, antenna gain, 2-way path loss, receiver sensitivity and the turbine Radar Cross Section (RCS) gain, the probability of the radar detecting the target (PD) can be calculated.

4.7.6. The static parts of the turbine (tower structure) are ignored in the calculation as these will be rejected by the radar Moving Target filter. In this refined model, 3 parts of the turbine blade are considered: the hub, the blade tip, and a point midway along the turbine blade. Each part of the turbine blade is assigned an RCS of 60m^2 based on a blade length of 77.5m (half of 155m rotor diameter). Path loss calculations are made to all turbines. The received signal at the radar from each component part of the turbine is then summed to determine the total signal level.

4.7.7. The path loss calculation carried out for each turbine component is as follows:

	Tx Power	dBm
+	Antenna Gain	dB
-	Path Loss	dB
+	RCS Gain	dB (60m^2 ~ +48dB)
-	Path Loss	dB
+	Antenna Gain	dB
=	Received Signal	dBm

4.7.8. The received signal is then compared with the radar receiver Minimum Detectable Signal level.

4.7.9. An example of the calculation from Shannon PSR to turbine T01 is shown in Figure 14.

Radar 2-Way Path Loss Calculator

Data		
Tx Frequency	2800	MHz
Tx Power	28000	Watts
Antenna Gain	34	dBi
Rx Sensitivity	-125	dBm
Target		
RCS	60	m^2
Path Loss (1-way)	126.7	dB
Calculations		
Tx Wavelength	0.11	m
Tx power	74.47158	dBm
EIRP	108.4716	dBm
Power at Target	-18.2284	dBm
RCS Gain	48.18	dB
Power at Rx	-62.75	dBm
dB over Rx Threshold	62.25	dB

Figure 14: Example path loss calculation

4.7.10. The two-way path losses from the turbine components are tabulated and combined to give total radar received signals from each turbine. The results are colour-coded to indicate the likelihood of detection. Radar returns >3dB above the detection threshold are coloured green as these values show a high probability of detection. Those between +3dB and -3dB are coloured yellow and indicate a possibility of detection. Between -3dB and -6dB, results are coloured orange to show only a small possibility of detection. Signals >6dB below the threshold of detection are shaded red as these values show that detection is unlikely.

4.7.11. Using this representation provides a ready visual comparison of different scenarios. The final result is shown in the final column (TOTAL) of each colour-coded chart.

4.7.12. The results of the Shannon PSR PD calculations for each turbine are shown in Table 2.

Initial data from '2-Way'			KEY:	Unlikely to be detected
A	126.7	Path Loss		Small possibility of detection
B	62.25	dB over Rx Thr		Possibility of detection
C	60.00	RCS (m^2)		High probability of detection
	Turbine Nacelle	Blade mid-point	Blade Tip	TOTAL
Turbine	Path Loss dB	Path Loss dB	Path Loss dB	dB over RX threshold
1	126.7	126.7	126.7	67.03
2	126.6	126.6	126.6	67.23
3	127.1	127.1	127.1	66.23
4	127.1	127.1	127.1	66.23
5	127.0	127.0	127.0	66.43
6	127.3	127.3	127.3	65.83
7	127.6	127.6	127.6	65.23
8	127.7	127.7	127.7	65.03
9	127.9	127.9	127.9	64.63
10	128.0	128.0	128.0	64.43
11	142.3	128.1	128.1	62.47
12	127.9	127.9	127.9	64.63
13	134.6	128.2	128.2	62.38
14	128.0	128.0	128.0	64.43
15	128.8	128.8	128.8	62.83
16	128.9	128.9	128.9	62.63
17	126.0	126.0	126.0	68.43
18	125.7	125.7	125.7	69.03

Table 2: Shannon PSR PD results

4.7.13. From Table 2 it appears that there is a high probability that Shannon PSR will detect all of the Violet Hill turbines.

4.7.14. The above calculations are based on the optimum performance of the radar, however the gain of a radar antenna in the vertical axis is not uniform with elevation angle. The beam is a complex shape to minimise ground returns by having low gain at elevations close to the horizontal but having high gain at elevations just a few degrees above the horizon.

4.7.15. The Star 2000 PSR has a dual beam antenna. At short ranges the radar uses a high beam to reduce the effects of close-in ground clutter. Beyond these ranges a low beam is used. It is likely that the proposed wind farm lies in Shannon PSR's high beam area.

4.7.16. The maximum high beam gain for a Star 2000 antenna usually occurs at an elevation angle of 6.5° above the horizontal. If the mechanical tilt of the antenna is altered, then the angle of maximum gain will change by a corresponding amount. The mechanical tilt of the antenna is set at the commissioning of the radar to achieve the best compromise between suppressing ground returns and detecting low altitude aircraft targets. Gain falls off rapidly at lower elevation angles as a function of the antenna Vertical Polar Diagram (VPD). Radar VPD data can be plotted as a smoothed line of elevation versus gain to enable intermediate values of antenna gain to be determined.

4.7.17. The Star 2000 VPD data gives the graph shown in Figure 15.

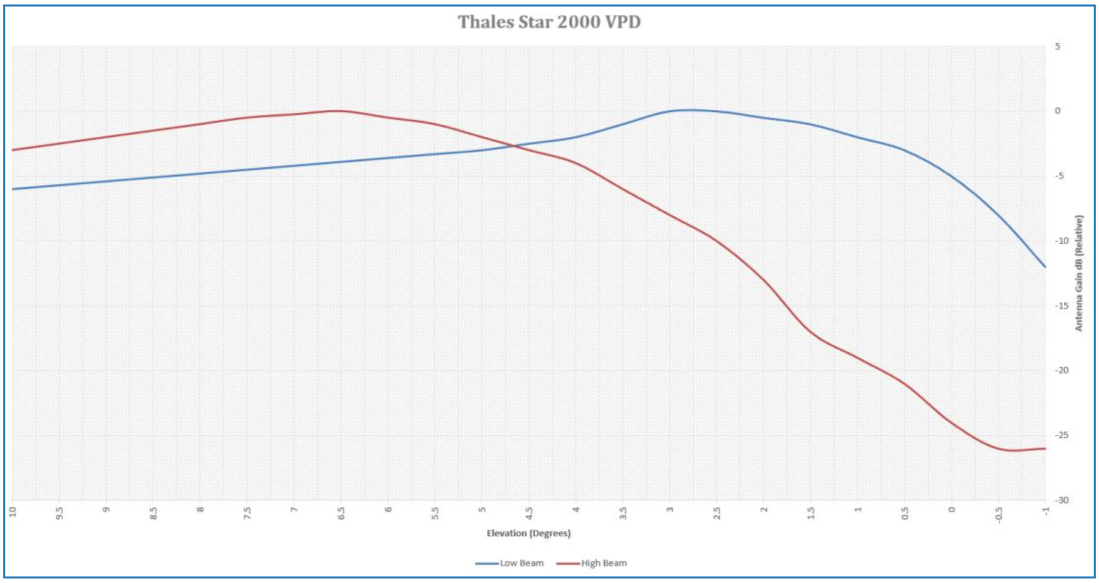


Figure 15: Thales Star 2000 VPD

4.7.18. The vertical angle from Shannon PSR to the tips of the turbines varies between 0.76° and 1.33°. If a 0° mechanical antenna tilt is assumed, this means a high beam gain reduction of approximately -19dB at these elevations. Table 3 shows the results of the PD calculations incorporating the reduction in antenna gain.

Initial data from '2-Way'			KEY:	Unlikely to be detected
A	**126.7**	Path Loss		Small possibility of detection
B	**41.25**	dB over Rx Thr		Possibility of detection
C	**60.00**	RCS (m^2)		High probability of detection

Turbine	Turbine Nacelle Path Loss dB	Blade mid-point Path Loss dB	Blade Tip Path Loss dB	TOTAL dB over RX threshold
1	126.7	126.7	126.7	46.03
2	126.6	126.6	126.6	46.23
3	127.1	127.1	127.1	45.23
4	127.1	127.1	127.1	45.23
5	127.0	127.0	127.0	45.43
6	127.3	127.3	127.3	44.83
7	127.6	127.6	127.6	44.23
8	127.7	127.7	127.7	44.03
9	127.9	127.9	127.9	43.63
10	128.0	128.0	128.0	43.43
11	142.3	128.1	128.1	41.47
12	127.9	127.9	127.9	43.63
13	134.6	128.2	128.2	41.38
14	128.0	128.0	128.0	43.43
15	128.8	128.8	128.8	41.83
16	128.9	128.9	128.9	41.63
17	126.0	126.0	126.0	47.43
18	125.7	125.7	125.7	48.03

Table 3: Shannon PSR PD results – corrected for VPD

4.7.19. Despite the gain reduction, there is still a high probability that Shannon PSR will detect all of the Violet Hill turbines.

4.8. Woodcock Hill MSSR Path Loss

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

4.8.2. An illustration of the path loss profile between Woodcock Hill MSSR and turbine T01 is shown in Figure 16. As with all the other Violet Hill turbines, Woodcock Hill MSSR has uninterrupted RLoS to the top of the turbine tower.

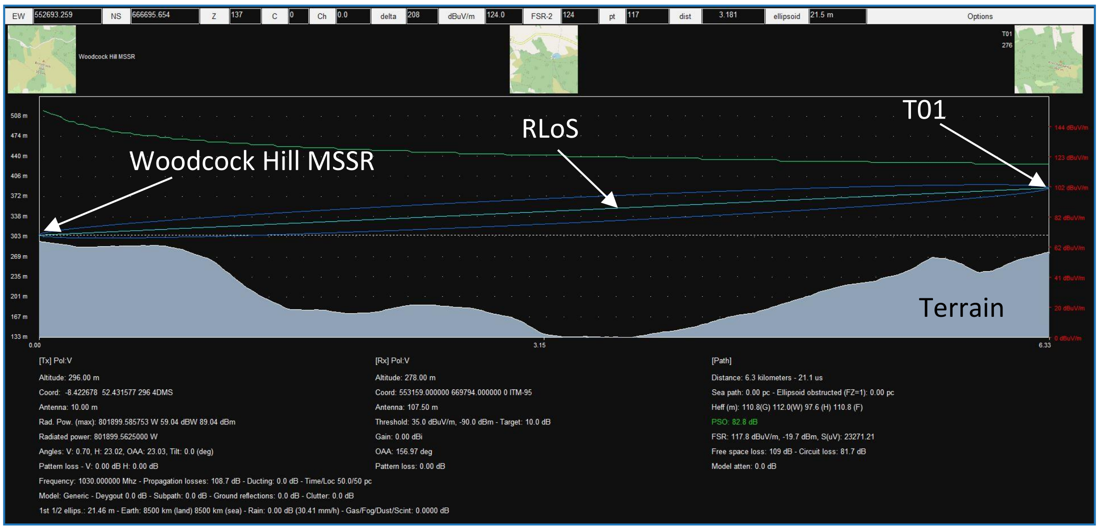


Figure 16: Path loss profile between Woodcock Hill MSSR and top of turbine tower T01

4.8.3. All of the path profiles between Woodcock Hill MSSR and the 18 Violet Hill turbines are shown in Annex B of this report.

4.8.4. As explained in Section 4.2, 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 ATCOs deconflicting real traffic from targets that do not physically exist.

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

4.8.6. 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.

4.8.7. EUROCONTROL Guidelines[3] 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.

4.8.8. 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

4.8.9. 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.

4.8.10. 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.

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

4.8.12. The path loss results between Woodcock Hill MSSR and the tops of the 18 Violet Hill turbine towers are shown in Table 4.

Turbine	Path Loss dB
T01	108.7
T02	108.1
T03	108.5
T04	109.0
T05	109.1
T06	109.7
T07	109.8
T08	109.7
T09	109.7
T10	110.1
T11	110.8
T12	110.3

[3] EUROCONTROL Guidelines for Assessing the Potential Impact of Wind Turbines on Surveillance Sensors, EUROCONTROL-GUID-0130 Edition Number 1.2, September 2014

Turbine	Path Loss dB
T13	110.5
T14	109.9
T15	111.8
T16	111.9
T17	108.0
T18	107.5

Table 4: Woodcock Hill MSSR path loss results

4.8.13. From Table 4 it can be seen that the worst-case or smallest path loss is 107.5dB to turbine T18.

4.8.14. The Tx Power for a Thales RSM 970 S MSSR is 60.35dBm at the antenna input. As with the PSR, 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 17.

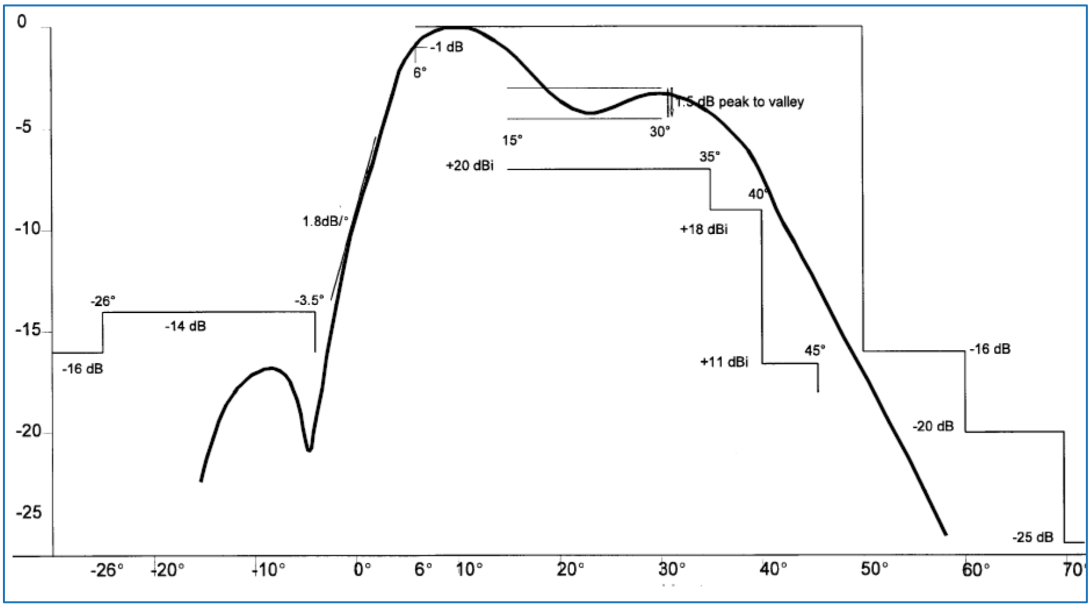


Figure 17: Thales RSM 970 S VPD

4.8.15. The vertical angle from Woodcock Hill MSSR to the hub of turbine T18 is 0.32°. If a mechanical tilt of 0° is assumed this means a reduction in gain of -7.5dB at this elevation.

4.8.16. Using these values results in a reflected power of 29.1dBm from turbine T18.

4.8.17. 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+29.1=106.1dB.

4.8.18. The Free Space Path Length for an MSSR frequency of 1030MHz and path loss of 106.1dB is 4680m. This means that aircraft beyond this distance from the turbine will not detect a reflected signal. Reflected signals from other Violet Hill turbines will only be detected at ranges less than 4680m.

4.8.19. Annex D of the EUROCONTROL Guidelines states that an airborne transponder will be insensitive for 35µs following reception of a radar interrogation through radar sidelobes. 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.

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

4.8.21. 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 (5.5 - 9.1km)
- λ = wavelength (0.29m)
- S = diameter of support structures (6m)
- PL = acceptable power loss (0.5/3dB as per guidelines)

4.8.22. The depth of the shadow region beyond each of the Violet Hill turbines will vary between 1710m and 1950m for Woodcock Hill MSSR.

4.8.23. The EUROCONTROL Guidelines also provide equations for calculating the width and height of the shadow regions. For Woodcock Hill MSSR the shadow regions will be up to 48m wide and will vary in height between 1,100ft and 1,700ft Above Mean Sea Level (AMSL). The maximum height of the shadow region for each turbine varies between approximately 25ft and 160ft above the turbine maximum tip height.

4.8.24. The volume of the Woodcock Hill MSSR shadow regions beyond the proposed turbines is considered sufficiently small to be operationally tolerable.

4.9. Conclusions

4.9.1. All the proposed Violet Hill turbines are likely to be detected by Shannon PSR. This can result in turbine-induced clutter and false targets. In such areas of high clutter, the radar receiver sensitivity is reduced which can lead to track seduction of genuine aircraft targets in the vicinity of the turbines. A form of mitigation for Shannon PSR over the proposed Violet Hill development may be required.

4.9.2. All the proposed sites for the Violet Hill turbines are outside the Eurocontrol recommended 16km turbine assessment zone for Shannon MSSR, therefore an impact assessment on this facility was not required.

4.9.3. 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.

4.9.4. No mitigation measures are considered necessary for either Shannon MSSR or Woodcock Hill MSSR.

5. Shannon PSR Mitigation

5.1. Mitigation Strategy

5.1.1. It is generally not tolerable for an airport to have to cope with a variety of mitigation solutions, each tailored for individual wind farm developments. Ideally, an airport is best served by a single coherent strategy which will cope with the turbine developments foreseen within its designated operational coverage (DOC). New development applications can then be assessed on whether they will be covered by that strategy. Terms of inclusion within the strategy can then be negotiated with the developer as part of the planning approval process. This approach keeps the airport in control of its destiny and able to work positively with the renewables industry, rather than reacting against each application on the grounds that it will cause interference.

5.2. Mitigation Solutions

5.2.1. Physical PSR mitigation options include blanking of PSR transmissions in the azimuth sector over the proposed wind farm, or suppressing radar returns in the wind farm range azimuth sector. Both of these options may need to be combined with in-fill of the blanked sector from another source of radar information.

5.2.2. An operational PSR mitigation solution could involve the application of a Mandatory Transponder Zone (MTZ) in the airspace over the PSR blanked area. An MTZ means detecting aircraft using MSSR facilities only and requires aircraft within the MTZ to be equipped with a functioning transponder.

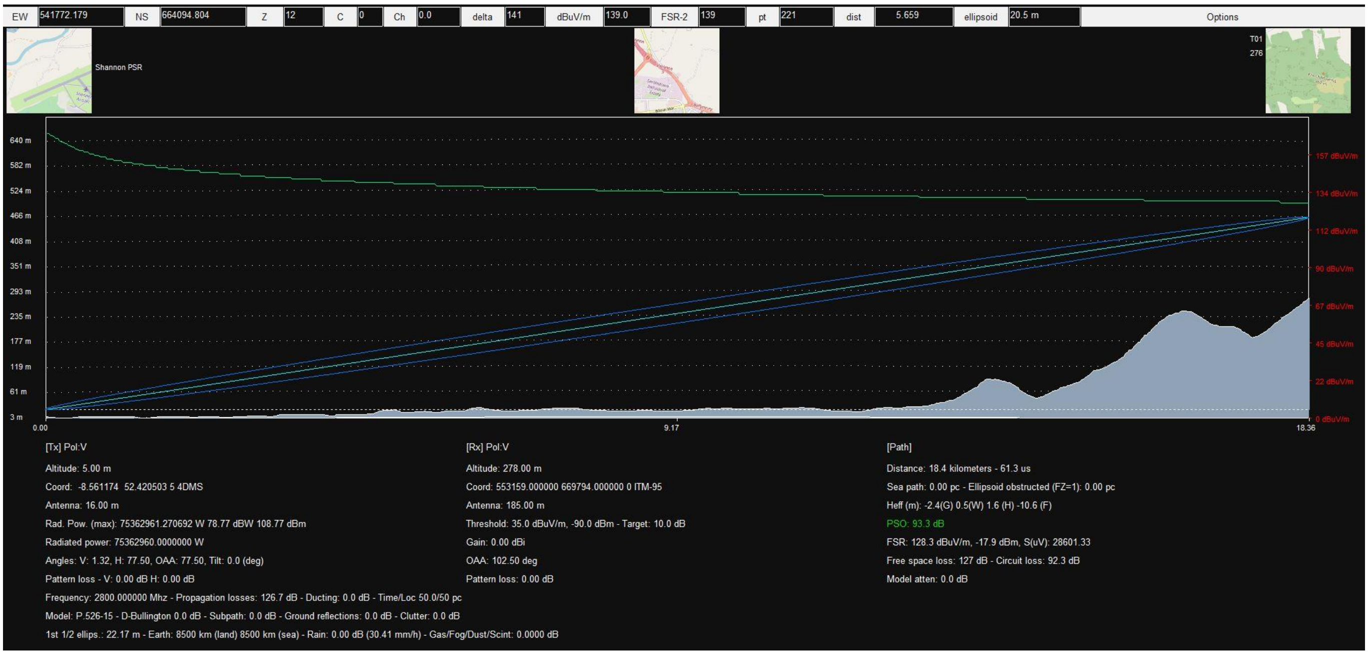
5.2.3. In-fill solutions using existing remote PSR data rely on the remote radar having suitable airspace coverage in the blanked area without having visibility of the turbines and depends on suitable terrain screening. A remote in-fill radar may also introduce problems of synchronisation with Shannon PSR and slant range errors.

5.2.4. Companies such as Terma offer dedicated 2D in-fill radar solutions for wind turbines. The in-fill radar must be located in close proximity to the airport PSR and be synchronised to it, enabling the mitigation radar to be used instead of the Airport PSR in the wind farm area. Terma radars have a narrow beamwidth that enables them to filter out turbines while continuing to track aircraft and can provide mitigation to a range of up to approximately 40NM.

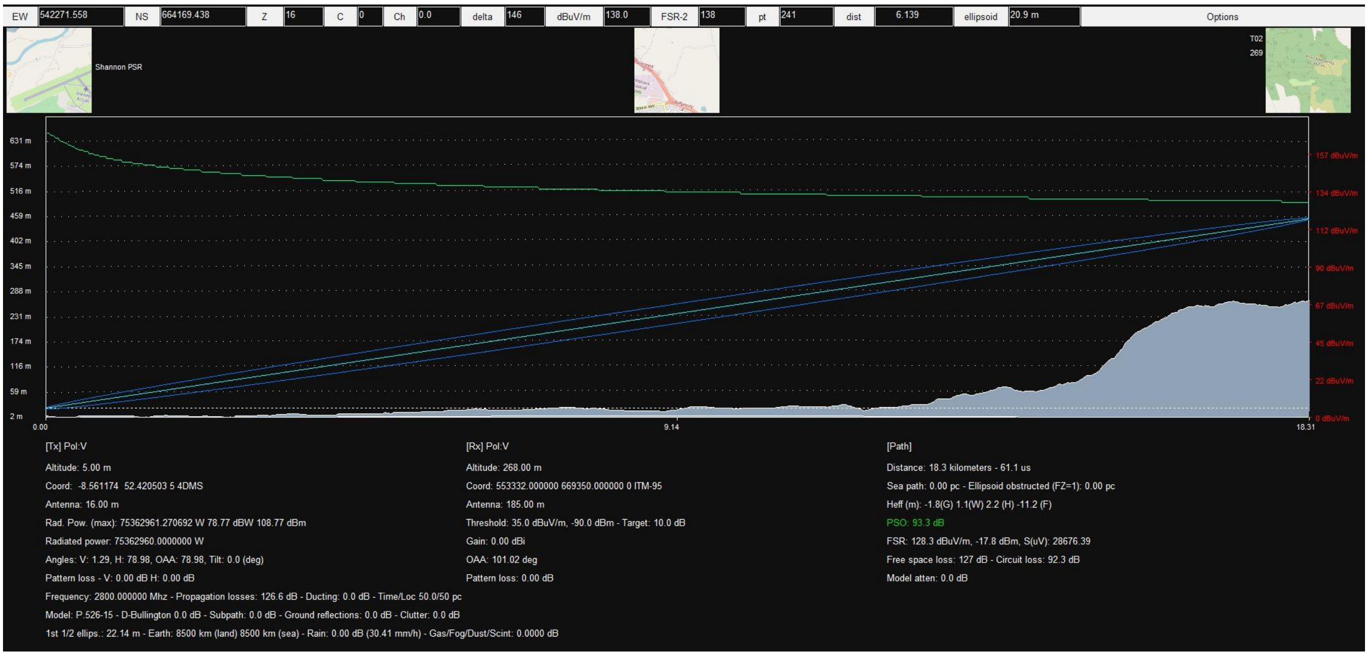
5.2.5. Aveillant offer a 3D radar mitigation solution with their Holographic Radar™. It is quite different to 2D mitigation radars as it has no rotating antenna and has continuous surveillance throughout its coverage volume. It can discriminate the distinct Doppler signatures of turbines from aircraft and as a result does not need to mask turbine returns to eliminate their false reports. The 3D output of this mitigation radar means that it does not need to be located in close proximity to the airport PSR and its target output can be coordinate transformed to the PSR origin without introducing slant range errors.

