Response to Request for Further Information – ABP-318943-24

PROPOSED RENEWABLE ENERGY DEVELOPMENT IN THE TOWNLANDS OF CAPPATEEMORE EAST, BALLYCANNON WEST, BALLYCANNAN EAST, BALLYCAR SOUTH, BALLYCAR NORTH AND GLENNAGROSS, COUNTY CLARE.

BALLYCAR GREEN ENERGY LIMITED

SEPTEMBER 20TH, 2024

BALLYCAR GREEN ENERGY LIMITED | STATION ROAD, ADARE, CO. LIMERICK

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1.0 Introduction

This document has been prepared in response to the Request for Further Information (RFI) issued by An Bord Pleanála (the Board) dated 26th July 2024 in respect of the live Strategic Infrastructure Development (SID) planning application (the Application) before them for consideration (ref: ABP-318943-24) regarding the proposed renewable energy development (the Proposed Development) by Ballycar Green Energy Limited (the Applicant) in the townlands of Cappateemore East, Ballycannon West, Ballycannan East, Ballycar South, Ballycar North and Glennagross, County Clare.

The RFI was issued via post to Malachy Walsh and Partners (MWP), Blennerville, Tralee, Co. Kerry, the planning consultant engaged by the Applicant. It should be noted that MWP did not receive this RFI request via post and both MWP and Applicant were not aware of the RFI until 15th August 2024. This submission comprehensively sets out the Applicant's response to the RFI received.

1.1 Background

The Applicant sought planning permission from the Board in January 2024 for the following Proposed Development, set out in the public notices as follows:

The proposed development for which permission under Section 37E is being sought will include the following:

- *12 No. Wind Turbines (blade tip height up to 158m). Eleven of the turbines will have a hub height of 90m and a blade length of 68m and one turbine (T10) will have a hub height of 82m and a blade length of 68m.*
- *12 No. Wind Turbine foundations and Hardstand areas.*
- *1 No. Permanent Meteorological Mast (90m height) and foundation and associated hardstand areas.*
- *1 No. electrical substation (110kV) including associated ancillary buildings, security fencing and all associated works.*
- *2 No. Developed Site Entrances, one temporary entrance to facilitate construction traffic and one permanent entrance.*
- *New and upgraded internal site access tracks.*
- *Provision of an on-site Visitor cabin and parking.*
- *All associated underground electrical and communications cabling connecting the proposed turbines to the proposed onsite substation.*
- *Laying of approximately 1.5km of underground electricity cabling to facilitate the connection to the national grid from the proposed onsite substation to connect to an existing 110kV overhead line.*
- *Temporary works on sections of the public road network along the turbine delivery route (including hedge or tree cutting, relocation of powerlines/poles, lampposts, signage, and local road widening).*
- *1 No. Temporary construction site compound and additional mobile welfare unit.*
- *1 No. Borrow pit to be used as a source of stone material during construction.*
- *3 No. spoil deposition areas (one at borrow pit location).*
- *Associated surface water management systems.*
- *Tree felling for wind farm infrastructure.*

The applicant is seeking a ten-year permission and an operational period of no less than 35 years from the date of commissioning the Wind Farm.

An Environmental Impact Assessment Report (EIAR) and a Natural Impact Statement (NIS) have been prepared in respect of the proposed development and accompany this application.

An RFI in relation to the Proposed Development was issued by the Board, dated July 26th.

2.0 Item 1 of the RFI

Item 1 of the RFI from the Board is as follows:

Significant concerns in relation to Aviation Safety have arisen given the proximity and scale of the proposed development to the Woodcock Hill Radar as set out in the observations received by the Board from AirNav Ireland and Shannon Airport Authority DAC. Notwithstanding the Applicant's response to the observations received, the Applicant is requested to review these submissions further and respond accordingly e.g. through the submission of a technical report. The applicant is advised that their response should demonstrate that sufficient consultation with AirNav Ireland and Shannon Airport Authority has been undertaken and all Aviation concerns have been addressed to their satisfaction.

2.1 Review of AirNav Ireland Submission

A comprehensive review of the AirNav Ireland submission dated 8th March 2024 was undertaken. A summary of this is provided below.

- AirNav Ireland state that they have reviewed the "Ballycar Wind Farm Aviation Technical Assessment", compiled by CYRRUS on behalf of the Applicant.
- They have analysed the potential impact on the surveillance infrastructure from the Proposed Development and conclude that it would degrade the performance of the Woodcock Hill radar.
- They further state that there are no credible and implementable mitigations on the Woodcock Hill radar itself to eliminate the radar beam deflections, reflections and shadowing from the proposed turbines.
- It is the opinion of AirNav Ireland that the Proposed Development would compromise the Woodcock Hill radars compliance with EU mandated surveillance performance criteria required to support 5 Nautical Mile horizontal separation of aircraft in En-Route Irish airspace and 3 Nautical Mile horizontal separation in Dublin airspace.
- AirNav Ireland have engaged in meetings and in a workshop in Dublin in February 2024 to explain and illustrate the potential impact of the Proposed Development on the Woodcock Hill radar.
- It is the opinion of AirNav Ireland that the Proposed Development would result in a reduction in the level of safety in the Shannon En-Route and Dublin Air Traffic Control centres and therefore, objects to the development proceeding.

2.2 Response to AirNav Ireland Submission

Background

The AirNav Ireland concerns communicated to the Board relate to the operation of the Woodcock Hill radar station. The independent expert technical assessments provided as part of the planning application were compiled by Cyrrus, an Irish Aviation Authority (IAA) approved procedure designer.

These technical assessments were undertaken in accordance with EUROCONTROL Guidelines (pan-European, civil-military organisation supporting European aviation).

The independent expert opinions commissioned and provided to the Board held either that:

a) the performance of the radar equipment at Woodcock Hill will not be impacted by the Proposed Development; or
b) as indicated by the manufacturer, modest upgrading of the equipment can be undertaken to fully mitigate any impact.

Update

This position is confirmed by the attached technical report, with further illustration and detail provided to validate the position. Furthermore, details are provided regarding reference sites where aviation safety has been fully maintained in conjunction with the operation of wind farm installations. Such sites include Newcastle International Airport and UK Department of Defence radar installations which are operated in conjunction with significant wind farm presence.

The Aviation Response Statement contained in Appendix 1 addresses and resolves each of the concerns raised by AirNav Ireland as follows.

2.2.1 Deflections

- Expert reports demonstrate that Woodcock Hill radar station will not experience deflections due to the Proposed Development.
- The radar equipment installed at Woodcock Hill uses inbuilt processing techniques to remove the issue of deflections from its system. As confirmed by the manufacturer, no additional optimisation is required of the system as this functionality is part of the equipment's standard processing.

2.2.2 Reflections

- The Thales RSM970 MSSR at Woodcock Hill utilises a two-stage system to prevent reflections being displayed.
- To prevent possible reflection issues some minor optimisation of the radar may be required.
- This can be incorporated in scheduled maintenance, and the Applicant has confirmed to AirNav Ireland that they are willing to provide for any associated costs either in whole or, in conjunction with other interested parties, in part.

2.2.3 Shadowing

- This issue will not compromise the operation of the Woodcock Hill radar since the shadow regions that may be generated beyond the Proposed Development will not extend into airspace where aircraft are flying.

- This is demonstrated by the expert technical reports completed by Cyrrus who have calculated the depth, width and height of the shadowing associated with the Proposed Development using EUROCONTROL Guidelines.
- The maximum depth of the shadow regions beyond the Proposed Development will vary between 2.3km and 3.6km, with widths of up to 65m and with a maximum height of 352m or 1,155 feet above sea level, as per EUROCONTROL calculation methods.
- The Shannon Airport Minimum Altitudes, as published by the Irish Aviation Authority, in the area of the Proposed Development are a minimum of 2,300 feet to 3,000 feet above sea level i.e., the altitude of the shadow region generated by the turbines is significantly below that where aircraft flight is permitted in this area. Furthermore, en-route aircraft travelling through the airspace are at a minimum altitude of 7,500 feet above sea level (significantly above the shadow region).
- The maximum shadow area determined by Cyrrus is backed up by field trials conducted in the UK and UK Civil Aviation policy, as referenced in the attached Aviation Response Statement.

2.2.4 En-Route Traffic

In AirNav Ireland's submission to the Board a concern – not previously raised – was included regarding EU mandated surveillance required to support aircraft separation in respect of en-route traffic.

In maintaining the previous position that all aviation concerns can be satisfactorily addressed, please see Appendix 1: Aviation Response Statement which notes:

- Woodcock Hill radar station will not experience reflections (with minor optimisation) or deflections due to the Proposed Development. Therefore, there will be no impact on en-route traffic within Irish or Dublin airspace from reflections or deflections.
- Any potential shadows fall below an altitude of 1,115 feet above sea level. The minimum flying height for en-route traffic through Irish airspace is 7,500 feet. Therefore, there is no possibility for any shadowing impacts of the Proposed Development on en-route traffic.
- Due to intervening landform and the Earth's curvature (see section 3.4.4 of the Aviation Response Statement), the Woodcock Hill radar is not suitable for detection or control of aircraft below approximately 9,000 feet in Dublin airspace. Therefore, the introduction of the Proposed Development would have no material impact on the operation of the radar with respect to Dublin airspace and would not compromise EU mandated surveillance aircraft separation in Dublin airspace.
- It is clear that the Proposed Development will not result in any compromise regarding EU mandated surveillance required to support aircraft separation, including in respect of en-route traffic in Irish airspace and in respect of aircraft in Dublin airspace.

2.2.5 Conclusion on AirNav Ireland Submission

As summarised above from Appendix 1: Aviation Response Statement, the Applicant's position is consistent in relation to aviation safety and addressing concerns satisfactorily. Appendix 1 contains further detail, illustration and references to validate this position. In particular, the specific concern regarding en-route aircraft raised by AirNav Ireland in their submission has been conclusively addressed.

In addition, EU aviation regulations are also relevant whereby air navigation services will transition from ground-based radar systems such as the Woodcock Hill MSSR to satellite navigation systems. Such systems will negate current issues with ground based radar systems (topography, built environment, etc.). The IAA has developed a transition plan outlining the movement to satellite based navigation systems and rationalisation of navigation infrastructure up to 2030. Satellite based aircraft navigation systems will negate any potential impacts associated with wind farms on aircraft navigation.

The Applicant has provided AirNav Ireland with an undertaking that the cost of any radar equipment optimisation will be met by the Applicant (in association with other interested parties, if applicable). Due to the timelines applying to the delivery of the Proposed Development, this optimisation can be done in conjunction with normal AirNav Ireland maintenance schedules i.e. with no operational impact.

2.3 Consultation with AirNav Ireland

As has been acknowledged by AirNav Ireland, the Applicant has engaged extensively with the IAA/AirNav Ireland since January 2022. This engagement continued after the planning application was submitted for the Proposed Development, with additional engagement in February and May 2024. The attached Aviation Response Statement shall be issued to AirNav Ireland.

Following review of the Aviation Response Statement we would respectfully request that AirNav Ireland will revert to its previous position of support in principle for the Proposed Development.

Should AirNav Ireland require that additional information or clarification needs to be considered in relation to the Proposed Development, we would respectfully suggest that the Board give consideration to exercising its right to convene a “limited agenda” hearing with both parties.

2.4 Further Considerations

In addition to the resolution of safety concerns, it is highlighted that the location of the Proposed Development is consistent with the statutory Clare County Development Plan and the local authority’s Wind Energy Strategy. The Proposed Development is in an area designated as “Strategic” for wind energy developments in the County Development Plan which was adopted following extensive public consultation. The Chief Executive of Clare County Council has advised An Bord Pleanála that the development will “positively contribute to national, regional and local objectives in relation to renewable energy.” The Proposed Development supports the delivery of Government climate and energy policy, including the legally binding targets set out in the Climate Action and Low Carbon Development Act, 2021 and the requirement on public bodies to support the delivery of climate action under the Public Sector Climate Action Strategy 2023-2025. Additionally, it is noted that “Environment” is one of AirNav Ireland’s five corporate values. AirNav Ireland has committed to reducing climate impact through innovation and the Proposed Development provides a clear and tangible means to do so.

2.5 Review of Shannon Airport Authority Submission

A comprehensive review of the Shannon Airport Authority DAC submission dated 3rd March 2024 was undertaken. A summary of this is provided below.

- In general terms, the siting of the wind turbines associated with the Proposed Development may have implications for the operations of the communication, navigation and surveillance systems used by AirNav Ireland. The geographical siting of these turbines may also have implications for the flight paths of aircraft.

- Arising from their own internal assessment, the Proposed Development will have no impact on the aerodrome OLS (obstacle limitation surface). It is unlikely that there will be any Annex 14 OLS impacts due to the Proposed Development.
- Shannon Airport notes and shares the concerns of AirNav Ireland specifically relating to radar systems and notably the Woodcock Hill radar surveillance system.
- It was initially thought that with appropriate mitigation measures any impacts on this piece of infrastructure by the Proposed Development would potentially be negated.
- Following recent engagement between the developer, AirNav Ireland, State Aerodromes and IAA Aerodrome Division, it became apparent that these impacts could not currently be mitigated against.
- Shannon Airport Authority fully supports the updated AirNav Ireland position of not being able to support the development on the basis that appropriate mitigation measures cannot be deployed to prevent impacts on the Woodcock Hill radar site and therefore objects to this development proceeding.
- Shannon Airport Authority suggest that for developments of this type the following conditions/requirements must be mandated:
    - If the turbines are within 45km of Shannon Airport's ARP and are greater than 100m in height they would be required to be included in the IAA Electronic Air Navigation Obstacle Dataset;
    - Also, standard: Chapter Q (Visual Aids for Denoting Obstacles) of the Certification Specifications for Aerodrome Desing – Issue 6 contained in the EASA aerodrome rules must be applied to the turbines as they would be regarded as an extensive object; and
    - During the construction phase of the any development, any crane activity on the site must be pre-approved by the completion of the Shannon Airport Crane Operations application form (at least 30 days in advance) of any crane erection taking place.

2.6 Response to Shannon Airport Authority Submission

In response to the Shannon Airport Authority submission and RFI issued by the Board, please see Aviation Response Statement contained in **Appendix 1**.

It is important to note that, as communicated to the Board by Shannon Airport in its submission dated 3rd March 2024, the Proposed Development will have no impact on the Shannon Airport obstacle limitation surfaces which define the limits for objects affecting the aerodrome's airspace. It has also been confirmed that the Proposed Development will not affect the Shannon Airport Instrument Flight Procedures including flight paths into/from Shannon Airport.

It is noted that Shannon Airport Authority has advised the Board that it supports the AirNav Ireland position in relation to concerns about the operation of the Woodcock Hill radar. These concerns have been satisfactorily addressed in Appendix 1: Aviation Response Statement and summarised above in Section 2.2.

3.0 Item 2 of the RFI

Item 2 of the FRI from the Board is as follows:

A planning application for a Strategic Infrastructure Development wind farm case number ABP-318782-24 (Oatfield) was received by the Board on the 22/12/2023 in close proximity to the subject application site. The applicant is requested to submit a revised/updated NIS addressing in-combination considerations that may arise from the proposed development and the Oatfield wind farm proposal.

3.1 Response to Item 2

In response to item 2 of the RFI issued by the Board, please see Natura Impact Statement (NIS) contained in **Appendix 2**. The updated NIS addresses in-combination considerations with reference to SID case number ABP-318782-24, Oatfield Wind Farm. Furthermore, the NIS also considers in-combination effects with reference to SID case number ABP-320705-24, Knockshanvo Wind Farm. A planning application for the Knockshanvo Wind Farm was lodged with the Board on August 20th 2024, postdating the issuing of an RFI from the Board for the Proposed Development. As a result of this, and due to the proximity of the Knockshanvo Wind Farm to the Oatfield Wind Farm and the Proposed Development, its inclusion in the NIS is deemed relevant.

The NIS concludes that:

Following an examination, analysis and evaluation of the relevant information and best scientific knowledge, including in particular the nature of the predicted impacts from the proposed development, and with the implementation of the mitigation measures proposed, it has been determined the proposed construction, operation and eventual decommissioning of a 12-turbine wind farm at Ballycar in County Clare will not adversely affect (either directly or indirectly) the integrity of either the Lower River Shannon SAC or the River Shannon and River Fergus SPA, either alone or in combination with other plans or projects, in light of the specific conservation objectives of each site.

4.0 Consideration of Cumulative Effects

RFI item 2 requests a revised/updated NIS addressing in-combination considerations that may arise from the Proposed Development and the Oatfield wind farm proposal. In the initial planning application for the Proposed Development, the Oatfield wind farm was not cumulatively assessed by the Applicant, due to the timeline associated with the submission of this development. A planning application for the Knockshanvo Wind Farm was lodged with the Board on August 20th 2024, therefore this was not cumulatively assessed by the Applicant. Where relevant, the Oatfield and Knockshanvo planning applications cumulatively assess the Proposed Development and other relevant plans or projects and conclude that there are no significant cumulative impacts with the Proposed Development.

5.0 Conclusion

This report and the associated appendices address the Request for Further Information issued by the Board on 26th July 2024. Notwithstanding that the Applicant did not receive the RFI until 15th August 2024 and therefore had a reduced timeline for response to the RFI, this report and associated appendices comprehensively addresses the RFI.

In relation to RFI item 1, the Aviation Response Statement provided in Appendix 1 confirms that the Proposed Development will not result in a reduction in the level of safety in the Shannon En-route and Dublin Air Traffic Control centres and that aviation concerns identified by AirNav Ireland and Shannon Airport Authority DAC have been addressed satisfactorily by the Applicant.

Should AirNav Ireland not withdraw its objections, despite the extensive expert justification for doing so, we would respectfully suggest that An Bord Pleanála give consideration to exercising its right to convene a “limited agenda” hearing with both parties.

Alternatively, the Applicant would be amenable to the Board inserting a planning condition that the Applicant agrees with AirNav Ireland in relation to the optimisation of Woodcock Hill radar equipment to be undertaken and its financing prior to commencement. For example:

> *“Prior to the commencement of development, and following consultations with AirNav Ireland, a detailed aviation mitigation plan which incorporates the commitments set out in the aviation technical report submitted as further information, including details of any required minor optimisations of the Woodcock Hill Radar and the developer’s financial contribution for same, shall be submitted to, and agreed in writing with, the relevant planning authority.”*

Regarding RFI item 2, the Natura Impact Statement provided in Appendix 2 confirms that the Proposed Development will not adversely affect the integrity of either the Lower River Shannon SAC or the River Shannon and River Fergus SPA, either alone or in combination with other plans or projects, including the Oatfield and Knockshanvo Wind Farms.

Examination of the EIAR submitted as part of the application for the Proposed Development, and the respective EIAR’s submitted for the Oatfield and Knockshanvo Wind Farms, identifies that there will be no in-combination significant cumulative adverse effects.

The Proposed Development, which is located in an area designated as “Strategic” for wind energy developments in the Clare County Development Plan, would make a significant positive contribution to local, regional and national green energy targets.

Appendix 1: Aviation Response Statement

Aviation Response Statement

Response to the Request for Further Information from An Bord Pleanála on the Ballycar Green Energy Ltd Strategic Infrastructure Development Application

Case Reference ABP-318943-24 / Ballycar Green Energy Limited

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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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Appendices

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1. An Bord Pleánala – Request for Further Information

- This Response Statement relates to a Request for Further Information (RFI) received from An Bord Pleanála regarding the aviation concerns raised by AirNav Ireland and Shannon Airport Authority DAC in relation to the proximity of the proposed development to the Woodcock Hill Radar. The RFI was dated 26th July 2024.

- An Bord Pleanála acknowledges that Ballycar Green Energy Limited (the "Applicant") have responded to the observations to-date.

- An Bord Pleanála request that the Applicant review the submissions to-date and respond accordingly by means of a technical report.

- The Applicant is also advised that they should demonstrate, in their response, that sufficient consultation with AirNav Ireland and Shannon Airport Authority has been undertaken and all aviation concerns have been addressed.

2. Response Statement Overview

This Response Statement has been prepared in support of a Request for Further Information by An Bord Pleanála in relation to the planning application for Ballycar Wind Farm and responds to the request to review all submissions to-date and also demonstrate that sufficient consultation has been undertaken with AirNav Ireland and Shannon Airport Authority to ensure all aviation concerns have been addressed.

At the feasibility stage in 2021, the EIAR Consultants for the project, Malachy Walsh & Partners (MWP), appointed Cyrrus Limited to conduct an Aviation Technical Assessment. In addition, MWP also engaged with IAA-approved aviation specialists (FCSL Limited) to conduct detailed technical Navigation Aids assessments on behalf of the applicant.

During the consultation process with the Irish Aviation Authority (IAA)/AirNav Ireland (commenced in January 2022) summarized in Section 2.3 below, specific concerns were raised in relation to aviation and requests were made for more detailed assessments. Ai Bridges have prepared this Response Statement in reply to the Request for Further Information to demonstrate the extensive consultation undertaken in relation to aviation concerns, raised by the IAA/AirNav Ireland and to further demonstrate that the proposed Ballycar Wind Farm will not result in an impact on aviation. The full detailed technical assessments conducted since 2021 to 2024 are included as appendices to this report.

The submission from AirNav Ireland contained the following concerns:

- Potential impact of radar beam deflections on the Woodcock Hill Radar;

- Potential impact of radar beam reflections on the Woodcock Hill Radar;
- Potential impact of shadowing on the Woodcock Hill Radar;
- Woodcock Hill compliance with EU mandated surveillance performance criteria required to support 5 Nautical Mile horizontal separation of aircraft in En-Route Irish airspace and 3 Nautical Mile horizontal separation of aircraft in Dublin airspace.

During the extensive engagement process as part of pre-application consultation in 2022 – 2023, potential impacts to En-route traffic was not raised by IAA/AirNav Ireland.

The submission from Shannon Airport Authority DAC highlighted that the proposed development will have no impact on the aerodrome obstacle limitation surfaces (OLS) and that the development is not within the protection areas as per their safeguarding maps. It highlights that there will be no impacts to the Annex 14 OLS surfaces due to the proposed wind farm. Therefore, no impact on the operations of Shannon Airport are envisaged. The submission notes that Shannon Airport shares the concerns of AirNav Ireland in relation to the potential impacts on the En-route Radar Facilities at Woodcock Hill.

The *Ballycar Wind Farm Aviation Impact Assessment & Mitigation Report* and the *Mitigation Options Study* (as shown in Appendices 4 and 5 respectively) and associated Technical Assessments (as shown in Appendices 1, 2 and 3) submitted to An Bord Pleanála as part of the planning application highlighted the following:

- Ballycar Wind Farm will not result in radar beam deflections on the Woodcock Hill Radar, as stated in the Mitigation Options Study (shown in Appendix 4, Table 1) as the Woodcock Hill Radar already has inbuilt radar processing to eliminate deflections.
- Ballycar Wind Farm will not result in radar beam reflections on the Woodcock Hill Radar (with minor optimisation as part of scheduled maintenance), as stated in the Mitigation Options Study (shown in Appendix 4, Table 1) as the Woodcock Hill Radar has inbuilt radar processing to eliminate reflections.
- Ballycar Wind Farm will not result in shadowing impacts on the Woodcock Hill Radar as any shadowing caused will be below the published Air Traffic Control allowable altitudes for surveillance and are operationally tolerable.

This Response Statement further confirms the above and also confirms:

- Ballycar Wind Farm will not result in any impacts to en-route aircraft and will not impact Woodcock Hill Radar compliance with EU mandated surveillance performance criteria required to support 5 Nautical Mile horizontal separation of aircraft in En-Route Irish airspace and 3 Nautical Mile horizontal separation of aircraft in Dublin airspace.

2.1 Statement Of Authority

Ai Bridges Limited:

Ai Bridges Limited has been engaged by Ballycar Green Energy Limited to manage the aviation assessments and conduct aviation statement reviews and Response Statement submissions in respect of the proposed Ballycar Wind Farm.

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 telecommunications and aeronautical 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 is an Irish Aviation Authority Approved Procedure Designer Organisation.

Cyrrus Limited were contracted, as requested by Ballycar Green Energy Limited, by Ai Bridges on behalf of the applicant to address the IAA request for detailed technical IFP and Radar Assessments. Cyrrus provides specialized Radar Engineering & Consultancy Services, IFP Assessments and IFP Procedure Design Services.

Cyrrus is a leading international consultancy providing a range of specialist aviation support services to help airports and developers manage and overcome the varied and often complex technical requirements associated with the running of airports or delivering development projects on or adjacent to airports.

Cyrrus is an accredited Instrument Flight Procedure design organization approved by the United Kingdom Civil Aviation Authority and the Irish Aviation Authority. Cyrrus uses modelling and computer simulation to determine the effects of development and, if required, how these effects can be mitigated.

Cyrrus have significant relevant experience in the areas of UK Civil Aviation and MoD (Ministry of Defense) Radar Assessments and provide Radar Engineering & Consultancy Services and IFP Procedure Design Services. Kevin Sissons, a principal consultant engineer, conducted the Radar Assessment Studies and has significant Radar Systems Engineer experience with NATS UK (National Air Traffic Services).

2.2 Regulatory Context

The International Civil Aviation Organization (ICAO) published their Global Air Navigation Plan 2013 – 2028 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. It will move today's ground-based air traffic control system (such as Woodcock Hill Monopulse Secondary Surveillance Radar (MSSR)) to a more efficient one that relies on satellite navigation and on-board aircraft avionics. 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). This dictates that air navigation services will transition from ground-based radar systems such as the Woodcock Hill MSSR to satellite navigation systems. Such satellite systems will negate current issues with ground based radar systems (topography, built environment, etc.).

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.

In the en-route phase, navigation is conducted under the State PBN plan – primarily realised through Global Navigation Satellite Systems (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. This includes a Plan to develop Direct/Free route airspace throughout the Shannon FIR/UIR (Flying Information Region/Upper Information Region). 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. The IAA's ATM system capability has been updated with the introduction of the COOPANS system at the Shannon and Dublin ATCCs since 2011.

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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.

The movement to satellite based navigation systems in Irish airspace is due to take place by June 6th, 2030. Satellite based aircraft navigation systems will negate any potential impacts associated with wind farms on aircraft navigation.

2.3 IAA/AirNav Ireland Consultations

Extensive consultations, engagements, meetings and detailed email and letter correspondences with the IAA/AirNav Ireland commenced in January 2022 up to submission of the planning application.

Following submission and prior to the receipt of a Request for Further Information, additional significant consultation (meetings and email correspondence) has been undertaken with AirNav Ireland.

A summary of these engagements has been included below and demonstrates the extended consultation process that has taken place with the IAA and AirNav Ireland since 2022.

2.3.1 Malachy Walsh & Partners (EIAR Consultants) – January 2022 - May 2022:

In January 2022, Malachy Walsh and Partners (MWP) engaged and submitted a scoping report to the IAA with a request for comments in relation to the proposed wind farm on lands at and near Ballycar, Co. Clare.

There were further rounds of consultations in January 2022 with the Airspace and Navigation Team at the IAA where it was highlighted that there are a number of aviation surfaces under the responsibility of the IAA Air Navigation Service Provider (ANSP) regarding safeguarding around Shannon Airport. These were referred internally within the IAA and the Shannon Airport Operator for further response on potential impacts to the following:

- Navigational Aids
- Surveillance Radar
- Instrument Flight Procedures (IFPs)

The consultation between with the IAA from January 2022 to May 2022 served to:

- Identify the main concerns of the IAA in relation to the potential impacts on aviation surfaces.

- Present the findings of the detailed Aviation Technical Assessments to the IAA in relation to Instrument Flight Procedures, showing a “No Impact” condition.

- Present the findings of the detailed Aviation Technical Assessments to the IAA in relation to Navigational/Flight Calibration Impact Assessments, demonstrating a “No Impact” condition.

- Present the findings of the detailed Aviation Technical Assessments to the IAA in relation to Radar Surveillance including the Primary Surveillance Radar (PSR) at Shannon Airport and the Monopulse Secondary Surveillance Radar (MSSR) at Woodcock Hill, showing a "Potential Impact" condition which can be appropriately mitigated.

2.3.2 IAA Consultation Responses – February 2022:

The IAA has welcomed and accepted the findings presented within the detailed Aviation Technical Assessments and in a consultation response to MWP on February 28th, 2022, responded as follows:

1. *In relation to the IFP Opinion (Attachment 1) I'm happy to accept that the proposed turbines will not affect the Shannon Airport Instrument Flight Procedures and nothing further is required from this perspective.*

   Note: If planning is granted and the construction goes ahead, these turbines will need to be notified to the IAA Aviation Safety Regulator, each being higher than 100m elevation.
2. *Technical Assessment Report:*
   - *Building Restricted Areas: SAA's Paul Hennessy copied for information.*
   - *NAVAIDs: The report confirms no issues for Airport NAVAIDs: Fergal Doyle copied to confirm this.*
   - *Surveillance: The report notes that mitigations are required for the Shannon PSR and the Woodcock Hill MSSR most particularly to prevent false targets and ghost signals respectively. While the report outlines how these mitigations could be applied, this must be assessed by our surveillance team*

2.3.3 IAA/AirNav Ireland Correspondence – November 2022:

A further consultation response was received from the IAA on 29 November 2022 from the Management Surveillance ME Systems Team. This response is shown in Appendix 4 (shown in section Appendix A – IAA Consultations). In this response the IAA raise ten concerns relating specifically to deflections, reflections and shadowing impacts of the proposed development on the Woodcock Hill MSSR and conclude that the proposed development would degrade the performance of the Woodcock Hill Radar.

Ai Bridges Limited was commissioned by MWP, the EIAR consultants acting on behalf of Ballycar Green Energy Limited, to review the IAA consultation response. Ai Bridges then recommended that a detailed technical assessment be carried out that would include a Mitigation Options Report to address the concerns raised by the IAA and engaged with Cyrrus Limited to conduct this study. This Mitigation Options Study is included Appendix 5.

2.3.4 AirNav Ireland Correspondence - December 2023:

Following the submission of the Mitigations Option Study and further consultation, a letter was received from AirNav Ireland (specifically from the AirNav Manager Airspace and Navigation) in December 2023 acknowledging the proactive engagement by the applicant. The letter states:

> *"Based on the interactions with you and your Consultants, I'm satisfied that there is adequate time to consider how to mitigate issues related to the Woodcock Hill Radar site that at this point do not present a reason for us to object to the proposed development going to Planning application stage."*
>
> *"Noting the comparator development supplied through our ongoing correspondence, I support this application in principle, on behalf of AirNav Ireland, subject to our ongoing interaction with you and your consultants in developing appropriate mitigations for the potential surveillance impacts, as outlined above. I also note the willingness of the developer to bear costs associated with these mitigations".*

This correspondence is included in the planning application for Ballycar Wind Farm in Appendix 1B Stakeholder Consultation and Responses.

2.3.5 Radar Workshop – Dublin - February 2024:

Following the submission of the planning application for the Ballycar Wind Farm further additional consultation was undertaken and continued with AirNav Ireland. A radar workshop was held in Dublin with representatives of the Irish Aviation Authority, AirNav Ireland, Shannon Airport Authority and Ballycar Green Energy in February 2024. The purpose of this was to facilitate discussion between radar manufacturers and the representatives present from the IAA, AirNav Ireland and Shannon Airport. The workshop did not specifically relate to the proposed Ballycar Wind Farm development. Over the course of the workshop, a representative from AirNav Ireland introduced the topic of the Proposed Development and potential impacts on the Woodcock Hill radar. The information presented was in relation to the potential impacts to "En-route" airspace and had not been referenced in any previous consultation with the IAA/AirNav between dates of January 2022 to January 2024. The IAA/AirNav representative stated that the information presented on potential shadowing impacts of the Proposed Development was "not quantified". It was also stated that they are in the process of upgrading all Thales radar equipment in the State within the next 2 – 5 years which would allow for optimisations and implementation of the Thales Windfarm Mitigation Filters.

2.3.6 AirNav Ireland Correspondence - February 2024:

Following the workshop, a further letter was received in February 2024 from the AirNav Manager Airspace and Navigation, rescinding the letter of support in principle supplied.

No technical aviation reason was included in relation to the rescinding.

2.3.7 AirNav Ireland Observation – March 2024:

In March 2024 an observation was submitted by IAA/AirNAV Ireland and they highlight their concerns and restate that the proposed development would degrade the performance of the Woodcock Hill Radar. There is no reference to the Mitigations Options study that was prepared by Cyrrus Limited and which shows that there are viable upgrades that can be implemented on the radar equipment.

> The AirNav Ireland Surveillance Domain has analyzed the potential impact on our Surveillance infrastructure of the proposed Ballycar Wind Farm development. Our conclusion is that this proposed Ballycar Wind Farm development would degrade the performance of the Woodcock Hill Radar.
>
> Due to the proximity and scale of the proposed development, there are no credible and implementable mitigations on the Woodcock Hill Radar itself to eliminate the Radar beam deflections, reflections, and shadowing from the proposed turbines. This development would compromise the Woodcock Hill radars compliance with EU mandated surveillance performance criteria required to support 5 Nautical Mile horizontal separation of aircraft in Irish En-Route airspace and 3 Nautical Mile horizontal separation of aircraft in Dublin controlled airspace.
>
> I have engaged in meetings and in a workshop in Dublin on 22 February to explain and illustrate the potential impact of the proposed development on our Woodcock hill radar. As previously presented, the Woodcock Radar region impacted is a sector over 30 degrees wide extending over Ireland and the Irish sea. Much of our En-Route air traffic from Europe and the UK to North America fly through this sector, and much of the Dublin Airport arrivals and departures fly through this sector.
>
> In summary, the AirNav Ireland Surveillance Domain, as part of AirNav Ireland's Technical Services CNS (Communications, Navaids, Surveillance) safeguarding processes will be recommending that AirNav Ireland object to the development of the proposed Windfarm at Ballycar proceeding.

Figure 1: Extract from AirNav Ireland Correspondence, March 2024

2.3.8 IAA/AirNav Meeting, Shannon Airport Head Offices – May 2024:

A meeting was convened with representatives of the IAA Management Surveillance M&E Systems Team and Ballycar Green Energy Limited, as well as from Cyrrus Limited and Ai Bridges Limited. At this meeting a presentation was given by Cyrrus on the shadowing impacts of the Proposed Development on Woodcock Hill Radar. The presentation contained material based on the Response Statement prepared by Cyrrus (shown in Appendix 6 – "AIRNAV Response Statement Ballycar Windfarm")

The IAA/AirNAV confirmed that they had upgraded all of the monopulse secondary surveillance radar equipment in the State to Mode S technology. It was noted that the current air traffic control system was experiencing some tracking issues. Minor optimisation to the Woodcock Hill MSSR to ensure no reflections from the Proposed Development would present an opportunity to analyse and resolve such issues.

It was suggested at this meeting that the issue of aircraft tracking in the vicinity of Dublin Airport was a known issue (Standard Deviation Error) due to a limitation of the radar when max-ranging the radar capabilities. The manufacturer of the Woodcock Hill Radar notes that beyond a certain distance that a standard deviation error applies. This is also stated in the EUROCONTROL Guidelines. This a common issue that is reported by ANSP's whereby if the radar system goes out of alignment, when the radar is max-ranged i.e. beyond a distance of 90NM, the standard deviation error (sometimes up to 10's of meters) can be fed into the multi radar tracking (MRT) system. This would give rise to "error" areas which could cause an issue in the MRT system. Radar systems can be tuned to allow for this known issue of standard deviation error i.e. in the event of certain permanent echoes, the bearings of these echoes will be known and the ATC operators would know if the system goes out of alignment.

At this meeting representatives from Ballycar Green Energy proposed a planning condition whereby the wind farm could not commence until all aviation concerns were fully addressed to the satisfaction of AirNav Ireland.

2.3.9 Email Correspondence between Ballycar Green Energy Ltd and AirNav Ireland – May 2024:

Following the meeting with AirNav representatives in May 2024, email correspondence was issued from Ballycar Green Energy to AirNav Ireland in relation to a planning condition being placed on the project (should planning permission be received) whereby the wind farm could not commence until all aviation concerns were fully addressed to the satisfaction of AirNav Ireland.

An acknowledgment of the request was received from AirNav Ireland who outlined that the request was to be assessed by senior management and the legal team. At the time of writing this Response Statement, a reply in relation this request is outstanding from AirNav Ireland.

2.4 Aviation Assessment Methodology

The methodologies used for the Aviation Assessments are outlined in Appendix 7.

The 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 assessment and mitigations measure proposals.

3. Technical Reports

A number of technical reports have been prepared since 2021 that assess risks to aviation safeguarding by the Proposed Development at Ballycar. These include specialist detailed technical assessments of the flight procedures and the communications, navigation and surveillance infrastructure at Shannon International Airport and at Woodcock Hill Radar.

A review of these detailed technical assessments was carried out by Ai Bridges in December 2023 and the findings of these assessments were summarized including reference to mitigation measure required, if any, as well as noting residual impacts where mitigation measures are required. All of these assessments are reviewed in the sections below.

3.1 Instrument Flight Procedures & Air Traffic Control Surveillance Minimum Altitude Charts

In November 2021 Malachy Walsh & Partners engaged Cyrrus Limited to conduct a review of the Instrument Flight Procedure Safeguarding Assessment.

The findings presented by Cyrrus in their IFP Opinion (shown in Appendix 2) in November 2021 concludes that the proposed development would have no impact to the Instrument procedures for Shannon Airport.

As noted in Section 2.3 above, there were extensive engagements with the IAA between January 2022 to May 2022 in relation to the 12-turbine design layout. During the consultation process, the IAA highlighted that there would be no impacts to Instrument Flight Procedures or on the Air Traffic Control Surveillance Minimum Altitude Charts (ATCSMAC).

The Ballycar Wind Farm IFP Opinion Report, in Appendix 2, identifies that the proposed wind farm does not impact the current published procedures at Shannon airport. This is however limited to the ATC Surveillance Minimum Altitude Chart (ATC SMAC). Although a full IFP assessment is normally required to identify an impact, it is normally recommended to submit the opinion report to the IAA Air Service Navigation Provider for consideration as to whether a full assessment is required. Following a review of the IFP Opinion, the IAA deemed that a full IFP Assessment is not required and that there would be a “No Impact” condition on IFP surfaces and therefore, no mitigation is required.

3.1.1 Mitigation Options:

In their IFP Opinion Cyrrus identify that there will be no impact to the existing ATCSMAC Charts for Shannon Airport.

No Mitigations are required.

Aviation Impact Assessment	Mitigation Measure Action	Residual Impact
Instrument Flight Procedures surfaces	No action	None

3.2 NAVAIDS – Flight Inspection Procedures

The Ballycar Wind Farm Impact on ILS Inspection Report, in Appendix 3 shows that there is no impact on the Airport Navigational Aids at Shannon Airport. The IAA 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. The assessment presented within the report outlines that the 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 Ballycar Wind Farm site and therefore there would be no impacts.

3.2.1 Mitigation Options:

The review of the bi-annual calibration flights conducted in 2021 shows no impact to NAVAID Flight Inspection Services.

No Mitigations are required.

Aviation Impact Assessment	Mitigation Measure Action	Residual Impact
Runway 24 ILS Flight Inspection Procedures	No action	None

3.3 IAA Radar Surveillance

The Radar Surveillance Domain at the IAA is responsible for the provision of Surveillance Sensors and Surveillance Data Processing Systems to deliver a current and accurate picture of the air traffic and airport surface traffic to IAA Air Traffic Controllers. The Surveillance Domain is responsible for the provision of Surveillance Sensors and Surveillance Data Processing Systems to deliver a current and accurate picture of the air traffic and airport surface traffic to IAA Air Traffic Controllers, enabling them to safely and efficiently maintain separation. The IAA has nine radar sites strategically placed throughout the country. These sites have new Mode-S radars and three new Solid State Primary Radars at the three state airports.

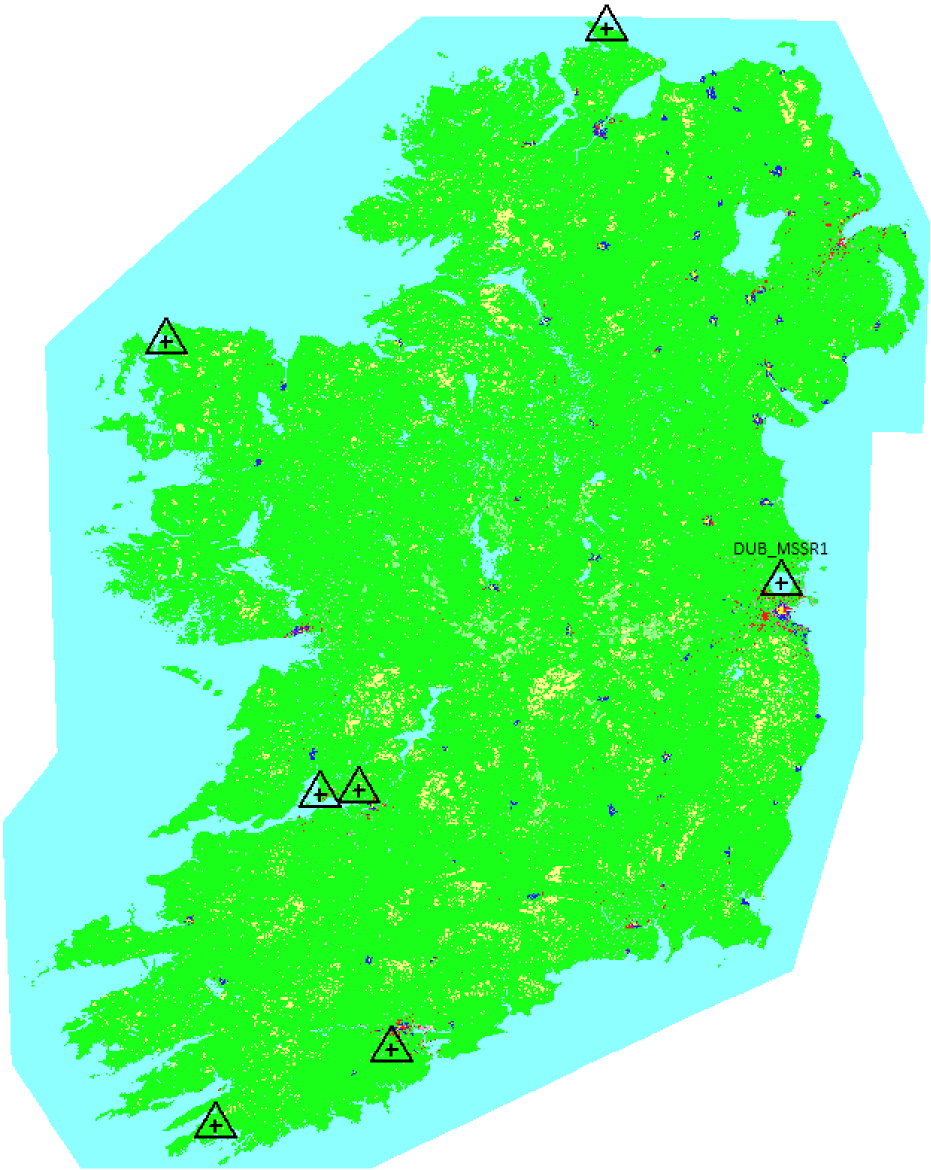

Figure 2: Location of Radars

Figure 3 below outlines the coverage of the radar systems in Ireland and the overlapping coverage. As is evident, there is overlapping radar coverage from multiple radar systems over the location of the proposed Ballycar Wind Farm.