A. Annex A – Shannon PSR Path Profiles

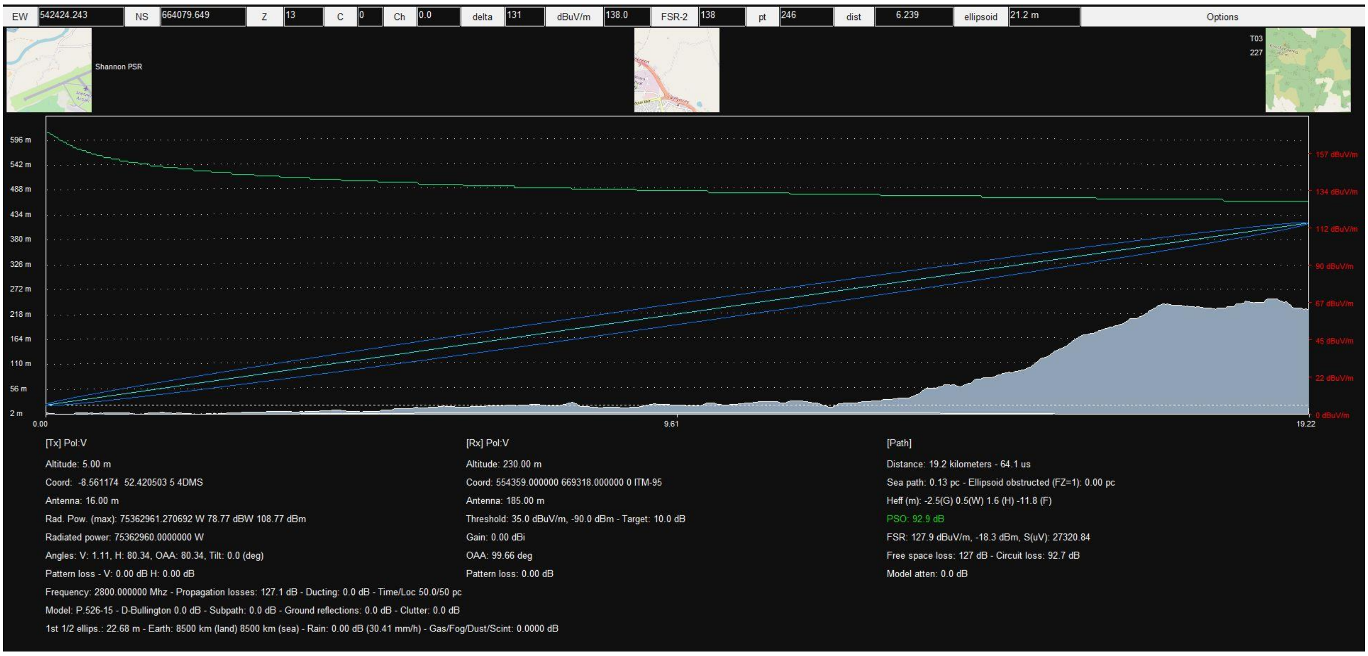
A.1. Turbine T01



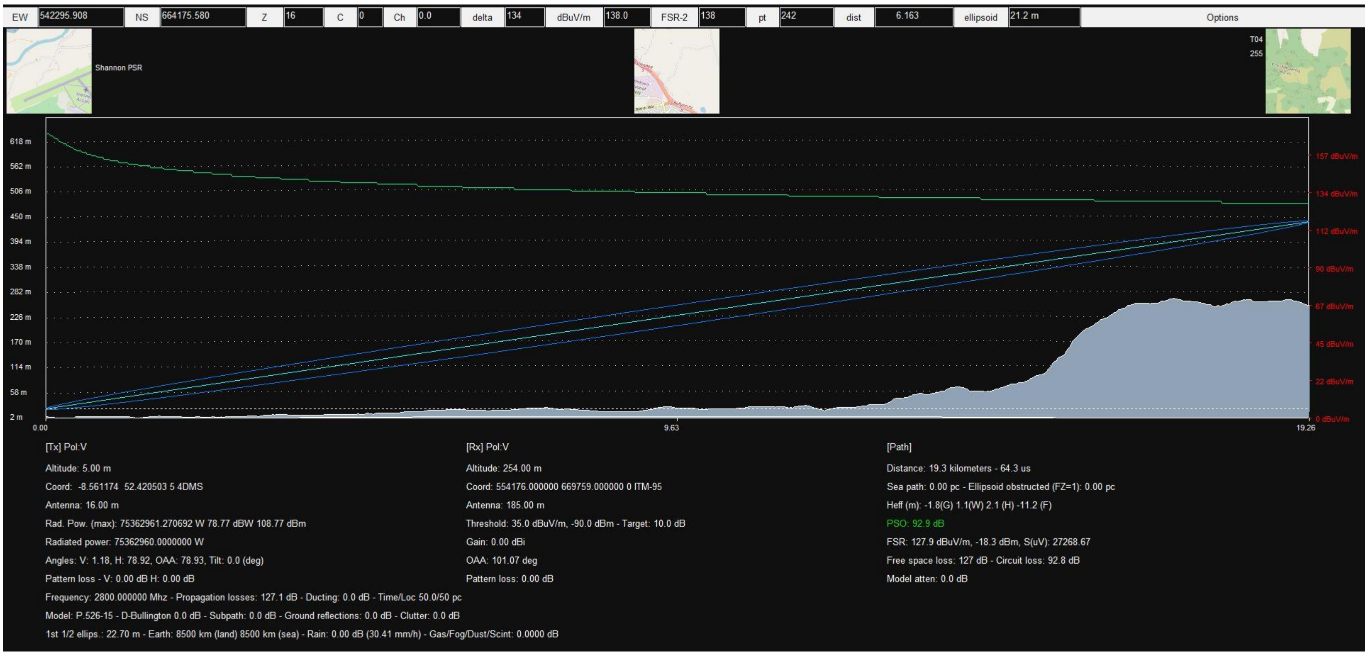
A.2. Turbine T02



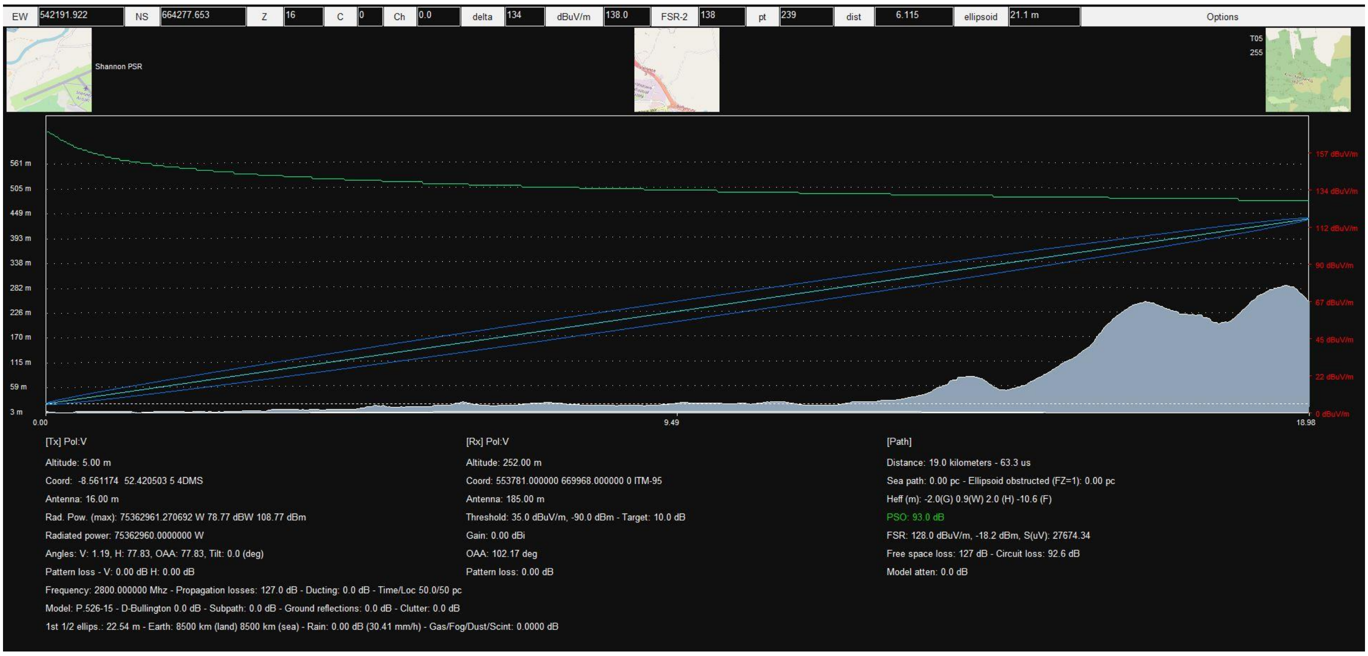
A.3. Turbine T03



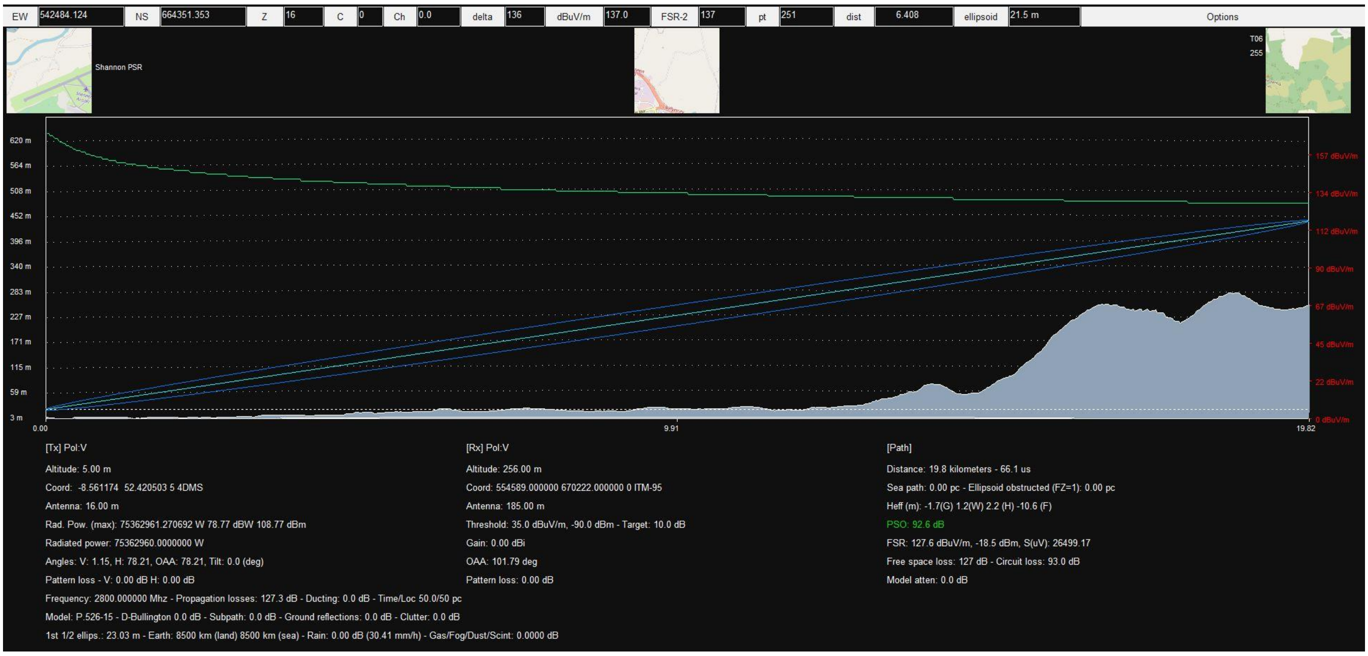
A.4. Turbine T04



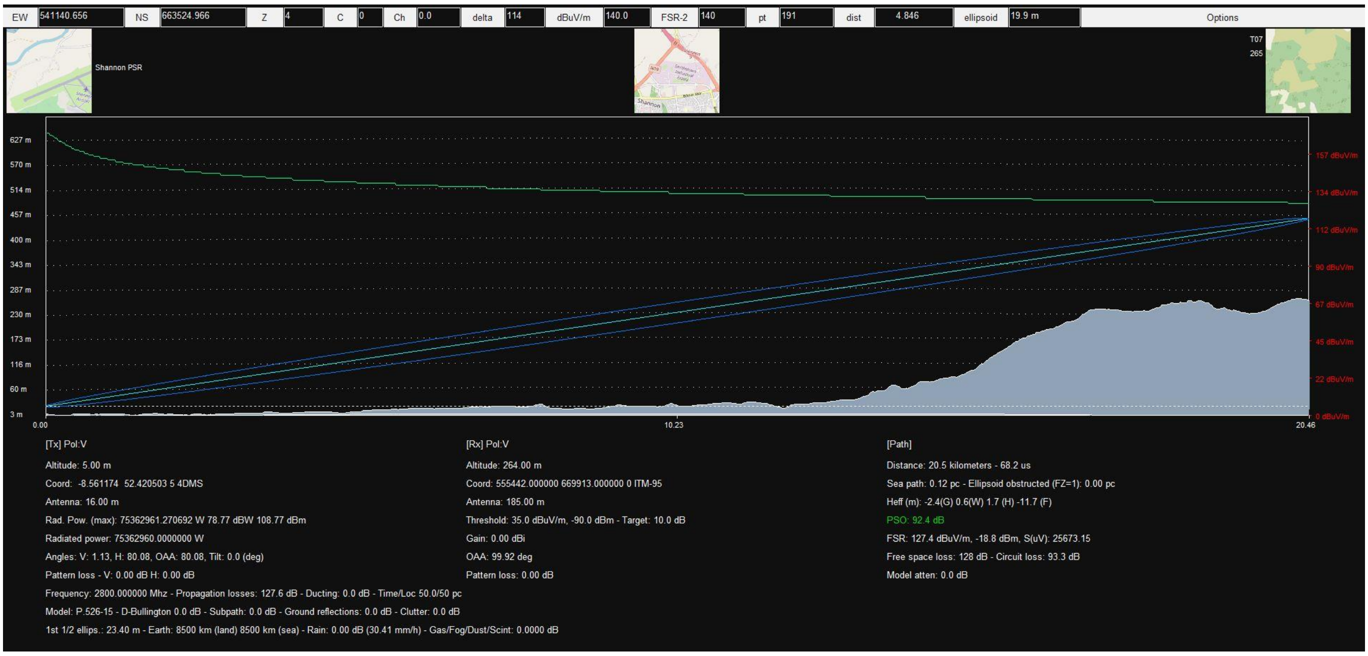
A.5. Turbine T05



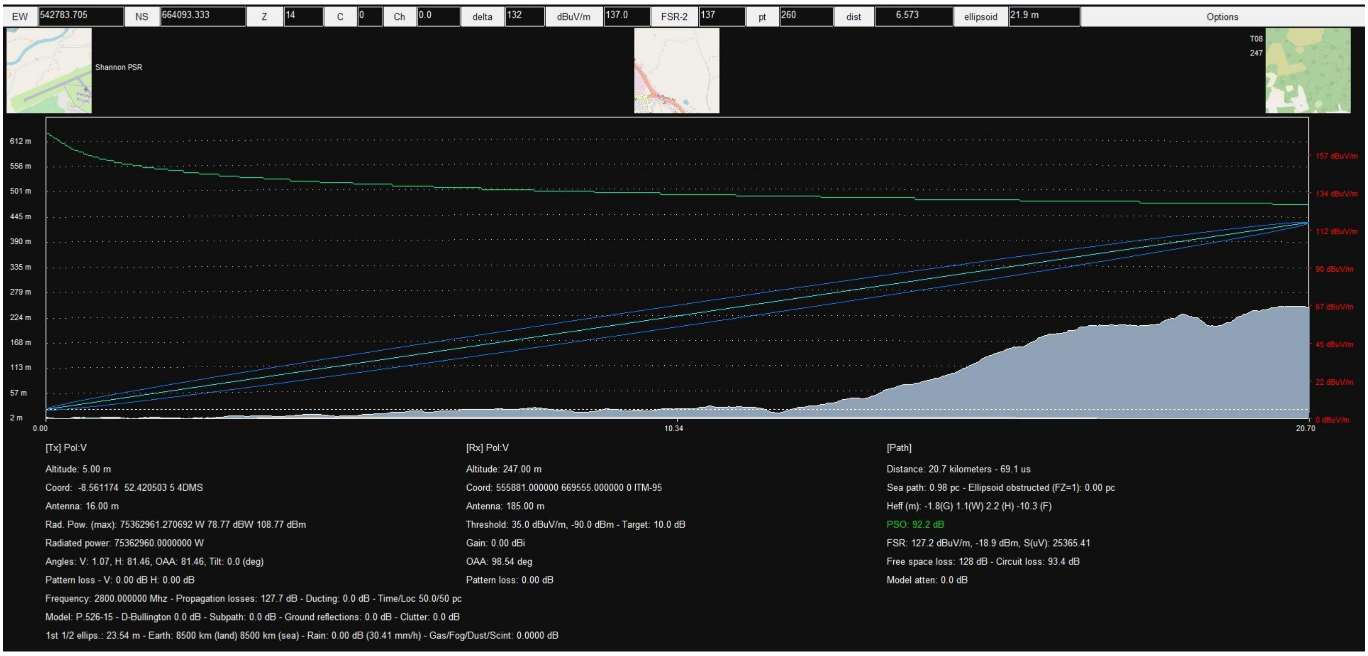
A.6. Turbine T06



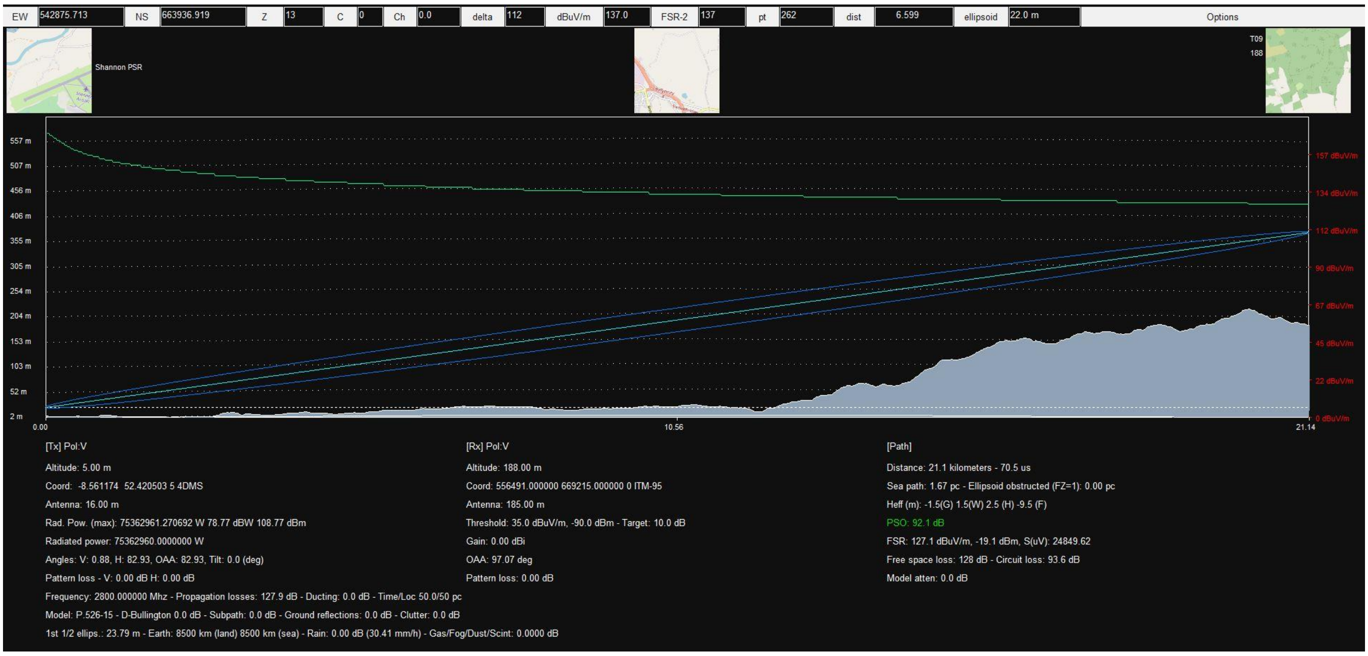
A.7. Turbine T07



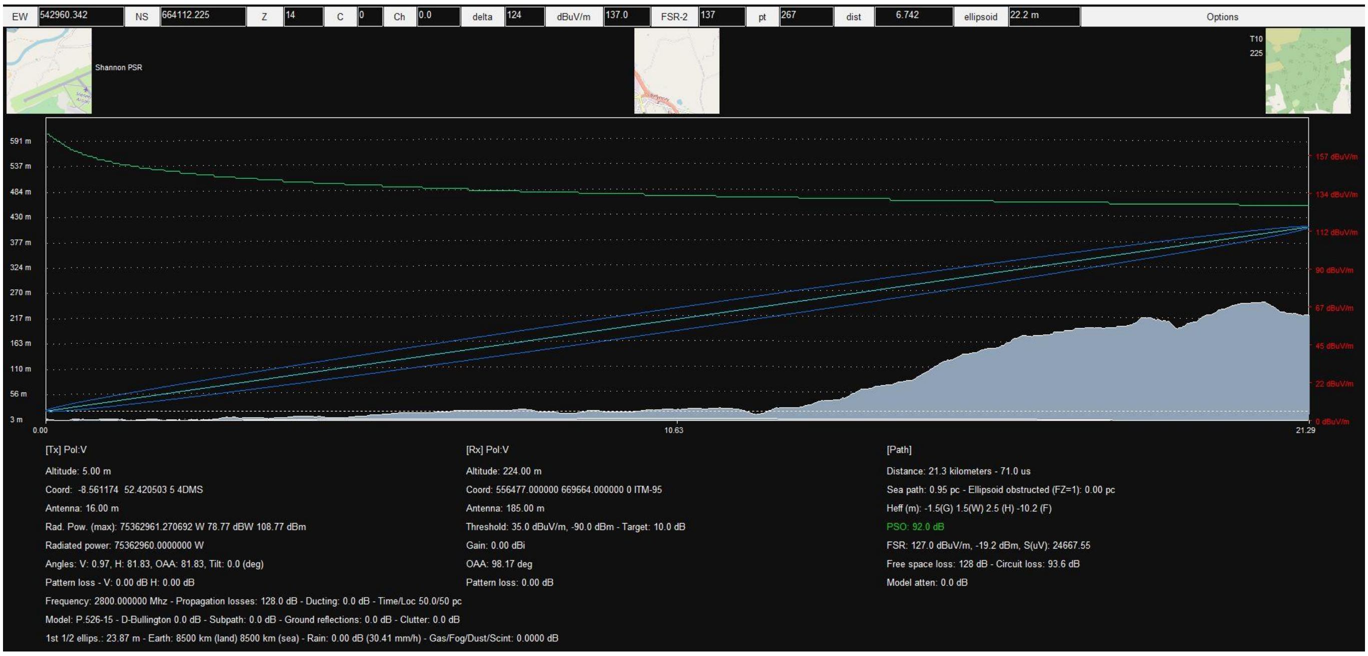
A.8. Turbine T08



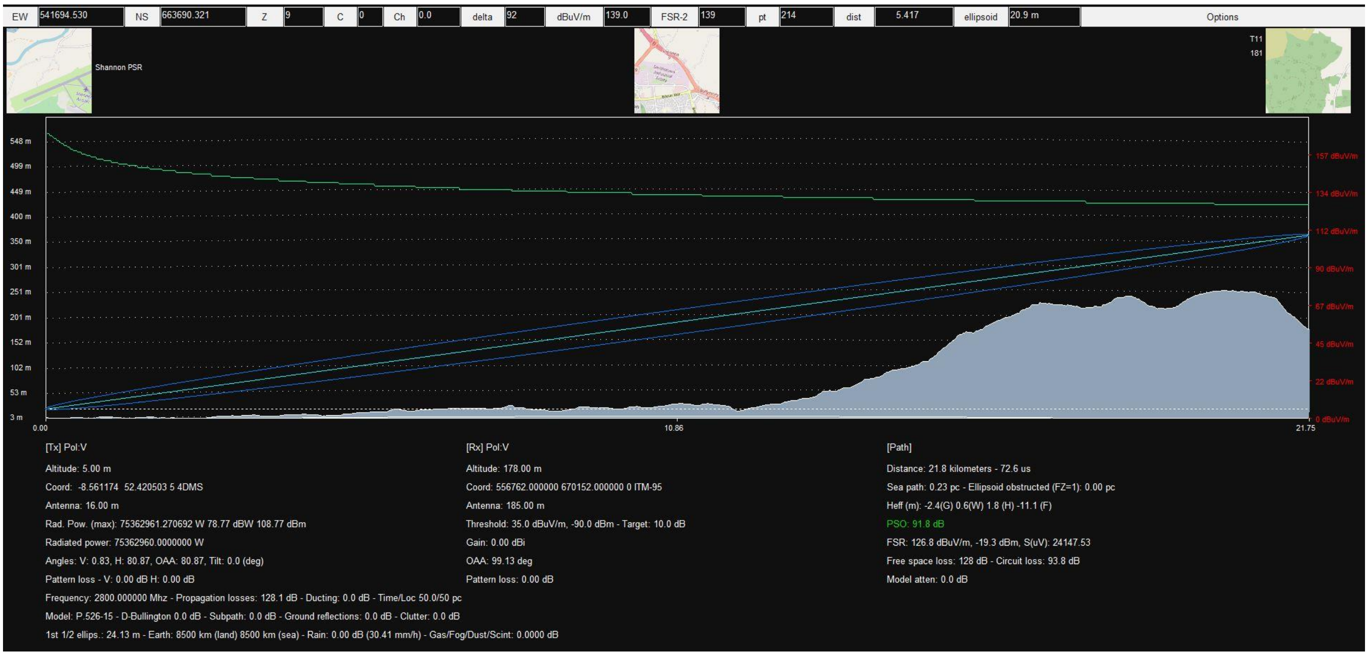
A.9. Turbine T09



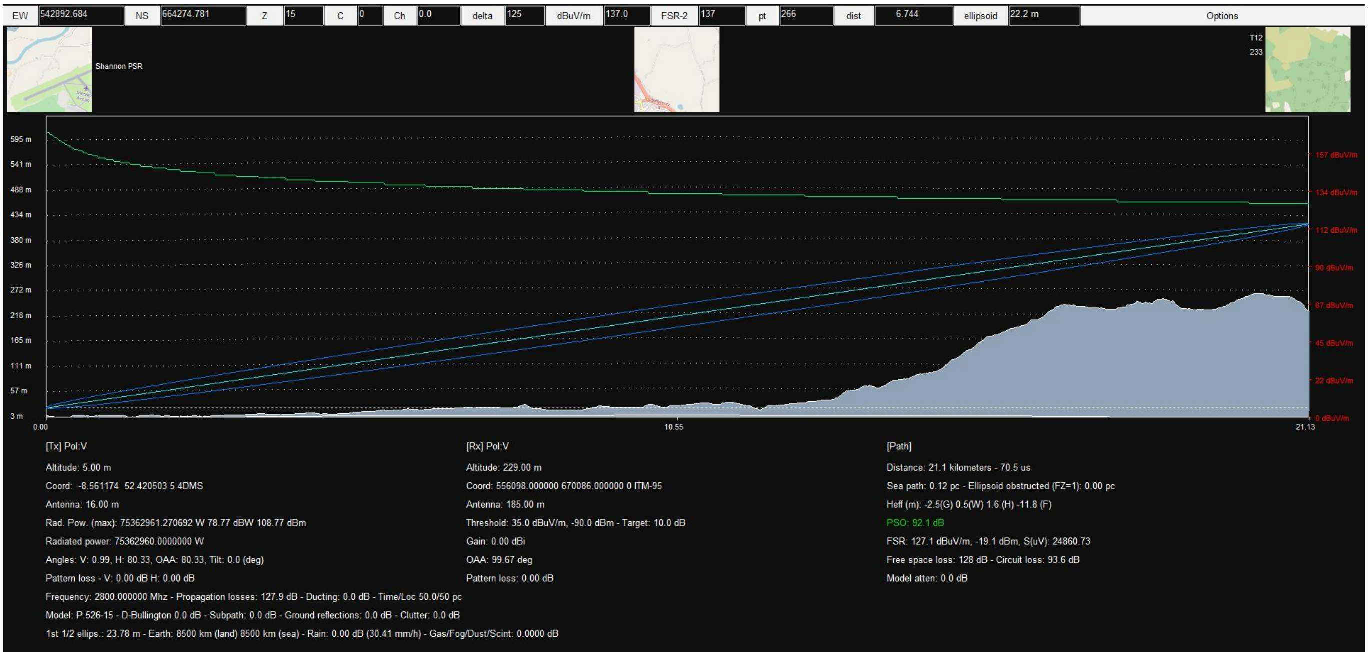
A.10. Turbine T10



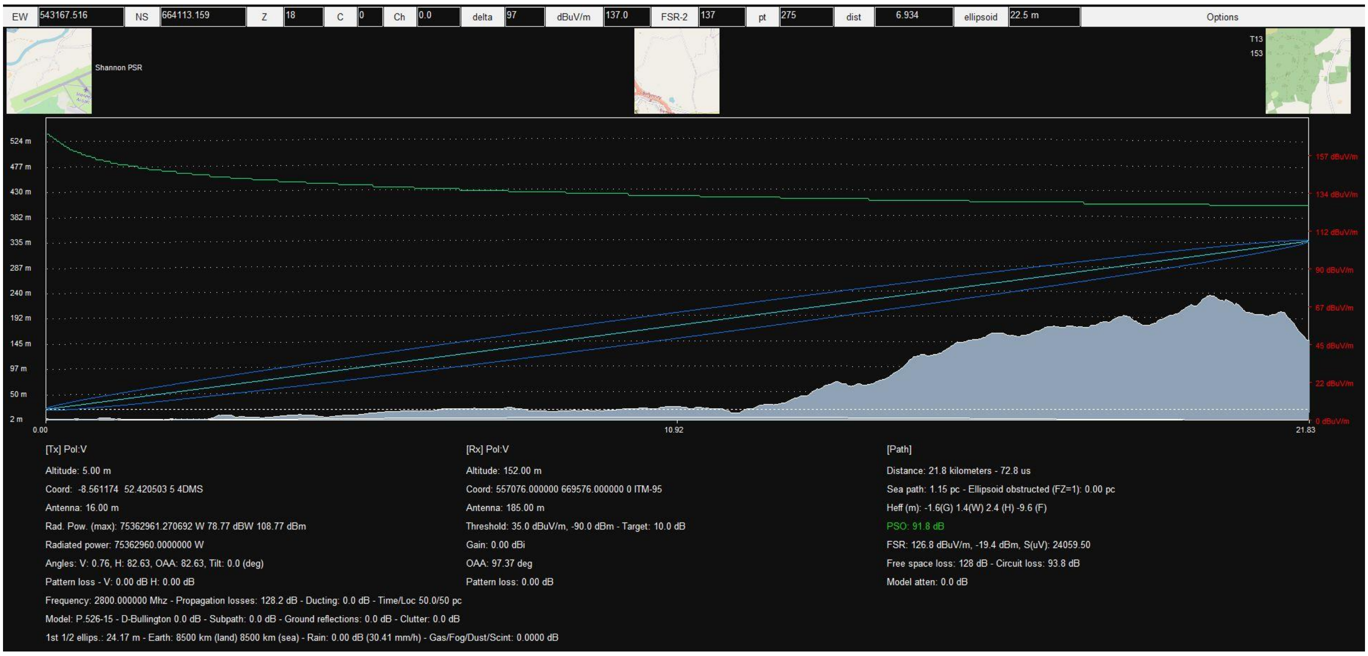
A.11. Turbine T11



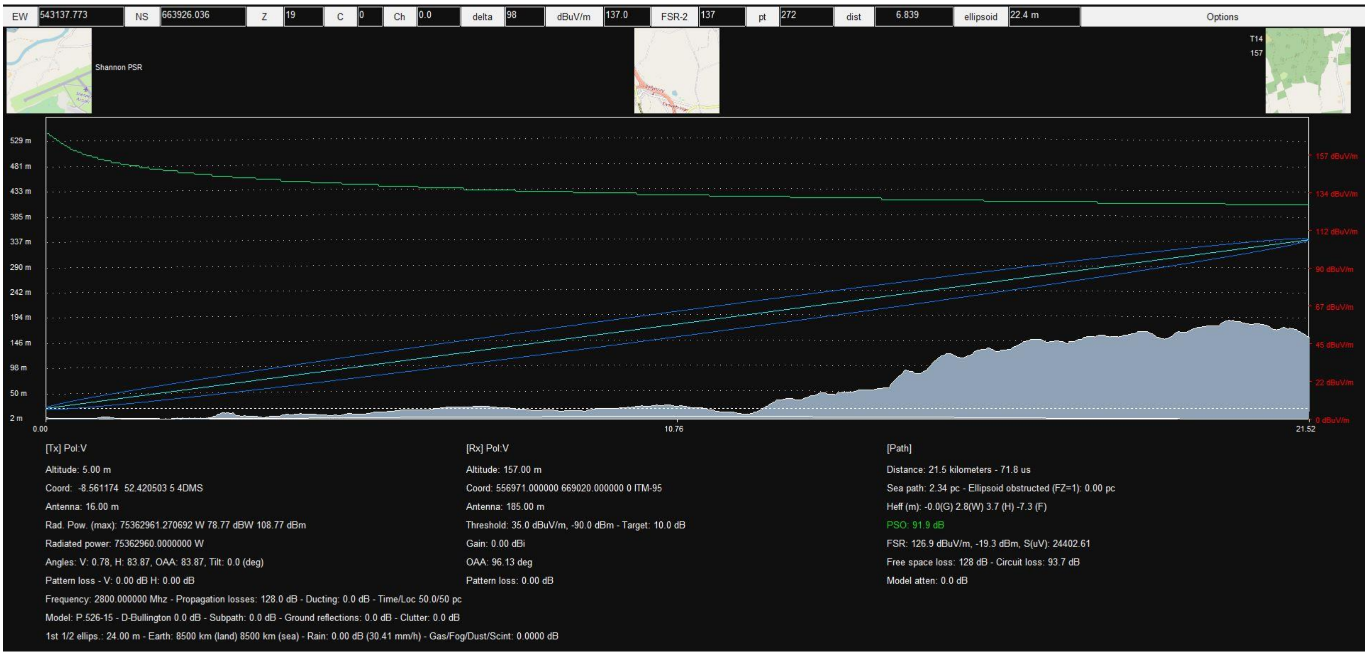
A.12. Turbine T12



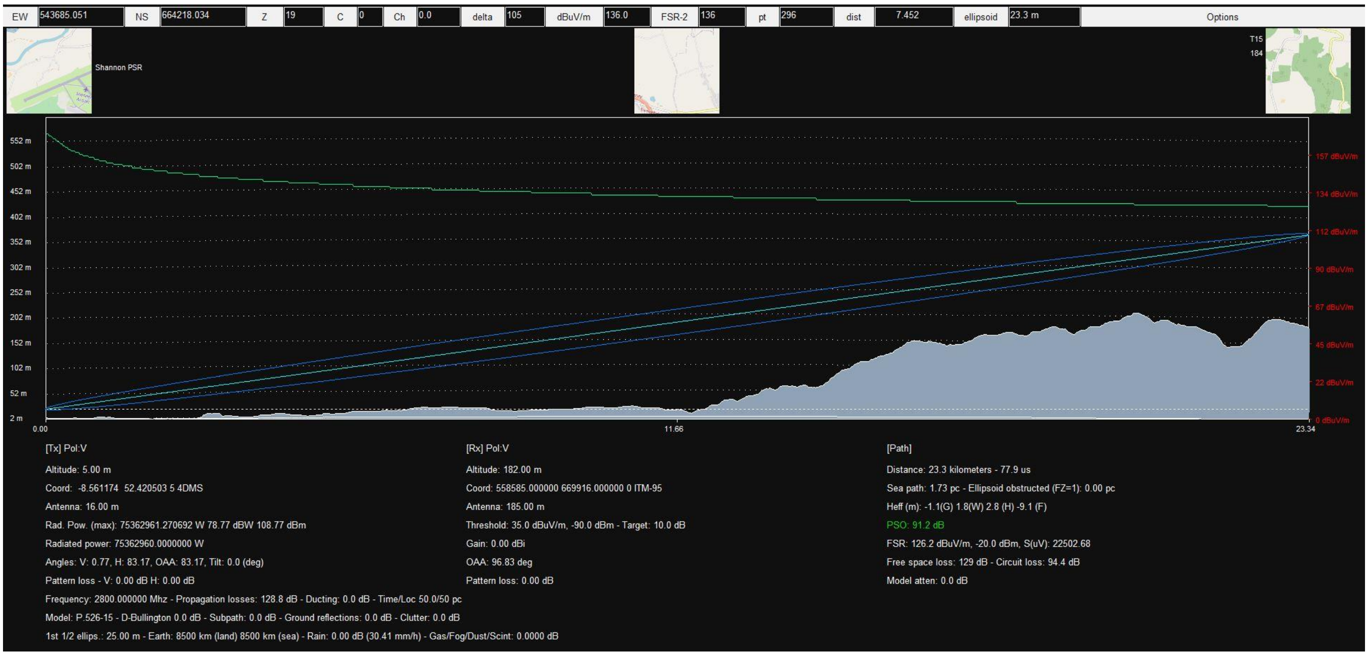
A.13. Turbine T13



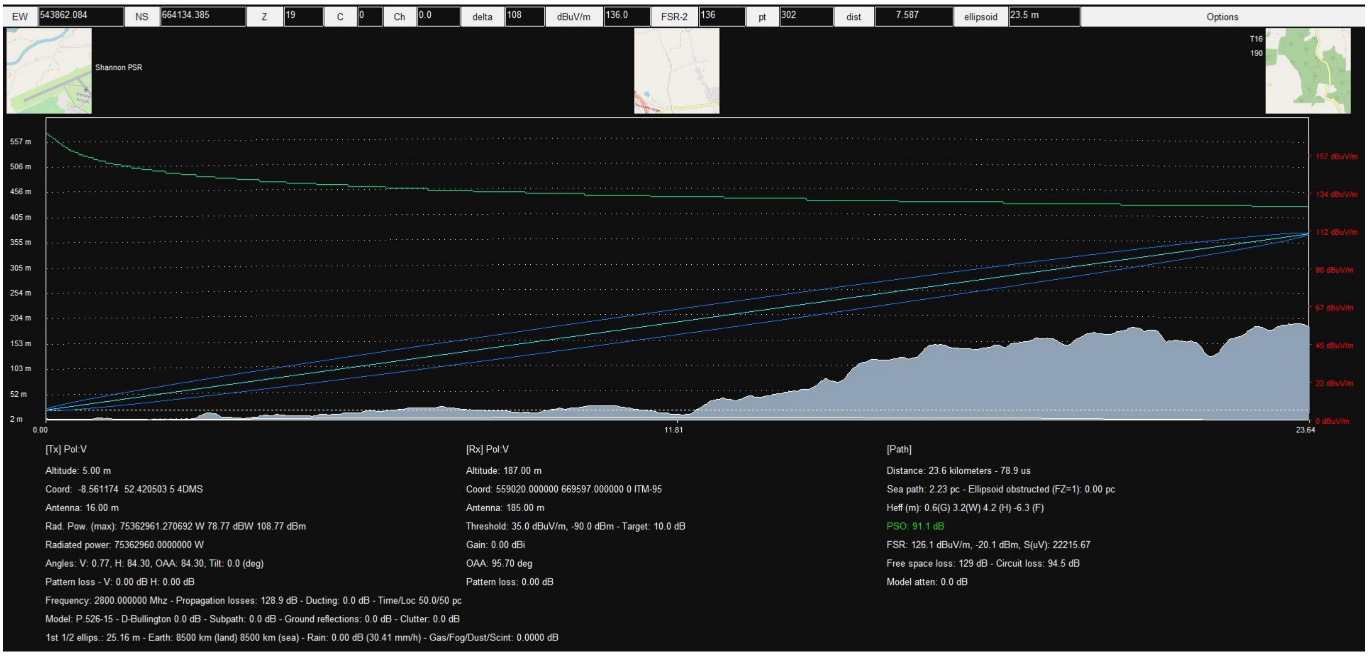
A.14. Turbine T14



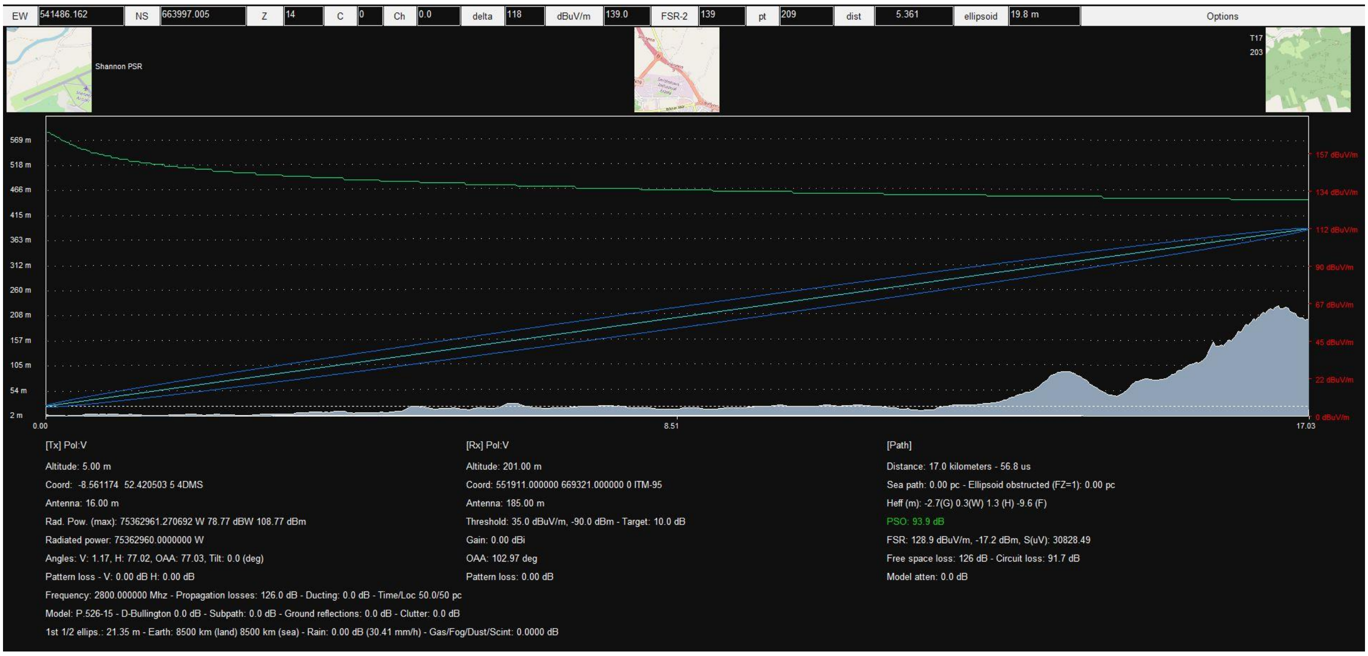
A.15. Turbine T15



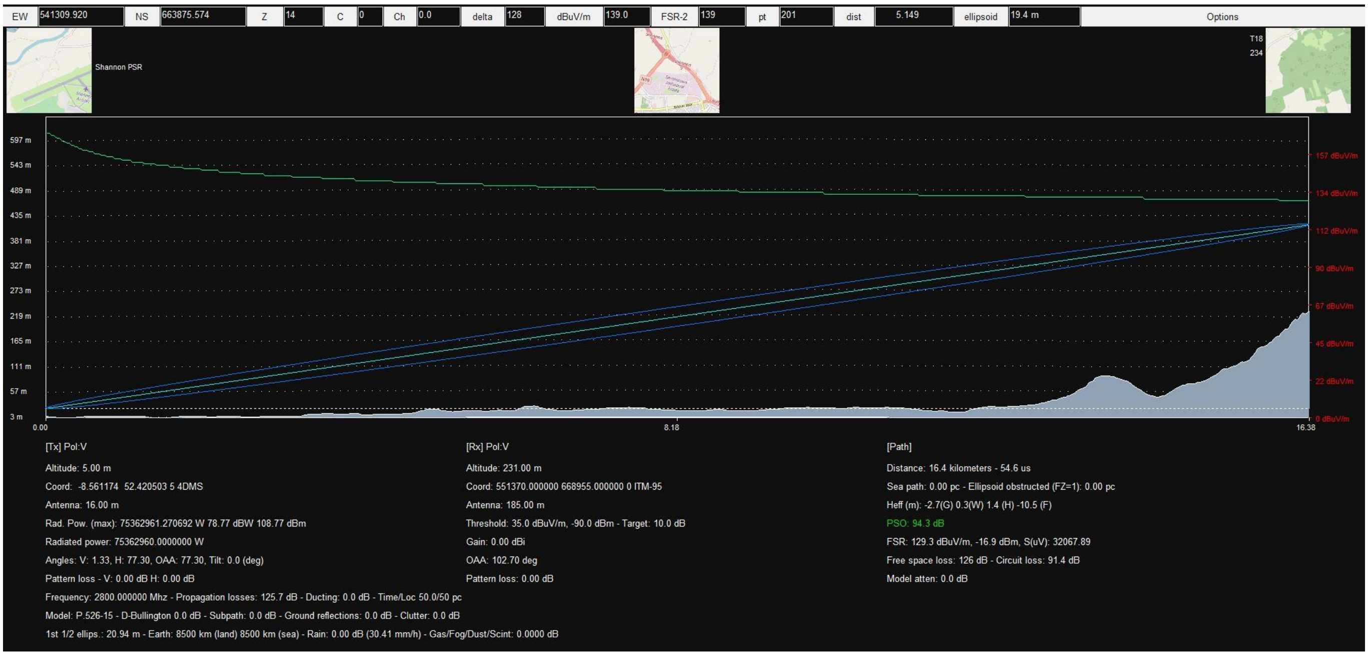
A.16. Turbine T16



A.17. Turbine T17

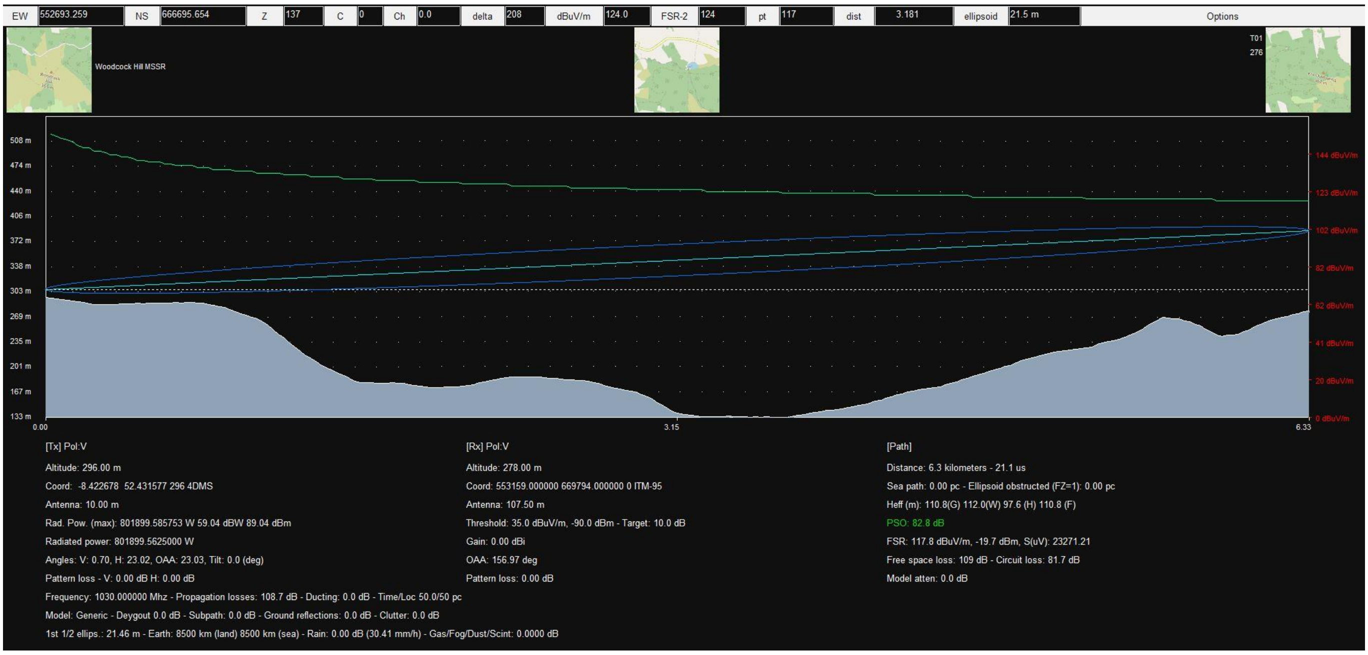


A.18. Turbine T18



B. Annex B – Woodcock Hill MSSR Path Profiles

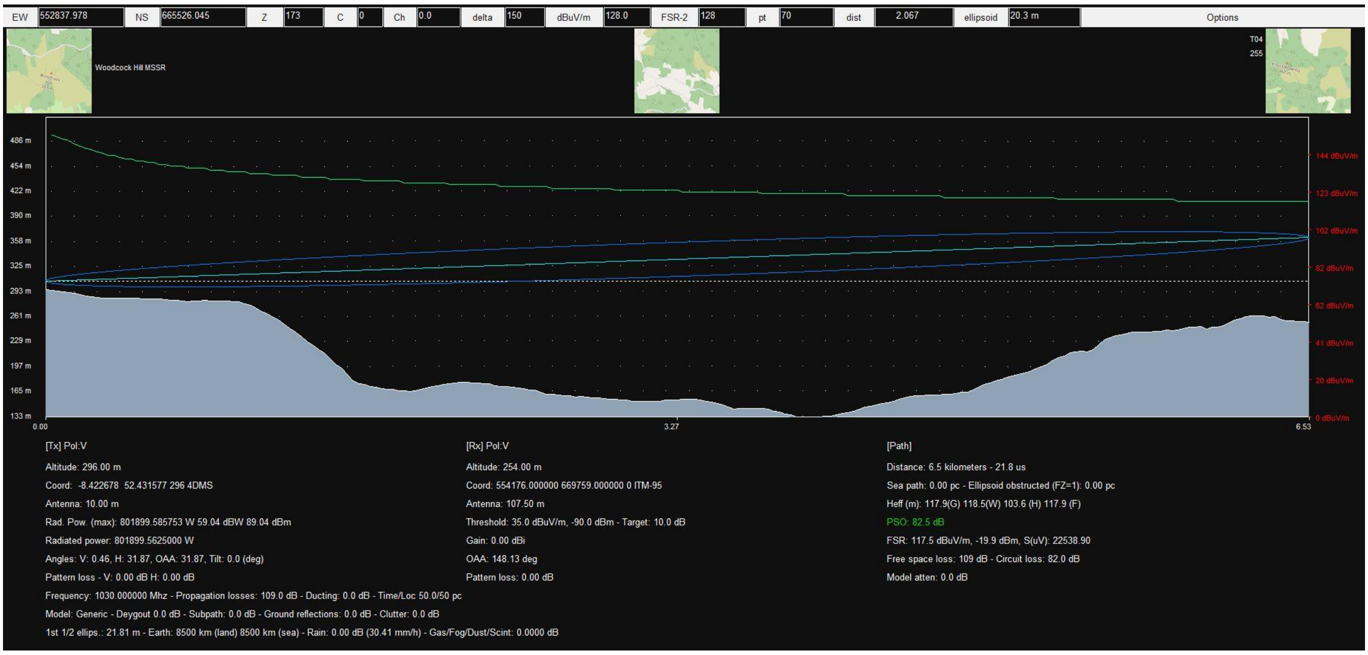
B.1. Turbine T01



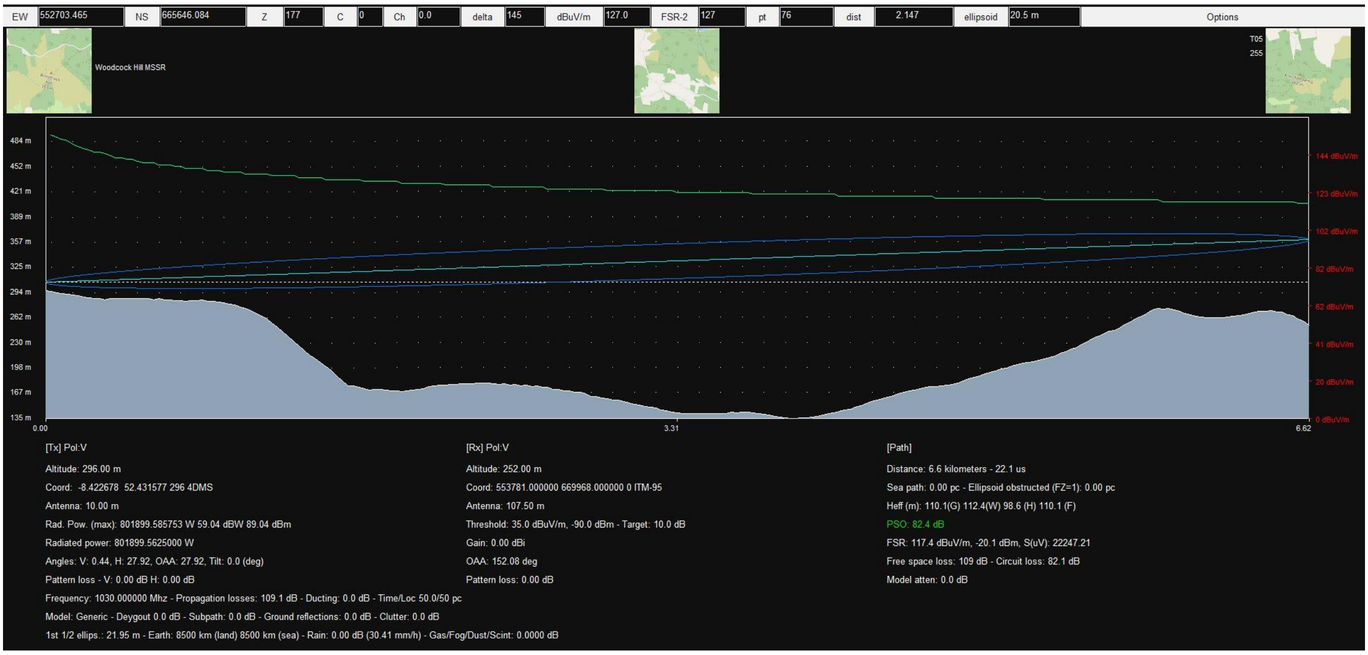
B.2. Turbine T02

B.3. Turbine T03

B.4. Turbine T04

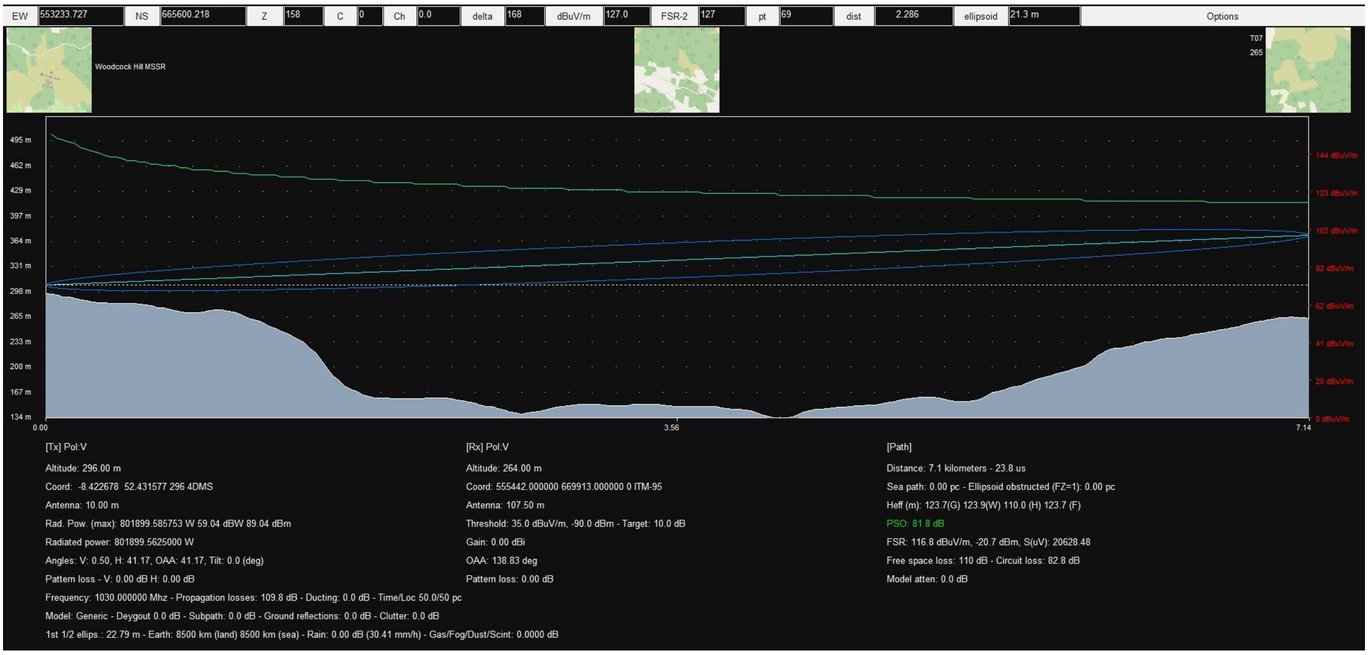


B.5. Turbine T05

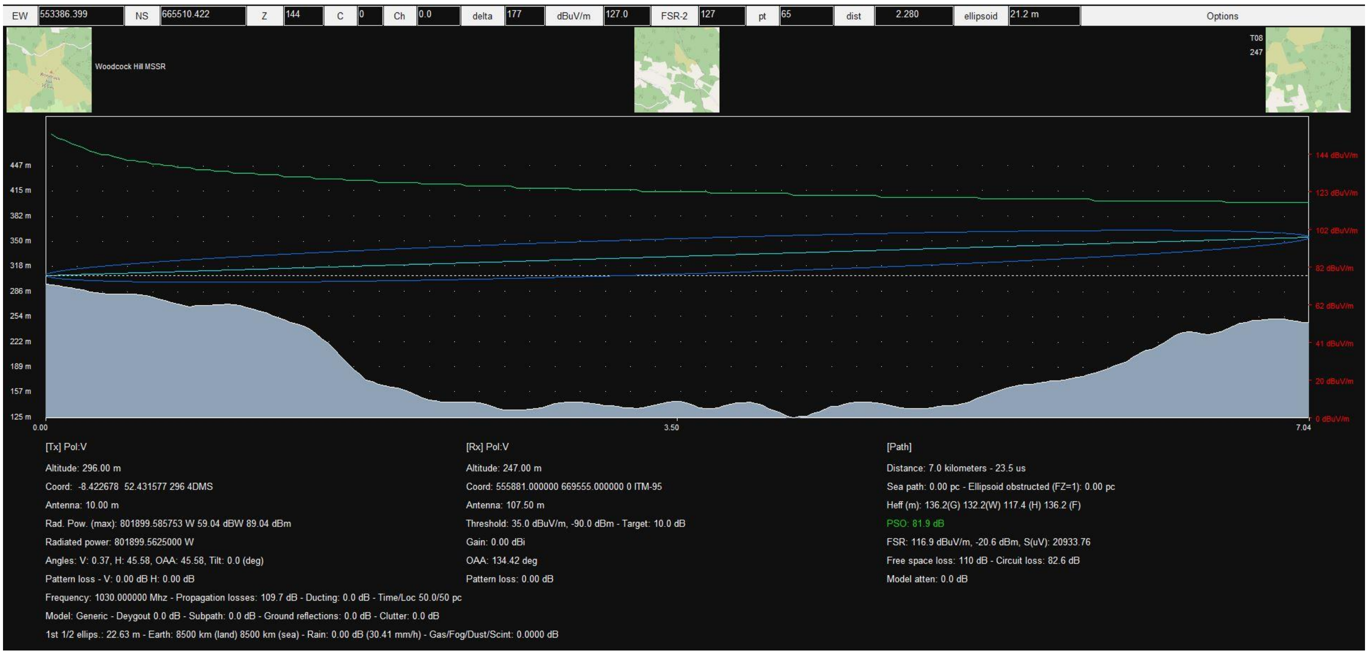


B.6. Turbine T06

B.7. Turbine T07

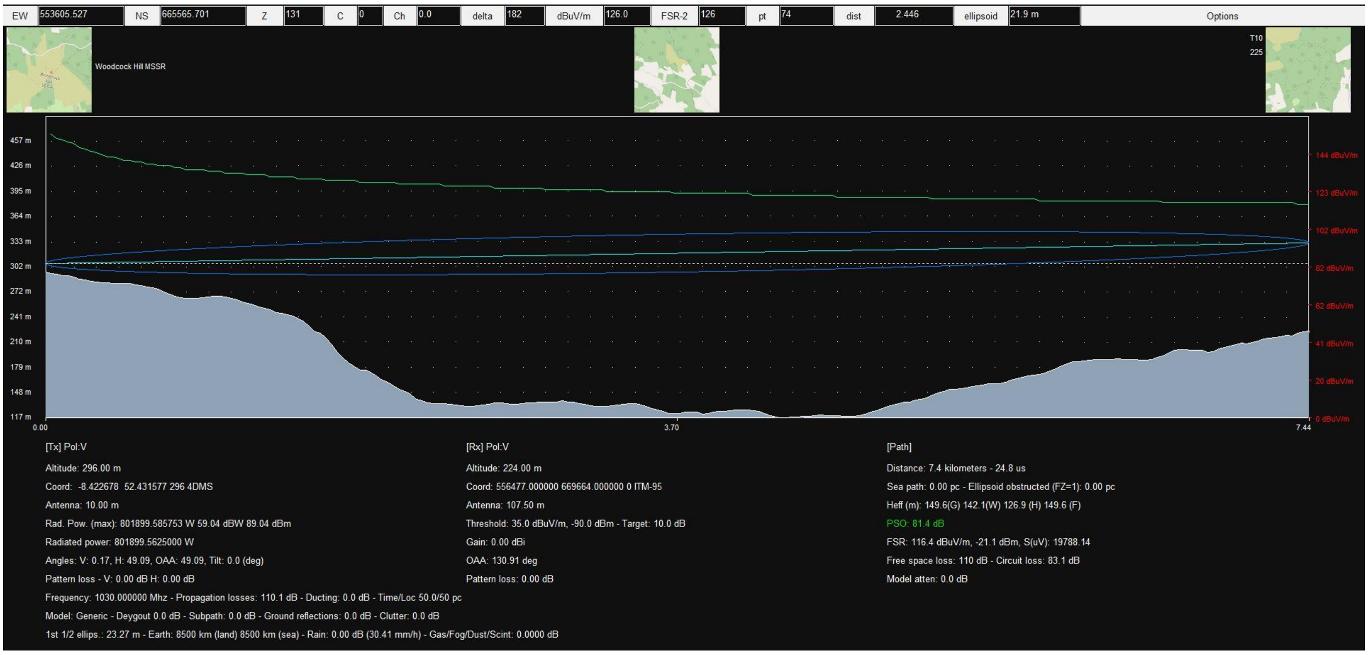


B.8. Turbine T08



B.9. Turbine T09

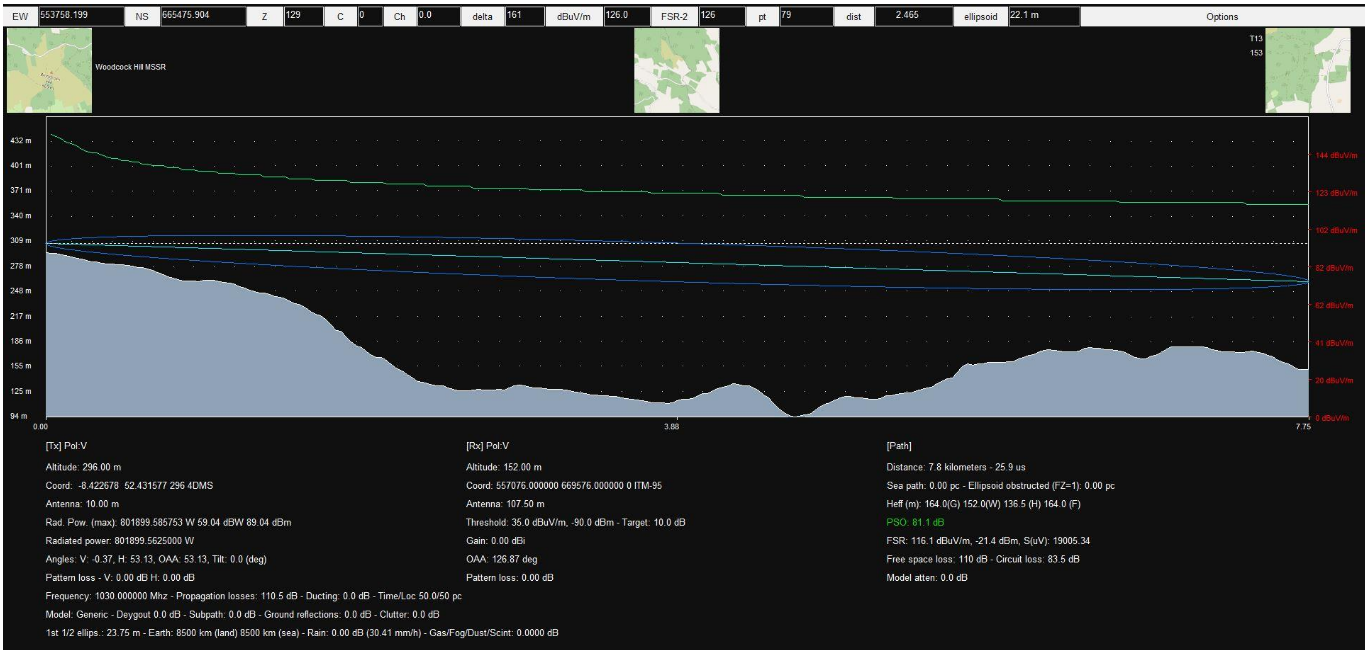
B.10. Turbine T10



B.11. Turbine T11

B.12. Turbine T12

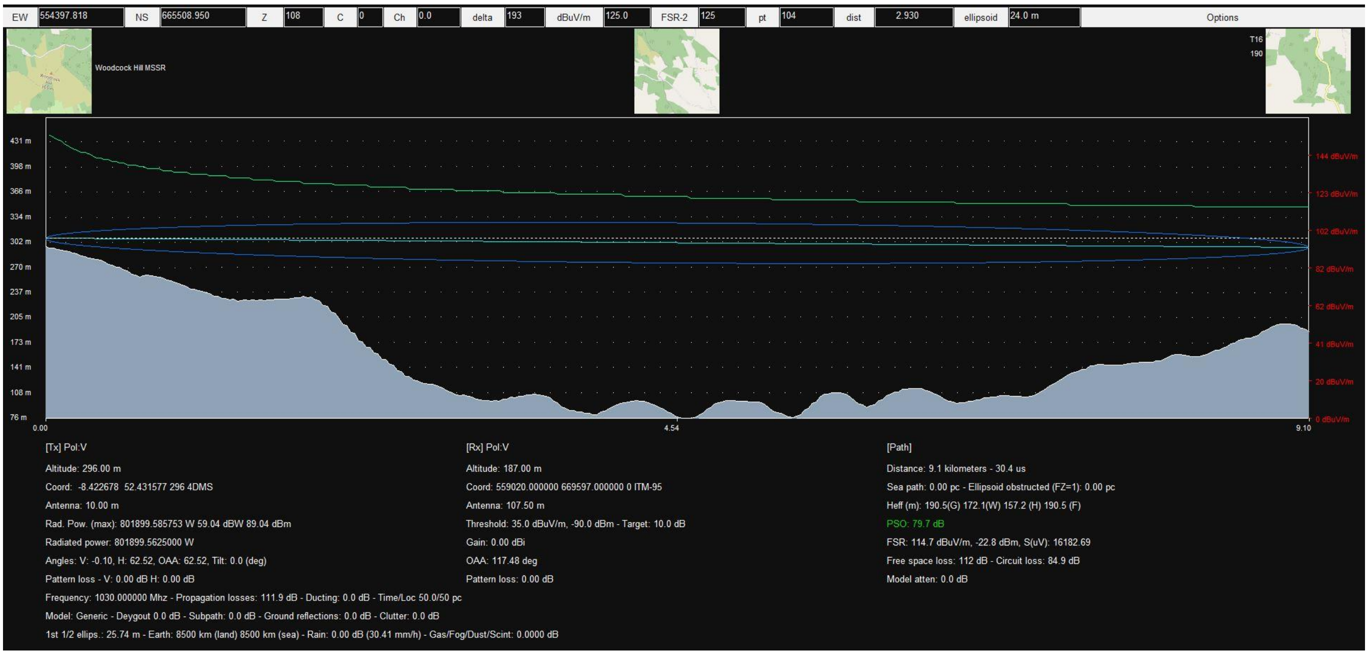
B.13. Turbine T13



B.14. Turbine T14

B.15. Turbine T15

B.16. Turbine T16



B.17. Turbine T17

B.18. Turbine T18

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Appendix 8

Concept Design ATCSMAC Shannon Airport

Concept Design

ATCSMAC

Shannon Airport

15 February 2022

CL-5765-RPT-002 V1.0

www.cyrrus.co.uk

info@cyrrus.co.uk

ISO 9001 QUALITY MANAGEMENT

ISO 14001 ENVIRONMENTAL MANAGEMENT



Executive Summary

In 2021, Cyrrus Limited was engaged by Ai Bridges Limited (The Client) to provide guidance on aviation issues arising from the planned development of Violet Hill Wind Farm in County Clare in the West of Ireland. The proposed Wind Farm comprises 18 turbines. Cyrrus delivered an IFP Safeguarding Assessment which highlighted impact to the IFPs currently published at Shannon Airport.

After a discussion with the IAA, it was agreed that the main area of concern to is the Air Traffic Control Surveillance Minimum Altitude Chart (ATCSMAC). The client has requested Cyrrus to review the ATCSMAC, to determine what possible design options exist to reduce the impact the Wind Farm poses and allow Shannon Airport to continue with safe and efficient vectoring operations.

The design options consider a Surveillance RADAR lateral separation certified at 3 nm.

The following options have been identified:

- Option A – Raise the Sector 1 Minimum Vectoring Altitude
- Option B – Extend Sector 2 area to cater for the Wind Farms
- Option C – Create a new Sector to address the Wind Farms
- Option D - Create two new Sectors to address the Wind Farms

Whilst the list of options determined is not exhaustive, the Minimum Vectoring altitudes determined in each option are not likely to change and any further design optimisation would be to the Surveillance Minimum Altitude Areas (SMAA) Sector shape and size.

Abbreviations

ATC	Air Traffic Control
ATCSMAC	ATC Surveillance Minimum Altitude Chart
ATM	Air Traffic Management
ATS - Authority	Air Traffic Services
DME	Distance Measuring Equipment
EGPWS	Enhanced Ground Proximity Warning System
GP	Glide Path
IAA	Irish Aviation Authority
IAP	Instrument Approach Procedure
ICAO	International Civil Aviation Organisation
IFP	Instrument Flight Procedure
ILS	Instrument Landing System
MVA	Minimum Vectoring Altitude
OPS	Operations
PANS	Procedures for Air Navigation Services
RWY	Runway
SMAA	Surveillance Minimum Altitude Area
THR	Threshold
VHF	Very High Frequency
VOR	VHF omnidirectional range

References

[1] ICAO Doc 4444, Procedures for Air Navigation Services — Air Traffic Management Sixteenth Edition 10 November 2016

[2] ICAO DOC 8168 - Procedures for Air Navigation Services, Aircraft Operations, Vol II, 7th Ed, Amendment 9, dated 05 November 2020.

Contents

List of figures

1. Air Traffic Control Surveillance Minimum Altitude Chart (ATCSMAC)

1.1. Criteria

1.1.1. There is no prescribed limit on the size, shape, or orientation of the ATCSMAC; however, in all cases the boundary of the ATCSMAC subdivisions must be located at a distance not less than 5.6 km (3 nm) from an obstacle which is to be avoided.

1.1.2. Criteria for the determination of minimum altitudes applicable to procedures based on radar vectoring are contained in Procedures for Air Navigation Services — Aircraft Operations (PANS-OPS, Doc 8168). A minimum of 300 m (1 000 ft) vertical separation shall be applied

1.1.3. Whenever possible, minimum vectoring altitudes should be sufficiently high to minimize activation of aircraft enhanced ground proximity warning systems (EGPWS). Activation of such systems may induce aircraft to pull up immediately and climb steeply to avoid hazardous terrain and obstacles, possibly compromising separation between aircraft.

1.1.4. The ATCSMAC shall enable the aircraft to be established on the final approach course or track, in level flight for at least 2.0 nm prior to intercepting the Glide Path (GP) or vertical path for the selected instrument approach procedure.

1.2. Purpose

1.2.1. It is the responsibility of the Air Traffic Service (ATS) authority to provide the controller with minimum altitudes corrected for temperature effect.

1.2.2. Used by ATC to vector aircraft in the airspace, it provides obstacle clearance until the aircraft reaches the point where the pilot will resume own navigation.

1.2.3. The ATCSMAC is commonly split into several Surveillance Minimum Altitude Areas (SMAA) which provide relief from obstacles which would only affect vectoring on one runway circuit direction.

1.2.4. The minimum altitudes available within the SMAA sector should be adequate to permit vectoring of an aircraft to the final approach of a published IAP.

Shannon Airport ATCSMAC

1.2.5. Shannon Airports ATCSMAC is configured into four SMAA sectors.

- Sector 1: 2300 ft
- Sector 2: 3000 ft
- Sector 3: 4000 ft
- Sector 4: 4400 ft

1.2.6. The sectors are depicted in Figure 1, with a red line to represent the extended runway centreline.

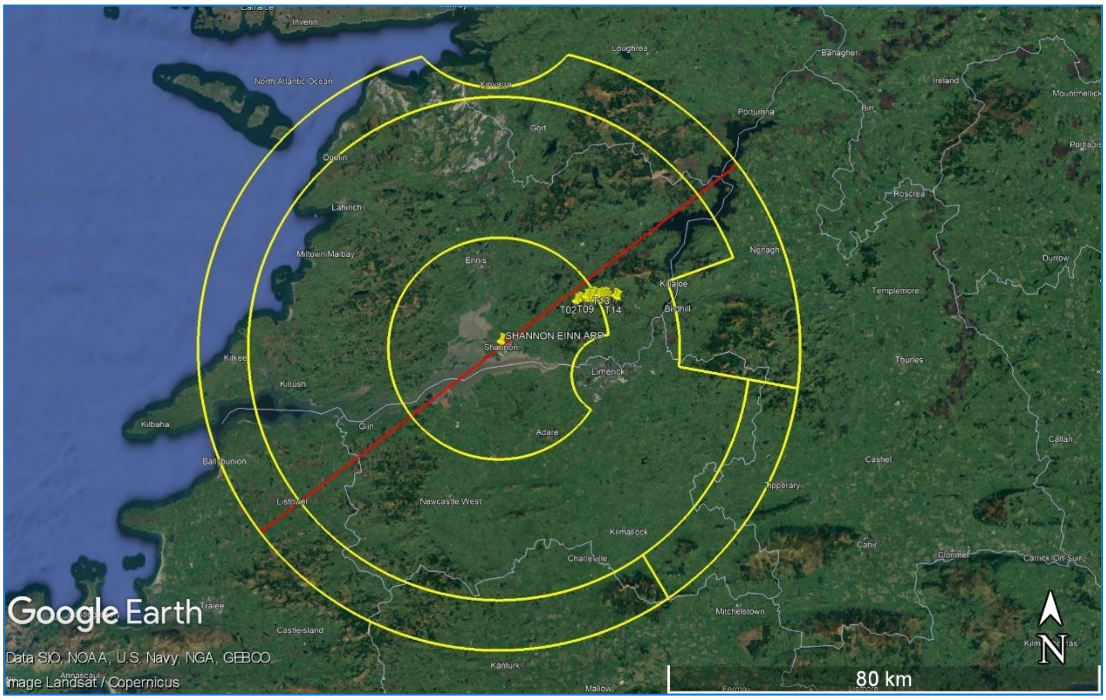

Figure 1: Wind Farm Location in ATCSMAC

2. Design Options

2.1. Overview

2.1.1. Four design options are proposed, whilst this is not a definitive list of potential options, they enable the evaluation of the potential ways to reduce the impact to the ATCSMAC.

2.1.2. The concept design options would need to be evaluated by the Airport and IAA to determine if the proposed options reduce the impacts to a level where safe and effective vectoring can continue.

2.1.3. If a design option looks to have potential, a full design would be required to further optimise the concept and consider all obstacles.

2.1.4. The design options consider a Surveillance RADAR lateral separation certified at 3 nm.

2.2. Design Option A

2.2.1. Option A provided the simplest solution to implement, with minimal modification to the ATCSMAC as published.

2.2.2. The proposed solution is to increase Minimum Vectoring Altitude (MVA) associated with the Surveillance Minimum Altitude Area (SMAA) sector 1 from 2300 ft to 2600 ft as depicted in Figure 2. This would provide sufficient Minimum Obstacle Clearance (MOC) above the wind turbines.

2.2.3. Aircraft crossing into the sector 1 SMAA would be at a nominal altitude of around 3200 ft, as indicated in Figure 3. As the Instrument Landing System (ILS) intercept is at 3000ft at around 9.3 nm from the applicable Threshold (THR).

2.2.4. SMAA Sector 3 is approximately 2 nm from the nominal 2600 ft altitude position. Air Traffic Control (ATC) would still have the capability to vector the Aircraft onto the ILS Localiser for GP intercept and other Instrument Approach Procedures (IAPs). However, this reduction in capability could potentially hinder ATC when sequencing inbound traffic during busy periods.

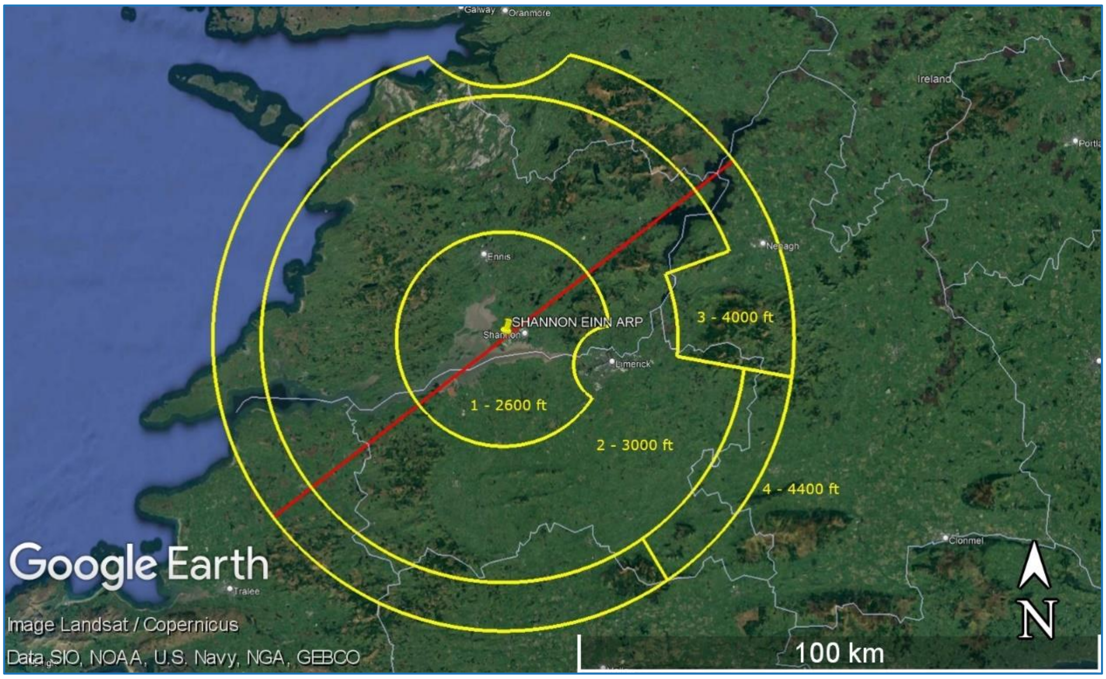

Figure 2: ATCSMAC Design Option A

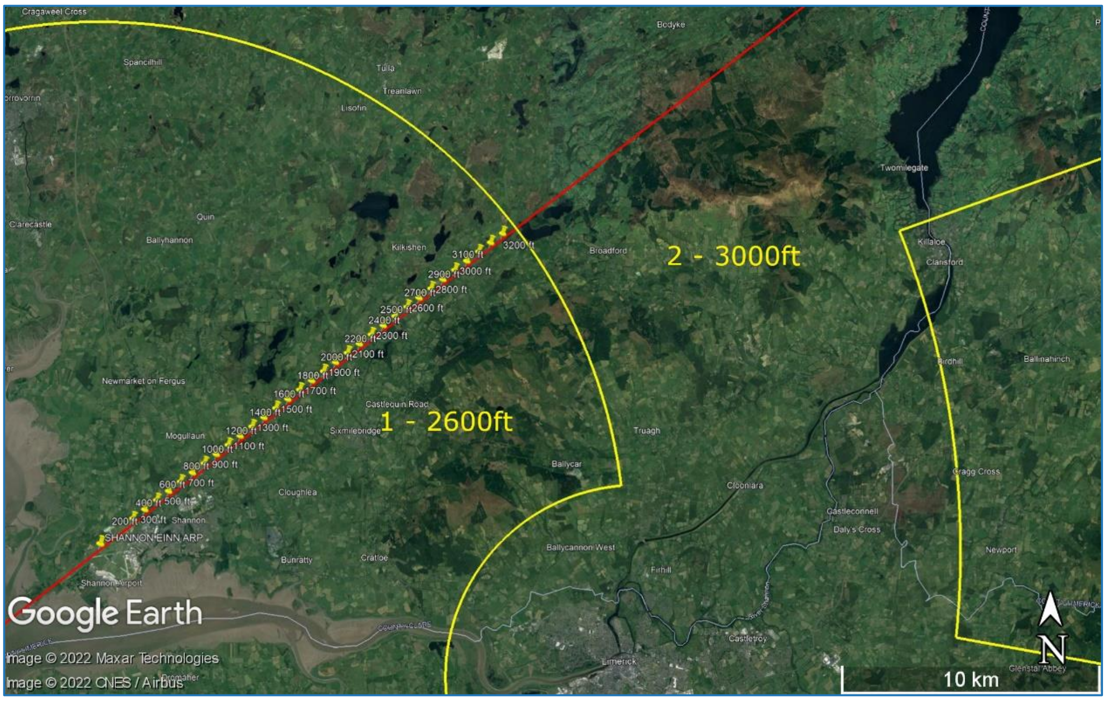

Figure 3: Option 1 – Nominal Altitudes

2.3. Design Option B

2.3.1. Option B considers adaption of Sector 2 to incorporate the Wind Farm.

2.3.2. Each Turbine is considered with a 3 nm radius (plus the rotor radius) to determine the area which is required to be excluded. The area is combined with the existing SMAA Sector 2 and simplified using tangent radials from the Shannon VOR/DME (SHA) and existing buffer area due to Prohibited Airspace EI P6 as indicated in Figure 4.

2.3.3. Aircraft crossing into the Option B SMAA sector 1 would be at a nominal altitude of around 1600 ft, as indicated in Figure 5. At this point aircraft would have to be full established on the ILS, ATC would only be able to vector aircraft onto the ILS within sector 2, at a distance of around 9 nm or greater from THR RWY 26.

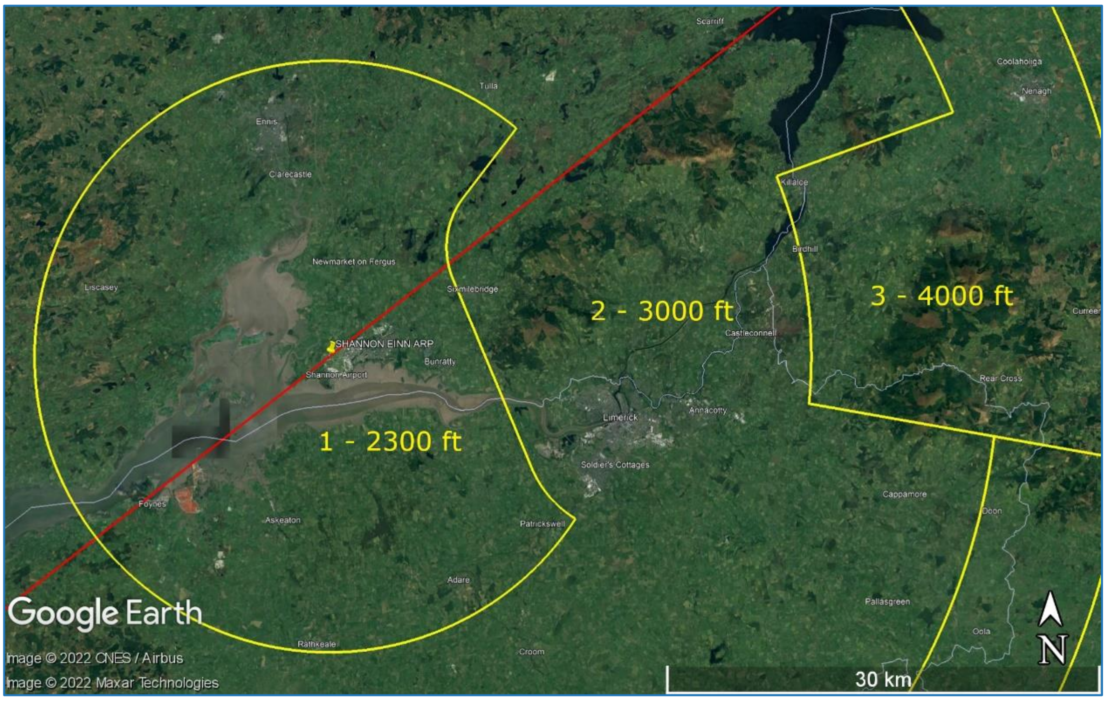

Figure 4: ATCSMAC Option B

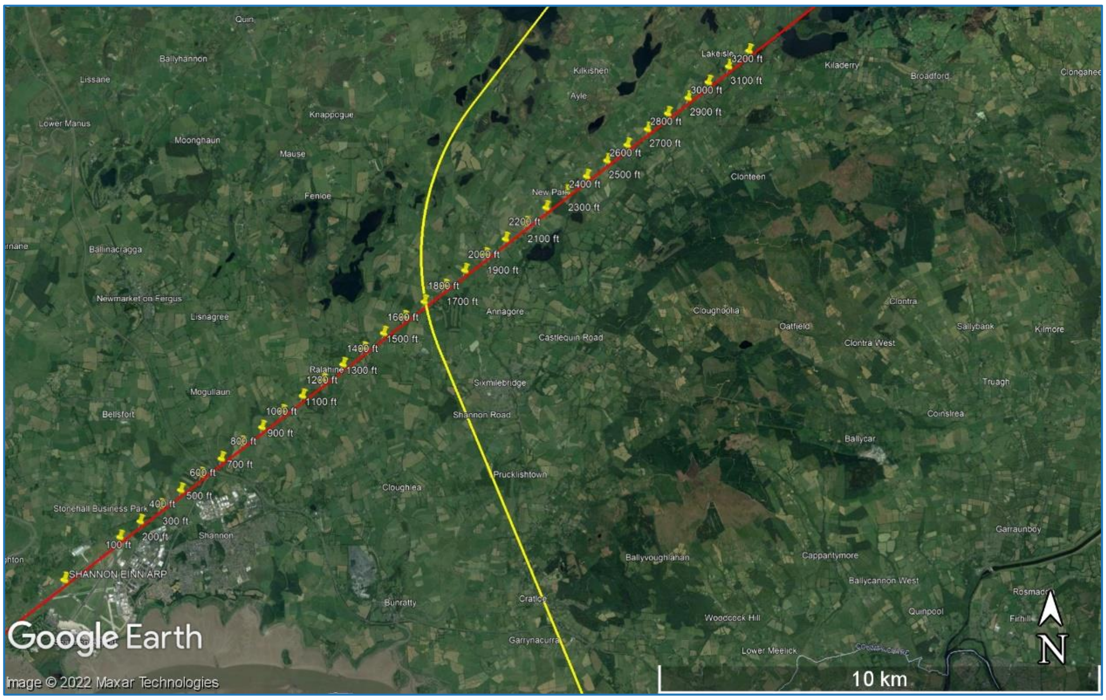

Figure 5: ATCSMAC Option B Nominal Altitudes

2.4. Design Option C

2.4.1. Option C considers the introduction of a new SMAA sector.

2.4.2. The SMAA sector considers each Turbine with a 3 nm radius (plus the rotor radius) to determine the new sector. The area is simplified using tangent radials from the Shannon VOR/DME (SHA). (New sector highlighted in purple in Figure 6)

2.4.3. Aircraft on the nominal path will enter the Proposed SMAA from sector 3 at around 3200 ft and leave the Proposed SMAA to enter sector 1 at around 1600 ft. This allows for ATC to vector aircraft down to 2600 ft to intercept the GP at around 8 nm from THR RWY 26.

2.4.4. The nominal altitude of 2300 ft is achieved at around 7 nm From THR RWY 26.

2.4.5. Whilst this configuration will allow the Wind Farm to be built, there will still be a potential reduction in efficiency and flexibility for ATC.

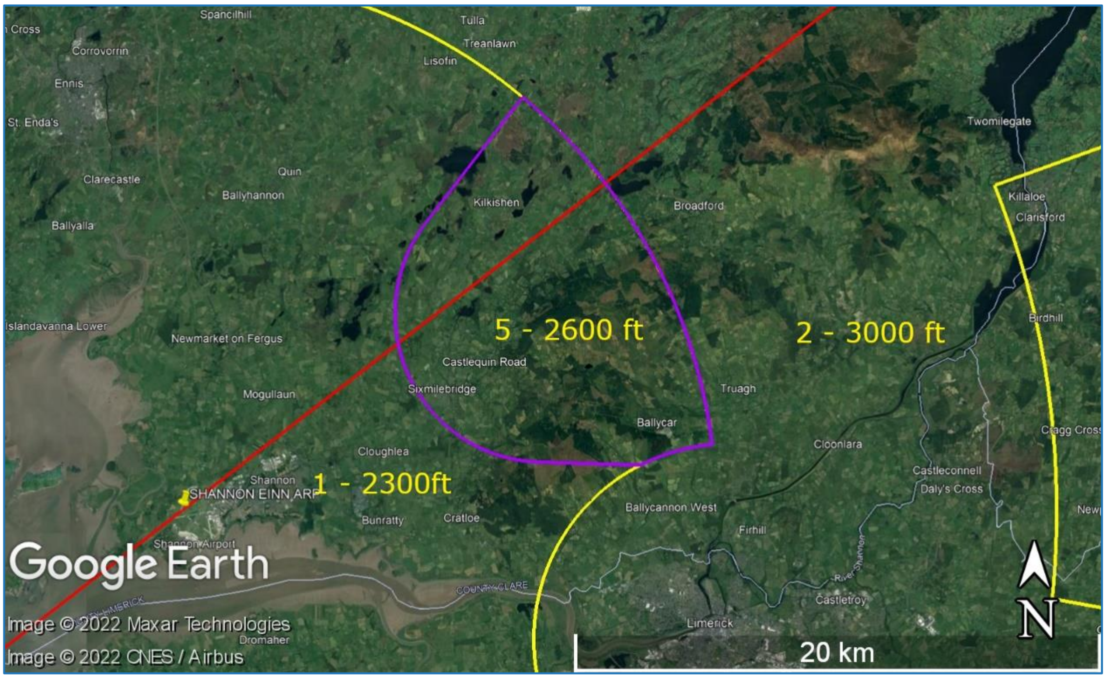

Figure 6: ATCSMAC - Option C

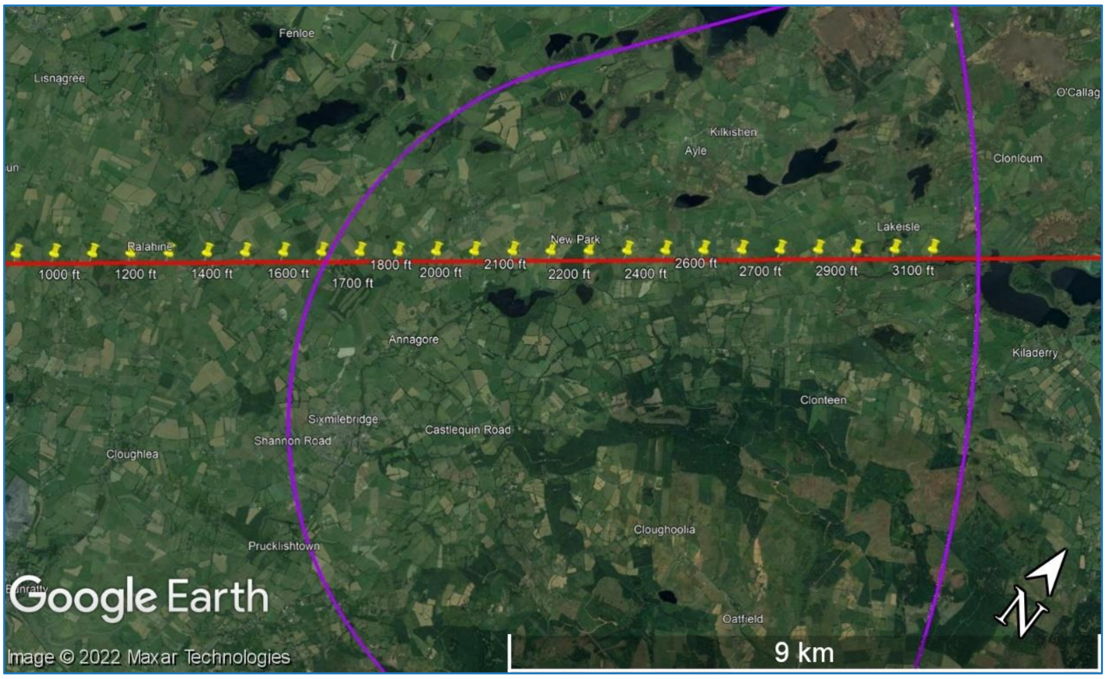

Figure 7: ATCSMAC - Option C Nominal Altitudes

2.5. Design Option D

2.5.1. Option D looks at further optimisations for the Minimum Vectoring Altitude (MVA) based on the elevation of each Turbine.

2.5.2. To determine the optimal area, the MVA (rounded up to the next 1000 ft) was calculated for each Turbine with an area of radius 3 nm (plus turbine rotor radius) was assigned. The areas were combined to show only the maximum levels as depicted in Figure 8.

2.5.3. Simplification of the areas determined that two new SMAA options could be created. These have a level of 2400 ft and 2600 ft and are depicted in Figure 9.

2.5.4. Whilst this would provide an additional SMAA sector at 2400 ft, the usable width varies from 0.5 nm to 1 nm. It may be difficult to vector aircraft within the constraints of such a corridor.

2.5.5. The nominal approach altitudes depicted in Figure 10, indicate that Aircraft would need to be fully established on the ILS in the 2400 ft SMAA, rendering the area unusable for vectoring.

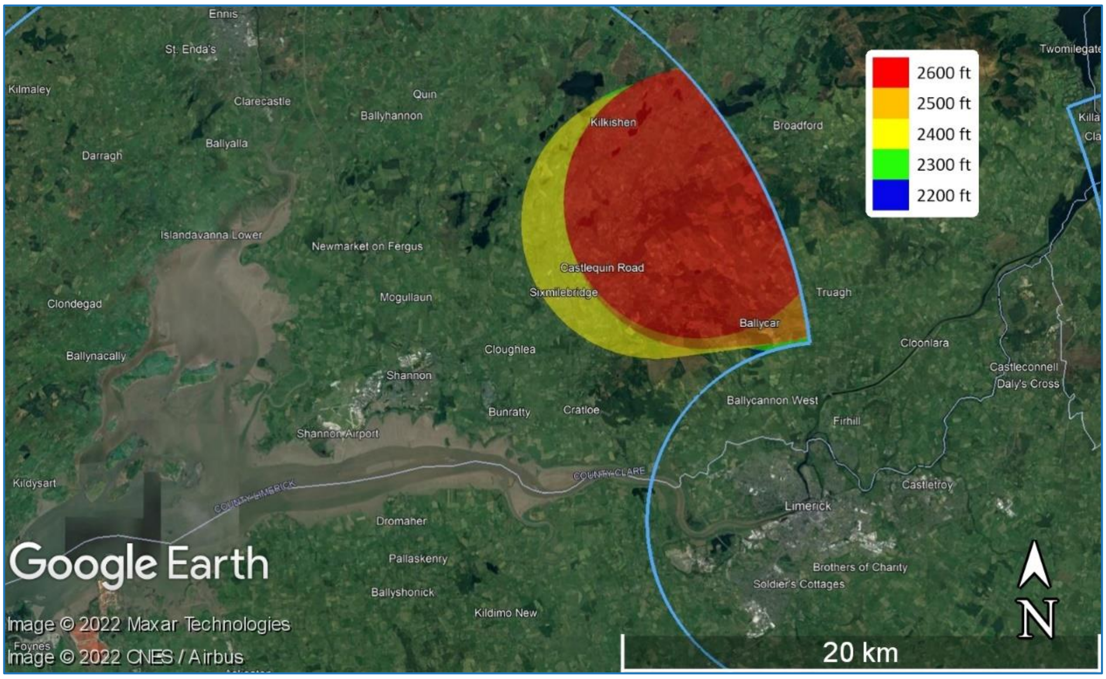

Figure 8: ATCSMAC - Option D Calculated MVA

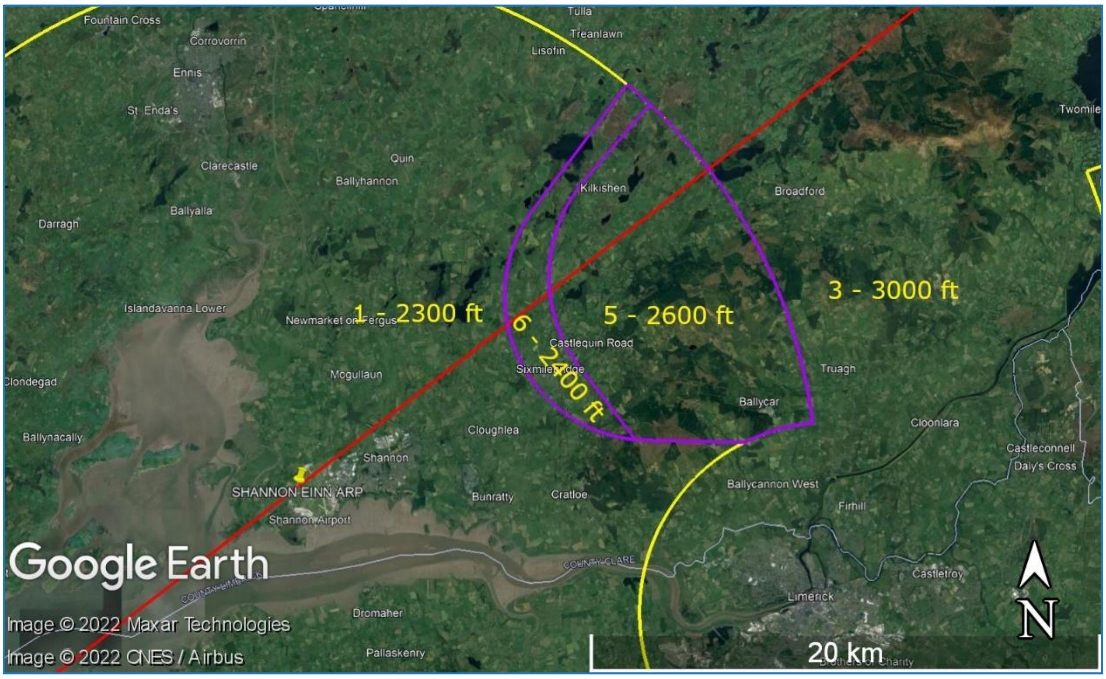

Figure 9: ATCSMAC - Option D

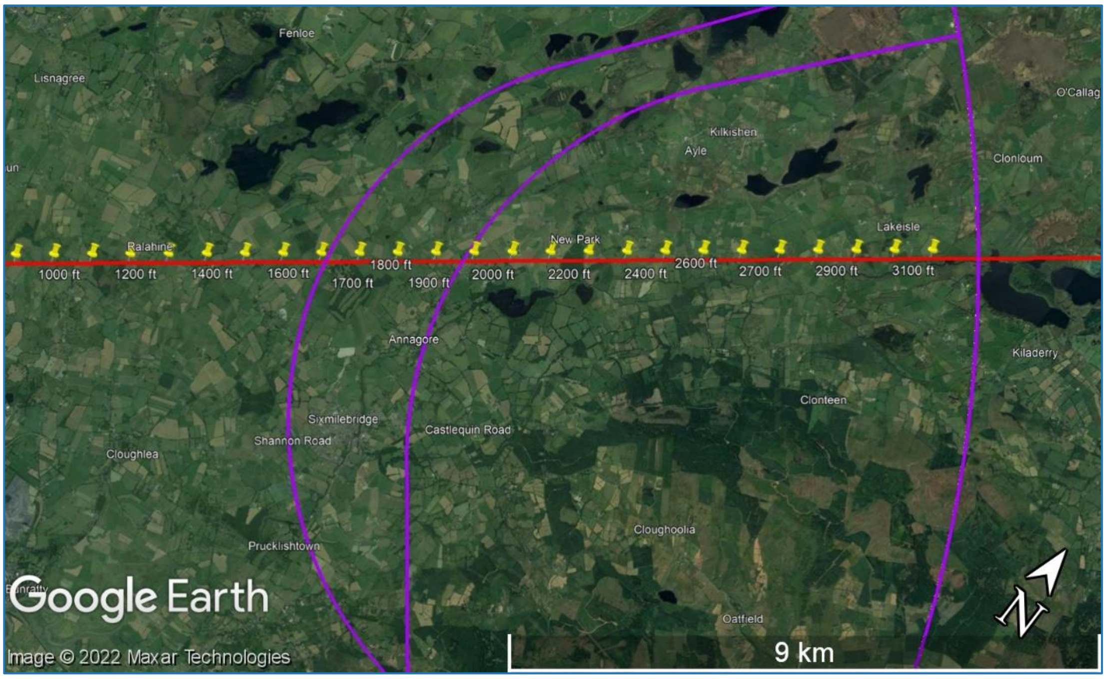

Figure 10: ATCSMAC - Option D - Nominal Altitudes

3. Conclusion

3.1. The Wind Farm will still have an impact to the ATCSMAC. Whilst all the identified options would allow for safe vectoring onto the IAPs, the Airport and the IAA would have to determine if the proposed options would still allow for effective vectoring operations. If it is deemed that the Wind Farm can be mitigated by a redesign, the full design process will need to be conducted.

3.2. Design option A will still allow for aircraft to be vectored onto an Instrument Approach Procedure for RWY 26. Aircraft would be required to be established on the IAP at 8 nm from THR RWY 26 to descend below the MVA.

3.3. Design option B would allow for the current SMAA sector 1 to remain at 2300 ft, however SMAA sector 2 would be expanded to encompasses the Wind Farm. ATC would be unable to vector aircraft onto the RWY 26 IAPs within SMAA sector 1.

3.4. Design option C would allow for the current SMAA sector 1 to remain at 2300 ft, although its area would reduce. A new SMAA is proposed as part of this option which will give ATC the ability to vector aircraft to intercept the IAPs at 2600 ft for RWY 26 whilst keeping a 2300 ft MVA for RWY 08.

3.5. Design option D reduces the area of SMAA sector 1 and creates two new SMAA sectors at 2600 ft and 2400 ft. Whilst this option provided more flexibility due to the distance from THR RWY 26, the area of the 2400 ft SMAA is too small for effective vectoring and aircraft would likely be established on an IAP and be descending below the MVA. Therefore, it is unlikely that any benefit could be gained from its additional complexity.

3.6. The stability of approaches by landing aircraft is coming evermore to the forefront of Airline Safety Departments and National Authorities safety agenda's and less and less operators are accepting of aircrew conducting 'shortened' ILS approaches. However, this does not mean that flexibility of ATC vectoring operations should no longer be considered important. Busy sequences of traffic sometimes require aircraft that are able to accept manoeuvring that, although obviously still safe, does not necessarily meet other Operators SOPs and are placed into the 'approach plan' to create an overall efficient flow of air traffic – a core element of ATC.

3.7. This, of course, needs to be balanced (obviously with safety as the foundation) with the Country's Green Energy aspirations. Ultimately, only Shannon ATC can decide whether the options presented in this report are operationally feasible. As the report has stated, any option deemed to have merit would need to be fully assessed and, possibly, refined so as to meet Shannon ATC expectations and provide them with the confidence of a solution that is safe and, on balance, expedient to the majority of users.

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Appendix 9.1

Shannon Runway 24

Special ILS Flight Inspection

Appendix L – Shannon Runway 24 Special ILS Flight Inspection (FCSL April 2022)

FLIGHT CALIBRATION SERVICES LTD

SHANNON RUNWAY 24

SPECIAL ILS FLIGHT INSPECTION

Prepared For:	Ai Bridges Ltd
Author:	John Wilson
Reviewed by:	David Bartlett
Reference:	FCSL 0141
Issue:	1
Date:	30 April 2022

SHANNON RUNWAY 24

Special ILS Flight Inspection

TABLE OF CONTENTS

ABBREVIATIONS

AMSL	Above Mean Sea Level
FCSL	Flight Calibration Services Ltd
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
NM	Nautical Mile
RF	Radio Frequency
VMC	Visual Meteorological Conditions

1 INTRODUCTION

The developer of the proposed Violet Hill wind farm 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). The height of the highest turbine (to blade tip) is 461 m (1,512 ft) AMSL

This assessment presented in FCSL Report FCSL 0138 shows that in IMC, Glide Path level runs will need to be flown at an altitude of at least 2,512 ft to remain 1,000 ft above the highest wind turbine. The altitude will be rounded up to the nearest 100 ft, so the ILS Glide Path left slice 8° (level run) will therefore have to be flown at 2,600 ft in IMC.

FCSL Report FCSL 0138 recommends that additional flight checks should be conducted at the next routine ILS flight inspection to assess the RF signal levels for an extended Glide Path level run at an altitude of 2,600 ft. This report presents the results of additional ILS Glide Path flight checks that were conducted by FCSL at Shannon Airport on 20 April 2022.

2 SPECIAL FLIGHT INSPECTION PROCEDURES

ICAO Annex 10 Volume I states that ILS Glide Path coverage shall extend 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).

If Glide Path flight inspection level runs (slice profiles) are to be flown at higher altitudes to provide sufficient clearance above obstacles, the length and duration of the runs, and distance from the runway will increase correspondingly as shown in Figure 2.1 below.

FCSL Report FCSL 0138 recommends that additional flight checks should be conducted at the next routine ILS flight inspection to assess the RF signal levels for an extended Glide Path level run at an altitude of 2,600 ft. In addition to the recommended level runs at 2,600 ft, additional level runs were flown at an altitude of 3,000 ft AMSL. This altitude corresponds to the altitude specified for initial approach as promulgated on the Runway 24 ILS instrument approach chart.

Table 2.1 below shows the additional slice (level run) flight profiles flown.

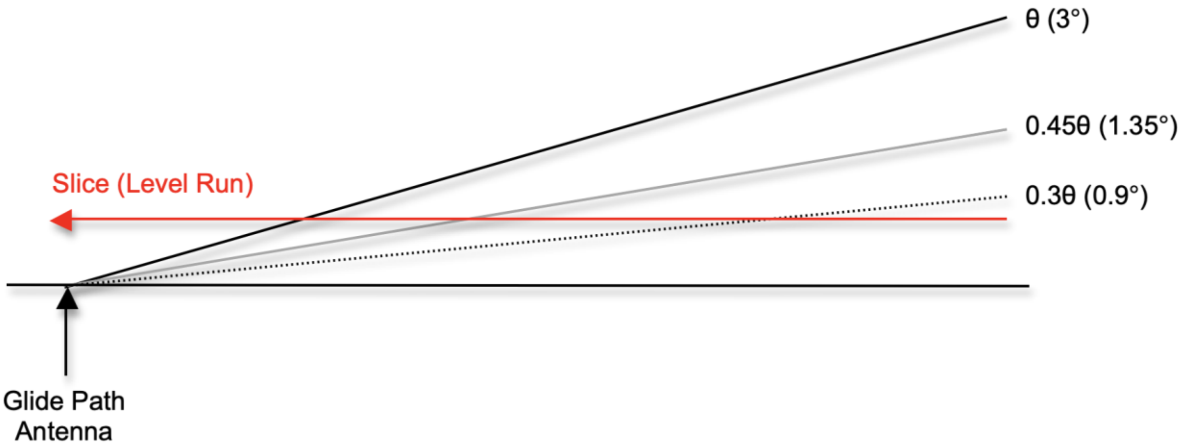


Figure 2.1 – ILS Glide Path Level Run

Flight Profile	Height AMSL (ft)
Slice	2,600
Left Slice 8°	2,600
Right Slice 8°	2,600
Slice	3,000
Left Slice 8°	3,000
Right Slice 8°	3,000

Table 1.1 – Special Glide Path Flight Inspection Profiles

3 FLIGHT INSPECTION RESULTS

Figures 3.1 to 3.6 below show flight inspection plots for the additional Glide Path level runs flown at 2,600 ft and 3,000 ft AMSL.

3.1 Slice 2,600 ft

Figure 3.1 below shows that for Glide Path level run flown at an altitude of 2,600 ft AMSL, the minimum signal level of -95 dBW/m^2 is achieved at a range of approximately 20 NM from runway threshold. Figure 3.1 also shows that adequate fly-up guidance exists from this range.

3.2 Left Slice 2,600 ft

Figure 3.2 below shows that for Glide Path left slice level run flown at an altitude of 2,600 ft AMSL, the minimum signal level of -95 dBW/m^2 is achieved at a range of approximately 18.4 NM from runway threshold. Figure 3.2 also shows that adequate fly-up guidance exists from this range.

3.3 Right Slice 2,600 ft

Figure 3.3 below shows that for Glide Path right slice level run flown at an altitude of 2,600 ft AMSL, the minimum signal level of -95 dBW/m^2 is achieved at a range of approximately 18 NM from runway threshold. Figure 3.3 also shows that adequate fly-up guidance exists from this range.

3.4 Slice 3,000 ft

Figure 3.4 below shows that for Glide Path level run flown at an altitude of 3,000 ft AMSL, the minimum signal level of -95 dBW/m^2 is achieved at a range of approximately 22 NM from runway threshold. Figure 3.3 also shows that adequate fly-up guidance exists from this range.

3.5 Left Slice 3,000 ft

Figure 3.5 below shows that for Glide Path left slice level run flown at an altitude of 3,000 ft AMSL, the minimum signal level of -95 dBW/m^2 is achieved at a range of approximately 21.25 NM from runway threshold. Figure 3.5 also shows that adequate fly-up guidance exists from this range.

3.6 Right Slice 3,000 ft

Figure 3.6 below shows that for Glide Path right slice level run flown at an altitude of 3,000 ft AMSL, the minimum signal level of -95 dBW/m^2 is *not achieved*, but is within 1 dB of the minimum requirement. Figure 3.6 also shows that adequate fly-up guidance exists to a range of 21.5 NM from runway threshold.

3.7 Summary of Results

Figures 3.1 to 3.3 below show that for a level runs at an altitude of 2,600 ft, Glide Path RF signal levels exceed minimum RF signal level of -95 dBW/m^2 and sufficient fly-up guidance is achieved below the Glide Path sector.

Figures 3.4 and 3.5 below show that for a level runs at an altitude of 3,000 ft, Glide Path RF signal levels exceed minimum RF signal level of -95 dBW/m^2 and adequate fly-up guidance is achieved below the Glide Path sector.

Figure 3.6 below shows that for a left slice level run at an altitude of 3,000 ft the minimum signal level of -95 dBW/m^2 is *not achieved*, but is within 1 dB of the minimum requirement. Adequate fly-up guidance is achieved below the Glide Path sector.

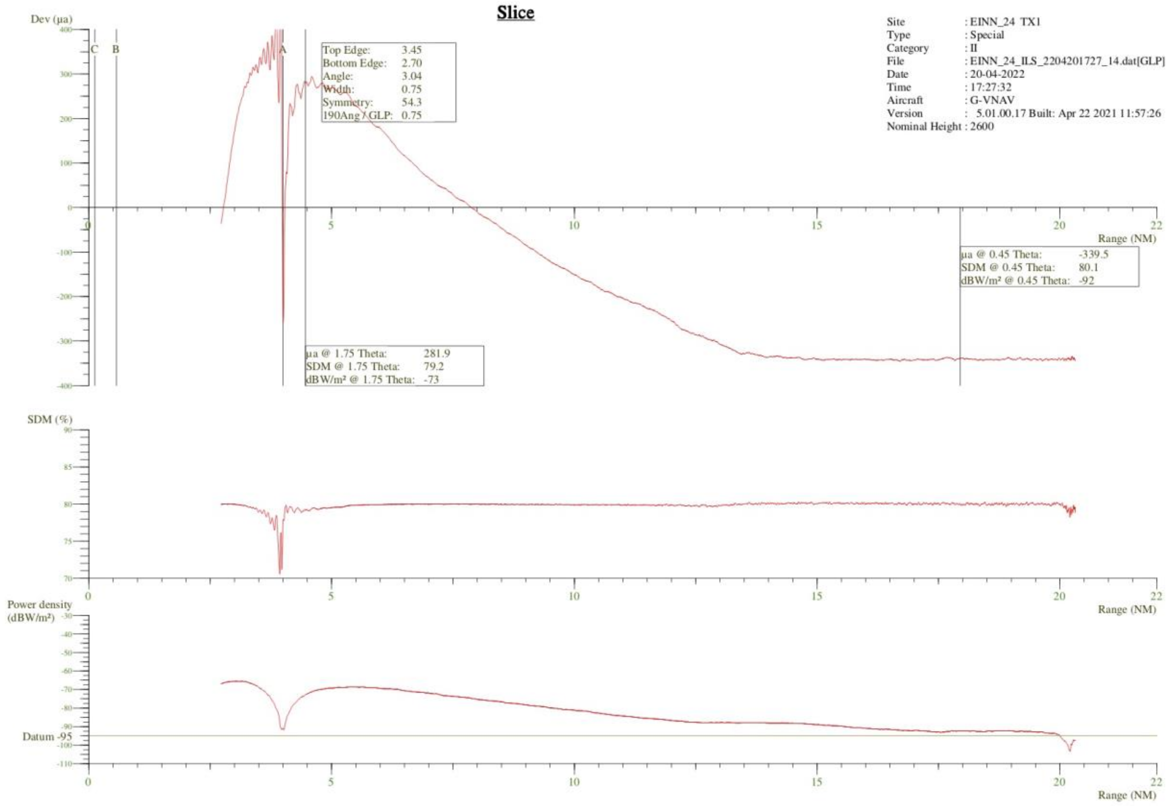


Figure 3.1 - Slice 2,600 ft

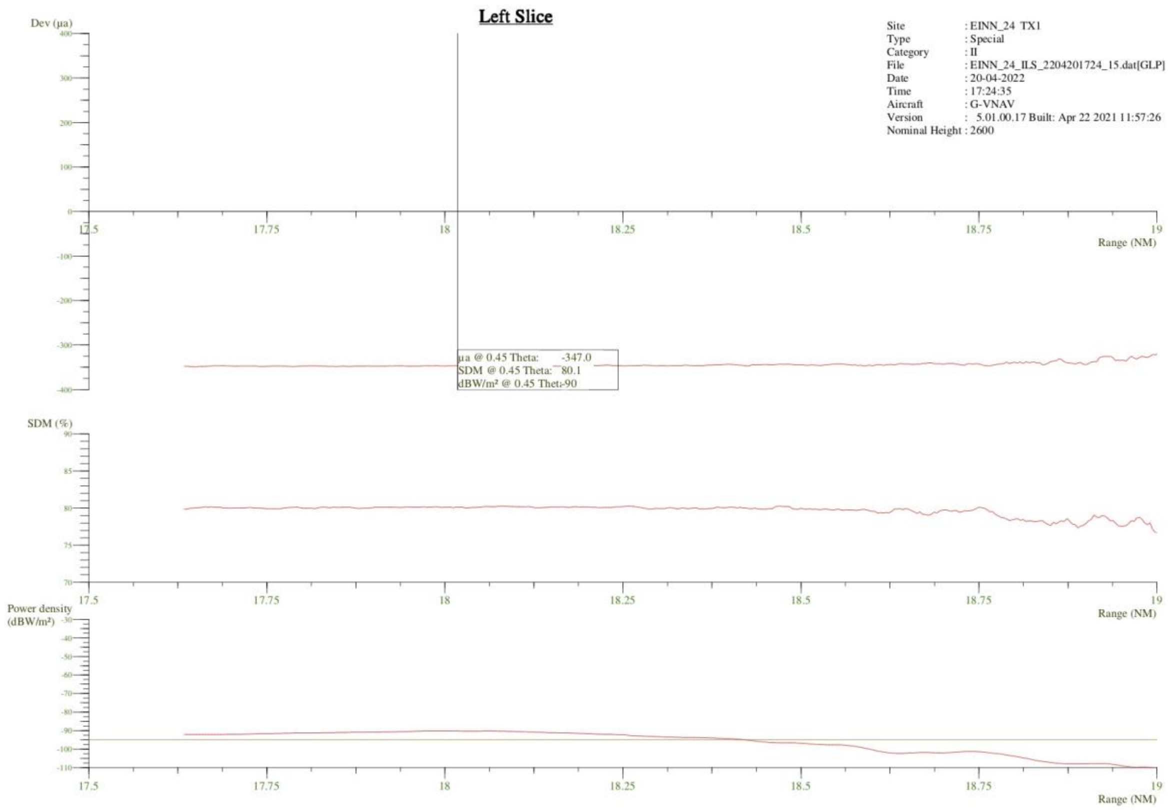


Figure 3.2 - Left Slice 2,600 ft

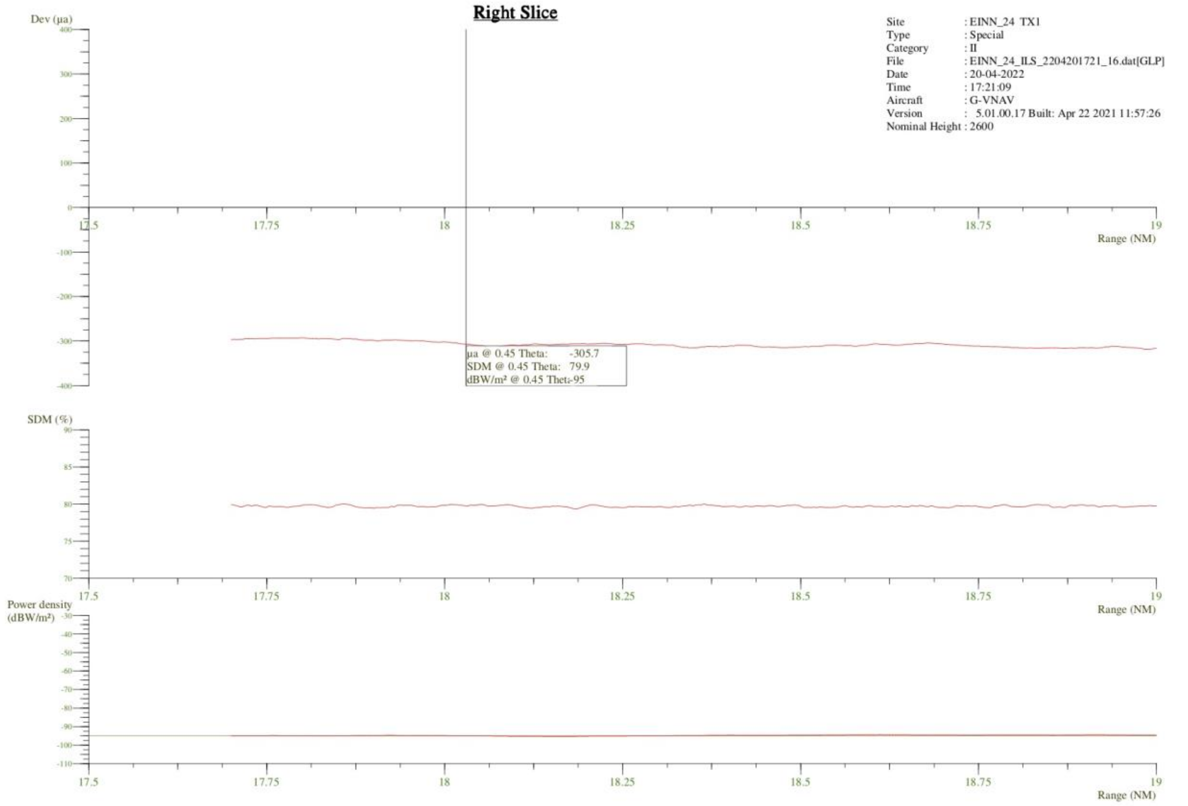


Figure 3.3 - Right Slice 2,600 ft

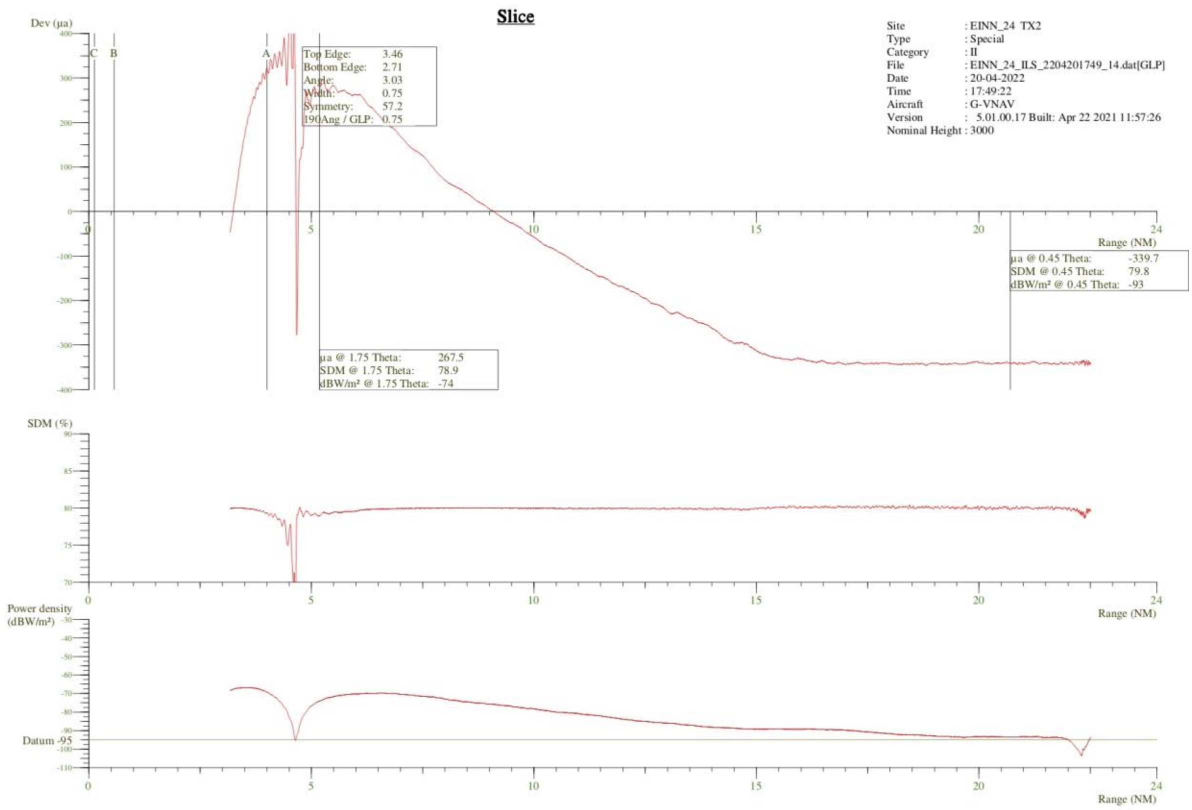


Figure 3.4 - Slice 3,000 ft

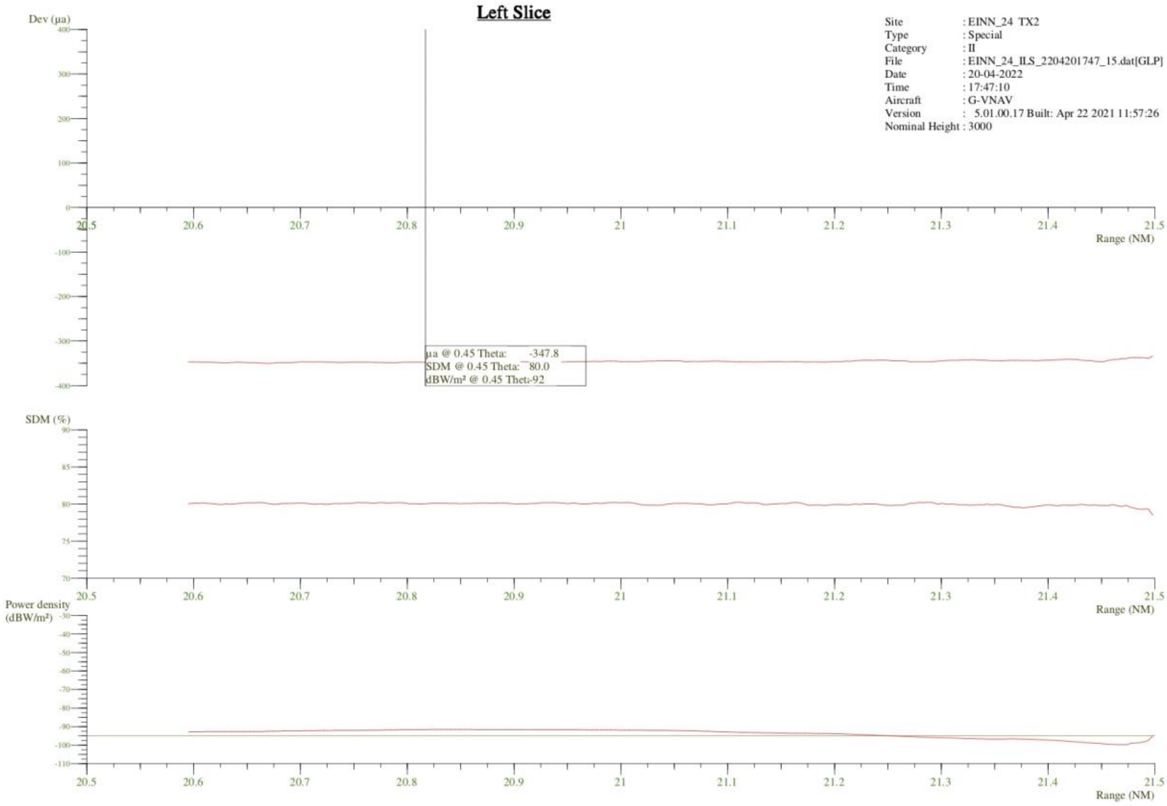


Figure 3.5 - Left Slice 3,000 ft

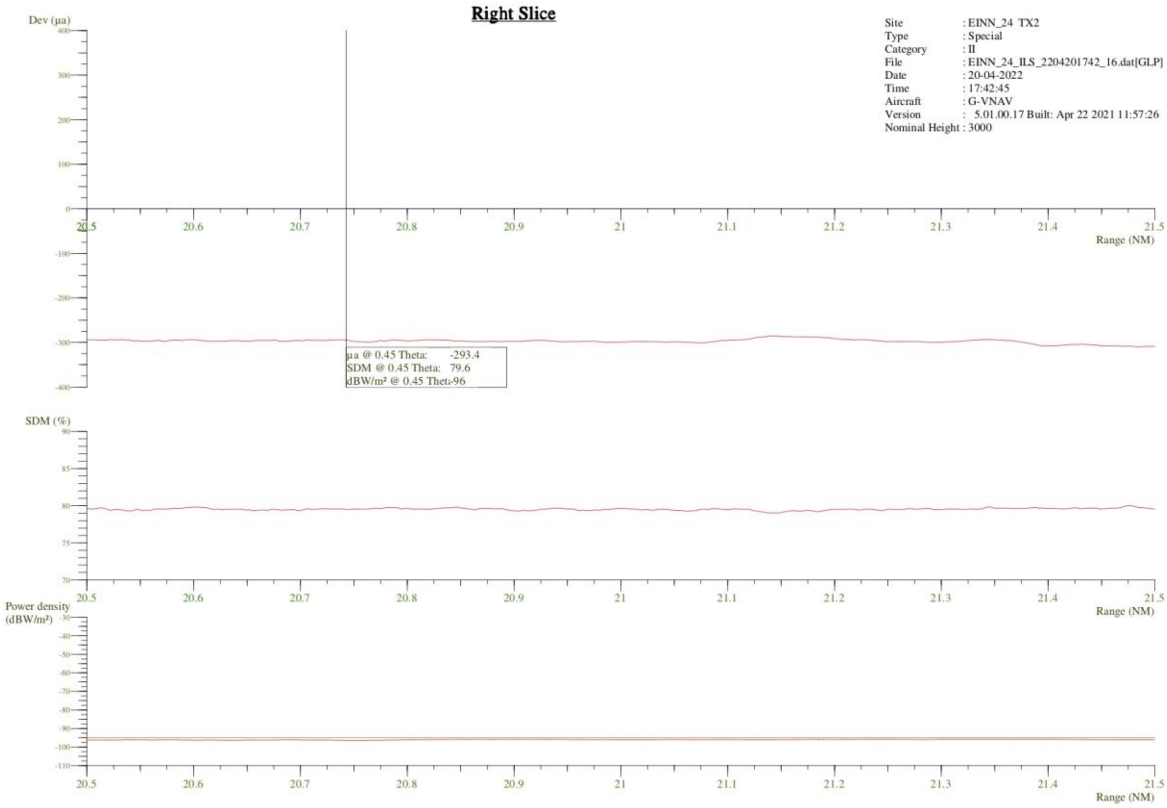


Figure 3.6 - Right Slice 3,000 ft

4 CONCLUSIONS

The results of the special Glide Path flight inspection presented in section 3 above show that, with the exception of the right slice 8° profile flown at an altitude of 3,000 ft, adequate Glide Path RF signal levels were received at the higher slice (level run) altitudes of 2,600 ft and 3,000 ft. Adequate fly-up guidance was achieved below the Glide Path sector for all level run profiles flown.

This means that if ILS flight inspection operations are conducted in IMC, the flight inspection level runs can be flown at 2,600 ft and the proposed Violet Hill wind farm will therefore not have any adverse effect on Runway 24 ILS flight inspection procedures and flight profiles.

If a replacement Runway 24 ILS is to be commissioned at Shannon Airport at some time in the future, commissioning flight inspections will be conducted in VMC, so the proposed Violet Hill wind farm will therefore not have any adverse effect on future ILS commissioning flight inspection procedures and flight profiles.

Appendix 9.2

Email Correspondences with Flight Calibration Services Ltd (FCSL)

Appendix J – Email Correspondences with Flight Calibration Services Ltd (FCSL)

APPENDIX J – Email Correspondences with FCSL

Relevant extracts from the email correspondences between Ai Bridges Ltd and Flight Calibration Services Ltd (FCSL) in relation to Knockshanvo wind farm, formally known as Violet Hill wind farm are presented below.

FCSL Email to Ai Bridges Ltd - 27 August 2021

From: John Wilson [mailto:john.wilson@flight-cal.com]
To: Kevin Hayes <khayes@aibridges.ie>
Sent: 27 August 2021 13:37
Subject: Flight Inspection Impact Assessment - Violet Hill Wind Farm

Hi Kevin

Please find attached our report FCSL 0138 - Violet Hill Wind Farm - Impact on ILS Flight Inspection.

The report concludes that there may be some obstacle clearance issues in IMC conditions for the Glide Path slice (level run) flight inspection profiles. Please note our recommendations in section 7 of the report. Please contact me or David Bartlett if you have any questions or queries.

Regards
John Wilson
Flight Calibration Services Ltd

Ai Bridges Ltd Email to FCSL – 02 September 2021

***From**: Kevin Hayes*
***Sent**: 02 September 2021 14:44*
***To**: David Bartlett <david@flight-cal.com>*
***Subject**: RE: Flight Inspection Impact Assessment - Violet Hill Wind Farm*

David,

Thank you for your time on our call earlier.
As discussed I would be grateful if you could revert with the following

- *Estimates for the cost adjustments to the increased contract costs of bi-annual FCSL flight inspections*
- *Estimates or the costs of ILS Computer Simulations i.e. Estimate 4 days at FCSL standard daily rates*

We will require these costs to prepare a Mitigation Cost Summary for our client.

Also as discussed we will be looking to make contact with IAA \ SAA in the coming 1 – 2 weeks we would like to request your availability for a call with them to discuss your findings.

Best Regards,
Kevin Hayes,
Ai Bridges Ltd.,
...Total Communications Solutions...

Ai Bridges Ltd Email to FCSL – 02 September 2021

From: *Kevin Hayes*
Sent: *04 April 2022 14:06*
To: *'John Wilson' <john.wilson@flight-cal.com>*
Subject: *RE: Flight Inspection Impact Assessment - Violet Hill Wind Farm*

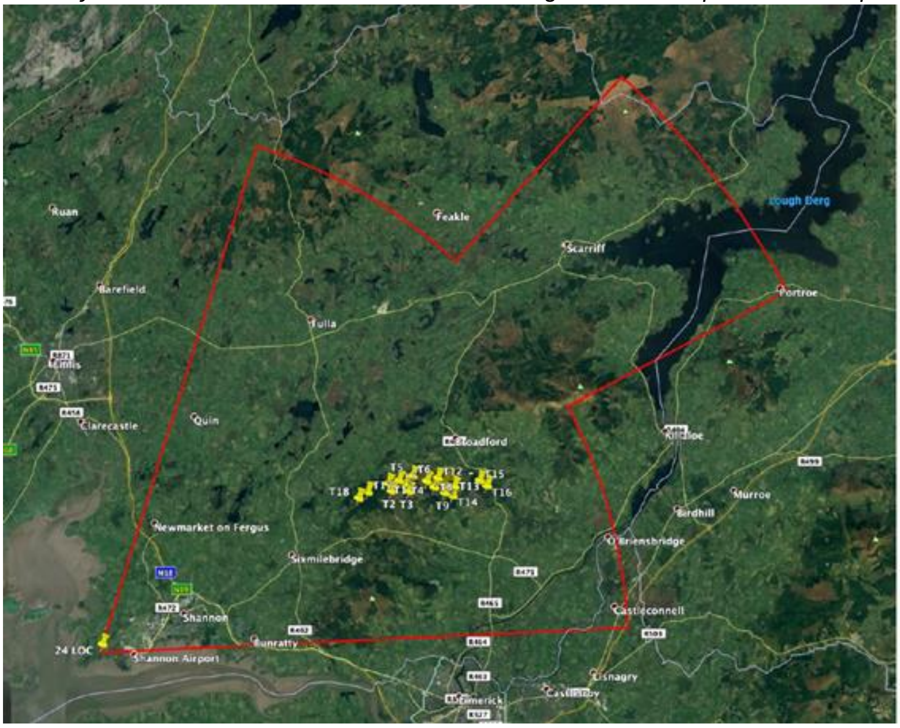
Hello David, John

I am following up from our last communication in relation to the ILS Flight Inspection Impact Assessment Report that you prepared.

As we are co-ordinating all aspects of the Aviation Assessments we have been awaiting an overall response from IAA including Radar, IFP impact assessments. We have reviewed a recent response back from the IAA and they have the following comments. Would you be able to confirm that you were able to conduct the additional flight as we discussed on our last call ? During our discussions with the IAA since last September since last September they did not give any indication that they expected issue based on the FCSL report.
We have allowed for a computer simulation and the cost of an additional flight.
In particular the comment that "if a flight or schedule is missed , this could result in (temporary) withdrawal of ILS systems ". The same point could be made for the existing calibration flights due to weather preventing these flights as well.

Would you be available for a call to discuss the points below so that we can discuss the points and address the remediatrion and associated costs

1. ***NAVAIDs Potential Issues (Attachment 2: FCSL Report) Comments:***
    - *Once again the level of detail and effort here is appreciated*
    - *Correctly the main area of concern is for ILS coverage areas as depicted in the report:*



    - *The main conclusion noted from this report is: " The flight inspection Glide Path left slice 8° profile (level run) will have to be raised to an altitude of 2,600ft in IMC to provide the flight inspection aircraft adequate coverage over the proposed wind turbines. This will result in increased flight inspection costs for the extended Glide Path level runs. If there* *is insufficient Glide Path RF signal for the extended level run at 2,600 ft then it may not be possible to conduct this flight inspection in conditions of bad visibility. This may result in additional cost if the flight inspection aircraft is delayed while waiting for VFR conditions.*

-

Overall IAA ANSP Position for this Item: *Conclusions of the report are noted potential delays to flight calibration activity resulting from the Wind Farm development as constructed, are not acceptable. This is because the ANSP is regulatory required to complete NAVAIDs flight calibration twice yearly. If schedule is affected or missed, this could result in (temporary) withdrawal of ILS systems, in turn adversely affecting airport arrival operations to RWY 24.*

Best Regards,
Kevin Hayes,
Ai Bridges Ltd.,

Ai Bridges Ltd Email to FCSL – 12 April 2022

From: Kevin Hayes <khayes@aibridges.ie>
Sent: 12 April 2022 10:27
To: John Wilson <john.wilson@flight-cal.com>; David Bartlett <david@flight-cal.com>
Subject: RE: Flight Inspection Impact Assessment - Violet Hill Wind Farm

Hello David,

Thank you for taking my call just now . As discussed I would be grateful if you could confirm that FCSL have availability to run an additional flight on your upcoming bi-annual flight inspections

Just to conform that we have submitted the finding in your report to the IAA who in turn have brought to the attention of the relevant stakeholder within the ANSP for Shannon Airport

I would be grateful if you could advise on availability to conduct this additional flight if required as we want to address the concerns\ comments from the IAA below

"if a flight or schedule is missed , this could result in (temporary) withdrawal of ILS systems ".

Best Regards,
Kevin Hayes,
Ai Bridges Ltd.,

FCSL Email to Ai Bridges Ltd - 14 April 2022

From: *David Bartlett <david@flight-cal.com>*
Sent: *14 April 2022 11:34*
To: *Kevin Hayes <khayes@aibridges.ie>*
Subject: *RE: Flight Inspection Impact Assessment - Violet Hill Wind Farm*

Hi Kevin,

We are scheduled to complete the next Shannon inspection on 21st / 22nd April and we could include a couple of additional coverage runs for the Glidepath if you give us the go-ahead.

Please confirm if you wish us to proceed as soon as possible as we will need to brief the Flight crew and submit a revised flight profile schedule for Shannon.

Best Regards

David

David Bartlett
Director

FCSL Email to Ai Bridges Ltd – 30 April 2022

From*: John Wilson <john.wilson@flight-cal.com>*
Sent*: 30 April 2022 14:34*
To*: Kevin Hayes <khayes@aibridges.ie>*
Subject*: Additional flying 21 22 April Purchase Order- Violet Hill Wind Farm Flight check*

Hi Kevin
Please find attached our report FCSL 0141 - Shannon Runway 24 - Special ILS Flight Inspection.

The report concludes that the proposed Violet Hill wind farm will not have any adverse effect on Runway 24 ILS flight inspection procedures and flight profiles

Please contact me or David Bartlett if you have any comments or queries.

Regards
John Wilson
Flight Calibration Services Ltd

Appendix 10

Knockshanvo Wind Farm

Aviation Review Statement

Report

Knockshanvo Wind Farm

Aviation Review Statement

Document Number: 001/KO202309

Author: PT\DMG\KH\MOD

Approved for Release: Rev. 2.0 KH **Date:** 19/09/23

Document Filename: *Knockshanvo Wind Farm - Aviation Review Statement*

Executive Summary

In March 2023 Ai Bridges Ltd was commissioned by Future Energy Ireland (formerly Coillte CGA) to review the possible impacts of proposed Knockshanvo Wind Farm development (consisting of 9 wind turbines) on the existing aeronautical and aviation infrastructure at Shannon Airport and Woodcock Hill. This Aviation Review was informed by the Violet Hill Wind Farm development which was previously proposed at the same site in 2021 and at the time consisted of 18-turbines. Due to technical and environmental constraints, there were several iterations of the turbine layout since the initial aviation assessments were carried out in 2021. This Aviation Review addresses the potential impacts to and the proposed Knockshanvo Wind Farm development based on the finalized 9-turbines layout

Ai Bridges commenced the Aviation Review on March 2023 following the consultation process between the Irish Aviation Authority (IAA) and the EIAR Consultant, MKO. The IAA as Air Navigation Service Provider highlighted that they would require further analysis. This assessment includes a review all Radar Surveillance Systems at Woodcock Hill, a review of the Instrument Flight Procedures Safeguarding and as well as a review of the Navigational Aid Flight Inspections and Communications Systems used for Shannon Airport. All of the reviews based on International Civil Aviation Organisation (ICAO) standards and recommended practices.

A due-diligence review of all of the potentially affected aviation and Aeronautical surfaces was conducted and the findings are presented in Section 2 below. An additional aeronautical analysis on the Safeguarding of the Irish Air Corp \ Department of Defence was also carried out in accordance with the Irish Air Corps Position Paper "*Air Corps Wind Farm/ Tall Structures Position Paper*".

It was identified in the Aviation Review that there would be a potential impact on the Instrument Flight Procedures for the Flight Departures and Approaches at Shannon Airport. It was also identified that there would be a potential wind farm impact on the Radar Surveillance Systems at Woodcock as the proposed development is within 16km of the MSSR. Ai Bridges made a recommendation to contract an IAA-approved Procedure Designer (Cyrrus) to conduct a detailed Technical Safeguarding Assessment of the Instrument Flight Procedures as well as a detailed Technical Assessment of the Radar Surveillance Systems. An additional assessment of Instrument Landing Systems (ILS) Flight Inspection Procedures was undertaken and was informed by the previous assessments conducted for the Violet Hill Wind Farm.

IAA Consultation Response :

It was a request of the IAA, in their consultation response shown in Appendix A, that they would require further analysis and they highlighted the following potential impacts of the proposed Knockshanvo development to aviation safeguarding at Shannon Airport and Woodcock Hill

1. ***Instrument Flight Procedures (IFPs) Shannon Airport:*** *the ANSP is required to Safeguard these IFPs*

2. ***Woodcock Hill Radar:*** *Surveillance effect (IAA ANSP Surveillance Domain copied). Generally any significant obstacle within 16km of this facility may have impact. In the case of this proposed Wind farm, this is highly likely and will need to be assessed with mitigations proposed. Please note that previous experience has shown that mitigations suggested for similar developments have been prohibitively costly for the ANSP and ultimately don't guarantee that the surveillance service is not affected. Third attachment is the EUROCNTROL Guidelines on How to Assess the Potential Impact of Wind Turbines Surveillance Sensors*
3. ***Navigation Aids (NAVAIDS):*** *This will need to be considered by my NAVAID colleagues (copied), although generally there should not be an impact. There is however another aspect to this. On a 6-monthly basis, these NAVAIDs have to be flight calibrated. The calibration aircraft flies in this area at low altitudes to achieve this and a report from this company (FCSL) may be required also.*

Previous IAA Consultations (2021 – 2022) – Violet Hill Wind Farm :

Ai Bridges engaged with the IAA from November 2021 to May 2022 in relation to the proposed 18-turbine Violet Hill Wind Farm. During the consultation process Ai Bridges

i) Presented the findings of the IFP Safeguarding and Radar Surveillance Technical Assessments, conducted by Cyrrus, to the IAA for review.

ii) Engaged Cyrrus, the Approved Aviation Design Specialist, in co-operative technical reviews of the IFP Safeguarding issues

iii) Address their main concerns in relation to IFP Safeguarding and specifically Air Traffic Control Surveillance Minimum Altitude Chart (ATCSMAC) and present mitigation measures to determine what possible design options exist to reduce the impact the Wind Farm poses and allow Shannon Airport to continue with safe and efficient vectoring operations i.e. to ensure there was obstacle clearance for Air Traffic Controllers to vector aircraft in the airspace until the aircraft reaches the point where the pilot would resume their own navigation.

iv) Presented the findings ILS Flight Calibration Impact Assessments, carried out by FCSL Ltd, and also commissioned FCSL Ltd to conduct additional Flight Inspections at increased heights as well as conduct computer simulations to quantify potential impacts on Navigational Aids at Shannon.

Mitigation Measures Proposals (2021 – 2022)

It was identified through the engagement process that possible Mitigation Measure solutions that could be implemented to remediate potential impacts from the proposed wind farm on the Shannon Airport aviation infrastructure. The following mitigation measures were proposed and recommended to remediate the potential impacts to the aviation infrastructure in the vicinity of Shannon Airport and Woodcock Hill

i) Implementation of upgrades on the Woodcock Hill Surveillance Radar to blank wind turbine interference

ii) Review and selection of the ATC SMAC conceptual design options provided by Cyrrus in order to determine if the proposed options reduce the impacts to a level where safe and effective Ait Traffic Control vectoring could continue. This would require a full design based on the most suitable design option to further optimise the concept and consider all obstacles

iii) Conduct additional Flight Inspections at increased heights noting that an additional desktop computer simulation, carried out by FCSL Ltd, has already confirmed that there would be no adverse impacts on the Flight Calibration Procedures flown at higher altitudes.

Subsequent to the IAA consultations conducted on 2021 – 2022 as outlined above, the turbine layout has been reduced from eighteen turbines down to just nine. This reduction in wind turbines is likely to reduce the impacts to the IFP Safeguarding and Air Traffic Control Surveillance Minimum Altitude Chart (ATCSMAC), subject to further detailed technical assessments. This will also significantly reduce the amount of impacts detected by the MSSR Radar at Woodcock Hill.

Summary

The Aviation Review of the proposed Knockshanvo Wind Farm development finds that

i) A detailed technical assessment be carried out by that IAA-approved Procedure Designer, Cyrrus, to assess the impacts of the proposed Knockshanvo development on the IFP's and the ATCSMAC at Shannon Airport

ii) Are-design of instrument flight procedures specifically in relation to the ATC SMAC would be subject to an IAA \ Shannon ATC review of the design options presented by Cyrrus.

iii) A detailed Radar Safeguarding Assessment be carried out by Cyrrus to assess the potential impacts of the finalised 9-turbine layout proposed development on the Secondary Surveillance Radar at Woodcock Hill which would propose mitigation measure solutions

iv)

Sections

Appendices

1. Introduction

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

1.1 Wind Farm Site Information

The proposed wind farm development is located approximately 6 km northeast of Sixmilebridge, Co Clare. Figure 1 shows the proposed wind farm location with respect to Shannon Airport.

There have been several iterations of the turbine layout due to technical and environmental constraints and has been reduced down to 9 turbines. Details of the 9-turbine layout are provided in Table 1 below.

Figure 1. Location of proposed wind farm at Knockshanvo

Turbine ID	WGS84		Ground Level (m AMSL)	Max Turbine Tip Height (m AGL)	Max Turbine Tip Elevation (m AMSL)
	Latitude	Longitude			
T01	52 46 25.63 N	8 41 31.25 W	262	185	447
T02	52 46 46.91 N	8 41 25.42 W	232	185	417
T03	52 46 39.73 N	8 41 04.49 W	264	185	449
T04	52 46 27.30 N	8 38 56.23 W	220	185	405
T05	52 46 45.51 N	8 38 32.48 W	194	185	379
T06	52 46 32.57 N	8 38 19.82 W	180	185	365
T07	52 46 14.45 N	8 38 28.56 W	172	185	357
T08	52 46 43.11 N	8 36 56.36 W	188	185	373
T09	52 46 31.70 N	8 36 34.80 W	196	185	381

Table 1. Knockshanvo 9-Turbine Layout

1.2 Shannon Airport

Table 2 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 Ref. Point ARP	Distance to Proposed Wind Farm
Shannon, Co Clare	International Airport	Single Asphalt Runway Airspace: Class C	52 42 07 N 008 55 29 W (Mid-point of Runway 06/24).	17.6 km

Table 2. Shannon Airport Details

The aeronautical navigation aids at the aerodrome include DVOR/DME, NDB, ILS LOC and ILS GP.

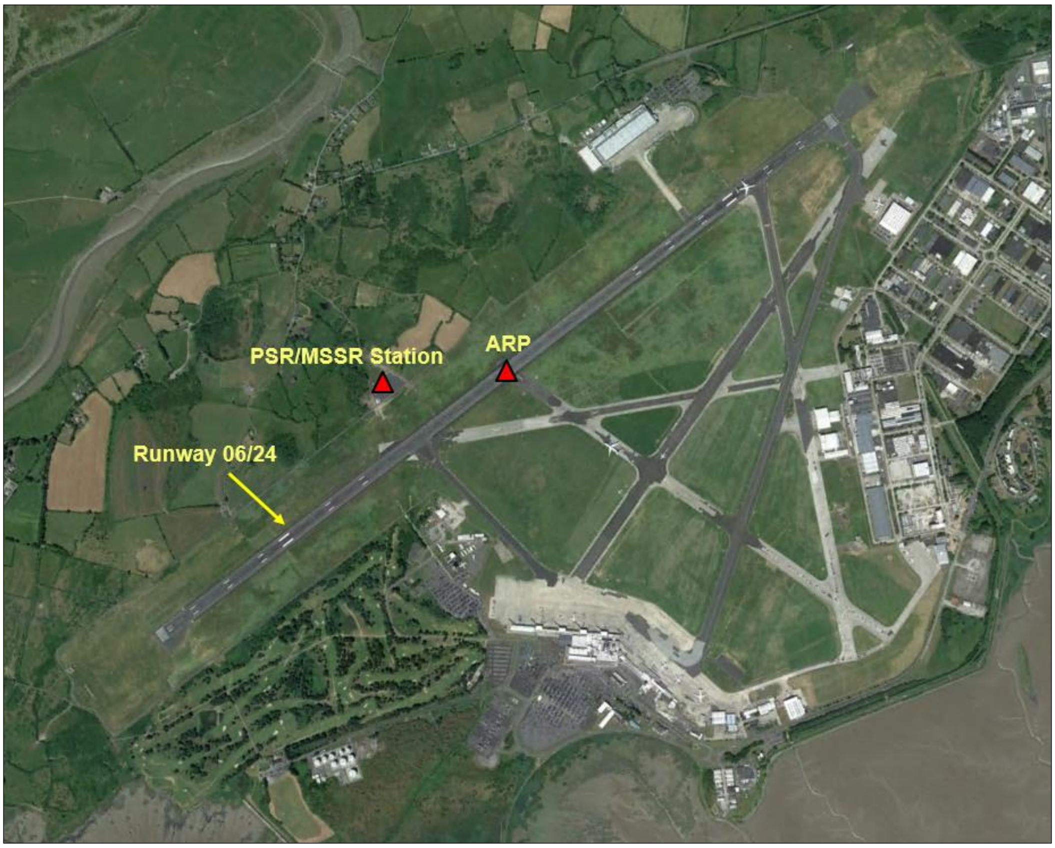


Figure 2. Shannon International Airport

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
- 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
- Irish Air-Corps / DoD Safeguarding

Annex 14 - Obstacles Limitation Surfaces (OLS)

A review shows that the proposed wind farm would be located outside the Outer Horizontal Surface of the Shannon International Airport Runway Obstacles Limitation Surfaces, as defined in ICAO (International Civil Aviation Organization) Annex 14.