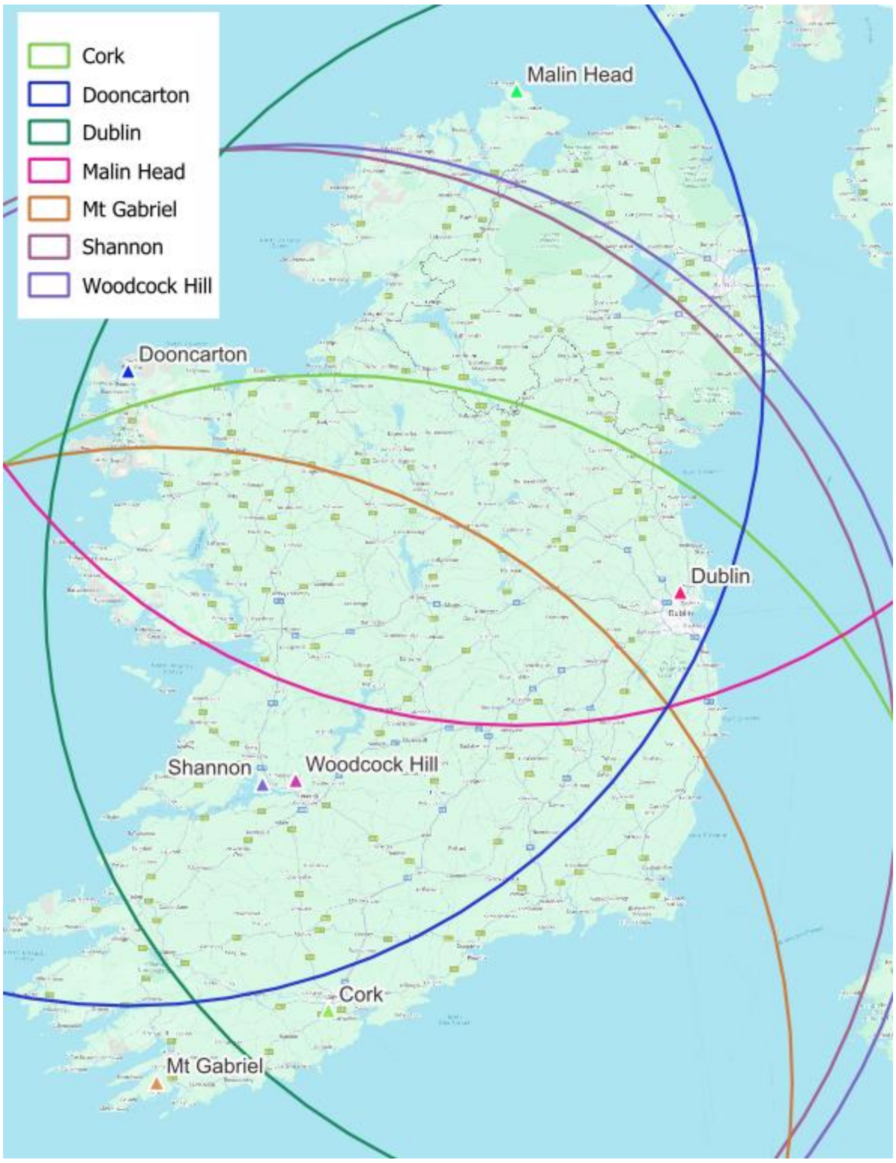

Figure 3: Radar Overlapping Coverage

At these radar sites, there are new Mode-S radars and three new Solid State Primary Radars at the three state airports. Radar coverage of the airspace, for which the Irish Aviation Authority is responsible, is provided from Monopulse Secondary Surveillance Radar (MSSR) Sensors and Primary Surveillance Radar (PSR) Sensors, located at Dublin Airport (two co-located MSSR/PSR), Cork Airport (PSR), Mount Gabriel (two MSSRs), Co. Cork, Shannon Airport (co-located MSSR/PSR), Woodcock Hill (MSSR) Co. Clare, and Dooncarton (MSSR) Co. Mayo. Each MSSR sensor is equipped with a rotating radar antenna, and dual interrogators, receivers, extractors and trackers. Having received aircraft replies, to interrogations from the radar sensor, the extractors and trackers process the received replies and generate tracks, which are transmitted over data lines to the Air Traffic Control Centres (Shannon, Dublin, Cork). The Shannon En-route ATC receives tracks from the selected Mt. Gabriel MSSR Sensor, Woodcock Hill, Shannon, Dooncarton and the selected Dublin MSSR/PSR Sensor, which are then processed by the Radar Data Processing System (RDPS). The RDPS Multi Radar Tracking (MRT) process generates a single system track output from the combined track inputs. The MRT system track is then sent to the controller's radar display. If an aircraft is transmitting, it is assigned a code and a flight plan exists in the Flight Data Processing System (FDPS) associated with that particular a Code. Then a correlated track containing the aircraft flight identification will be sent to the controller's radar display.

A system area, in nautical miles, is defined in the RDPS. The system area is divided into nautical mile cells with up to three radars, on a priority basis, defined in each cell. The MRT calculates the position of an aircraft based on the input data from each mono radar track.

Radar coverage in the extreme southwest and extreme northwest of Ireland is mostly single radar coverage, while the southwest and northwest has double radar coverage, rising to triple and quadruple coverage to the west and overland. Providing more than single radar coverage, by locating radar sensors with diverse geographic locations, helps to overcome problems of poor single radar coverage, such as screening by hills or mountains, reflections, garbling etc. Garbling (‘ghost’ aircraft/plots/tracks) is a limitation on the radar system which can occur when data arriving at the SSR sensor from one aircraft overlaps with data from another. This may not be a problem if the overlapping transponder replies can be deconflicted, but when simultaneously arriving data cannot be separated, the SSR data from either or all of the aircraft can be corrupted. Modern monopulse SSR sensors, such as the Woodcock Hill Radar include techniques to minimise the effects of garbling.

The radars deliver full duplicated coverage of AirNav Ireland's airspace to the advanced ARTAS Surveillance Data Processing systems located in Shannon and Dublin Air Traffic Control centres. The ARTAS system is one of the most advanced and successful surveillance data processing systems in the world. The IAA use the ARTAS system for Air Traffic Management Surveillance in Irish Airspace. The system merges the radar data and distributes the appropriate air situation picture to the controllers. In the event of a lack of coverage from one radar, the system automatically uses data from another radar providing overlapping coverage, thereby ensuring an accurate picture to air traffic controllers.

The integration of data in the ARTAS system allows for the application of the 5 NM separation throughout the area covered by the system, 3 NM separation may also be applied. In their submission to the Board, AirNav Ireland reference maintaining these separation distances which the ARTAS system allows for. The IAA operate to the legislative standards set by the European Union Aviation Safety Agency (EASA) and EUROCONTROL. EASA acts as the European regulator of the EU aviation systems, while EUROCONTROL is the pan-European civil aviation organisation playing a central coordination role. Over the last 25 years, EUROCONTROL has been committed to tackling the fragmentation of the European surveillance systems and has developed a distributed and interoperable surveillance tracker and server. All aviation technical assessments and reviews were carried out against EUROCONTROL GUIDELINES as requested by the IAA/AirNav Ireland.

3.4 Woodcock Hill Monopulse Secondary Surveillance Radar (MSSR)

MSSR 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 along with additional information to allow the identification of a particular aircraft and its height.

The Woodcock Hill MSSR is a Thales RSM970 which has inbuilt two stage reflection processing to eliminate reflections. The Surveillance Data Processor will mitigate against any reflections, also known as “sporadic” or “dynamic” reflections for buildings, terrain and man-made objects such as wind turbines. The radar is also able to process out deflections which give rise to the common issue of “false returns” i.e. a phenomenon which is experienced by most aviation radars which can be caused by terrain, buildings as well as by wind turbines etc. The correct terminology for these deflections/false returns is False Returns Uncorrelated in Time (FRUIT). The Surveillance Data Processer within the RSM970 at Woodcock Hill is equipped with De-FRUITER to remove these false targets.

3.4.1 Reflections

MSSR radars are 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. 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.

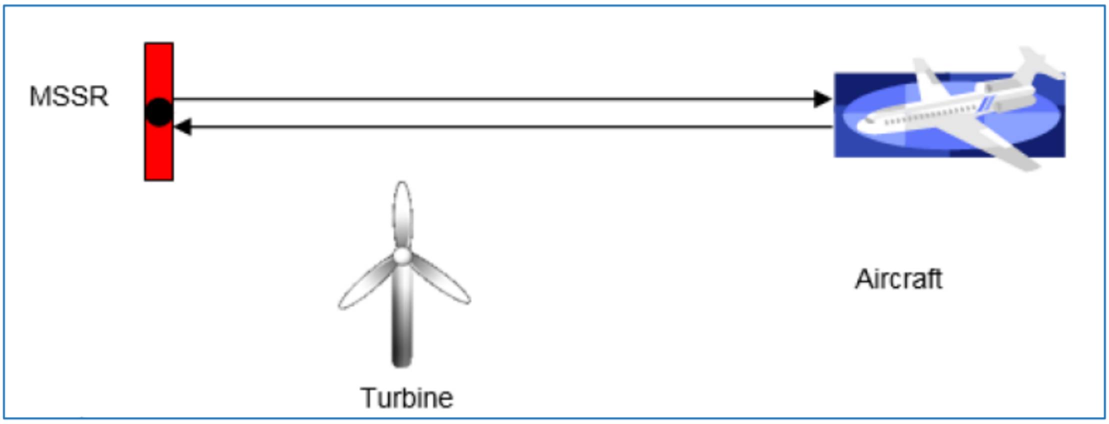

Figure 4: Direct Interrogation and Reply Pulses

In Figure 4, 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.

In Figure 5 below, 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 and potentially causes 'ghost' targets on MSSR.

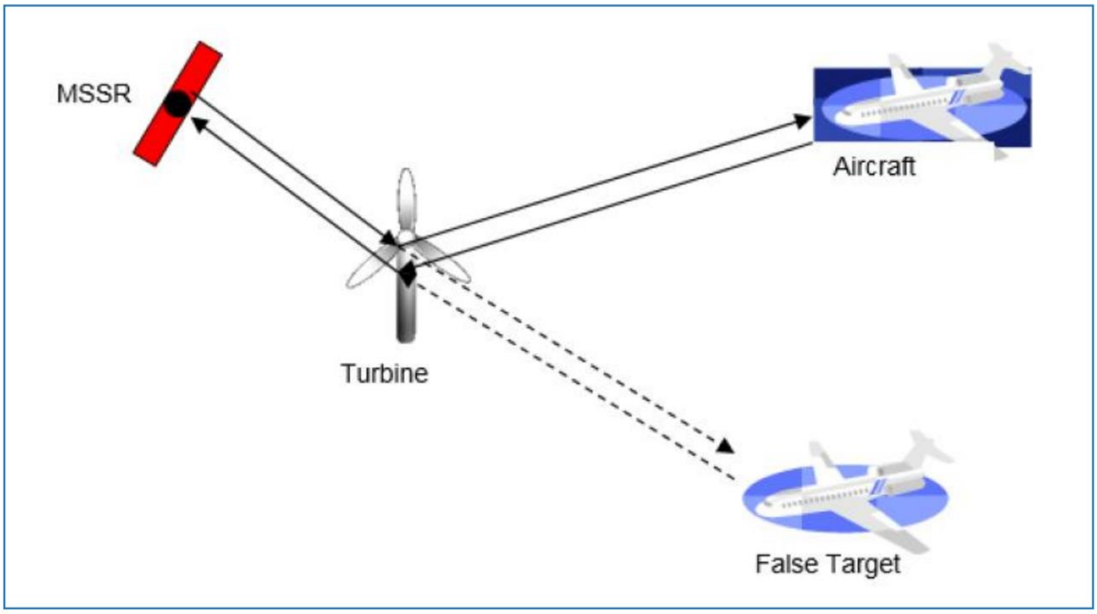

Figure 5: Reflected Interrogation and Reply Pulse

The Thales RSM970 MSSR at Woodcock Hill is sited 2.4km from the nearest wind turbine proposed in the Ballycar wind farm.

As detailed in the Ballycar Wind Farm Aviation Technical Assessment (shown in Appendix 1), the likelihood of bistatic reflections can be determined. The assessment for the Ballycar wind farm, outlines that aircraft between 5,250m and 10,536m from the proposed turbines may respond to reflected MSSR interrogations from Woodcock Hill, potentially resulting in MSSR ‘ghost’ targets. As outlined in the technical assessment carried out by Cyrrus, aircraft closer than 5,250m will not reply to reflected interrogations and aircraft beyond 10,536m will not detect a reflected signal.

The Woodcock Hill MSSR is a Thales RSM970 which has inbuilt two stage reflection processing to eliminate reflections. The Surveillance Data Processor will mitigate against any reflections, also known as “sporadic” or “dynamic” reflections for buildings, terrain and man-made objects such as wind turbines.

This is referenced in the Thales RSM970 MSSR Technical Description Document (Appendix 8). To prevent possible reflection issues, some minor optimisation of the radar may be required. This is usually carried out as part of the scheduled maintenance of the equipment.

With the implementation of this optimisation, the radar at Woodcock Hill will not experience reflections due to the Ballycar Wind Farm.

3.4.2 Deflections

Deflections occur when a radar interrogation signal is deflected by a structure such as terrain, vegetation, buildings and man-made obstacles such as wind turbines i.e. which introduce an error in the measured bearing of an aircraft. It can generate dual aircraft tracks.

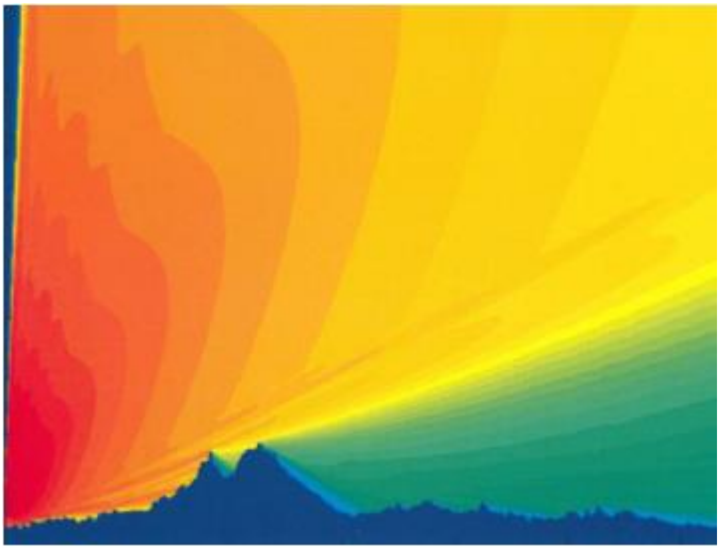

Figure 6: Visualisation of Deflections by Hill/Mountain Range.

The Thales RSM970 MSSR installed at Woodcock Hill uses a well-established processing system to remove deflected targets which are known as False Replies Uncorrelated In Time (FRUIT). The MSSR operated at Woodcock Hill can use one of its own specific inbuilt processing techniques within its Surveillance Data Processor (SDP) to remove these false targets. This process removes the issue of deflections from the system. This is referenced in the Thales RSM970 MSSR Technical Description Document (Appendix 8). No additional optimisation is required as a DEFRUITER is part of the standard MSSR processing on the Thales system.

Therefore, the radar at Woodcock Hill will not experience deflections due to the Ballycar Wind Farm.

3.4.3 Shadowing

Objects can produce a radar shadow in the airspace behind the object. As a wind turbine is narrow compared to the radar beam width, shadows are 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 radar line of sight (RLoS) between the radar and the aircraft target.

EUROCONTROL Guidelines provide equations for calculating the depth, width and height of shadow regions. Table 7 of the Ballycar Wind Farm Aviation Technical Assessment (Appendix 1) outlines the calculated depth, width and height of predicted shadow regions due to the proposed wind farm. The depth of the shadow regions beyond the Ballycar turbines will vary between 2.3km and 3.6km for Woodcock Hill MSSR, with widths of up to 65m and with a maximum height of 352m or 1,155 feet AMSL.

Figure 7: Maximum Shadow Region (2D) Due to Ballycar Wind Farm

In Figure 8 below it is shown that shadowing of radar signals can be caused by terrain (hills/mountains) beyond the wind farm. This is later shown to be the case where there is shadowing caused by the Slieve Bloom range on the radar signal from the Woodcock Hill Radar.

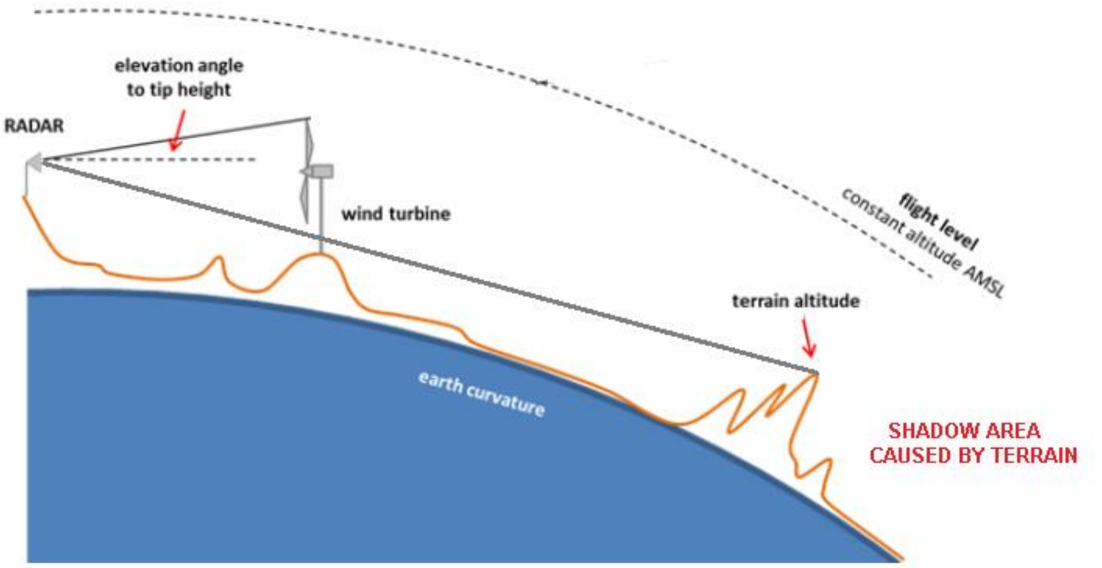

Figure 8: Shadow Region Caused by Terrain beyond Wind Farm

Based on Shannon Airport's ATC Surveillance Minimum Altitude Chart, as published by the Irish Aviation Authority, turbines T1 to T10 of the Ballycar wind farm are within Sector 1 where the minimum flying altitude is 2,300 feet AMSL. Turbines T11 and T12 are in Sector 2 where the minimum altitude is 3,000 feet AMSL. Aircraft at these minimum altitudes will not be low enough for the shadow regions to have any impact, as the calculated worst case shadow will extend to 1,115 feet AMSL.

Therefore, the shadow regions that may be generated beyond the proposed turbines will not extend into airspace where aircraft are flying (see Figure 9 below).

3.4.4 En-route Radar Facilities

As part of the submission by AirNav Ireland to An Bord Pleánala in relation to the Ballycar wind farm, a concern was raised regarding impacts to en-route traffic within Irish airspace due to the degraded performance of the Woodcock Hill radar equipment, as a result of the presence of the Ballycar wind farm.

As detailed in Sections 3.5.1 and 3.5.2 above, the Woodcock Hill MSSR will not experience reflections (with minor optimisation) or deflections due to the Ballycar wind farm and therefore, the performance of the radar equipment will not be degraded. As a result, there will be no impact to en-route traffic within Irish airspace from reflections and deflections or compromise to the Woodcock Hill MSSR EU mandated surveillance performance criteria required to support 5 Nautical Mile horizontal separation of aircraft in en-route Irish airspace.

As concluded in Section 3.5.3 above, any potential shadows generated from the Ballycar wind farm will be limited to a height of 1,115 feet AMSL. The minimum flying height for en-route traffic through controlled Irish airspace is 7,500 feet. Therefore, there is no possibility for any shadowing impacts from the Ballycar wind farm on En-route traffic, which will not result in any compromise to the Woodcock Hill MSSR EU mandated surveillance performance criteria required to support 5 Nautical Mile horizontal separation of aircraft in En-route airspace. Figure 9 graphically represents this.

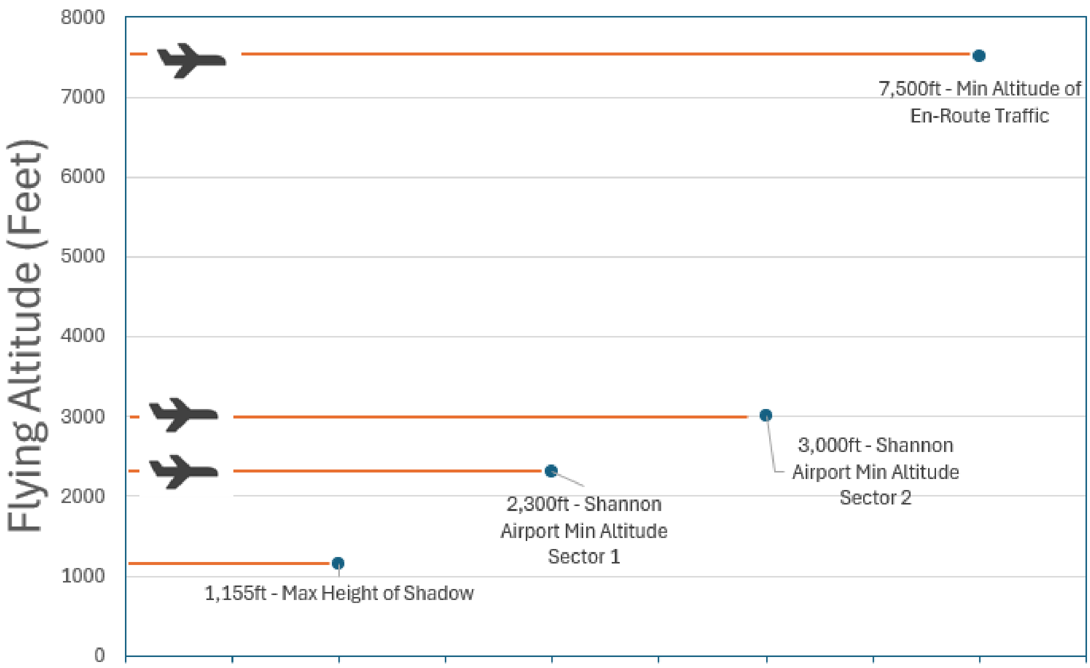

Figure 9: Altitude of Shadow Region and Minimum Flying Altitudes

The Irish Airspace Structure is shown below in Figure 10.

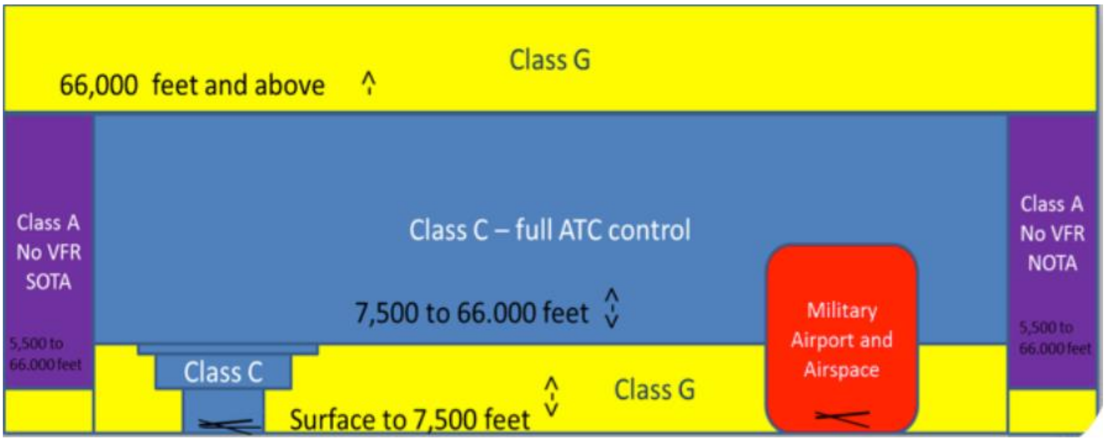

Figure 10: Irish Airspace Structure

At the Radar Workshop Meeting in February 2024, the IAA Surveillance M&E Team presented on the shadowing impact of the proposed development and identified an un-quantified impact area by drawing lines from the Woodcock Hill Radar location bounded by the most northerly and southerly wind turbine locations of the proposed development and separated by an angle of 30 degrees and arbitrarily extending these lines out to the Irish Sea and connecting then with a vertical line. This area cannot be relied upon as an accurate service coverage from the Woodcock Hill radar as there is no consideration given to terrain blocking by the Slieve Bloom mountain range in the midlands and is a manual sketch that should be used for demonstrative purposes only. This conceptual sketch presented by the IAA is shown in Figure 11 below.

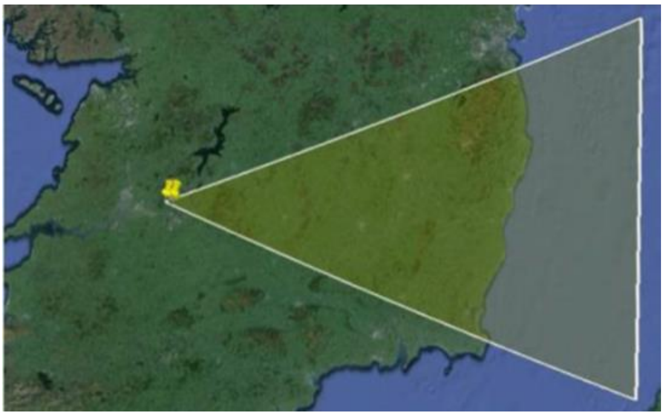

Figure 11: Arbitrary shadowing zone presented by IAA

As previously outlined in Section 3.5.3, the maximum calculated shadow region due to the presence of the Ballycar turbines is 3.6km. Therefore, any shadow region will not extend as demonstrated in Figure 11 and will not impact on Dublin airspace.

Additional analysis from Cyrrus in relation to shadow regions identifies that while there may be some limited shadowing behind the Ballycar wind farm, there will be no shadowing impact to Woodcock Hill Radar Surveillance of En-route aircraft at heights of 7,500 to 35,000ft. Radar Service coverage plots are shown in Figures 12 and 13 below at En-route flight levels of 35,000 ft (FL350) showing no impact.

Figure 12: Woodcock Hill radar service coverage at 35,000ft – without turbines

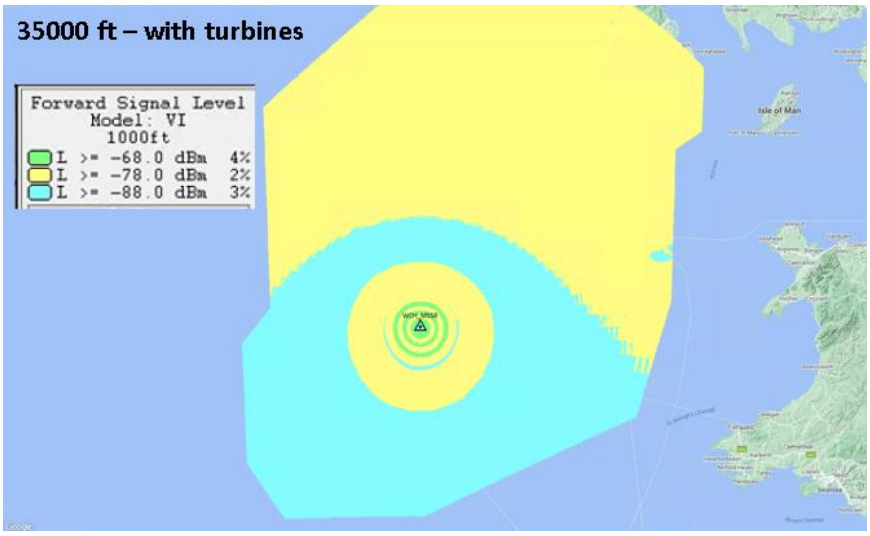

Figure 13: Woodcock Hill radar service coverage at 35,000ft – with turbines

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 (shown in

Appendix 6 in section) 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."*

These trials demonstrate and further prove that shadowing is limited and does not extend for significant distances past the wind farm. At the meeting in May 2024 at AirNav Ireland Offices in Shannon, Co. Clare reference to these flight trials conducted by the UK CAA was made to AirNav Ireland.

Also, it should be noted that in Appendix 9 there is a reference by Thales, the manufacturer of the Woodcock Hill Radar, to dedicated flight trials that they have conducted of their Wind Farm Filter in difficult terrain circumstances such as low Radar Cross Section targets, ground targets and low altitudes.

At the meeting with AirNav officials in May 2024, there were a number of points made in relation to the Woodcock Hill radar range and which have been documented and shown in Appendix 6. One of the points made was in relation the cone of silence of the radar. There is an area above ground based radar system that does not track En-route traffic and this is also the case for the Woodcock Hill MSSR. In essence, the radar cannot see above itself and therefore, cannot track aircraft through this area. This is referred to as the conical zone of silence. All radar in the state will have these "non-coverage" areas and this is demonstrated in the graphic below in Figure 14 (for demonstrative purposes only).

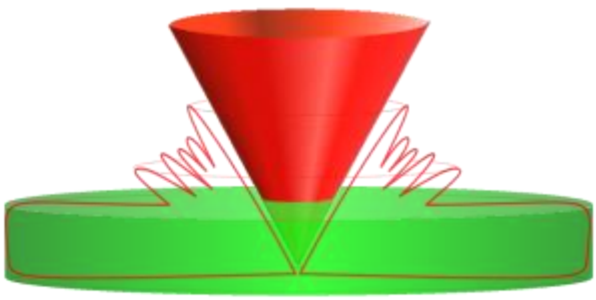

Figure 14: Graphic showing the conical zone of silence over Woodcock Hill Radar

Due to this cone of silence, overlapping radar coverage from multiple radar systems is required to ensure surveillance and tracking of aircraft through this zone. In the event of a failure of a radar in any part of the state there is overlapping coverage from another alternate radar providing identical radar surveillance which all feed into the air traffic control systems. Figure 15 below illustrates the coverage area over Woodcock Hill from various other radars.

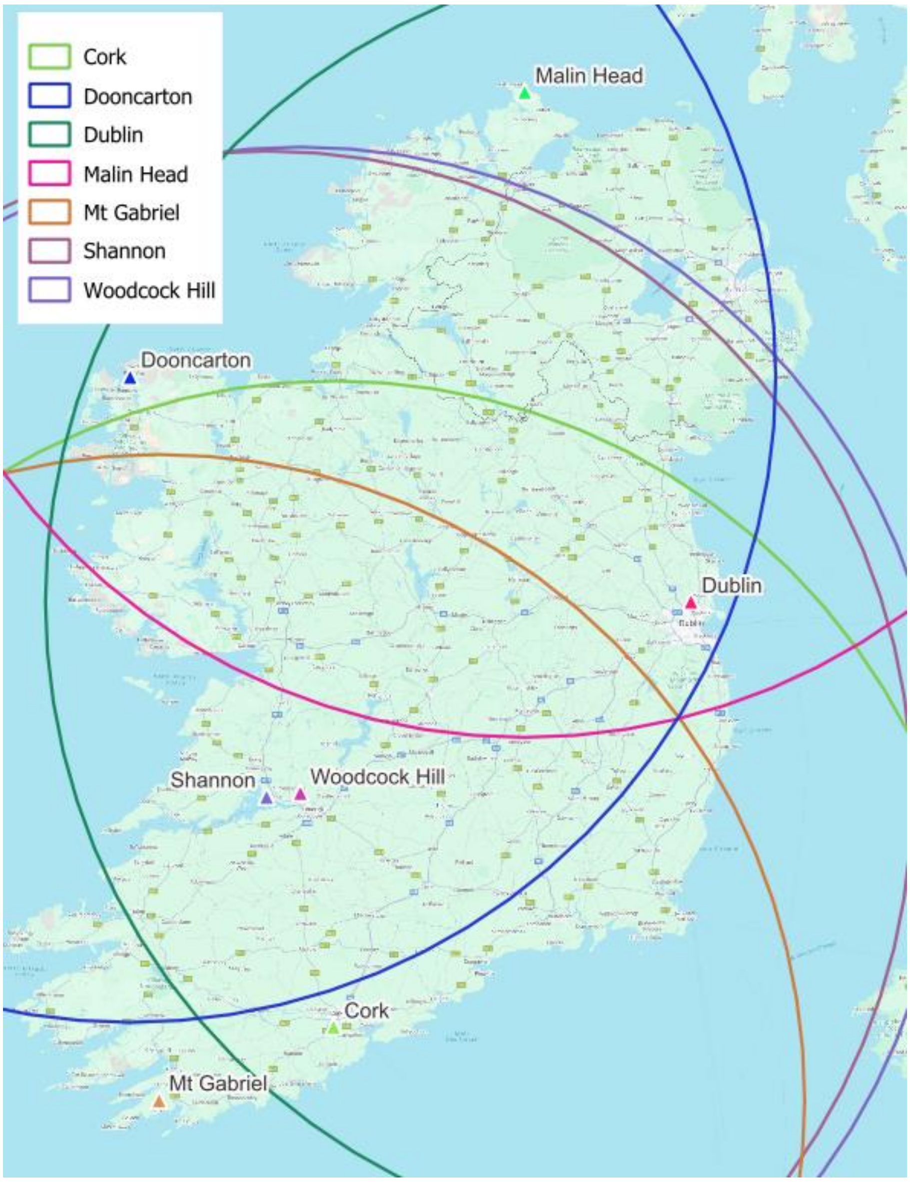

Figure 15: Overlapping Coverage Map shows that there is multi radar tracking capability of the AirNav Radar equipment i.e. if Woodcock Hill MSSR were to fail/undergo maintenance there is overlapping coverage from Dooncarton, Cork Airport, Mt Gabriel

As previously discussed, the ARTAS system used by AirNav Ireland merges the radar data and distributes the appropriate air situation picture to the controllers. Therefore, it has the ability to incorporate data from other radar systems to provide coverage over the cone of silence over the Woodcock Hill radar. Therefore, using data from other radar systems, the shadow area caused by the Ballycar turbines will have duplicated radar service coverage using the ARTAS multi-radar tracking system.

Due to the curvature of the earth, Air Traffic Controllers usually calculate that for every 10NM from the radar, they would lose approximately 1000ft of cover. As Woodcock Hill is >90NM from Dublin Airport, it is estimated that aircraft below 9000ft would not be detected or controlled in the Dublin CTA using the Woodcock Hill MSSR radar. Therefore, there will be no compromise to compliance with EU mandated surveillance performance criteria required to support 3 nautical mile horizontal separation of aircraft in Dublin airspace.

Figure 16 below outlines the radar signal path from Woodcock Hill to the Dublin Airport Terminal area. As referenced earlier in section 3.4.3 there is terrain blocking due to the Slieve Bloom Mountain range which screens any potentials impacts from the Ballycar wind farm from projecting aircraft tracking issues into the En-route airspace in the vicinity of Dublin Airport.

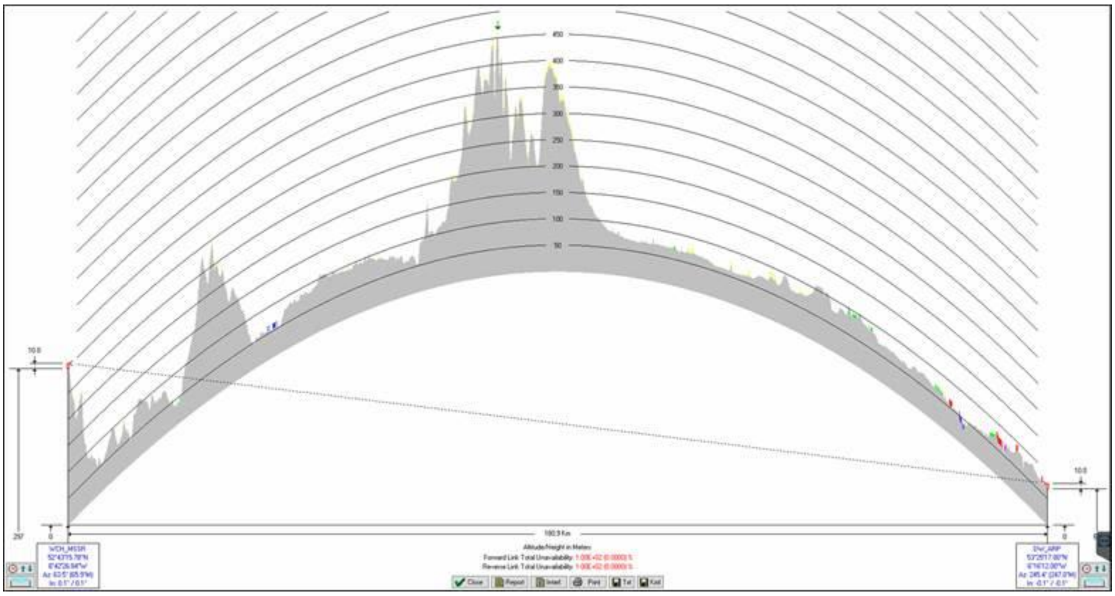

Figure 16: Radar Signal Path from Woodcock Hill – Dublin Airport Terminal Area

4. 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 optimisation of the existing radar system may be required. Should the Woodcock Hill Radar require optimisation, this would be completed one channel at a time and allow the system to remain operational throughout. If upgrades or optimisation are required to the Woodcock Hill Radar system, transitional arrangements can be managed to ensure minimal operational disruption occurs. As outlined in this report, there is overlapping radar coverage over the Woodcock Hill radar area, therefore in the event that the radar system was offline for a short period, sufficient coverage can be provided by other radar systems.

4.1 International & National Precedence

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

- that any operational impact caused by the proposed development 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 would 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 (Appendix 12), 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.

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 13. 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, if required, subject to a conditions survey by the manufacturer of the radar. Cyrrus state in their Radar Mitigations Options Study in Appendix 5 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.*

Dutch Government Radar Modelling: The Dutch Government have commissioned detailed radar modelling using Computer Aided Radar Performance Evaluation Tools which involved use of a comprehensive computer program which alleviates the difficult task of designing and evaluating surface based radar systems. The modelling tools considers the entire radar system and its environment, emitter and receiver characteristics, clutter and propagation phenomena. The program produces diagrams which are particularly useful in assessing the detection performance of a radar system.

These radar modelling tools were also used on UK onshore and offshore wind farm projects. The radar impact assessments conducted in relation to the wind farm south of Manchester Airport were able to demonstrate that the shadowing impacts of the wind farm where blocked/screened by the mountain range further south of the wind farm i.e. all shadowing impacts were blocked.

4.2 UK Aviation Plan – Wind Turbines and Aviation Radar

The Newcastle Airport reference site (as attached in Appendix 12) 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 13), 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 Radar 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 UK 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 stated that they had no alternative but to object to proposed wind farm developments where an unacceptable impact was predicted. However, following a detailed engagement process with all stakeholders Newcastle Airport were satisfied a technological solution was found in the form of radar optimisation, which involved updating the airport's radar software system. The software upgrade mitigated the potential impact of the wind farm sites, thereby preventing turbines appearing, so they could not be mistaken for moving aircraft. The Thales Windfarm filter incorporates this feature.

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". This Plan was endorsed by representatives from the relevant stakeholders within the Aviation Sector.

5. Other Wind Farm Developments in the Area

There are a number of wind farms in East Clare/Limerick at various stages in the planning process, some of which have been consented and single turbine projects which are operational. All of these wind farms are within the EURCONROL 16km Safeguarding Assessment Area for Secondary Surveillance Radar for Woodcock Hill Radar.

An overview of the consented wind farms and wind farms in the planning process in East Clare/Limerick have also been included.

5.1 Consented/Operational Wind Farms Developments in East Clare/Limerick

The Planning References for the Wind Farm(s) in the vicinity of the proposed Ballycar Project are shown in Table 2 below. These wind farms are depicted in Figure 17 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 Ballycar wind farm.

Wind Farm	Planning Status	Planning Reference	Wind Farm Description
Carrownagowan	Consented	https://www.pleanala.ie/en-ie/case/308799	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 8-turbine Wind Farm (No Impacts on Instrument Flight Procedures or Radar Surveillance Facilities)
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 11-Turbine Wind Farm In Planning
Knockshanvo	Submitted for Planning	https://www.pleanala.ie/en-ie/case/320705	Proposed 9-Turbine Wind Farm In Planning
Johnson & Johnson	Operational	https://www.eplanning.ie/LimerickCCC/AppFileRefDetails/13746/0	1-Turbine Wind Farm
Limerick Blow Mounding	Operational	https://www.eplanning.ie/ClareCC/AppFileRefDetails/22254/0	1-Turbine Wind Farm

Table 2: East Clare/Limerick Wind Farm Planning Reference

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 state that all Radar Assessment should be completed to EUROCONTROL Guidelines i.e. any significant obstacle within 16km of the Woodcock Hill Radar may have an impact. The IAA/AirNAV Ireland deemed there to be no impact from both wind farm developments on En-route Radar.

No adverse impacts to En-route Secondary Surveillance Radar facilities at Woodcock Hill were noted by the IAA/AirNav Ireland for either the Carrownagowan or Fahybeg wind farms even though both were inside the 16km exclusion zone. The Radar Safeguarding Assessments for both projects were conducted according to EURCONTROL guidelines and the IAA deemed there to be no adverse impact to the Woodcock Hill Radar.

The **Lackareagh** wind farm development has been submitted for planning and no adverse impacts to En-route Secondary Surveillance Radar facilities at Woodcock Hill have been identified by AirNav Ireland. The Lackareagh wind farm development is also inside the 16km assessment zone. The Radar Safeguarding Assessments was conducted according to EURCONTROL guidelines and the IAA deemed there to be no adverse impact to the Woodcock Hill Radar.