As the proposed wind farm is situated outside the Outer Horizontal Surfaces and there are no penetration of the take-off or approach surfaces, it is unlikely that there will be any impacts to the OLS surfaces for Shannon International Airport.

Annex 15 - Aerodrome Surfaces

Following a review of ”Terrain and obstacle requirements Area 1” as defined in ICAO Annex 15, the proposed 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 windfarm 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.

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 specified distance from an airport. For Shannon International Airport MSAs are defined to an area which extends 25 nautical miles (46 km) from the VOR/DME located at the airport. The proposed wind farm site is located within the eastern MSA sector. There is over 1000 ft from the maximum height of the wind farm to the relevant MSA altitude and therefore there would appear to be no impact on the published MSA altitudes for Shannon International Airport.

Instrument Flight Procedures

The preliminary assessment of the Instrument Flight Procedures (IFP) for Shannon Airport carried out by Ai Bridges, indicated that at least two of the IFPs were potentially impacted by the finalised layout. To further investigate the possible impact on the IFPs, Ai Bridges engaged with Cyrrus, the IAA Approved Design Specialists, to undertake a detailed technical assessment. This IFP Safeguarding Assessment conducted by Cyrrus also showed that the Flight Procedures for flights departing from runway RWY06 and for flights arriving into runway RWY24 would be impacted. This assessment also showed that the Air Traffic Control Surveillance Minimum Altitude Chart (ATC SMAC) using by Air Traffic Controllers to vector flights for landing into Shannon Airport would also be impacted.

.

Communications, Navigation Systems

As the proposed wind farm is more than 15km from the Localizer and transmitting antennas at Shannon International Airports, the proposed wind farm will have any impact on these ATS communications and radio navigational aids.

Radar Surveillance Systems

For Radar Surveillance Systems, EUROCONTROL Guidelines require a 16km safe distance from the surveillance radar system (SSR), for a "*Zone 4 - No Assessment*" condition. It has been highlighted in the analysis that turbines located at the proposed Knockshanvo development would be located at a distance within 16km from the Secondary Surveillance Radar at Woodcock Hill.

Flight Inspection and Calibration

Flight checks are conducted bi-annually to ensure that flight procedures and associated navigational aids are safe and accurate for the Instrument Landing Systems (ILS). 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 for Shannon Airport for calibration of instrument landing systems. .

Aeronautical Obstacle Warning Light Scheme

In the event of a grant of planning consent the IAA would 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 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.

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 turbines and the airport obstacle surfaces. The obstacle limitation surfaces for Shannon Airport 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 Knockshanvo Hill Wind Farm. The distance from the Shannon Airport ARP, runway centre-point, to the nearest proposed wind turbine is 17.7 km. The analysis of the OLS plots indicates that the proposed turbines do not penetrate the Outer Horizontal Surface which extends to 15 km from the Shannon Airport Reference Point (ARP) or runway centre-point.

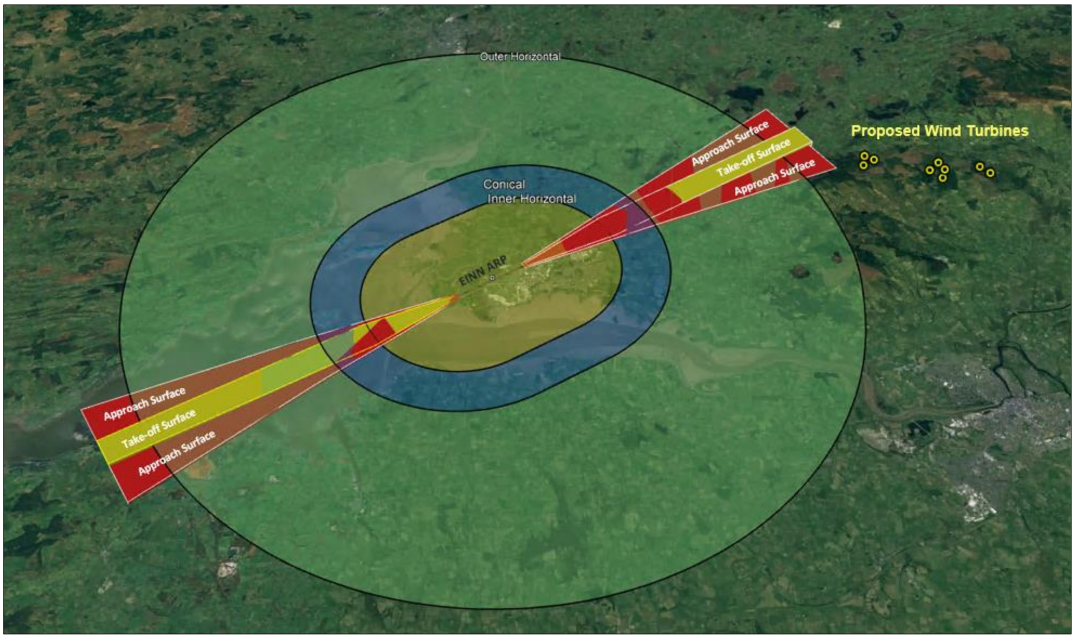


Figure 3. Proposed Wind Farm in relation to Shannon Airport OLS.

A 3D-modelling assessment was also carried and shows that the proposed turbines would 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 9-turbine layout.

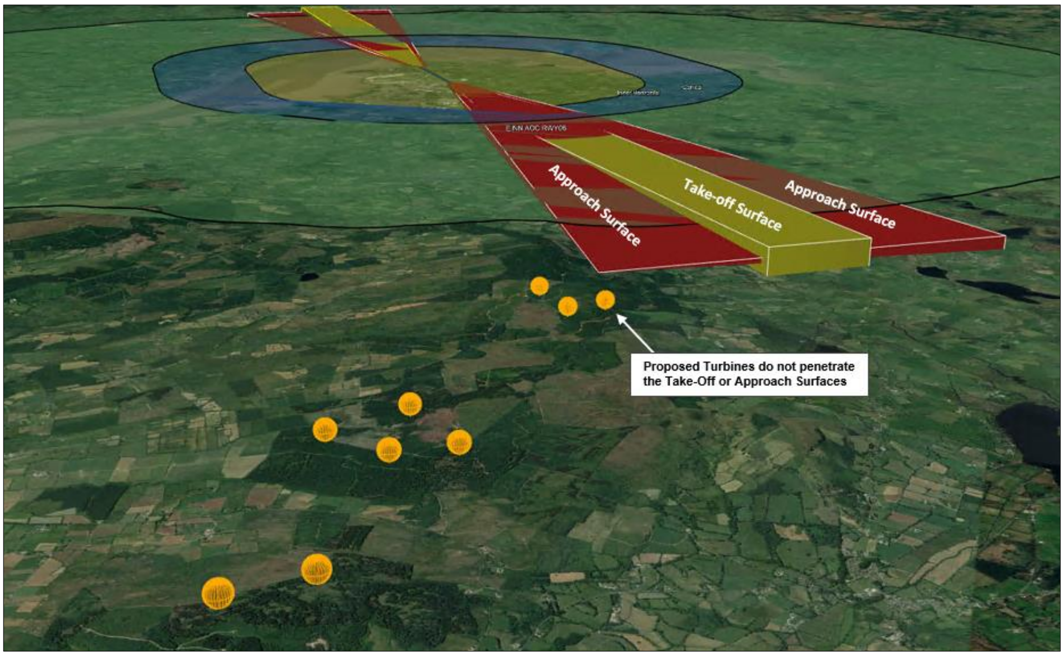


Figure 4. 3D Analysis showing the proposed turbines do not penetrate the Take-Off or Approach Surfaces

2.1.1 Obstacle Limitation Surfaces – Mitigation Measures and Residual Impacts

The table below outlines the mitigation requirements to offset the possible impacts due to the proposed wind farm development at Knockshanvo and the associated residual impacts.

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

Table 3. OLS – Mitigation Measures and Residual Impacts

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.

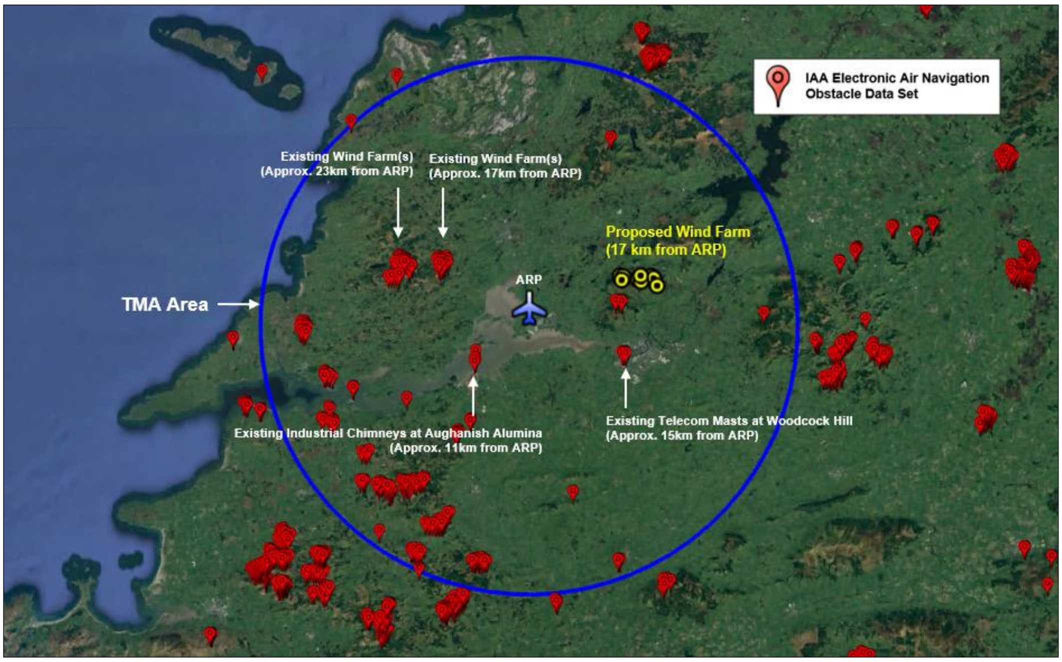


Figure 5. Annex 15 Aerodrome Surfaces and IAA Electronic Air Navigation Obstacle Data Set

2.2.1 Aerodrome Surfaces – Mitigation Measures and Residual Impacts

The table below outlines the mitigation requirements to offset the possible impacts due to the proposed wind farm development at Knockshanvo and the associated residual impacts.

Aviation Impact Assessment	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

Table 4. Aerodrome Surfaces – Mitigation Measures and Residual Impacts

2.3 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 quadrants.

Wind turbines at the proposed site would be located within the eastern sector (MSA 3400 ft) shown in Figure 6. 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 T03 is highest of the proposed turbines with a maximum tip-height of 1473 ft. This is below the 2400 ft threshold, therefore the MSA of the Main Quadrant will not be affected and there will be no impact on the published MSA altitude figures.

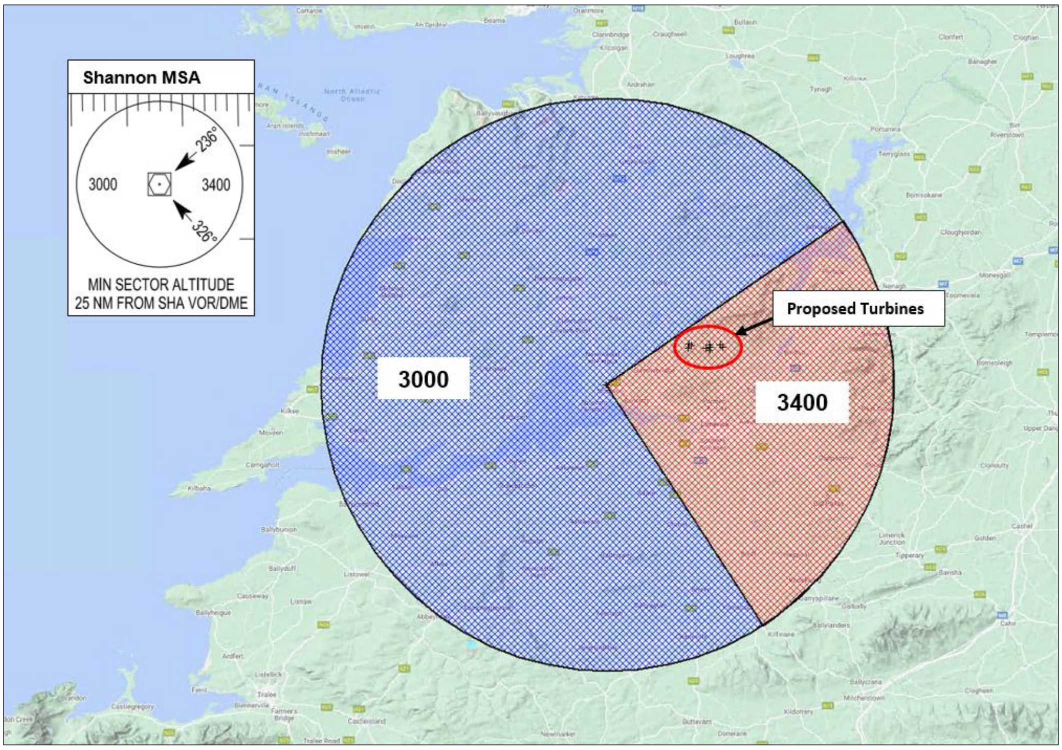


Figure 6. Minimum Sector Altitudes – Shannon Airport

2.3.1 Minimum Sector Altitudes – Mitigation Measures and Residual Impacts

The table below outlines the mitigation requirements to offset the possible impacts due to the proposed wind farm development at Knockshanvo and the associated residual impacts.

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

Table 5. Minimum Sector Altitudes – Mitigation Measures and Residual Impacts

2.4 Instrument Flight Procedures

There are 9 published Instrument and Visual Flight Procedures for arrivals to and departures from Shannon Airport. Table 6 below lists the Instrument Flight Procedures for Shannon Airport.

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

Table 6. Instrument and Visual Flight Procedures – Shannon Airport

In 2021, a preliminary assessment of the Instrument Flight Procedures (IFPs) for Shannon Airport was carried out by Ai Bridges which found that at least two of the IFPs were potentially impacted.

To further investigate the possible impact on the IFPs Ai Bridges engaged with Cyrrus, an Aviation Design Specialists approved by the IAA, to undertake a detailed IFP Safeguarding Assessment. The detailed technical assessment was completed by Cyrrus in 2021 and was based on the original 18-turbine layout. The purpose of the Cyrrus assessment was to assess if any of the turbines associated with the wind farm infringe the protection surfaces of the IFPs serving Shannon 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.

The findings in the Cyrrus report correlated with the findings of the Ai Bridges assessment; however, it was also shown that there was an impact on the Air Traffic Control Surveillance Minimum Altitude Chart which would require a re-design of the vectoring approach used by Air Traffic Controllers.

A summary of the Ai Bridges preliminary assessment is provided in Section 2.4.1 and a summary of the Cyrrus detailed technical assessment (18-turbine layout) is provided in Section 2.4.2.

2.4.1 Instrument Flight Procedures – Ai Bridges Assessment

The findings of the preliminary assessment of each of the nine aforementioned IFPs are presented in Section 2.4.1.1 to Section 2.4.1.9.

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

Figure 7 below shows the AIP chart associated with this flight procedure. As the chart shows, 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 shows a representation of the 9.1% and 3.3 climb gradients.

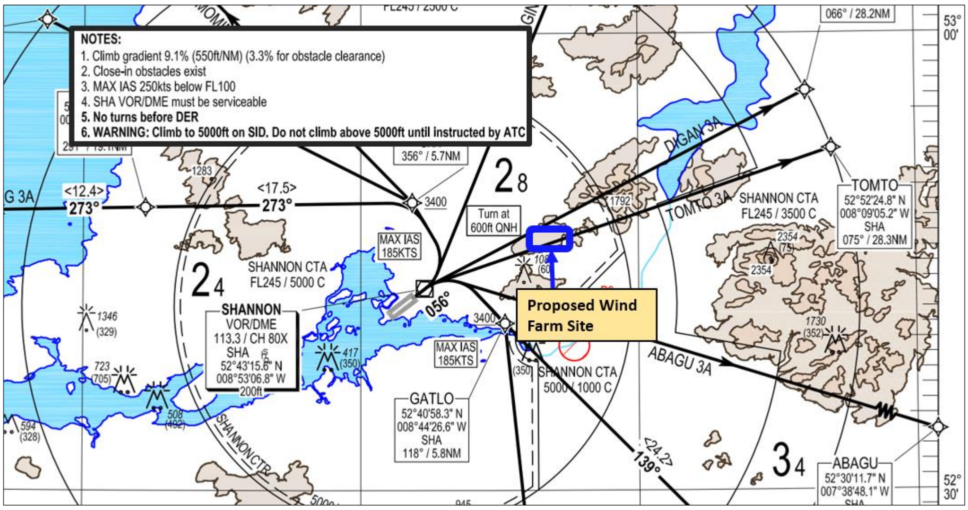


Figure 7. RNAV Standard Instrument Departure Chart RWY06 - Chart EINN AD 2.24-5

Figure 8. EINN AD 2.24-5 Climb Gradients

Figure 9 below shows a 3D-model which indicated that the proposed turbines would not impact the 3.3% Climb Gradient for flights departing runway RWY 06. As the departure climb gradients are unlikely to be impacted, there should be no impact to the RNAV Standard Instrument Departure procedure for RWY 06.

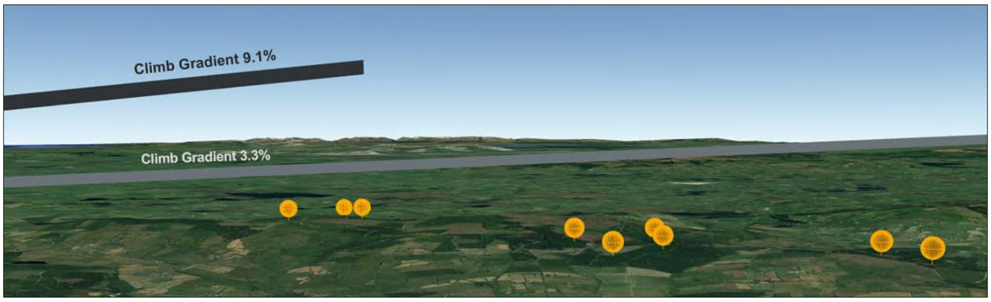


Figure 9. 3D Model indicating that proposed turbines would not impact the 3.3% Climb Gradient

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

Figure 10 below shows the AIP chart associated with this flight procedure. As the chart shows, flights departing from RWY 24 take-off to the southwest and do not fly over the proposed wind farm. As the flight paths do not fly over the proposed wind farm site, there should be no impact to this IFP.

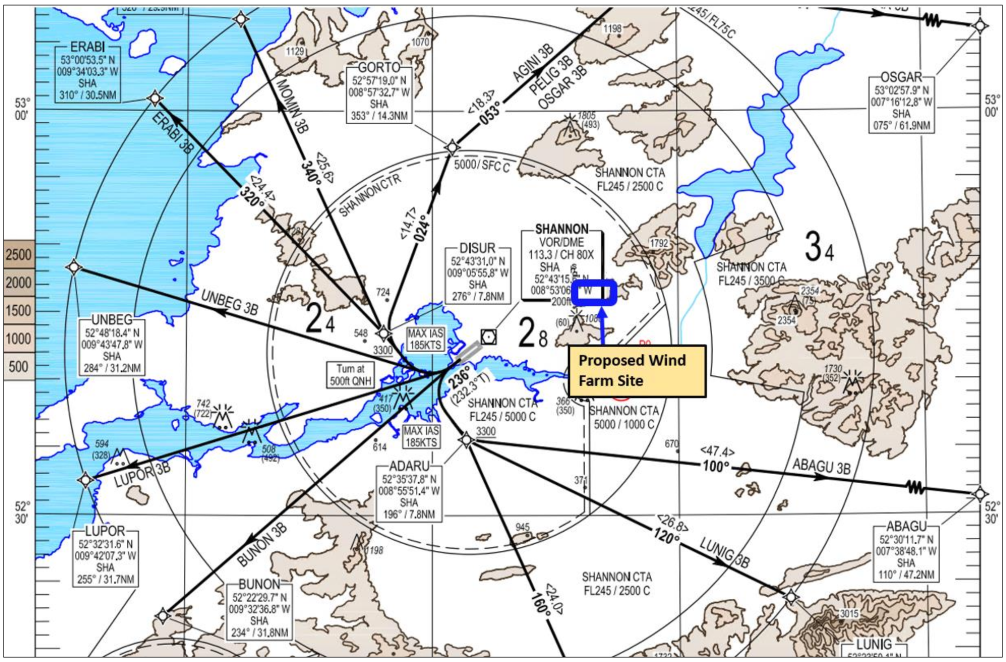


Figure 10. RNAV Standard Instrument Departure Chart RWY24 - EINN AD 2.24-6

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

Figure 11 below shows the AIP chart associated with this flight procedure. As the chart shows, flight routes for aircraft arriving to RWY 06 do not fly over the proposed wind farm site. As the flight paths do not fly over the proposed wind farm site, there should be no impact to this IFP.

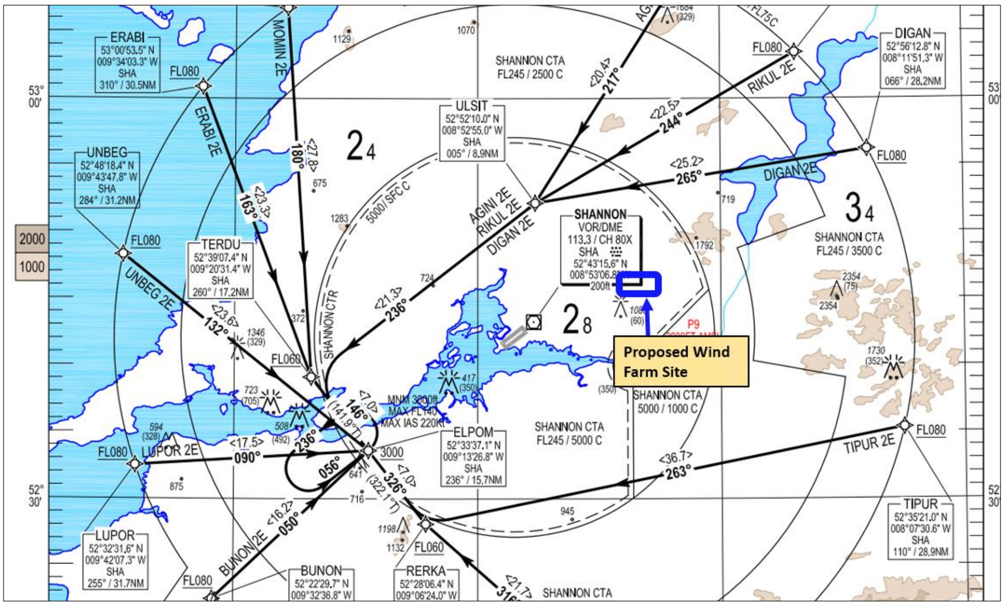


Figure 11. RNAV Standard Arrival Chart RWY 06 - EINN AD 2.24-7

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

Figure 12 below shows the AIP chart associated with this flight procedure. As the chart shows, flight routes for aircraft arriving to RWY 24 do not fly over the proposed wind farm site. As the flight paths do not fly over the proposed wind farm site, there should be no impact to this IFP.

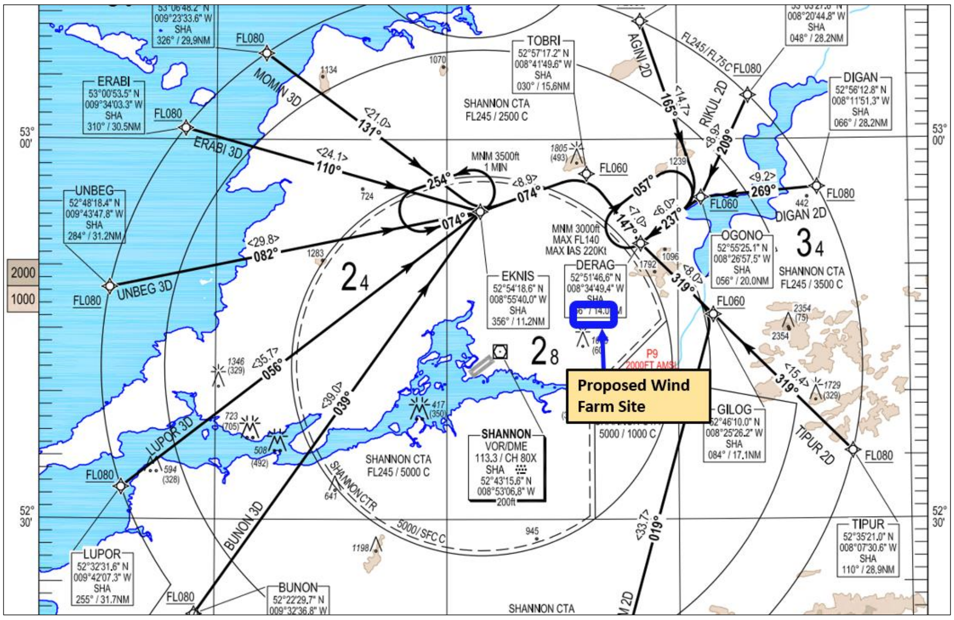


Figure 12. RNAV Standard Arrival Chart RWY 24 - EINN AD 2.24-8

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

Figure 13 below shows the AIP chart associated with this flight procedure. As the chart shows, flight routes for aircraft approaching ILS/ LOC RWY 06 do not fly over the proposed wind farm. As the flight paths do not fly over the proposed wind farm site, there should be no impact to this IFP.

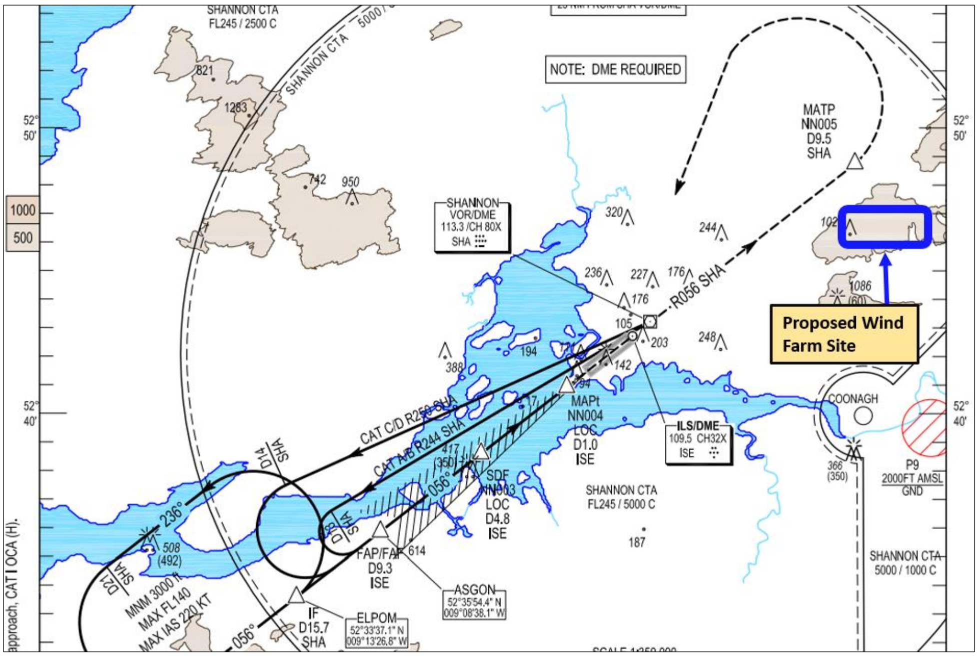


Figure 13. Instrument Approach Chart ILS or LOC RWY 06 - EINN AD 2.24-10

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

Figure 14 below shows the AIP chart associated with this flight procedure. As the chart shows, flight routes for aircraft approaching RWY 06 do not fly over the proposed wind farm. As the flight paths do not fly over the proposed wind farm site, there should be no impact to this IFP.

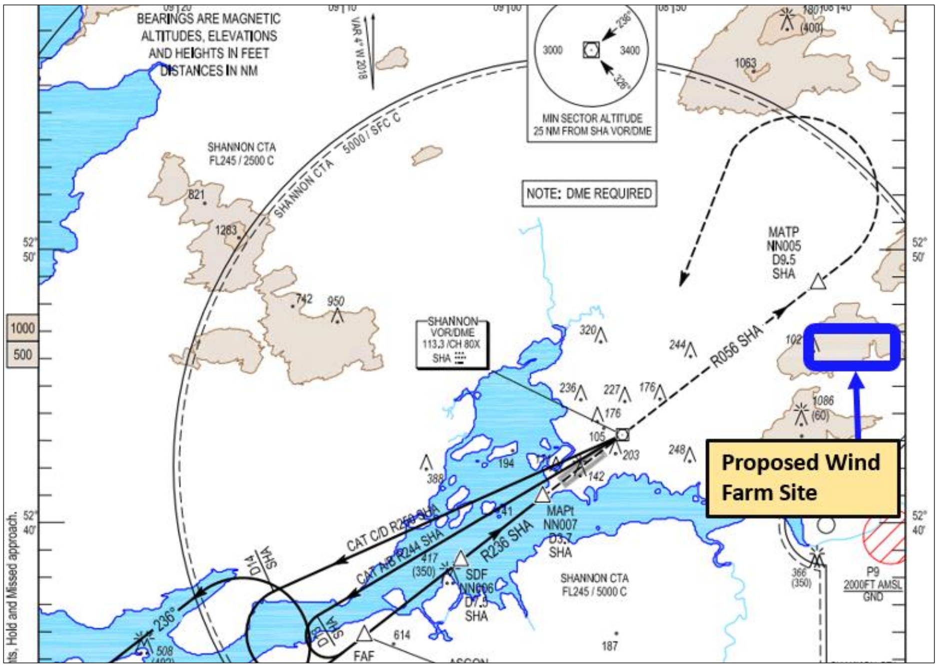


Figure 14. Instrument Approach Chart VOR RWY 06 - EINN AD 2.24-11

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

Figure 15 below shows the AIP chart associated with this flight procedure. As the chart shows, flights associated with this IFP do fly over the proposed wind farm site.

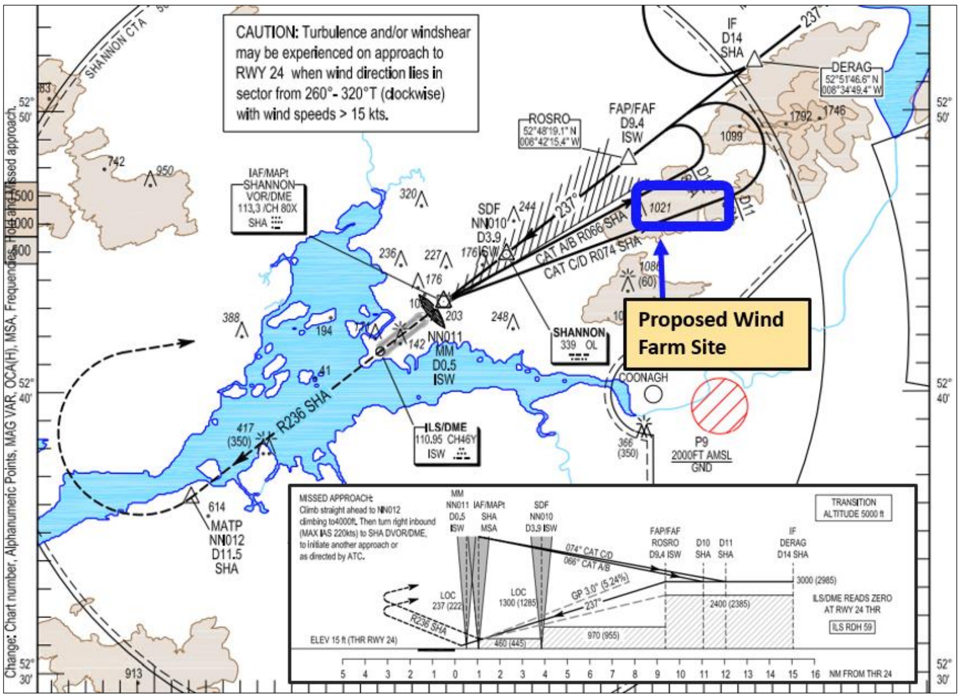


Figure 15. Instrument Approach ILS CAT I & II or LOC 24 - EINN AD 2.24-13

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 16 and 17.

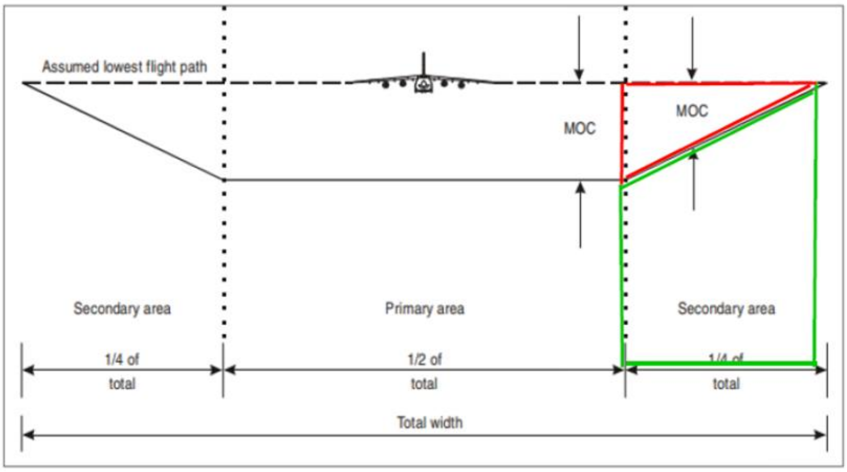


Figure I-2-1-2. Relationship of minimum obstacle clearances in primary and secondary areas in cross-section

- MOC = Minimum Obstacle Clearance of 1000ft

- Knockshanvo Wind Farm turbines in this area would not penetrate protected surface

- Knockshanvo Wind Farm turbines in this area would penetrate protected surface

Figure 16. Primary and Secondary Protected Approach Areas - Cross Section View

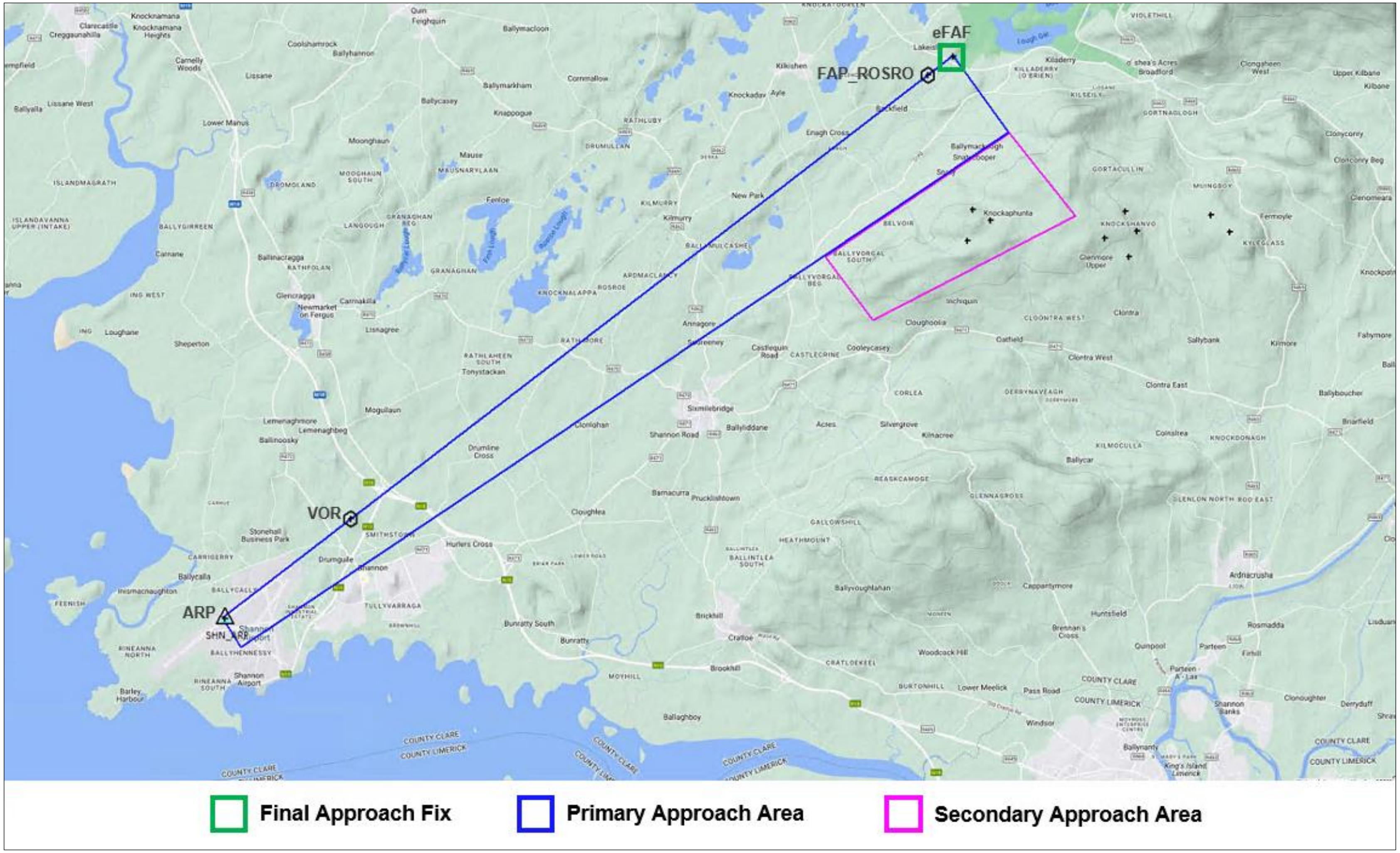


Figure 17. Primary and Secondary Protected Approach Areas - Plan View

Although three of 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 18.

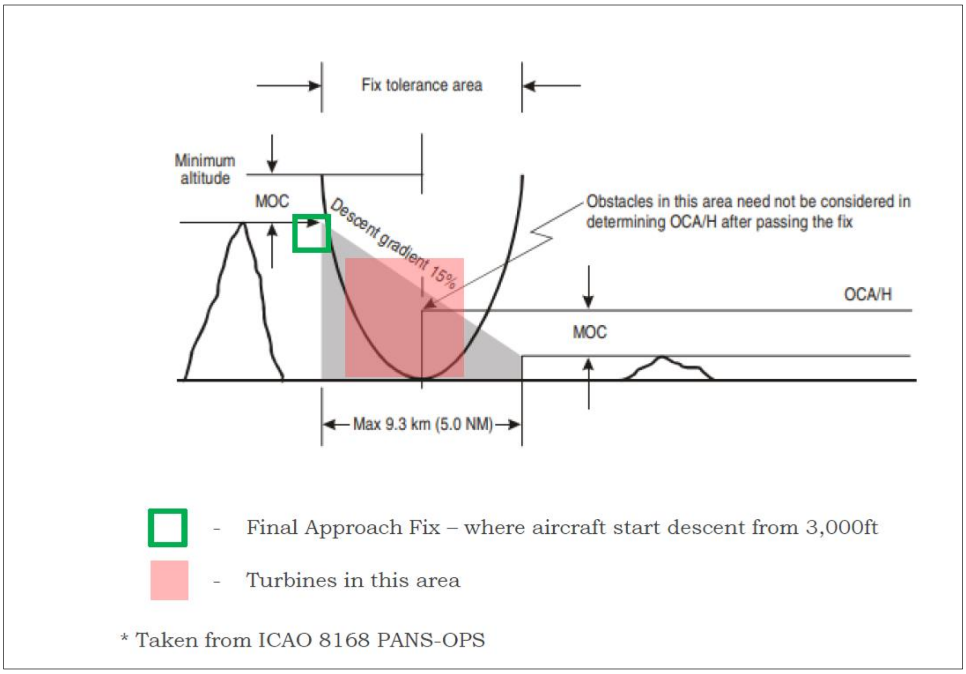


Figure 18. Areas where obstacles need not be considered

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

Figure 19 below shows the AIP chart associated with this flight procedure. As the chart shows, flights associated with this IFP do fly over the proposed wind farm site. As with the previous IFP, further investigations would be required to assess the potential impact on this flight approach procedure.

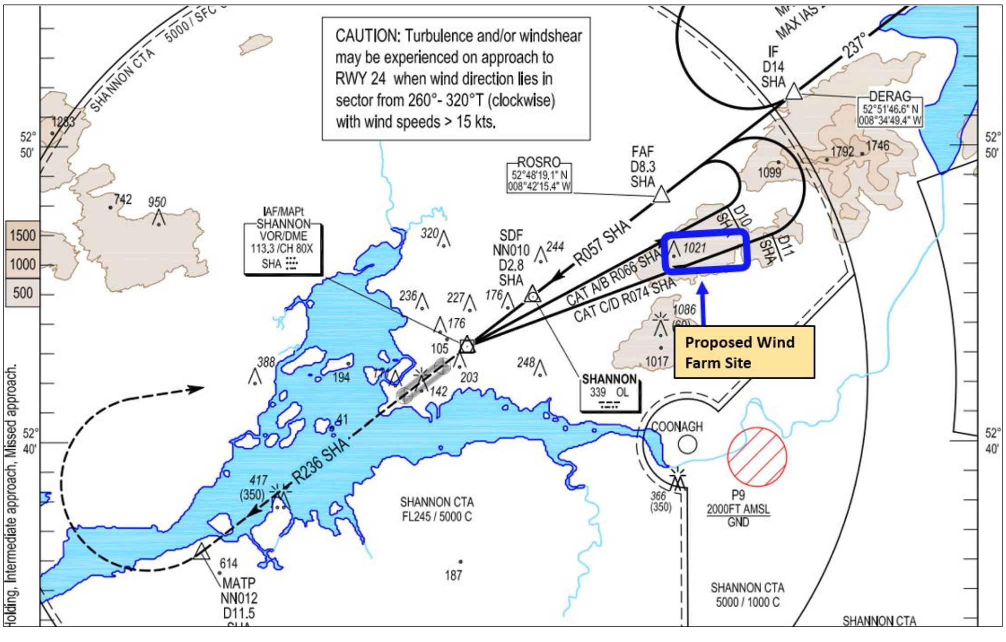


Figure 19. Instrument Approach Chart VOR RWY 24 - EINN AD 2.24-14

2.4.1.9 Visual Approach Chart (EINN AD 2.24-15)

Figure 20 below shows the AIP chart associated with this flight procedure. Should the proposed wind farm at Knockshanvo 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. As all relevant aviation charts would be updated there would be no impact due to the proposed wind farm development.

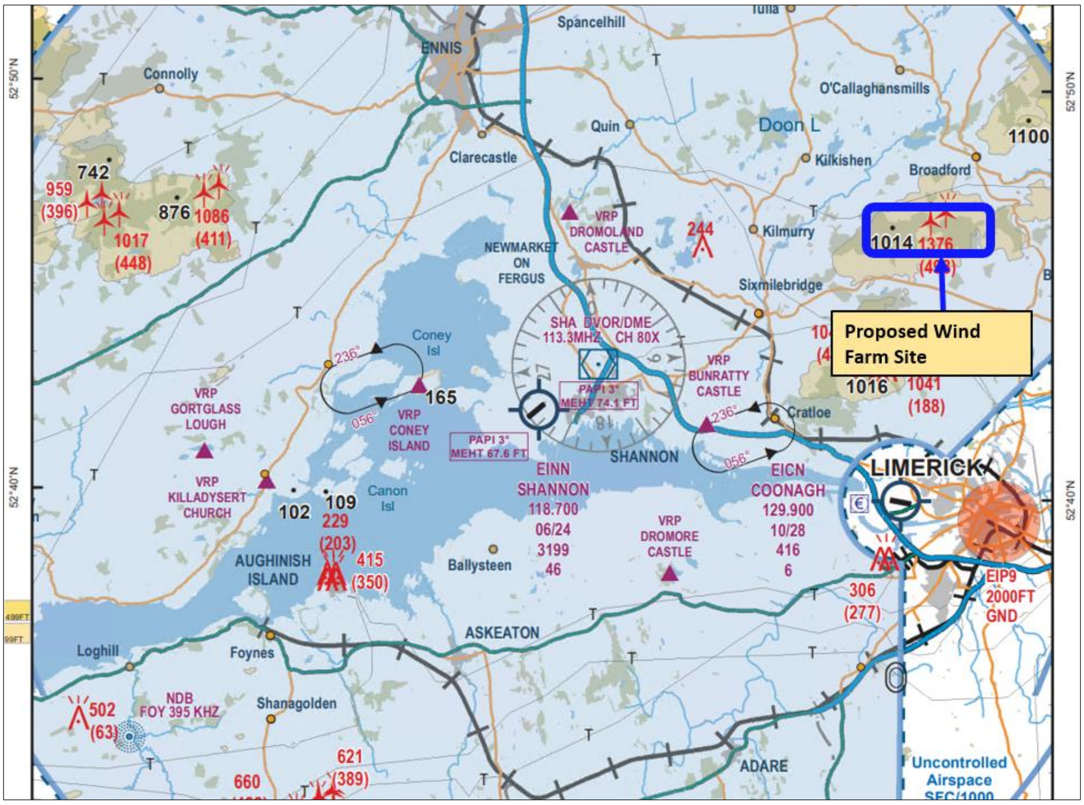


Figure 20. Visual Approach Chart - EINN AD 2.24-15

2.4.2 Instrument Flight Procedures – Cyrrus Assessment

The detailed technical assessment carried out by Cyrrus, was completed in 2021 and was based on the original 18-turbine layout for the proposed Violet Hill Wind Farm

A summary of the Cyrrus assessment findings is shown below in Figure 13 which indicates that the proposed turbines would have an impact on two of the current published IFPs for Shannon Airport as well as having an impact on the Air Traffic Surveillance Minimum Altitude Chart required for vectoring by Air Traffic Controllers.

<table>
<tr><th>Assessed Procedure</th><th>RWY</th><th>Impact</th><th>Comments</th></tr>
<tr><td>MSA</td><td>Both</td><td>No</td><td>Nil</td></tr>
<tr><td>ILS or LOC</td><td rowspan="5">06</td><td>No</td><td>Nil</td></tr>
<tr><td>VOR</td><td>No</td><td>Nil</td></tr>
<tr><td>RNAV STARs</td><td>No</td><td>Outside Protection Areas</td></tr>
<tr><td rowspan="2">RNAV SIDs</td><td rowspan="2">Yes</td><td>T18, T01, T02, T05, T17, T04 penetrates the turn area for TOMTO 3A which results in a higher PDG than the standard obstacle clearance PDG of 3.3%.</td></tr>
<tr><td>T18, T01, T02, T05, T17, T04 penetrate the turn area for ABAGU 3A which results in a higher PDG than the standard obstacle clearance PDG of 3.3%.</td></tr>
<tr><td>ILS CAT I & II or LOC</td><td rowspan="4">24</td><td>No</td><td>Nil</td></tr>
<tr><td>VOR</td><td>Yes</td><td>T01, T02, T05, T06, T18, T04, T17 penetrate the secondary area of the Final approach and raises the currently published MOCA by 400ft from 1270ft to 1670t. It also affects the gradient from the SDF to MAPt.</td></tr>
<tr><td>RNAV STARs</td><td>No</td><td>Outside Protection Areas</td></tr>
<tr><td>RNAV SIDs</td><td>No</td><td>Outside Protection Areas</td></tr>
<tr><td>ATCSMAC</td><td>Both</td><td>Yes</td><td>T01, T02, T07, T04, T05, T06, T08, T18, T12, T03, T17, T09 penetrate Sector 1 and raises the published minima by 300ft from 2300ft to 2600ft</td></tr>
</table>

Figure 21. Cyrrus IFP Safeguarding Assessment Summary (18-Turbine Layout)

The above findings were presented to and discussed with the IAA. Following the discussions the IAA it was agreed that the main area of concern was to the Air Traffic Control Surveillance Minimum Altitude Chart (ATCSMAC). Cyrrus were subsequently requested to review the ATCSMAC, to determine what possible design options exist to reduce the impact the proposed wind farm and allow Shannon Airport to continue with safe and efficient vectoring operations. The ATCSMAC Concept Design carried out by Cyrrus is described below in Section 2.4.2.1.

2.4.2.1 ATCSMAC Conceptual Design - Cyrrus

As part of the ATCSMAC Concept Design, IFP Constraining Surfaces for Shannon Airport were generated. Figure 22 below shows the constraining surfaces including the ATCSMAC Surface.

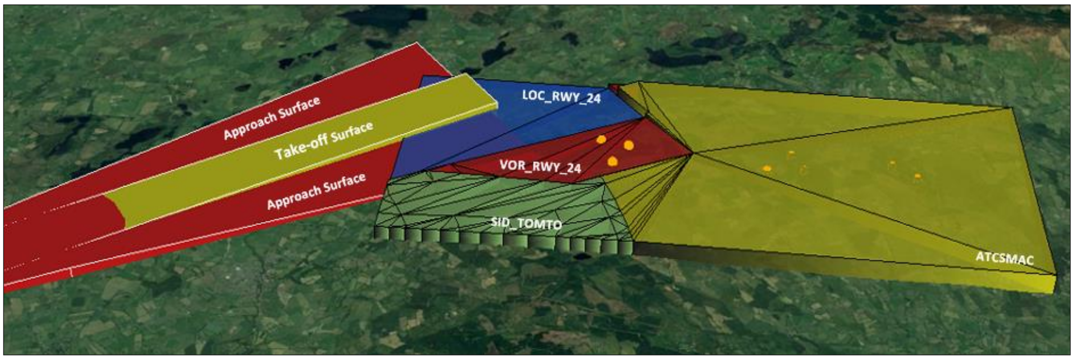


Figure 22. Shannon Airport - IFP Constraining Surfaces (18-Turbine Layout)

Four Design Options were identified to reduce the impact of the proposed wind farm to allow Shannon Airport to continue with safe and efficient vectoring operations:

- Option A – Raise the Sector 1 Minimum Vectoring Altitude
- Option B – Extend Sector 2 area to cater for the Wind Farms
- Option C – Create a new Sector to address the Wind Farms
- Option D - Create two new Sectors to address the Wind Farms

Each of the above options were designed and assessed and are included in the Cyrrus ATCSMAC Concept Design Report. The conclusions from the report are provided below.

ATCSMAC Concept Design – Conclusions:

- *The Wind Farm will still have an impact to the ATCSMAC. Whilst all the identified options would allow for safe vectoring onto the IAPs, the Airport and the IAA would have to determine if the proposed options would still allow for effective vectoring operations. If it is deemed that the Wind Farm can be mitigated by a redesign, the full design process will need to be conducted.*
- *Design option A will still allow for aircraft to be vectored onto an Instrument Approach Procedure for RWY 26. Aircraft would be required to be established on the IAP at 8 nm from THR RWY 26 to descend below the MVA.*
- *Design option B would allow for the current SMAA sector 1 to remain at 2300 ft, however SMAA sector 2 would be expanded to encompasses the Wind Farm. ATC would be unable to vector aircraft onto the RWY 26 IAPs within SMAA sector 1.*
- *Design option C would allow for the current SMAA sector 1 to remain at 2300 ft, although its area would reduce. A new SMAA is proposed as part of this option which will give ATC the ability to vector aircraft to intercept the IAPs at 2600 ft for RWY 26 whilst keeping a 2300 ft MVA for RWY 08.*
- *Design option D reduces the area of SMAA sector 1 and creates two new SMAA sectors at 2600 ft and 2400 ft. Whilst this option provided more flexibility due to the distance from THR RWY 26, the area of the 2400 ft SMAA is too small for effective*

vectoring and aircraft would likely be established on an IAP and be descending below the MVA. Therefore, it is unlikely that any benefit could be gained from its additional complexity.

- *The stability of approaches by landing aircraft is coming evermore to the forefront of Airline Safety Departments and National Authorities safety agenda's and less and less operators are accepting of aircrew conducting 'shortened' ILS approaches. However, this does not mean that flexibility of ATC vectoring operations should no longer be considered important. Busy sequences of traffic sometimes require aircraft that are able to accept manoeuvring that, although obviously still safe, does not necessarily meet other Operators SOPs and are placed into the 'approach plan' to create an overall efficient flow of air traffic – a core element of ATC.*
- *This, of course, needs to be balanced (obviously with safety as the foundation) with the Country's Green Energy aspirations. Ultimately, only Shannon ATC can decide whether the options presented in this report are operationally feasible. As the report has stated, any option deemed to have merit would need to be fully assessed and, possibly, refined so as to meet Shannon ATC expectations and provide them with the confidence of a solution that is safe and, on balance, expedient to the majority of users.*

Note: As previously mentioned the Cyrrus Technical Assessment was based on the original 18-turbine layout. As the proposed wind farm development is now a 9-turbine proposal, the impact on the IFP's/ ATCSMAC is likely to have significantly reduced. Cyrrus have been engaged regarding a new conceptual design for the ATCSMAC surfaces to reflect the final 9-turbine layout.

To illustrate the reduced impact of the 9-tubrine layout, Ai Bridges have plotted the 9 turbines relative to the IFP Constraining Surfaces (shown below in Figure 23). As the figure shows, only one of the nine turbines penetrates the ATCSMAC surface (subject to verification by Cyrrus).

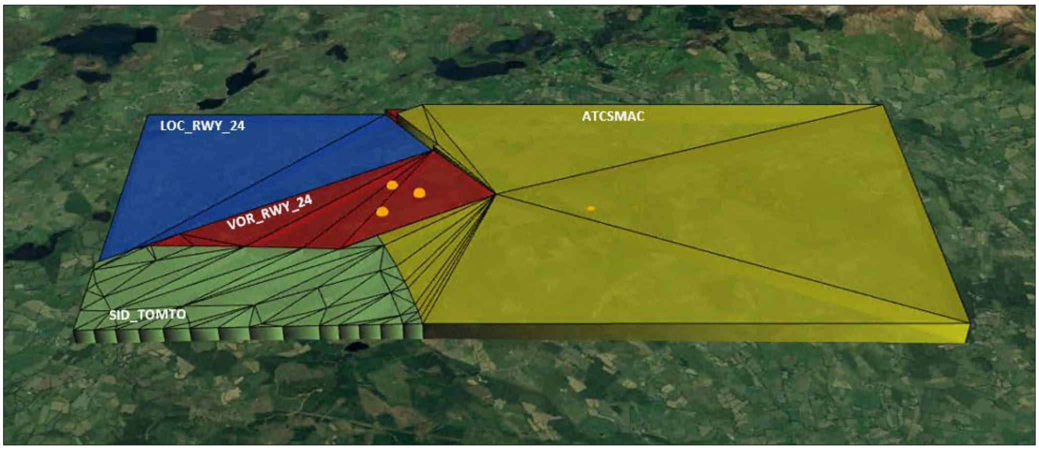


Figure 23. Shannon Airport - IFP Constraining Surfaces (9-Turbine Layout)

2.4.3 Instrument Flight Procedures – Mitigation Measures and Residual Impacts

The table below outlines the mitigation requirements to offset the possible impacts due to the proposed wind farm development at Knockshanvo and the associated residual impacts.

Aviation Impact Assessment	IFP	Procedure / Chart ID	Mitigation Measure Action	Residual Impact
Instrument Flight Procedures	RNAV Standard Instrument Departure Chart RWY 06 – ICAO	EINN AD 2.24-5	No action	None
	RNAV Standard Instrument Departure Chart RWY 24 – ICAO	EINN AD 2.24-6	No action	None
	RNAV Standard Arrival Chart RWY 06 – ICAO	EINN AD 2.24-7	No action	None
	RNAV Standard Arrival Chart RWY 24 – ICAO	EINN AD 2.24-8	No action	None
	Instrument Approach Chart ILS or LOC RWY 06 – ICAO	EINN AD 2.24-10	No action	None
	Instrument Approach Chart VOR RWY 06 – ICAO	EINN AD 2.24-11	No action	None
	Instrument Approach Chart ILS CAT I & II or LOC 24 – ICAO	EINN AD 2.24-13	Further Assessment Required. Discussions with Cyrrus are ongoing regarding a revised technical assessment for the final 9-turbine layout	Further Assessment Required. Cyrrus have been engaged regarding a revised technical assessment for the finalised 9-turbine layout
	Instrument Approach Chart VOR RWY 24 – ICAO	EINN AD 2.24-14	Further Assessment Required. Discussions with Cyrrus are ongoing regarding a revised technical assessment for the final 9-turbine layout	Further Assessment Required. Cyrrus have been engaged regarding a revised technical assessment for the finalised 9-turbine layout
	Visual Approach Chart – ICAO	EINN AD 2.24-15	No action	None
	ATCSMAC	N.A.	Further Assessment Required. Discussions with Cyrrus are ongoing regarding a revised technical assessment for the final 9-turbine layout	Further Assessment Required. Cyrrus have been engaged regarding a revised technical assessment for the finalised 9-turbine layout

Table 7. Instrument Flight Procedures – Mitigation Measures and Residual Impacts

2.5 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 8. As the Carrownagowan wind farm has been permitted there was no amendments or re-design of Instrument Flight Procedures required.