It should also be noted that there are single wind turbine developments at **Johnson & Jonshson** and **Limerick Blow Moulding**, both of which are operational and within the EUROCONTROL 16km zone with no operational impacts on the Woodcock Hill Radar En-route Facilities.

The **Oatfield** and **Knockshanvo** wind farms are currently in the planning process. In the concern raised by the IAA/AirNav Ireland regarding Radar Surveillance Systems Safeguarding, the developers state that there are suitable mitigations and optimisations available to mitigate out any impacts. These are included the respective Aviation Review Statements, available online for review. Both developers of the Oatfield and Knockshanvo Wind Farms have commissioned specialist detailed Technical Aviation Assessments that show that there will be no impacts to the Woodcock Hill Radar En-route Facilities.

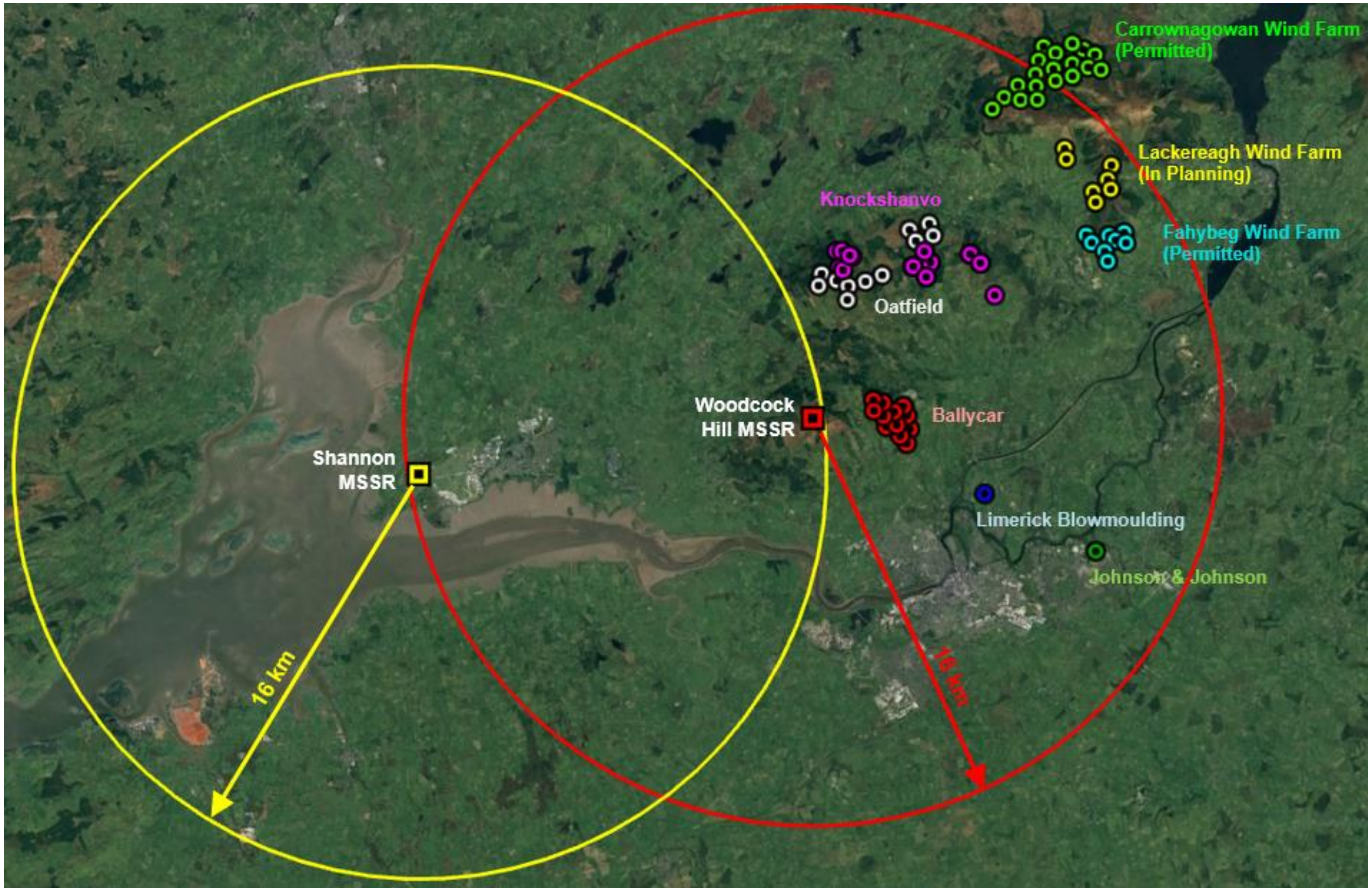

Figure 18: East Clare/Limerick Wind Farm Developments

6. Residual Impacts

During the engagements with the IAA in 2022, they state that Instrument Flight Procedures will not be impacted. It has been identified that there will be no impact to the existing ATCSMAC Charts for Shannon Airport.

The assessment completed by FCSL (Appendix 3) showed that there would be no adverse effect from the proposed wind farm on the flight inspection procedures on the Shannon Airport Instrument Landing Systems.

The Radar Mitigations Options Study carried out by Cyrrus shows that some shadowing will occur. It was considered any shadowing would be minimal, would be below minimum flying altitudes and would not have an impact on flights in En-route airspace. Once the wind farm is built, the radar systems may require optimisation by the Radar manufacturer (Thales) and a flight check may be required to confirm the systems performance according to the industry standard Eurocontrol Guidelines adopted by the IAA, thus ensuring that the radar performance is to the satisfaction of AirNav Ireland and no residual impacts remain.

The technical reports submitted as part of the planning application and this response statement determine that:

- Reflections – No residual impacts following optimisation if required of the Woodcock Hill MSSR.
- Deflections – No residual impacts on the Woodcock Hill MSSR as a result of the in-built DEFRUITER.
- Shadowing – Minimal and operationally tolerable shadow region which is below the minimal flying altitude.
- En-route traffic – No residual impacts.

7. Conclusions

The IAA/AirNav have not raised any concerns in relation to Instrument Flight Procedures against the Ballycar wind farm. It is not considered that any cumulative aviation impacts occur from the Ballycar wind farm and the other proposed/operational wind farms in the area on the Woodcock Hill MSSR because:

- Ballycar Wind Farm will not result in radar beam deflections on the Woodcock Hill Radar.
- Ballycar Wind Farm will not result in radar beam reflections (following optimisation if required) on the Woodcock Hill Radar.
- Shadowing from the Ballycar Wind Farm will extend for a maximum of 3.6km beyond the wind farm, with the height of the shadow region below minimum flying altitudes.
- Ballycar Wind Farm will not result in any impacts to en-route aircraft and will not impact Woodcock Hill Radar compliance with EU mandated surveillance performance criteria required to support 5 Nautical Mile horizontal separation of aircraft in En-Route Irish airspace and 3 Nautical Mile horizontal separation of aircraft in Dublin airspace.

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

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

<table>
<tr><th>Issues</th><th>Areas for Further Analysis</th><th>Assessment Outcomes \ Mitigations</th><th>Residual Impact</th></tr>
<tr><td rowspan="2">IFP's \ ATCSMAC Charts Shannon Airport</td><td>IFP's</td><td>No issue reported by IAA\AirNav Ireland.</td><td rowspan="2">None</td></tr>
<tr><td>ATCSMAC Chart</td><td>No issue reported by IAA\AirNav Ireland.</td></tr>
<tr><td>NAVAIDS at Shannon Airport.</td><td>Flight Inspection Procedures</td><td>The assessment completed by FCSL showed that there would be no adverse effect from the proposed wind farm on the flight inspection procedures on the Shannon Airport Instrument Landing Systems. No issue reported by IAA\AirNav Ireland or Shannon Airport.</td><td>None</td></tr>
<tr><td>MSSR at Woodcock Hill</td><td>Reflections</td><td>The Thales RSM970 MSSR sited at Woodcock Hill is 2.4 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 8). To prevent possible reflection issues, some minor optimisations may be required. The IAA/AirNav have scheduled an upgrade in the next two to five years of all the radar surveillance equipment in the state.</td><td>None</td></tr>
</table>

		Upgrades can be carried out to include updates to the two-stage system within MSSR to prevent reflections being displayed. This would be confirmed as part of an asset conductions survey by the Radar Manufacturer (Thales).	
	Deflections	The Thales RSM970 MSSR at Woodcock Hill uses a well-established processing system to remove any False Replies Uncorrelated 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 proximity of the turbines to the Woodcock Hill radar, some shadowing will occur. It was considered any shadowing would be minimal as outlined (section 3.4.3), will be below the minimum flying altitude and would not have an impact on flights in En-route airspace.	
	En-Route	The Woodcock Hill MSSR will not experience reflections or deflections due to the Ballycar wind farm and therefore, the performance of the radar equipment will not be degraded. As a result, there will be no impact to en-route traffic within Irish airspace from reflections and deflections or compromise to the Woodcock Hill MSSR EU mandated surveillance performance criteria required to support 5 Nautical Mile horizontal separation of aircraft in en-route Irish airspace. Any potential shadows generated from the Ballycar wind farm will be limited to a height of 1,115 feet AMSL. The minimum flying height for en-route traffic through Irish airspace is 7,500 feet. Therefore, there is no possibility for any shadowing impacts from the Ballycar wind farm on en-route traffic, which will not result in any compromise to the Woodcock Hill MSSR EU mandated surveillance performance criteria required to support 5 Nautical Mile horizontal separation of aircraft in en-route Irish airspace.	

It should also be noted that as previously discussed, the ARTAS system used by AirNav Ireland merges the radar data and distributes the appropriate air situation picture to the air traffic controllers. Therefore, there is duplication of radar tracking over the Woodcock Hill radar using coverage from other radar systems to provide a picture to air traffic controllers. Therefore, using data from other radar systems, the shadow area caused by the Ballycar turbines will have duplicated radar service coverage using the ARTAS multi-radar tracking system.

Following submission of the planning application for the Ballycar wind farm to An Bord Pleanála, further additional consultation was undertaken/continued with AirNav Ireland. As part of this continued consultation, a planning condition was proposed whereby the wind farm could not commence (should planning permission be received) until all aviation concerns were fully addressed to the satisfaction of AirNav Ireland.

An acknowledgment of the request was received from AirNav Ireland who outlined that the request was to be assessed by senior management and the legal team. At the time of writing this Response Statement, a reply in relation this request is outstanding from AirNav Ireland.

As such, the Applicant is amenable to the Board inserting a planning condition regarding agreement with AirNav Ireland upon the optimisation of Woodcock Hill radar equipment to be undertaken and its financing prior to commencement of the Proposed Development. For example:

> *"Prior to the commencement of development, and following consultations with AirNav Ireland, a detailed aviation mitigation plan which incorporates the commitments set out in the aviation technical report submitted as further information, including details of any required minor optimisations of the Woodcock Hill Radar and the developer's financial contribution for same, shall be submitted to, and agreed in writing with, the relevant planning authority."*

The applicant also notes that in certain circumstances due to the issues involved with the proposed development, that An Bord Pleanála can also decide to convene a limited agenda oral hearing.

At the meeting in May 2024 with AirNav Ireland, reference was made in relation to the flight trials that were conducted by the CAA UK in relation to wind turbine shadowing area (section 3.4.4) (as stated in the CAP 670 documentation). Cyrrus has submitted written requests to the CAA UK to obtain additional information in relation to the flight trials so that this information can be provided to the IAA/AirNav Ireland. A response from the CAA UK has not yet been received at the time of writing of this Response Statement.

Additional contact, through the offices of Cyrrus has been made directly to technical representatives from NATS and the UK CAA, both of whom have extensive knowledge of radar operations in the vicinity of wind farms. The nominated representatives from NATS and the UK CAA have confirmed that they would be available to engage directly with the IAA/AirNav Ireland. This would bring to bear the extensive working knowledge of Radar Surveillance Management and Policy adopted by the UK CAA in addressing operating radar systems in proximity to wind farms in the UK.

This Aviation Response Statement and associated appendices confirms that:

- Ballycar Wind Farm will not result in radar beam deflections on the Woodcock Hill Radar.
- Ballycar Wind Farm will not result in radar beam reflections (following optimisation if required) on the Woodcock Hill Radar.
- Shadowing from the Ballycar Wind Farm will extend for a maximum of 3.6km beyond the wind farm, with the height of the shadow region below minimum flying altitudes.

- Ballycar Wind Farm will not result in any impacts to en-route aircraft and will not impact Woodcock Hill Radar compliance with EU mandated surveillance performance criteria required to support 5 Nautical Mile horizontal separation of aircraft in En-Route Irish airspace and 3 Nautical Mile horizontal separation of aircraft in Dublin airspace.

Appendix 1

Ballycar Wind Farm Aviation Technical Assessment

Ballycar Wind Farm Aviation Technical Assessment

Greensource Limited

05 November 2021

CL-5715-RPT-002 V1.0

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Executive Summary

Cyrrus Limited has been engaged by Malachy Walsh and Partners to undertake an Aviation Study for the proposed Ballycar Wind Farm development in County Clare in the West of Ireland. The proposal comprises 12 wind turbines with a maximum tip height of up to 156.5m Above Ground Level.

An assessment of the Building Restricted Areas associated with the Instrument Landing Systems and Distance Measuring Equipment installed at Shannon Airport shows that the proposed turbines will have no impact on these navigation facilities.

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 11 of the 12 proposed turbines;
- There is a high probability that Shannon PSR will detect turbines T1 to T9 and turbines T11 and T12, leading to turbine-induced clutter and false targets, and track seduction of aircraft targets;
- It is unlikely that Shannon PSR will detect turbine T10;
- 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 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 12 proposed turbine towers;
- Aircraft between 5,250m and 10,536m from the proposed turbines may respond to bistatic reflections from these turbine towers, resulting in false targets on the bearings of the turbines;
- Provided the MSSR reflector file is updated with the turbine positions, the MSSR should be able to process out false targets caused by reflections from the turbine towers;
- The maximum heights of shadow regions from the turbines will be below published Air Traffic Control surveillance minimum altitudes and should therefore be operationally tolerable.

It is recommended that mitigation options are discussed with the Irish Aviation Authority (IAA), specifically Air Traffic Services. It is the surveillance network and operational use that will largely influence a suitable mitigation.

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
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
BRA	Building Restricted Area
CFAR	Constant False Alarm Rate
DME	Distance Measuring Equipment
DOC	Designated Operational Coverage
DTM	Digital Terrain Model
ICAO	International Civil Aviation Organisation
ILS	Instrument Landing System
MSSR	Monopulse Secondary Surveillance Radar
MWP	Malachy Walsh and Partners
NM	Nautical Miles
PD	Probability of Detection
PSR	Primary Surveillance Radar
RCS	Radar Cross Section
RLoS	Radar Line of Sight
RPM	Revolutions Per Minute
TMZ	Transponder Mandatory Zone
VPD	Vertical Polar Diagram

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1. Introduction

1.1. Overview

1.1.1. A new wind farm development, Ballycar Wind Farm, is being proposed in County Clare in the West of Ireland. The proposed development is planned to comprise 12 wind turbines with a maximum tip height of up to 156.5m Above Ground Level (AGL).

1.2. Aviation Study

1.2.1. Cyrrus Limited has been engaged by Malachy Walsh and Partners (MWP), on behalf of Greensource Limited, to undertake an Aviation Study for the development.

1.2.2. This report is concerned with the possible impacts the turbines may have on aviation navigation and surveillance facilities and includes an assessment of the Instrument Landing System (ILS) and combined Primary Surveillance Radar/Monopulse Secondary Surveillance Radar (PSR/MSSR) installations at Shannon Airport, and the MSSR at Woodcock Hill.

1.2.3. A review of the Building Restricted Areas (BRAs) that safeguard the ILS Localiser, Glidepath and Distance Measuring Equipment (DME) facilities at Shannon Airport will be used to determine the likelihood of any impact from the turbines.

1.2.4. 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 v23.4.2 x64;
- Global Mapper v21.1;
- ZWCAD+ 2015 SP1 Pro v2014.11.27(26199).

2.2. Terrain Data

- ATDI 20m Digital Terrain Model (DTM), 2020, Irish Grid projection.

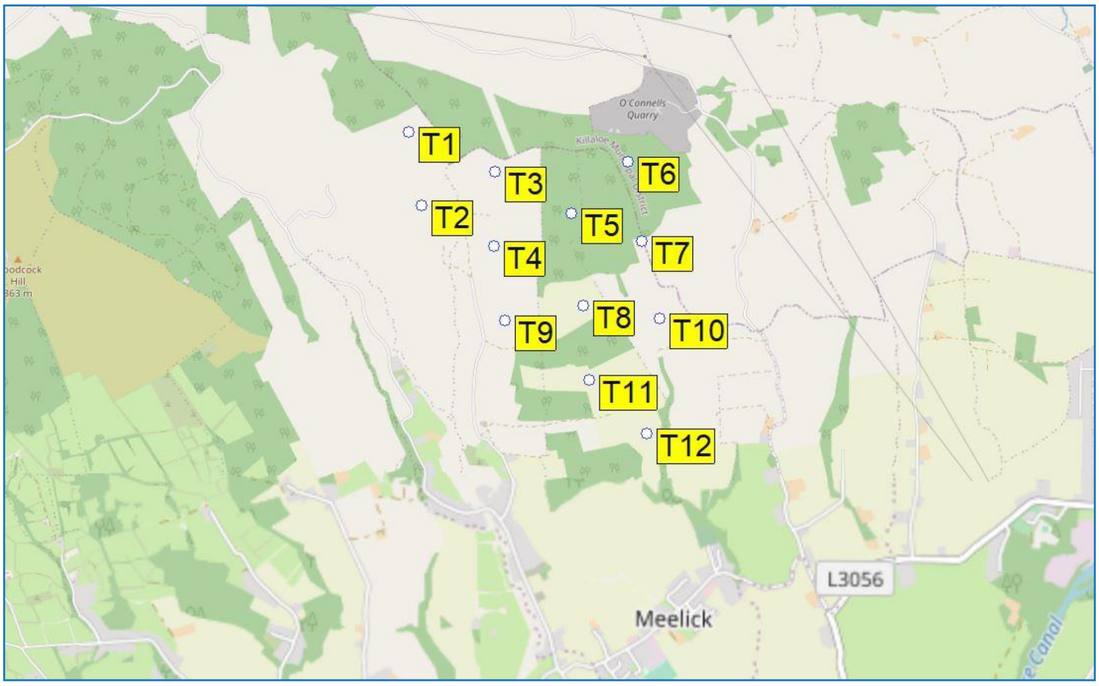
2.3. Data Provided by the Client

- 22156-MWP-00-00-SK-C-0003-P01 Site Location.pdf;
- Turbine Layout 2021-09-29.xls.

3. Development

3.1. Location

3.1.1. The indicative 12 turbine layout used for the modelling is shown in Figure 1.



© OpenStreetMap contributors

Figure 1: Indicative turbine layout

3.2. Turbine Data

3.2.1. Turbine T10 has a planned hub height of 83m AGL and blade length of 66.5m, to give a tip height of 149.5m AGL.

3.2.2. The other turbines have a planned hub height of 90m AGL and blade length of 66.5m, to give a tip height of 156.5m AGL.

3.2.3. Location data for the 12 proposed turbines has been supplied by MWP. The Irish Transverse Mercator grid coordinates for each turbine are presented in Table 1, together with each site elevation Above Mean Sea Level (AMSL).

Turbine ID	Easting (m)	Northing (m)	Site Elevation AMSL (m)
T01	554531.3	664275.1	234
T02	554604.7	663847.3	207
T03	555029.9	664043.7	238
T04	555027.2	663611.2	198

Turbine ID	Easting (m)	Northing (m)	Site Elevation AMSL (m)
T05	555475.6	663803.6	243
T06	555804.8	664103.9	254
T07	555885.7	663643.1	198
T08	555546.9	663267.0	160
T09	555090.4	663180.2	166
T10	555989.9	663191.0	124
T11	555582.0	662836.6	113
T12	555912.5	662520.8	77

Table 1: Turbine location data

4. ILS Assessment

4.1. Locations of Turbines and Shannon Airport

4.1.1. The closest turbine within the proposed development lies approximately 17.3km east of the centre of the main runway at Shannon Airport, as shown in Figure 2.

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Figure 2: Locations of turbines and Shannon Airport

4.2. Building Restricted Areas

4.2.1. The navigation facilities under consideration at Shannon Airport are the ILS Localisers, Glidepaths and DMEs that provide guidance for aircraft landing on runways 06 and 24. The minimum safeguarded areas for these facilities are defined by the International Civil Aviation Organisation (ICAO) in the document ICAO EUR DOC 015[1].

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

4.2.2. Figure 3 shows an example of the BRA shape for directional facilities such as ILS Localisers, Glidepaths and DMEs, as depicted in ICAO EUR DOC 015 Figures 3.1, 3.2, 3.3 and 3.4.

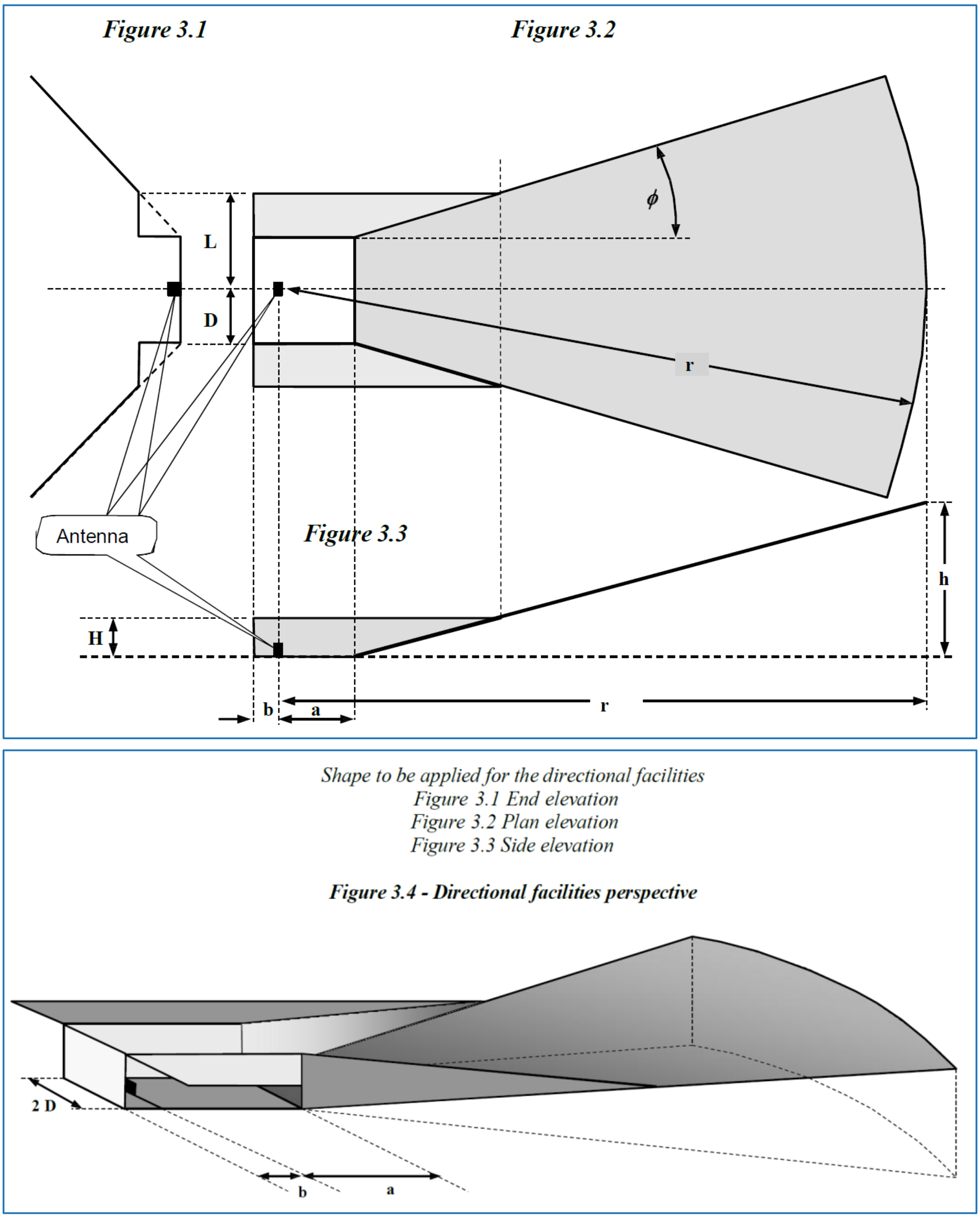


Figure 3: ICAO EUR DOC 015 Figures 3.1-3.4 – BRA shape for directional facilities

4.2.3. Applicable dimensions to be applied for the various directional navigation facilities are reproduced in Figure 4.

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

Figure 4: ICAO EUR DOC 015 Table 2 – Harmonised guidance figures for directional navigation facilities

4.2.4. The purpose of the safeguarded areas is to identify developments with the potential for causing unacceptable interference to navigation facilities. Developments that infringe a safeguarded area must undergo technical assessments to determine the degree of interference, if any, and whether the interference will be acceptable to the Airport operator.

4.2.5. The ILS Localiser, Glidepath and DME safeguarded areas for runways 06 and 24 are shown in Figure 5 and Table 2.

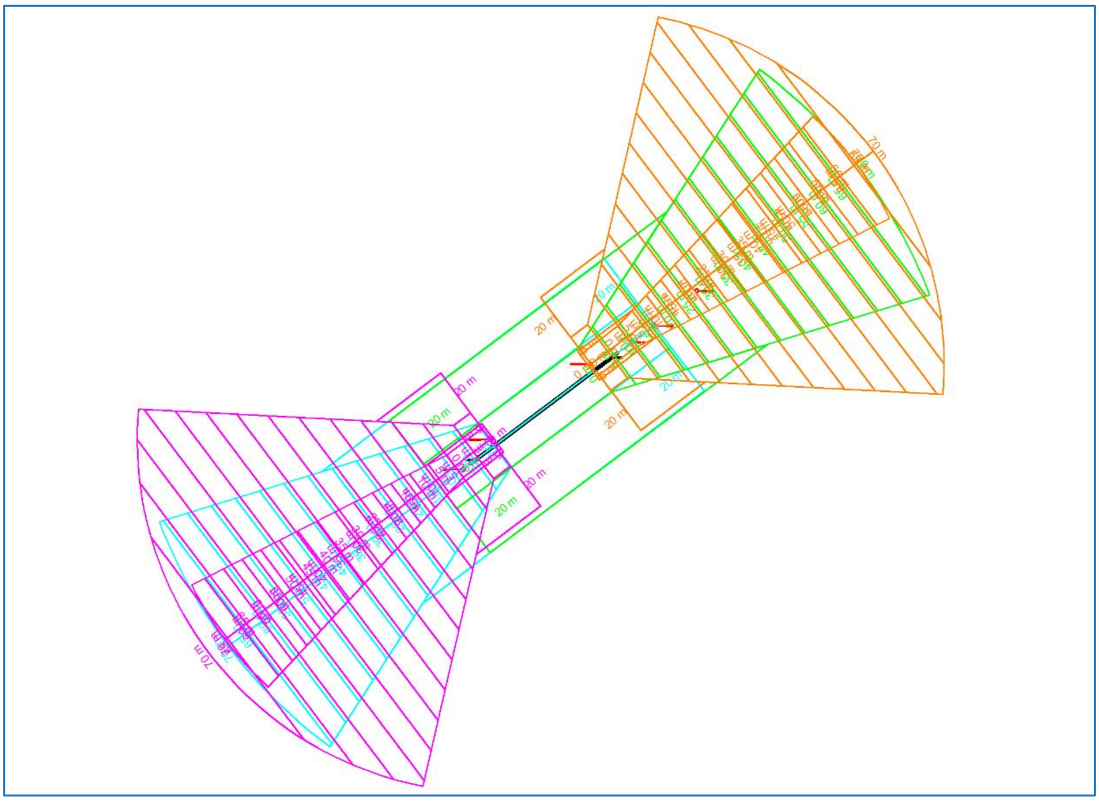


Figure 5: ILS safeguarded areas at Shannon Airport

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

Table 2 - Safeguarded areas colour reference

4.2.6. The same safeguarded areas are shown in Figure 6 relative to the proposed turbines.

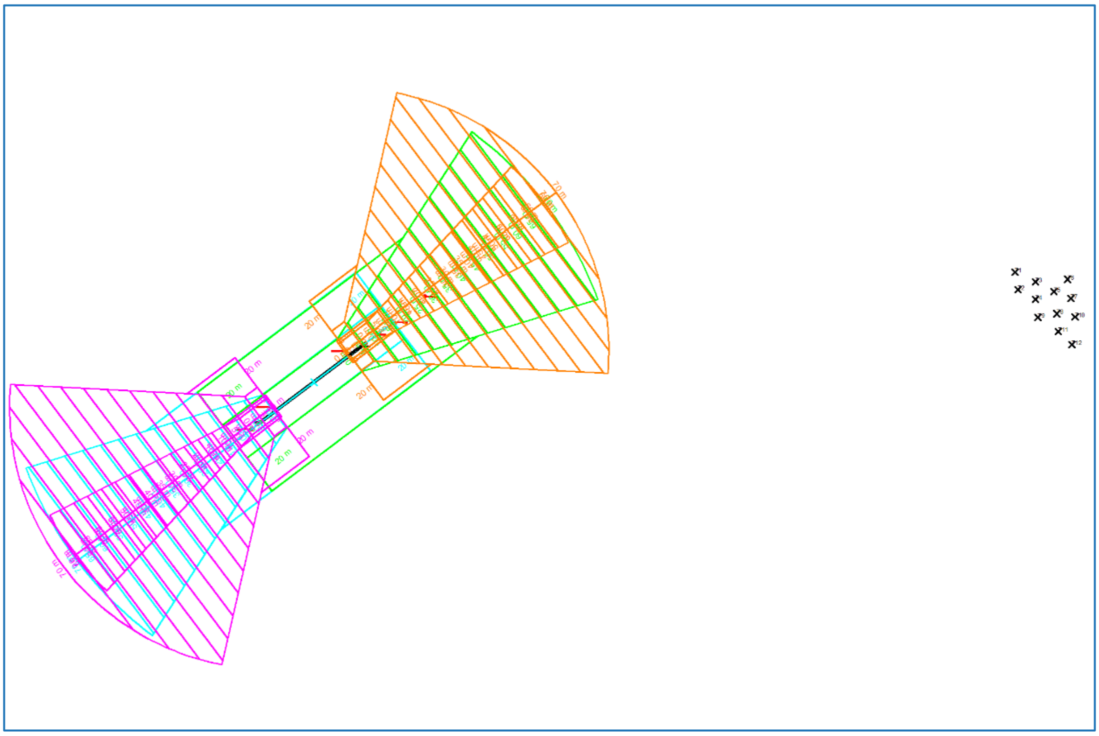


Figure 6: ILS safeguarded areas relative to proposed turbines

4.2.7. The proposed turbines lie outside the ILS safeguarded areas and will have no impact on ILS signals. No further technical assessment for the ILS facilities at Shannon Airport is required.

5. Radar Assessment

5.1. Potential Impact of Wind Turbines on PSR

5.1.1. 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.

5.1.2. 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'.

5.1.3. 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.

5.1.4. 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.

5.1.5. 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.

5.2. Potential Impact of Wind Turbines on MSSR

5.2.1. 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.

5.2.2. 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.

5.2.3. 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.

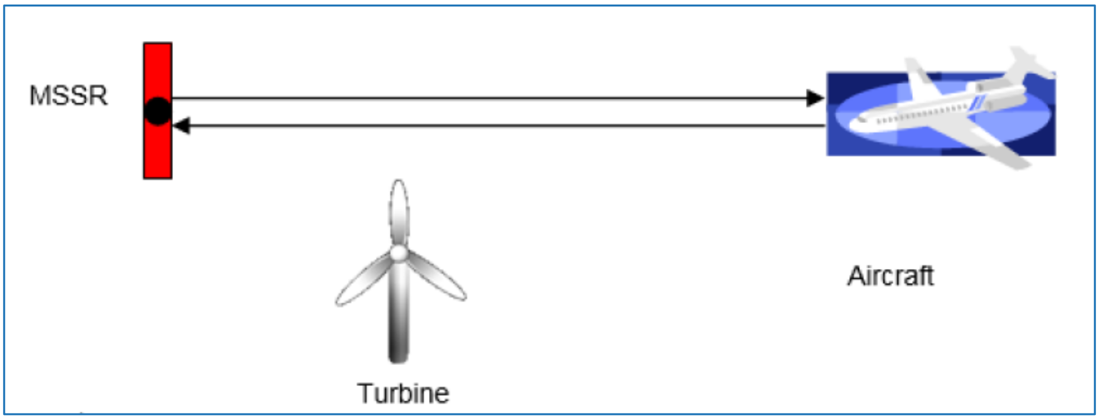


Figure 7: Direct interrogation and reply pulses

5.2.4. In Figure 7, 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.

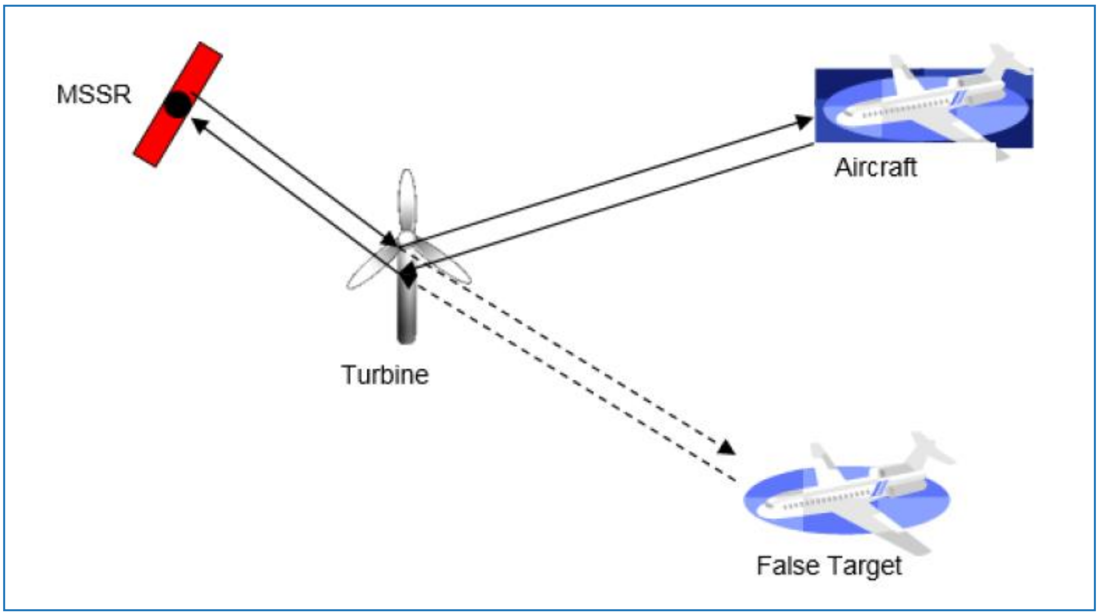


Figure 8: Reflected interrogation and reply pulse

5.2.5. In Figure 8, the MSSR beam illuminates a wind turbine which reflects the interrogation to an aircraft on a different bearing. The aircraft transponder replies, and this is received by the radar via the turbine. The radar processes this as a false target on the bearing of the wind turbine and at a distance proportional to the path length, which is slightly longer than the direct path length.

5.2.6. 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.

5.3. Shannon Airport Radar

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

5.3.2. 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.

5.3.3. The MSSR model is a Thales RSM 970 S. It meets the current standard of MSSR capability to the European Mode S Functional Specification[2] and has an instrumented range of 256NM.

Image © 2021 Google © 2021 Europa Technologies

Figure 9: Shannon PSR/MSSR

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

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

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

5.3.6. The location of Shannon PSR/MSSR is shown in Figure 10.

© OpenStreetMap contributors

Figure 10: Location of Shannon PSR/MSSR

5.4. Woodcock Hill Radar

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

Image © 2021 Google

Figure 11: Woodcock Hill MSSR

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

5.4.3. The MSSR antenna height is 10m AGL.

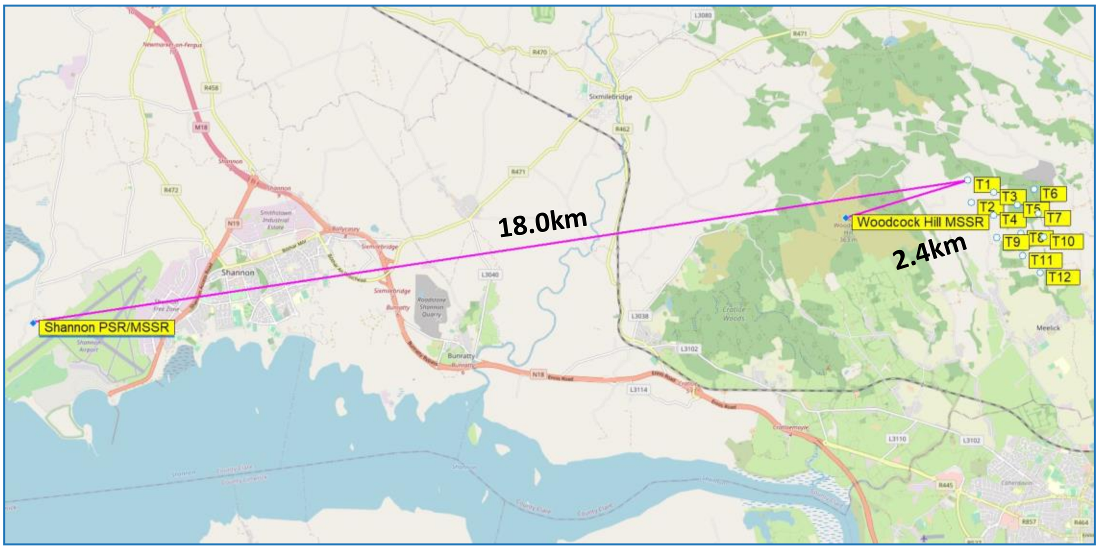
5.4.4. The location of Woodcock Hill MSSR is shown in Figure 12.

© OpenStreetMap contributors

Figure 12: Location of Woodcock Hill MSSR

5.5. Locations of Turbines and Radars

5.5.1. The relative locations of the proposed turbines and the radars at Shannon Airport and Woodcock Hill are shown in Figure 13.



© OpenStreetMap contributors

Figure 13: Locations of radars and proposed turbines

5.5.2. The closest proposed turbine within Ballycar Wind Farm (T1) is 18.0km from the Shannon PSR/MSSR, and 2.4km from Woodcock Hill MSSR.

5.5.3. In accordance with Eurocontrol Guidelines[3], 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.

5.6. Radar Line of Sight Modelling

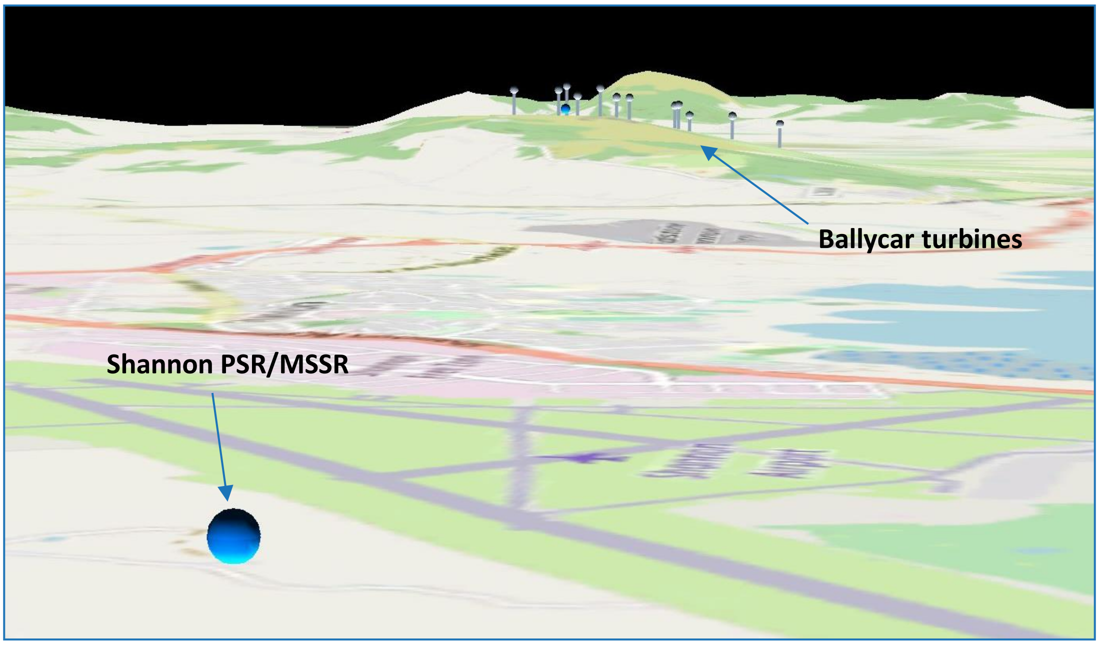
5.6.1. RLoS is determined from a radar propagation model (ATDI HTZ communications) using 3D DTM data with a 20m horizontal resolution. Radar data is entered into the model and RLoS to the turbines from the radars is calculated.

5.6.2. 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.

5.6.3. 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. 156.5m AGL.

5.6.4. 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. 90m AGL.

5.6.5. A 3D view of the turbines and the terrain model, as viewed from Shannon PSR/MSSR, is shown in Figure 14.

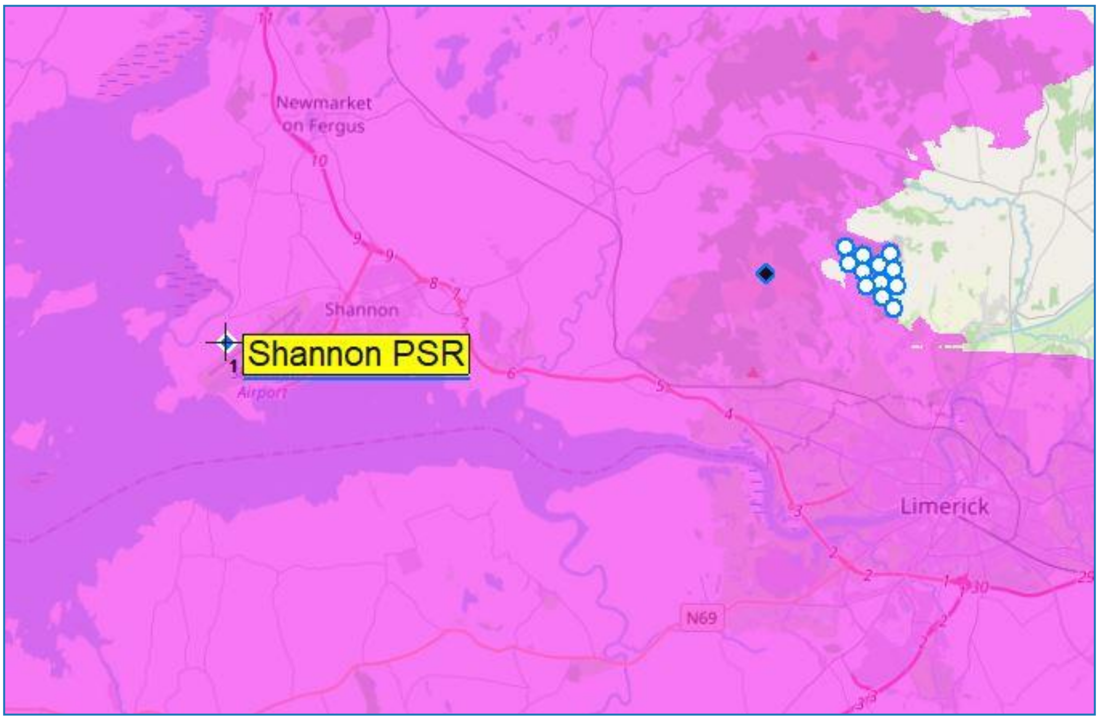


© OpenStreetMap contributors

Figure 14: 3D view from Shannon PSR/MSSR towards turbines

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

5.6.6. The magenta shading in Figure 15 illustrates the RLoS coverage from Shannon PSR to turbines with a blade tip height of 156.5m AGL.



© OpenStreetMap contributors

Figure 15: Shannon PSR RLoS to 156.5m AGL

5.6.7. A zoomed view of the RLoS coverage in the vicinity of the proposed turbines is shown in Figure 16.

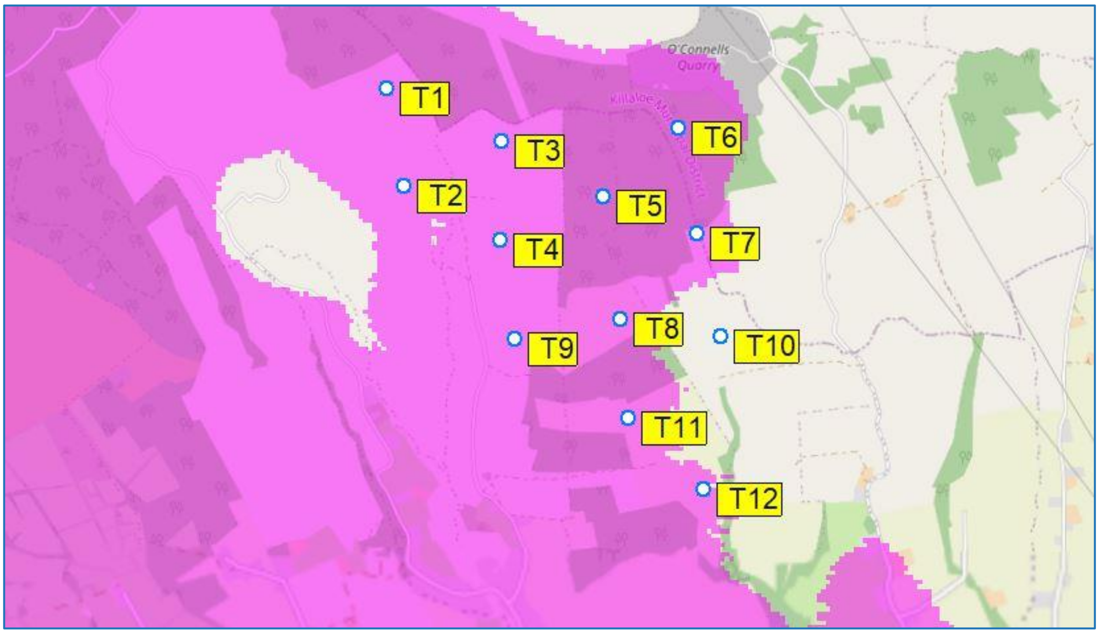


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Figure 16: Shannon PSR RLoS to 156.5m AGL – zoomed

5.6.8. The magenta shading indicates that RLoS exists between Shannon PSR and all the turbines except turbine T10 in the indicative layout. The planned turbine T10 tip height is 149.5m AGL. RLoS will not exist between Shannon PSR and turbine T10 at the lower tip height.

5.6.9. Where RLoS exists it can be assumed that the PSR will detect the turbines, and where there is no RLoS it can generally be assumed that the turbine will not be detected. However, this can only be confirmed by analysing the path profiles between the PSR and each turbine and calculating the PD using known PSR parameters. This is undertaken in Section 5.7.

5.6.10. A 3D view of the turbines and the terrain model, as viewed from Woodcock Hill MSSR, is shown in Figure 17.

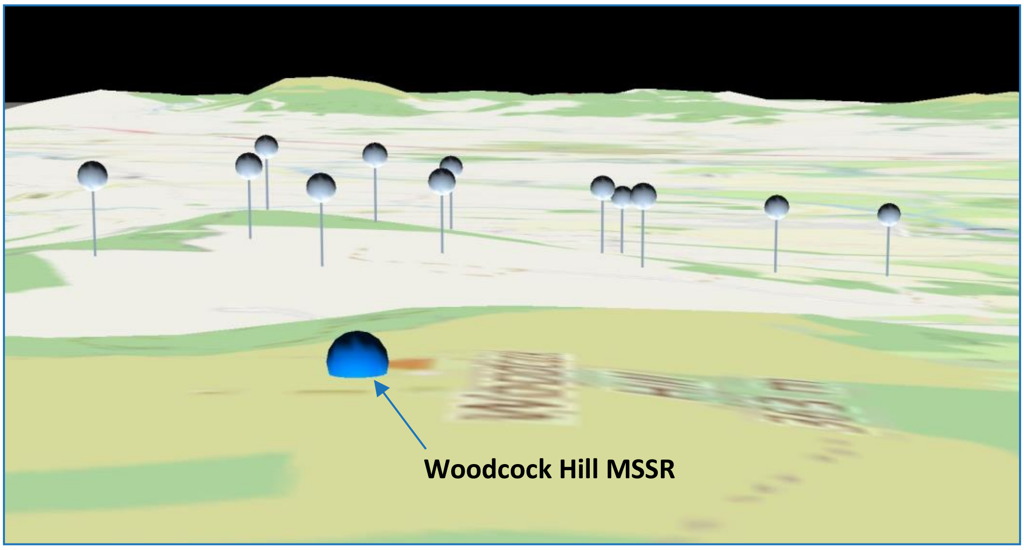

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Figure 17: 3D view from Woodcock Hill MSSR towards turbines

5.6.11. The magenta shading in Figure 18 illustrates the RLoS coverage from Woodcock Hill MSSR to turbines with a tower hub height of 90m AGL.

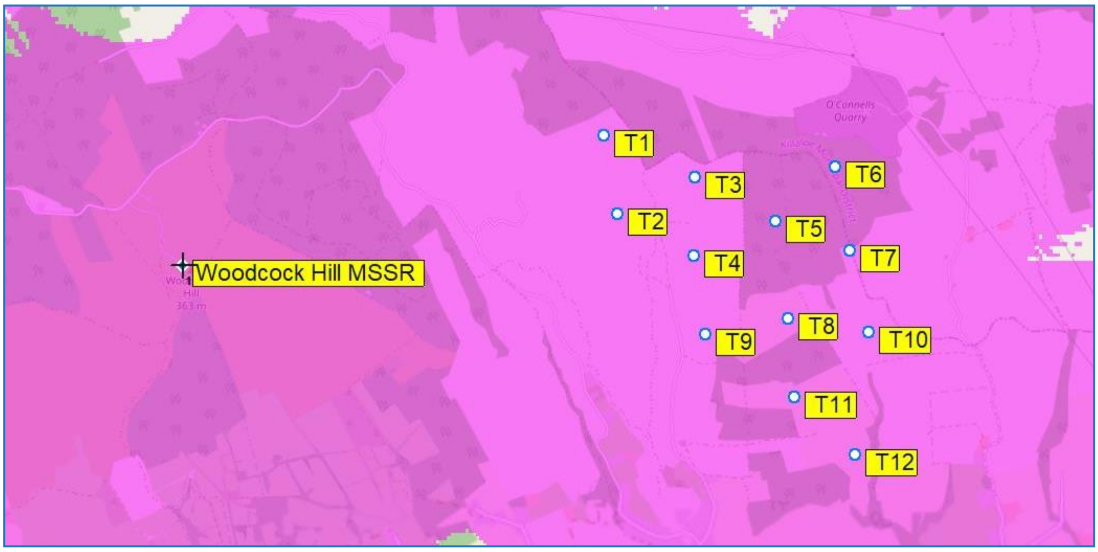

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Figure 18: Woodcock Hill MSSR RLoS to 90m AGL

5.6.12. RLoS at 90m AGL exists between Woodcock Hill MSSR and all the turbines in the indicative layout.

5.6.13. To account for the reduced T10 hub height, RLoS coverage at 83m AGL is shown in Figure 19.

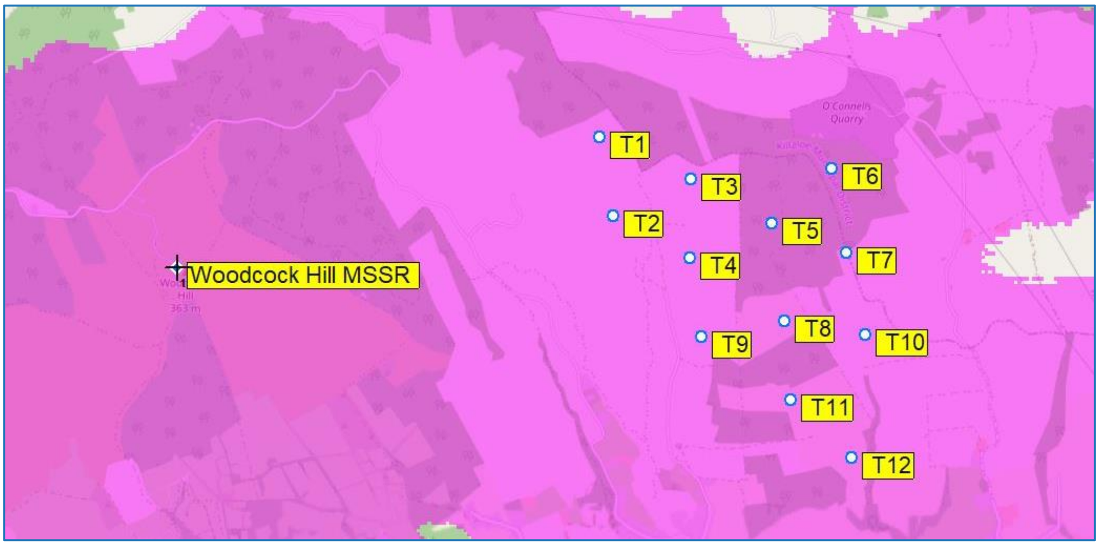

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Figure 19: Woodcock Hill MSSR RLoS to 83m AGL

5.6.14. RLoS between Woodcock Hill MSSR and turbine T10 still exists at the reduced hub height of 83m AGL.

5.7. Shannon PSR Path Loss and Probability of Detection

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

5.7.2. An illustration of the path loss profile between Shannon PSR and the tip of turbine T1 is shown in Figure 20. Shannon PSR has uninterrupted RLoS to the turbine tip.

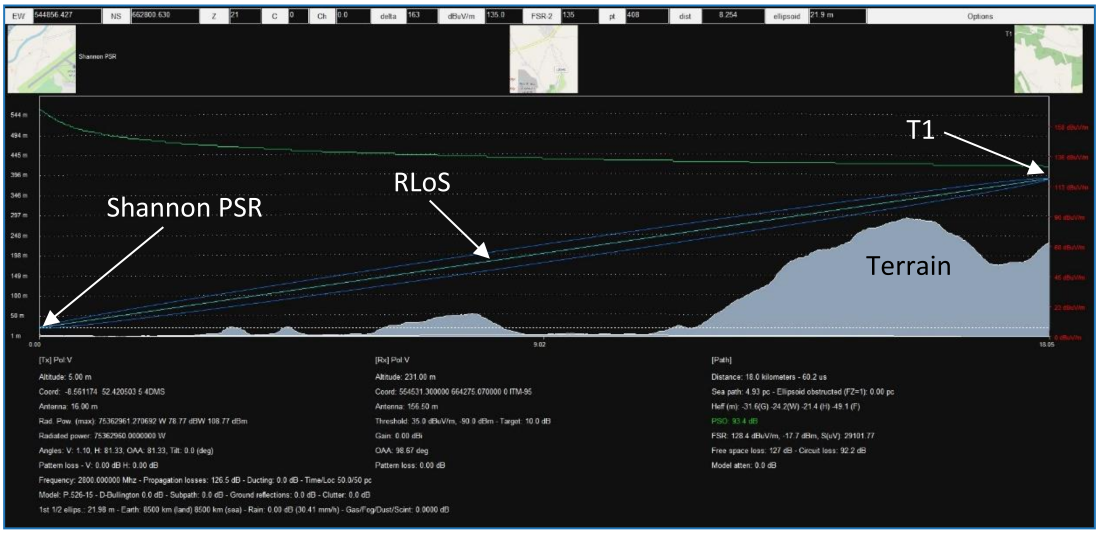


Figure 20: Path loss profile between Shannon PSR and tip of turbine T1

5.7.3. The path loss profile between Shannon PSR and the tip of turbine T10 is shown in Figure 21. In this case there is intervening terrain which blocks RLoS.

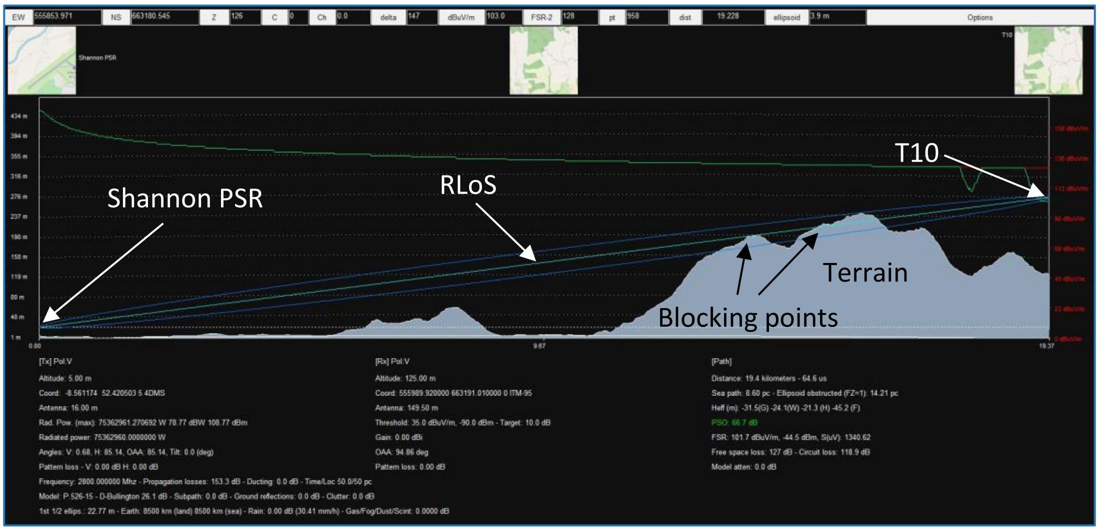


Figure 21: Path loss profile between Shannon PSR and tip of turbine T10

5.7.4. All the path profiles between Shannon PSR and the 12 Ballycar turbines are shown in Annex A of this report.

5.7.5. 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.

5.7.6. 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.

5.7.7. 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 $50m^2$ based on a blade length of 66.5m. 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.

5.7.8. 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 ($60m^2$ ~ +47dB)
-	Path Loss	dB
+	Antenna Gain	dB
=	Received Signal	dBm

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

5.7.10. An example of the calculation from Shannon PSR to turbine T1 is shown in Figure 22.

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	50	m^2
Path Loss (1-way)	126.5	dB
Calculations		
Tx Wavelength	0.11	m
Tx power	74.47158	dBm
EIRP	108.4716	dBm
Power at Target	-18.02842	dBm
RCS Gain	47.39	dB
Power at Rx	-63.14	dBm
dB over Rx Threshold	61.86	dB

Figure 22: Example path loss calculation

5.7.11. 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.

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

5.7.13. The results of the Shannon PSR PD calculations for each turbine are shown in Table 3.

Initial data from '2-Way'			KEY:	Unlikely to be detected
A	**126.5**	Path Loss		Small possibility of detection
B	**61.86**	dB over Rx Thr		Possibility of detection
C	**50.00**	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	152.2	126.5	126.5	**64.87**
2	161.4	151.1	126.5	**61.86**
3	155.1	130.2	126.7	**62.25**
4	160.1	148.3	126.7	**61.46**
5	154.5	130.0	126.9	**62.00**
6	152.6	127.1	127.1	**63.67**
7	160.6	152.0	127.1	**60.66**
8	160.5	150.6	126.9	**61.06**
9	158.0	139.9	126.7	**61.47**
10	165.5	161.3	153.3	**8.39**
11	161.6	152.7	126.9	**61.06**
12	162.5	155.5	137.0	**40.86**

Table 3: Shannon PSR PD results

5.7.14. From Table 3 it appears that there is a high probability that Shannon PSR will detect all the Ballycar turbines.

5.7.15. 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.

5.7.16. 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.

5.7.17. The maximum high beam gain for a Star 2000 antenna usually occurs at an elevation angle of 6.5° above the horizontal and the maximum low beam gain at about 3°. If the mechanical tilt of the antenna is altered, then the angles 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.

5.7.18. The Star 2000 VPD data gives the graph shown in Figure 23.

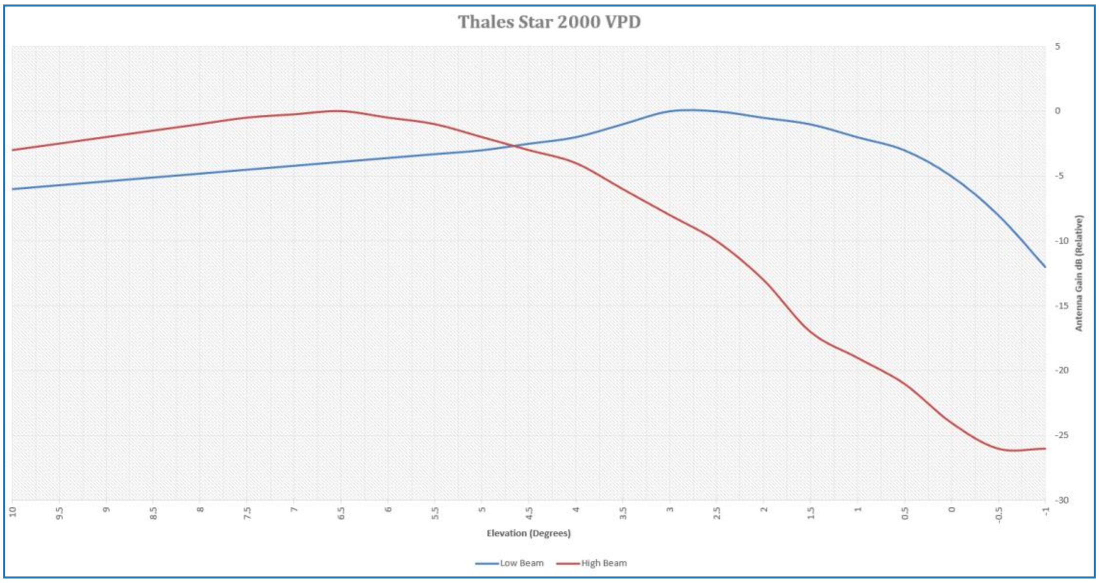


Figure 23: Thales Star 2000 VPD

5.7.19. The vertical angle from Shannon PSR to the tips of the turbines varies between 0.57° (turbine T12) and 1.10° (turbine T1). If a 0° mechanical antenna tilt is assumed, this means a high beam gain reduction of approximately -20dB and a low beam gain reduction of approximately -3dB at these elevations. Table 4 shows the results of the PD calculations incorporating the reduction in antenna gain.

Initial data from '2-Way'				
			KEY:	Unlikely to be detected
A	**126.5**	Path Loss		Small possibility of detection
B	**38.86**	dB over Rx Thr		Possibility of detection
C	**50.00**	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	152.2	126.5	126.5	**41.87**
2	161.4	151.1	126.5	**38.86**
3	155.1	130.2	126.7	**39.25**
4	160.1	148.3	126.7	**38.46**
5	154.5	130.0	126.9	**39.00**
6	152.6	127.1	127.1	**40.67**
7	160.6	152.0	127.1	**37.66**
8	160.5	150.6	126.9	**38.06**
9	158.0	139.9	126.7	**38.47**
10	165.5	161.3	153.3	**-14.61**
11	161.6	152.7	126.9	**38.06**
12	162.5	155.5	137.0	**17.86**

Table 4: Shannon PSR PD results – corrected for VPD

5.7.20. With the gain reduction, it is unlikely that Shannon PSR will detect turbine T10. However, there is still a high probability that Shannon PSR will detect the rest of the Ballycar turbines.

5.8. Woodcock Hill MSSR Path Loss

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

5.8.2. An illustration of the path loss profile between Woodcock Hill MSSR and turbine T1 is shown in Figure 24. As with all the other Ballycar turbines, Woodcock Hill MSSR has uninterrupted RLoS to the top of the turbine tower.

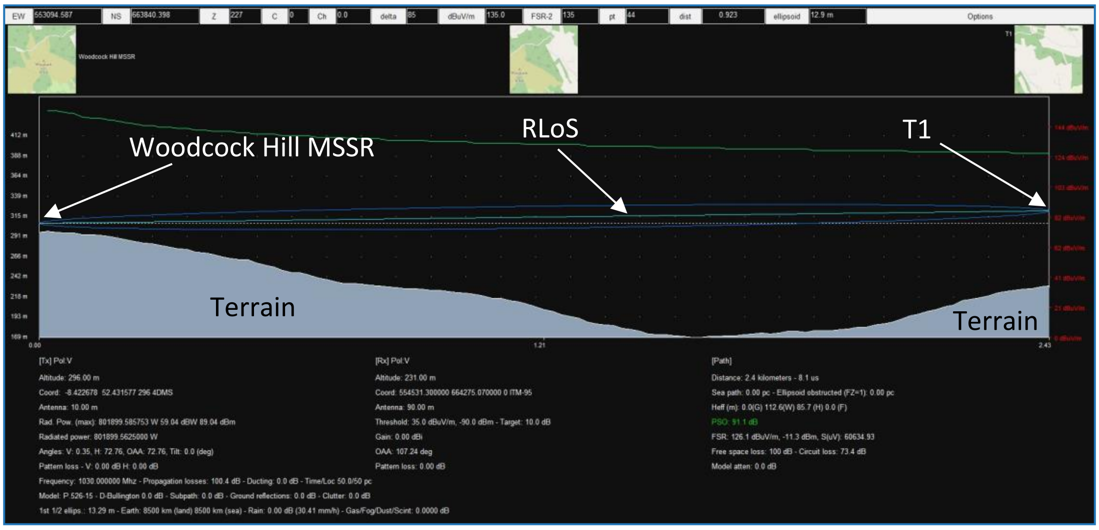


Figure 24: Path loss profile between Woodcock Hill MSSR and top of turbine tower T1

5.8.3. All the path profiles between Woodcock Hill MSSR and the 12 Ballycar turbines are shown in Annex B of this report.

5.8.4. As explained in Section 5.2, 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.

5.8.5. 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.

5.8.6. 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.

5.8.7. EUROCONTROL Guidelines[4] 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] EUROCONTROL Guidelines for Assessing the Potential Impact of Wind Turbines on Surveillance Sensors, EUROCONTROL-GUID-0130 Edition Number 1.2, September 2014

5.8.8. 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

5.8.9. 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.

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

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

5.8.12. The path loss results between Woodcock Hill MSSR and the tops of the 12 Ballycar turbine towers are shown in Table 5.

Turbine	Path Loss (dB)
T1	100.4
T2	100.4
T3	101.8
T4	101.7
T5	103.0
T6	103.9
T7	104.0
T8	103.2
T9	102.0
T10	104.3
T11	103.4
T12	104.4

Table 5: Woodcock Hill MSSR path loss results

5.8.13. From Table 5 the worst-case or smallest path loss is 100.4dB to turbines T1 and T2.

5.8.14. 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 25.

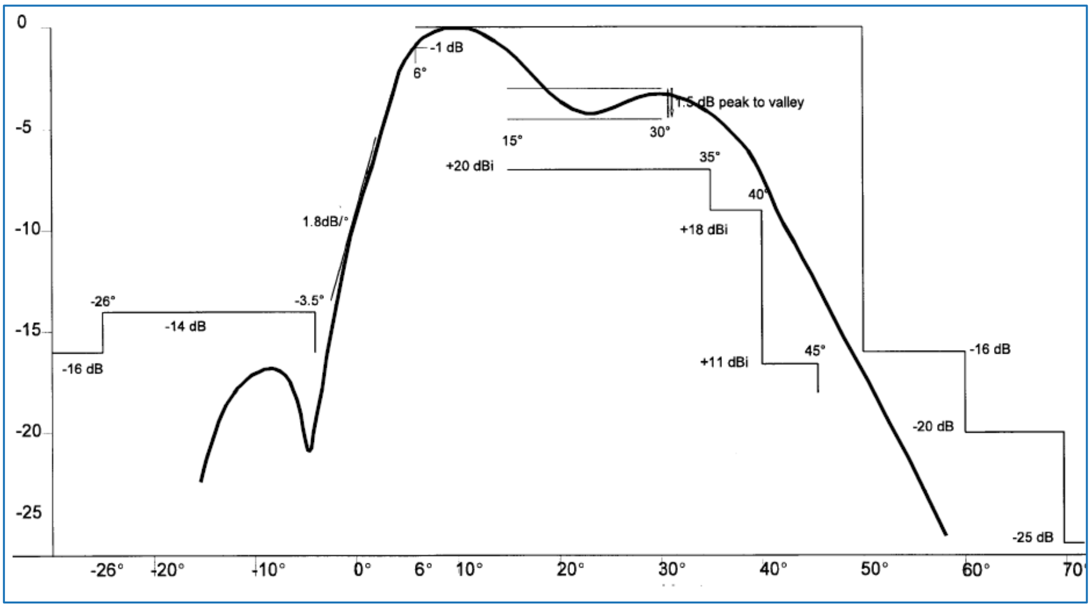


Figure 25: Thales RSM 970 S VPD

5.8.15. The vertical angle from Woodcock Hill MSSR to the hub of turbine T1 is 0.35° and to the hub of turbine T2 is -0.27°. If a mechanical tilt of 0° is assumed this means a reduction in gain of -7.5dB for T1 and -8.5dB for T2 at these elevations.

5.8.16. The T1 reduction in gain will be worst-case, and results in a reflected power of 36.2dBm from turbine T1.

5.8.17. 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+36.2=113.2dB.

5.8.18. The Free Space Path Length for an MSSR frequency of 1030MHz and path loss of 113.2dB is 10,536m. This means that aircraft beyond this distance from the turbine will not detect a reflected signal. Reflected signals from other Ballycar turbines will only be detected at ranges less than 10,536m.

5.8.19. 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 5,250m (half of the distance corresponding to 35µs) to the source of a reflected interrogation will not reply to reflected interrogations because the path length between the direct and reflected signals will always be smaller than 35µs.

5.8.20. Aircraft between 5,250m and 10,536m from the proposed turbines may respond to reflected Woodcock Hill MSSR interrogations, potentially resulting in MSSR 'ghost' targets.

5.8.21. The calculations can be repeated to determine the maximum reflection ranges for all the Ballycar turbines, as shown in Table 6.

Turbine	Maximum Reflection Range (m)
T1	10,536
T2	9,390
T3	8,967
T4	8,085
T5	7,810
T6	7,041
T7	6,204
T8	5,724
T9	6,571
T10	4,243
T11	4,443
T12	3,738

Table 6: Woodcock Hill MSSR maximum reflection ranges

5.8.22. Table 6 shows that for turbines T1 to T9 the maximum reflection range is more than 5,250m. Reflections from these turbines may result in MSSR 'ghost' targets.

5.8.23. The maximum reflection ranges for turbines T10 to T12 are less than 5,250m. An aircraft will not respond to reflected Woodcock Hill MSSR interrogations from these turbines as they will only be detected when the aircraft is within 5,250m of the turbines.

5.8.24. 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
- λ = wavelength (0.29m)
- S = diameter of support structures (6m)
- PL = acceptable power loss (0.5/3dB as per guidelines)

5.8.25. The EUROCONTROL Guidelines also provide equations for calculating the width and height of the shadow regions.

5.8.26. The volumes of the Woodcock Hill MSSR shadow regions created by each of the Ballycar turbines are shown in Table 7.

Turbine	Depth of shadow region (km)	Width of shadow region (m)	Height of shadow region AMSL (m)
T1	3.6	65	352
T2	3.6	65	285
T3	2.9	58	351
T4	3.0	59	270
T5	2.6	55	355
T6	2.4	53	370
T7	2.3	52	277
T8	2.5	54	210
T9	2.9	58	208
T10	2.3	52	147
T11	2.5	54	128
T12	2.3	52	83

Table 7: Woodcock Hill MSSR shadow regions

5.8.27. The depth of the shadow regions beyond the Ballycar turbines will vary between 2.3km and 3.6km for Woodcock Hill MSSR, with widths of up to 65m and with a maximum height of 352m or 1,155 feet AMSL.

5.8.28. Figure 26 shows an extract of Shannon Airport's ATC Surveillance Minimum Altitude Chart, as published by the Irish Aviation Authority in the current Integrated Aeronautical Information Publication[5]. The Ballycar turbine locations are overlaid on the chart, which shows that turbines T1 to T10 are within Sector 1 where the minimum altitude is 2,300 feet AMSL. Turbines T11 and T12 are in Sector 2 where the minimum altitude is 3,000 feet AMSL. Aircraft at these minimum altitudes will not be low enough for the shadow regions to have any impact, and therefore the shadow regions that may be generated beyond the proposed turbines should be operationally tolerable.

[5] ATC SURVEILLANCE MINIMUM ALTITUDE CHART – ICAO, EINN AD 2.24-16.1, 17 JUN 2021

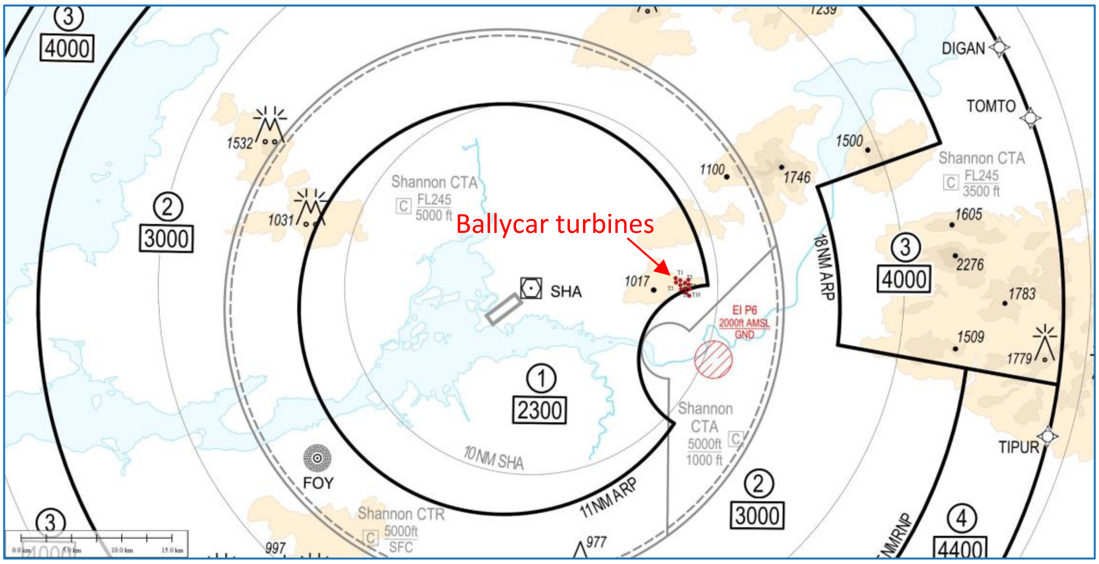


Figure 26: Shannon Airport ATC Surveillance Minimum Altitude Chart

5.9. Conclusions

5.9.1. All the proposed Ballycar turbines except turbine T10 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 Ballycar development may be required and this is discussed in Section 6.

5.9.2. All the proposed sites for the Ballycar turbines are outside the Eurocontrol recommended 16km turbine assessment zone for Shannon MSSR, therefore an impact assessment on this facility was not required. No mitigation measures are therefore necessary for Shannon MSSR.

5.9.3. Calculations have shown that false targets due to bistatic reflections from the turbine towers may occur for Woodcock Hill MSSR. Aircraft between 5,250m and 10,536m from the proposed turbines may respond to reflected Woodcock Hill MSSR interrogations, potentially resulting in MSSR 'ghost' targets appearing on the bearings of the turbines.

5.9.4. The Woodcock Hill MSSR has a reflection processing capability which enables the positions of permanent reflecting objects, such as the turbine towers, to be stored in a 'reflector file'. Once the reflector file is updated it should eliminate any false targets caused by reflections from the turbine towers.

5.9.5. The maximum heights of shadow regions from the turbines will be below the published ATC surveillance minimum altitudes and should therefore be operationally tolerable.

6. Shannon PSR Mitigation

6.1. Mitigation Strategy

6.1.1. 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.

6.1.2. It is recommended that mitigation options are discussed with the Irish Aviation Authority (IAA), specifically Air Traffic Services. It is the surveillance network and operational use that will largely influence a suitable mitigation.

6.2. Mitigation Solutions

6.2.1. 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.

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

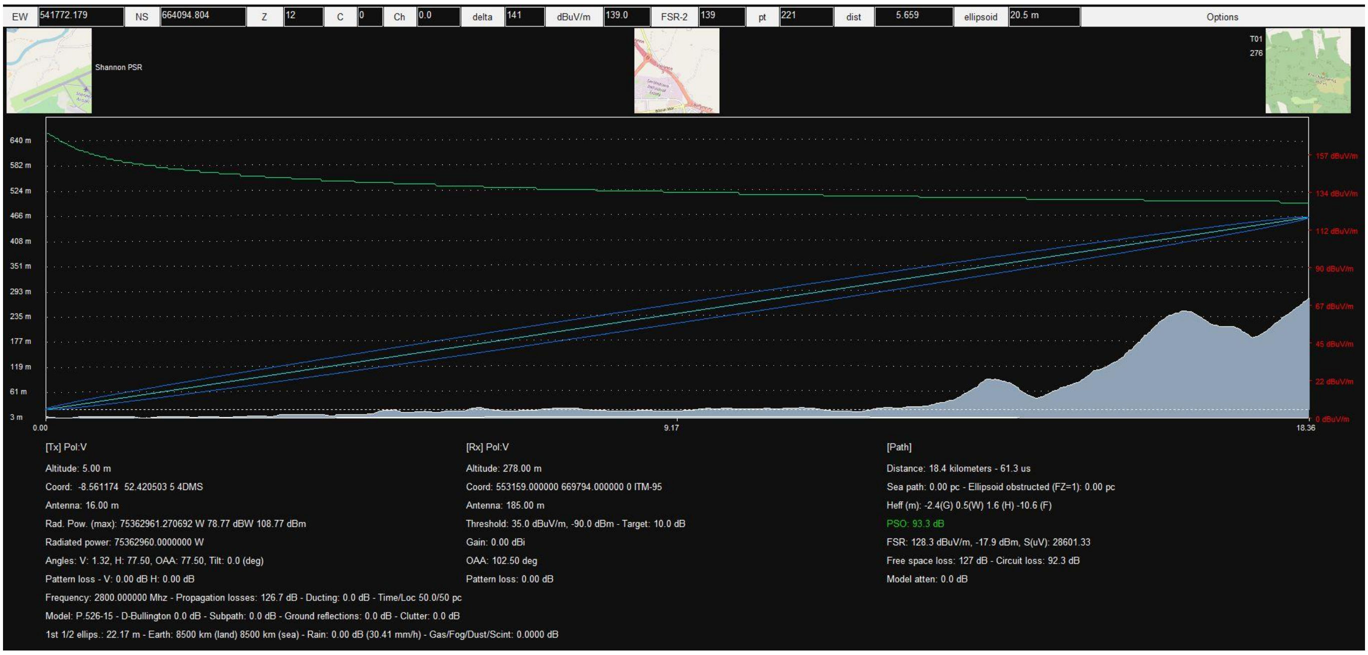
6.2.3. In-fill solutions using existing remote PSR data rely on the remote radar having suitable airspace coverage in the blanked area without having visibility of the turbines and depends on suitable terrain screening. A remote in-fill radar may also introduce problems of synchronisation with Shannon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

6.2.4. 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.