Wind Farm	Planning Status	Planning Reference	Wind Farm Description
Carrownagowan	Consented	Planning Application: 229000 (Clare County Council) https://www.eplanning.ie/ClareCC/AppFileRefDetails/229000/0	Permitted 19-Turbine Wind Farm
Fahybeg	Consented	https://www.pleanala.ie/en-ie/case/317227	Permitted 8-turbine Wind Farm
Oatfield	Planning Submitted	https://www.pleanala.ie/en-ie/case/318782	Proposed 11-Turbine Wind Farm
Lackareagh	Pre-submission	-	Proposed 7-Turbine Wind Farm

Table 8. Permitted wind farms in vicinity of proposed wind farm.

2.5.1 Carrownagowan 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 is available via the following URL:

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

2.6 Communication and Navigation Systems

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

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	17 km	No impacts

Table 9. Impacts on Communications and Navigation Systems

As the proposed wind farm is over 15km 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.

2.6.1 Communication and Navigation Systems – Mitigation Measures and Residual Impacts Summary

The table below outlines the mitigation requirements to offset the possible impacts due to the proposed wind farm development at Knockshanvo and the associated residual impacts.

Aviation Impact Assessment	Mitigation Measure Action	Residual Impact
Communications and Navigation Systems	No action	None

Table 10. Communication and Navigation Systems – Mitigation Measures and Residual Impacts

2.7 Radar Surveillance Systems

The tables below show the Irish Aviation Authority 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 and in radar line of sight	Simple Assessment
Zone 4	Not in radar line of sight	No Assessment

Table 11. 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 12. 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 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 in Figure 15 below.

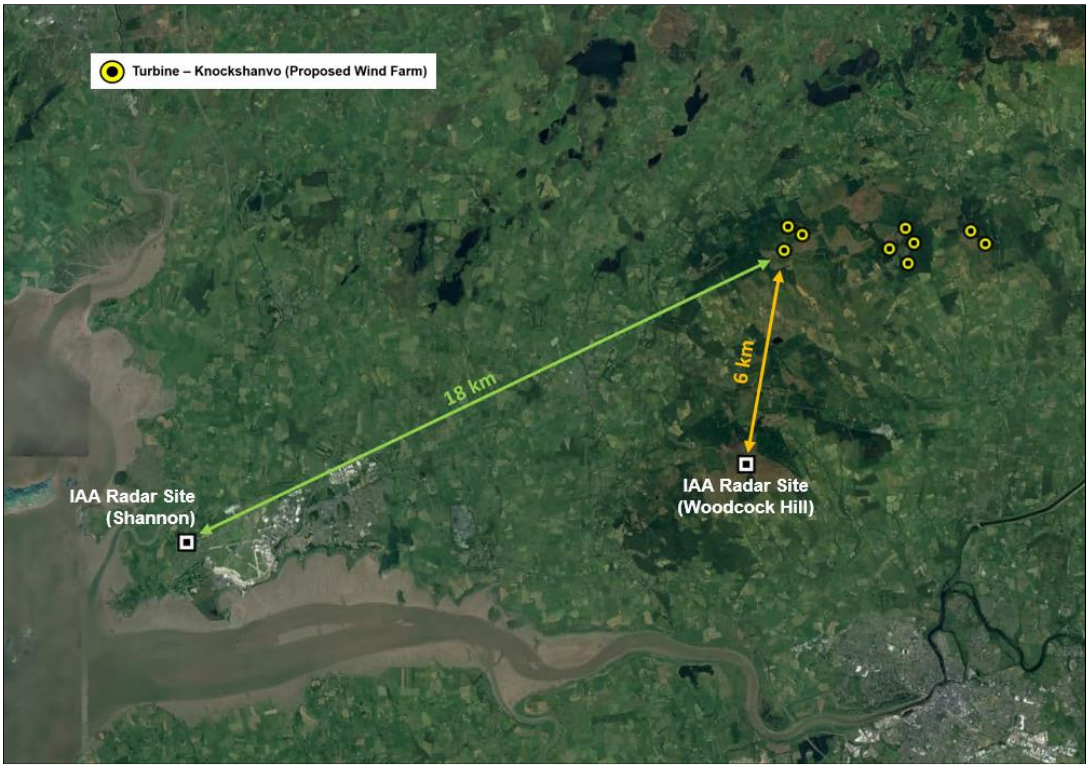


Figure 24. IAA Radar Surveillance Sites relative to proposed wind farm.

A preliminary radar assessment was carried out by Ai Bridges which found that a detailed technical assessment for the SSR radar station at Woodcock Hill would be required. To further investigate the possible impact on the IAA Radar Surveillance System, Ai Bridges have engaged with Cyrrus, the IAA-approved contractors , to undertake a detailed technical study.

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.

2.7.1 Radar Surveillance Systems – Ai Bridges Assessment

A summary of the radar assessment for the IAA Radar Stations at Shannon Airport and Woodcock Hill are provided below in Section 2.7.1.1 and Section 2.7.1.2 respectively. The complete Ai Bridges Radar Assessment can be found in Appendix F of this report

2.7.1.1 Shannon PSR/SSR Radar Assessment

The radar site at Shannon Airport consists of a PSR system and an SSR system. The PSR and the SSR antennas are co-located on the same structure at Shannon Airport as shown below.

Figure 25. PSR and SSR at Shannon Airport

Table 7 below shows the (EuroControl & NATS) assessment zone applicable to the nearest point where a turbine could potentially be located. The applicable assessment zone has been based on distance from the Radar Station and whether a radar line-of-sight condition exists.

Radar Station	Radar Type	Distance to nearest Turbine	Detailed Radar Assessment Required	
			(EuroControl Guidelines)	(NATS Guidelines – UK)
Shannon Airport	PSR	18 km	Not Required (Assessment Zone 3)	Not Required (> 10km)
Shannon Airport	SSR	18 km	Not Required (Assessment Zone 4)	Not Required (> 10km)

Table 13. EuroControl / UK Safeguarding Guidelines – Shannon PSR/SSR

As the table above shows, the EUROCONTROL Guidelines indicate that a detailed radar assessment should not be required for the PSR or the SSR at Shannon Airport.

2.7.1.2 Woodcock Hill SSR Radar Assessment

The radar site at Woodcock Hill consists of an SSR system which is housed in the dome-shaped structure shown in the Figure below.

Figure 26. SSR at Woodcock Hill

Table 8 below shows the (EuroControl & NATS) assessment zone applicable to the nearest turbine to the SSR Radar Station. The applicable assessment zone has been based on distance from the Radar Station and whether a radar line-of-sight condition exists.

Radar Station	Radar Type	Distance to nearest Turbine	Detailed Radar Assessment Required	
			(EuroControl Guidelines)	(NATS Guidelines – UK)
Woodcock Hill	SSR	6 km	Required (Assessment Zone 2)	Required (<10km)

Table 14. 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.

2.7.2 Radar Surveillance Systems – Cyrrus Assessment

The technical assessment carried out by Cyrrus, was completed in 2021 and was based on the original 18-turbine layout.

The detailed radar modelling undertaken by Cyrrus of the indicative layout against the combined Primary Surveillance Radar/Monopulse Secondary Surveillance Radar (PSR/MSSR) facility at Shannon Airport showed the following:

The detailed radar modelling undertaken by Cyrrus of the indicative layout against the MSSR at Woodcock Hill showed the following:

- *RLoS exists between Woodcock Hill MSSR and all 18 proposed turbine towers*
- *Bistatic reflections from these turbine towers will not result in false targets for Woodcock Hill MSSR;*
- *Woodcock Hill MSSR shadow regions from the turbines are considered operationally tolerable;*

Note: As previously mentioned the Cyrrus Technical Assessment was based on the original 18-turbine layout. As the proposed wind farm development is now a 9-turbine proposal, the amount of detected by the Woodcock Hill MSSR is likely to be significantly reduced. Cyrrus have been engaged regarding a new Radar Safeguarding Assessment to reflect the final 9-turbine layout.

2.7.3 Radar Surveillance Systems – Mitigation Measures and Residual Impacts

The table below outlines the mitigation requirements to offset the possible impacts due to the proposed wind farm development at Knockshanvo and the associated residual impacts.

Aviation Impact Assessment	Mitigation Measure Action	Residual Impact
Radar Surveillance Systems	Further Assessment Required. Discussions with Cyrrus are ongoing regarding a revised technical assessment for the final 9-turbine layout	Further Assessment Required. Cyrrus have been engaged regarding a revised technical safeguarding assessment for the finalised 9-turbine layout

Table 15. Radar Surveillance Systems – Mitigation Measures and Residual Impacts

2.8 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 Knockshanvo.

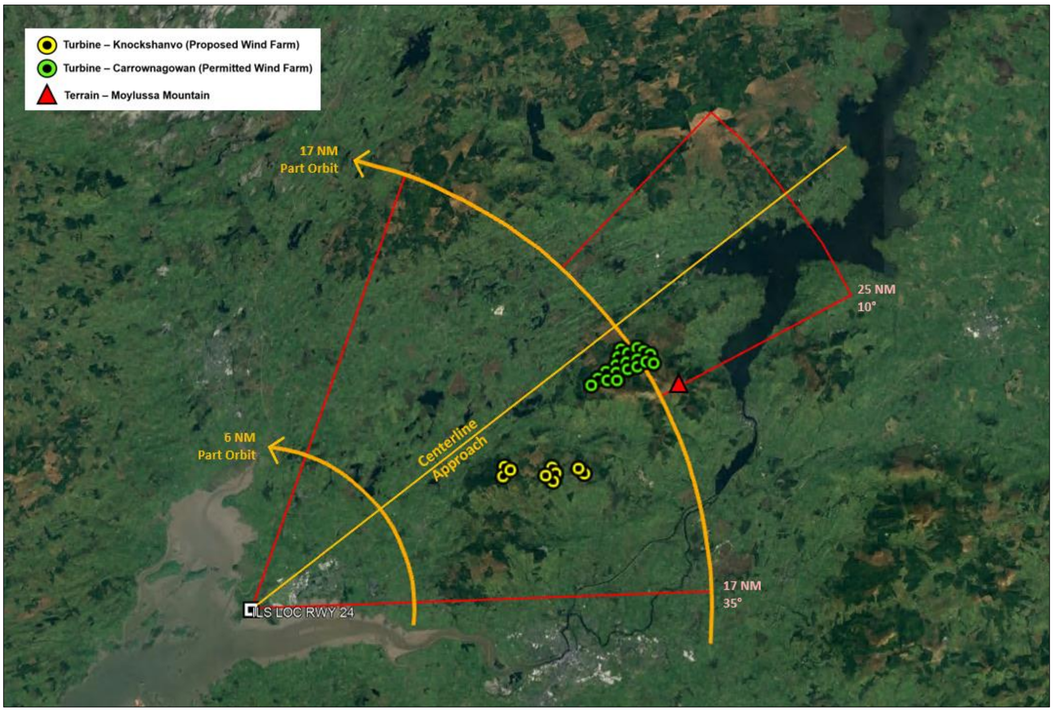


Figure 27. Flight Inspection and Calibration Test Procedures should account for Existing Obstacles (i.e. existing/permitted wind farms and terrain)

A preliminary assessment of the Flight Check Procedures for Shannon Airport was carried out by Ai Bridges which found that the IFPs were potentially impacted. To further investigate the possible impact on the Flight Check procedures Ai Bridges engaged with FCSL (in 2021), the IAA approved Flight Inspection Service Provider, to undertake a detailed technical study. A summary of the FCSL assessment findings is provided in Section 2.8.1 below.

In 2023, Ai Bridges obtained the flight path data for the 2023 flight inspection and calibration checks for Shannon Airport. An assessment of the 2023 flight insertion and calibration test flights is provided in Section 2.8.2.

2.8.1 Flight Inspection and Calibration – FCSL Assessment

In August 2021, FCSL were requested to carry out a detailed technical assessment to determine if the flight inspection procedures for Shannon Airport would be impacted by the proposed turbines. The findings of the FCSL report indicated that the ILS flight procedures would potentially be impacted. FCSL also recommended that Flight Trials and ILS Computer Simulations be carried out to assess RF Signal Levels and levels of potential interference.

A further Assessment Report was conducted by FCSL in April 2022, which found that the proposed wind farm would not have any adverse effect on Runway 24 ILS flight inspection procedures or flight profiles.

A summary of the findings of the 2021 and 2022 FCSL assessment reports is provided in Section 2.8.1.1 and Section 2.8.1.2.

2.8.1.1 FCSL Assessment – August 2021

Assessment Summary:

- *Flight inspection aircraft flying centreline, part orbit and bottom edge flight profiles associated with the Shannon Airport Runway 24 ILS would remain sufficiently clear of the proposed Wind Farm Site.*
- *The ILS slice and left slice 8° profiles, the proposed wind farm will require that these profiles are flown at higher altitudes to provide sufficient clearance above the proposed wind turbines. The flight inspection Glide Path left slice 8° profile (level run) will have to be raised to an altitude of 2,600ft in IMC to provide the flight inspection aircraft adequate coverage over the proposed wind turbines. This will result in increased flight inspection costs for the extended Glide Path level runs. If there is insufficient Glide Path RF signal for the extended level run at 2,600 ft then it may not be possible to conduct this flight inspection in conditions of bad visibility. This may result in additional cost if the flight inspection aircraft is delayed while waiting for VFR conditions.*

Assessment Recommendations:

- *Flight Trials*
  Additional flight trials should be conducted at the next routine ILS flight inspection to assess the RF signal levels for an extended level Glide Path run at an altitude of 2,600 ft.
- *ILS Computer Simulations*
  The proposed Violet Hill Wind Farm site is within the Shannon Runway 24 Localiser lateral coverage sector (see Figure 3.3 above).
  As the proposed Violet Hill Wind Farm site is within 8° azimuth and 1.3° 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 10 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.

2.8.1.2 FCSL Assessment – April 2022

Assessment Summary:

- *The results of the special Glide Path flight inspection presented in section 3 above show that, with the exception of the right slice 8° profile flown at an altitude of 3,000 ft, adequate Glide Path RF signal levels were received at the higher slice (level run) altitudes of 2,600 ft and 3,000 ft. Adequate fly-up guidance was achieved below the Glide Path sector for all level run profiles flown.*

  This means that if ILS flight inspection operations are conducted in IMC, the flight inspection level runs can be flown at 2,600 ft and the proposed Violet Hill wind farm will therefore not have any adverse effect on Runway 24 ILS flight inspection procedures and flight profiles.

  If a replacement Runway 24 ILS is to be commissioned at Shannon Airport at some time in the future, commissioning flight inspections will be conducted in VMC, so the proposed Violet Hill wind farm will therefore not have any adverse effect on future ILS commissioning flight inspection procedures and flight profiles.

2.8.2 Flight Inspection and Calibration – Ai Bridges Assessment

FCSL Ltd conducted their 2023 flight checks over two days in June and July. Figure 28 below shows the flight route undertaken by FCSL on the 12th June 2023 and Figure 29 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.

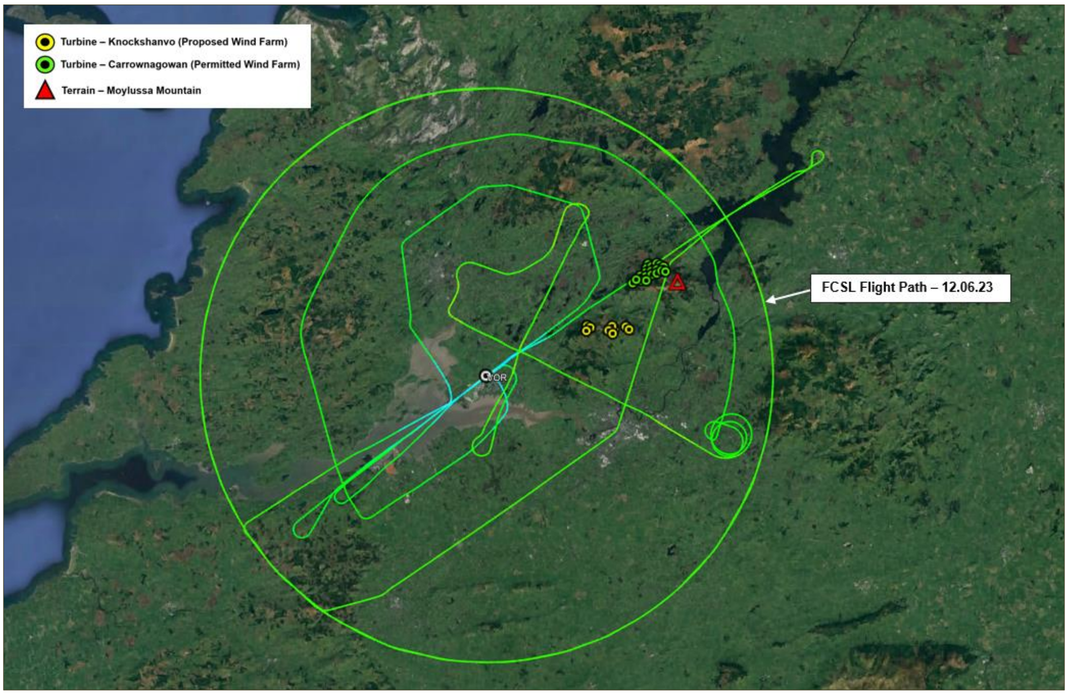


Figure 28. FCSL Flight Route - 12th June 2023

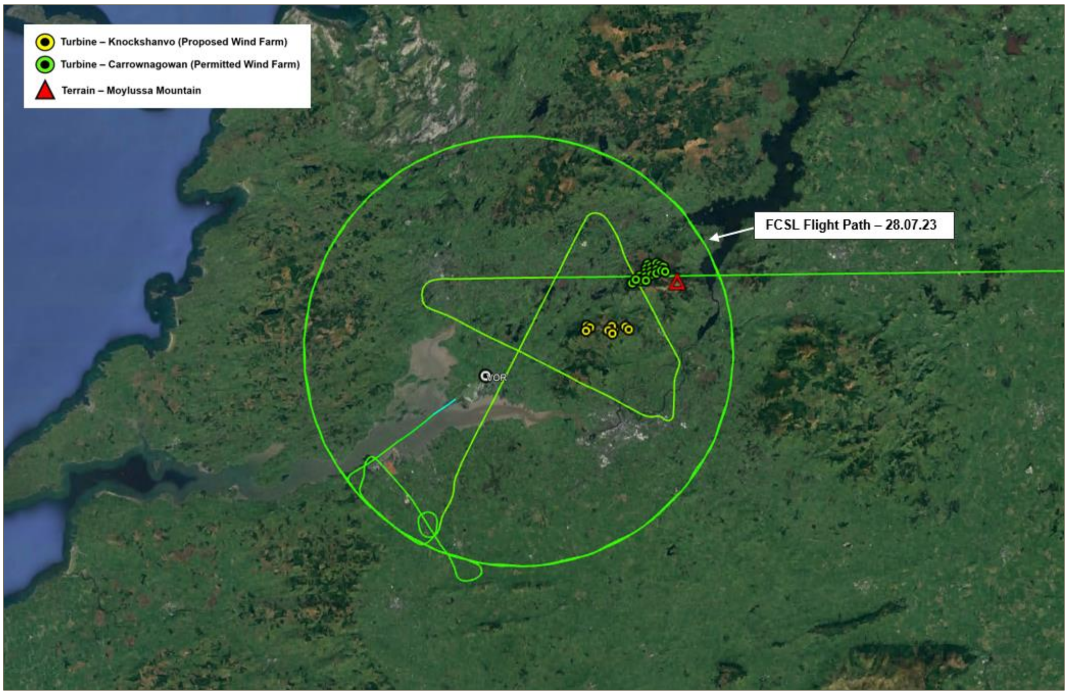


Figure 29. FCSL Flight Route - 28th July 2023

Figure 30 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 1000 ft higher than the highest of the proposed turbines.

As the test aircraft flies over 1000 ft above the proposed turbines and does not fly directly over the proposed development, there would be no adverse effects on the FCSL flight procedure.

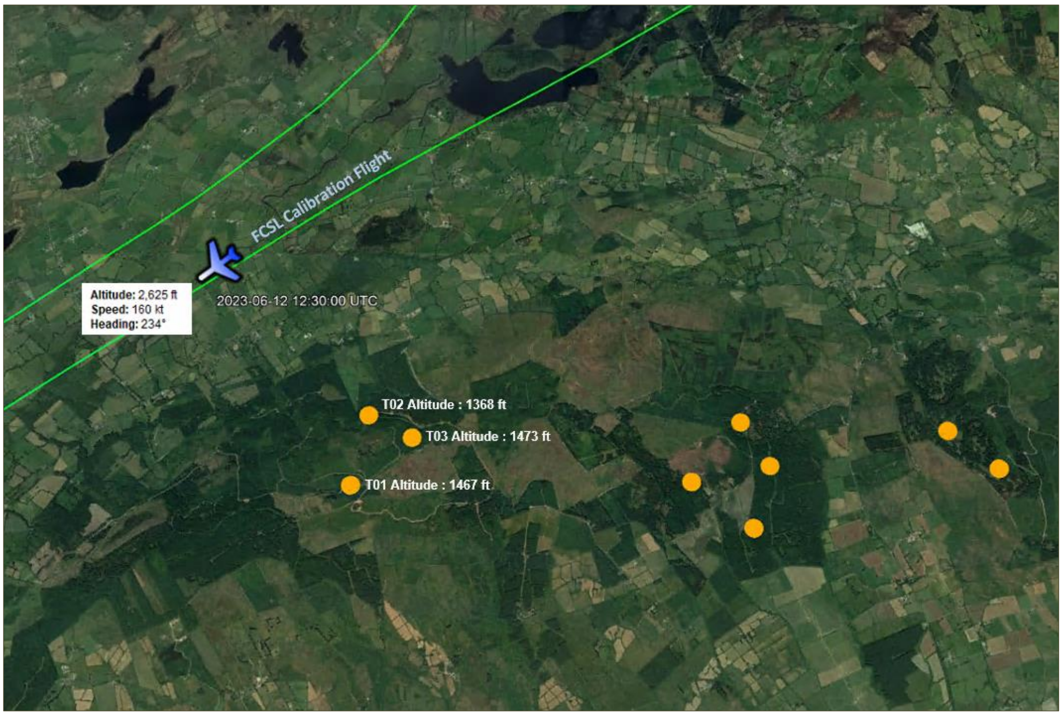


Figure 30. Close-up View of FCSL Flight Route - 12th June 2023

2.8.3 Flight Inspection and Calibration – Mitigation Measures and Residual Impacts

The table below outlines the mitigation requirements to offset the possible impacts due to the proposed wind farm development at Knockshanvo and the associated residual impacts.

Aviation Impact Assessment	Mitigation Measure Action	Residual Impact
Flight Inspection and Calibration	No action	None.

Table 16. Flight Inspection and Calibration – Mitigation Measures and Residual Impacts

2.9 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."*

2.9.1 Aeronautical Obstacle Warning Light Scheme – Mitigation Measures and Residual Impacts

The table below outlines the mitigation requirements to offset the possible impacts due to the proposed wind farm development at Knockshanvo and the associated residual impacts.

Aviation Impact Assessment	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

Table 17. Aeronautical Obstacle Warning Light Scheme – Mitigation Measures and Residual Impacts

2.10 Irish Air Corps \ DoD Safeguarding

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

- Lands underlying military airspace for flying activity.
- Low Flying Area – LFTA WEST.
- A distance of 5NM or less from military installations.
- Critical low level flying routes in support of Air Corps operation requirements.

The nearest of the Air Corps restricted areas to the proposed wind farm is the low level flight route around the M7 motorway. The proposed wind farm site is 6 NM (11 km) from the M7 and is outside the 3NM restricted area. As the proposed wind farm is located outside the restricted area, there should be no impacts on Irish Air Corps activities.

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 31. Irish Air Corps – Critical Low Level Routes

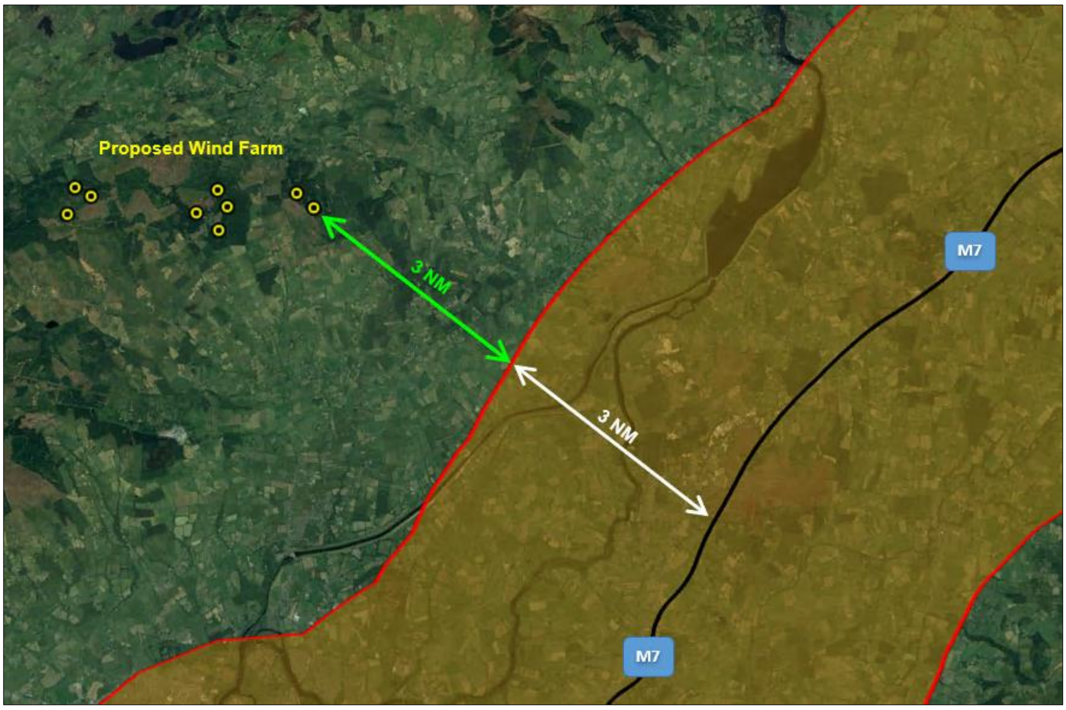


Figure 32. Proposed Wind Farm relative to Critical Low Level Flight Route (M7)

2.10.1 Irish Air Corps / Department of Defence Safeguarding – Mitigation Measures and Residual Impacts

The table below outlines the mitigation requirements to offset the possible impacts due to the proposed wind farm development at Knockshanvo and the associated residual impacts.

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

Table 18. Irish Air Corps / Department of Defence Safeguarding – Mitigation Measures and Residual Impacts

3. Summary

A summary of the aviation review for Knockshanvo wind farm is provided in Table 19 below.

Item	Impact	Summary
Annex 14 - Obstacle Limitation Surfaces (OLS)	None	The proposed wind turbines are located outside the Obstacle Limitation 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.
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 relevant Quadrant is 2400ft (AMSL). Turbines at the proposed wind farm would not exceed the 2400ft threshold, therefore the MSA of the Main Quadrant will not be affected and there will be no impact on the published MSA altitude figures.
Instrument Flight Procedures	Impacted	The detailed Instrument Flight Procedure Assessment (conducted by Cyrrus in 2021) showed that the initial 18-turbine layout would impact of the two of the flight procedures for flights to/from Shannon Airport. The ATCSMAC for safe vectoring operations into Shannon Airport would also be impacted. Conceptual designs to offset the impact of the proposed 18-tubrines were proposed in 2021. As the number of turbines at the proposed development has been reduced to 9, the impact on the IFPs and ATCSMAC should be reduced. Cyrrus have been engaged regarding an updated IFP/ATCSMAC assessment to reflect the final 9-turbine layout.
Communication and Navigation Systems	None	As the proposed wind farm is over 15km from the Localizers and transmitting antennas 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	In 2021, it was determined that he initial 18-turbine layout site would be located in Assessment Zone 4 (EuroControl Guidelines) for the IAA PSR instruments. As the number of turbines at the proposed development has been reduced to 9, the MSSR Radar at Woodcock Hill will not be unacceptably impacted . Cyrrus have been engaged regarding an updated radar assessment to reflect the final 9-turbine layout. For the SSR at Woodcock Hill, a detailed Technical Safeguarding Assessment should be carried out which should include mitigation measure proposals.
Flight Inspection and Calibration	None.	The Technical Assessment conducted in 2022 by FCSL, the IAA approved Flight Inspection Service Provider found that the proposed wind farm would not have any adverse effect on Runway 24 ILS flight inspection procedures or flight profiles. The desktop assessment conducted by Ai Bridges , based on the actual inspection flights conducted in June – July 2023 showed that no flights were conducted over the proposed Knockshanvo development site
Aeronautical Obstacle Warning Light Scheme	None	In the event of Planning being granted, it is recommended that an aeronautical obstacle lighting scheme be implemented and agreed with the IAA.
Irish Air Corps / DoD Safeguarding	None	The proposed wind farm is located outside the Irish Air Corps Restricted Areas.

Table 19. Knockshanvo Wind Farm – Aviation Review Summary

Appendix A – IAA Consultations

IAA Email to EIAR Consultant (MKO) – 23 January 2023 :

From: Emily Lynch <elynch@mkoireland.ie>
Sent: 23 January 2023 15:37
To: Comments <comments@shannonairport.ie>
Subject: [External] 200513-Knockshanvo Wind Farm- Scoping

Dear Sir/Madam,

Please find attached a scoping document for FuturEnergy Irelands (FEI) proposed construction of a wind energy development at Knockshanvo, approximately 3km south of Broadford, Co. Clare. The proposed site covers an area of approximately 931 hectares. At this scale the site has the potential to accommodate a wind energy development in excess of 50 Megawatts. The number and layout of turbines will be defined during the upcoming project design stages.

The following application will be seeking determination from An Bord Pleanala in relation to the developments Strategic Infrastructure Development Status. If the Proposed Development does not fall under Section 182A of the Planning and Development Act 2000, an application for planning permission for any relevant works will be made to Clare County Council.

As part of the scoping exercise for the proposed development, we would welcome any comments in relation to the proposed project.

If you have any queries, please do not hesitate to contact me.

Kind regards,

Emily

PDF 210323 ENVH EIA SD F1 - 2023.01.19 - 200513- Red.pdf
3 MB

PDF Shannon Airport 200513 2023.01.23.pdf
384 KB

PDF 20140909-impact-wind-turbines-sur-sensors-guid-v1.2 (2).pdf
1 MB

IAA Email to EIAR Consultant (MKO) – 03 February 2023 :

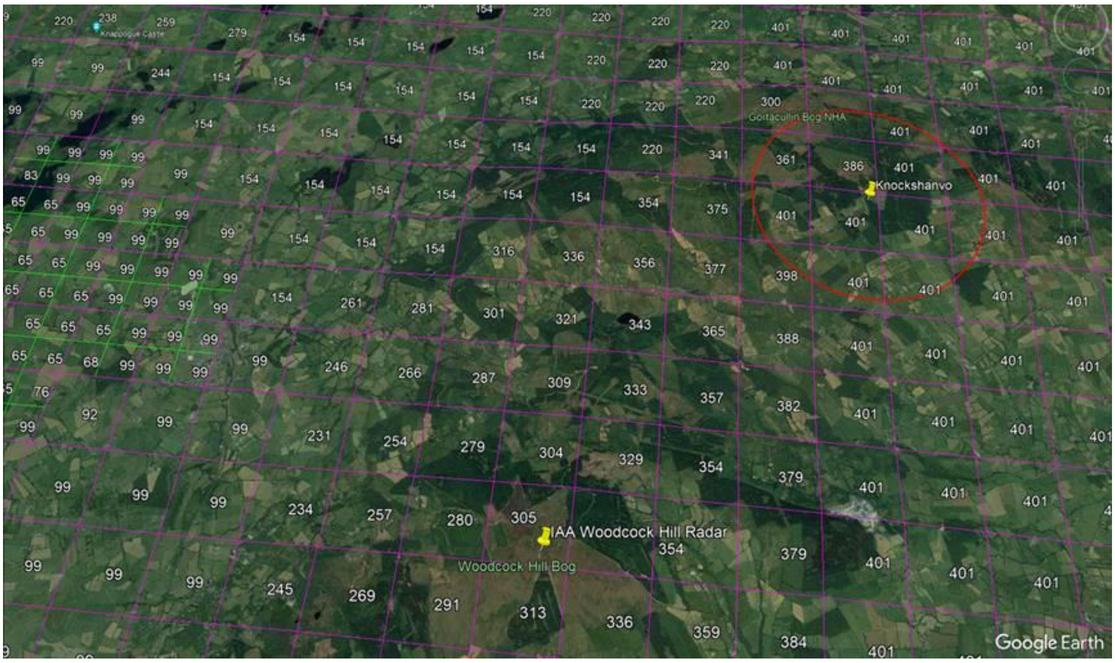
From: MACCRIOSTAIL Cathal <Cathal.MacCriostail@IAA.ie>
Sent: 03 February 2023 12:27
To: Emily Lynch <elynch@mkoireland.ie>
Cc: Paul Hennessy <paul.hennessy@snnairportgroup.ie>; SYMMANS Terry <Terry.Symmans@IAA.ie>; BYRNE Jonathan <Jonathan.Byrne@IAA.ie>; O'KEEFFE Martin <Martin.O'KEEFFE@IAA.ie>; OLOUGHLIN Charlie <Charlie.OLOUGHLIN@IAA.ie>; CORRIGAN Gary <GARY.CORRIGAN@IAA.ie>; FLYNN Mark <Mark.FLYNN@IAA.ie>; DOYLE Fergal <FERGAL.DOYLE@IAA.ie>; O'CONNOR Brendan <BRENDAN.O'CONNOR@IAA.ie>; Planning <planning@iaa.ie>
Subject: 230203 Knockshanvo Wind Farm - Scoping - IAA ANSP Response
Importance: High

Dear Emily,

Correspondence below and attached refer, with thanks to Paul Hennessy for passing on this.

From an IAA Air Navigation Service Provider (ANSP) perspective, there are areas where we would need more analysis:

4. Instrument Flight Procedures (IFPs) Shannon Airport: the ANSP is required to Safeguard these IFPs See below a Google Earth snapshot:



- The Grids displayed represent the Max Above Mean Sea Level elevation of any new obstacles, above which, an IFP Assessment is needed.
- In the area around Knockshanvo as per the attached report, there are a range of grid values from 361m to 401m. I understand that the proposed blade-tip heights are c.170m. This equates to a c.370m AMSL elevation based on a general site elevation of 200m. Added to this any potential cranage used during construction will need a full IFP Assessment.

5. Woodcock Hill Radar: Surveillance effect (IAA ANSP Surveillance Domain copied). Generally any significant obstacle within 16km of this facility may have impact. In the case of this proposed Wind farm, this is highly likely and will need to be assessed with mitigations proposed. Please note that previous experience has shown that mitigations suggested for similar developments have been prohibitively costly for the ANSP and ultimately don't guarantee that the surveillance service is not affected. Third attachment is the EUROCNTROL Guidelines on How to Assess the Potential Impact of Wind Turbines Surveillance Sensors

6. Navigation Aids (NAVAIDS): This will need to be considered by my NAVAID colleagues (copied), although generally there should not be an impact. There is however another aspect to this. On a 6-monthly basis, these NAVAIDs have to be flight calibrated. The calibration aircraft flies in this area at low altitudes to achieve this and a report from this company (FCSL) may be required also.

Please feel free to revert by e-mail or phone as needed with any queries or clarifications needed.

Kind regards,

Cathal

Cathal Mac Criostail
Údarás Eitlíochta na hÉireann / Irish Aviation Authority

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Appendix B – Knockshanvo Wind Farm Turbine Layout

APPENDIX A - Knockshanvo Wind Farm Turbine Layout

The co-ordinates of the 9-turbine layout are shown below in Section B1.

A1. 9-Turbine Layout

Turbine ID	WGS84	
	Latitude	Longitude
T01	52 46 25.63 N	8 41 31.25 W
T02	52 46 46.91 N	8 41 25.42 W
T03	52 46 39.73 N	8 41 04.49 W
T04	52 46 27.30 N	8 38 56.23 W
T05	52 46 45.51 N	8 38 32.48 W
T06	52 46 32.57 N	8 38 19.82 W
T07	52 46 14.45 N	8 38 28.56 W
T08	52 46 43.11 N	8 36 56.36 W
T09	52 46 31.70 N	8 36 34.80 W

Table A1. 9-Turbine Layout

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

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

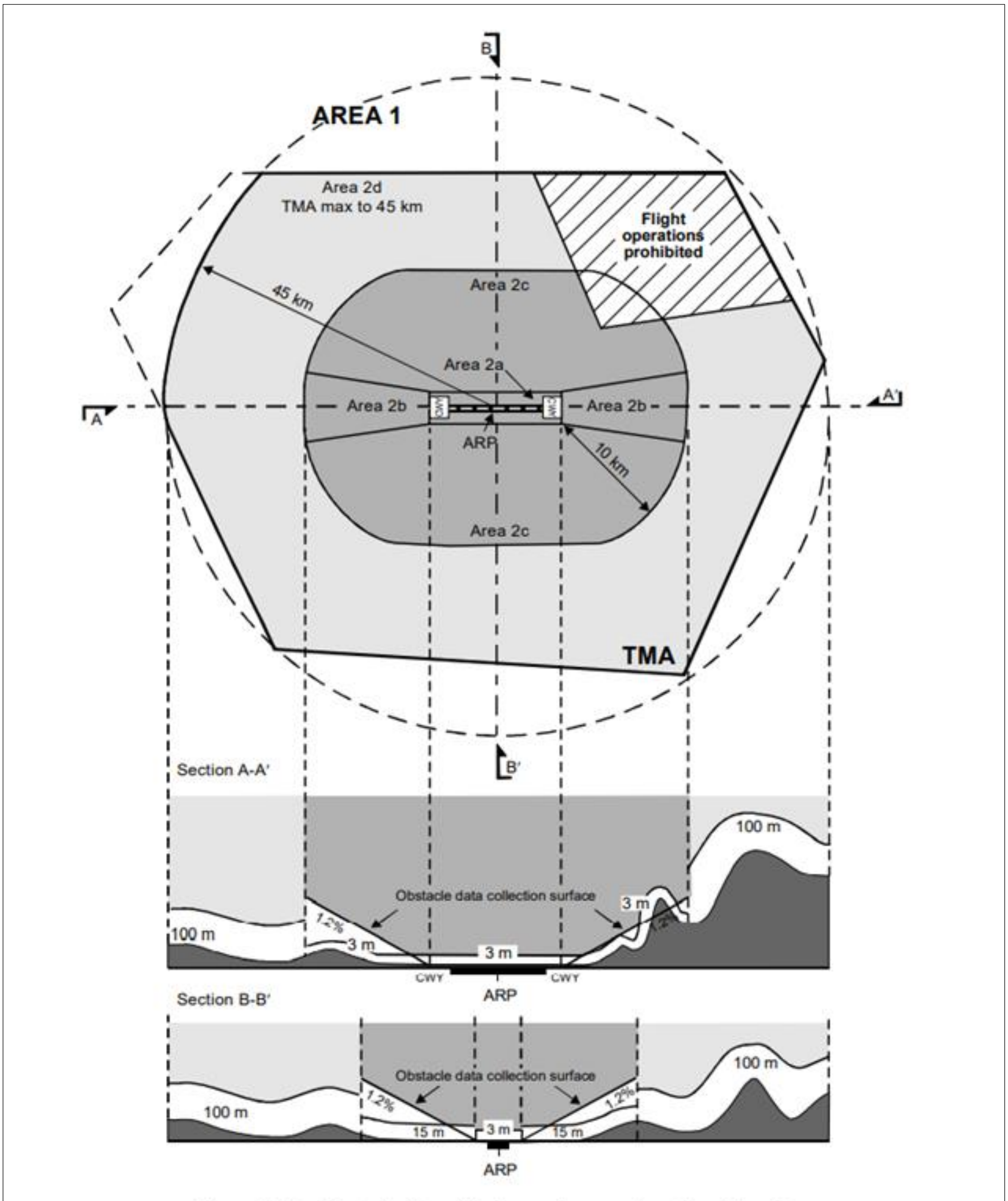

Figure A8-2. Obstacle data collection surfaces — Area 1 and Area 2

ICAO Annex 15 Area 1 Surface.

Appendix 11

Knockshanvo Windfarm Radar Mitigation Options

Knockshanvo Windfarm

Radar Mitigation Options

Al Bridges

12 December 2023

CL-6005-RPT-005 v1.0

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Document Information

Document title	Knockshanvo Windfarm
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Document reference and Version	CL-6005-RPT-005 v1.0
Date of release	8/12/2023

Change History Record

Issue	Change Reference	Date	Details
1.0	Initial Issue	12/12/2023	Initial Issue

Executive Summary

Cyrrus was requested by AI Bridges to provide Aviation support for the Knockshanvo Windfarm proposal.

Previously in September 2021, Cyrrus published a report [1] providing the technical evidence that the proposed Violet Hill windfarm with 18 turbines would have Line of Sight with the Shannon Airport and Woodcock Hill radars. The report concluded that **no mitigation was required** for either the Shannon Airport or Woodcock Hill Monopulse Secondary Surveillance Radar systems. The Shannon Airport Primary Surveillance Radar may require mitigation.

Wind turbines can cause clutter to Air Traffic Control displays, because older generations of Primary Surveillance Radar cannot distinguish between aircraft and wind turbines. More modern radar systems have options to use advanced processing techniques or other means to discriminate between these types of targets.

Monopulse Secondary Radar Systems (MSSR) (also known as cooperative sensors) work by transmitting a series of pulses to the Aircraft. The Aircraft will receive these pulses using a transponder. The transponder will then decode this series of pulses and transmit a response on a separate frequency. The Radar will receive this response and use the information in the Surveillance Data Processor to display the aircraft position, height etc on the Air Traffic Controllers display. As MSSR systems require two frequencies to operate they are not as vulnerable to problems from the wind turbines.

There are some common problems which can occur when wind turbines are sited near to radars. Table 1 uses a traffic light system to highlight the mitigation available for the Shannon Airport and Woodcock Hill radars which should allow them to operate alongside the proposed Knockshanvo windfarm.

Issue	Mitigation	Operationally Acceptable
	Shannon Airport MSSR	Y / N
Reflections	The Thales RSM970 MSSR Sited at Shannon Airport is 18.4 km from the nearest wind turbine. Eurocontrol recommend that MSSR systems should be assessed if turbines are within 16 km of the radar. The fact Shannon Airports MSSR is outside the assessment zone, along with the evidence that the Thales system has inbuilt adaptive reflection processing, referenced in The Thales RSM970 MSSR Technical Description Document[2] , gives assurance the radar can work alongside the wind turbines. The radar utilises a two-stage system to remove both temporary (Dynamic) and permanent (Static) reflections from the system.	Y
Deflections	Although no assessment is necessary, The Thales RSM970 MSSR uses a well established processing system to remove any False Replies Unsynchronised In Time (FRUIT). This process removes the issue of deflections from the system.	Y

Shadowing	The Shannon Airport radar is beyond the Eurocontrol wind turbine assessment zone. Any Shadowing from the Turbines would be minimal and have no Operational effect.	Y
Woodcock Hill MSSR		
Reflections	The Thales RSM970 MSSR Sited at Woodcock Hill is 5.6 km from the nearest wind turbine. The Thales radar utilises a two-stage system to prevent both temporary (Dynamic) and permanent (Static) reflections being displayed. It also has inbuilt adaptive reflection processing. This is referenced in The Thales RSM970 MSSR Technical Description Document[2]. To prevent possible reflection issues, some minor optimisation may be required. This is usually carried out as part of the scheduled maintenance of the equipment.	Y
Deflections	The Thales RSM970 MSSR uses a well established processing system to remove any False Replies Unsynchronised In Time (FRUIT). This process removes the issue of deflections from the system. No additional optimisation is required as a DEFRUITER is part of the standard MSSR processing on the Thales system.	Y
Shadowing	Due to the close proximity of the Turbines to the Woodcock Hill radar, some shadowing will occur. A detailed previous assessment was completed by Cyrrus on the previous 18-turbine design. It was considered any shadowing would be minimal and be operationally tolerable. With the reduction in turbines to 9, it is assumed the shadowing would be no worse than the previous assessment and so remain operationally tolerable.	Y
Shannon Airport PSR		
Clutter caused by turbine blades	The Shannon Airport Thales STAR2000 radar was designed to operate in areas with wind turbines. Over the last 10-years, several improvements have been made to the processing systems used to prevent unacceptable clutter being caused by wind turbines. Some optimisation of the current radar may be required. This should be assessed by Thales and, if required, they can provide a series of staged upgrades to address this issue.	Y
Desensitisation of radar	As above, Thales could assess if optimisation or upgrades would be required to address any desensitisation issues.	Y

Table 1: Radar Issues and Mitigation solutions

Since 2021, Cyrrus have worked on several projects involving Thales STAR2000 Primary Surveillance Radars. The STAR2000 as used at Shannon Airport is a solid-state S-band radar designed to be windfarm tolerant. Thales has completed several dedicated impact studies of STAR2000 systems working successfully in areas with multiple wind turbines.

Cyrrus recommend that a survey be carried out on the Shannon Airport STAR2000 radar system to confirm its suitability to provide an operationally acceptable radar picture once the turbines are built. The survey will be an opportunity to clarify and formally define the ATC User Requirements for the associated Airspace.

The radar mitigation solution may not require an upgrade. Thales may determine the existing radars capability includes sufficient wind turbine filtering. If required system optimisation or upgrades are available to maximise the radars ability to comply with the ATC User Requirement. Thales has a suite of upgrade packages ranging from simple software updates to full system refresh’s depending on the systems current configuration.

Due to the radar’s modular system architecture, if upgrades are required on the Shannon Airport Primary Surveillance Radar, it is likely any downtime would be minimal. Thales have confirmed they have completed many projects of this type using tried and tested transition plans to allow the systems to remain operational throughout.

The erection of 9-wind turbines at the proposed Knockshanvo windfarm would have no operational impact on the Shannon Airport and Woodcock Hill MSSR systems. If upgrades are required to the Shannon Airport Primary Surveillance Radar, these should be completed before the windfarm is built. Any effect from the windfarm on the operational picture should have minimal effect. Should the Woodcock Hill radar require optimisation, this would be completed one channel at a time and allow the system to remain operational throughout.

In Summary, both the Shannon Airport and Woodcock Hill radars could Mitigate against adverse effects caused by the proposed Knockshanvo 9-turbine windfarm.

Abbreviations

MSSR	Monopulse Secondary Surveillance Radar
NM	Nautical Miles
PSR	Primary Surveillance Radar
RDP	Radar Data Processor
RLoS	Radar Line of Sight

References

[1] CL-5693-RPT-002 v1.0 Violet Hill Wind Farm Radar Assessment

[2] EUROCONTROL Guidelines for Assessing the Potential Impact of Wind Turbines on Surveillance Sensors – GUID-0130 – 9/9/2014

[3] Thales STAR2000 datasheet – 1/1/2014

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1. Introduction

1.1. History

1.1.1. In September 2021, Cyrrus published a report [1] providing the technical evidence that the proposed Violet Hill windfarm with 18 turbines had Radar Line of Sight with the Shannon Airport and Woodcock Hill radars.

1.1.2. The Shannon Airport Monopulse Secondary Surveillance Radar system is beyond the 16 km assessment zone recommended by Eurocontrol[2] so does not require an assessment.

1.1.3. The Woodcock Hill Monopulse Secondary Surveillance Radar is 5.6 km from the nearest turbine. The previous report [1] concluded that any shadow region beyond the proposed turbines would be sufficiently small to be operationally tolerable.

1.1.4. The Shannon Airport Primary Surveillance Radar would likely require some mitigation.

2. Overview

2.1. Knockshanvo Windfarm

2.1.1. The previously proposed Violet Hill windfarm with 18-turbines has now been renamed as the Knockshanvo Windfarm with the number of turbines reduced to 9.

2.1.2. Table 2 details the turbine positions for the Knockshanvo windfarm. Figure 1 shows the positions.

Label	X_ITM	Y_ITM	Latitude	Longitude
T01	553306.444	669419.531	52.77379	-8.69201
T02	553421.846	670076.257	52.7797	-8.6904
T03	553812.149	669850.553	52.7777	-8.68458
T04	556212.277	669444.129	52.77425	-8.64895
T05	556662.506	670000.996	52.77929	-8.64236
T06	556896.229	669600.869	52.77571	-8.63884
T07	556727.353	669042.335	52.77068	-8.64127
T08	558463.188	669913.098	52.77864	-8.61566
T09	558864.227	669556.784	52.77547	-8.60967

Table 2: Knockshanvo Turbine Positions

Figure 1: Knockshanvo Turbine Positions

2.1.3. The windfarm is 18.4 km from the Shannon Airport Primary Surveillance Radar with co-mounted Monopulse Secondary Surveillance Radar. Section 2.2 covers common issues which can occur when wind turbines are sited in close proximity to radars.

2.2. Common Issues

2.2.1. All radar systems can suffer from problems when working alongside windfarms. Table 2 below details the most common issues, and how they can be mitigated using the current systems.

Issue	Mitigation	Operationally Acceptable
	Shannon Airport MSSR	Y / N
Reflections	The Thales RSM970 MSSR Sited at Shannon Airport is 18.4 km from the nearest wind turbine. Eurocontrol dictate that MSSR systems should be assessed if turbines are closer than 16 km. This, along with the fact the Thales system has inbuilt adaptive reflection processing. This is referenced in The Thales RSM970 MSSR Technical Description Document[2] The radar utilises a two stage system to prevent both temporary (Dynamic) and permanent (Static) reflections being displayed.	Y
Deflections	Although no assessment is necessary, The Thales RSM970 MSSR uses a well established processing system to remove any False Replies Unsynchronised In Time (FRUIT). This process removes the issue of deflections from the system.	Y
Shadowing	The Shannon Airport radar is beyond the Eurocontrol wind turbine assessment zone. Any Shadowing from the Turbines would be minimal and have no Operational effect.	Y
Woodcock Hill MSSR		
Reflections	The Thales RSM970 MSSR Sited at Woodcock Hill is 5.6 km from the nearest wind turbine. The Thales radar utilises a two-stage system to prevent both temporary (Dynamic) and permanent (Static) reflections being displayed. It also has inbuilt adaptive reflection processing. This is referenced in The Thales RSM970 MSSR Technical Description Document[2]. To prevent possible reflection issues, some minor optimisation may be required. This is usually carried out as part of the scheduled maintenance of the equipment.	Y
Deflections	The Thales RSM970 MSSR uses a well established processing system to remove any False Replies Unsynchronised In Time (FRUIT). This process removes the issue of deflections from the system. No additional optimisation is required as a	Y

	DEFRUITER is part of the standard MSSR processing on the Thales system.	
Shadowing	Due to the close proximity of the Turbines to the Woodcock Hill radar, some shadowing will occur. A detailed previous assessment was completed by Cyrrus on the previous 18-turbine design. It was considered any shadowing would be minimal and be operationally tolerable. With the reduction in turbines to 9, it is assumed the shadowing would be no worse than the previous assessment and so remain operationally tolerable.	Y
Shannon Airport PSR		
Clutter caused by turbine blades	The Shannon Airport Thales STAR2000 radar was designed to operate in areas with wind turbines. Over the last 10-years, several improvements have been made to the processing systems used to prevent unacceptable clutter being caused by wind turbines. Some optimisations of the current radar may be required. This should be assessed by Thales and If required, they can provide a series of staged upgrades to address this issue.	Y
Desensitisation of radar	As above, Thales could assess if optimisations or upgrades would be required to address any desensitisation issues.	Y

Table 3: Radar Issues and Mitigation solutions

2.2.2. Sections below provide detail on the Shannon Airport and Woodcock Hill radar systems and the likelihood of them being able to comply with the Operational Requirements in the presence of the proposed 9-Turbine Knockshanvo Windfarm.

3. MSSR

3.1. Shannon Airport

Figure 2: Shannon Airport PSR with co-mounted MSSR

3.1.1. Figure 3 shows the location of the Shannon Airport radar in relation to the Windfarm. The distance between the radar and the nearest turbine is 18.4 km. Therefore the Shannon Airport MSSR is beyond the 16 km assessment zone recommended by Eurocontrol [2], no assessment is required.

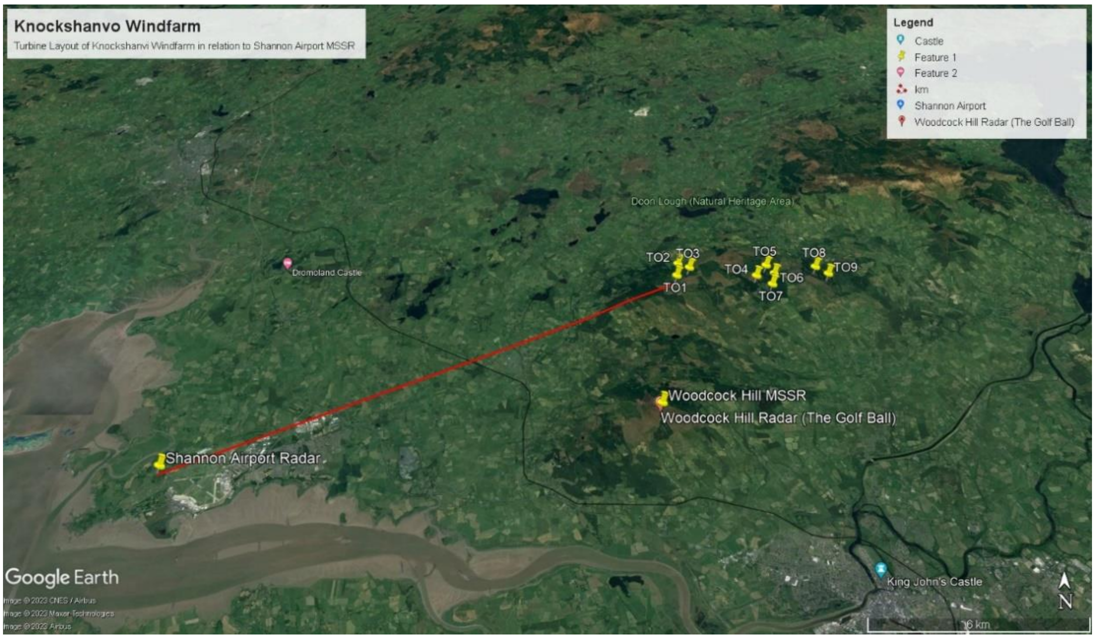

Figure 3: Shannon Airport Radar to Knockshanvo Windfarm

3.1.2. To confirm Line of Sight (LoS) between the radar and the wind turbines the HTZ Communication tool by ATDI was used. Figures 4 and 5 show that LoS exists to the nearest and furthest turbines. All turbines have been assessed and found to have LoS.

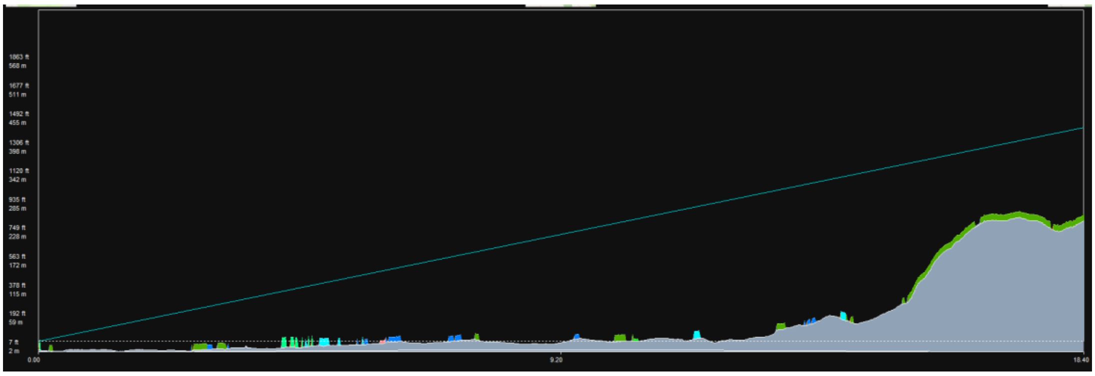

Figure 4: LoS from Shannon Airport Radar to the Nearest Turbine.

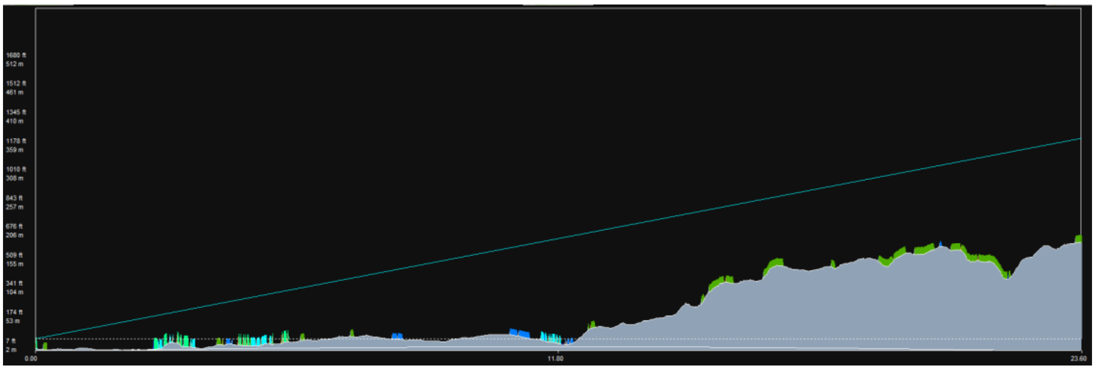

Figure 5: LoS from Shannon Airport Radar to the Furthest Turbine

3.2. Woodcock Hill

Figure 6: Woodcock Hill MSSR system

3.2.1. Figure 7 shows the location of the Woodcock Hill radar in relation to the Windfarm. The distance between the radar and the nearest turbine is 5.6 km. Eurocontrol recommend an impact assessment be completed for turbines closer than 16 km.