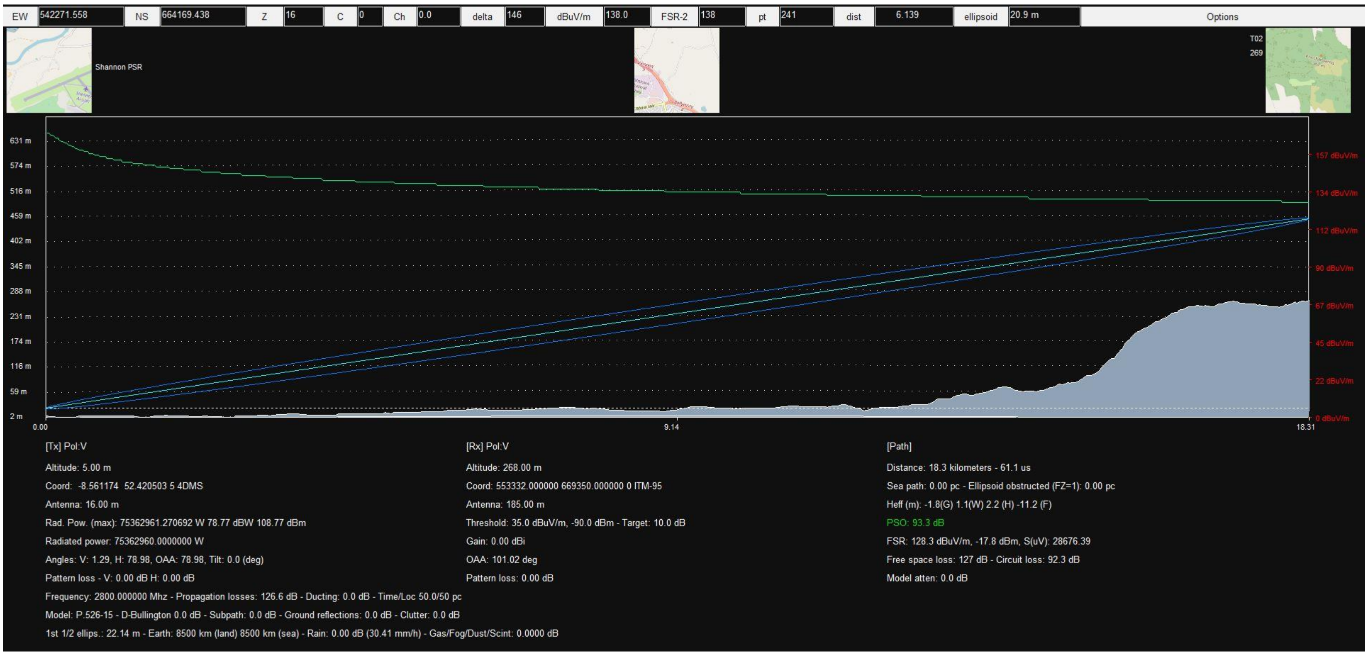
6.2.5. Aveillant offer a 3D radar mitigation solution with their Holographic Radar™. It is quite different to 2D mitigation radars as it has no rotating antenna and has continuous surveillance throughout its coverage volume. It can discriminate the distinct Doppler signatures of turbines from aircraft 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

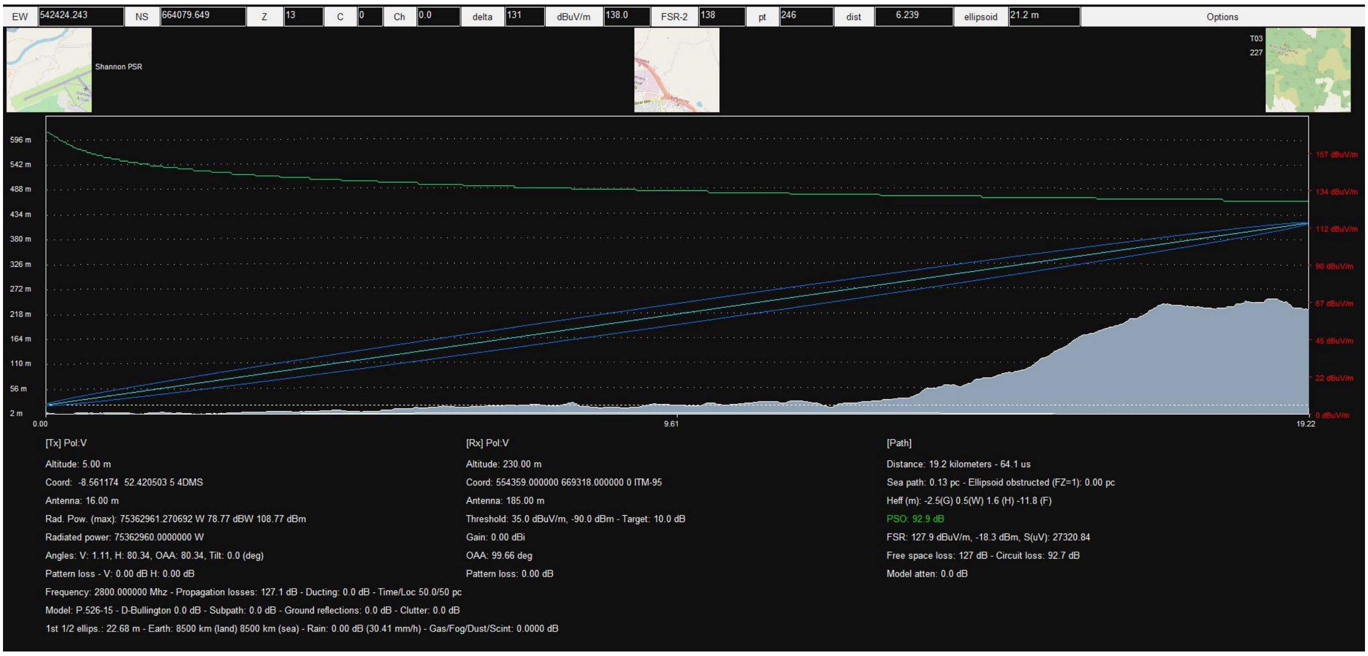
A.1. Turbine T1



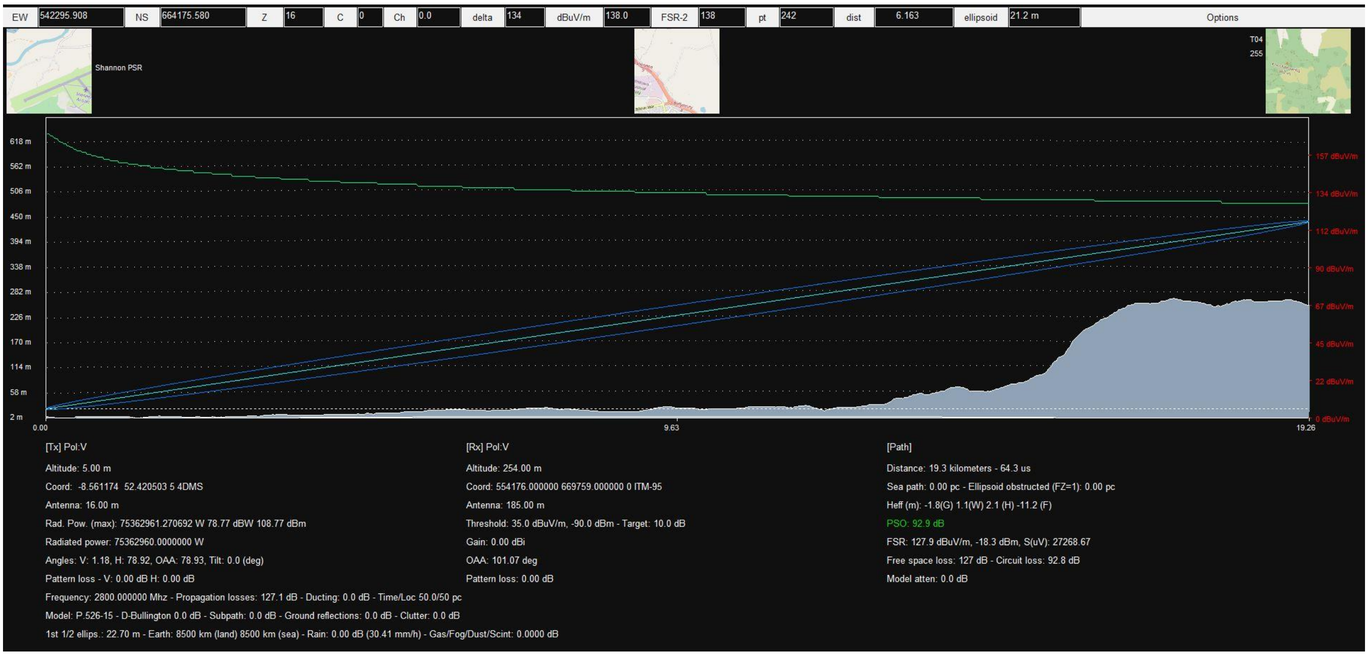
A.2. Turbine T2



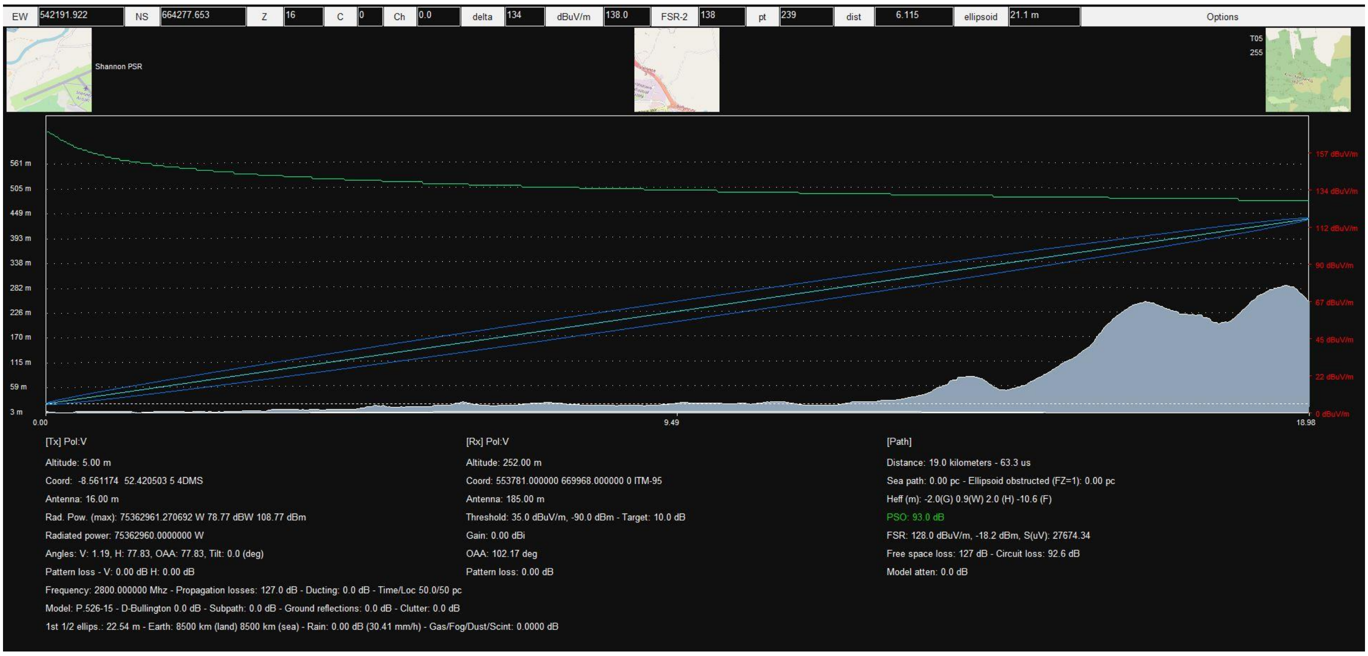
A.3. Turbine T3



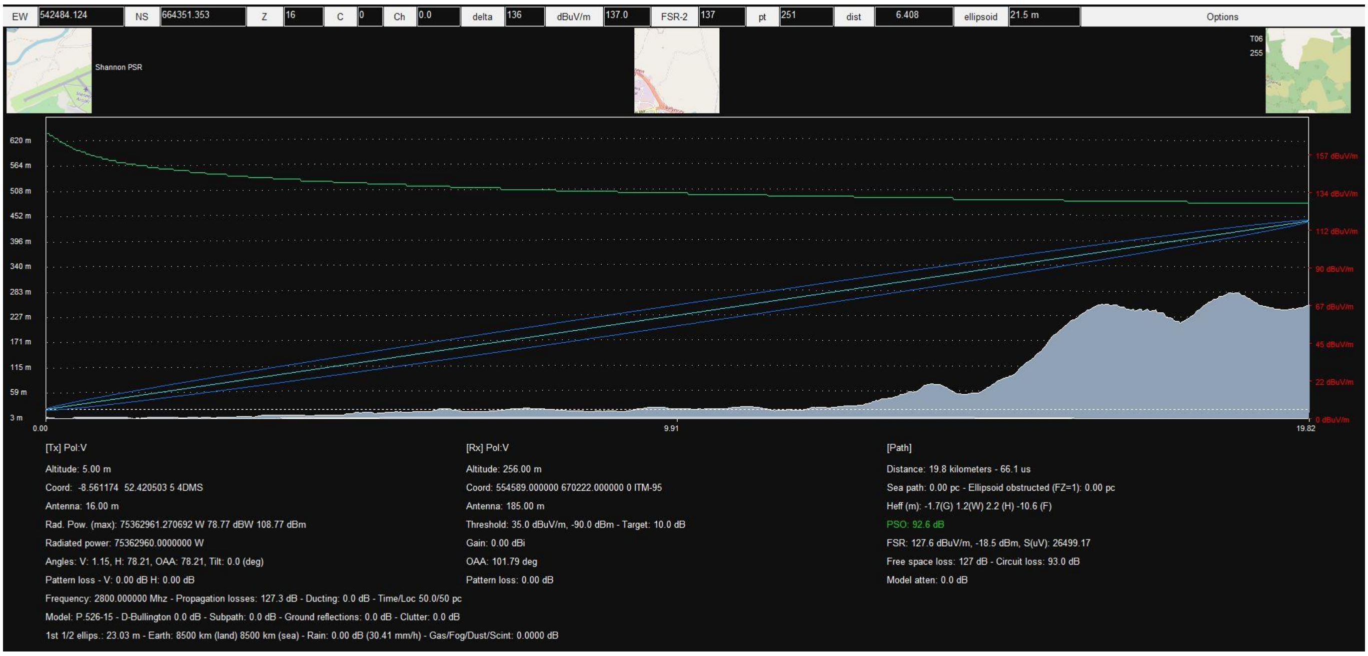
A.4. Turbine T4



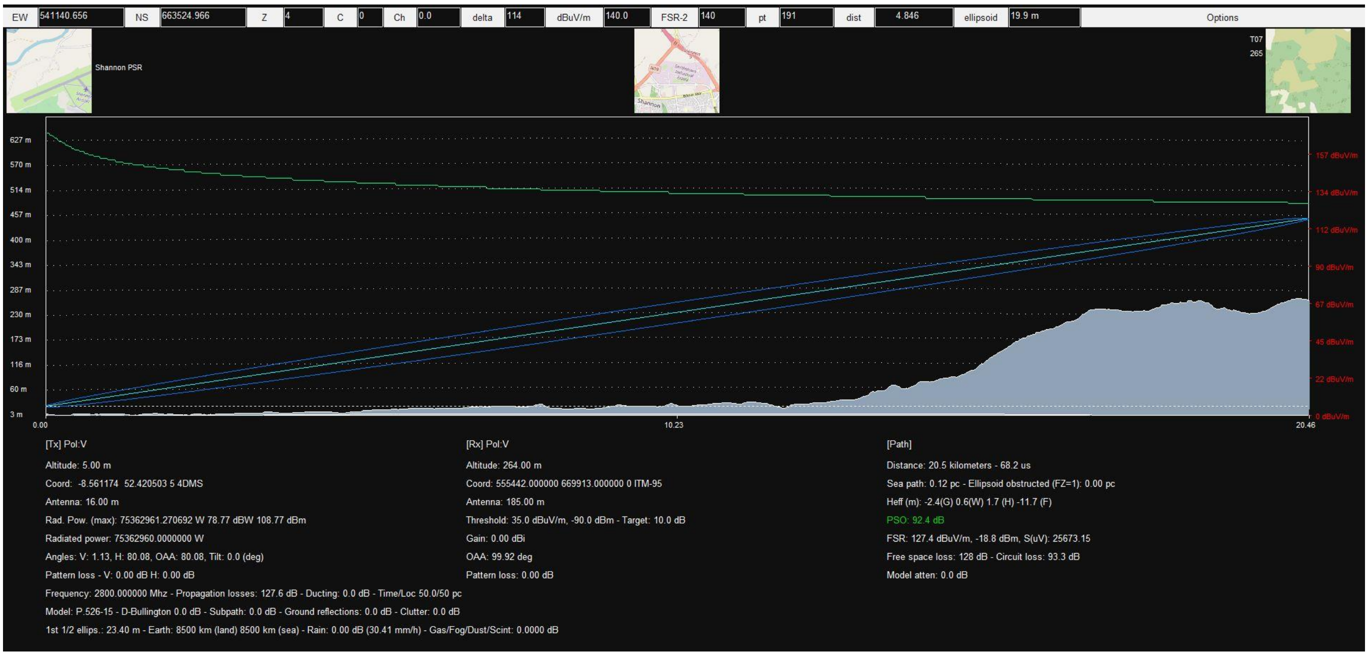
A.5. Turbine T5



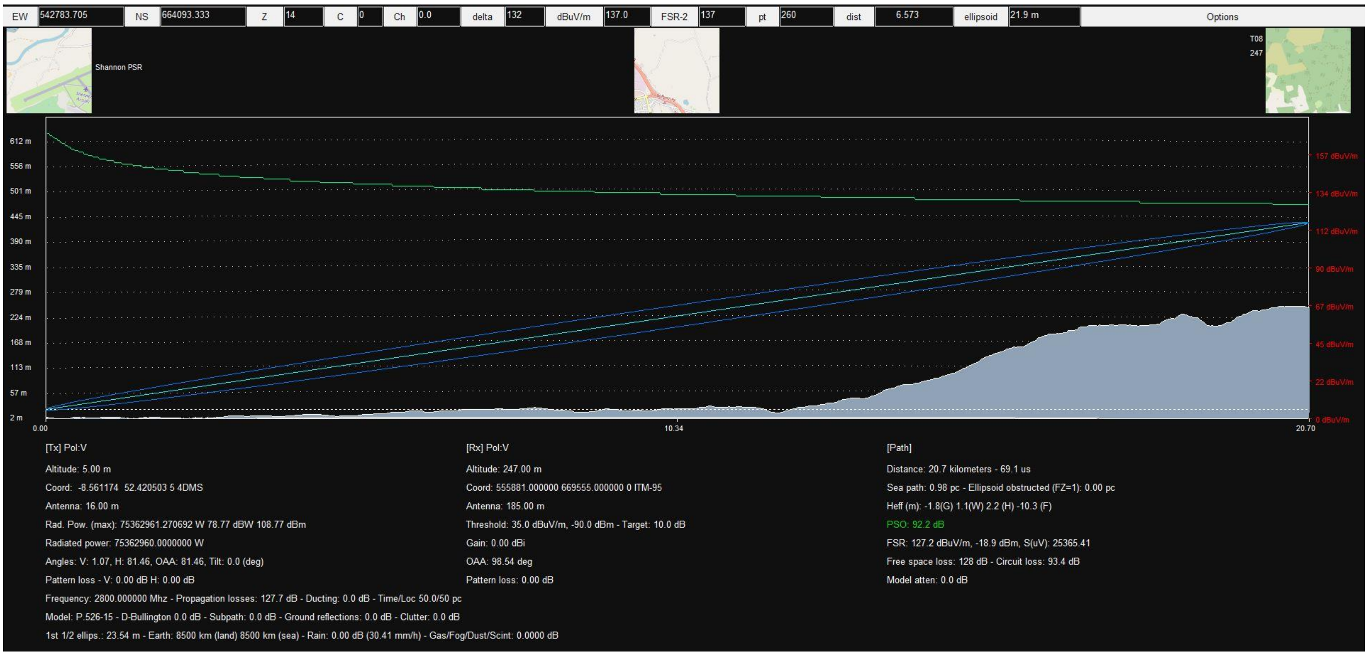
A.6. Turbine T6



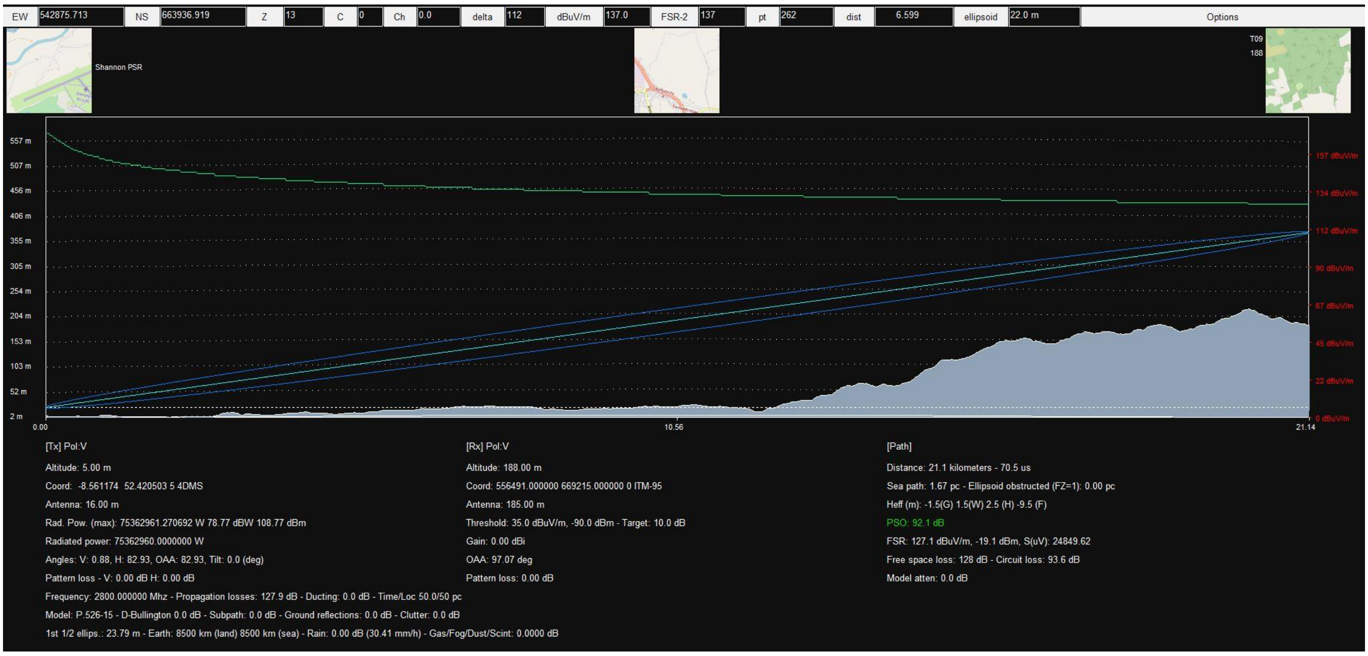
A.7. Turbine T7



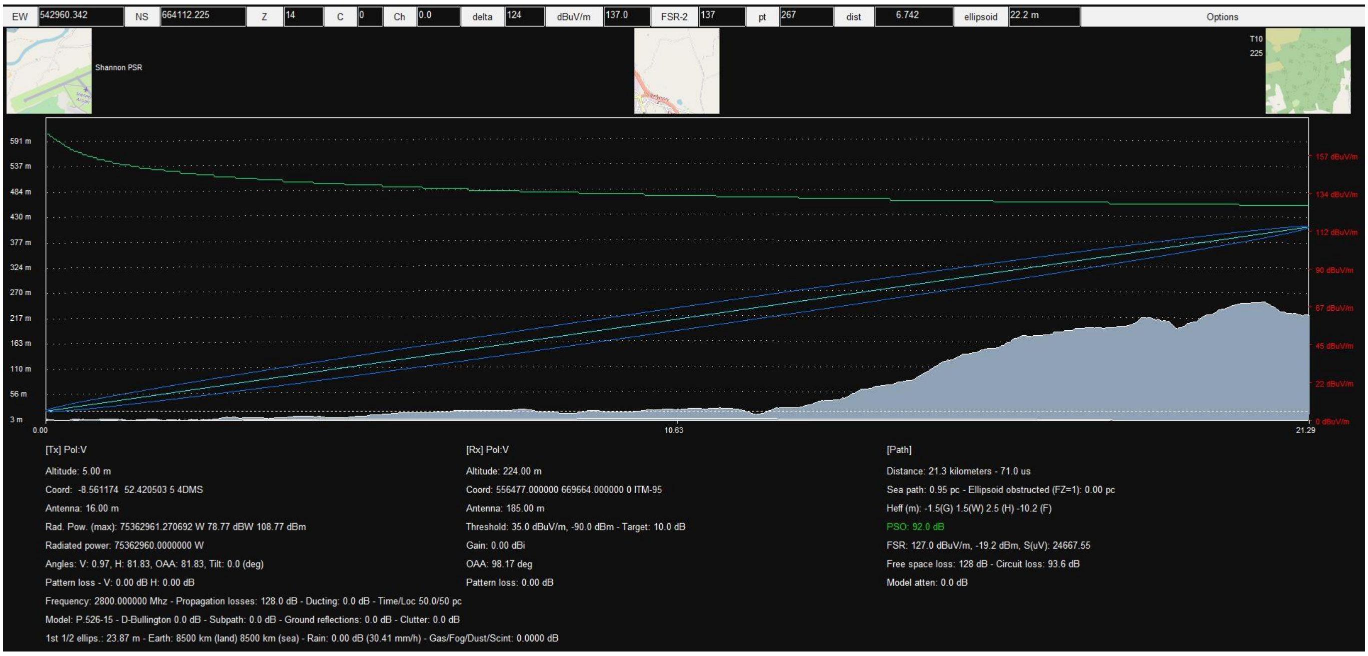
A.8. Turbine T8



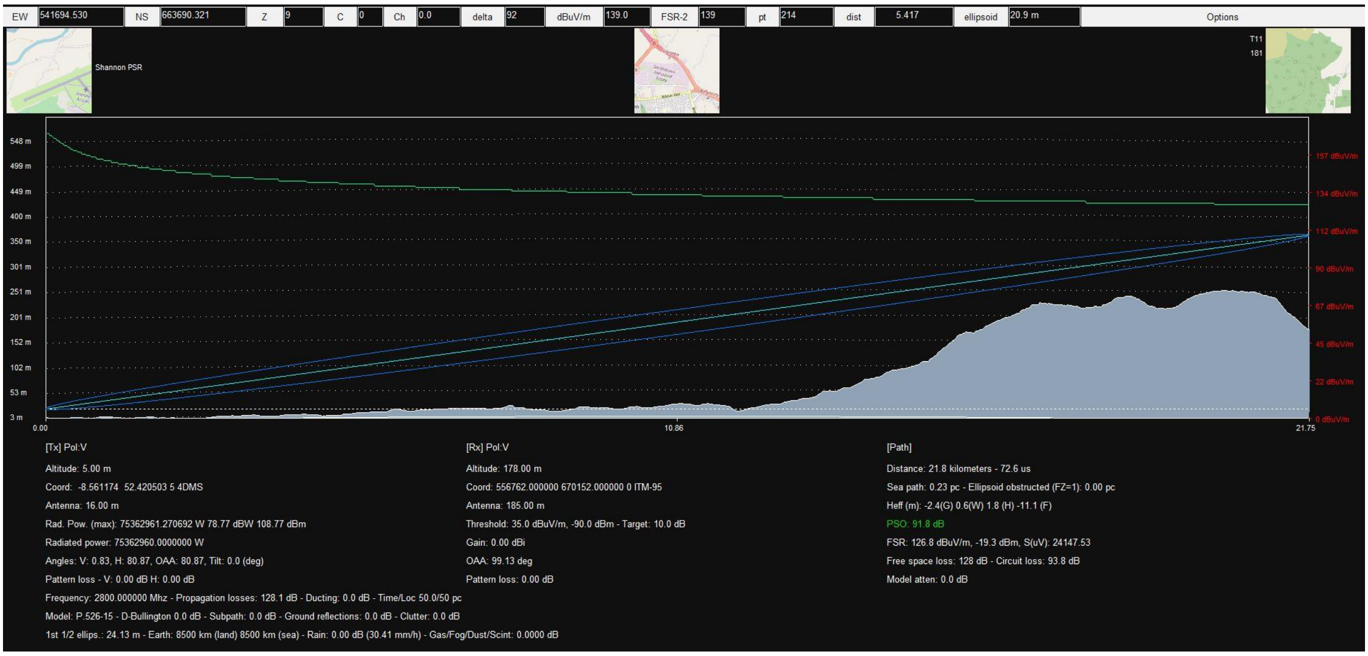
A.9. Turbine T9



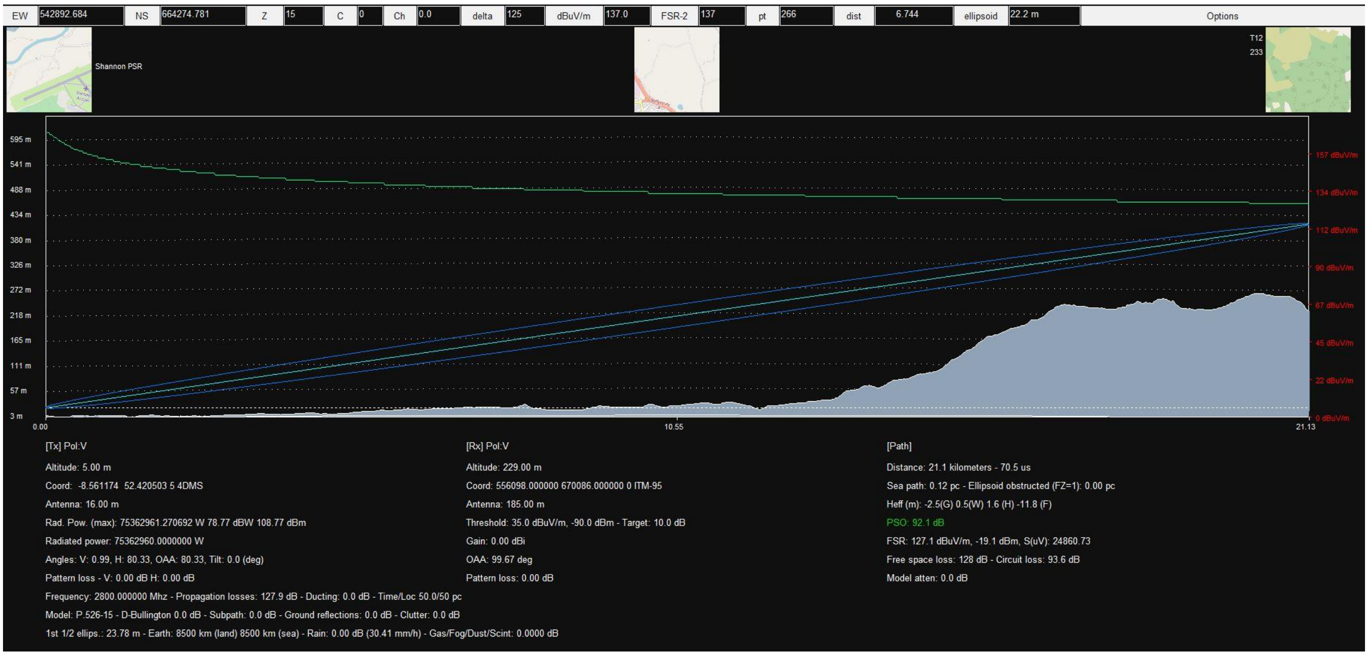
A.10. Turbine T10



A.11. Turbine T11

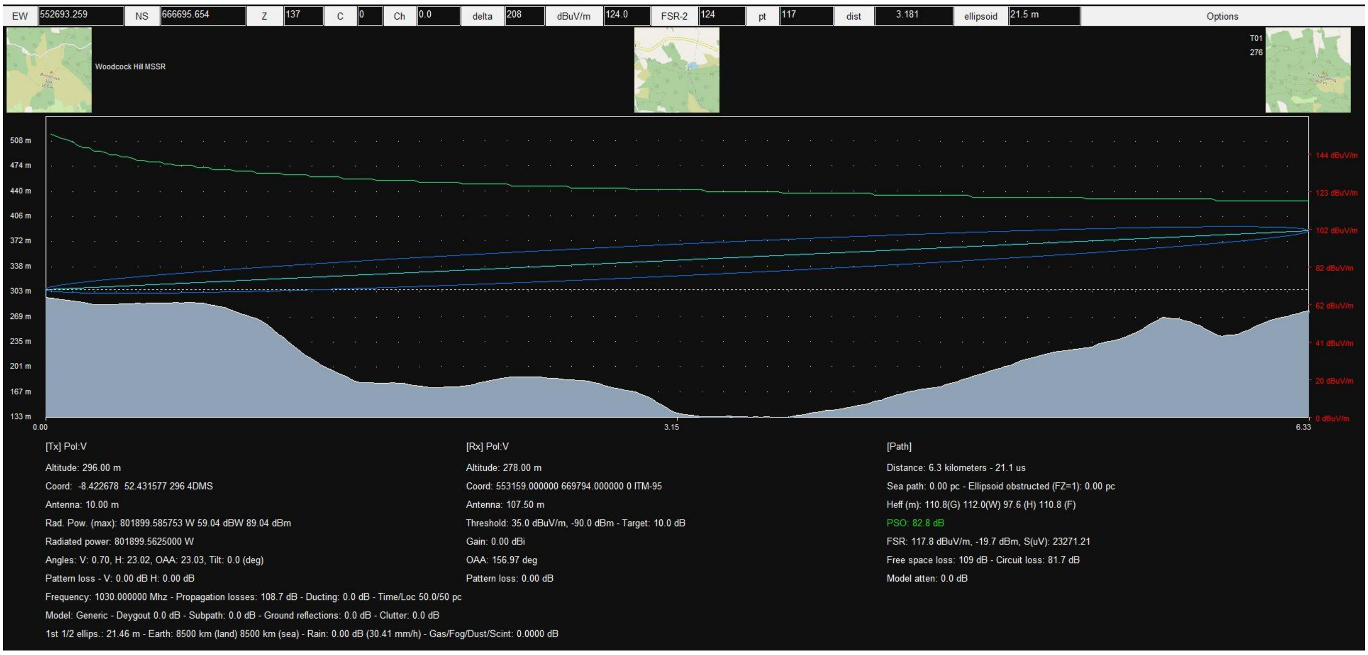


A.12. Turbine T12



B. Annex B – Woodcock Hill MSSR Path Profiles

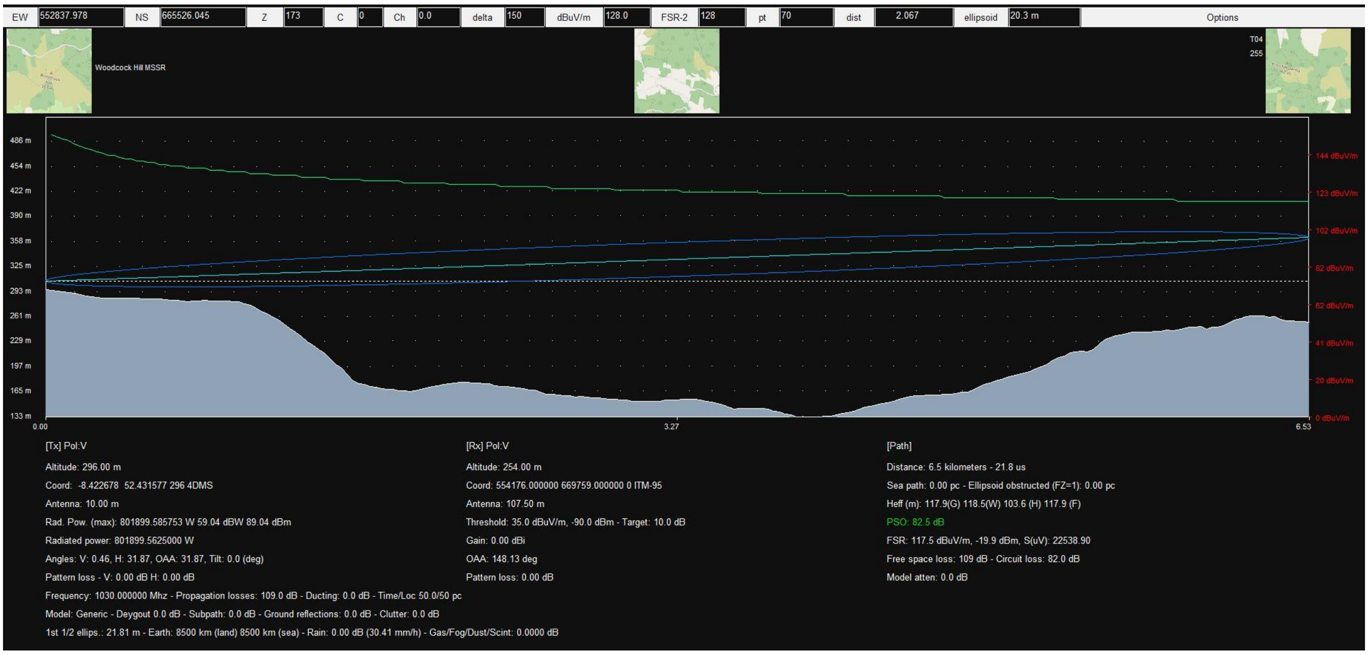
B.1. Turbine T1



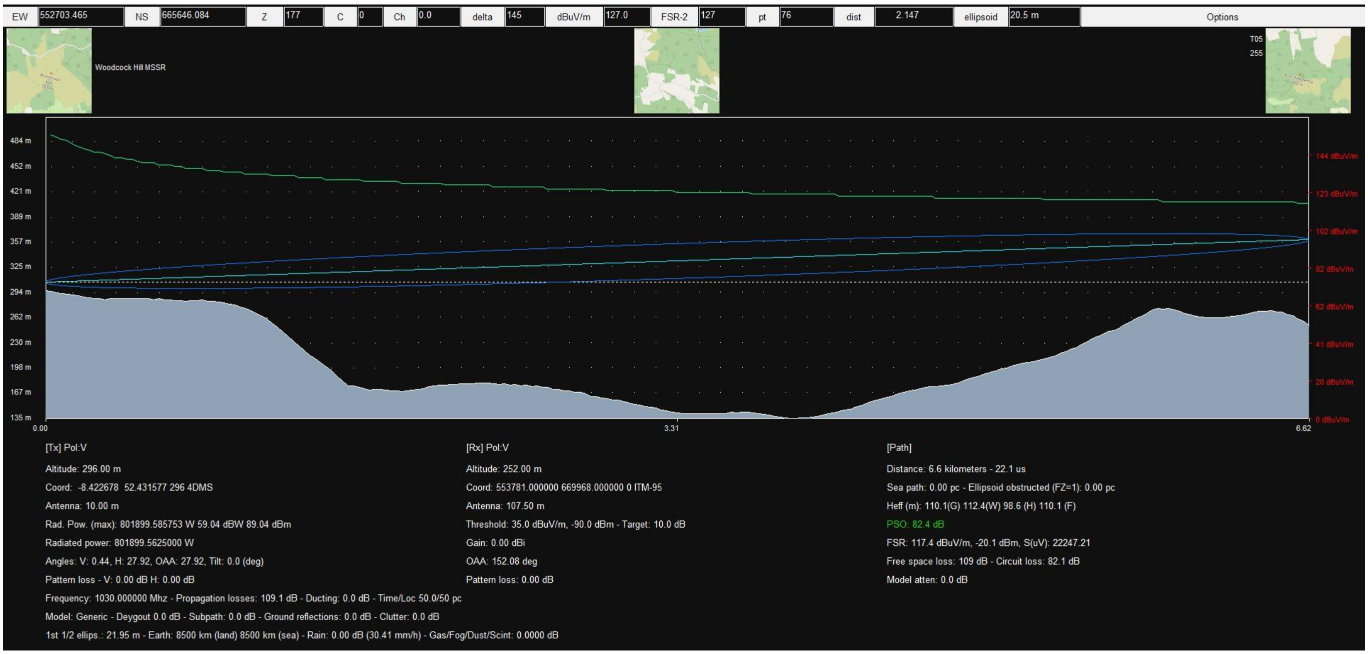
B.2. Turbine T2

B.3. Turbine T3

B.4. Turbine T4

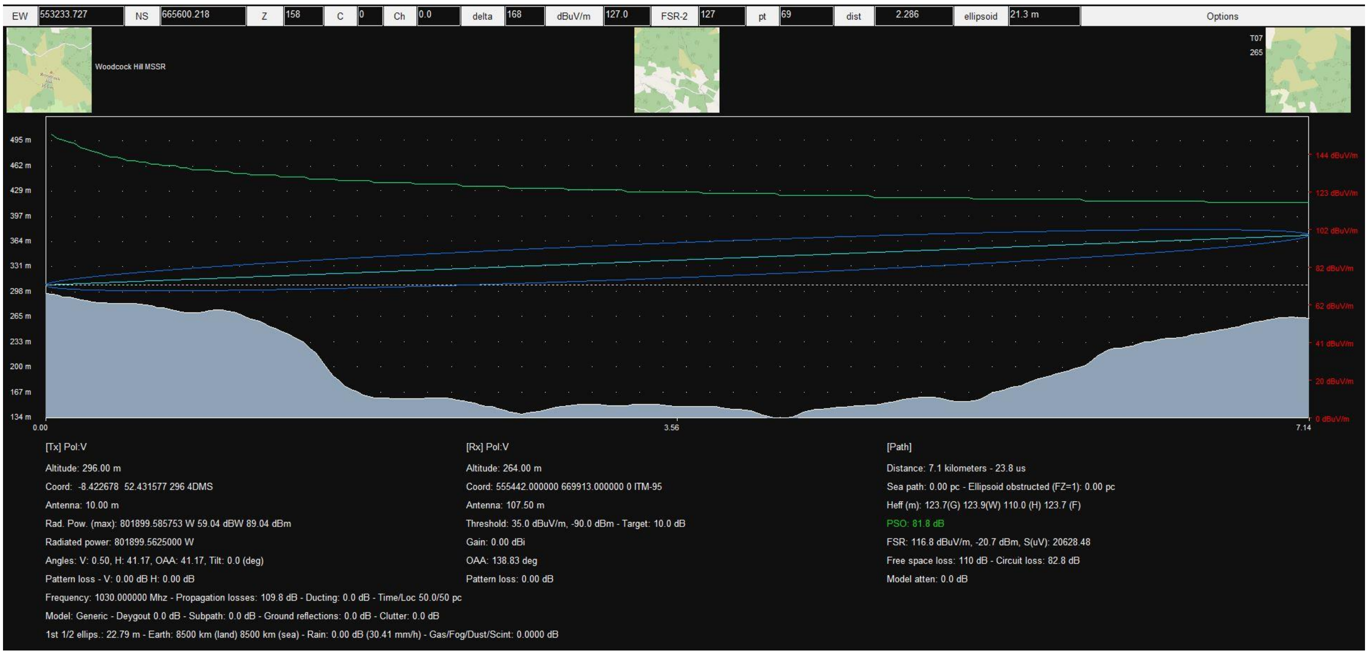


B.5. Turbine T5

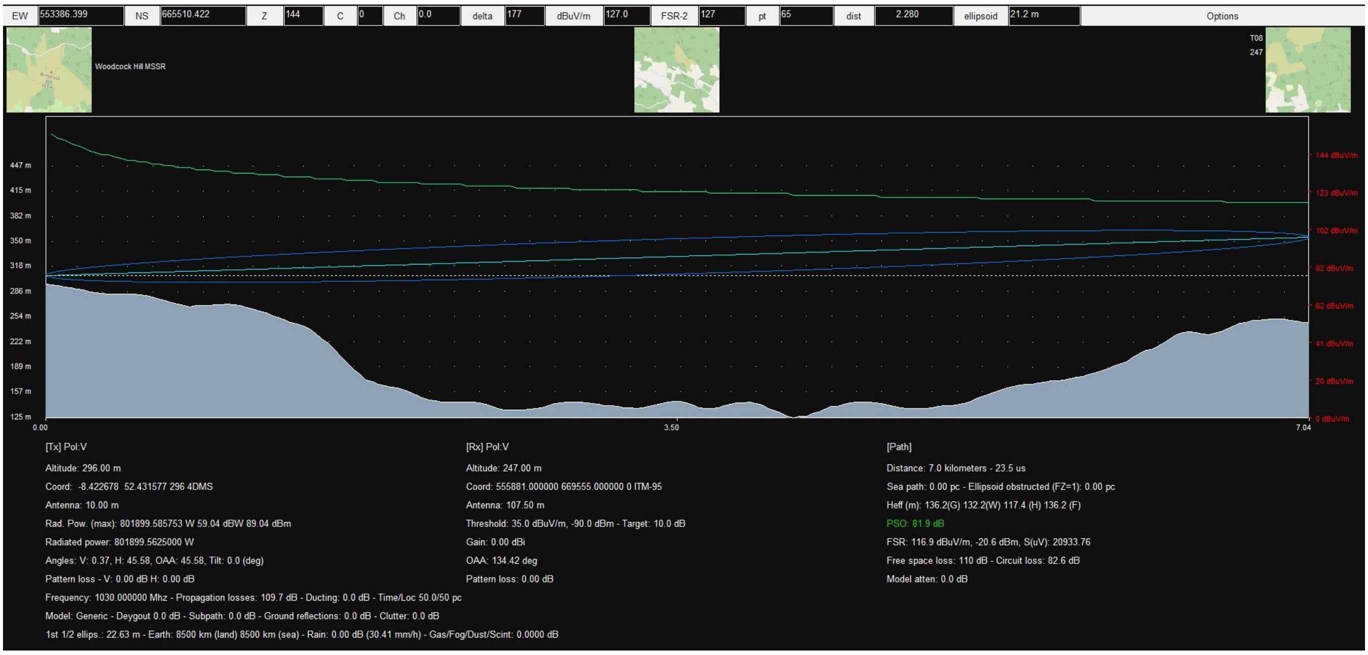


B.6. Turbine T6

B.7. Turbine T7

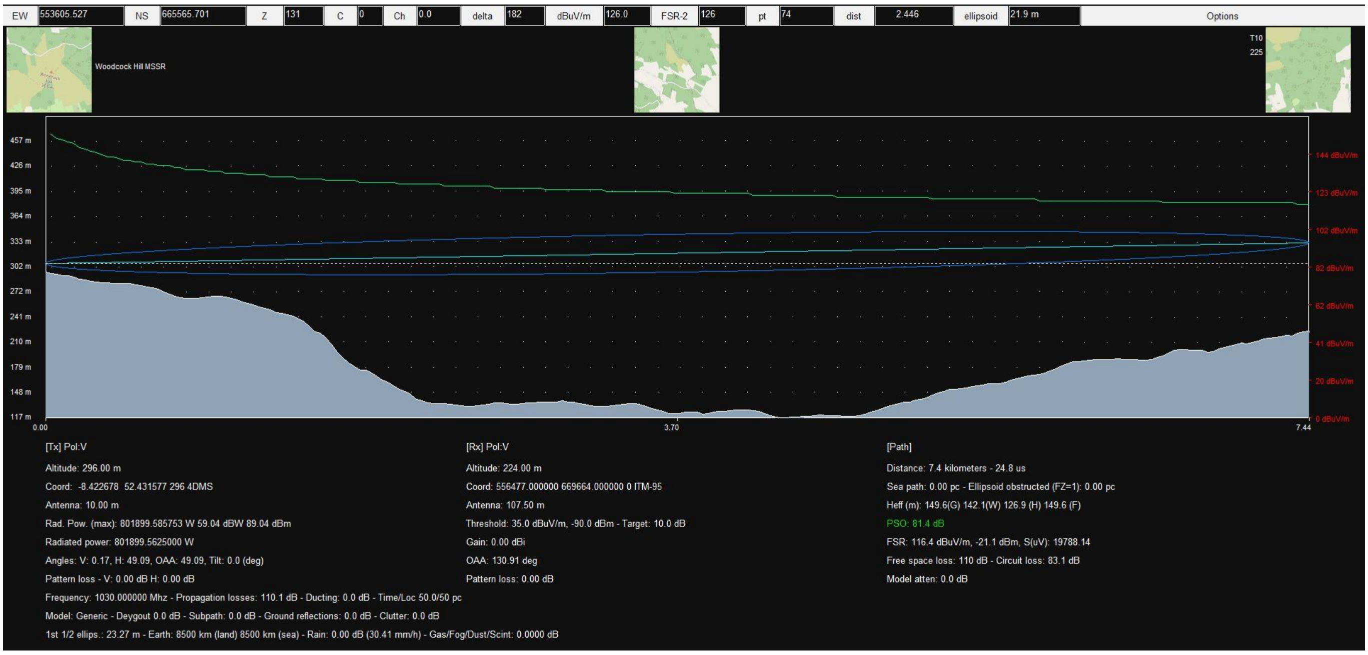


B.8. Turbine T8



B.9. Turbine T9

B.10. Turbine T10



B.11. Turbine T11

B.12. Turbine T12

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Appendix 2

Ballycar Wind Farm IFP Opinion

IFP Opinion

Ballycar Wind Farm

Shannon Airport

05 November 2021

CL-5715-RPT-002 V1.0

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Executive Summary

MWP (hereafter referred to as the Client) has requested an Instrument Flight Procedure (IFP) review in respect of a proposed windfarm development (Ballycar) near Shannon Airport.

The process of providing an 'opinion' still requires a review of the applicable IFP lateral and horizontal surfaces. This process only determines whether there is a 'surface penetration' and not whether the obstacle impacts the IFP. If there is a penetration a full IFP assessment will be noted.

The proposed development is approximately 10NM north-east of Shannon Airport, as shown in Figure 1.

The windfarm does impact to the current published IFPs for Shannon Airport but is only limited to the ATC Surveillance Minimum Altitude Chart. Although a full IFP assessment is normally required for any identified impact, it is recommended to submit this report to the IAA for consideration whether a full assessment is required.

Figure 1: Wind Farm Position from Threshold 24

IFP's Assessed

The following IFPs, as published in the IAA Aeronautical Information Publication (AIP) were assessed.

- RNAV STANDARD INSTRUMENT DEPARTURES RWY06
- RNAV STANDARD INSTRUMENT DEPARTURE RWY24
- RNAV STANDARD ARRIVALS RWY06
- RNAV STANDARD ARRIVALS RWY24
- INSTRUMENT APPROACH ILS OR LOC RWY06
- INSTRUMENT APPROACH VOR RWY06
- INSTRUMENT APPROACH ILS CAT I & II OR LOC RWY24
- INSTRUMENT APPROACH VOR RWY24
- ATC SURVEILLANCE MINIMUM ALTITUDE

Data

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 10/2021 effective 26 August 2021
- Email titled "RE_CYB1329 –Ballycar Wind Farm Aviation Studied.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.

Turbine No	Easting (ITM)	Northing (ITM)	Lat (UTM29N)	Long (UTM29N)
1	554531	664275	522072.59	5842025.21
2	554605	663847	522152.51	5841598.38
3	555030	664044	522574.63	5841801.22
4	555027	663611	522577.64	5841368.32
5	555476	663804	523023.81	5841567.49
6	555805	664104	523348.54	5841871.96
7	555886	663643	523435.91	5841412.23
8	555547	663267	523102.25	5841031.65
9	555090	663180	522646.61	5840938.34
10	555990	663191	523546.15	5840961.83
11	555582	662837	523143.2	5840602.28
12	555912	662521	523477.48	5840290.97

Table 1: Positional Data

Turbine dimensions as indicated in Table 2 were used.

In the absence of surveyed ground elevations, a vertical tolerance of 10 m was added.

Turbine No	Hub Height (m)	Rotor (m)	Ground Elevation (m)	Vertical Tolerance (m)	Max Tip Height
1	90	66.5	234	10	400.5
2	90	66.5	207	10	373.5
3	90	66.5	238	10	404.5
4	90	66.5	198	10	364.5
5	90	66.5	243	10	409.5
6	90	66.5	254	10	420.5
7	90	66.5	198	10	364.5
8	90	66.5	160	10	326.5
9	90	66.5	166	10	332.5
10	83	66.5	124	10	283.5
11	90	66.5	113	10	279.5
12	90	66.5	77	10	243.5

Table 2: Data used for the Assessment

Conclusion

The proposed wind farm does impact the current published procedures at Shannon airport. This is however limited to the ATC Surveillance Minimum Altitude Chart.

Although a full IFP assessment is normally required for any identified impact, it is recommended to submit this report to the IAA for consideration whether a full assessment is required.

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Appendix 3

Ballycar Wind Farm Impact on ILS Inspection Report

FLIGHT CALIBRATION SERVICES LTD

BALLYCAR WIND FARM

IMPACT ON ILS FLIGHT INSPECTION

Prepared For:	Malachy Walsh & Co Ltd
Author:	John Wilson
Reviewed by:	David Bartlett
Reference:	FCSL 0140
Issue:	1
Date:	14 May 2022

BALLYCAR 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

Ballycar Wind Farm is a proposed renewable energy project in County Clare located approximately 16 km (8.6 NM) 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 Ballycar Wind Farm comprises 12 wind turbines and associated infrastructure including turbine foundations, access tracks, an electricity substation and underground cabling located in an area of approximately 140 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 158 m (518 ft) above ground level. Ground height at the highest turbine (T6) is 253 m (830 ft) AMSL.

The height of the highest turbine (to blade tip) is therefore 411 m (1,348 ft) AMSL.

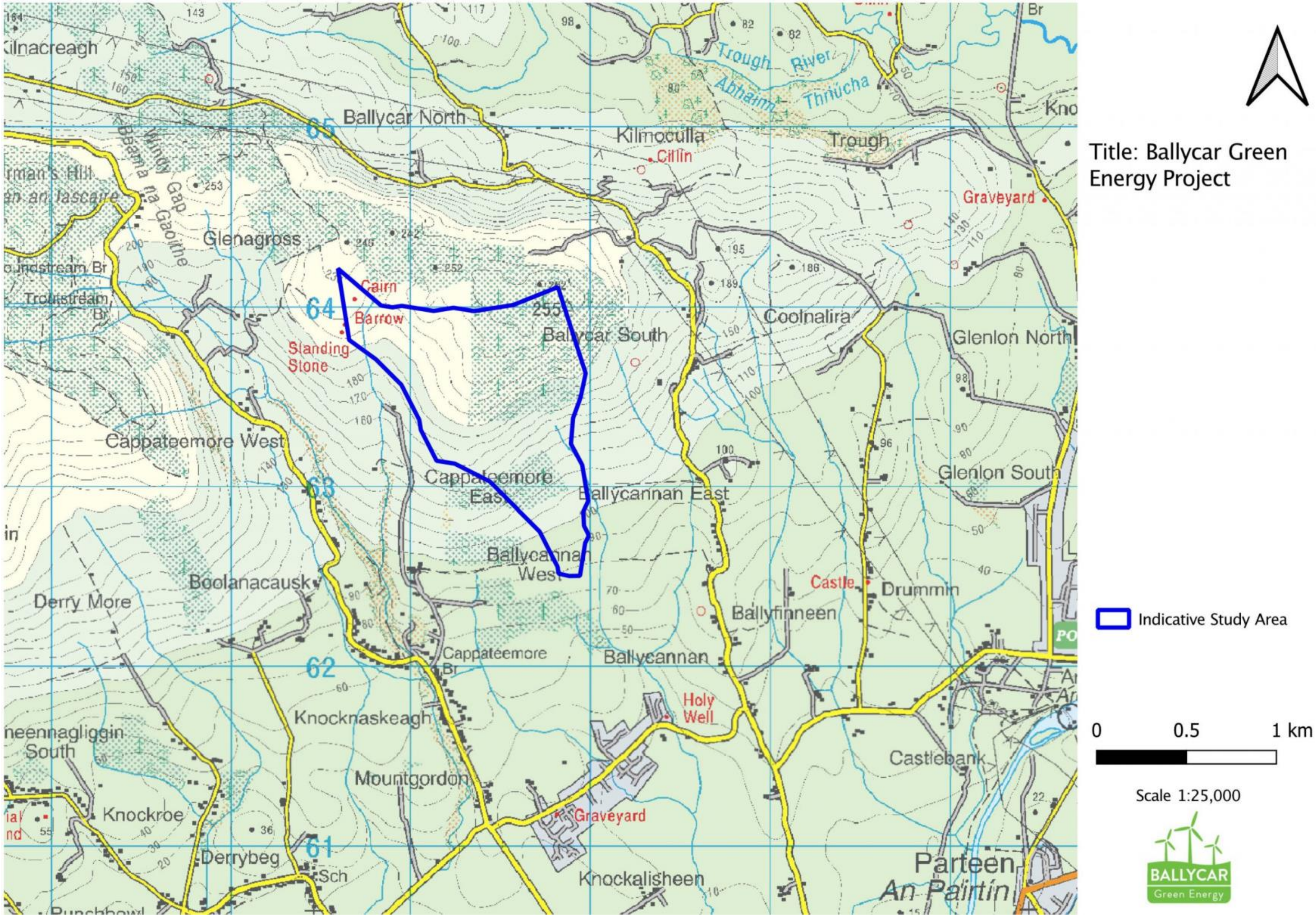


Figure 2.1 - Proposed Ballycar Wind Farm Site

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

Turbine	ITM Coordinates		WGS-84 Coordinates		Ground Level AMSL (m)
	X	Y	Latitude	Longitude	
T1	554589	664237	52.727317	-8.672287	234
T2	554609	663823	52.723595	-8.671932	205
T3	554964	664122	52.726317	-8.666729	232
T4	554981	663600	52.721624	-8.666394	193
T5	555405	663769	52.723181	-8.660152	241
T6	555821	664101	52.726198	-8.654033	253
T7	555913	663616	52.721845	-8.652613	192
T8	555503	663247	52.718497	-8.658624	160
T9	555084	663192	52.717965	-8.664818	166
T10	556023	663087	52.717097	-8.650911	115
T11	555645	662822	52.714689	-8.656465	107
T12	555899	662525	52.712041	-8.652666	236

Table 2.1 - Proposed Turbine Coordinates

3 ILS INFORMATION

3.1 ILS Site Information

The Runway 24 ILS provides radio navigation 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 Ballycar 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 Ballycar Wind Farm.

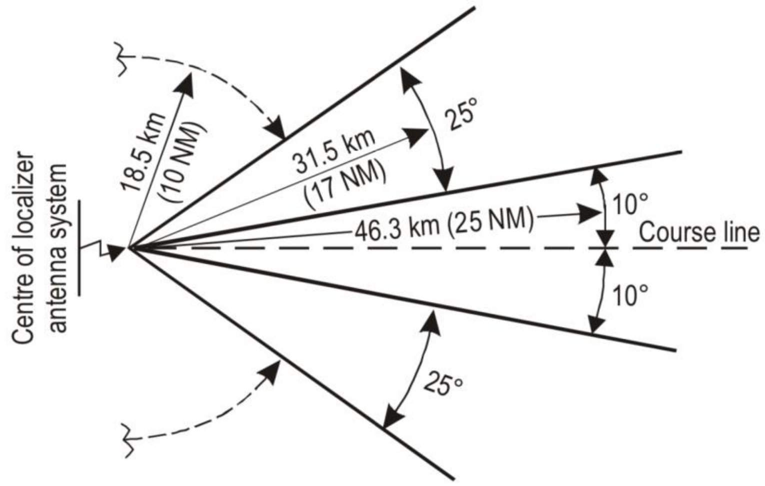
3.2.3 DME Coverage

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

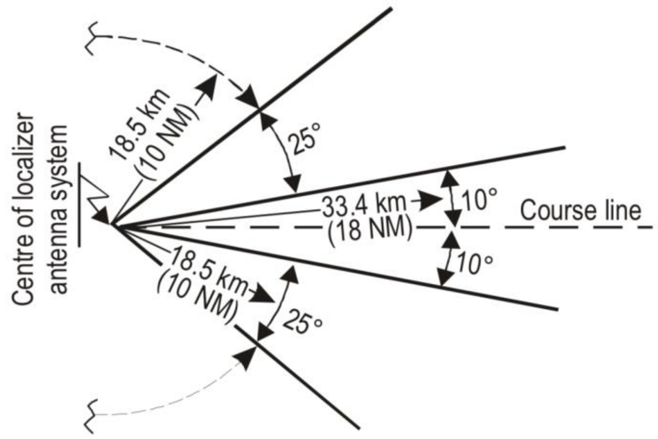
EINN AD 2.19 RADIO NAVIGATION AND LANDING AIDS

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.
NDB	FOY	395 kHz	H24	523358.5N 0091143.5W			Designated Operational Coverage 50 NM
ILS LOC RWY 06 CAT 1 4º W 2017	ISE	109.5 MHz	H24	524245.3N 0085408.2W			Coverage restricted to 35º either side of course line. Signals received outside coverage sector, (including back beam radiation), should be ignored.
ILS GP RWY 06		332.6MHz	H24	524147.2N 0085623.1W			GP Angle 3º RDH 55ft Full scale fly down indication may not be maintained when above GP sector. Full scale fly up indication may not be maintained when left of LOC sector and below GP.
ILS DME RWY 06	ISE	CH32X (109.5 MHz)	H24	524147.2N 0085623.1W	100ft		DME Zero ranged to THR 06. DME zero range is displaced from DME antenna by 445M.
ILS LOC RWY 24 CAT II 4º W 2017	ISW	110.95MHz	H24	524129.4N 0085649.6W *			Coverage restricted to 35° either side of the course line. Signals received outside coverage sector, (including back beam radiation), should be ignored. No LOC coverage below 3000ft MSL AT 25 NM EINN *Data whose accuracy has not been quality assured.
ILS GP RWY 24		330.65MHz	H24	524232.1N 0085447.7W			GP Angle 3° RDH 59ft
LO RWY 24	OL	339 kHz	H24	524456.4N 0084926.0W			Designated Operational Coverage 15NM
OM RWY 24	2 Dashes per sec	75 MHz	H24	524455.5N 0084927.0W			
MM RWY 24	Dots and Dashes	75 MHz	H24	524254.8N 0085347.9W			
ILS DME RWY 24	ISW	CH46Y (110.95 MHz)	H24	524232.1N 0085447.7W	100ft		DME Zero ranged to THR 24. DME zero range is displaced from DME antenna by 391M.

Figure 3.1 - AIP Ireland



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



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

Figure 3.2 - ILS Localiser Lateral Coverage Sector

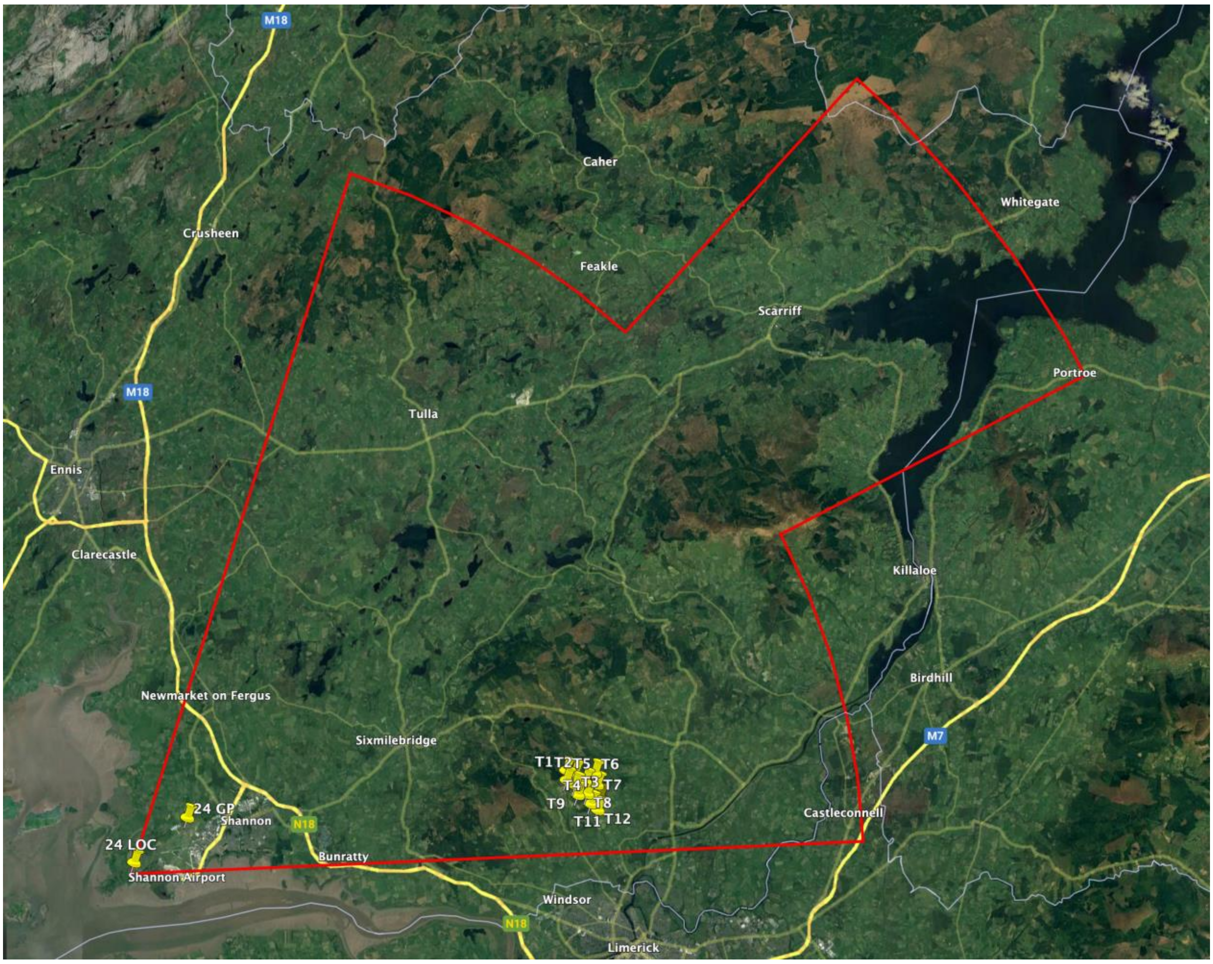


Figure 3.3 - Runway 24 ILS Localiser Lateral Coverage Sector

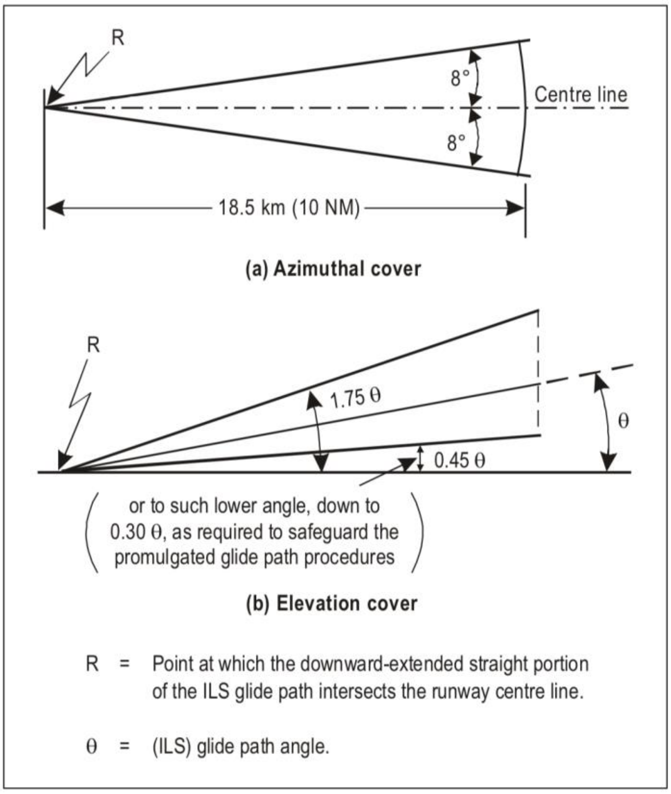


Figure 3.4 - ILS Glide Path Coverage

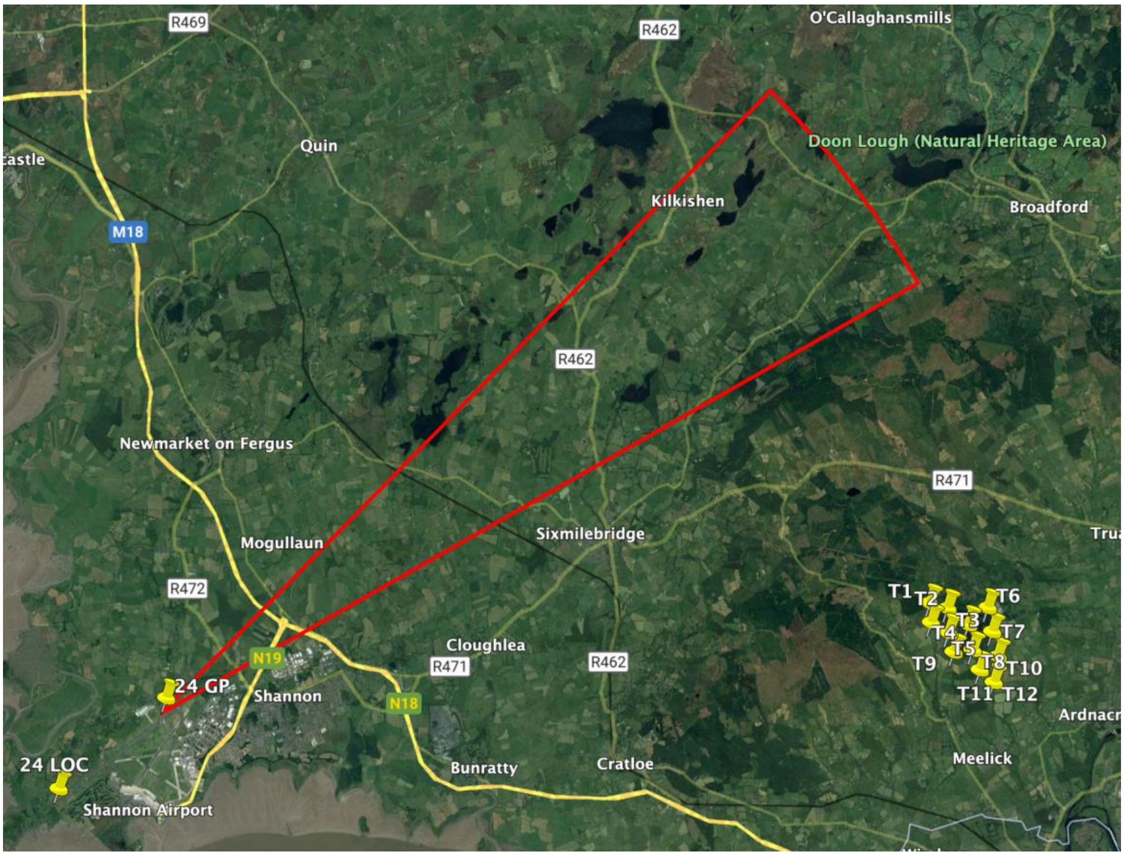


Figure 3.5 - Runway 24 ILS Glide Path Lateral Coverage Sector

4 ICAO ILS FLIGHT INSPECTION RECOMMENDATIONS

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

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

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

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.

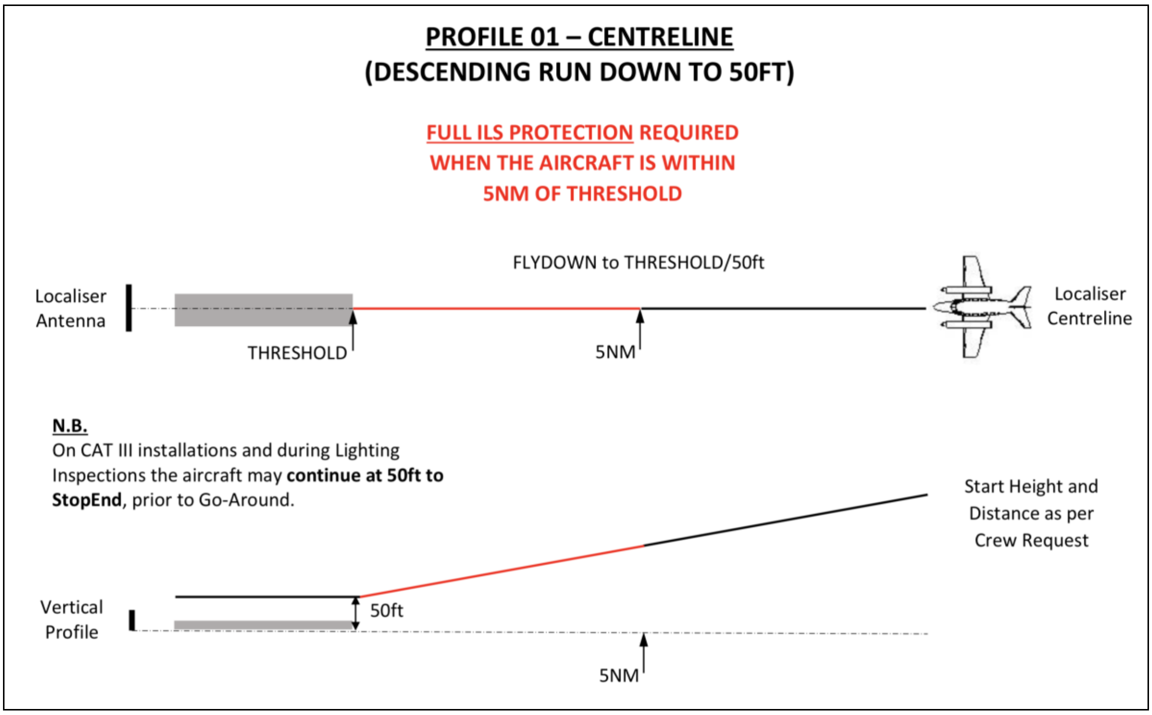


Figure 5.1 - Centreline Approach Flight Profile

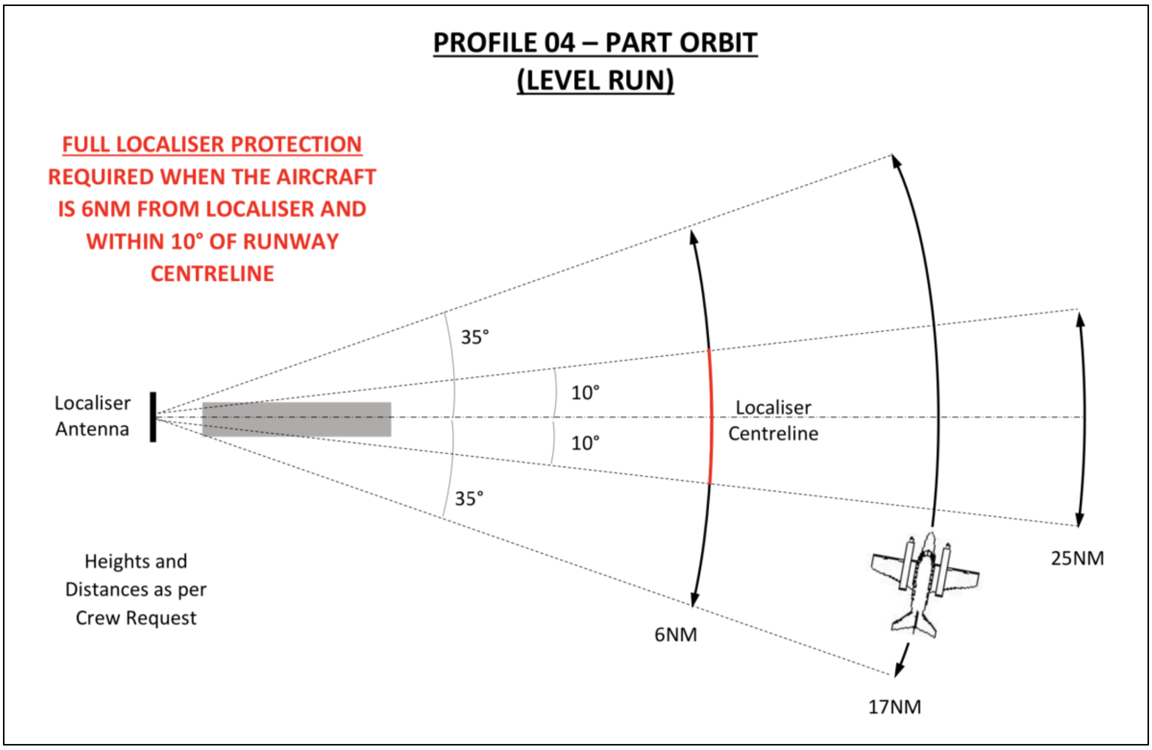


Figure 5.2 – Part Orbit Flight Profile

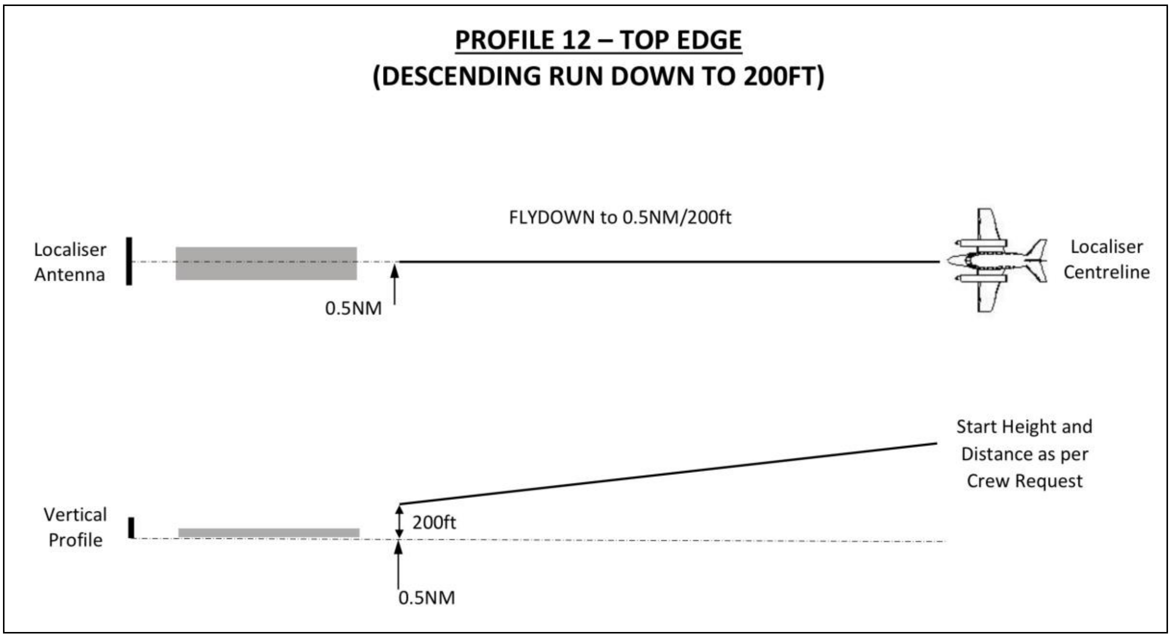


Figure 5.3 – Top Edge Flight Profile

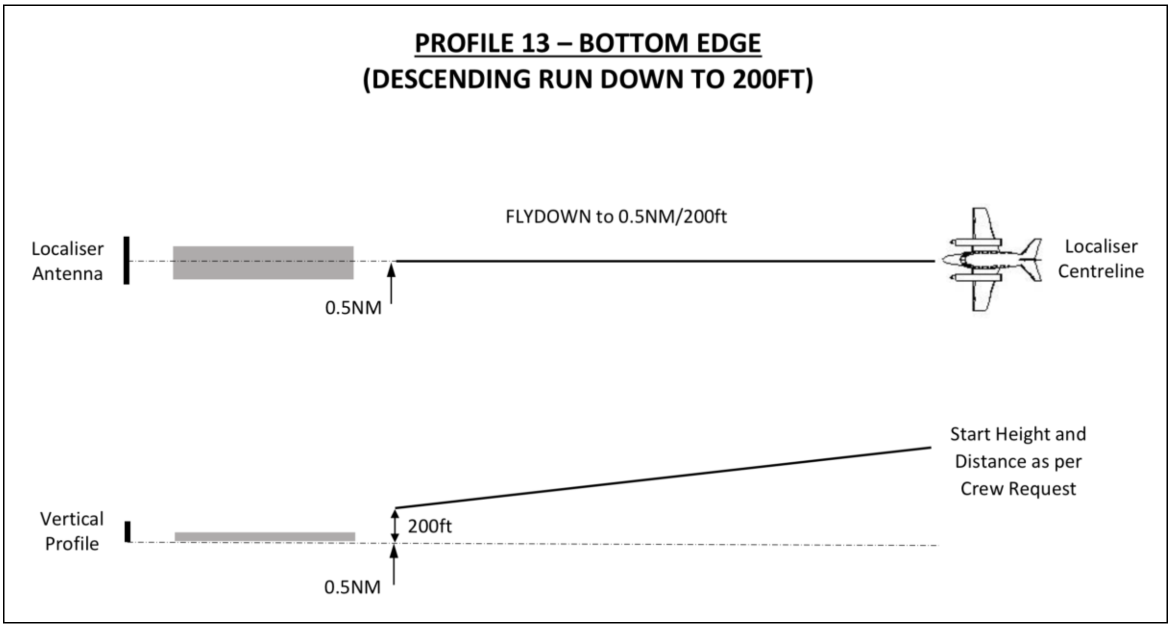


Figure 5.4 – Bottom Edge Flight Profile

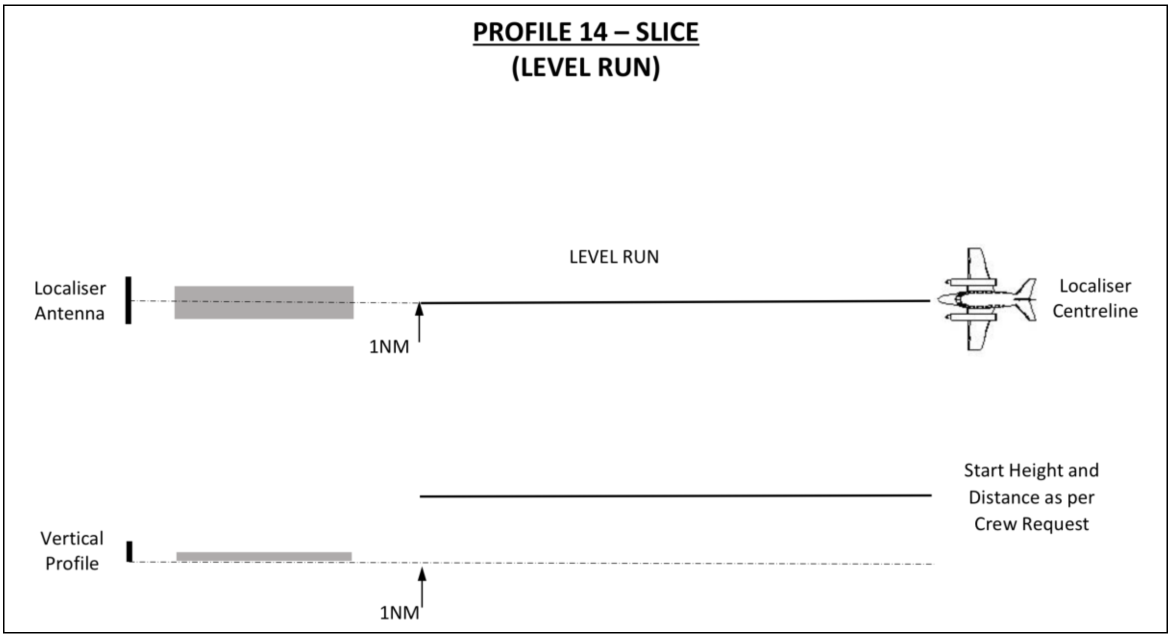


Figure 5.5 – Slice Flight Profile

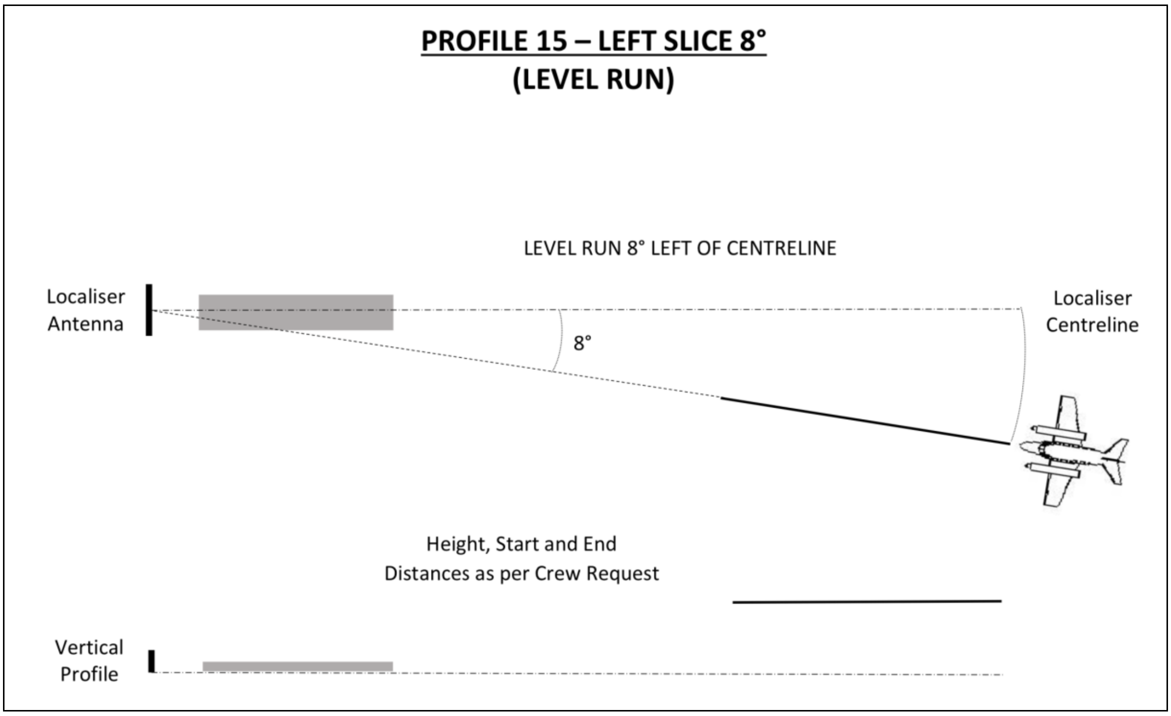


Figure 5.6 – Left Slice 8° Flight Profile

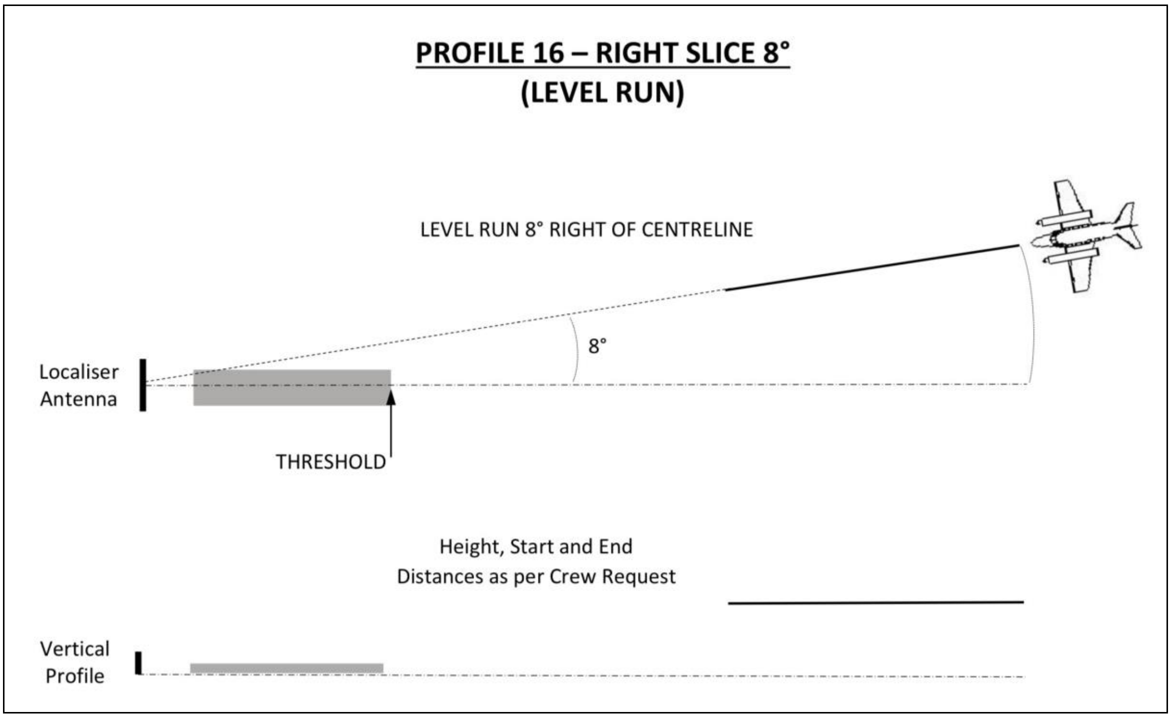


Figure 5.7 – Right Slice 8° Flight Profile

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 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 4.4 NM laterally from the nearest wind turbine (T1) 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 4.4 NM laterally distant from, the proposed Ballycar Wind Farm site. The flight inspection aircraft vertical clearance above the highest turbine (T6) can be estimated as follows (see Figure 6.1):

Horizontal distance from 24 Glide Path antenna (on boresight) to Turbine T6

= 15,208 m

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

Clearance (h) above highest turbine (T6)

$= (15{,}208\ m \times \tan 3.0°) - (253\ m - 14\ m) - 158\ m = 400\ m = 1{,}312\ ft$

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

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 tracks of the 6 NM and 17 NM part orbit profiles are 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 4.2 NM from the nearest wind turbine (T2) 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 6.1 NM from the nearest wind turbines (T6, T7 and T10) at a point on the part orbit track closest to the wind farm site. This distance is greater than the minimum clearance required from any object in IMC and VMC, 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 (T6) can be estimated as:

Ground height + maximum turbine height = 253 m + 158 m = 411 m (1,348 ft).