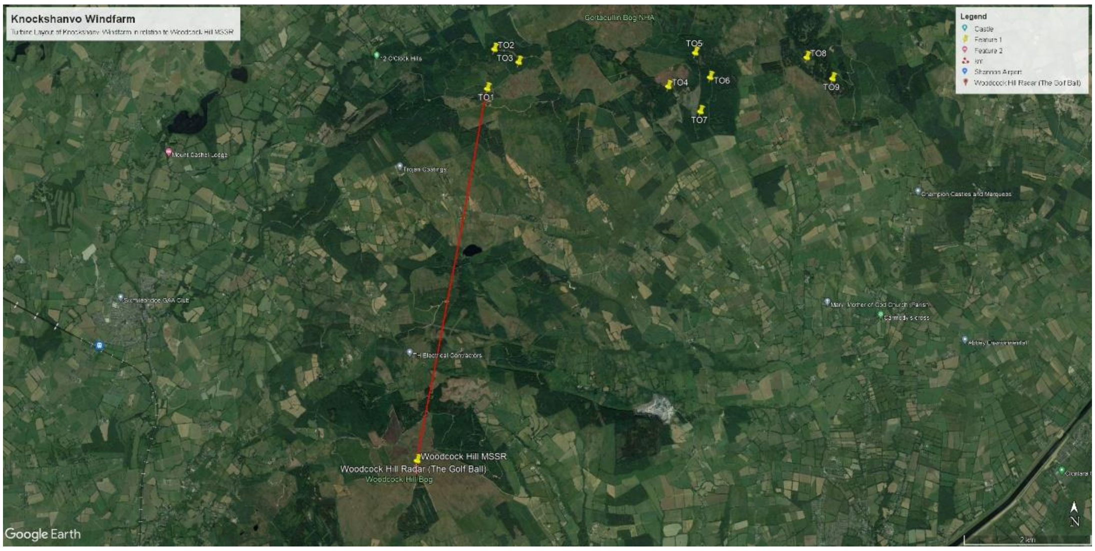

Figure 7: Woodcock Hill MSSR in relation to the proposed windfarm

3.2.2. The rationale behind the Eurocontrol assessment is to ensure the Operational impact is acceptable or that a suitable mitigation is in place to ensure continued compliance.

3.2.3. The previous Cyrrus report [1] stated that the turbines could impact radar performance. The impact has been considered, along with additional technical information on the Thales radar mitigation solution.

3.2.4. To confirm the radar has Line of Sight with the turbines, the HTZ Communication tool by ATDI was used. Figures 8 and 9 show that LoS exists to the nearest and furthest turbines. All turbines have been assessed and found to have LoS.

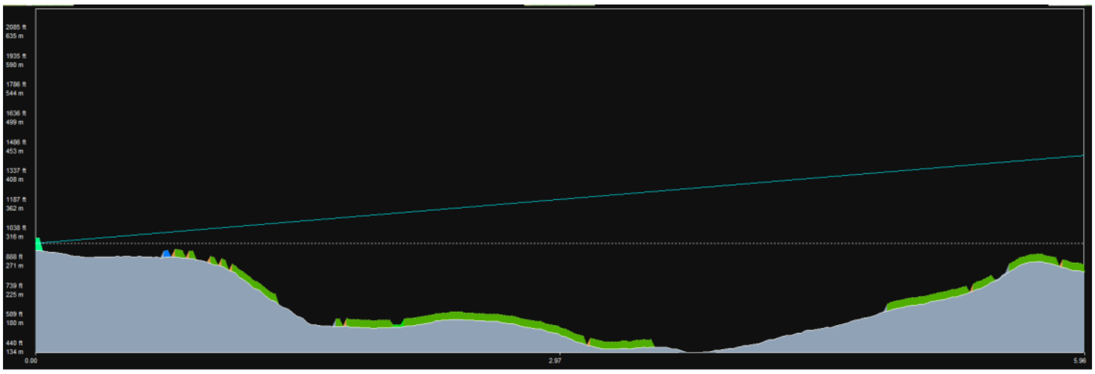

Figure 8: LoS Woodcock Hill MSSR and TO1

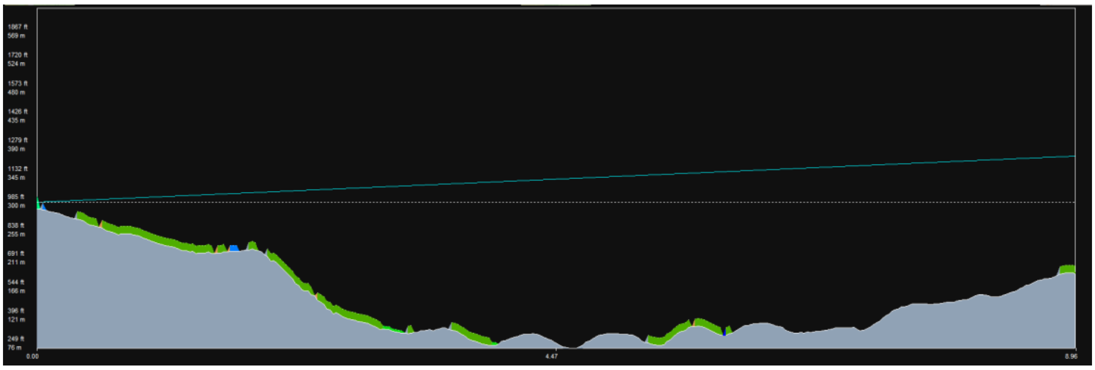

Figure 9: LoS Woodcock Hill to TO9

4. PSR

4.1. Overview of PSR

4.1.1. Wind turbines can impact Primary Surveillance Radars (PSR) performance, as their processing algorithms can 'see' turbine blades as moving targets and display them as clutter to ATC. Modern Surveillance Data Processing systems use advanced techniques prevent this clutter from the Wind turbines from being displayed on the ATC Controllers Display.

4.2. Shannon Airport PSR

4.2.1. The Shannon Airport PSR is a Thales STAR 2000 PSR installed in 2011 / 12. The system was designed to work in coverage volumes containing wind turbines. The Thales STAR2000 data sheet[3] explains how wind turbine filtering is achieved. For a relatively small windfarm within the radar's coverage volume, the turbines should have a minimal impact on performance.

4.2.2. Thales has a suite of optimisation and upgrade packages available for the STAR2000. If required, these could further enhance the STAR 2000 capability to filter the turbines at Knockshanvo and elsewhere.

4.2.3. Thales state that they have a mature transition framework which allows system upgrades and optimisation to be implemented without the requirement for long periods of operational downtime. Cyrrus has experience of working with Airports and ANSPs to produce Transition Plans that minimise downtime, risk and comply with Safety Management Systems as required by regulators.

5. Conclusion

5.1. Recommendations

5.1.1. An asset condition survey on the Shannon Airport and Woodcock Hill radar systems should be undertaken by Thales. This will include the current build state.

5.1.2. As the manufacturer and Design Authority of both radar systems, Thales will be able to assess the type of mitigation package required (if any). They will confirm costs and timescales based on their scope of work.

5.2. Summary

5.2.1. The performance of the MSSR systems at both Shannon Airport and Woodcock Hill will not be unacceptably impacted by the proposed 9-turbines at Knockshanvo. Both systems have the inbuilt capabilities to filter wind turbine impacts.

5.2.2. The PSR at Shannon Airport may already be capable of filtering the wind turbines. Furthermore, Thales can provide various upgrades to further reduce the impact. These mitigations would result in the proposed 9-turbine windfarm at Knockshanvo having no operational effect.

5.2.3. If upgrades and optimisation is required to the systems, transitional arrangements can be managed to ensure minimal operational disruption occurs.

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Appendix 12

IFP Safeguarding Knockshanvo Windfarm

Shannon Airport

IFP Safeguarding

Knockshanvo Windfarm

Shannon Airport

11 March 2024

CL-6005-RPT-003 V2.0

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Change History Record

Issue	Change Reference	Date	Details
1.0	Initial Issue	29 November 2023	First Issue
1.1	Amendments to ATCMAC section and Mitigation Options	12 December 2023	Second Issue
2.0	Amendments to Mitigation Options and inclusion of ATCSMAC concept designs	11 March 2024	Third Issue

Executive Summary

The assessment has been carried out against the proposed Knockshanvo windfarm development approximately 9.51 Nautical Miles (NM) northeast of Shannon Airports Aerodrome Reference Point (ARP).

The purpose of this assessment is to assess if the proposed windfarm development penetrates the protection areas/surfaces of the IFPs serving the Airport. These protection areas and surfaces (sloping or level) are established based upon the runway (RWY) and thresholds (THR), Aerodrome Reference Point (ARP), clearways, ground navigation equipment, and established waypoints.

The assessment has determined that the proposed windfarm does impact the currently published IFPs for Shannon Airport.

The Wind Farm has an impact to the following procedures:

- SID RWY 06 DIGAN 3A (EINN AD 2.25-5.1)
- SID RWY 06 TOMTO 3A (EINN AD 2.25-5.1)
- SID RWY 06 ABAGU 3A (EINN AD 2.25-5.1)
- Instrument Approach VOR RWY 24 (EINN AD 2.24-14.1)
- ATC Surveillance Minimum Altitude Chart (EINN AD 2.24-16.1)

Possible mitigation options to remove impact to the Instrument Flight Procedures are listed in the conclusion.

After discussion with AirNav Ireland, it was agreed that of the Impacted IFPs, the primary concern is the ATCSMAC. Four design options have identified, these are described in Annex A.

Whilst the list of options determined is not exhaustive, the Minimum Vectoring Altitude (MVA) determined in each option are not likely to change, any further design optimisation would be to the Surveillance Minimum Altitude Area (SMAA) Sector size and shape.

Abbreviations

AIP	Aeronautical Information Publication
AIRAC	Aeronautical Information Regulation and Control
ARP	Aerodrome Reference Point
ATC	Air Traffic Control
ATCSMAC	Air Traffic Control Surveillance Minimum Altitude Chart
ATM	Air Traffic Management
ATS - Authority	Air Traffic Services
CAT	Category
DME	Distance Measuring Equipment
EGPWS	Enhanced Ground Proximity Warning System
GP	Glide Path
IAA	Irish Aviation Authority
IAP	Instrument Approach Procedure
ICAO	International Civil Aviation Organisation
IFP	Instrument Flight Procedure
ILS	Instrument Landing System
LOC	Localiser
m	Meters
MOC	Minimum Obstacle Clearance
MOCA	Minimum Obstacle Clearance Altitude
MSA	Minimum Sector Altitudes
MVA	Minimum Vectoring Altitude
NM	Nautical Mile
OPS	Operations
PANS	Procedures for Air Navigation Services
PDG	Procedure Design Gradient
RWY	Runway
SID	Standard Instrument Departure
SMAA	Surveillance Minimum Altitude Area
THR	Threshold
UTM	Universal Transverse Mercator
VHF	Very High Frequency
VOR	Very High Frequency Omnirange
WGS-84	World Geodetic System 1984
WTG	Wind Turbine Generator

References

[1] ICAO DOC 8168 - Procedures for Air Navigation Services, Aircraft Operations, Vol III, 7th Ed, Amendment 9, Corrigendum 2, dated 21 March 2022.

[2] ICAO Annex 4 – Aeronautical Charts, 11th Ed, Corrigendum (12/10/17), Amendment 61 dated 4 November 2021.

[3] ICAO DOC 4444 – Procedures for Air Navigation Services, Air Traffic Management , Sixteenth Edition, 2016.

[4] ASAM 017 – Guidance Material on Instrument Flight Procedure Design, dated 24 January 2022.

[5] ICAO DOC 8168 - Procedures for Air Navigation Services, Aircraft Operations, Vol III, First Edition, dated 8 November 2018.

Contents

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List of tables

1. General

1.1. Geodesic Datum

Name	Ireland-WGS84[1]-UTM29[2]
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
Reference Latitude	00°00'00.00"N

Table 1: Geodesic Datum Parameters

1.2. Notes

Table below indicates the criteria used for this assessment.

Criteria	Comments
Height	In metres (m)
Bearings	True bearings
Speed	Knots
Temperature	IAS+15 used for all speed conversions from Indicated Air Speed (IAS) to True Air Speed (TAS)
Aircraft categories	As Defined
Mountainous terrain	No
Buffer for trees and unknown structures not defined in CAP232/1732 surveyed areas (see Section 1.6)	N/A
Cold Temperature Adjustments	ICAO DOC 8168 volume III

Table 2: Criteria

[1] World Geodetic System 1984
[2] Universal Transverse Mercator

1.3. Runway Information

Runway	Bearing (°T)	Latitude	Longitude	Elevation (ft)
06	052.22°	524135.42N	0085636.67W	46
24	232.25°	524236.03N	0085427.87W	15

Table 3: Runway Information

2. IFP Safeguarding

2.1. Overview

The assessment has been carried out in relation to 9 Wind Turbine Generator (WTG) positions approximately 9.5 Nautical Miles (NM) northeast from Shannon Airports Aerodrome Reference Point (ARP).

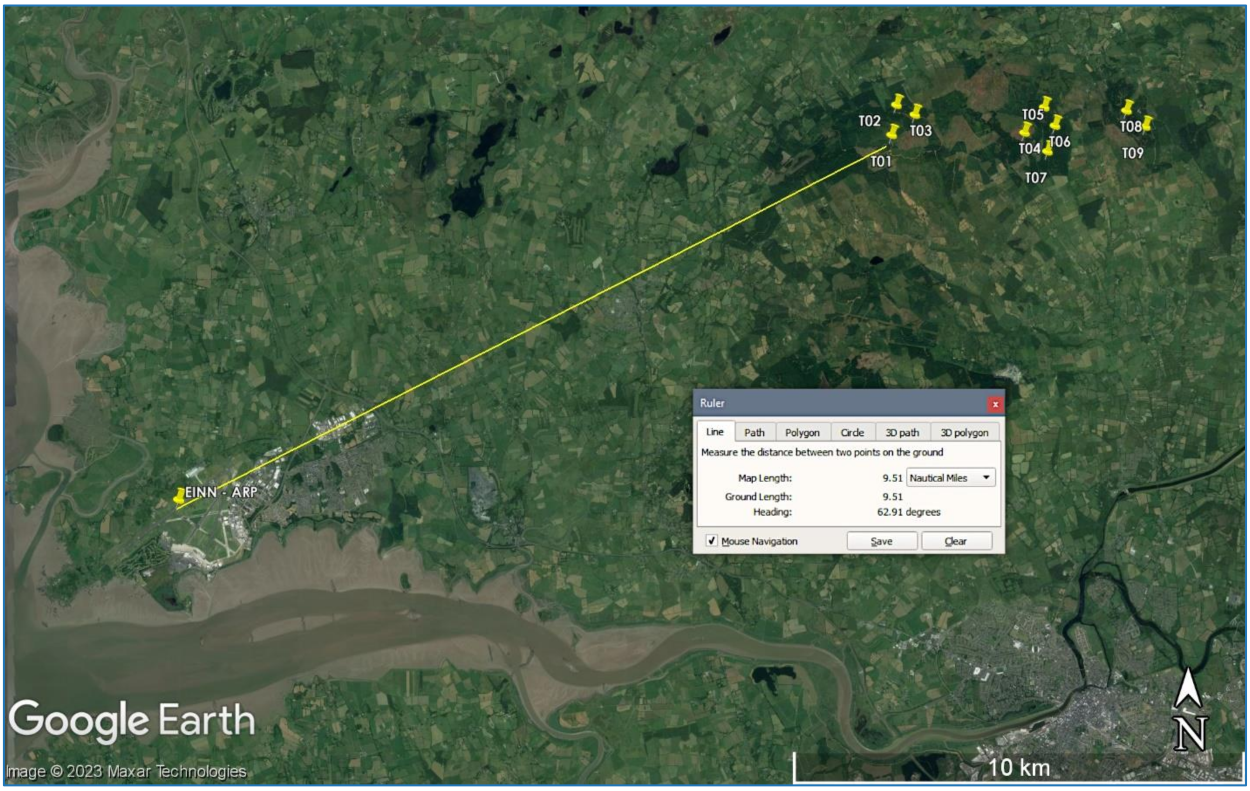

Figure 1: WTG layout Relative to ARP

2.2. IFP's Assessed

The following IFPs, as published in the Irish Aviation Authority (IAA) Aeronautical Information Publication (AIP), Aeronautical Information Regulation and Control (AIRAC) effective 22 February 2024 were assessed.

- RNAV Standard Instrument Departure RWY 06
- RNAV Standard Instrument Departure RWY 24
- RNAV Standard Arrival RWY 06
- RNAV Standard Arrival RWY 24
- Instrument Approach ILS or LOC RWY 06
- Instrument Approach VOR RWY 06
- Instrument Approach ILS CAT I & II or LOC 24
- Instrument Approach VOR RWY 24
- ATC Surveillance Minimum

2.3. Data

The following data received from the client was used for the purpose of this assessment:

- Turbine Coordinates and Elevations - RE_ Knockshanvo Windfarm Proposal East Clare - ANSP Update.msg

The ground elevations at each turbine position were obtained by Cyrrus using Osi 10m DTM data.

The Turbines dimensions used for the assessment are based on the worst-case turbine tip height of 185 m.

The resulting data used is indicated in Table 4 below.

Name	Latitude (DMS WGS84)	Longitude (DMS WGS84)	Ground Height (m AGL)	Tip Elevation (m AMSL)	Radius (m)
T01	52°46'25.64"N	008°41'31.24"W	250.4	435.4	77.5
T02	52°46'46.92"N	008°41'25.44"W	234.1	419.1	77.5
T03	52°46'39.72"N	008°41'04.49"W	266.5	451.5	77.5
T04	52°46'27.30"N	008°38'56.22"W	222.9	407.9	77.5
T05	52°46'45.44"N	008°38'32.50"W	192.1	377.1	77.5
T06	52°46'32.56"N	008°38'19.82"W	181.9	366.9	77.5
T07	52°46'14.45"N	008°38'28.57"W	175.8	360.8	77.5
T08	52°46'43.10"N	008°36'56.38"W	182.4	367.4	77.5
T09	52°46'31.69"N	008°36'34.81"W	196.0	381.0	77.5

Table 4: Wind Turbine Assessment Data

2.4. Discrepancies and Assumptions

No ground / base elevations were provided. To calculate the Turbine Tip Elevation Above Mean Sea Level, ground elevations were extracted from Ordnance Survey Ireland 10m DTM.

2.5. IFP Safeguarding Assessment

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

For each departure and approach the Pans-Ops obstacle protection areas were constructed. These areas were then checked to determine if the proposed development was inside or outside of the obstacle protection areas. A further in-depth assessment would only be required if the proposed structure was inside these areas and the Obstacle Clearance Altitude (OCA) required by the obstacle was above the published OCA value.

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[3]. 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[4]. Where an impact was identified, only the assessment of the respective segment for said procedure, is provided.

The IFPs were assessed using PHX V23.0.4.17017.

2.6. Assessment Summary

Table 5 provides an impact summary of all the Instrument Approach Procedures (IAPs) that were assessed.

Assessed Procedure	RWY	Impact	Comments
MSA	Both	No	Nil
ILS or LOC	06	No	Nil
VOR		No	Nil
RNAV STARs		No	Outside Protection Areas
RNAV SIDs		Yes	T01, T02, and T03 penetrates the turn area for DIGAN 3A which results in a higher Procedure Design Gradient (PDG) than the standard obstacle clearance PDG of 3.3%. T01, T02, and T03 penetrates the turn area for TOMTO 3A which results in a higher PDG than the standard obstacle clearance PDG of 3.3%.

[3] 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.
[4] Mitigation for the IFPs is for the Airport (Sponsor) to decide upon as these may have a direct impact on their operations. It is recommended that further discussion and guidance is obtained from the IAA.

			T01, T02, and T03 penetrate the turn area for ABAGU 3A which results in a higher PDG than the standard obstacle clearance PDG of 3.3%.
ILS CAT I & II or LOC	24	No	Nil.
VOR		Yes	T01, T02, and T03, penetrate the secondary area of the Final approach and raises the currently published MOCA by 400ft from 1270ft to **1670ft.**
RNAV STARs		No	Outside Protection Areas
RNAV SIDs		No	Outside Protection Areas
ATCSMAC	Both	Yes	T01, T02, T03, T04, T05, T06, T08, and T09 penetrate Sector 1 and raises the published minima by 300ft from 2300ft to **2600ft.**

Table 5: IFP Assessment Impact Summary

2.7. IFP's not assessed

The following IFPs, although considered, were not assessed as the turbines lie outside the protection areas of the following procedures.

- RNAV STARs RWY 06
- RNAV STARs RWY 24
- RNAV SIDs RWY 24

2.8. Assessment Details

2.8.1. Minimum Sector Altitude (MSA)

The turbines fall into sector 1 (056°M to 146°M 3400ft) and sector 2 (146°M to 056°M 3000ft), 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
Sector 1	
From	056° M
To	146° M
Calculated Minimum	2500 ft
Number of Checked Obstacles	9
Sector 2	
From	146° M

To	056° M
Calculated Minimum	2500 ft
Number of Checked Obstacles	9

Table 6: Minimum Sector Altitudes (MSA) - General

Name	Latitude	Longitude	Alt. (m)	MOC applied (m)	OCA (ft)
T03	52°46'39.72"N	008°41'04.49"W	451.5	300.0	2465.5
T01	52°46'25.64"N	008°41'31.24"W	435.4	300.0	2412.8
T02	52°46'46.92"N	008°41'25.44"W	419.1	300.0	2359.3
T04	52°46'27.30"N	008°38'56.22"W	407.9	300.0	2322.6
T09	52°46'31.69"N	008°36'34.81"W	381.0	300.0	2234.3
T05	52°46'45.44"N	008°38'32.50"W	377.1	300.0	2221.5
T08	52°46'43.10"N	008°36'56.38"W	367.4	300.0	2189.6
T06	52°46'32.56"N	008°38'19.82"W	366.9	300.0	2188.1
T07	52°46'14.45"N	008°38'28.57"W	360.8	300.0	2168.0

Table 7: Minimum Sector Altitudes (MSA) - Checked Obstacles - 056° M - 146° M

Name	Latitude	Longitude	Alt. (m)	MOC applied (m)	OCA (ft)
T03	52°46'39.72"N	008°41'04.49"W	451.5	300.0	2465.5
T01	52°46'25.64"N	008°41'31.24"W	435.4	300.0	2412.8
T02	52°46'46.92"N	008°41'25.44"W	419.1	300.0	2359.3
T04	52°46'27.30"N	008°38'56.22"W	407.9	300.0	2322.6
T09	52°46'31.69"N	008°36'34.81"W	381.0	300.0	2234.3
T05	52°46'45.44"N	008°38'32.50"W	377.1	300.0	2221.5
T08	52°46'43.10"N	008°36'56.38"W	367.4	300.0	2189.6
T06	52°46'32.56"N	008°38'19.82"W	366.9	300.0	2188.1
T07	52°46'14.45"N	008°38'28.57"W	360.8	300.0	2168.0

Table 8: Minimum Sector Altitudes (MSA) - Checked Obstacles - 146° M - 056° M

As indicated in Table 7 and Table 8 there is no impact to the MSA.

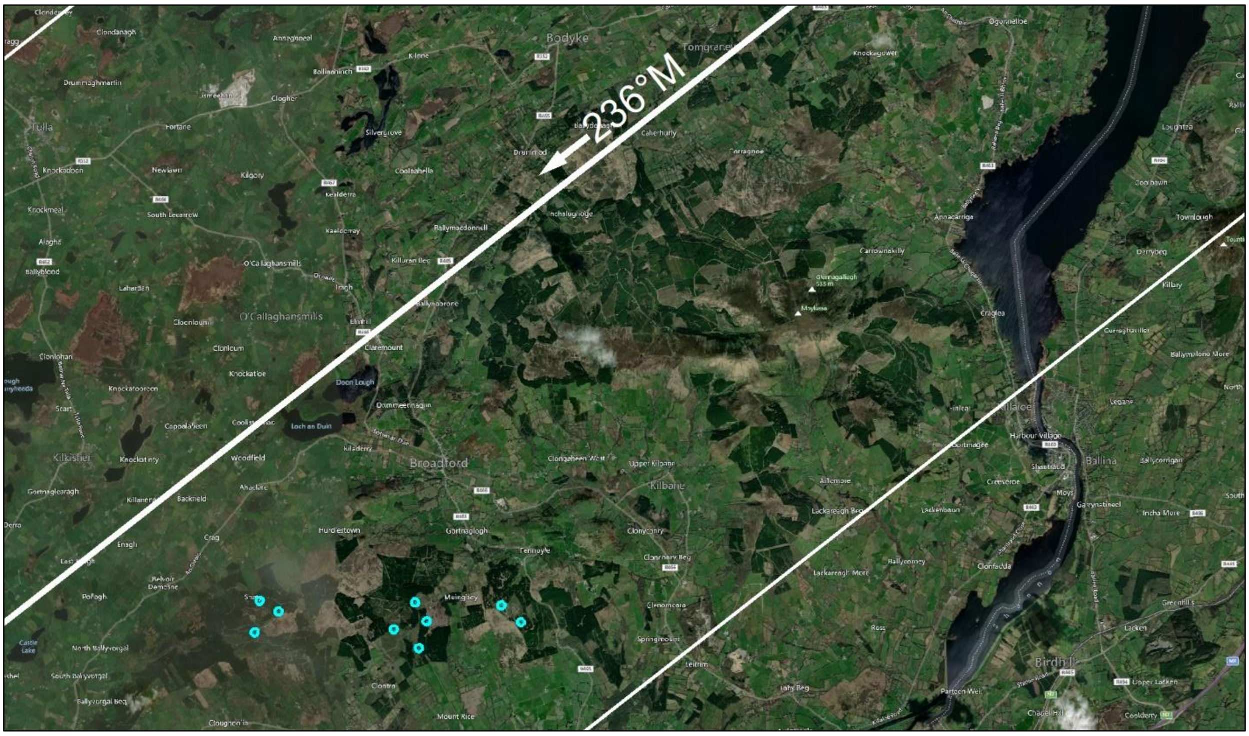

Figure 2: MSA VOR/DME SHA

2.8.2. DERAG HOLD (Conv)

The turbines fall into the buffer areas (1-2NM and 2-3NM) of the Hold, which has a Lowest Holding Altitude (LHA) of 3000ft.

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	232.25 °
Turns	Right
Obstacles	
Number of Checked Obstacles	9

Table 9: VOR/DME Holding DERAG - General

Name	Latitude	Longitude	Alt. (m)	Surface	MOC applied (m)	OCA (ft)	Controlling
T03	52°46'39.72"N	008°41'04.49"W	451.5	Buffer (2 NM - 3 NM)	120.0	1874.9	No
T02	52°46'46.92"N	008°41'25.44"W	419.1	Buffer (1 NM - 2 NM)	150.0	1867.1	No
T01	52°46'25.64"N	008°41'31.24"W	435.4	Buffer (2 NM - 3 NM)	120.0	1822.3	No
T09	52°46'31.69"N	008°36'34.81"W	381.0	Buffer (1 NM - 2 NM)	150.0	1742.1	No
T04	52°46'27.30"N	008°38'56.22"W	407.9	Buffer (2 NM - 3 NM)	120.0	1732.1	No
T05	52°46'45.44"N	008°38'32.50"W	377.1	Buffer (1 NM - 2 NM)	150.0	1729.4	No
T08	52°46'43.10"N	008°36'56.38"W	367.4	Buffer (1 NM - 2 NM)	150.0	1697.5	No
T06	52°46'32.56"N	008°38'19.82"W	366.9	Buffer (1 NM - 2 NM)	150.0	1696.0	No
T07	52°46'14.45"N	008°38'28.57"W	360.8	Buffer (2 NM - 3 NM)	120.0	1577.5	No

Table 10: VOR/DME Holding DERAG - Checked Obstacles - All

Name	Latitude	Longitude	Alt. (m)	MOC applied (m)	OCA (ft)	Controlling
T02	52°46'46.92"N	008°41'25.44"W	419.1	150.0	1867.1	No
T09	52°46'31.69"N	008°36'34.81"W	381.0	150.0	1742.1	No
T05	52°46'45.44"N	008°38'32.50"W	377.1	150.0	1729.4	No
T08	52°46'43.10"N	008°36'56.38"W	367.4	150.0	1697.5	No
T06	52°46'32.56"N	008°38'19.82"W	366.9	150.0	1696.0	No

Table 11: VOR/DME Holding DERAG - Checked Obstacles - Buffer (1 NM - 2 NM)

Name	Latitude	Longitude	Alt. (m)	MOC applied (m)	OCA (ft)	Controlling
T03	52°46'39.72"N	008°41'04.49"W	451.5	120.0	1874.9	No
T01	52°46'25.64"N	008°41'31.24"W	435.4	120.0	1822.3	No
T04	52°46'27.30"N	008°38'56.22"W	407.9	120.0	1732.1	No
T07	52°46'14.45"N	008°38'28.57"W	360.8	120.0	1577.5	No

Table 12: VOR/DME Holding DERAG - Checked Obstacles - Buffer (2 NM - 3 NM)

As indicated in Table 10, no turbines impact the Hold.

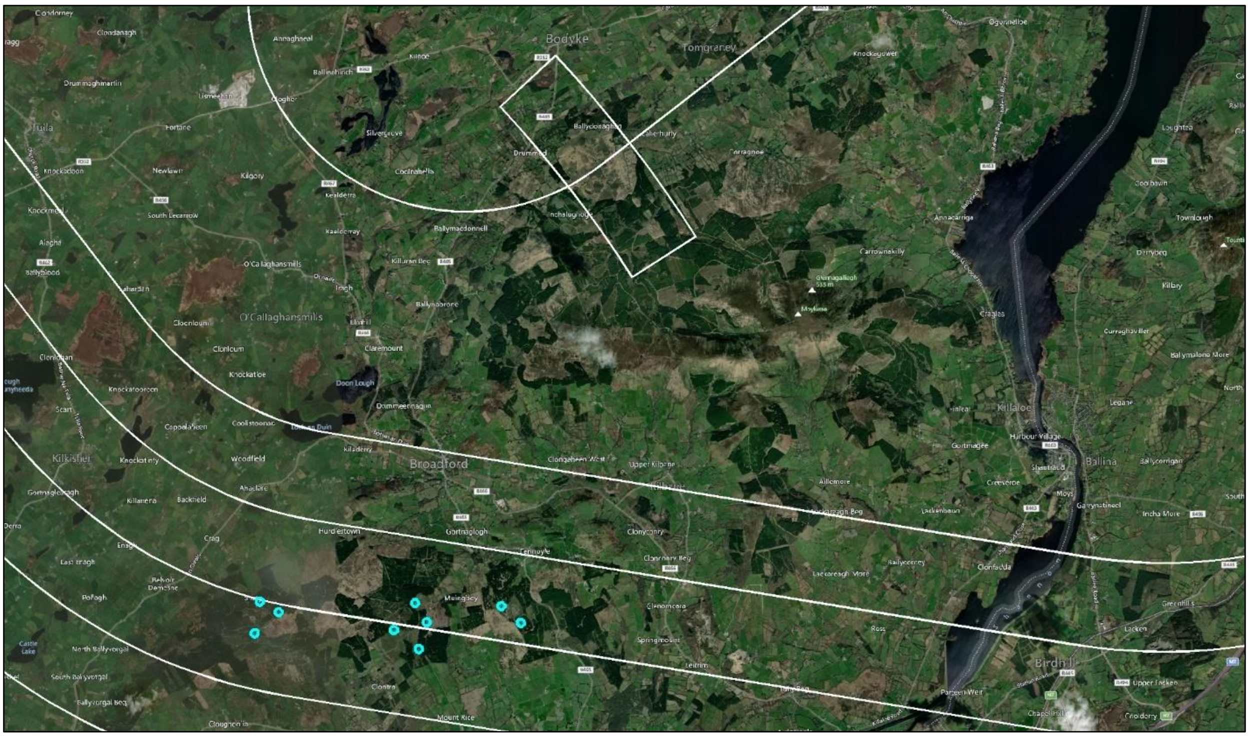

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Figure 3: DERAG Conventional HOLD - Wind farm Location

2.8.3. DERAG HOLD (RNAV)

The turbines fall withing the primary area of the Hold, which has a LHA of 3000ft.

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	Time
IAS	220 kts
TAS	280.6 kts
Altitude	14000 ft
ISA	15 °C
Time	1 min
Wind	74.6 kts (ICAO)
MOC	300 m
Cat. H (linear MOC reduction up to 2 NM)	No
Entry Areas	
70° Intercept	Yes
Sectors 1 & 2	Yes
Orientation	
In-bound Track	232.6 °
Turns	Right
Obstacles	
Number of Checked Obstacles	9

Table 13: DERAG HOLD (RNAV)

Name	Latitude	Longitude	Alt. (m)	Surface	MOC applied (m)	OCA (ft)	Ctrl?
T03	52°46'39.72"N	008°41'04.49"W	451.5	Primary Area	300.0	2465.5	No
T01	52°46'25.64"N	008°41'31.24"W	435.4	Primary Area	300.0	2412.8	No
T02	52°46'46.92"N	008°41'25.44"W	419.1	Primary Area	300.0	2359.3	No
T04	52°46'27.30"N	008°38'56.22"W	407.9	Primary Area	300.0	2322.6	No
T09	52°46'31.69"N	008°36'34.81"W	381.0	Primary Area	300.0	2234.3	No
T05	52°46'45.44"N	008°38'32.50"W	377.1	Primary Area	300.0	2221.5	No
T08	52°46'43.10"N	008°36'56.38"W	367.4	Primary Area	300.0	2189.6	No
T06	52°46'32.56"N	008°38'19.82"W	366.9	Primary Area	300.0	2188.1	No
T07	52°46'14.45"N	008°38'28.57"W	360.8	Primary Area	300.0	2168.0	No

Table 14: RNAV Holding DERAG - Checked Obstacles - All

As indicated in Table 14, no turbines impact the HOLD.

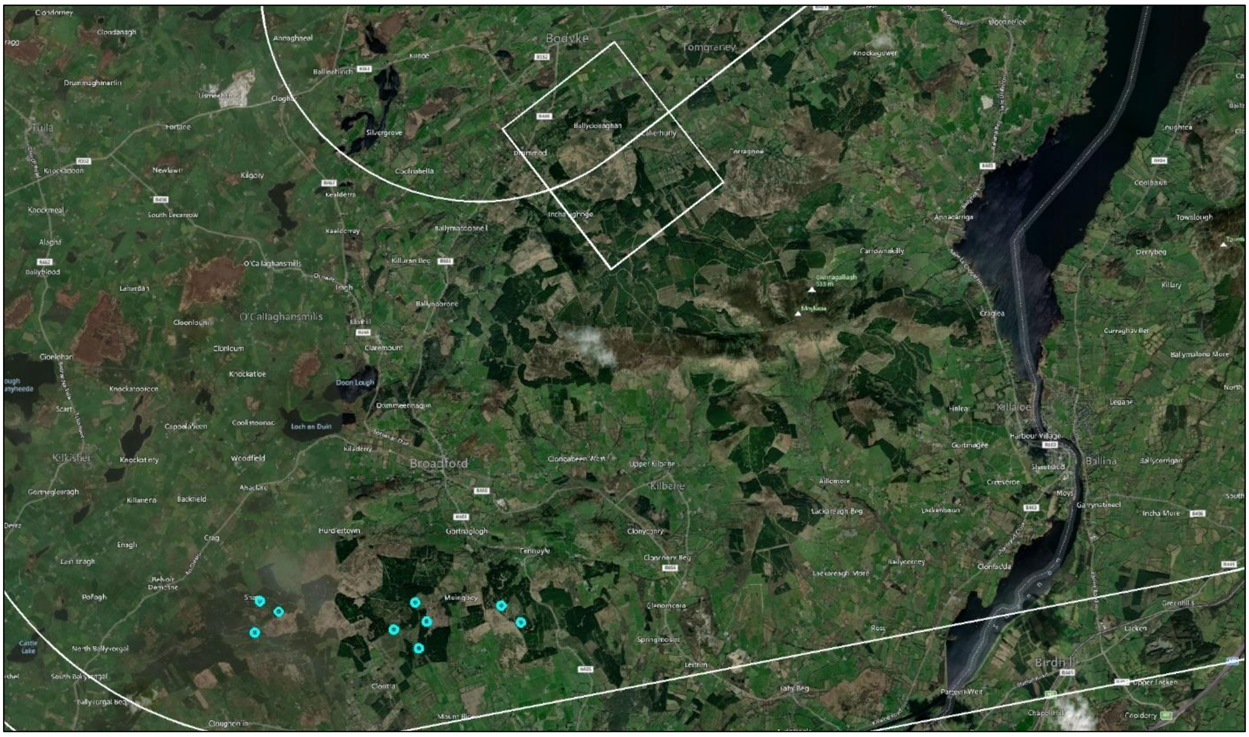

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Figure 4: DERAG HOLD (RNAV) - Wind farm Location

2.8.4. IAP – ILS Runway 06

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

Parameters	
SOC Position	
ID	SOC
Latitude	52°41'51.51"N
Longitude	008°56'02.51"W
Altitude	18.67 m (61.24 ft)
Track	052.17 °
MOC [int./fin.]	30 m / 50 m
MACG	2.5 %
Portion #2 (Turning Straight)	
Earliest Turning Point[ETP]	
Latitude	52°48'47.78"N
Longitude	008°41'14.15"W
Dist. DER -> ETP	21042.84 m
Nominal Track	052.17°
Obstacles	
Number of Checked Obstacles	7

Table 15: ILS RWY06 Missed Approach OA - General

Name	Latitude	Longitude	Alt. (m)	Area	Do (m)	MOC req. (m)	Ac. alt. (ft)	Alt. req. (ft)	MACG (%)	Controlling
T01	52°46'25.64"N	008°41'31.24"W	435.4	Primary	18033.0	30.0	1540.3	1526.9	2.5	No
T03	52°46'39.72"N	008°41'04.49"W	451.5	Primary	18695.5	30.0	1594.7	1579.6	2.5	No
T02	52°46'46.92"N	008°41'25.44"W	419.1	Primary	18520.0	30.0	1580.3	1473.4	2.4	No
T04	52°46'27.30"N	008°38'56.22"W	407.9	Primary	20366.7	30.0	1731.7	1436.7	2.1	No
T06	52°46'32.56"N	008°38'19.82"W	366.9	Primary	21006.4	30.0	1784.2	1302.2	1.9	No

Table 16: ILS RWY06 Missed Approach OA - Intermediate Phase - Checked Obstacles

Name	Latitude	Longitude	Alt. (m)	Area	Dz (m)	Do (m)	MOC req. (m)	Ac. alt. (ft)	Alt. req. (ft)	MACG (%)	Controlling
T05	52°46'45.44"N	008°38'32.50"W	377.1	Primary	21042.8	18.0	50.0	1788.7	1401.3	2.0	No
T06	52°46'32.56"N	008°38'19.82"W	366.9	Primary	21042.8	0.0	50.0	1787.2	1367.8	1.9	No

Table 17: ILS RWY06 Missed Approach OA - Final Phase - Checked Obstacles

As indicated in Table 16 and Table 17, the turbines do not impact to the procedure.

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Figure 5: ILS RWY 06 – Intermediate Missed Approach – Windfarm Location

2.8.5. IAP – LOC Runway 06

The Turbines fall into the Intermediate and Final Missed Approach segment 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	052.17 °
MOC [int./fin.]	30 m / 50 m
MACG	2.5 %
Portion #2 (Turning Straight)	
Earliest Turning Point[ETP]	
Latitude	52°51'04.98"N
Longitude	008°44'09.14"W
Dist. DER -> ETP	21354.93 m
Nominal Track	052.17°
Obstacles	
Number of Checked Obstacles	7

Table 18: LOC RWY06 Missed Approach OA - General

Name	Latitude	Longitude	Alt. (m)	Area	Do (m)	MOC req. (m)	Ac. alt. (ft)	Alt. req. (ft)	MACG (%)	Controlling
T03	52°46'39.72"N	008°41'04.49"W	451.5	Primary	19007.8	30.0	1909.0	1579.6	2.0	No
T01	52°46'25.64"N	008°41'31.24"W	435.4	Primary	18345.3	30.0	1854.7	1526.9	2.0	No

T02	52°46'46.92"N	008°41'25.44"W	419.1	Primary	18832.4	30.0	1894.6	1473.4	1.9	No
T04	52°46'27.30"N	008°38'56.22"W	407.9	Primary	20679.0	30.0	2046.1	1436.7	1.7	No
T06	52°46'32.56"N	008°38'19.82"W	366.9	Primary	21318.7	30.0	2098.6	1302.2	1.4	No

Table 19: LOC RWY06 Missed Approach OA - Intermediate Phase - Checked Obstacles

Name	Latitude	Longitude	Alt. (m)	Area	Dz (m)	Do (m)	MOC req. (m)	Ac. alt. (ft)	Alt. req. (ft)	MACG (%)	Controlling
T05	52°46'45.44"N	008°38'32.50"W	377.1	Primary	21354.9	25.7	50.0	2103.7	1401.3	1.5	No
T06	52°46'32.56"N	008°38'19.82"W	366.9	Primary	21354.9	0.0	50.0	2101.6	1367.8	1.5	No

Table 20: LOC RWY06 Missed Approach OA - Final Phase - Checked Obstacles

As indicated in Table 19 and Table 20, the LOC procedure is not impacted.

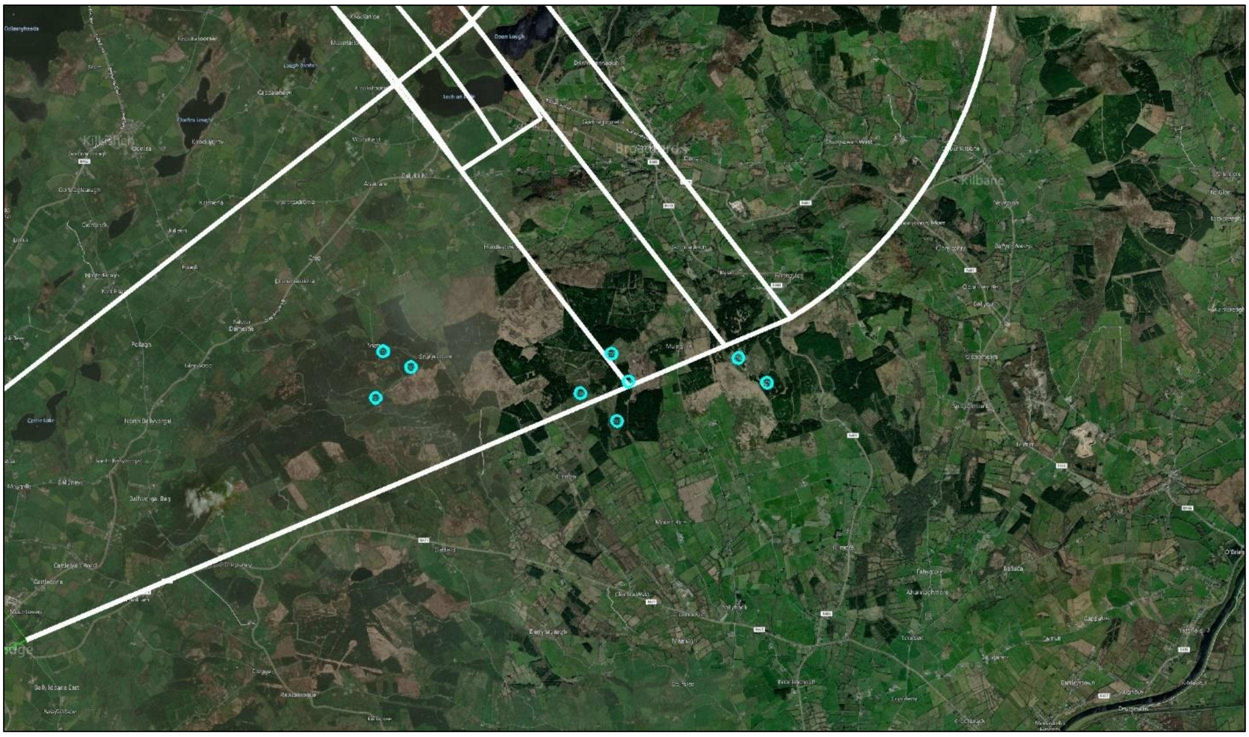

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Figure 6: LOC RWY 06 - Missed Approach – Windfarm Location

2.8.6. IAP – VOR Runway 06

The turbines fall in the Intermediate 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 [int./fin.]	30 m / 50 m
MACG	2.5 %

Portion #1 (Turning Straight)	
Earliest Turning Point[ETP]	
Latitude	52°48'49.78"N
Longitude	008°41'16.72"W
Dist. DER -> ETP	21274.31 m
Nominal Track	052.02°
Obstacles	
Number of Checked Obstacles	3

Table 21: VOR RWY 06 - CAT A-D - Missed Approach

Name	Latitude	Longitude	Alt. (m)	Area	Dist. in (m)	Do (m)	MOC req. (m)	Ac. alt. (ft)	Alt. req. (ft)	MACG (%)	Ctrl
T03	52°46'39.72"N	008°41'04.49"W	451.5	Sec.	1300.4	18918.7	9.7	1911.7	1513.1	1.9	No
T01	52°46'25.64"N	008°41'31.24"W	435.4	Sec.	1383.8	18256.2	7.9	1857.4	1454.4	1.9	No
T02	52°46'46.92"N	008°41'25.44"W	419.1	Sec.	896.3	18744.4	15.9	1897.4	1427.3	1.8	No

Table 22: VOR RWY 06 - CAT A-D – Intermediate Missed Approach Phase - Checked Obstacles

As indicated in Table 22, there is no impact to the procedure.

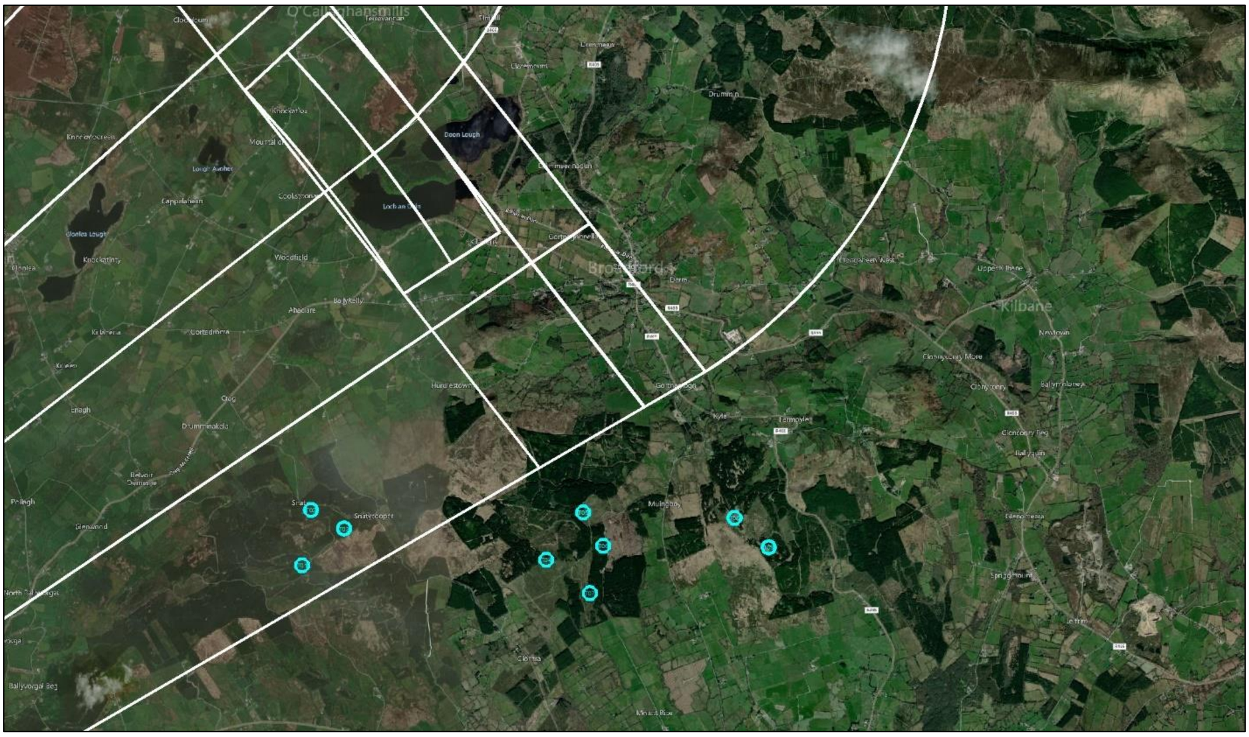

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Figure 7: VOR RWY 06 – Intermediate Missed Approach – Windfarm Location

2.8.7. RNAV SID (DIGAN 3A) RWY 06

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 23: SID - SID - RWY 06 - DIGAN3A - Turn Area - Obstacle Assessment

9 obstacles and terrain points were checked. The 9 most controlling obstacles are listed in the following table.

Name	Latitude	Longitude	Alt. (m)	Area	Dist. in (m)	Dr (m)	Do (m)	MOC. (m)	Ac. alt. (ft)	Alt. req. (ft)	PDG (%)	Ctrl?
T01	52°46'25.64"N	008°41'31.24"W	435.4	Pri.	N/A	5251.8	10471.0	125.8	1733.7	1841.2	3.7	Yes
T03	52°46'39.72"N	008°41'04.49"W	451.5	Pri.	N/A	5251.8	11133.5	131.1	1805.4	1911.3	3.6	Yes
T02	52°46'46.92"N	008°41'25.44"W	419.1	Pri.	N/A	5251.8	10958.4	129.7	1786.4	1800.4	3.4	Yes
T04	52°46'27.30"N	008°38'56.22"W	407.9	Pri.	N/A	5251.8	12803.3	144.4	1986.2	1812.2	2.9	No
T05	52°46'45.44"N	008°38'32.50"W	377.1	Pri.	N/A	5251.8	13497.6	150.0	2061.4	1729.3	2.6	No
T07	52°46'14.45"N	008°38'28.57"W	360.8	Pri.	N/A	5251.8	12971.6	145.8	2004.4	1662.0	2.5	No
T06	52°46'32.56"N	008°38'19.82"W	366.9	Pri.	N/A	5251.8	13442.8	149.6	2055.4	1694.5	2.5	No
T09	52°46'31.69"N	008°36'34.81"W	381.0	Sec.	114.0	5251.8	14986.1	150.7	2222.5	1744.3	2.4	No
T08	52°46'43.10"N	008°36'56.38"W	367.4	Pri.	N/A	5251.8	14880.8	161.1	2211.1	1733.7	2.4	No

Table 24: SID - SID - RWY 06 - DIGAN3A - Turn Area - Obstacle Assessment - Checked Obstacles

As indicated in Table 24, the turbines have an impact on the procedure, which results in a higher PDG than the standard obstacle clearance PDG of 3.3%.

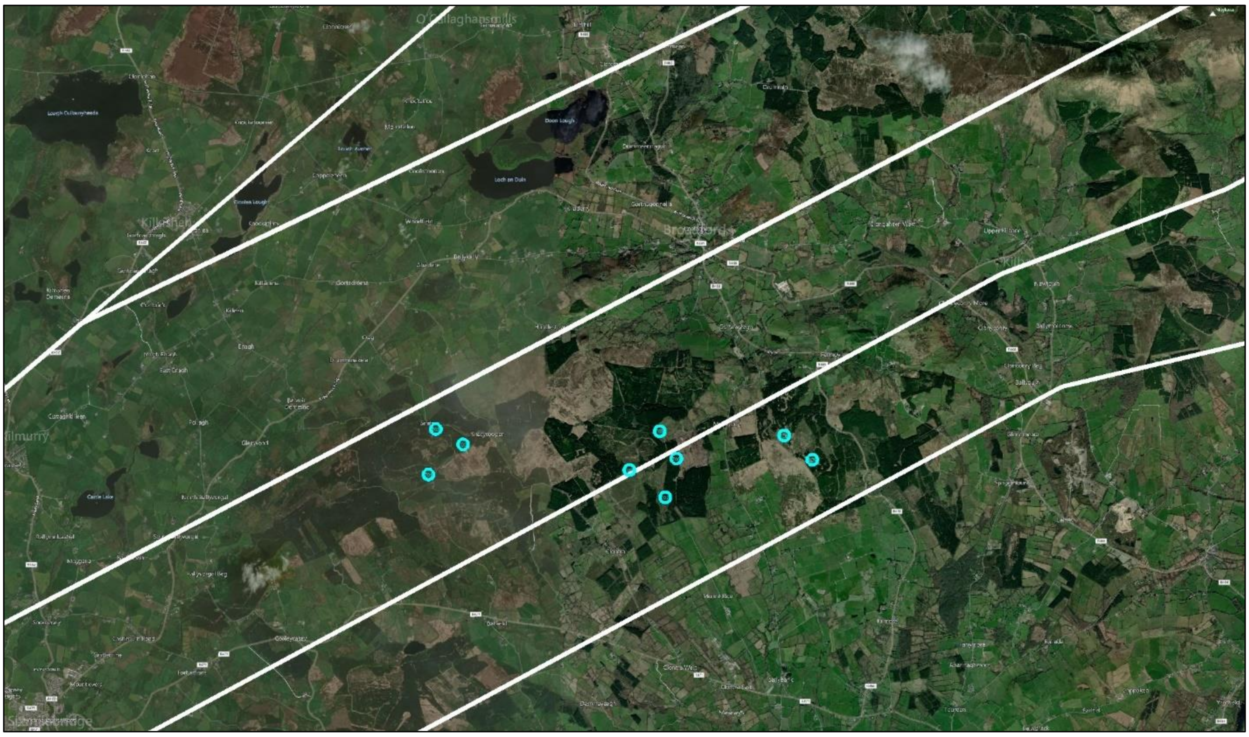

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Figure 8: SID - DIGAN3A – Windfarm Location

2.8.8. RNAV SID (TOMTO 3A) RWY 06

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 25: SID - RWY 06 - TOMTO3A - Turn Area - Obstacle Assessment

9 obstacles and terrain points were checked. The 9 most controlling obstacles are listed in the following table.

Name	Latitude	Longitude	Alt. (m)	Trees (m)	Area	Dr (m)	Do (m)	MOC (m)	Ac. alt. (ft)	Alt. req. (ft)	PDG (%)	Ctrl?
T01	52°46'25.64"N	008°41'31.24"W	435.4	0.0	Pri.	5251.8	10612.9	126.9	1749.0	1844.9	3.6	Yes
T03	52°46'39.72"N	008°41'04.49"W	451.5	0.0	Pri.	5251.8	11261.3	132.1	1819.2	1914.6	3.6	Yes
T02	52°46'46.92"N	008°41'25.44"W	419.1	0.0	Pri.	5251.8	11032.5	130.3	1794.5	1802.4	3.4	Yes
T04	52°46'27.30"N	008°38'56.22"W	407.9	0.0	Pri.	5251.8	13262.1	148.1	2035.9	1824.3	2.9	No
T05	52°46'45.44"N	008°38'32.50"W	377.1	0.0	Pri.	5251.8	13891.8	153.1	2104.0	1739.7	2.6	No
T06	52°46'32.56"N	008°38'19.82"W	366.9	0.0	Pri.	5251.8	13954.8	153.7	2110.9	1707.9	2.5	No
T07	52°46'14.45"N	008°38'28.57"W	360.8	0.0	Pri.	5251.8	13600.3	150.8	2072.5	1678.5	2.5	No
T09	52°46'31.69"N	008°36'34.81"W	381.0	0.0	Pri.	5251.8	15787.0	168.3	2309.2	1802.1	2.4	No
T08	52°46'43.10"N	008°36'56.38"W	367.4	0.0	Pri.	5251.8	15529.0	166.2	2281.3	1750.7	2.3	No

Table 26: SID - RWY 06 - TOMTO3A - Turn Area - Obstacle Assessment - Checked Obstacles

As indicated in Table 29, the turbines have an impact on the procedure, which results in a higher PDG than the standard obstacle clearance PDG of 3.3%.

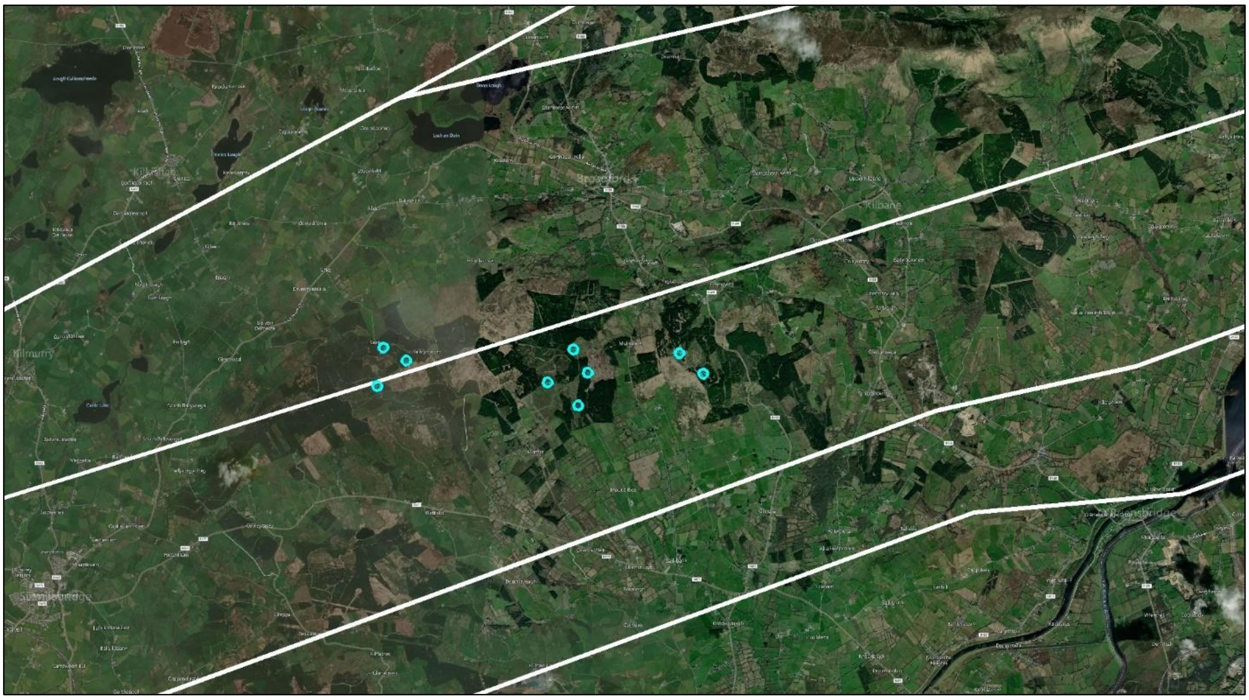

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Figure 9: SID TOMTO3A

2.8.9. RNAV SID (ABAGU 3A) RWY 06

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 27: SID - RWY06 ABAG3A - Turn Area - Obstacle Assessment

8 obstacles and terrain points were checked. The 8 most controlling obstacles are listed in the following table.

Name	Latitude	Longitude	Alt. (m)	Area	Dr (m)	Do (m)	MOC (m)	Ac. alt. (ft)	Alt. req. (ft)	PDG (%)	Ctrl?	Close-in
T01	52°46'25.64"N	008°41'31.24"W	435.4	Pri.	5251.8	10612.9	126.9	1749.0	1844.9	3.6	Yes	No
T03	52°46'39.72"N	008°41'04.49"W	451.5	Pri.	5251.8	11261.3	132.1	1819.2	1914.6	3.6	Yes	No
T02	52°46'46.92"N	008°41'25.44"W	419.1	Pri.	5251.8	11032.5	130.3	1794.5	1802.4	3.4	Yes	No
T04	52°46'27.30"N	008°38'56.22"W	407.9	Pri.	5251.8	13262.1	148.1	2035.9	1824.3	2.9	No	No
T05	52°46'45.44"N	008°38'32.50"W	377.1	Pri.	5251.8	13891.8	153.1	2104.0	1739.7	2.6	No	No
T06	52°46'32.56"N	008°38'19.82"W	366.9	Pri.	5251.8	13954.8	153.7	2110.9	1707.9	2.5	No	No
T07	52°46'14.45"N	008°38'28.57"W	360.8	Pri.	5251.8	13600.3	150.8	2072.5	1678.5	2.5	No	No
T09	52°46'31.69"N	008°36'34.81"W	381.0	Pri.	5251.8	15787.0	168.3	2309.2	1802.1	2.4	No	No

Table 28: SID - RWY 06 - ABAGU3A - Turn Area - Checked Obstacles

As indicated in Table 28, the turbines have an impact on the procedure, which results in a higher PDG than the standard obstacle clearance PDG of 3.3%.

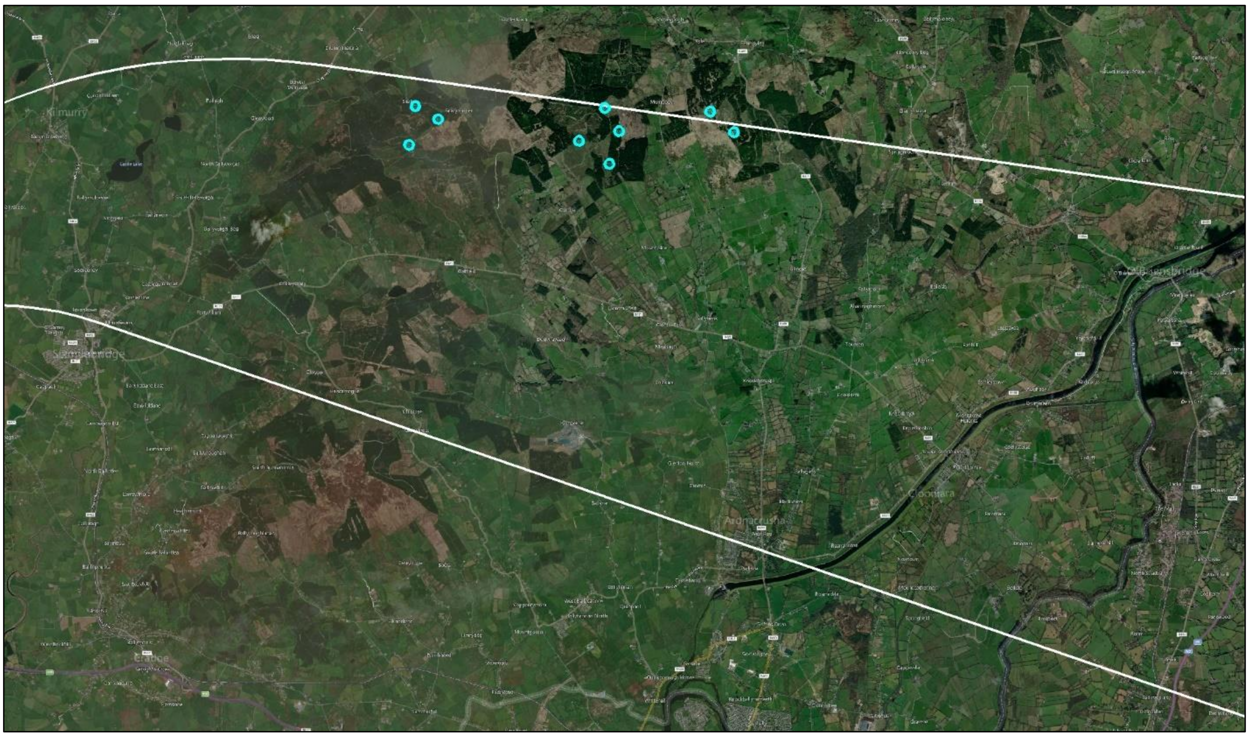

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Figure 10: SID - ABAGU3A

2.8.10. IAP – ILS Runway 24

The turbines fall within the Initial approach Base turns, which have a lowest altitude of 3000ft .

General	
Primary MOC	300 m
Obstacles	
Number of Checked Obstacles	9

Table 29: ILS CAT I & II RWY 24 - Base Turn CAT A/B

Name	Latitude	Longitude	Alt. (m)	Area	Dist. in (m)	MOC (m)	MOCA (ft)
T03	52°46'39.72"N	008°41'04.49"W	451.5	Pri.	N/A	300.0	2465.5
T01	52°46'25.64"N	008°41'31.24"W	435.4	Pri.	N/A	300.0	2412.8
T02	52°46'46.92"N	008°41'25.44"W	419.1	Pri.	N/A	300.0	2359.3
T04	52°46'27.30"N	008°38'56.22"W	407.9	Sec.	374.0	275.8	2243.1
T05	52°46'45.44"N	008°38'32.50"W	377.1	Sec.	94.8	293.9	2201.4
T06	52°46'32.56"N	008°38'19.82"W	366.9	Sec.	558.1	263.8	2069.4
T08	52°46'43.10"N	008°36'56.38"W	367.4	Sec.	1020.8	233.9	1972.6
T07	52°46'14.45"N	008°38'28.57"W	360.8	Sec.	970.8	237.1	1961.6
T09	52°46'31.69"N	008°36'34.81"W	381.0	Sec.	1523.9	201.3	1910.3

Table 30: ILS CAT I & II RWY 24 - Base Turn CAT A/B - Checked Obstacles

As indicated in Table 30, the turbines do not impact the procedure.

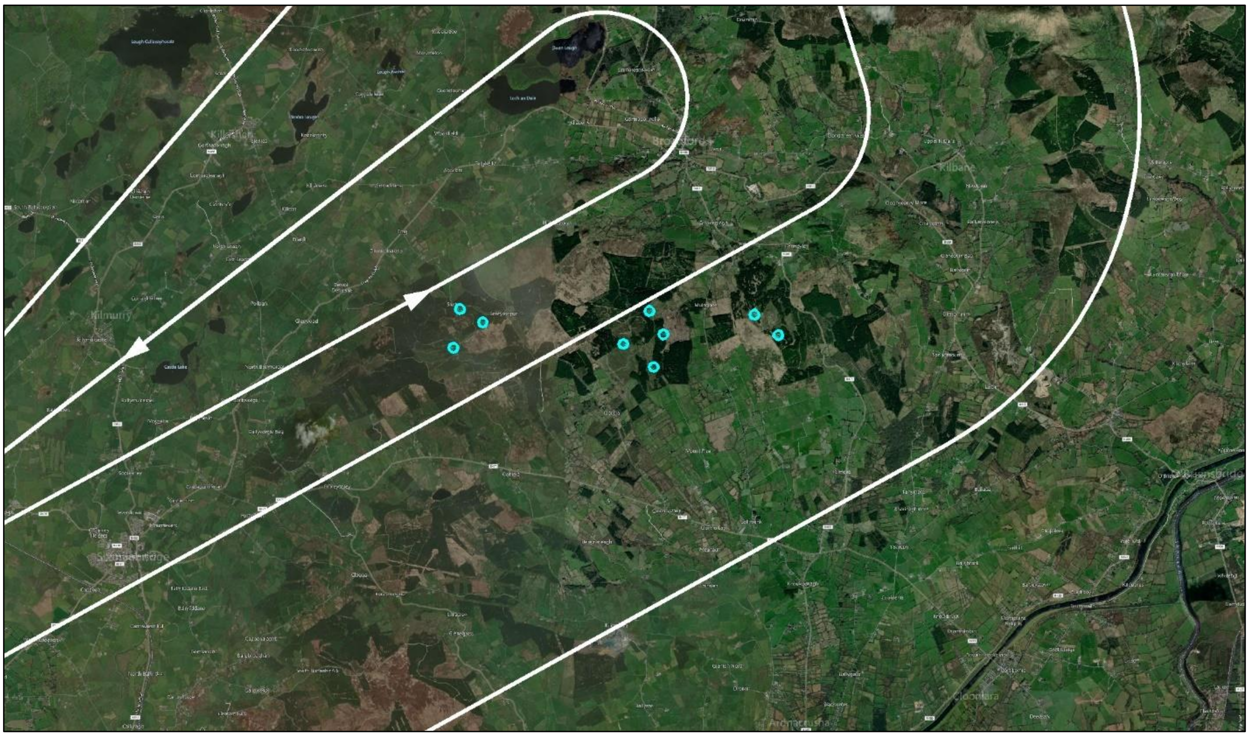

Figure 11: ILS / LOC RWY 24 - Base Turn CAT AB – Windfarm Location

General	
Primary MOC	300 m
Obstacles	
Number of Checked Obstacles	9

Table 31: ILS CAT I & II RWY 24 - Base Turn CAT CD

Name	Latitude	Longitude	Alt. (m)	Area	MOC applied (m)	MOCA (ft)
T03	52°46'39.72"N	008°41'04.49"W	451.5	Pri.	300.0	2465.5
T01	52°46'25.64"N	008°41'31.24"W	435.4	Pri.	300.0	2412.8
T02	52°46'46.92"N	008°41'25.44"W	419.1	Pri.	300.0	2359.3
T04	52°46'27.30"N	008°38'56.22"W	407.9	Pri.	300.0	2322.6
T09	52°46'31.69"N	008°36'34.81"W	381.0	Pri.	300.0	2234.3
T05	52°46'45.44"N	008°38'32.50"W	377.1	Pri.	300.0	2221.5
T08	52°46'43.10"N	008°36'56.38"W	367.4	Pri.	300.0	2189.6
T06	52°46'32.56"N	008°38'19.82"W	366.9	Pri.	300.0	2188.1
T07	52°46'14.45"N	008°38'28.57"W	360.8	Pri.	300.0	2168.0

Table 32: ILS CAT I & II RWY 24 - Base Turn CAT CD - Checked Obstacles

In indicated in Table 32 the turbines have an impact on the procedure, and it raises the currently published Initial approach MOCA by 100ft from 2400ft to **2500**ft.

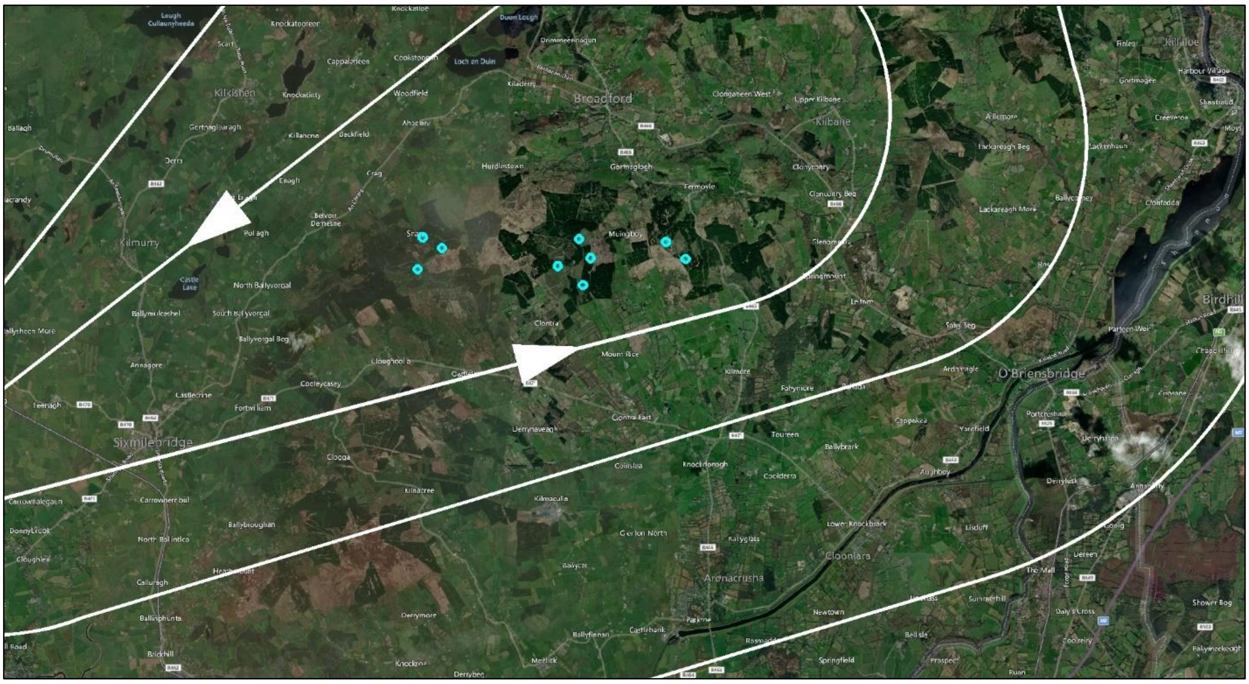

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Figure 12: ILS/LOC RWY 24 - Base Turn CAT CD – Windfarm Location

2.8.11. IAP – LOC Runway 24

The turbines fall within the Initial approach for the procedure. The Initial approach via base turn is common to the ILS RWY 24 procedure and is reported on in section 2.8.10 above.

2.8.12. IAP – VOR Runway 24

The Turbines fall within the Initial approach (base turn) for CAT A/B and C/D, which have a lowest altitude of 3000ft, and the final approach segment for the procedure.

General	
Primary MOC	300 m
Obstacles	
Number of Checked Obstacles	9

Table 33: VOR RWY 24 - Base Turn CAT AB

Name	Latitude	Longitude	Alt. (m)	Area	Dist. in (m)	MOC (m)	MOCA (ft)
T03	52°46'39.72"N	008°41'04.49"W	451.5	Pri.	N/A	300.0	2465.5
T01	52°46'25.64"N	008°41'31.24"W	435.4	Pri.	N/A	300.0	2412.8
T02	52°46'46.92"N	008°41'25.44"W	419.1	Pri.	N/A	300.0	2359.3
T04	52°46'27.30"N	008°38'56.22"W	407.9	Sec.	373.9	275.8	2243.1
T05	52°46'45.44"N	008°38'32.50"W	377.1	Sec.	94.8	293.9	2201.4
T06	52°46'32.56"N	008°38'19.82"W	366.9	Sec.	558.1	263.8	2069.5
T08	52°46'43.10"N	008°36'56.38"W	367.4	Sec.	1020.8	233.9	1972.6
T07	52°46'14.45"N	008°38'28.57"W	360.8	Sec.	970.8	237.1	1961.6
T09	52°46'31.69"N	008°36'34.81"W	381.0	Sec.	1523.8	201.3	1910.3

Table 34: VOR RWY 24 - Base Turn CAT AB - Checked Obstacles

As indicated in Table 34, the turbines do not impact the procedure.

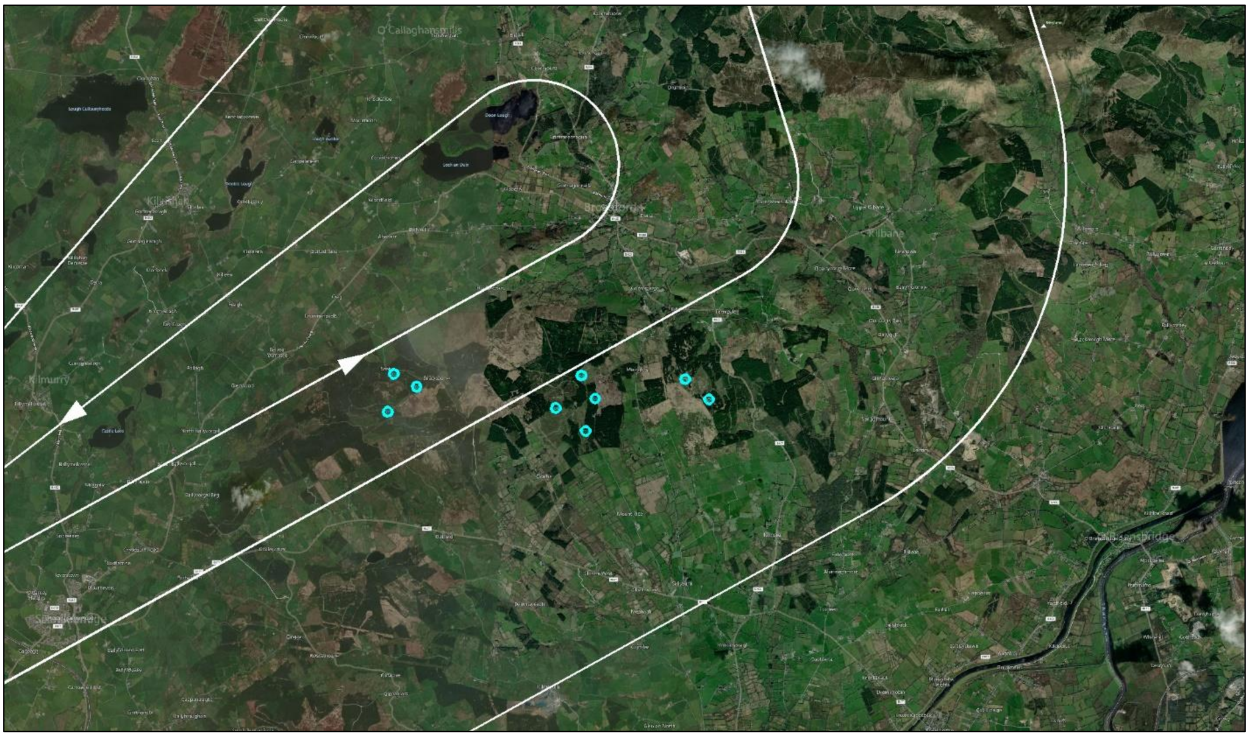

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Figure 13: VOR RWY 24 - Base Turn CAT AB Windfarm Location

General	
Primary MOC	300 m
Obstacles	
Number of Checked Obstacles	9

Table 35: VOR RWY 24 - Base Turn CAT CD - General

Name	Latitude	Longitude	Alt. (m)	Area	MOC (m)	MOCA (ft)
T03	52°46'39.72"N	008°41'04.49"W	451.5	Pri.	300.0	2465.5
T01	52°46'25.64"N	008°41'31.24"W	435.4	Pri.	300.0	2412.8
T02	52°46'46.92"N	008°41'25.44"W	419.1	Pri.	300.0	2359.3
T04	52°46'27.30"N	008°38'56.22"W	407.9	Pri.	300.0	2322.6
T09	52°46'31.69"N	008°36'34.81"W	381.0	Pri.	300.0	2234.3
T05	52°46'45.44"N	008°38'32.50"W	377.1	Pri.	300.0	2221.5
T08	52°46'43.10"N	008°36'56.38"W	367.4	Pri.	300.0	2189.6
T06	52°46'32.56"N	008°38'19.82"W	366.9	Pri.	300.0	2188.1
T07	52°46'14.45"N	008°38'28.57"W	360.8	Pri.	300.0	2168.0

Table 36: VOR RWY 24 - Base Turn CAT CD - Checked Obstacles

As indicated in Table 36, the turbines do not impact the procedure.

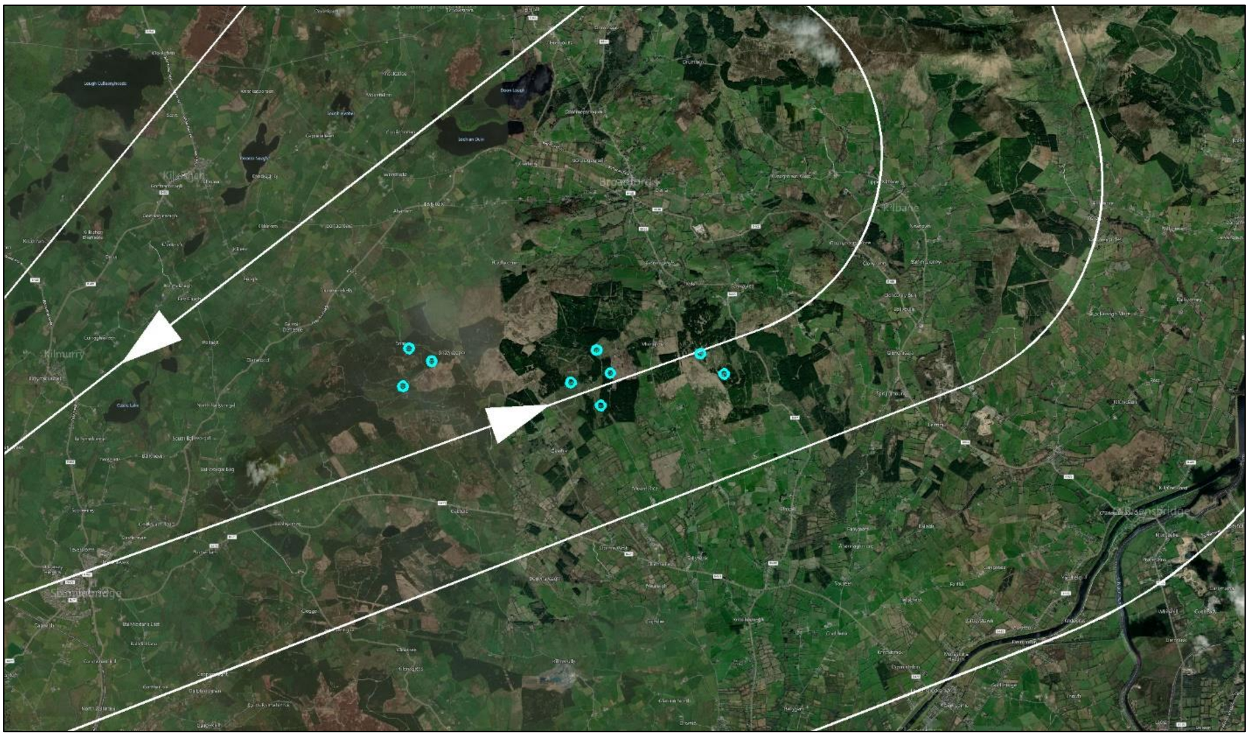

Figure 14: VOR RWY 24 - Base Turn CAT CD – Windfarm Location

General	
Primary MOC	75 m
Obstacles	
Number of Checked Obstacles	3

Table 37: VOR RWY 24 - Final Approach

Name	Latitude	Longitude	Alt. (m)	Area	Dist. in (m)	MOC (m)	MOCA (ft)
T03	52°46'39.72"N	008°41'04.49"W	451.5	Sec.	1253.3	26.0	1566.5
T02	52°46'46.92"N	008°41'25.44"W	419.1	Sec.	850.9	41.5	1511.1
T01	52°46'25.64"N	008°41'31.24"W	435.4	Sec.	1338.5	21.4	1498.8

Table 38: VOR RWY 24 - Final Approach - Checked Obstacles

As indicated in Table 38, the turbines have an impact on the procedure and raises the currently published MOCA by 400ft from 1270ft to **1670ft**.

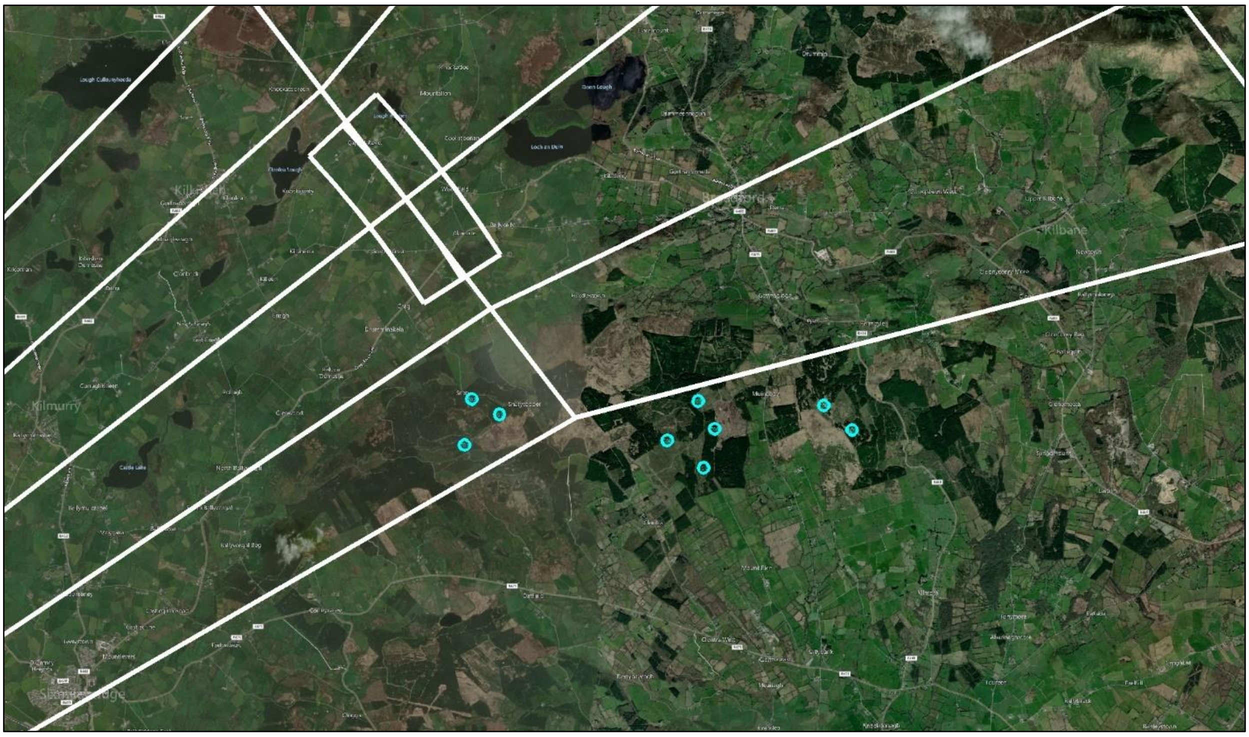

Figure 15: VOR RWY 24 - Final Approach – Windfarm Location

2.8.13. ATC Surveillance Minimum Altitude Chart

The ATC Surveillance Minimum Chart consists of four sectors. The turbines fall within Sector 1 **(2300ft)** and Sector 2 **(3000ft)** areas of the ATCSMAC. A 3 NM buffer has been incorporated to account for turbines located within 3 NM of the area boundary.

A temperature correction factor has been used to determine the Minimum Obstacle Clearance[5].

- The cold temperature AIP EINN AD 2.24-16 (0°C)
- Aerodrome elevations as published in the AIP EINN AD 2.2.3 (46 ft AMSL)
- Height Above the Altimeter Setting Source, published MOCA used.

[5] Cyrrus is aware that Ireland applies an adjustment for temperature correction. Assessments based on the cold temperature correction are for the airport and regulatory authority to inspect with reference to the information available to us at the time of issuing this report.

Parameters	
Aerodrome Minimum Temperature	0 °C
Aerodrome Elevation	46 ft
Altimeter Setting Source Elevation	46 ft
Height Above the Altimeter Setting Source	2300 ft
Results	
Approximate Correction	40.97 m / 134.42 ft
Linear Standard Correction	40.97 m / 134.42 ft
Off-standard Accurate Correction	35.84 m / 117.57 ft

Table 39: Temperature Correction Calculation - 2300 ft

Parameters	
Aerodrome Minimum Temperature	0 °C
Aerodrome Elevation	46 ft
Altimeter Setting Source Elevation	46 ft
Height Above the Altimeter Setting Source	3000 ft
Results	
Approximate Correction	53.69 m / 176.16 ft
Linear Standard Correction	49.7 m / 163.04 ft
Off-standard Accurate Correction	47.08 m / 154.46 ft

Table 40: Temperature Correction Calculation- 3000 ft

General	
Primary MOC	335.84 m
Obstacles	
Number of Checked Obstacles	9

Table 41: ATCSMAC Sector 1

Name	Latitude	Longitude	Alt. (m)	Area	MOC applied (m)	MOCA (ft)
T03	52°46'39.72"N	008°41'04.49"W	451.5	Sector 1	335.84	2583.2
T01	52°46'25.64"N	008°41'31.24"W	435.4	Sector 1	335.84	2530.4
T02	52°46'46.92"N	008°41'25.44"W	419.1	Sector 1	335.84	2476.9
T04	52°46'27.30"N	008°38'56.22"W	407.9	Sector 1	335.84	2440.1
T09	52°46'31.69"N	008°36'34.81"W	381.0	3 NM Buffer	335.84	2351.9
T05	52°46'45.44"N	008°38'32.50"W	377.1	3 NM Buffer	335.84	2339.1
T08	52°46'43.10"N	008°36'56.38"W	367.4	3 NM Buffer	335.84	2307.3
T06	52°46'32.56"N	008°38'19.82"W	366.9	3 NM Buffer	335.84	2305.6
T07	52°46'14.45"N	008°38'28.57"W	360.8	3 NM Buffer	335.84	2285.6

Table 42: ATCSMAC Sector 1 - Checked Obstacles

As indicated in Table 42, the MOCA is 2583.2 ft rounded to 2600 ft. The currently published is 2300 ft therefor the turbines have an impact on the procedure and raises the published minima for Sector 1 by 300ft from 2300ft to **2600ft.**

General	
Primary MOC	347.08 m
Obstacles	
Number of Checked Obstacles	9

Table 43: ATCSMAC Sector 2

Name	Latitude	Longitude	Alt. (m)	Area	MOC applied (m)	MOCA (ft)
T03	52°46'39.72"N	008°41'04.49"W	451.5	3 NM Buffer	347.08	2620.1
T01	52°46'25.64"N	008°41'31.24"W	435.4	3 NM Buffer	347.08	2567.2
T02	52°46'46.92"N	008°41'25.44"W	419.1	3 NM Buffer	347.08	2513.8
T04	52°46'27.30"N	008°38'56.22"W	407.9	3 NM Buffer	347.08	2477.0
T09	52°46'31.69"N	008°36'34.81"W	381.0	Sector 2	347.08	2388.8
T05	52°46'45.44"N	008°38'32.50"W	377.1	Sector 2	347.08	2376.0
T08	52°46'43.10"N	008°36'56.38"W	367.4	Sector 2	347.08	2344.1
T06	52°46'32.56"N	008°38'19.82"W	366.9	Sector 2	347.08	2342.5

Table 44: ATCSMAC Sector 2 - Checked Obstacles

As indicated in Table 44, the MOCA is 2620.1 ft rounded to 2700 ft. The currently published minima is 3000 ft therefore the turbines have no impact on the procedure.

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Figure 16: ATC Surveillance Minimum Altitude Chart - Windfarm Location

3. Conclusion

The assessment has been carried out against the proposed windfarm development approximately 9.51 NM northeast from Shannon ARP.

The assessment has determined that the proposed windfarm does impact the currently published IFPs for Shannon Airport.

Mitigation Options

The mitigation options listed below are for the Airport to consider, this will be subject to their Safety Management System (SMS) requirements and the commercial benefit of accepting the mitigation.

1. Raise the applicable MOCA or PDG of the affected procedures, this option will be for the airport to consider.

    a. SIDS (TOMTO3A, DIGAN3A, ABAGU3A) RWY06, increase the obstacle clearance PDG from 3.3% to 3.7%

    b. VOR RWY06 Final Approach, increase MOCA from 1270ft to 1670ft, an additional Step-down fix (SDF) may be required to prevent an increase to the final approach gradient.

    c. ATCSMAC increase Sector 1 MVA from 2300ft to 2600ft, or redesign the ATCSMAC to reduce the size of Sector 1 but keep the remaining Sector 1 area at the existing 2300ft MVA, possible redesign options are indicated in Annex A.

A. ATCSMAC Redesign Concepts

A.1. Air Traffic Control Surveillance Minimum Altitude Chart (ATCSMAC)

A.1.1. Criteria

A.1.1.1. There is no prescribed limit on the size, shape, or orientation of the ATCSMAC; however, in all cases the boundary of the ATCSMAC subdivisions must be located at a distance not less than 5.6 km (3 NM) from an obstacle which is to be avoided.

A.1.1.2. Criteria for the determination of minimum altitudes applicable to procedures based on radar vectoring are contained in Procedures for Air Navigation Services — Aircraft Operations (PANS-OPS, Doc 8168). A minimum of 300 m (1 000 ft) vertical separation shall be applied.

A.1.1.3. Whenever possible, minimum vectoring altitudes should be sufficiently high to minimize activation of aircraft enhanced ground proximity warning systems (EGPWS). Activation of such systems may induce aircraft to pull up immediately and climb steeply to avoid hazardous terrain and obstacles, possibly compromising separation between aircraft.

A.1.1.4. The ATCSMAC shall enable the aircraft to be established on the final approach course or track, in level flight for at least 2.0 nm prior to intercepting the Glide Path (GP) or vertical path for the selected instrument approach procedure.

A.1.2. Purpose

A.1.2.1. It is the responsibility of the Air Traffic Service (ATS) authority to provide the controller with minimum altitudes corrected for temperature effect.

A.1.2.2. Used by ATC to vector aircraft in the airspace, it provides obstacle clearance until the aircraft reaches the point where the pilot will resume own navigation.

A.1.2.3. The ATCSMAC is commonly split into several Surveillance Minimum Altitude Areas (SMAA) which provide relief from obstacles which would only affect vectoring on one runway circuit direction.

A.1.2.4. The minimum altitudes available within the SMAA sector should be adequate to permit vectoring of an aircraft to the final approach of a published IAP.

A.1.3. Shannon Airport ATCSMAC

A.1.3.1. Shannon Airports ATCSMAC is configured into four SMAA sectors.

- Sector 1: 2300 ft
- Sector 2: 3000 ft
- Sector 3: 4000 ft
- Sector 4: 4400 ft

A.1.3.2. The sectors are depicted in Figure 17, with a red line to represent the extended runway centreline.

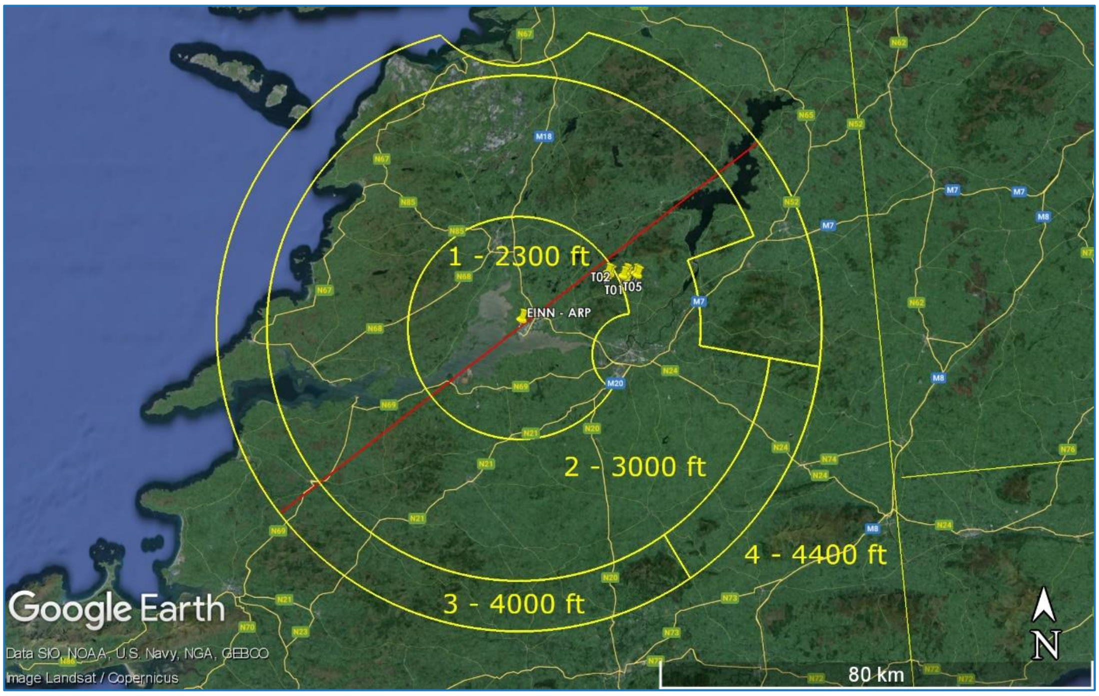

Figure 17: Shannon ATCSMAC with Wind Farm Location

A.2. Design Options

A.2.1. Overview

A.2.1.1. Four design options are proposed, whilst this is not a definitive list of potential options, they enable the evaluation of the potential ways to remove the impact to the ATCSMAC.

A.2.1.2. The concept design options would need to be evaluated by the Airport and IAA to determine if the proposed options would still allow for safe and effective vectoring of aircraft.

A.2.1.3. If a design option looks to have potential, full design would be required to further optimise the concepts and consider all obstacles in the evaluation.

A.2.2. Design Option A

A.2.2.1. Option A provides the simplest solution to implement, with minimal modification to the ATCSMAC as currently published.

A.2.2.2. The proposed solution is to increase the Minimum Vectoring Altitude (MVA) associated with the Surveillance Minimum Altitude Area (SMAA) sector 1 from 2300 ft to 2600 ft as depicted in Figure 18, this would provide sufficient Minimum Obstacle Clearance (MOC) above the wind turbines.

A.2.2.3. Aircraft crossing into sector 1 SMAA would be at a nominal altitude at or above 3000 ft. The Instrument Landing System (ILS) Glide Path (GP) intercept is at 3000 ft which occurs around 9.3 NM from the applicable Threshold (THR).

A.2.2.4. SMAA Sector 3 is approximately 2.5 NM from the nominal 2600 ft altitude position. Air Traffic Control (ATC) may still have the capability to vector an Aircraft onto the ILS Localiser (LOC) for GP intercept and to other Instrument Approach Procedures (IAPs). However, this reduction on capability could potentially hinder ATC when sequencing inbound traffic during busy periods.

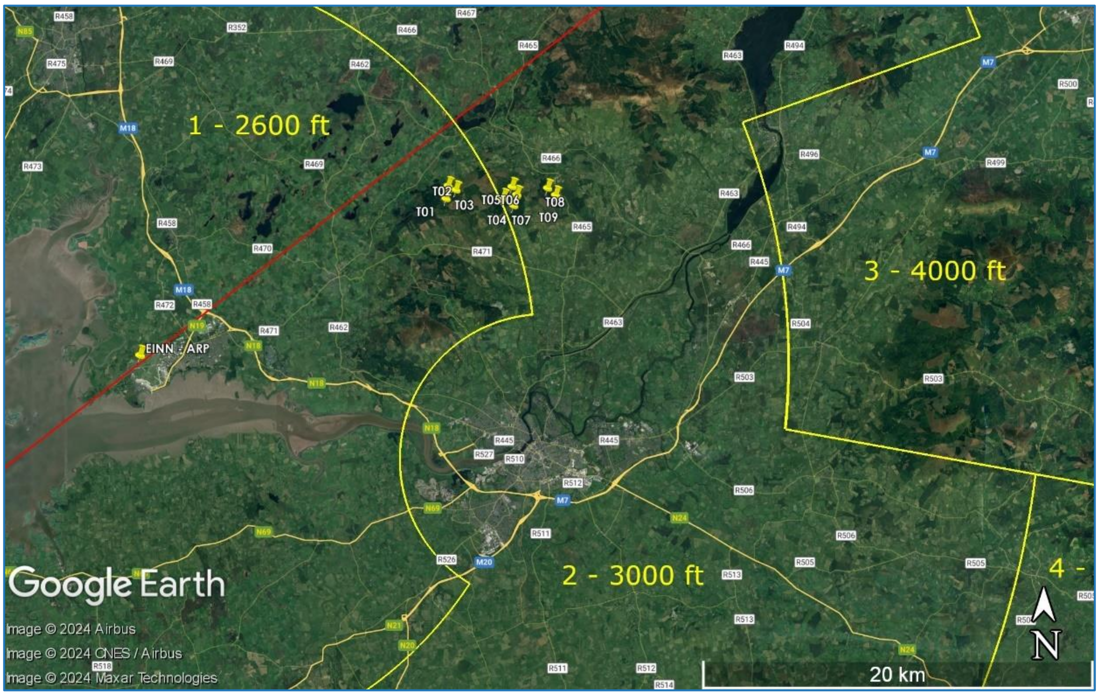

Figure 18: ATCSMAC Design Option A

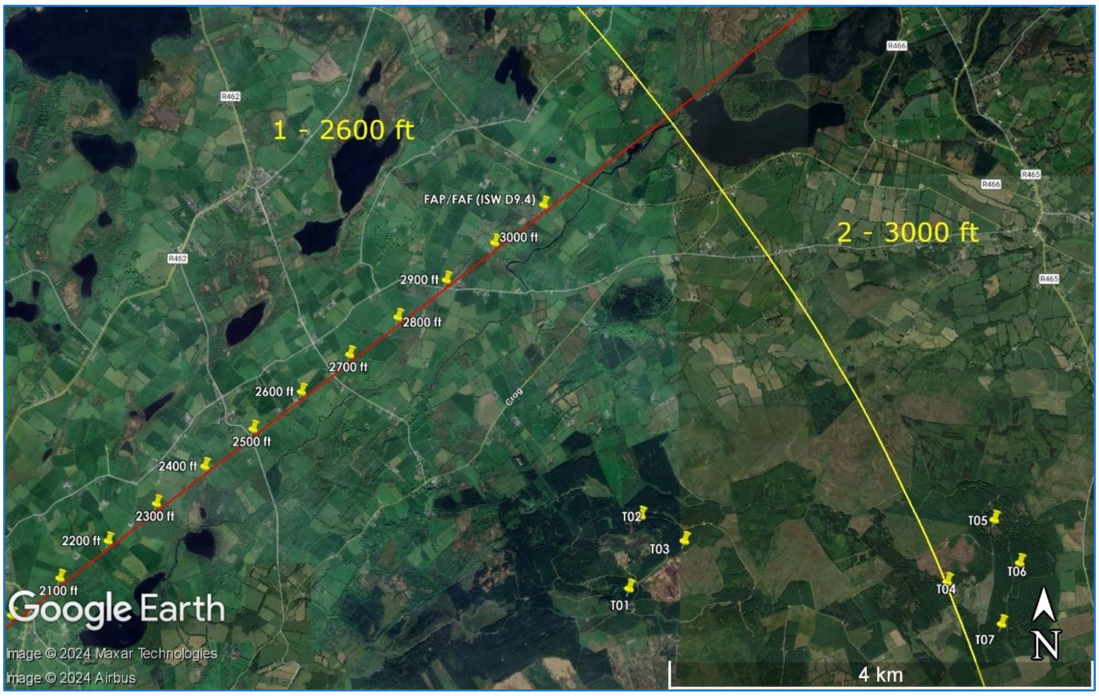

Figure 19: ATCSMAC Design Option A – Nominal Approach Altitudes

A.2.3. Design Option B

A.2.3.1. Design option B considers the adaptation of SMAA Sector 2 to incorporate the Wind Farm.

A.2.3.2. Each Turbine is considered with a 3 NM radius (plus the rotor radius) to determine the area which is required to be excluded. The area is combined with the existing SMAA Sector 2.

A.2.3.3. Aircraft crossing into the Option B SMAA sector 1 would be at a nominal altitude of around 2000 ft, as indicated in Figure 21. At this point aircraft would have to be fully established on the ILS, ATC would only be able to vector aircraft onto the ILS within sector 2, at a distance of around 9 NM or greater from THR RWY 26.

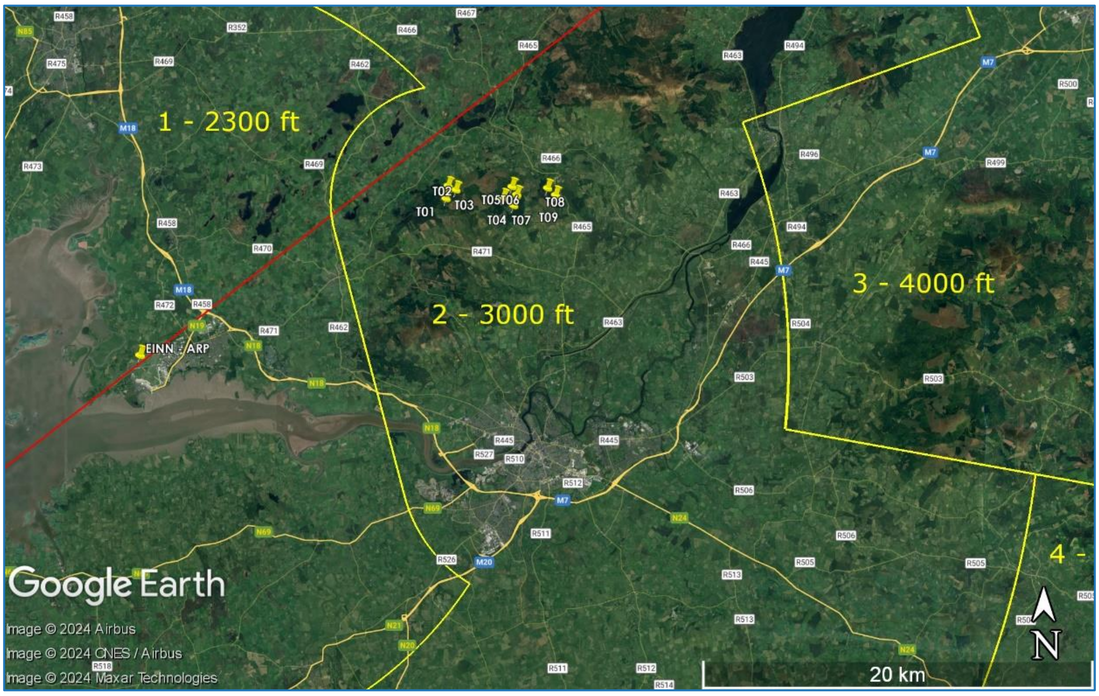

Figure 20: ATCSMAC Design Option B

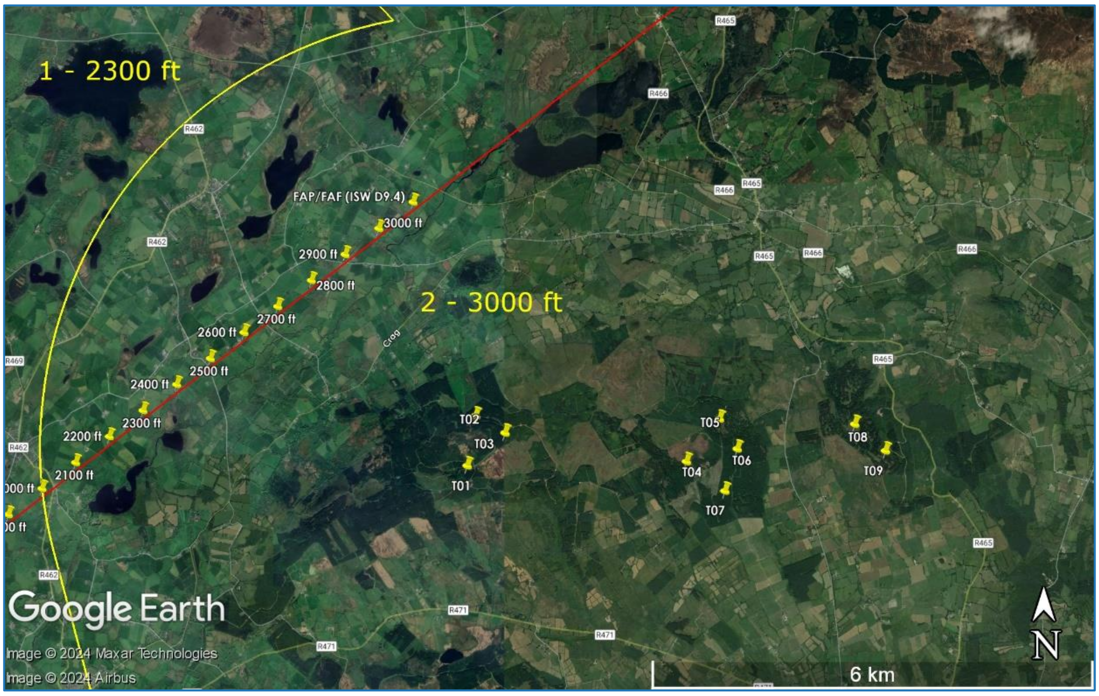

Figure 21: ATCSMAC Design Option B - Nominal Approach Altitudes

A.2.4. Design Option C

A.2.4.1. Design Option C considers the introduction of a new SMAA sector.

A.2.4.2. The SMAA sector consider each Turbine with a 3 NM radius (plus the rotor radius) to determine the new sector. The area is simplified using tangential radials from the Shannon VOR/DME (SHA) and defined using a single radius of 3.2 NM.

A.2.4.3. The proposed SMAA sector would have a MVA of 2600 ft, the area is indicated as SMAA sector 5 below in Figure 22.

A.2.4.4. Aircraft on the nominal path would enter the proposed SMAA from SMAA sector 3 at or above 3000 ft and leave the proposed SMAA sector to enter SMAA sector 1 at around 2000 ft. This should allow for ATC to vector aircraft down to 2600 ft to intercept the GP at around 8 NM from THR RWY 26.

A.2.4.5. The nominal altitude of 2300 ft is achieved around 7 NM from THR RWY 26.

A.2.4.6. Whilst this configuration would allow the Wind Farm to be built, there would still be a potential reduction in efficiency and flexibility for ATC.

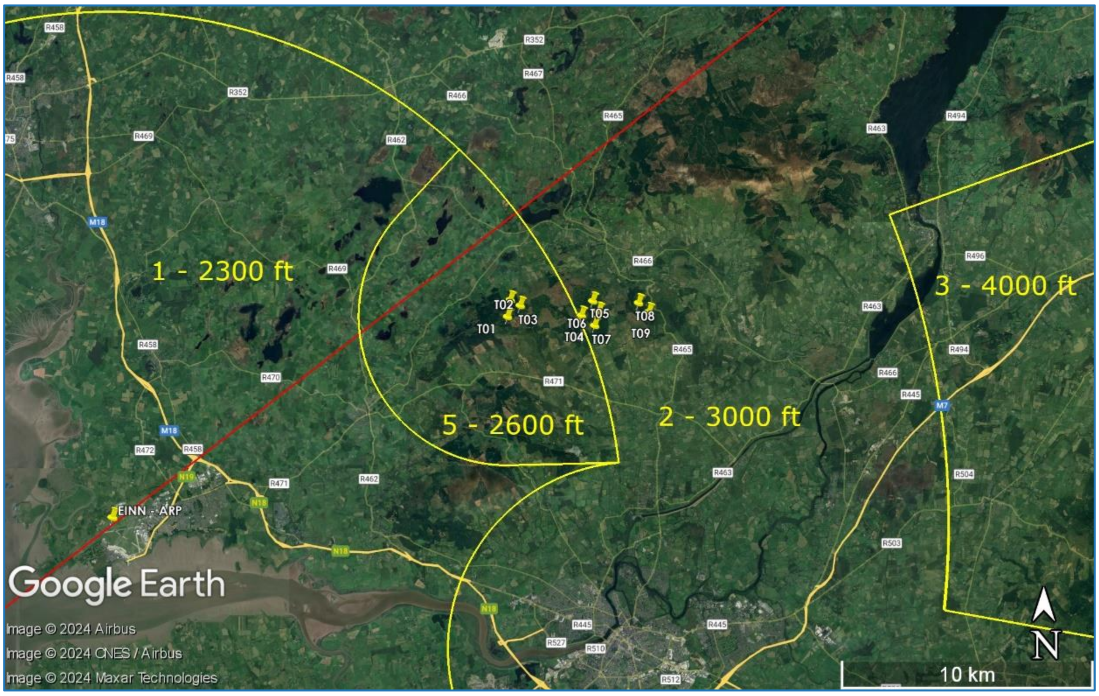

Figure 22: ATCSMAC Design Option C

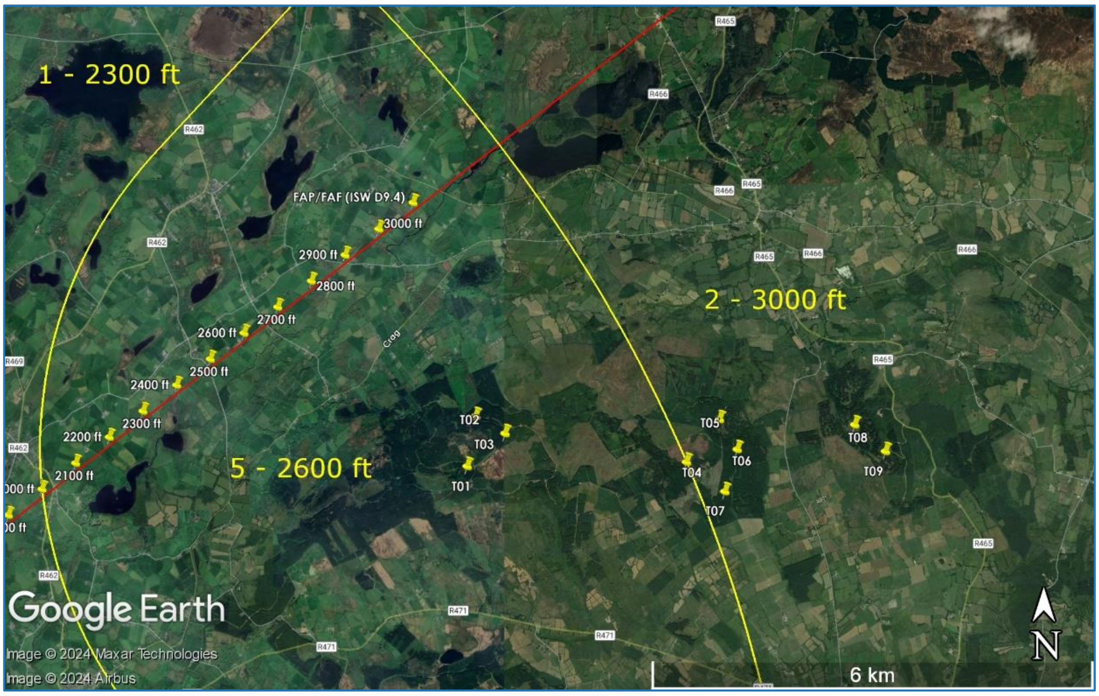

Figure 23: ATCSMAC Design Option C - Nominal Approach Altitudes

A.2.5. Design Option D

A.2.5.1. Design Option D, considers the introduction of a new SMAA sector whilst redefining the existing SMAA areas to provide an ATCSMAC which may be more operationally suited.

A.2.5.2. SMAA sector 2 has been redefined using radials and distances from the ARP, this would eliminate small areas between SMAA sectors where vectoring is not practical.

A.2.5.3. The proposed SMAA sector 5 is positioned next to the reconfigured SMAA sector 2, with a MVA of 2600 ft.

A.2.5.4. Aircraft on the nominal path would enter the proposed SMAA from SMAA sector 3 at or above 3000 ft and leave the proposed SMAA sector to enter SMAA sector 1 at around 1900 ft. This should allow for ATC to vector aircraft down to 2600 ft to intercept the GP at around 8 NM from THR RWY 26.

A.2.5.5. Whilst this configuration would allow the Wind Farm to be built, there would still be a potential reduction in efficiency and flexibility for ATC.