For an orbit height of 2,745 ft AMSL, a flight inspection aircraft will therefore have a clearance of 1,397 ft above the highest wind turbine. This height exceeds the minimum clearance required above terrain and obstacles in IMC and VMC.

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 4.4 NM laterally from the nearest wind turbine (T1) 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 4.4 NM laterally distant from, the proposed Ballycar Wind Farm site. The flight inspection aircraft vertical clearance above the highest turbine (T6) can be estimated as follows:

Horizontal distance from 24 Glide Path antenna (on boresight) to Turbine T6

= 15,208 m

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

Clearance (h) above highest turbine (T1)

$= (15{,}208\ m \times \tan 2.64°) - (253\ m - 14\ m) - 158\ m = 304\ m = 997\ ft$

This height exceeds the minimum clearance required above terrain and obstacles in VMC, but is less than the minimum clearance required 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 4.4 NM laterally from the nearest wind turbine (T1) 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 2,348 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 2,400 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 be approximately 3.1 NM laterally from the nearest wind turbine (T1) 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.

6.5.2 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 2,348 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 2,400 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.

6.7 Runway 24 Glide Path Special Flight Inspection

As part of an impact assessment for another proposed wind farm, to be located approximately 9 NM north east of Shannon Airport, FCSL recently performed additional Runway 24 Glide Path level runs at an altitude of 2,600 ft AMSL. These additional level runs were flown on 20 April 2022, to verify that adequate RF signal level is achieved (to ensure correct ILS receiver operation) and to ensure that adequate fly-up guidance is obtained below the Glide Path sector.

The results of the additional Glide Path level runs are shown in Figures 6.7 and 6.8 below.

6.7.1 Slice 2,600 ft

Figure 6.7 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 20 NM from runway threshold. Figure 6.7 also shows that adequate fly-up guidance exists from this range.

6.7.2 Left Slice 2,600 ft

Figure 6.8 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 6.8 also shows that adequate fly-up guidance exists from this range.

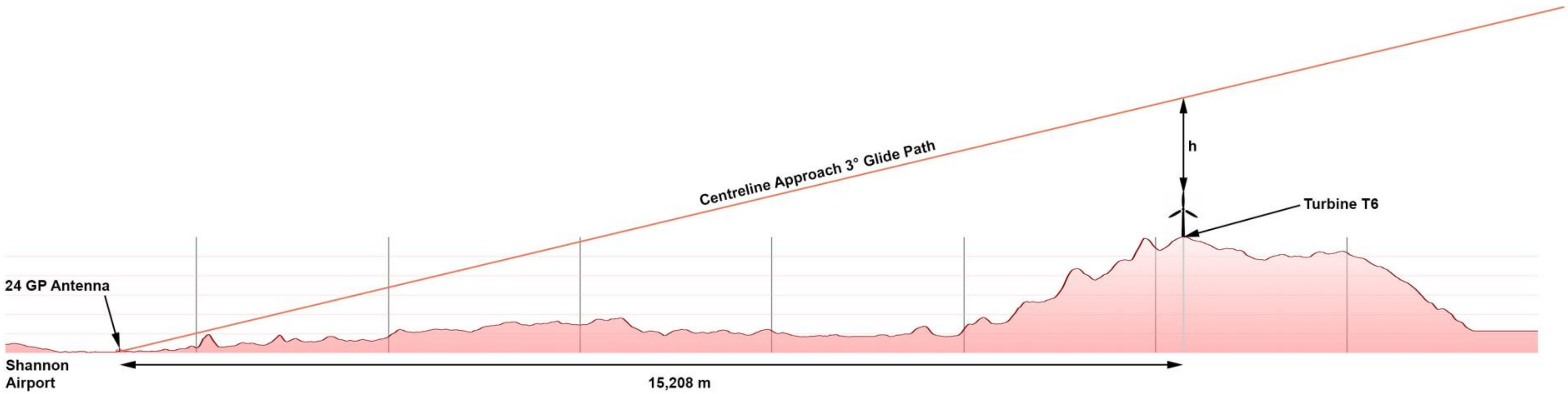


Figure 6.1 – ILS Centreline Approach Profile

(Not to scale)

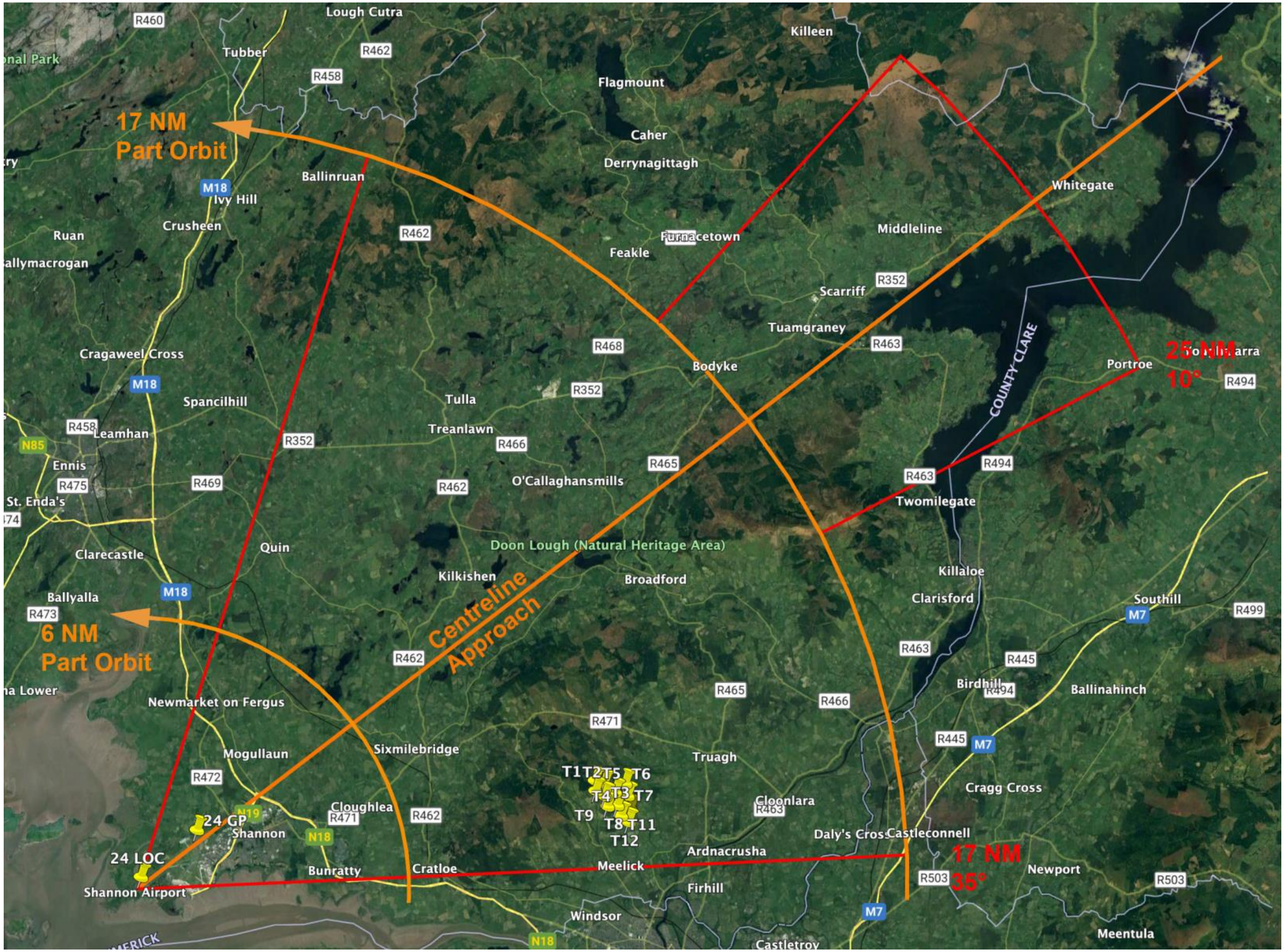


Figure 6.2 – ILS Centreline Approach and Part Orbit Tracks

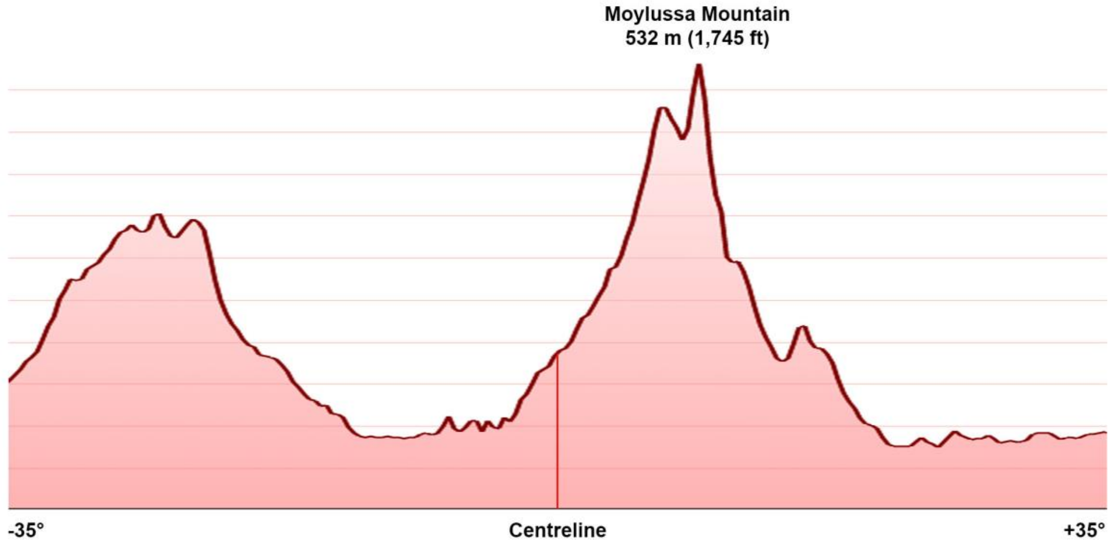


Figure 6.3 – 17 NM Part Orbit Terrain Elevation Profile

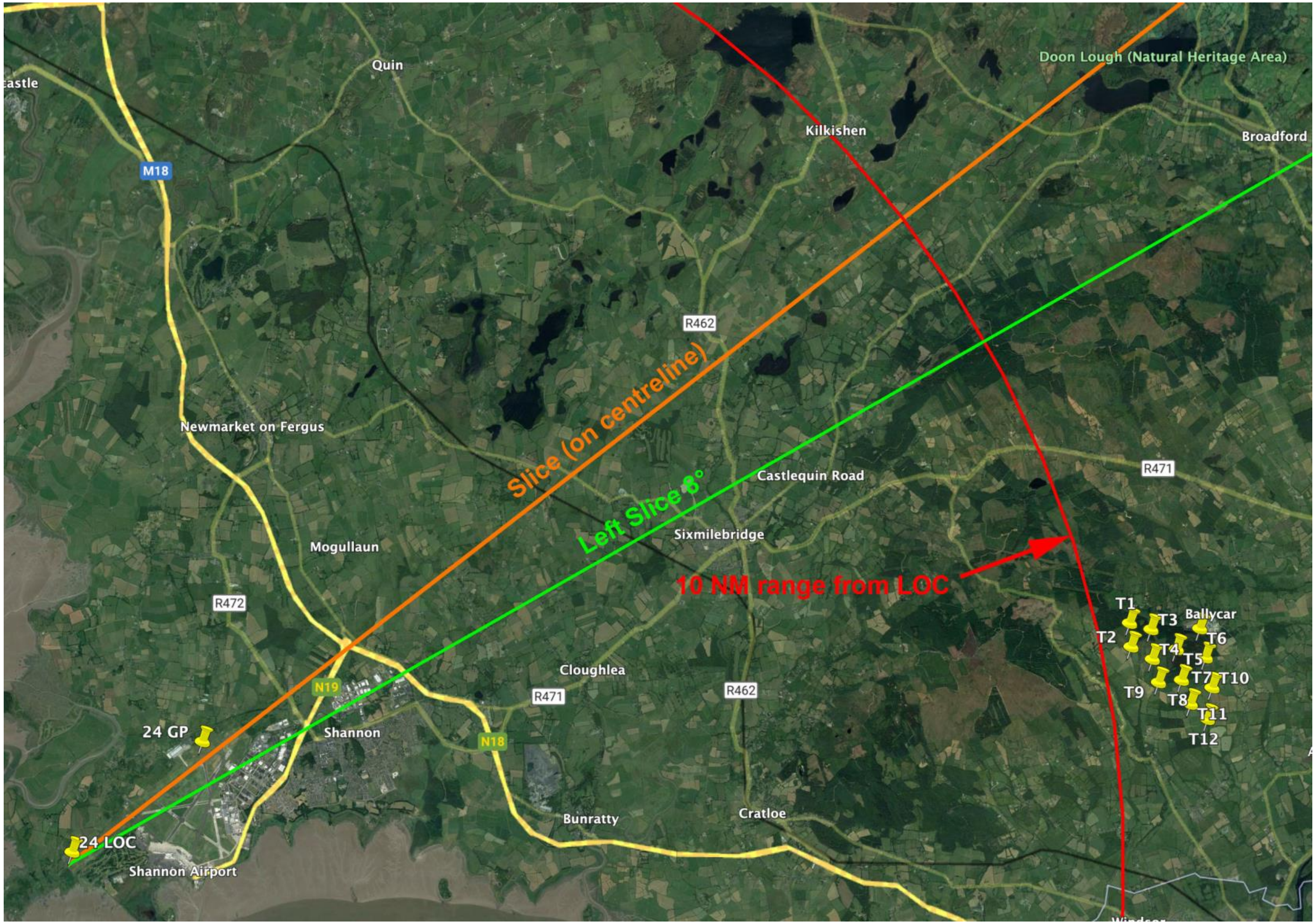


Figure 6.4 – Slice and Left Slice 8° Tracks

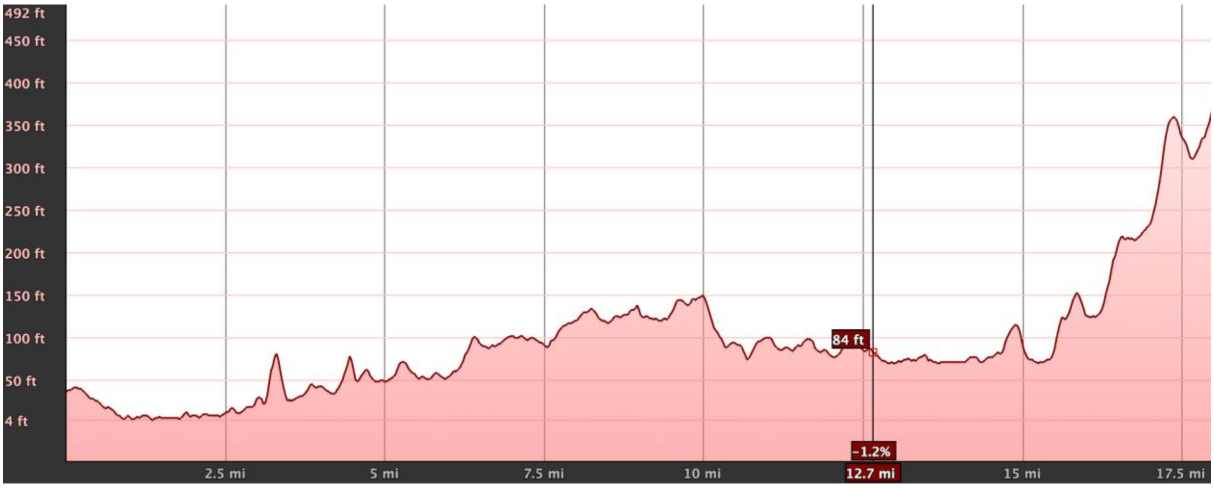


Figure 6.5 – Slice Terrain Elevation Profile

Figure 6.6 – Left Slice 8° Terrain Elevation Profile

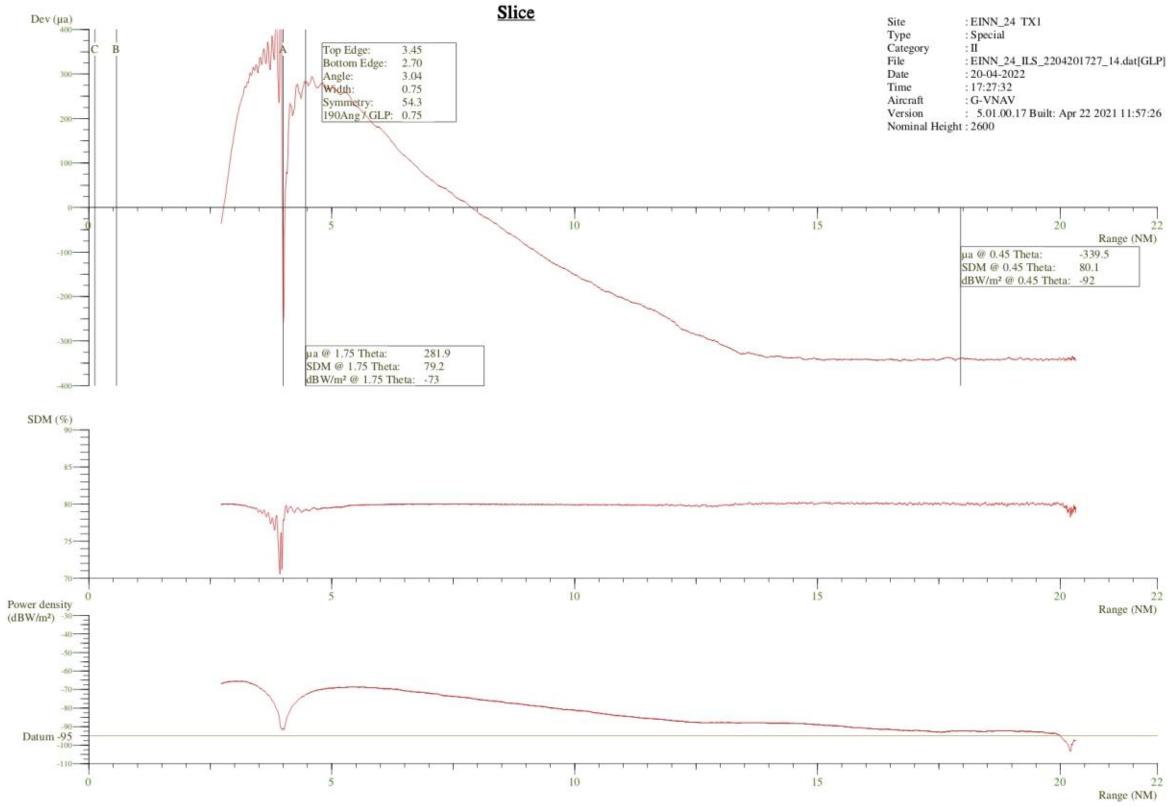


Figure 6.7 - Slice 2,600 ft

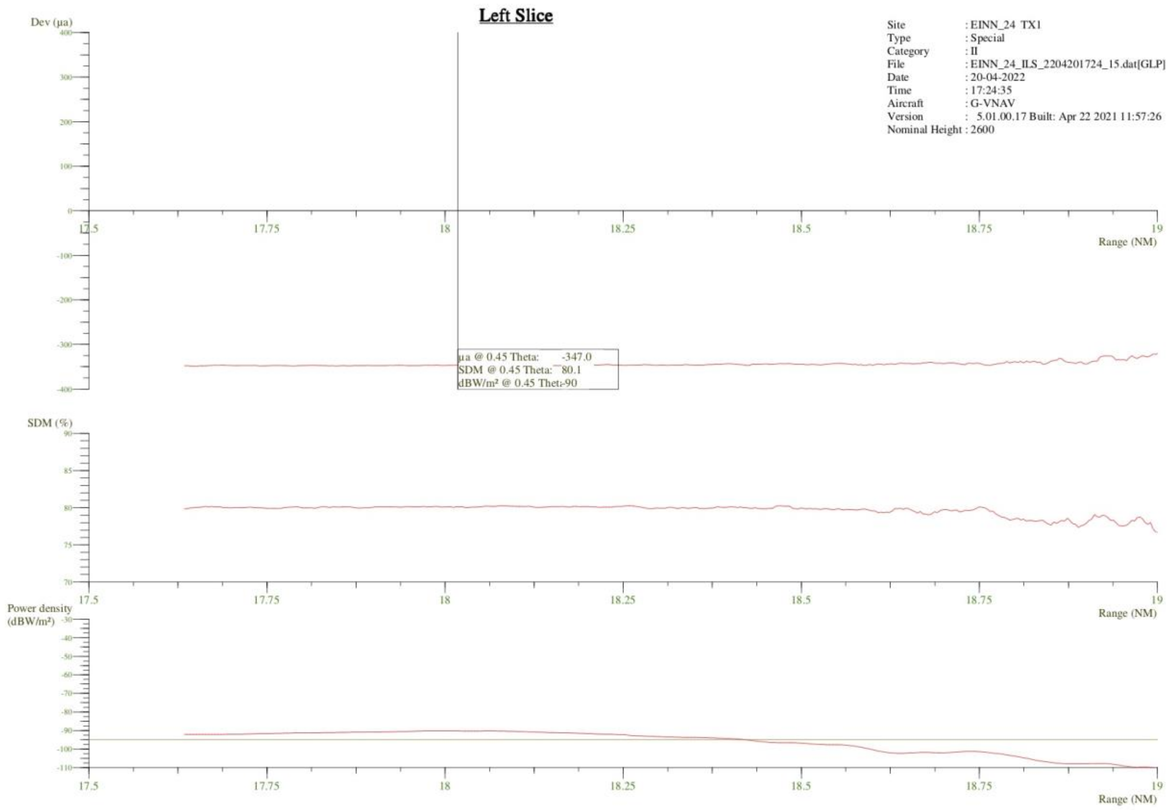


Figure 6.8 - Left Slice 2,600 ft

7 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 Ballycar 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 slice and left slice 8° profiles (level runs) will have to be raised to an altitude of 2,400ft in IMC to provide the flight inspection aircraft adequate coverage over the proposed wind turbines.

Section 6.7 above shows that for level runs flown at an altitude of 2,600 ft, Glide Path RF signal levels exceed minimum level of -95 dBW/m^2 and sufficient fly-up guidance is achieved below the Glide Path sector.

The proposed Ballycar wind farm will therefore not have any adverse effect on Runway 24 ILS flight inspection procedures and flight profiles.

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 4

Ballycar Wind Farm Aviation Impact Assessment & Mitigation Report

Report

Ballycar Wind Farm

Aviation Impact Assessment

& Mitigation Report

Document Number:	001/VH202104			
Author:	PT\DMG\KH			
Approved for Release:	Rev 3.0	KH	**Date:**	11/08/23

Document Filename: *Ballycar Wind Farm – Aviation Impact Assessment & Mitigation Report*

Executive Summary

Ai Bridges Ltd was commissioned by the Environmental Planning Consultants, Malachy Walsh and Partners (hereafter referred to as MWP) to review a consultation response from the Irish Aviation Authority (hereafter referred to as IAA) received in November 2022 in relation to the possible interference impacts of the proposed Ballycar wind farm on the Surveillance Radar equipment at Shannon Airport and Woodcock Hill.

In their response the IAA noted that there was:

> *"… no credible and implementable mitigations on the Woodcock hill radar itself to eliminate the Radar beam deflections, reflections and shadowing from the proposed turbines…"*

The IAA also noted that:

> *"… the proposed development would introduce false primary targets or clutter on the Shannon Primary radar. Mitigation for the primary clutter would degrade the performance of the Shannon primary radar…"*

Ai Bridges subsequently conducted a full review of all correspondence between MWP and the IAA and recommended a further detailed technical assessment to be carried out by a third party IAA Approved Procedure Designer, Cyrrus Limited, to investigate all possible Mitigation Measure options to remediate the impacts on surveillance radar systems. It was also recommended to engage with the manufacturers of the Surveillance Radar equipment being used by the IAA to confirm if said equipment supported wind farm mitigation features.

The findings from the Mitigation Options Study included the following recommendation that states that the radar technical documentation provides assurance that mitigation for proposed the Ballycar Wind Farm is possible subject to an on-site condition survey to ascertain if updates or upgrades would be required :

> *" … The technical documentation provided by the manufacturer (Thales) of the two systems provides assurance that mitigation for the Ballycar Windfarm is possible. Cyrrus would recommend that an onsite condition survey is carried out by Thales on both the Shannon Airport and Woodcock Hill systems to confirm their current operational state and ascertain whether updates or upgrades would be required …"*

IAA Consultations

1. In January 2022, MWP engaged and submitted a scoping report to the IAA with a request for comments in relation to a proposed wind farm on lands at and near Ballycar, Co. Clare.

2. There were further rounds of consultations in January 2022 with the Airspace and Navigation Team at the IAA where it was highlighted that there are a number of

aviation surfaces under the responsibility of the IAA Air Navigation Service Provider (ANSP) regarding safeguarding around Shannon Airport. These were referred internally within the IAA and the Shannon Airport Operator for further response on potential impacts to the following:

- Navigational Aids
- Surveillance Radar
- Instrument Flight Procedures (IFPs)

The MWP consultation engagements with the IAA from January 2022 to May 2022 served to:

i) Identify the main concerns of the IAA in relation to the potential impacts on aviation surfaces.

ii) Present the findings of the detailed Aviation Technical Assessments to the IAA in relation to Instrument Flight Procedures, showing a ***"No Impact"*** condition.

iii) Present the findings of the detailed Aviation Technical Assessments to the IAA in relation to Navigational/Flight Calibration Impact Assessments , demonstrating a **"No Impact"** condition.

iv) Present the findings of the detailed Aviation Technical Assessments to the IAA in relation to Radar Surveillance including the Primary Surveillance Radar (PSR) at Shannon Airport and the Monopulse Secondary Radar (MSR) at Woodcock Hill, showing a **"Potential Impact"** condition which can be appropriately mitigated.

IAA Consultation Reponses

The IAA has welcomed and accepted the findings presented within the detailed Aviation Technical Assessments and in a consultation response to MWP on February 28th 2022 responded as follows:

1. *In relation to the IFP Opinion (Attachment 1) I'm happy to accept that the proposed turbines will not affect the Shannon Airport Instrument Flight Procedures and nothing further is required from this perspective.*

   Note: If planning is granted and the construction goes ahead, these turbines will need to be notified to the IAA Aviation Safety Regulator, each being higher than 100m elevation.
2. *Technical Assessment Report:*
   - *Building Restricted Areas: SAA's Paul Hennessy copied for information.*
   - *NAVAIDs: The report conforms no issues for Airport NAVAIDs: Fergal Doyle copied to confirm this.*
   - *Surveillance: The report notes that mitigations are required for the Shannon PSR and the Woodcock Hill MSSR most particularly not prevent false targets and ghost signals respectively. While the report outlines how these mitigations could be applied, this must be assessed by our surveillance team*

On November 29th 2022 there was a response from the IAA Surveillance M&E Division following their review of the detailed Technical Assessment Report by Cyrrus. The response stated as follows:

> *"… The IAA Surveillance Domain conclusion is that this proposed Ballycar Wind Farm development, would degrade the performance of the Woodcock Hill Radar. As a consequence the IAA would object to a Ballycar Wind Farm development planning application …"*

Wind Farm Mitigation Measures

It was identified through the consultation process with the IAA that there were no impacts on Instrument Flight Procedures, Navigational Aids or Flight Inspection Procedures and that no mitigation measures were required.

In their detailed technical aviation assessment report Cyrrus, did identify potential surveillance radar impacts stating that:

> " a form of mitigation for Shannon PSR over the proposed Ballycar development may be required … "
>
> " .. It is recommended that mitigation options are discussed with the Irish Aviation Authority (IAA), specifically Air Traffic Services. It is the surveillance network and operational use that will largely influence a suitable mitigation.."

Ai Bridges commissioned Cyrrus to review the possible Mitigation Measures and undertake a Mitigation Options Study Report that would address the ten concerns identified by the IAA in their final consultation response on November 28th 2022. Cyrrus were requested to engage with the manufacturer of the radar equipment in use at Shannon Airport and Woodcock Hill to provide supporting evidence of "wind farm mitigation" features including upgrade availability.

Cyrrus produced a "Mitigations Options Study" report following research conducted over a three-month period with references to other wind farm mitigation projects as well as reliance on data provided by the radar equipment manufacturer. The report addressed all of the IAA concerns on radar performance degradation and provides viable mitigation measures. The report has been provided with supporting evidence of workable mitigation measures with references to third-party Wind Farm Mitigation Projects.

Summary

Following the investigation of the mitigation options along with discussions with the manufacturer of the radar equipment, it has been shown that there are viable options available for the mitigation / remediation of the ten concerns raised by the IAA . The Mitigation Options Study report concludes that:

- The development of the Windfarm at Ballycar would require minimal optimization of the Woodcock Hill and Shannon Airport radars.
- The systems in place have the capacity to provide a service even if a large number of turbines were developed in the coverage area.
- The manufacturer can also provide upgrades and enhancements to both systems should they be required in future.

Sections

Appendices

1. Introduction

Malachy Walsh and Partners (MWP) commissioned an independent aviation assessment in reponse to concerns raised by the IAA in relation to a Scoping Report consultation request in January 2022 concerning the proposed Ballycar Wind Farm development. The IAA raised concerns in relation to:

- Instrument Flight Procedures (IFP) surfaces
- Navigational Aids\ ISL Flight Inspection surfaces
- Surveillance Systems

MWP commenced the consultation process with the IAA in January 2022 with the final response from the IAA being received in November 2022. The consultations and communications are detailed in Appendix A of this report.

A series of technical aviation assessment reports were submitted by MWP to the IAA Air Navigation Service Provider which satisfied the concerns raised in relation to Instrument Flight Procedures detailing that there is no impact to the IFP surfaces. This report, prepared by Cyrrus, is included in Appendix B (Ballycar Wind Farm IFP Opinion). MWP also commissioned FCSL Ltd., a certified flight inspection company retained by the IAA for bi-annual flight inspection services, to prepare a study to assess the impacts on ILS Inspection flights. The study findings reported that there were no impacts to ILS flight inspections. The full details of the report are included in Appendix D (Ballycar Wind Farm Impact on ILS Inspection Report).

MWP commissioned Cyrrus to undertake a further Technical Aviation Assessment Study to assess the impacts of the proposed wind farm development on surveillance radar systems. The study reported that there would be an impact on the surveillance radar and outlined some mitigation options. The IAA Airspace Navigation Team referred the report to their Surveillance M&E Systems Team. A response from the IAA in November in 2022 to MWP noted that the proposed Ballycar Wind Farm development would degrade the performance of the radar at Woodcock Hill and also introduce false targets or clutter on the Shannon Airport primary surveillance radar.

Ai Bridges conducted a full review of all the consultations and the aviation assessment reports and then engaged with Cyrrus to undertake a review of the IAA consultation response and undertake further research into the concerns raised by the IAA. Ai Bridges also requested Cyrrus to engage with the manufacturer to further investigate the capabilities of the radar equipment at Woodcock Hill and Shannon Airport for possible service upgrades and/or feature upgrades to mitigate the impacts. Cyrrus produced a Mitigations Options Study, shown in Appendix E, that addressed each of the concerns raised by the IAA and provided mitigation measure proposals that would allow the development of the Ballycar Wind Farm, without any residual impact on the radar systems.

Sections 1.1 to 1.3 below provides a more detailed description of the concerns raised by the IAA Air Navigation Service Provider in relation to IFP, Navigational Aid surfaces and Surveillance Radar systems.

1.1 Instrument Flight Procedures (IFP)

The Ballycar Wind Farm IFP Opinion Report, in Appendix B, identifies that the proposed wind farm does impact the current published procedures at Shannon airport. This is however limited to the ATC Surveillance Minimum Altitude Chart (ATC SMAC). Although a full IFP assessment is normally required to identify an impact, it is normally recommended to submit the opinion report to the IAA Air Service Navigation Provider for consideration as to whether a full assessment is required. Following a review of the IFP Opinion, the IAA deemed that a full IFP Assessment is not required and that there would be a No Impact condition on IFP surfaces and that no mitigation is required.

Aviation Impact Assessment	Mitigation Measure Action	Residual Impact
Instrument Flight Procedures surfaces	No action	None

1.2 Flight Inspection Procedures

The Ballycar Wind Farm Impact on ILS Inspection Report, in Appendix D shows that there is no impact on the Airport Navigational Aids at Shannon Airport. The IAA 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. The assessment presented within the report outlines that the 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 Ballycar Wind Farm site and therefore there would be no impacts.

Aviation Impact Assessment	Mitigation Measure Action	Residual Impact
Runway 24 ILS Flight Inspection Procedures	No action	None

1.3 Surveillance Radar Systems

The Aviation Technical Assessment, in Appendix C conducted by Cyrrus identified that there would be wind farm impact degradation on the PSR at Shannon Airport which would require some form of mitigation.

Ai Bridges then engaged with Cyrrus, to undertake a Mitigations Options Study, included in Appendix E, that would investigate and address all of the concerns of the IAA in radar performance degradation, false targets and clutter raised by the IAA Surveillance M&E Systems Division.This Mitigations Options Study by Cyrrus provides a constructive technical view on how both the Woodcock Hill **Thales RSM970** Monopulse Secondary Surveillance Radar (MSSR), and the Shannon Airport **Thales STAR 2000** Primary Surveillance Radar (PSR) with co-mounted MSSR can operate without disruption to the controlled airspace and allow the development of Ballycar Windfarm. Below is an extract from this Mitigation Options Study:

> *"..Cyrrus have engaged with the manufacturer of both radar systems to confirm their capability to operate in the presence of Wind Turbines with minimal intervention. The RSM970 MSSR at Woodcock Hill and STAR 2000 PSR with co-mounted MSSR at Shannon Airport have been developed to allow this capability. The STAR 2000 PSR was designed to work in areas with wind turbines, a continual development cycle has been carried out by Thales to ensure the systems performance is not impacted by Wind Turbines. If required upgrades and enhancements for the STAR 2000 are available. Thales have provided evidence that they are confident that with minor optimisation the proposed wind turbines at Ballycar should have minimal effect on the coverage provided by the radars. This evidence is provided as commercial in confidence. Cyrrus have permission from Thales to reference relevant parts but not provide the Thales documents in full.."*

> *"..Table 1 below highlights the IAAs concerns, and the expected impacts should the windfarm be permitted to be developed. Thales have provided evidence that each of their systems has the capability of handling multiple windfarms within the coverage area. Examples include the Star 2000 sited at Schiphol Airport and the STAR 2000 based at Newcastle. The Aeronautical Information Service (AIS) for Newcastle Airport, Reference [9], has been provided for reference. The UK MoD has contracted NATS / AQUILA under project Marshall to provide a large number of these systems due to their inbuilt capability. Reference [10] gives some detail of project Marshall. Thales have also provided a structured list of upgrades, Reference [6] within the Mitigations Options Study, available to ensure the systems can continue to provide this service into the future.."*

1.3.1 IAA Concerns in relation to Surveillance Radar Systems

The IAA have raised ten concerns in relation to impacts on the Surveillance Radar Systems. Each of these concerns is individually addressed below by referencing the evidence-based material identified in the Mitigation Options Study.

1.3.1.1 IAA Concern #1 :

This concern relates to the false returns from deflected targets which are known as FRUIT (False Returns Un-correlated in Time). The Thales Monopulse Secondary Surveillance Radar (MSSR) operated at Woodcock Hill can use one of its own specific inbuilt processing techniques within its Surveillance Data Processor (SDP) to remove these false targets. This technique is used within most MSSR radars and is called a DE-FRUITER.

The Mitigation Measure solution to eliminate the radar beam deflections is highlighted within the radar manufacturer's documentation under section 3.1.3.1.1 of Reference [3] in the Mitigation Options Study and is shown in Figure 1 below.

3.1.3.1.1 MSSR/Mode S beam management

The MRP_SBM function manages all activities that must be performed within the main beam of the antenna and regulates the use of the RF channel. Its main functions are the followings:

- it prepares all information necessary to process All-Call and Roll-Call periods,
- it processes all SSR and Mode S replies received during All-Call periods,
- it manages the real-time scheduling of Mode S surveillance and data link transactions within the Roll-Call periods.

The MRP_SBM function is composed of the following sub-functions:

- Mode S Modulator and eXtractor Control (SBM_MMXC), which manages the interface between MRP CSCI and MMXC,
- Roll Call Period Processing (SBM_RCPP), which manages activities within the Roll Call periods,
- Mode S All Call Period Processing (SBM_MACPP), which manages Mode S activities within the All Call periods,
- SSR All Call Period Processing (SBM_SACPP), which manages SSR activities within the All Call periods. It includes the defruitor function.

Figure 1: Evidence of the Mitigation Measure Solution for Radar beam deflections

Additional supporting evidence within the radar manufacturer's documentation in relation to the concern of false returns is highlighted in Figure 2 below from the radar manufacturer's documentation in section 1.3.1 of Reference [3] in the Mitigation Options Study :

1.3.1 General

The RSM 970S Mode S ensures a high quality and reliable coverage to contribute to radar operational separation of 3 NM, 5 NM and 10 NM according to EUROCONTROL standard.

The radar is capable of determining range, azimuth and height positional data, along with the identity, on each target detected, during each revolution of the antenna.

Since the MSSR systems are used in an environment which often includes multiple SSR coverage, the system has been designed in order to cope with a high fruit density (MSSR and/or Mode S fruit). Therefore, the performance will be optimised such that the output of the false data is minimised, while meeting the guaranteed parameters.

The MSSR RSM 970 S Mode S is designed to meet all the guaranteed performance in the presence of a fruit rate of 11,000 replies per second.

The performance of the RSM 970 S MODE S equipment have been confirmed through the various fields and validated by Eurocontrol and French DSNA in the frame of the POEMS pre-operational European Mode S programme. Significant breakthroughs have been achieved in the fields of:

- Discrimination,
- Phantom processing,
- Reflection processing.

Typical performance characteristics are summarised below :

GENERAL	
Modes	1; 2; 3/A; C; S
Output transmitter peak power	2570 W
Transmitter frequency	1030 ± 0.01 MHz
Range	Up to 256 NM
Scan rate	Up to 15 rpm
Antenna:	
- Azimuth beamwidth	2.4°
- Maximum gain	27 dBi
Fruit density	11,000 fruit/sec in the main lobe

Figure 2: Evidence of the Mitigation Measure Solution for Radar beam deflections

The Mitigation Measure Solution in relation to this IAA concern has been extracted from Table 1 of the Mitigation Options Study and is shown below. Based on the inbuilt DE-FRUITER capability of the MSSR, no residual impact is envisaged.

No	Description of Concern	Mitigation Measure Solution	Residual Impact
1	*no credible and implementable mitigations on the Woodcock hill radar itself to eliminate the Radar beam deflections from the proposed turbines*	Thales RSM970 MSSR has inbuilt DE-FRUITER to eliminate deflected targets. **Reference 3 –3.1.3.1.1** Thales description of how the system automatically deals with deflections (FRUIT).	None

1.3.1.2 IAA Concern #2 :

This concern relates to the reflections that will caused by the proposed turbines. The Surveillance Data Processor (SDP) in Thales RSM970 Monopulse Secondary Surveillance Radar (MSSR) can use a two-stage reflection removal process to eliminate this problem of reflections.

The Mitigation Measure solution to eliminate the radar beam deflections is highlighted within the radar manufacturer's documentation under section 1.2.2.3 of Reference [3] in the Mitigation Options Study and is shown in Figure 3 below.

1.2.2.3 Signal and Data Processor

The signal and data processing chain performs:

1. MSSR/Mode S Processor (MMXC)
   - MSSR/Mode S scheduling,
   - MSSR/Mode S signal processing,
2. Data Processor Computer (DPC)
   - MSSR/Mode S extractor and
   - PSR/MSSR/Mode S plot combination and tracking.

The MMXC and DPC cope with garbling situations in dense surveillance areas. The Off Boresight Angle measure on each code pulse is associated to the reply message with specific flags and is routed to the monopulse post-processing. The monopulse post-processing performs plot extraction and solves conflict conditions such as garbling, phantoms, saturated presences and specifically processes emergency and distress codes.

Reflections which are common phenomena in SSR systems, are detected and processed using the monopulse information. This reflection may be found either at track level or at plot level. At track level, this function is based on an auto-adaptive process : the reflections are identified as permanent or temporary. This Thales unique feature provides automatic site environment adaptation. At plot level (prior to scan-to-scan correlation), the site environment is taken into account by windows programming.

Figure 3: Evidence of the Mitigation Measure Solution for reflections

The Mitigation Measure Solution in relation to this IAA concern has been extracted from Table 1 of the Mitigation Options Study and is shown below highlighting the Concern versus Residual Impact condition. Based on the inbuilt two stage reflection processing capability to eliminate reflections, no residual impact is envisaged.

No	Description of Concern	Mitigation Measure Solution	Residual Impact
2	*no credible and implementable mitigations on the Woodcock hill radar itself to eliminate the Radar reflections from the proposed turbines*	Thales RSM970 MSSR has inbuilt two stage reflection processing to eliminate reflections. **Reference 3 – 1.2.2.3**	None

1.3.1.3 IAA Concern #3 :

This concern relates to the volumes of the Woodcock Hill MSSR shadow regions that may be created by the proposed turbines. The concern relating to shadowing has been addressed within the Aviation Technical Assessment Report prepared by Cyrrus which concluded that the effects of shadowing would be minimal and should be operational tolerable.

As shadowing from the proposed wind farm development at Ballycar will be below the Air Traffic Control (ATC) surveillance minimum altitudes and should be operationally tolerable then no Mitigation Measure solutions are required. This is addressed under section 5.9.5 of Reference [1], the CL-5715-RPT-002 V1.0 Ballycar Wind Farm Aviation Technical Assessment, and is shown in Figure 4 below

5.9.5. The maximum heights of shadow regions from the turbines will be below the published ATC surveillance minimum altitudes and should therefore be operationally tolerable.

Figure 4: Evidence showing Shadowing is operationally tolerable

Further evidence from Reference [1], sections 5.8.24 – 5.8.28 as shown below in Figure 5, provides the technical calculation of the shadow regions based on the EUROCONTROL Guidelines. The volumes of the shadow regions created by each of the turbines have been calculated and tabulated. In the Aviation Technical Assessment, the proposed turbines have been overlaid on the Air Traffic Control Surveillance Minimum Altitude Chart (ATC SMAC) with a maximum height of 352m or 1,155 feet AMSL for turbine T1 which is located within Sector 1 where the minimum altitude is 2,300 feet AMSL . Also, turbines T11 and T12 are in Sector 2 where the minimum altitude is 3,000 feet AMSL . Any aircraft flying at these minimum altitudes will not be flying low enough to be impacted by the shadow regions of the turbines and therefore the shadow regions should be operationally tolerable

5.8.24. 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
- λ = wavelength (0.29m)
- S = diameter of support structures (6m)
- PL = acceptable power loss (0.5/3dB as per guidelines)

5.8.25. The EUROCONTROL Guidelines also provide equations for calculating the width and height of the shadow regions.

5.8.26. The volumes of the Woodcock Hill MSSR shadow regions created by each of the Ballycar turbines are shown in Table 7.