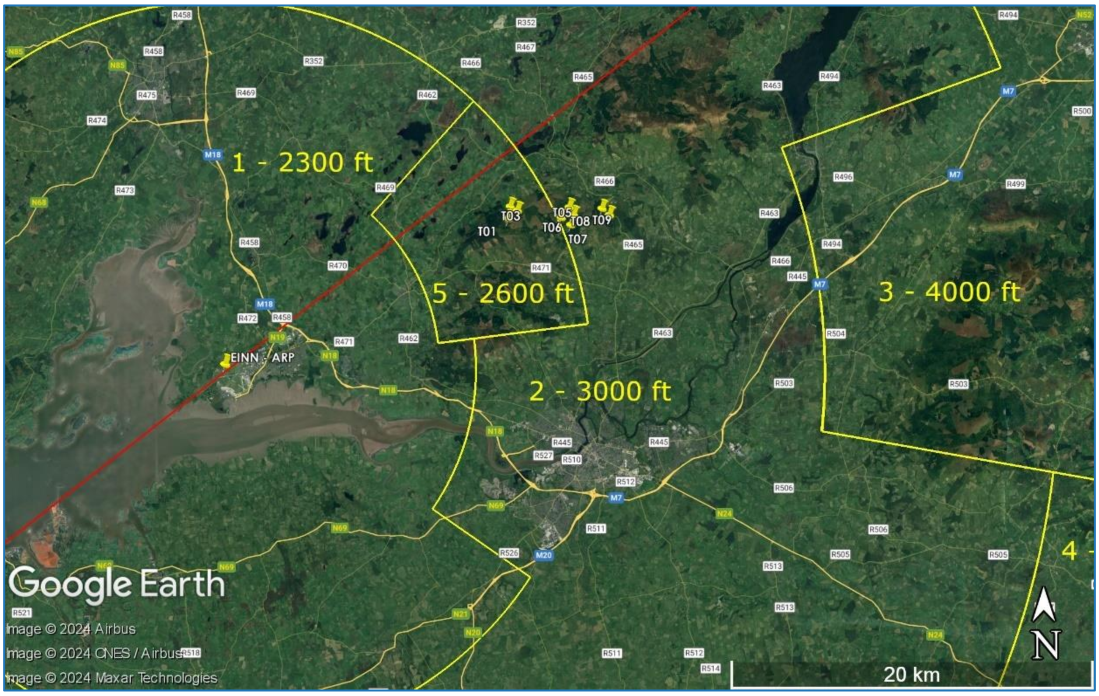

Figure 24: ATCSMAC Design Option D

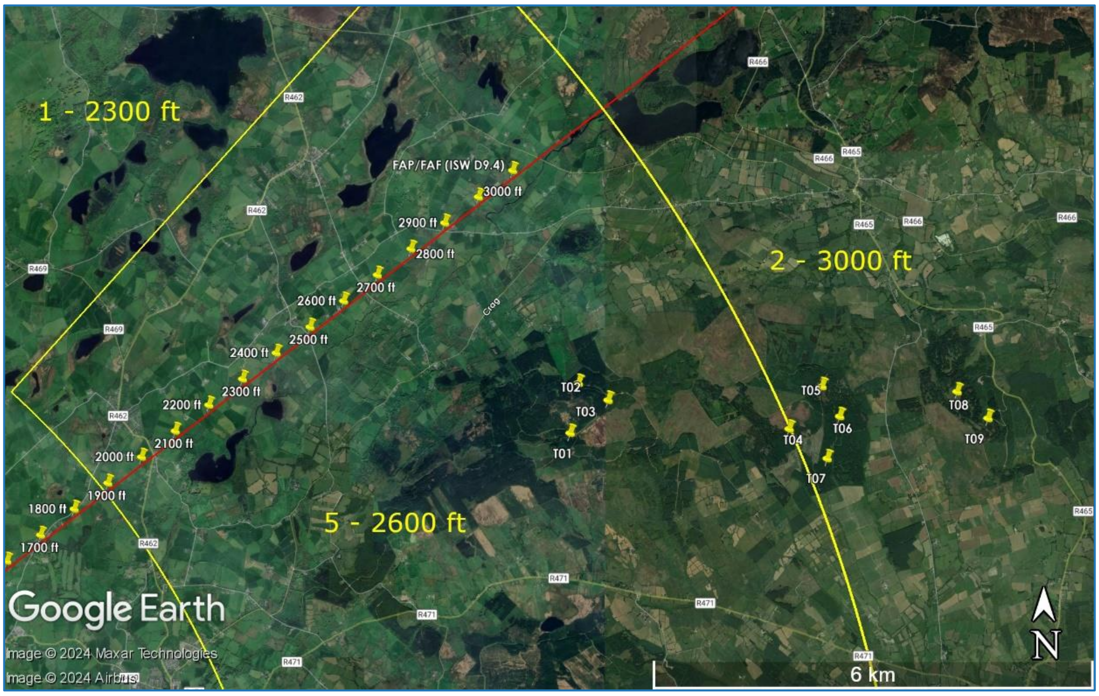

Figure 25: ATCSMAC Design Option D - Nominal Approach Altitudes

A.3. Conclusion

A.3.1. The Wind Farm will still have an impact to the ATCSMAC. Whilst all the identified options could allow for safe vectoring onto the IAPs, the Airport and the IAA would have to determine if the proposed options would still allow for effective vectoring operations. If it is deemed that the Wind Farm can be mitigated by a redesign, the full design process will need to be conducted.

A.3.2. Design option A will still allow for aircraft to be vectored onto an Instrument Approach Procedure for RWY 24. Aircraft would be required to be established on the IAP at 8 nm from THR RWY 24 to descend below the MVA.

A.3.3. Design option B would allow for the current SMAA sector 1 to remain at 2300 ft, however SMAA sector 2 would be expanded to encompasses the Wind Farm. ATC would be unable to vector aircraft onto the RWY 24 IAPs within SMAA sector 1.

A.3.4. Design options C and D would allow for the current SMAA sector 1 to remain at 2300 ft, although its area would reduce. A new SMAA is proposed as part of this option which will give ATC the ability to vector aircraft to intercept the IAPs at 2600 ft for RWY 24 whilst keeping a 2300 ft MVA for RWY 06.

A.3.5. The stability of approaches by landing aircraft is coming evermore to the forefront of Airline Safety Departments and National Authorities safety agenda's and less and less operators are accepting of aircrew conducting 'shortened' ILS approaches. However, this does not mean that flexibility of ATC vectoring operations should no longer be considered important. Busy sequences of traffic sometimes require aircraft that are able to accept manoeuvring that, although obviously still safe, does not necessarily meet other Operators SOPs and are placed into the 'approach plan' to create an overall efficient flow of air traffic – a core element of ATC.

A.3.6. This, of course, needs to be balanced (obviously with safety as the foundation) with the Country's Green Energy aspirations. Ultimately, only Shannon ATC can decide whether the options presented in this report are operationally feasible. As the report has stated, any option deemed to have merit would need to be fully assessed and, possibly, refined so as to meet Shannon ATC expectations and provide them with the confidence of a solution that is safe and, on balance, expedient to the majority of users.

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Appendix 13

CAP670 Air Traffic Services Safety Requirement

acknowledged that the likelihood of wind turbine generated receiver saturation is low; however, any possibility of receiver saturation should be taken into consideration.

Receiver De-sensitisation causing Loss of Targets with Small RCS

SUR13A.65 Trials have shown that the large RCS of wind turbines and the blade flash effect have lead to a decrease in radar sensitivity. Reduced receiver sensitivity increases the minimum detectable signal by a radar receiver, therefore loss of small targets and the maximum range at which the smallest targets can be detected can be reduced as a result. Radar's clutter suppression circuitry uses noise thresholds which increases as the average noise levels increase leading to lack of receiver sensitivity.

SUR13A.66 Since wind turbines can have relatively high RCS they can obscure other targets in the same resolution cell, and so when an aircraft flies over a densely packed wind farm, the turbines' RCS will tend to be higher than that of the aircraft as it passes through the same resolution cell seen by the radar and so the aircraft is obscured.

Loss of Targets due to Adaptive Moving Target Indication (AMTI) Techniques

SUR13A.67 The AMTI processing assesses the background Doppler returns being received in each of its range cells and sets a velocity for which returns are 'notched out'. As the tip speed of the turbines can reach speeds similar to aircraft, it is possible that aircraft detected in the same AMTI range cell as a rotating turbine may fall into the AMTI Doppler notch and be discarded. It is, therefore, possible for some aircraft returns to be lost due to the presence of an AMTI Doppler notch in radars having such capability.

Shadowing behind the Turbines caused by Physical Obstruction

SUR13A.68 Trials have indicated that wind turbines also create a shadow beyond the wind farm so that low flying aircraft flying within this shadow go undetected. The magnified shadows of the turbine blades and the moving rotors are visible on the radar screens of weather and ATC radars [Reference 3]. However recent trial measurements have indicated that the shadow region behind the wind turbines would last only a few hundred meters and would hide only very small objects.

SUR13A.69 The wind turbine's tower and nacelle components present a large physical obstruction in the radar coverage areas in the same way as any other structure, such as a large building. The presence of a physical obstruction with a large RCS in the path of the radar beam creates a region behind the turbine farm within which aircraft would not be detected. The shadow region behind a wind turbine farm within which primary radar contact is lost by interference with the propagation of the radar beam is believed to be defined by a straightforward where an additional (false) track is initiated and seduced away from the true track, leading to confusion as to which the true target is.

SUR13A.73 The tracking algorithms in a radar associates the plots confirmed as targets, in to individual tracks it believes to be from the same target. The false declarations of targets caused by wind turbines can confuse the tracking algorithms and the plot association function in a plot extracted radar, causing the effects described above.

Degradation of Target Processing Capability

SUR13A.74 Most modern ATC primary radars are fitted with a plot extractor. The plot extractor takes the output of the signal processor, i.e. the hits generated across the beam width, and declares a plot position which may also include course and radial speed information. Plot extraction ranges from a simple position declaration to advanced hit processing, which takes the output of an MTI filter bank and generates plots taking account of amplitude information and Doppler information. There is normally a maximum number of targets the radars processing systems can handle at any one time. Therefore, if a radar experiences a large number of clutter and false plots returned by wind turbines, its processing capacity may be reached and the processing capability can be affected as a result. This may lead to errors and processing delays.

Effects on SSR

Physical blanking and diffraction effects

SUR13A.75 Wind turbine effects on SSR 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 only a consideration when the turbines are located very close to the SSR, i.e less than 10 km.

Reflections causing false targets

SUR13A.76 SSR energy may be reflected off the structures in both the uplink and downlink directions. This can result in aircraft, which are in a different direction to the way the radar is looking, replying through the reflector and tricking the radar into outputting a false target in the direction where the radar is pointing, or at the obstruction.

Introducing range and azimuth errors

SUR13A.77 Monopulse secondary radar performance is also affected by the presence of wind turbines (Theil & van Ewijk, 2007). The azimuth estimate obtained with the monopulse principle can be biased when the interrogated target emits its response when partially obscured by an large obstacle such as a wind turbine.

Appendix 14

State PBN Implementation Plan for Ireland

PBN IMPLEMENTATION PLAN FOR IRELAND

<u>COMMENTS AND OBSERVATIONS TO:</u>
airspace@iaa.ie

Version 11.0 Mar 2021

Table of Contents

1. Document Change Control Sheet

Date	Version	Author	Revision Description
29/01/2010	1.0	SRD	Document Created
22/06/2012	2.0	SRD	Detailed implementation tables updated
16/01/2015	3.0	SRD	EASA NPA & detailed implementation tables updated & removal of Galway
01/04/2017	4.0	SRD	SES Navigation Strategy
17/08/2018	5.0	SRD	Implementation dates update;
27/04/2020	6.0	SRD	Review and update
05/06/2020	7.0	SRD	Incorporation of consultation responses
17/06/2020	8.0	SRD	Note regarding EICK Rwy 25
23/11/2020	9.0	SRD	Removal of EIME & EIWT from para 27, 28 & 29; Update of EISG runway designators.
28/01/2021	10.0	SRD	EISG implementation dates update
25/03/2021	11.0	SRD	Implementation date updates & insertions of runway classifications.

2. Acronyms

The following is a list of acronyms used in this document:

ADS-B	Automatic Dependent Surveillance - Broadcast
ADS-C	Automatic Dependent Surveillance - Contract
ANSP	Air Navigation Service Provider
APCH	Approach
APV	Approach Procedures with Vertical Guidance
ATC	Air Traffic Control
ATM	Air Traffic Management
ATS	Air Traffic Service
ANS	Air Navigation Services
AWS	Automated Weather Station
Baro-VNAV	Barometric Vertical Navigation
CCO	Continuous Climb Operations
CDO	Continuous Descent Operations
CFIT	Controlled Flight into Terrain
CNS/ATM	Communication Navigation Surveillance/Air Traffic Management
CPDLC	Controller Pilot Data Link Communications
CTA	Controlled Airspace
DTTAS	Department of Transport, Tourism and Sport
DME	Distance Measuring Equipment
EASA	European Aviation Safety Agency
EGNOS	European Geostationary Navigation Overlay Service
ETS	Emissions Trading Scheme
FANS	Future Air Navigation System
FMS	Flight Management System
Galileo	Is a global navigation satellite system (GNSS) currently being built by the European Union (EU) and European Space Agency (ESA)
GPS	US Military Global Positioning System
GHG	Greenhouse Gas
GLONASS	GLObal NAvigation Satellite System
GNSS	Global Navigation Satellite System
IAA	Irish Aviation Authority
IAC	Irish Air Corps
ICAO	International Civil Aviation Organisation
IFR	Instrument Flight Rules

ILS	Instrument Landing System
INS	Inertial Navigation System
IRU	Inertial Reference Unit
LPV	Localiser Performance with Vertical guidance
MEL	Minimum Equipment Lists
MSSR	Mono-pulse Secondary Surveillance Radar
NDB	NonDirectional Beacon
OCA	Oceanic Control Area
PBN	Performance Based Navigation
PSR	Primary Surveillance Radar
RAIM	Receiver Autonomous Integrity Monitoring
RCP	Required Communication Performance
RSP	Required Surveillance Performance
RNAV	Area Navigation
RNP	Required Navigation Performance
RNP AR	Required Navigation Performance Authorisation Required
SBAS	Satellite Based Augmentation System
SID	Standard Instrument Departure
SJU	Single European Sky ATM Research Joint Undertaking
SRD	Safety Regulation Division
STAR	Standard Instrument Arrival
TMA	Terminal CTA
VOR	VHF Omni-directional Radio-range
WAM	Wide Area Multilateration

3. Executive Summary

3.1. ICAO's Global Air Navigation Plan (GANP) 2013-2028 sets out the introduction of Performance Based Navigation (PBN) as its highest priority. Whilst ICAO has generally sought to remain flexible in its approach, the ICAO Assembly Resolution A37-11 took a more top-down approach and, reflecting the importance of PBN, called for implementation of PBN required navigation performance (RNP) approaches with vertical guidance (APV) using either satellite-based augmentation system (SBAS) or barometric vertical navigation (Baro-VNAV) by 2016, with the following intermediate milestones: 30% by 2010 and 70% by 2014. Where vertical guidance is not feasible due to lack of availability of local altimeter setting or APV-equipped aircraft, lateral guidance, to most instrument flight rules (IFR) runway ends, was prescribed by 2016.

3.2. Evidently Ireland's/Europe's implementation of PBN approach operations remains well below the ICAO GANP target, despite EGNOS (the EU SBAS) being available (i.e. certified for use in aviation) since March 2011 and the wide availability of BARO-VNAV for decades.

3.3. ICAO's GANP also sets out a roadmap for the reversionary technologies to be used in case of widespread GNSS failure. Whilst the robustness of GNSS is expected to be improved through the use of multi-frequency and multi-constellation technologies, a reversionary mode based on purely non-GNSS technologies is still considered necessary. This back-up is intended to be realised in the form of ILS for approaches and for en-route a combination of DME/DME and radar vectoring.

3.4. In order to achieve a transition to a more modern navigation system and most of all to reap the economic, capacity and environmental benefits from it, there is a need for a navigation roadmap that outlines the various steps and the desired end-state. Although for the time being there is no pressing operational need to transfer to a new navigation system, there are several aspects that support the need for a navigation strategy:

- Technological innovation has enabled an increasing variety of navigation applications with a continuous expansion of an air navigation "toolbox". Substantial benefit may be gained by selecting a set of solutions in order to clarify the main thrust forward for Ireland, thus facilitating investment decisions, speeding development and avoiding operational complexity for air traffic controllers and flight crews;

- Globally, the indication that PBN is the future, is clear, and this needs to be structured in an Irish context together with an intelligent rationalisation plan for the navigation infrastructure in order to control maintenance and replacement costs. Lack of clarity will perpetuate the current first mover disadvantage that demotivates both airspace users and ANSPs from investing in new technology;

- Finally, whilst the EASA opinion on PBN rule is well founded, it needs to be set in the broader context of what the end-state and timing for the EU navigation system should be at least in the next 20-30 years.

3.5. Use of area navigational concept while providing some operational benefits, is not sufficient in itself to produce the required overall benefits with respect to both operational and economic improvements. Much of the economic benefit comes from a rationalisation of the ground infrastructure, incentivising ground as well as on board equipment and decommissioning the outdated legacy navigation infrastructure. Furthermore, PBN also contributes to increased accessibility of less equipped airfields and supports improved traffic flow.

3.6. The PBN concept differs from classic navigational concepts by relying on defining the required navigational performance rather than the precise equipment to be used. In practise the most convenient means for position determination today is using GNSS together with an on-board RNAV system. GNSS use in the EU is based on EGNOS, but soon to be joined by Galileo – satellite constellation(s), thus introducing a potential single point of failure whether because of environmental or deliberate interference, technological issues etc. Furthermore, the nature of GNSS services exposes them to new kinds of security threats (intentional spoofing etc.). Therefore, in deciding about PBN, we also need to focus carefully on the possible failure modes and the reversionary (back-up through radar vectoring or DME/DME) modes of operation that are required to maintain a minimum level of service with an acceptable level of safety.

4. Stakeholders Roles

4.1. IAA SRD / DTTAS

- Ensure that the relevant Safety Cases, IAA processes, Irish Aviation Notices and guidance material enable a safe and efficient PBN environment that aligns with both ICAO Standards and European Regulation.

- Ensure that the national infrastructure (CNS/ ATM capability) will support the airspace concepts and the performance specifications associated with each phase of PBN implementation.

4.2. Air Navigation Service Providers

- Affirming responsibility to seek continual improvements to the safety, access, capacity, efficiency and environmental sustainability of the air transport system. Recognising that PBN provides a catalyst for these improvements to air traffic operations, while enabling a seamless and cost-effective solution throughout the entire flight.

4.3. Aircraft Operators

- Ensure that investment in aircraft fleet capability is aligned with both the performance specifications outlined in this plan and the timeframe associated with each phase.

4.4. Aerodrome Operators

- Ensure the supporting aerodrome infrastructure for PBN operations is coordinated with aircraft operators and IAA SRD.

4.5. All Stakeholders ensure that sufficient trained and qualified personnel are available to support the implementation of PBN.

5. **SESAR**

5.1. Whilst the Pilot Common Projects AF1 provided the first SES-related implementation decision of PBN, a wider implementation plan is also underway. The European ATM Master Plan and related more detailed SJU studies have largely followed the ICAO approach for the short term (until 03 December 2020, phase 1), though there are some important differences for the longer term. Generally speaking, the current SJU documentation is mainly focused on charting out the technological options while final strategy decisions still remain to be made. A general update of the ATM Master Plan is also underway and scheduled to complete the update in 2018. It will link navigation aspects more firmly to communication and surveillance issues, both as regards involved timing and technology. It will also include specific provisions for drones and cybersecurity that may influence the future CNS environment.

5.2. In the short term PBN is seen as the major enabler, though – whilst not contradicting GANP -with more stress on a co-existence of SBAS and GBAS than in ICAO GANP, whereby GBAS is expected to see increased use as a method for precision approaches.

5.3. As regards the important decision on reversionary technologies, SJU foresees a two-staged approach where short term solutions may later on be replaced by a selection of alternative technologies providing reversionary capability. As Europe's DME network is already very dense, DME/DME has been a natural choice for primary back-up technology. However SJU documentation notes that if the intention is to achieve identical operational capability as the GNSS-based PBN system provides, the current system will need some upgrades both for its ground and airborne components, so that its use in the planned (SESAR) functionality as an alternative means to operate PBN, would still involve considerable investments.

5.4. For aircraft without DME/DME capability, the reversionary technology will be a reduced VOR-network. For approaches ILS should continue to serve as the main back-up to GBAS operations.

5.5. Where SESAR differs from ICAO is the longer-term reversionary solution. Whereas ICAO GANP is more inclined towards a single-stage reversionary technology decision, SJU considers a multitude of new technologies that could be introduced in the longer term as additional reversionary positioning and navigation means to enhance or even replace DME and VOR. Options for these long-term solutions include Enhanced DME, Mosaic/DME, LDACS-NAV (based on cellular network), e-LORAN, Wide-Area Multilateration/TIS-B, pseudolite (pseudo-satellite) network, Mode-N or inertial systems.

6. Fundamental assumptions for the future system in the EU

6.1. Drawing on the ICAO and SESAR plans as well as discussions with various aviation stakeholders, the future system is to be based on two basic technologies:

- The "new" technology (in civilian IFR use since circa 1993) is PBN realised primarily via GNSS. Whilst area navigation techniques have existed since the 1950's, only its realisation though GNSS navigation has really brought it into the limelight as the all-round solution. Nominally PBN is written to be independent of technology, but currently GNSS positioning – where necessary augmented by SBAS, ABAS and/or GBAS - is the foundation for PBN approaches. From the viewpoint of space infrastructure, the ultimate goal will be to establish a multi-frequency, multi-constellation GNSS system that also complies with the safety regulatory requirements for certification of navigation service providers (N.B. not necessarily systems themselves) in order to provide the required reliability for the EU air navigation system. However, with right mitigation measures, PBN implementation can – and has - already started with todays' GNSS constellations.

- The main CATII/III precision approach technology is and will remain ILS except where supplemented in the longer term by GBAS or a combination of GNSS and on-board systems, such as EVS or SVS to allow operations below CAT I minima. ILS has been in approved use since circa 1941 and operated with autoland systems since the 1960's so there is abundant data on its reliability and failure modes. It is also currently the only widespread technology able to support CATIII approaches.

6.2. After this basic framework is agreed, the next question is related to the type and extent of the reversionary system to be maintained. Maximal economic benefits could be achieved by aiming for a (long-term) introduction of purely PBN-based navigation system, without ground-based reversionary options. However, we should also consider the different failure modes that need to be tackled and consequently decide what level of service should be maintained in each case. Generally, a failure could be:

- Airframe (receiver) specific failure, affecting only one aircraft at time.

- Local or regional (such as in case of intentional or accidental satellite signal jamming) GNSS provision failure leading to a loss of PBN capability on a restricted amount of routes and runway-ends.

- Total GNSS failure, wiping out GNSS availability in all, or most, of European airspace.

6.3. Depending on the type of failure, different reversionary solutions may be employed. These solutions need to consider also the fact that GNSS is used in many other applications (e.g. ADS-B, datalink etc.) so whilst surveillance and communication systems form an important part of the back-up systems, they must be able to provide for operations independent from these also affected systems e.g.

through the use of SSR rather than ADS-B. Future roadmaps on surveillance and communications must thus be aligned with the navigation roadmap to ensure they support each other fully. It is also important to determine what level of service we wish to provide in the case of GNSS failure, as that has a direct impact on the cost of the reversionary system to airspace users and ANSP's.

6.4. Finally; whilst the liability regimes of GNSS constellations used are beyond the scope of this paper, further work should be undertaken to determine the Member States and ANSP's liabilities when using third country GNSS constellations. As regards EU's regulatory framework, the use of GNSS constellations for the provision of air navigation services fall under existing legal provisions and as their oversight will thus be regularised, and liability responsibility for them will be taken by the service provider and competent authority as applicable. Future equipment mandates could also take into account the related level of safety assurance for the various systems.

7. Proposed layout of the future system

7.1. The traditional navigation infrastructure has been relatively simple and easy to comprehend for pilots and controllers. Apart from en-route navigation, there were essentially two kinds of approaches; precision approaches with ILS or non-precision approaches with VOR or NDB. The current system includes the legacy options (until 06 June 2030, phase 3), but has also introduced a wide variety of PBN solutions – many of which are overlapping but, may require slightly different equipment or crew qualifications. Also, the terminology, charting, training and phraseology for these operations is unnecessarily different. Whilst this may have been an inevitable result of historical development when the technology was evolving, the future system should be able to provide the desired performance improvements whilst also returning the general understand ability and interoperability of the system so as to facilitate the maximum number of aircraft with the minimum number of technical variations.

7.2. In essence, the navigation system should be laid out so that all current navigation systems are progressively replaced by roughly the following framework:

8. **En-route**

8.1. In the en-route phase navigation is conducted under PBN – primarily realised through GNSS positioning. In this phase of flight, the PBN specification should be such to ensure that aircraft can navigate from point to point in a structured manner.

8.2. **Oceanic – Retain RNP 10 (RNAV 10) and RNP 4** with existing communications and surveillance requirements (CPDLC and ADS-C where necessary to support application of 30/30 separation standards).

8.3. As at December 2019, approximately 85% of current Ireland oceanic airspace users are FANS 1A capable and therefore able to benefit from the 30/30 separation standard, traffic forecasts do not indicate capacity will be constrained with current standards.

8.4. **Domestic – Specify RNAV 5** for all promulgated routes in domestic CTA.

8.5. Plan to develop Direct/Free route airspace throughput the Shannon FIR/UIR

8.6. Surveillance will be provided by the existing Mode–S capable MSSR network. This will be supplemented by the existing PSR systems at Dublin, Cork and Shannon.

8.7. Communications provided by VHF network.

8.8. The IAA's ATM system capability has been updated with the introduction of the COOPANS system at the Shannon and Dublin ATCCs since 2011.

9. **TMA Procedures**

9.1. Arrival and departure routes from all aerodromes with instrument procedures, are also provided as PBN routes to RNAV 1 or where required by operational considerations to RNP 1 specification, so as to allow aircraft to operate PBN from take-off to landing. For helicopters PinS specifications will apply.

9.2. **Specify RNAV 1** for all terminal routes with surveillance services and **RNP 1** for routes without surveillance services. Where a surveillance service is available, it will be provided by the existing PSR/Mode–S capable MSSR network.

9.3. Communications provided by VHF network.

9.4. The IAA's ATM system capability has been updated with the introduction of the COOPANS system at the Shannon and Dublin ATCCs since 2011.

10. Non-Precision Runways. Approaches will be offered at all non-precision instrument runway ends using PBN. Minima shall be laid out so as to provide for not only LNAV & LNAV/VNAV but also LPV minima using SBAS (taking due account of the given geographical and meteorological environment including the aerodrome infrastructure and required utilisation). Due to the additional safety benefit of SBAS when compared e.g. to BARO-VNAV, and although legacy aircraft will be accommodated by the provision of different minima lines, the overall target is RNP APCH to the lowest feasible LPV minima. On runway ends that currently have only non-precision approaches, or that currently do not have instrument approaches, but intend to implement them, PBN approaches shall be established by 03 December 2020 (phase 1).

11. Precision Instrument Runways

11.1. CAT II/III precision approaches to major hubs or other airports that require better operational capability are provided with a combination of PBN arrival and departure routes and ILS-based final approaches.

11.2. Additionally RNP approaches (LNAV & LNAV/VNAV & LPV Minima) will also be provided at all instrument runway ends on these airports in the same manner as to other airports, in order to add flexibility and as a back-up, as well as to facilitate those aircraft that only have PBN navigation capability.

11.3. Eventually, some precision approaches may be converted to GBAS, but for reasons of redundancy ILS approaches will still be needed at least at some runway ends so GBAS cannot be the only solution. The case for GBAS should be made considering both the benefit of e.g. curved approaches and the additional burden on aircraft equipage.

11.4. On runway ends that currently have precision approaches, RNP approaches (LNAV & LNAV/VNAV & LPV Minima) shall be established at the same time as the PCP airports, by 25 January 2024 (phase 2).

12. Mixed mode operations. Mixed mode operations will be phased out and navigation infrastructure rationalised by 06 June 2030 (phase 3).

13. Back-up solutions. PBN specifications require infrastructure support from either GNSS or DME/DME or radar vectoring capability. The capability of the existing DME network to support DME/DME updating needs to be verified to ensure it will be adequate for planned future use in both en-route and terminal airspace throughout the entire state or ensure that radar vectoring can meet the backup needs for all aerodromes (State as well as regional) in the event of a GNSS failure.

14. **Non-GNSS ANS failure**. Autonomous navigation in case of ANS failure (i.e. loss of communications, surveillance, ATC unit etc.) is provided by PBN. It will allow aircraft to fly out of the area of ANS failure and if required also to land without ANS support.

15. **Failure of primary navigation infrastructure**. Total long-term failure of GNSS would provide major issues for ATM Operations. Airspace capacity will be limited to most essential flights only, so very few new flights will take off and many of these will be State aircraft capable of operating independently. For shorter term outages or as a means of reducing airspace capacity in a controlled manner by limiting airborne flights, the following back-ups will be maintained for the foreseeable future:

- For aircraft with DME/DME capability (i.e. larger modern airlines) DME/DME provides PBN capability, combined with access to ILS-equipped airports. Considering the past reliability of GNSS, it seems unlikely that a DME-system upgrade to achieve RNP-specification capabilities would actually bring sufficient benefits to warrant the required investment. Some minor adjustment of the DME-network may be required to ensure sufficient coverage, but generally SJU and Eurocontrol studies have indicated that the existing framework is sufficient both in numbers and location.

- For those flights without DME/DME capability (mostly regional aircraft, military and general aviation) the alternative navigation means is to leave a minimum operational network (MON) of VOR's so that an aircraft will never be more than e.g. 100-150 nm away from a functioning VOR. However, this network will be truly minimal and not enable sustained operations in case of total GNSS failure. The VOR MON infrastructure will eventually be fully replaced (06 June 2030, phase 3) by only DME and ATC vectoring within Ireland.

- Finally vectoring by ATC using non-GNSS based surveillance technology, to an airport with an ILS approach, RNP Approaches (LNAV & LNAV/VNAV & LPV Minima) or visual conditions, will provide the final recourse to navigating especially our regional airports.

- In case of local failure of ILS, aircraft will land either using RNP Approaches (LNAV & LNAV/VNAV & LPV Minima) or visual conditions at the destination or alternate airport or divert to an airport with functioning ILS.

- Transition and rationalisation of the ground-based navigation infrastructure

16. **Transition and rationalisation of the ground-based navigation infrastructure**. IAA SRD is liaising with the providers of ATM/ANS in accordance with EU Regulation 2018/1048, to ensure a smooth and safe transition to the provision of their services using performance-based navigation and the eventual rationalisation of the ground-based navigation infrastructure.

17. **Aircraft equipage**

17.1. In a performance-based environment, aircraft equipage is not dictated in detailed regulations, but it is determined by the required navigation (or communications or surveillance etc.) performance. In the past IFR-approved aircraft were required to equip with the full array of navigation equipment from ADF to ILS, regardless of whether all of them were ever actually needed. In the performance-based approach, it is for the aircraft operator to determine which routes they wish to operate and then equip the aircraft so as to provide for required navigation capability on that route. This principle is already enshrined in the Standardised European Rules of the Air (SERA) and in particular, the Air-OPS Regulation for EU operators and Regulation (EU) No 452/2014 for third country operators.

17.2. Such an approach helps rationalise equipage, but also ensures that aircraft are able to operate in the environment they fly in without causing hindrances to other stakeholders. Whilst the exact equipage solutions are open to the aircraft operators, it is expected that airlines will typically use a combination of DME/DME, GNSS (augmented as desired by ABAS, SBAS and/or GBAS) and ILS for positioning, whilst in the other end of spectrum General Aviation aircraft will probably rely increasingly on a combination of GNSS (augmented as per operator needs), ILS and VOR, with ADF being quickly phased-out and in the longer term probably also VOR seeing less and less use (06 June 2030, phase 3).

18. **Safety – Risks Associated with Major System Change**. During the transition to a mature PBN environment the government and industry will face significant challenges. The government challenges will include support of Irish Aviation Rule changes and associated preparatory work. The industry challenges will involve resourcing and managing a diverse range of navigation systems with equally diverse requirements. Some of the key identified challenges are:

- Adoption of supporting Irish Aviation Rules
- PBN capability register and aircraft minimum equipment lists (MEL)
- Integration of PBN capability into the ATM system (Flight Plan data fields)
- Mixed fleet/system operations
- Safety monitoring of ATM system
- Approach naming and charting conventions
- Navigation database integrity and control
- GNSS system performance and prediction of availability service
- Continued involvement in CNS/ATM and PBN development
- Resources of the IAA SRD to implement PBN
- Education and training of personnel employed by the IAA, ANSP's and aircraft operators.

19. **Environment**

19.1. Environmental challenges include minimising the impact of noise and emissions on both the communities in the proximity of aerodromes and the global environment. PBN may support the achievement of these goals while preserving aviation safety and efficiencies in the ATM system, but a collaborative approach will be essential to deliver all these objectives. The introduction of Ireland's emission trading scheme (ETS) provides aircraft operators flying domestic routes with a commercial incentive to upgrade their fleet, including PBN capability. With the introduction of regional or global emissions trading schemes for aviation, this commercial incentive could significantly increase and extend to international aircraft operators flying to and from Ireland.

19.2. Environmental challenges therefore include:

- Political developments/considerations
  - Increased ATM system capacity due to PBN efficiency gains
  - Emission control/management, including demonstrated efficiencies associated with PBN operations
  - Noise control/management
- Technological developments
  - Tension between noise outcomes and emissions reduction outcomes.

20. **Infrastructure Development**. Design and implementation of GNSS Instrument Flight Procedures is well advanced. Approved Procedure Design organisations have a significant workload in turning the design work into published documents. The following issues need to be addressed by the IAA SRD and the aviation industry:

- Terrestrial Navaids
  - Transition to GNSS based system
  - Decommissioning of existing aids (NDB's & VOR's)
- GNSS/RAIM prediction requirements including
  - Overall GNSS status monitoring, reporting and recording
  - Prediction of availability for a particular operation and aircraft
- Automatic Weather Station (AWS) for APV Baro-VNAV
  - Implementation will require coordination between the IAA, Met Eireann, ANSP's and aerodrome operators
  - Responsibilities for funding of these initiatives will need to be determined
- RNP Approach design
- Runway infrastructure
  - Aerodrome obstacle survey
  - Aerodrome lighting (approach and surface)
- Use of GNSS
  - Use of GNSS within Irish airspace is subject to the compliance with applicable international requirements and standards (for example ICAO Annex 10).
  - Formal safety assurance evidence will need to be provided to determine whether the performance of GNSS within Irish airspace is adequate to support the planned increase in reliance on this technology by the aviation industry. Such safety evidence will have to consider risks such as the susceptibility of GNSS signals to external sources of interference.
  - Co-operative agreements between NSAs may be required to address the regulatory oversight of GNSS providers and services (e.g. oversight of the EGNOS safety of life service).

21. Operational Efficiency Benefits

- Efficiency gains enabled through PBN include:
    - Reduced separation standards for air traffic routes in oceanic and some portions of domestic en-route airspace
    - Greater flexibility of airspace design in terminal area airspace
    - Reduced track distance, noise and fuel consumption through PBN enabled ATS routes and approach procedures
    - Reduced environmental impact.
- The synchronised integration of PBN and non-PBN air routes, airspace and aircraft will be vital if these efficiency gains are to be fully realised.

22. Helicopter Operations. The development of Point in Space (PinS) procedures & ATS routes is currently under discussion / development with operators.

23. **Implementation**

23.1. **Short Term**. On runway ends that currently have only non-precision approaches, or that currently do not have instrument approaches, but intend to implement them, (except at those airports listed in point 1.2.1 of the Annex to the PCP Regulation 716/2014). PBN approaches shall be established by 03 December 2020 (phase 1).

23.2. **Medium term**. On runway ends that currently have precision approaches, PBN approaches shall be established at the same time as the PCP airports, by 25 January 2024 (phase 2).

23.3. **Long Term**. Mixed mode operations will be phased out and navigation infrastructure rationalised by 06 June 2030, (phase 3).

24. Tables' Legend

Not Implemented, no plan.
Not Implemented, planned dates.
Implemented.

25. Runway Classifications

Aerodrome	Designator	RWY	Classification
Cork	EICK	34	Precision Approach Cat I
		16	Precision Approach Cat II
		25	Non-Precision Approach
		07	Non-Precision Approach
Donegal	EIDL	20	Non-Precision Approach
		02	Non-Precision Approach
Dublin	EIDW	28L	Precision Approach Cat IIIB
		10R	Precision Approach Cat IIIB
		16	Precision Approach Cat I
		34	Non-Precision Approach
Ireland West	EIKN	26	Precision Approach Cat II
		08	Non-Precision Approach
Kerry	EIKY	26	Precision Approach Cat I
		08	Non-Precision Approach
Shannon	EINN	24	Precision Approach Cat II
		06	Precision Approach Cat I
Sligo	EISG	28	Non-Precision Approach
		10	Non-Precision Approach
Waterford	EIWF	21	Precision Approach Cat I
		03	Non-Precision Approach

26. **Routes**.

RNAV 5 is fully implemented in all ATS routes above FL150

27. GNSS Departures and Arrivals

Aerodrome	Designator	RWY	Current Procedures	Proposed Procedures	Sensor
Cork	EICK	34 Q1/2017	SID & STAR (RNAV 1)		DME/DME or GNSS With radar backup
		16 Q1/2017	SID & STAR (RNAV 1)		DME/DME or GNSS With radar backup
		25 Q1/2017	SID & STAR (RNAV 1)		DME/DME or GNSS With radar backup
		07 Q1/2017	SID & STAR (RNAV 1)		DME/DME or GNSS With radar backup
Donegal	EIDL	20 Q3/2021	Nil	SID & STAR (RNAV 1)	GNSS With radar backup
		02 Q3/2021	Nil	SID & STAR (RNAV 1)	GNSS With radar backup
Dublin	EIDW	28L Q4/2018	SID & STAR (RNAV 1)		DME/DME or GNSS With radar backup
		10R Q4/2018	SID & STAR (RNAV 1)		DME/DME or GNSS With radar backup
		16 Q4/2018	SID & STAR (RNAV 1)		DME/DME or GNSS With radar backup
		34 Q4/2018	SID & STAR (RNAV 1)		DME/DME or GNSS With radar backup
Ireland West	EIKN	26 Q3/2016	SID & STAR (RNAV 1)		GNSS With radar backup
		08 Q3/2016	SID & STAR (RNAV 1)		GNSS With radar backup
Kerry	EIKY	26 Q3/2016	SID (RNAV 1)		GNSS With radar backup
		08 Q3/2016	SID (RNAV 1)		GNSS With radar backup
Shannon	EINN	24 Q4/2018	SID & STAR (RNAV 1)		DME/DME or GNSS With radar backup
		06 Q4/2018	SID & STAR (RNAV 1)		DME/DME or GNSS With radar backup
Sligo	EISG	28 Q3/2021	Nil	SID & STAR (RNAV 1)	GNSS With radar backup
		10 Q3/2021	Nil	SID & STAR (RNAV 1)	GNSS With radar backup
Waterford	EIWF	21 Q4/2021	Nil	SID & STAR (RNAV 1)	GNSS With radar backup
		03 Q4/2021	Nil	SID & STAR (RNAV 1)	GNSS With radar backup

28. **Approach Procedures (Phase 1)**. Facilitate a mix of ground-based approaches; RNP APCH (RNAV GNSS) including Baro-VNAV enabled Approach with Vertical Guidance and Localizer performance with vertical guidance (LPV), where possible. Where a surveillance service is available, it will be provided by existing PSR/Mode–S capable MSSR network or ADS-B and Wide Area Multilateration systems when these are commissioned, integrated with ATM system and certified for use. Communications provided by VHF network.

Aerodrome	Designator	RWY	Current Procedures	Proposed Procedures	Sensor
Cork	EICK	34 (NP) Q1/2017	ILS Cat II LOC VOR LNAV/VNAV LNAV LPV		DME/DME or GNSS With radar backup
		16 Q1/2017	ILS Cat I LOC VOR LNAV/VNAV LNAV LPV		DME/DME or GNSS With radar backup
		25 Q1/2017	VOR LNAV **Note**: Descent gradient of 3.7° for CAT AB is greater than max. allowable (3.5°) for an approach with vertical guidance.		DME/DME or GNSS With radar backup
		07 Q1/2017	VOR LNAV/VNAV LNAV LPV		DME/DME or GNSS With radar backup
Donegal	EIDL	20 Q3/2021	NDB	LNAV/VNAV LNAV LPV	GNSS With radar backup
		02 Q3/2021	NDB	LNAV/VNAV LNAV LPV	GNSS With radar backup
Dublin High density TMA; PCP IR Annex - 1.2.1	EIDW	28L Q4/2018	ILS Cat I & II LOC VOR LNAV/VNAV LNAV LPV		DME/DME or GNSS With radar backup
		10R Q4/2018	ILS Cat II LOC VOR LNAV/VNAV		DME/DME or GNSS With radar backup

			LNAV LPV		
		16 Q4/2018	ILS Cat II LOC VOR LNAV/VNAV LNAV LPV		DME/DME or GNSS With radar backup
		34 Q4/2018	VOR LNAV/VNAV LNAV LPV		DME/DME or GNSS With radar backup
Ireland West	EIKN	26 Q1/2021	ILS Cat I & II LOC VOR NDB LNAV/VNAV LNAV LPV		GNSS With radar backup
		08 Q1/2021	VOR NDB LNAV/VNAV LNAV LPV		GNSS With radar backup
Kerry	EIKY	26 Q1/2021	ILS Cat I LOC NDB LNAV/VNAV LNAV LPV		GNSS With radar backup
		08 Q1/2021	NDB LNAV/VNAV LNAV LPV		GNSS With radar backup
Shannon	EINN	24 Q4/2021	ILS Cat I & II LOC VOR	LNAV/VNAV LNAV LPV	DME/DME or GNSS With radar backup
		06 Q4/2021	ILS Cat I & II LOC VOR	LNAV/VNAV LNAV LPV	DME/DME or GNSS With radar backup
Sligo	EISG	28 Q1/2021	LNAV/VNAV LNAV LPV NDB		GNSS With radar backup
		10 Q1/2021	LNAV/VNAV LNAV LPV NDB		GNSS With radar backup
Waterford	EIWF	21 Q3/2021	ILS Cat I LOC	LNAV/VNAV LNAV	GNSS With radar backup

			NDB	LPV	
		03 Q3/2021	NDB	LNAV/VNAV LNAV LPV	GNSS With radar backup

29. **Point in Space (PinS) Approach Procedures (Phase 2)**. Facilitate PinS approach procedures for the following:

Aerodrome	Designator	RWY	Current Procedure	Proposed Procedure	Sensor
Sligo	EISG	28 Q3/2021	Nil	PinS	GNSS With radar backup
		10 Q3/2021	Nil	PinS	GNSS With radar backup
Waterford	EIWF	21 Q4/2021	Nil	PinS	GNSS With radar backup
		03 Q4/2021	Nil	PinS	GNSS With radar backup
Castletownbere	Nil	Helipad Q1/2022	Nil	PinS	GNSS With radar backup
Blacksod	Nil	Helipad Q1/2022	Nil	PinS	GNSS With radar backup
Custume Bcks Athlone	EIAC	Helipad Q1/2022	Nil	PinS	GNSS With radar backup
Kerry University Hospital	Nil	Helipad Q1/2022	Nil	PinS	GNSS With radar backup
Galway University Hospital	Nil	Helipad Q1/2022	Nil	PinS	GNSS With radar backup
Letterkenny University Hospital	Nil	Helipad Q1/2022	Nil	PinS	GNSS With radar backup

30. **Conclusion**. The implementation of PBN in Ireland's controlled airspace will require the allocation of significant resources by each of the key industry stakeholders and the Irish Aviation Authority (IAA). This investment is considered essential to securing the benefits for Ireland at the earliest opportunity.

30.1. Benefits:

- Safety improvements through greater adherence to a safe flight trajectory (e.g. use of Continuous Descent Operations (CDO)/Continuous Climb Operations (CCO) which is a key component of the ICAO strategy to address Controlled Flight into Terrain (CFIT) accidents).

- Efficiency improvements through changes to air route and approach procedure designs that minimise the air miles flown and enhance schedule reliability, provide greater conformance to the flight plan and reduce enroute traffic delays, which will collectively reduce total operating costs and improve on-time performance.

- Improved environmental performance through greater use of uninterrupted climb and descent trajectories which ensure that both Green House Gas (GHG) emissions and the noise footprint for aviation are minimised.

30.2. Ireland's methodology for the transition to PBN is:

- Maintenance of the present area navigation capability
- Transition to the SES Navigation Strategy
- Introduction of APV capability through barometric vertical navigation
- Development of RNP APCH (to include LPV's) for all runways as well as RNAV SID's & STAR's
- Non-Precision runways by 03 December 2020 (phase 1) and precision runways by 25 January 2024 (phase 2).
- Utilise the European GNSS as the enabling technology for the implementation of PBN
- Utilise radar vectoring (the backup system) for all aerodromes.
- Removing by 06 June 2030 (phase 3) of conventional instrument flight procedures and mixed mode traffic
- Removal of ground based navigational aids by 06 June 2030 (phase 3)
- Installation of GBAS for Dublin

31. Consultation.

31.1. **Process**. Written consultation was carried out with the key stakeholders as listed below. A period of one month was given for responses.

31.2. The key stakeholders are:

- Air Navigation Service Providers & Aerodrome Operators
  - ATM Operations & Strategy, IAA (EICK, EINN, EIDW)
  - daa (EICK, EIDW)
  - EIDL
  - EIKN
  - EIKY
  - EIME (Irish Air Corps)
  - EISG
  - EIWF
  - EIWT
  - saa
- Aircraft Operators
- IAA SRD / DTTAS
- Network Manager, EuroControl
- Network Manager, ATM Operations & Strategy, IAA
- Airspace users and representative organisations
- Providers of ATM/ANS that provide their services in adjacent airspace blocks (CAA, UK).

Appendix 15

UK Aviation Plan – Wind Turbines and Aviation Radar

MEMORANDUM OF UNDERSTANDING – 2010 UPDATE

WIND TURBINES AND AVIATION RADAR (MITIGATION ISSUES)

1. The Climate Change Act 2008 sets a legally binding target of at least an 80% cut in UK greenhouse gas emissions by 2050. In the shorter term it sets a target rate of a reduction in emissions of at least 34% by 2020. As part of EU-wide action to increase the use of renewable energy, the UK also has a legally-binding commitment to source 15% of its energy from renewable sources by 2020. This represents an increase in the share of renewables by a factor of at least 5 between 2010 and 2020.

2. The long-term target requires the UK to decarbonise our electricity supply during the 2030s, which will be achieved by a major expansion of renewable and nuclear energy, and the introduction of carbon capture and storage. This expansion will also be essential in order to ensure the security of our electricity supplies.

3. Deployment of about 28GW of wind energy by 2020 - onshore and offshore - is expected to be needed to deliver the targets, compared with current deployment of 5GW. The Government also intends to realise the economic development benefits from wind deployment, including many thousands of new green jobs.

4. Wind turbines can have significant effects on radar, which in turn is a major barrier to deployment. Aviation radar objections to wind farms arise from three distinct groups of aviation stakeholders: the MoD (for air defence and military air traffic control); NATS En Route in respect of its regulated en route air traffic control service; and terminal civilian air navigation service providers, namely airports.

5. This conflict illustrates the constraint on aviation's ability to meet its commitment to Government policies, international obligations and licence conditions. It is noted that the licence conditions of certain air navigation service providers prevent them from investing in technologies that do not directly benefit their aviation customers. Solutions will need to be found which compromise neither the safe operation nor the significant benefits delivered by the aviation industry to the UK economy.

6. In recent years, planning law and policy throughout the UK has come to focus more on early pro-active pre-planning consultation to identify key issues for the decision maker, particularly when considering large offshore wind farm

projects where the developer is expected to have identified aviation mitigation solutions before submission of the planning application.

7. These changes highlight the need for early assessment of potential aviation issues and, where appropriate, consideration of potential and proportionate mitigation solutions. Aviation stakeholders recognise that they will need to provide resources and expertise to help the wind industry identify the most pragmatic solutions for mitigating sites, whilst not compromising on their licence obligations to provide safe and efficient aviation services.

8. In the UK, it is estimated that over 10GW of onshore wind energy and 15-20 GW of offshore wind energy could be held up by aviation objections over the next decade.

9. In 2010, radar issues accounted for over 6.5GW worth of objections in the planning system. It is estimated that a further 5GW of projects that are likely to be held up by aviations constraints are in development pre-planning, while approximately 1.3GW of projects are consented but with aviation issues outstanding that require solutions before construction can begin.

10. DECC (formerly BERR), DfT, MoD, RenewableUK (formerly BWEA), CAA and NATS/NERL signed an MOU in 2008 which committed them to work together to identify mitigation solutions, and drive forward progress on projects corralled under an 'Aviation Plan'. The Aviation Plan was endorsed by representatives of the relevant aviation stakeholders and focused on those workstreams most likely to succeed in bringing forward workable solutions.

11. The Aviation Plan is an evolving document. To own it and take responsibility for monitoring progress and driving delivery, three bodies were set up: the senior-level Aviation Management Board (AMB); the technical Aviation Advisory Panel (AAP); and the Fund Management Board (FMB). The projects under the Aviation Plan and the membership of these groups have evolved as progress has been made. With the Scottish Government, the Crown Estate and AOA joining the MOU, representatives from each of these organizations will join the AMB as well as continuing to be engaged with the AAP. Beyond this, we do not expect any further changes in governance as a result of this MOU.

12. The Aviation Plan has seen considerable achievements so far, with contracts being let to further research and development on En-Route and Air Defence radar and integration software to eliminate the problems of interference; and new defence radar being jointly purchased and installed.

13. The Plan is now entering a new phase where it needs to continue supporting relevant resource, research and development projects, while at the same time ensuring that software and hardware solutions are implemented. In addition, it is an opportunity to address other aspects beyond radar to deliver a cohesive and coordinated way forward related to all aviation issues, including navigation and communications.

14. Delivering the Aviation Plan will also require that all signatories commit to best efforts to delivering their part of the work on time, and to working together to scope a workplan to roll out effective mitigations and identify the means to fund and deliver the plan, subject to resources. As this is a highly innovative and complex field it is critical that credible technical advice and expertise is also made available by the signatories to this MOU to support the development and deployment of the Aviation Plan.

15. The wind industry recognises that it is the responsibility of the wind farm developer to achieve an acceptable aviation mitigation solution when required in cooperation with the aviation industry. The aviation industry recognises that it is the responsibility of the aviation stakeholder to engage with the developer in a manner that will allow for reasonable, consistent and timely advice on the identification of mitigation solutions. The wind industry also recognises that the current budgetary constraints within Government and through the FMB will continue to support, so far as possible, the investment into research and development projects.

16. For their part Government Departments will continue to explore financial, regulatory and legislative levers to push forward the delivery of mitigation solutions where a national approach is necessary, within the legal and financial constraints that signatories to this MOU and others (airlines and other ANSPs) are required to operate in, or where a change in the regulatory paradigm to facilitate the deployment of sub-national / regional mitigations would be of assistance. It is further recognised that only the Government authorities can effect change to the regulatory frameworks under which aviation stakeholders and wind farm developers operate.

We, the signatories to this Memorandum of Understanding (MOU), commit to working together to implement the Aviation Plan and to ensuring the timely and effective delivery of solutions to mitigate the effects of wind turbines on aviation in order to promote the deployment of wind energy generation, whilst taking all necessary steps to protect air safety and air defence requirements.

We accept that the development and deployment of radar and wind-turbines which can more effectively co-exist, together with new ways of working, will be increasingly necessary if the Government's ambitions for wind energy deployment are to be met.

Signed:

CAA

DECC — DfT

MoD — NATS/NERL

AOA — M. McCaffery. RenewableUK

Scottish Executive — The Crown Estate

Appendix 16

Newcastle Airport Reference

Newcastle Airport embraces wind power, allaying fears about radar interference

Tuesday, 25 January 2011

Newcastle International Airport in north-eastern England has launched a unique, groundbreaking Radar Blanking Strategy which will allow for a number of potential wind farm schemes in the North East to go ahead without disruption air traffic control.

Since 2005, the airport has received over 250 consultations for on and off-shore wind farm developments from across the region, all aiming to meet government-set targets for renewable energy. Many of the schemes have the potential to affect the daily operations of Newcastle Airport's Air Traffic Control since wind turbines in operation can appear on the airport radar with similar markings to a moving aircraft.

In the absence of a solution, in the past, the airport has had no alternative but to object to schemes where an unacceptable impact was predicted. However, a technological solution has been found in the form of Radar Blanking software, which updates the airport's radar system. In effect, the new software places a 'patch' to cover the potential wind farm sites, thereby preventing turbines appearing, so they cannot be mistaken for moving aircraft.

"RenewableUK welcomes the proactive work that Newcastle Airport has undertaken in developing a radar mitigation strategy. This is a great example of where the aviation industry is working with wind farm developers to allow wind energy and aviation interests to co-exist," Nicola Vaughan, head of aviation at RenewableUK (formally the British Wind Energy Association, BWEA).

Over the past two years, the airport has worked closely with the aviation industry, the renewables sector and regional partners to facilitate this mitigation. "For several years One North East has hosted meetings between airport and industry representatives, including RenewableUK, to help find a solution to these issues and we therefore welcome Newcastle International Airport's work in preparing this new strategy and hope it will benefit both the airport and the renewables sector," commented Ian Williams, Director of Business and Industry at the One North East regional development agency.

“We recognise the importance of the renewables agenda, not just to the region, but on a national and even global level. We were very keen to explore ways in which we could work to facilitate wind turbine developments. This strategy allows certain developments to proceed whilst growing the region’s largest airport, which annually contributes £400 million to the regional economy,” explains Graeme Mason, planning and corporate affairs director at Newcastle Airport.

It is expected that there will be a limit to the number of Radar Blanking Areas that are possible. Given its finite nature, the Radar Blanking Strategy is therefore seen as short-term mitigation. The Civil Aviation Authroity and others throughout the industry have made, and continue to make, a concerted effort to explore a long-term solution to this issue, yet none of the emerging technologies have been proven at this time.

“Newcastle Airport, alongside other stakeholders, is open and committed to exploring all alternatives which might emerge to find lasting solutions which will allow for further development of wind farm schemes in the North East,” said the airport in a statement.

Appendix 17

Project Marshall - Installation of New and Upgraded Thales RSM970S Radars at MOD Sites in the UK

Project Marshall - Installation of new and upgraded radars at MOD sites

Site	Planned start date for transition work (correct at June 2019 but subject to change in accordance with the Marshall contract)	Planned date of commission or to complete the upgrade and/or replacement. (correct at June 2019 but subject to change in accordance with the Marshall contract).	Type & Model of Radar
RAF Akrotiri	Quarter (Q) 2 2020	Quarter (0)1 2022	Co-mounted Thales Star NG PSR, SSR (Thales RSM970S)
RAF Aberporth	Q1 2020	042020	Co-mounted Thales Star NG PSR, SSR (Thales RSM970S)
RAF Benson	Q1 2020	Q1 2021	Thales Star NG PSR
RAF Brize Norton	01 2020	Q1 2021	Thales Star NG PSR
RAF Coningsby	Q4 2019	Q4 2020	Thales Star NG PSR
RAF Cranwell	Q2 2019	02 2020	Thales Star NG PSR
RNAS Culdrose	Q3 2019	Q3 2020	SSR (Thales RSM970S)
	042020	Q3 2021	BAE Watchman PSR
Gibraltar	042020	Q4 2021	Co-mounted Thales Star NG PSR, SSR (Thales RSM970S)
RAF Leuchars	Under review	Under review	Under review
RAF Linton-on-Ouse	Q1 2021	Q1 2022	Thales Star NG PSR
RAF Lossiemouth	Q4 2019	Q3 2021	Thales Star NG PSR
RAF Marham	Q1 2019	02 2020	Thales Star NG PSR
RAF Odiham	Q1 2020	Q1 2021	Ihales Star NG PSR
RAF Mount Pleasant	Q1 2021	04 2021	Thales Star NG PSR
RNAS Portland	Q3 2020	Q2 2021	.SSR (Thales RSM970S),
	Q1 2021	Q4 2021	BAE Watchman PSR .
Porton Down	Under review	Under review	Thales Star NG PSR
RAF Shawbury	01 2019	Q4 2019	Thales Star NG PSR

Site	**Planned start date for transition work** (correct at June 2019 but subject to change in accordance with the Marshall contract)	**Planned date of commission or to complete the upgrade and/or replacement.** (correct at June 2019 but subject to change in accordance with the Marshall contract).	**Type & Model of Radar**
RAF Spadeadam (Dead Water Fell)	02 2019	Q4 2021	Upgrade existing radar to Thales STAR NG PSR
RAF Spadeadam (Berry Hill)	03 2019	01 2021	Co-mounted Thales Star NG PSR, SSR (Thales RSM970S)
RAF St !<ilda	02 2020	Q1 2021	Co-mounted Thales Star NG PSR, SSR (Thales RSM970S)
RAF Valley	03 2019	032020	Thales Star NG PSR
RAF Wattisham	02 2019	02 2020	Thales Star NG PSR
RAFWembury	03 2019	032020	SSR (Thales RSM970S),
	04 2020	03 2021	BAE Watchman PSR
RAF West Freugh	03 2020	02 2021	Thales Star NG PSR
RAF Wittering	Under review	Under review	Under review

Appendix 18

Irish State Plan for Aviation Safety 2023 –2025 Vol. II

2.2 Controlled Flight into Terrain

2.1.5 Actions

ACTIONS		TARGET DATE
a)	The IAA will focus on the management of the risk of LOC-I occurrences with Irish regulated organisations, as appropriate to their operations, as part of safety oversight and performance monitoring activities **EPAS References MST.028.**	Ongoing

2.1.6 Status Highlights

- Focus on management of risks associated with LOC-I during oversight of SMS
- Review of organisational safety objectives and SPIs to ensure they are appropriate and that they consider State level safety objectives (ref SPAS Volume I, Chapter 5)
- Monitoring of LOC-I related events and precursors
- Updating sector risk register to include new risks in this area
- Safety promotion of key risks in this area, such as entry of incorrect performance data

The actions in this chapter support the GASR 2023-2025 Operational SEI Mitigate contributing factors to LOC-I accidents and incidents

2.2 Controlled Flight into Terrain

2.2.1 Safety Issue

Controlled Flight Into Terrain describes an event where the aircraft is flown into terrain whilst under control of the flight crew, and is usually associated with loss of situational awareness in poor visibility conditions, or navigation errors. Controlled Flight Into Terrain (CFIT) is identified as one of the main contributory causes to fatal and non-fatal accidents across all sectors of civil aviation.

2.2.2 Safety Objective

To continuously improve safety by assessing and mitigating the risks of controlled flight into terrain involving Irish commercial aeroplane operators or operators flying in Irish controlled airspace.

2.2.3 Safety Performance Indicators (Ref SPAS Volume I, Chapter 5 for details)

Accident, Serious Incident and Incident rates and trends related to CFIT category occurrences involving Irish commercial aeroplane operators.

2.2.4 Stakeholders/Roles

Irish Aviation Authority – analysis of CFIT occurrences rates and trends and identification of sector-based safety issues

Industry (Air Operators) – managing CFIT related safety risks and reporting pre-cursor events that could result in a CFIT occurrence

Industry (ANSP's, airports) – developing approach procedures to minimise the risk of CFIT

2.2.5 Actions

	ACTIONS	TARGET DATE
a)	The IAA will focus on the management of the risk of CFIT occurrences with Irish regulated organisations, as appropriate to their operations, as part of safety oversight and performance monitoring activities **EPAS References MST.028.**	Ongoing

2.2.6 Status Highlights

- Focus on management of risks associated with CFIT during oversight of SMS
- Review of organisational safety objectives and SPIs to ensure they are appropriate and that they consider State level safety objectives (ref SPAS Volume I, Chapter 5)
- Monitoring of CFIT related events and precursors
- Updating sector risk register to include new risks in this area
- Safety promotion on new regulations affecting this risk area, such as new EASA AWO regulations
- PBN transition plan developed and the latest version is found at https://www.iaa.ie/docs/default-source/default-document-library/airspace/pbn-transition-plan-for-ireland-v11-0.pdf?sfvrsn=390818f3_2

The actions in this chapter support the GASR 2023-2025 Operational SEI Mitigate contributing factors to CFIT accidents and incidents