5.8.27. The depth of the shadow regions beyond the Ballycar turbines will vary between 2.3km and 3.6km for Woodcock Hill MSSR, with widths of up to 65m and with a maximum height of 352m or 1,155 feet AMSL.

5.8.28. Figure 26 shows an extract of Shannon Airport's ATC Surveillance Minimum Altitude Chart, as published by the Irish Aviation Authority in the current Integrated Aeronautical Information Publication[5]. The Ballycar turbine locations are overlaid on the chart, which shows that turbines T1 to T10 are within Sector 1 where the minimum altitude is 2,300 feet AMSL. Turbines T11 and T12 are in Sector 2 where the minimum altitude is 3,000 feet AMSL. Aircraft at these minimum altitudes will not be low enough for the shadow regions to have any impact, and therefore the shadow regions that may be generated beyond the proposed turbines should be operationally tolerable.

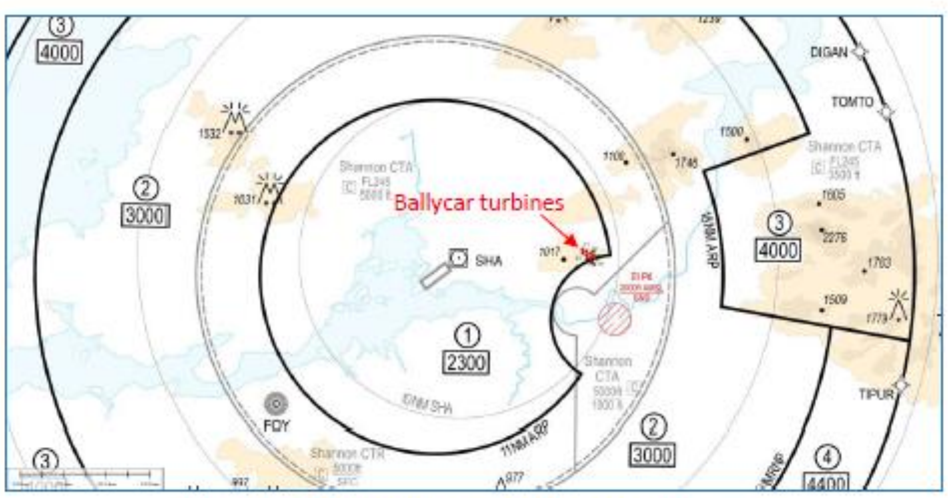


Figure 26: Shannon Airport ATC Surveillance Minimum Altitude Chart

Figure 5: Calculation of the shadow regions

The Concern versus Residual Impact condition has been extracted from Table 1 of the Mitigation Options Study showing no Mitigation Measure Solution is required as the shadowing from the proposed Ballycar windfarm will be below the published ATC SMAC altitudes and should therefore be operationally tolerable. The effect of shadowing will be minimal and of no consequence to Air Traffic Control, therefore there is no residual impact.

No	Description of Concern	Mitigation Measure Solution	Residual Impact
3	*no credible and implementable mitigations on the Woodcock hill radar itself to eliminate the Radar shadowing from the proposed turbines*	Shadowing from Ballycar Windfarm will be below the published ATC surveillance minimum altitudes and should therefore be operationally tolerable. **Reference 1 – 5.9.5**	None

1.3.1.4 IAA Concern #4 :

This concern relates to the false primary targets or clutter on the Primary Radar (Thales STAR 2000) at Shannon Airport. To address the concern relating to clutter, the Mitigation Options Study by Cyrrus concluded that the effects of shadowing would be minimal and should be operational tolerable. The STAR 2000 radar is quite advanced with a number of existing in-built capabilities for mitigating the effects of wind turbines. The STAR 2000 is an S-band solid-state approach radar. The current data sheet, Reference [2] of the Mitigation Options Study, for the STAR 2000 radar addresses wind farm mitigation:

"Windfarms: dedicated impact studies and implementation of optimal mitigation, among a large panel of solutions"

Thales, as stated on its website, offers upgrades for its radars including a feature enabling a proper windfarm mitigation. The Windfarm Filter is a dedicated algorithm that uses a specific adaptive Constant False Alarm Rate (CFAR) mechanism designed to minimize track loss and reduce false alarms above and around windfarms. It can be integrated to address both civil and military needs and, as a software capability, can also be activated into other Thales ATC radars already in service. Based on the fact that the Thales STAR 2000 uses an advanced SDP to prevent wind turbines causing clutter to be displayed on the controllers display and the availability of the Windfarm Filter upgrade , no residual impact is envisaged.

No	Description of Concern	Mitigation Measure Solution	Residual Impact
4	*Ballycar Wind Farm development would introduce false primary targets or clutter on the Shannon Primary radar*	Thales STAR 2000 uses an advanced SDP to prevent wind turbines causing clutter to be displayed on the controllers display. Windfarms : dedicated impact studies and implementation of optimal mitigation, among a large panel of solutions **Reference 2**	None

1.3.1.5 IAA Concern #5 :

This concern relates to the possible performance degradation of the PSR radar at Shannon Airport that may occur if mitigation measures for the impact of primary radar clutter were to be implemented.

The Thales STAR 2000 was designed to work in areas of wind farms without degradation of coverage . The Thales STAR 2000 would be able to process out the clutter by the processing capability of the Surveillance Data Processor (SDP). In the Mitigation Option Study prepared by Cyrrus, Reference [6], they highlight that Thales can provide upgrade options. The STAR 2000 has the processing capabilities to deal with wind turbines to ensure that the radar system performance is not impacted.

The Mitigation Measure Solution in relation to this IAA concern has been extracted from Table 1 of the Mitigation Options Study and is shown below highlighting that the Surveillance Data Processor (SDP) within the existing Shannon Airport Primary radar together with minimal optimisation will result in minimal impact, and therefore no significant residual impact is envisaged.

No	Description of Concern	Mitigation Measure Solution	Residual Impact
5	*Mitigation for the primary clutter would degrade the performance of the Shannon primary radar*	Thales STAR 2000 was designed to work in areas with wind turbines without degradation of coverage. If required upgrade options are available from Thales. A list of upgrade options has been provided. **Reference 6**	None

1.3.1.6 IAA Concern #6 :

This concern states that a non-mitigation approach relating to clutter would be operationally un-acceptable for Air Traffic Control.

The STAR 2000 would be able to process out the clutter by the Surveillance Data Processor. In the Mitigation Option Study prepared by Cyrrus, Reference [6], they highlight that Thales can provide upgrade options. The STAR 2000 has the processing capabilities to deal with wind turbines to ensure that the radar system performance is not impacted.

The Mitigation Measure Solution in relation to this IAA concern has been extracted from Table 1 of the Mitigation Options Study and is shown below highlighting that the clutter would be processed out by the Surveillance Data Processor (SDP) in the STAR 2000 radar and upgrade options are available if required to mitigate out clutter impacts and therefore no significant residual impact is envisaged.

No	Description of Concern	Mitigation Measure Solution	Residual Impact
6	*Not mitigating for the clutter would be operationally unacceptable and unsafe for Air traffic control*	Clutter would be processed out by the Thales STAR 2000 SDP. If required upgrade options are available from Thales. A list of upgrade options has been provided. **Reference 6**	None

1.3.1.7 IAA Concern #7 :

This concern relates to a maintenance service outage that may be required to mitigate reflections. A significant outage period would not be acceptable to the IAA and would compromise the safety of Air Traffic in Irish airspace.

The Thales RSM970 MMSR radar at Woodcock Hill has inbuilt two-stage processing to eliminate reflections and the radar would not have to be taken out of service for any significant period if optimisation was carried out. Only minor optimization would be required and Thales have completed successful upgrades based on a proven upgrade plan which would not require any operational downtime of the radar. In the Mitigation Option Study prepared by Cyrrus they conclude in Figure 6 below that :

The development of the Windfarm at Ballycar would require minimal optimisation of the Woodcock Hill and Shannon Airport radars. The systems in place have the capacity to provide a service even if a large number of turbines were developed in the coverage area. Thales can also provide upgrades and enhancements to both systems should they be required in future.

Figure 6: Minimal Optimization Requirement

The Mitigation Measure Solution in relation to this IAA concern has been extracted from Table 1 of the Mitigation Options Study and is shown below highlighting that the existing Woodcock Hill RSM970 MSSR radar will use its inbuilt two stage reflection processing to eliminate against reflections. Therefore, the radar would not be taken out of service for a significant period. The radar in question has a modular architecture and in the event that upgrades are required any downtime would be minimal. As Thales have completed may prjects involving similar upgrades thay have upgrade implementation plans to allow that radars to remain operational throughout. Based on the inbuilt capabilities and potentially minor optimisation, a residual impact is not envisaged.

No	Description of Concern	Mitigation Measure Solution	Residual Impact
7	*Taking the Woodcock Hill radar out of service for the many months required to mitigate reflections is not acceptable to IAA operations and would compromise the safety of Air Traffic in Irish airspace.*	The Woodcock Hill radar would not require to be taken out of service for any significant periods. Only minor optimisation should be required. Thales RSM970 MSSR has inbuilt two stage reflection processing to eliminate reflections. **Reference 3 – 1.2.2.3**	None

1.3.1.7 IAA Concern #8 :

This concern relates to the potential that radar reflection mitigations may be bypassed when the radar detects aircraft squawking Emergency, Hijack or Comms failure codes.

The Thales RSM970 MMSR radar at Woodcock Hill has inbuilt two-stage processing to eliminate reflections.

The Mitigation Measure Solution in relation to this IAA concern has been extracted from Table 1 of the Mitigation Options Study and is shown below highlighting that the Surveillance Data Processor (SDP) within the existing radars will mitigate against reflections. Based on the inbuilt capabilities, a residual impact is not envisaged.

No	Description of Concern	Mitigation Measure Solution	Residual Impact
8	*Radar reflection mitigations are bypassed when the radar detects aircraft squawking Emergency, Hijack or Comms failure codes.*	This is not correct. The radars SDP will still mitigate against reflections. Thales RSM970 MSSR has inbuilt two stage reflection processing to eliminate reflections. **Reference 3 – 1.2.2.3**	None

1.3.1.7 IAA Concern #9 :

This concern relates to the possible reduction of radar coverage and the scale of the non-initialisation area that would be required to mitigate deflections generated by the proposed wind turbines, with a reduction in radar performance below mandated requirements.

In the Mitigation Options Study, Cyrrus investigated the processing used to prevent deflected targets being displayed. The false returns from deflected targets are known as False Returns Uncorrelated in Time (FRUIT). The Surveillance Data Processor (SDP) within the Woodcock Hill MSSR will use a DE-FRUITER to remove these false targets. This technique is used in most MSSR systems.

Any deflections generated by the proposed wind turbines will be eliminated by the DE-FRUITER and a non-initialisation area should not be required. The Thales RSM970 MSSR radar at Woodcock Hill has an inbuilt DE-FRUITER to eliminate deflected targets. The Mitigation Options Study highlights, in Reference [3], the manufacturer's description of how the Woodcock Hill radar surveillance system automatically deals with deflections (FRUIT) as part of the MSSR/Mode S beam management of the Radar Processing hardware function (shown below in Figure 7).

3.1.3.1.1 MSSR/Mode S beam management

The MRP_SBM function manages all activities that must be performed within the main beam of the antenna and regulates the use of the RF channel. Its main functions are the followings:

- it prepares all information necessary to process All-Call and Roll-Call periods,
- it processes all SSR and Mode S replies received during All-Call periods,
- it manages the real-time scheduling of Mode S surveillance and data link transactions within the Roll-Call periods.

The MRP_SBM function is composed of the following sub-functions:

- Mode S Modulator and eXtractor Control (SBM_MMXC), which manages the interface between MRP CSCI and MMXC,
- Roll Call Period Processing (SBM_RCPP), which manages activities within the Roll Call periods,
- Mode S All Call Period Processing (SBM_MACPP), which manages Mode S activities within the All Call periods,
- SSR All Call Period Processing (SBM_SACPP), which manages SSR activities within the All Call periods. It includes the defruitor function.

Figure 7: MSSR/Mode S beam management DE-FRUITER function.

The Mitigation Measure Solution in relation to this IAA concern has been extracted from Table 1 of the Mitigation Options Study and is shown below highlighting that the Surveillance Data Processor (SDP) within the existing Woodcock Hill MSSR radar will use a DE-FRUITER to mitigate deflected targets. Based on this inbuilt capability, no residual impact in envisaged in relation to a reduction in radar coverage and performance below mandated requirements.

No	Description of Concern	Mitigation Measure Solution	Residual Impact
9	*Due to the proximity of the proposed Ballycar wind turbine development to Woodcock hill, the scale of the non-initialisation area required to mitigate for the Ballycar generated deflections would in effect remove almost 30-degrees of the radars 360-degree coverage, reducing its performance below mandated requirements*	This is not correct, any deflections generated by the Ballycar wind turbines will be eliminated by the DE-FRUITER. A non-initialisation area should not be required. Thales RSM970 MSSR has inbuilt DE-FRUITER to eliminate deflected targets. **Reference 3 – 3.1.3.1.1**, Thales description of how the system automatically deals with deflections (FRUIT).	None

1.3.1.7 IAA Concern #10 :

This concern relates to the volumes of the Woodcock Hill MSSR shadow regions that may be created by the proposed turbines. The concern relating to shadowing has been addressed within the Aviation Technical Assessment Report prepared by Cyrrus which concluded that the effects of shadowing would be minimal and should be operational tolerable.

As shadowing from the proposed wind farm development at Ballycar will be below the Air Traffic Control (ATC) surveillance minimum altitudes and should be operationally tolerable then no Mitigation Measure solutions are required. This is addressed under section 5.9.5 of Reference [1], the CL-5715-RPT-002 V1.0 Ballycar Wind Farm Aviation Technical Assessment, and is shown in Figure 8 below.

5.9.5. The maximum heights of shadow regions from the turbines will be below the published ATC surveillance minimum altitudes and should therefore be operationally tolerable.

Figure 8: Evidence showing Shadowing is operationally tolerable

Further evidence from Reference [1], sections 5.8.24 – 5.8.28 as shown below, provides the technical calculation of the shadow regions based on the EUROCONTROL Guidelines. The volumes of the shadow regions created by the proposed turbines have been calculated and tabulated. In the Aviation Technical Assessment, the proposed turbines have been overlaid on the Air Traffic Control Surveillance Minimum Altitude Chart (ATC SMAC) with a maximum height of 352m or 1,155 feet AMSL for turbine T1 which is located within Sector 1 where the minimum altitude of 2,300 feet. Also, turbines T11 and T12 are in Sector 2 where the minimum altitude is 3,000 feet for this sector . These minimum altitudes for each of these sectors can be seen below in the ATC Surveillance Minimum Altitude Chart excerpt in Figure 9 below. Any aircraft flying at these minimum altitudes within these sectors will not be flying low enough to be impacted by the shadow regions of the turbines and therefore the shadow regions should be operationally tolerable. The calculation methods are shown below in Figure 9 below.

5.8.24. 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.

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

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

5.8.25. The EUROCONTROL Guidelines also provide equations for calculating the width and height of the shadow regions.

5.8.26. The volumes of the Woodcock Hill MSSR shadow regions created by each of the Ballycar turbines are shown in Table 7.

5.8.27. The depth of the shadow regions beyond the Ballycar turbines will vary between 2.3km and 3.6km for Woodcock Hill MSSR, with widths of up to 65m and with a maximum height of 352m or 1,155 feet AMSL.

5.8.28. Figure 26 shows an extract of Shannon Airport's ATC Surveillance Minimum Altitude Chart, as published by the Irish Aviation Authority in the current Integrated Aeronautical Information Publication[3]. The Ballycar turbine locations are overlaid on the chart, which shows that turbines T1 to T10 are within Sector 1 where the minimum altitude is 2,300 feet AMSL. Turbines T11 and T12 are in Sector 2 where the minimum altitude is 3,000 feet AMSL. Aircraft at these minimum altitudes will not be low enough for the shadow regions to have any impact, and therefore the shadow regions that may be generated beyond the proposed turbines should be operationally tolerable.

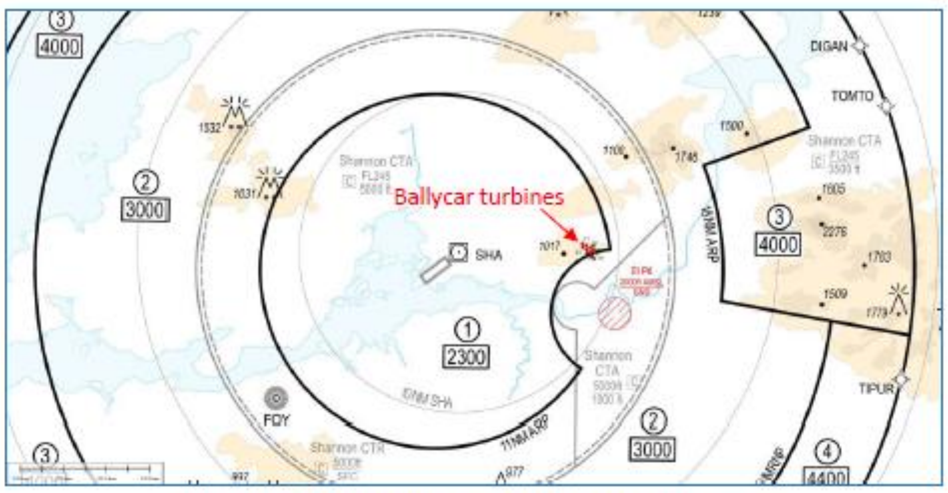


Figure 26: Shannon Airport ATC Surveillance Minimum Altitude Chart

Figure 9: Calculation of the Shadow Regions

The Concern versus Residual Impact condition has been extracted from Table 1 of the Mitigation Options Study showing no Mitigation Measure Solution is required as the shadowing from the proposed Ballycar windfarm will be below the published ATC SMAC altitudes and should therefore be operationally tolerable. The effect of shadowing will be minimal and of no consequence to Air Traffic Control and therefore, there is no residual impact.

No	Description of Concern	Mitigation Measure Solution	Residual Impact
10	*Shadowing from the turbines results in a degradation of the probability of detection of aircraft flying behind the proposed turbines*	Shadowing from Ballycar Windfarm will be below the published ATC surveillance minimum altitudes and should therefore be operationally tolerable. **Reference 1 – 5.9.5**	None

2. Summary

Table 1 (taken from the Mitigation Options Study) shows the concerns raised by the IAA and the likely impact on the Woodcock Hill and Shannon Airport systems. Based on the below it is apparent that the proposed Ballycar wind farm will not result in any residual impact on the systems due to the inbuilt systems capabilities and minor optimisation opportunities.

No	Description of Concern	Mitigation Measure Solution	Residual Impact
1	*no credible and implementable mitigations on the Woodcock hill radar itself to eliminate the Radar beam deflections from the proposed turbines*	Thales RSM970 MSSR has inbuilt DE-FRUITER to eliminate deflected targets. **Reference 3 – 3.1.3.1.1,** Thales description of how the system automatically deals with deflections (FRUIT).	None
2	*no credible and implementable mitigations on the Woodcock hill radar itself to eliminate the Radar reflections from the proposed turbines*	Thales RSM970 MSSR has inbuilt two stage reflection processing to eliminate reflections. **Reference 3 – 1.2.2.3**	None
3	*no credible and implementable mitigations on the Woodcock hill radar itself to eliminate the Radar shadowing from the proposed turbines*	Shadowing from Ballycar Windfarm will be below the published ATC surveillance minimum altitudes and should therefore be operationally tolerable. **Reference 1 – 5.9.5**	None
4	*Ballycar Wind Farm development would introduce false primary targets or clutter on the Shannon Primary radar*	Thales STAR 2000 uses an advanced SDP to prevent wind turbines causing clutter to be displayed on the controllers display. Windfarms: dedicated impact studies and implementation of optimal mitigation, among a large panel of solutions **Reference 2**	None
5	*Mitigation for the primary clutter would degrade the performance of the Shannon primary radar*	Thales STAR 2000 was designed to work in areas with wind turbines without degradation of coverage. If required upgrade options are available from Thales. A list of upgrade options has been provided. **Reference 6**	None
6	*Not mitigating for the clutter would be operationally unacceptable and unsafe for Air traffic control*	Clutter would be processed out by the Thales STAR 2000 SDP. If required upgrade options are available from Thales. A list of upgrade options has been provided. **Reference 6**	None
7	*Taking the Woodcock Hill radar out of service for the many months required to mitigate reflections is not acceptable to IAA operations and would compromise the safety of Air Traffic in Irish airspace.*	The Woodcock Hill radar would not require to be taken out of service for any significant periods. Only minor optimisation should be required. Thales RSM970 MSSR has inbuilt two stage reflection processing to eliminate reflections. **Reference 3 – 1.2.2.3**	None
8	*Radar reflection mitigations are bypassed when the radar detects aircraft squawking Emergency, Hijack or Comms failure codes.*	This is not correct. The radars SDP will still mitigate against reflections. Thales RSM970 MSSR has inbuilt two stage reflection processing to eliminate reflections. **Reference 3 – 1.2.2.3**	None
9	*Due to the proximity of the proposed Ballycar wind turbine development to Woodcock hill, the scale of the non-initialisation area required to mitigate for the Ballycar generated deflections would in effect remove almost 30-degrees of the radars 360-degree coverage, reducing its performance below mandated requirements*	This is not correct, any deflections generated by the Ballycar wind turbines will be eliminated by the DE-FRUITER. A non-initialisation area should not be required. Thales RSM970 MSSR has inbuilt DE-FRUITER to eliminate deflected targets. **Reference 3 – 3.1.3.1.1**, Thales description of how the system automatically deals with deflections (FRUIT).	None
10	*Shadowing from the turbines results in a degradation of the probability of detection of aircraft flying behind the proposed turbines*	Shadowing from Ballycar Windfarm will be below the published ATC surveillance minimum altitudes and should therefore be operationally tolerable. **Reference 1 – 5.9.5**	None

Table 1: IAA Concerns v Residual Impact

3. Recommendations

From the findings of the Mitigations Options Study Report prepared by Cyrrus the following recommendations have been made to remediate the concerns raised by the IAA ANSP in relation to surveillance radar impacts on the Woodcock Hill MSSR and the Shannon Airport PSR. Below is an extract from this Mitigation Options Study:

i) The technical documentation provided by the manufacturer (Thales) of the two systems provides assurance that mitigation for the Ballycar Windfarm is possible. Cyrrus would recommend that an onsite condition survey is carried out by Thales on both the Shannon Airport and Woodcock Hill systems to confirm their current operational state and ascertain whether updates or upgrades would be required.

ii) A limited operational flight trial may also be prudent at this stage to provide a baseline of the current systems coverage over the area of the proposed Windfarm.

iii) Once the windfarm is built, the systems may require minor optimisation by Thales. Once completed, a further Flight Check would be recommended to confirm the systems performance was acceptable over the Windfarm area

Appendix A – IAA Consultations

APPENDIX A - IAA Consultations

The consultations between Malachy Walsh & Partners (MWP) and the Irish Aviation Authority (IAA) in relation to Ballycar wind farm are presented below.

IAA Email to MWP - 05 January 2022

From: *O'LEARY Geraldine <Geraldine.O'LEARY@IAA.ie>*
Sent: *Wednesday 5 January 2022 14:04*
Subject: *Proposed Ballycar Wind Farm [Filed 07 Jan 2022 11:03]*

Dear Mr. Barry,

Thank you for your letter and scoping report and request for comments in relation to a proposed wind farm on lands at and near Ballycar, Co. Clare.

As the blade tip height proposed is not included, nor specific turbine positions and the ground elevation of each site is not provided, Safety Regulation Division - Aerodromes cannot make any specific comments at this time.

The development appears to be approximately 16km East of Shannon Airport, as such, the applicant should engage with Shannon Airport Authority and the IAA's Air Navigation Service Provider (ANSP) as a matter of urgency to undertake a preliminary screening assessment to confirm that the proposed wind farm and the associated cranes that would be utilised during its construction would have no impact on instrument flight procedures, communication and navigation aids or flight checking at Shannon Airport. Contact details are as below:

Aerodrome Operator – Shannon Airport:	IAA-ANSP:	Shannon Tower Business Unit
Mr. Paul Hennessy Safety Compliance and Environment Manager Shannon Airport Authority DAC t: +353-61-712471 m: +87-2382453 e: paul.hennessy@shannonairport.ie	Mr. Cathal Mac Criostail Airspace & Navigation Manager Údarás Eitlíochta na hÉireann / Irish Aviation Authority The Times Building, 11-12 D'Olier Street, Dublin 2, D02 T449, Ireland cathal.maccriostail@iaa.ie +353 (0)1 6031173 +353 (0)86 0527130	Mr. Jonathan Byrne Operations Manager STBU/CTBU Air Traffic Control Irish Aviation Authority jonathan.byrne@iaa.ie +353 61 703704 +353 87 9375486

Subject to any study noting a potential impact on the safety of operations at Shannon Airport, during the formal planning process, the Safety Regulation Division – Aerodromes would likely make the following general observation:

In the event of planning consent being granted, the applicant should be conditioned to contact the Irish Aviation Authority to: (1) agree an aeronautical obstacle warning light scheme for the wind farm development, (2) provide as-constructed coordinates in WGS84 format together with ground and tip height elevations at each wind turbine location and (3) notify the Authority of intention to commence crane operations with at least 30 days prior notification of their erection.

Yours sincerely

Deirdre Forrest
Corporate Affairs

MWP Email to IAA - 13 January 2022

From: *Peter Barry <Peter.Barry@mwp.ie>*
Sent: *Thursday 13 January 2022 10:35*
Subject: *RE: Proposed Ballycar Wind Farm*

Hi Geraldine,

Please find attached the turbine coordinates, hub height, rotor diameter and ground elevation as requested (email thread below).

If you need any more information, please let me know.
I would appreciate if you would acknowledge receipt of this email.

Peter Barry
BSc MSc CEnv
Principal Environmental Scientist

IAA Email to MWP - 13 January 2022

From: *MACCRIOSTAIL Cathal <Cathal.MacCriostail@IAA.ie>*
Sent: *Thursday 13 January 2022 13:41*
Subject: *220112 Proposed Ballycar Wind Farm*
Importance: *High*

Dear Peter,

Happy New Year and many thanks for the data supplied in the attached file.

There are a number of surfaces that the IAA Air Navigation Service Provider (ANSP) are responsible for safeguarding around Shannon Airport, including Navigation Aids, Surveillance Radar and Instrument Flight Procedures (IFPs).

In regard to the IFP surfaces, I am responsible for safeguarding here and we have a safeguarding grid to guide as to whether there is a potential impact on the IFP surfaces, generated by new obstacles, such as the proposed (12) wind turbines.

Below is a depiction of this safeguarding grid with a pin at Ballycar:

The values each grid cell represent an Above Mean Sea Level (AMSL: Site elevation + Height of obstacle) elevation value, above which, an IFP impact assessment will be required. In the case of the Ballycar area and taking the highest turbine height supplied, 254m added to an approximate site elevation of 240m, gives an AMSL elevation of in excess of 400m, which is above the safeguarding values in this area.

Separately, the heights proposed will likely impact the Surveillance Radar at Woodcock Hill and navigation aids for approaches to Shannon Airport. I've copied colleagues from the ANSP in these areas, for information.

This is not the only wind turbine proposal for this area and to be completely upfront, nearly all are creating issues for the surfaces referenced.

If you could supply confirmation of the AMSL elevations of the turbines and give co-ordinates in WGS 84 format (Latitude and Longitude), this would be appreciated and will allow me to give greater clarity on requirements for the ANSP and indeed SAA. If I have picked up on information incorrectly, please do correct me.

Kind regards,

Cathal
Cathal Mac Criostail
Údarás Eitlíochta na hÉireann / Irish Aviation Authority

MWP Email to IAA - 13 January 2022

From: *Peter Barry <Peter.Barry@mwp.ie>*
Sent: *Thursday 13 January 2022 15:16*
Subject: *RE: 220112 Proposed Ballycar Wind Farm*

Hi Cathal,

Attached table with Lat/ Long coordinates included. Also, to clarify the column rotor diameter was labelled wrong in the earlier table I emailed, it should have been labelled blade length, rotor diameter is then double. Corrected table attached with AMSL as requested.

We are happy to discuss findings once you have had a chance to carry out your internal studies. We are still in the design and assessment stage. Let me know if I can do anything else.

Peter

IAA Email to MWP - 14 January 2022

From: *MACCRIOSTAIL Cathal <Cathal.MacCriostail@IAA.ie>*
Sent: *Monday 14 February 2022 17:44*
Subject: *220214 Proposed Ballycar Wind Farm ANSP Update*
Importance: *High*

Dear Peter,

Many thanks for the email and the attached detailed outline of the proposed Turbine co-ordinates and AMSL elevations. Thanks also for the phone-call by way of reminder on this.

As I outlined there are three areas of concern for us the IAA Air Navigation Service Provider:

1. ***Instrument Flight Procedures (IFPs) surfaces:*** *Below is a Google Earth outline of the turbines with our IFP safeguarding girds overlayed:*

As you can see the guide (IFP) elevation which does not affect the IFPs, is exceeded for many of the proposed turbines. This does not mean that this is not acceptable. It does however require an IF assessment to be carried out by a certified IFP designer to assess possible impacts. When you're ready to engage on this I can advise on which companies are certified for this work. The result should confirm no impact, or recommend mitigations, e.g. lowering of some turbines elevations possibly

2. ***Navigation Aids:*** *The nearest turbine proposed is c. 16.5 km from Shannon Airport and as such should be outside area of concern for our ground-based navigation aids. This may need to be confirmed by the company who carry out flight checking if these systems. Fergal Arthurs and Fergal Doyle, Could you review and provide an opinion please?*

3. ***Surveillance:*** *The turbines as proposed are close to our surveillance systems at Woodcock Hill and will need to be considered for an effect on these systems. Attached is some guidance material and I'll refer this element to my colleague Charlie O'Loughlin for a view on this.*

If you are proceeding to planning application, could you advise all copied please and we can assess where we are at that point?

I hope this all makes sense.

Kind regards,
Cathal

Cathal Mac Criostail
Údarás Eitlíochta na hÉireann / Irish Aviation Authority

MWP Email to IAA – 25 February 2022

From: *Peter Barry <Peter.Barry@mwp.ie>*
Sent: *Friday 25 February 2022 14:47*
Subject: *RE: 220214 Proposed Ballycar Wind Farm ANSP Update*

Hi Cathal,

Thank you for below. We are proceeding with the application.

I attached a couple of reports which we commissioned by Cyrrus. You might review and we could discuss the findings and recommended mitigation. There have been a couple of iterations of the layout since, but the mitigation measures should be the same.

Do we need to have a meeting to discuss the attached?

IAA Email to MWP - 28 February 2022

From: *MACCRIOSTAIL Cathal <Cathal.MacCriostail@IAA.ie>*
Sent: *Monday 28 February 2022 12:50*
Subject: *220228 Proposed Ballycar Wind Farm ANSP Update (2)*
Importance: *High*

Dear Peter,

Many thanks for the attached reports.

1. *In relation to the IFP Opinion (Attachment 1) I'm happy to accept that the proposed turbines will not affect the Shannon Airport Instrument Flight Procedures and nothing further is required from this perspective.*

   Note: If planning is granted and the construction goes ahead, these turbines will need to be notified to the IAA Aviation Safety Regulator, each being higher than 100m elevation

2. *Technical Assessment Report:*

   - *Building Restricted Areas: SAA's Paul Hennessy copied for information*
   - *NAVAIDs: The report conforms no issues for Airport NAVAIDs: Fergal Doyle copied to confirm this*
   - ***Surveillance:*** *The report notes that mitigations are required for the Shannon PSR and the Woodcock Hill MSSR most particularly not prevent false targets and ghost signals respectively. While the report outlines how these mitigations could be applied, this must be assessed by our surveillance team (Charlie O'Loughlin and his team copied).*

This last item will be the main issue for then IAA ANSP in my experience. This proposed development is one of multiple application in the same general area which is all cases is leading to an assessment of Surveillance impacts. While in isolation "filtering" of PSR and /or updates to the reflector file for Woodcock Hill MSSR may seem straightforward, it may be of significant cost to the ANSP and if required for multiple developments, lead to a realistically unusable radar system for aircraft targets between 3500 and 10000 feet, which would be the altitude band serving Shannon Airport. Added to this, such system upgrades have not been planned for in the Surveillance work programme.

I suggest that Charlie and his team will need to assess and revert with their position. Please follow up with me in a week's time and I'll in turn check with Surveillance.

Best regards,
Cathal

Cathal Mac Criostail
Údarás Eitlíochta na hÉireann / Irish Aviation Authority

MWP Email to IAA – 09 March 2022

From: *Peter Barry <Peter.Barry@mwp.ie>*
Sent: *Wednesday 9 March 2022 09:46*
Subject: *RE: 220228 Proposed Ballycar Wind Farm ANSP Update (2)*

Hi Cathal,

Just following up on below, as you advised.

FYI, I have emailed FCSL and am waiting to hear back.

IAA Email to MWP - 09 March 2022

From: *MACCRIOSTAIL Cathal <Cathal.MacCriostail@IAA.ie>*
Sent: *09 March 2022 10:28*
Subject: *RE: 220228 Proposed Ballycar Wind Farm ANSP Update (2)*

Many thanks for all this Peter.

I appreciate your proactive engagement on this.

Kind regards,

Cathal

Cathal Mac Criostail
Údarás Eitlíochta na hÉireann / Irish Aviation Authority

IAA Email to MWP - 29 November 2022

From: *OLOUGHLIN Charlie <Charlie.OLOUGHLIN@IAA.ie>*
Sent: *Tuesday 29 November 2022 13:47*
Subject: *[Pending]RE: 220516 Proposed Ballycar Wind Farm ANSP Update-Surveillance Request*

Hi Peter,

My apologies for not replying to you sooner with a response from the IAA's Surveillance Domain in relation to the proposed Ballycar Wind Farm and our review of the Cyrrus Technical Assessment Report.
We assessed the Cyrrus report back in the summer but neglected to close the circle by replying with our comments and conclusions.

Our assessment is that the proposed Ballycar Wind Farm development would introduce Woodcock hill radar reflections, deflections and shadowing.

The IAA Surveillance Domain conclusion is that this proposed Ballycar Wind Farm development, would degrade the performance of the Woodcock Hill Radar.

As a consequence the IAA would object to a Ballycar Wind Farm development planning application.

I have outlined below a brief summary of Woodcock Hill radar impact concern. Reflections and shadowing are also identified in the CYRRUS report but the deflection issue is not.

IAA Radars must now meet EU mandated (EU 1207/2011) performance criteria in order to support 5 nautical Mile separation of aircraft in IAA airspace. Radar performance is assessed on an ongoing periodic basis as well as prior to implementation of any Radar configuration change. From our assessment Woodcock hill radar, without mitigation would not meet the mandated surveillance performance required relating to False Target reports and positional accuracy. The implementation of mitigations for the false target reports will compromise the radars probability of detection requirements and the testing of the mitigations will compromise our availability requirements. We believe there are no credible and implementable mitigations on the Woodcock hill radar itself to eliminate the Radar beam deflections, reflections and shadowing from the proposed turbines.
We also note the proposed Ballycar Wind Farm development would introduce false primary targets or clutter on the Shannon Primary radar. Mitigation for the primary clutter would degrade the performance of the Shannon primary radar. Not mitigating for the clutter would be operationally unacceptable and unsafe for Air traffic control.

> *Reflections generate dual aircraft tracks which set off IAA automation system (COOPANS) safety-net alarms such as Short-Term Conflict Alert (STCA) and Duplicate (DUPE) alerts. These alerts distract Air Traffic controllers who may attempt to deconflicting real Air traffic tracks from tracks that do not physically exist.*
> *Each Safety Net Alarm initiates a safety occurrence report.*
> *Reflections occur when an aircraft replies to both a radar interrogation directly and to an interrogation reflected by the Turbine tower or rotor blade; the radar generates both a real aircraft track and a false reflected track in the direction of the turbine.*
> *It is possible to reduce the probability of reflections through mitigation. This is normally done at the commissioning phase, where reflection mitigations for existing structures are implemented and tested prior to the operational use of the radar. Mitigating for multiple changing reflections during the construction and operation of wind Turbines within 4km of the woodcock radar, may require the radar to be taken out of service for the duration of the construction phase to implement and test the reflection mitigations. Taking the Woodcock Hill radar out of service for the many months required to mitigate reflections is not acceptable to IAA operations and would compromise the safety of Air Traffic in Irish airspace.*
> *Radar reflection mitigations are bypassed when the radar detects aircraft squawking Emergency, Hijack or Comms failure codes.*
>
> *Deflections also generate dual aircraft tracks which set off COOPANS safety-net alarms such as Short-Term Conflict Alert (STCA) and Duplicate (DUPE) alerts. These alerts distract Air Traffic controllers who may attempt to deconflicting real Air traffic tracks from tracks that do not physically exist.*
> *Each Safety Net Alarm initiates a safety occurrence report.*
> *Deflections occur when a Radar interrogation signal is deflected by the Wind Turbine introducing an error in the measured bearing of the Aircraft. This bearing error increases with range of the aircraft from the radar, becoming significant at ranges beyond 100Nautical miles. The radar bearing errors become an issue when the deflected Radar tracks are fused with the track data from other radars which calculate a different position for the aircraft track, and the deflected track is not associated with the true track position and a new Duplicate track is generated.*
> *We have mitigated for deflections from individual masts by implementing non-initialisation-areas in our Tracking systems (ARTAS). However, this non-initialisation-area mitigation must be kept to a minimum to avoid introducing holes in radar coverage. Due to the proximity of the proposed Ballycar wind turbine development to Woodcock hill, the scale of the non-initialisation area required to mitigate for the Ballycar generated deflections would in effect remove almost 30-degrees of the radars 360-degree coverage, reducing its performance below mandated requirements.*

Shadowing from the turbines results in a degradation of the probability of detection of aircraft flying behind the proposed turbines. This may result in the Woodcock hill radar not meeting its mandated Surveillance performance requirements.

Regards,
Charlie O'Loughlin.
Manager Surveillance M&E Systems,
Irish Aviation Authority,
Shannon Area Control Centre,
Ballycasey Cross, Shannon, Co. Clare, Ireland.

Appendix 5

Mitigation Options Study Ballycar Windfarm

CYRRUS

Mitigation Options Study

Ballycar Windfarm

AI Bridges Ltd

16 May 2023

CL-5912-RPT-002 v1.0

www.cyrrus.co.uk

info@cyrrus.co.uk

British Assessment Bureau UKAS MANAGEMENT SYSTEMS 8289 ISO 9001 QUALITY MANAGEMENT

British Assessment Bureau UKAS MANAGEMENT SYSTEMS 8289 ISO 14001 ENVIRONMENTAL MANAGEMENT

Document Information

Document title	Mitigation Options Study
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Document reference and Version	CL-5912-RPT-002 v1.0
Date of release	16 May 2023

Change History Record

Issue	Change Reference	Date	Details
1.0	Initial Issue	16 May 2023	Initial Issue

Executive Summary

Cyrrus have been requested by AI Bridges to provide a response to the Irish Aviation Authority email [6] which states *"**We believe there are no credible and implementable mitigations on the Woodcock hill radar itself to eliminate the Radar beam deflections, reflections and shadowing from the proposed turbines.**"*

This report provides a constructive technical view on how both the Woodcock Hill **Thales RSM970** Monopulse Secondary Surveillance Radar (MSSR), and the Shannon Airport **Thales STAR 2000** Primary Surveillance Radar (PSR) with co-mounted MSSR can operate without disruption to the controlled airspace and allow the development of Ballycar Windfarm.

Cyrrus have engaged with the manufacturer of both radar systems to confirm their capability to operate in the presence of Wind Turbines with minimal intervention. The RSM970 MSSR at Woodcock Hill and STAR 2000 PSR with co-mounted MSSR at Shannon Airport have been developed to allow this capability. The STAR 2000 PSR was designed to work in areas with wind turbines, a continual development cycle has been carried out by Thales to ensure the systems performance is not impacted by Wind Turbines. If required upgrades and enhancements for the STAR 2000 are available. Thales have provided evidence that they are confident that with minor optimisation the proposed wind turbines at Ballycar should have minimal effect on the coverage provided by the radars. This evidence is provided as commercial in confidence. Cyrrus have permission from Thales to reference relevant parts but not provide the Thales documents in full.

Table 1 below highlights the IAAs concerns, and the expected impacts should the windfarm be permitted to be developed. Thales have provided evidence that each of their systems has the capability of handling multiple windfarms within the coverage area. Examples include the Star 2000 sited at Schiphol Airport and the STAR 2000 based at Newcastle. The Aeronautical Information Service (AIS) for Newcastle Airport[9] has been provided for reference. The UK MoD has contracted NATS / AQUILA under project Marshall to provide a large number of these systems due to their inbuilt capability. Reference [10] gives some detail of project Marshall. Thales have also provided a structured list of upgrades [6] available to ensure the systems can continue to provide this service into the future.

Table 1 shows the concerns raised by the IAA and the likely impact on the Woodcock Hill and Shannon Airport systems.

	Description of Concern	Mitigation Measure Solution	Residual Impact
1	*no credible and implementable mitigations on the Woodcock hill radar itself to eliminate the Radar beam deflections from the proposed turbines*	Thales RSM970 MSSR has inbuilt DE-FRUITER to eliminate deflected targets. Reference 3 – 3.1.3.1.1, Thales description of how the system automatically deals with deflections (FRUIT).	None

2	*no credible and implementable mitigations on the Woodcock hill radar itself to eliminate the Radar reflections from the proposed turbines*	Thales RSM970 MSSR has inbuilt two stage reflection processing to eliminate reflections. Reference 3 – 1.2.2.3	None
3	*no credible and implementable mitigations on the Woodcock hill radar itself to eliminate the Radar shadowing from the proposed turbines*	Shadowing from Ballycar Windfarm will be below the published ATC surveillance minimum altitudes and should therefore be operationally tolerable. Reference 1 – 5.9.5	None
4	*Ballycar Wind Farm development would introduce false primary targets or clutter on the Shannon Primary radar*	Thales STAR 2000 uses an advanced SDP to prevent wind turbines causing clutter to be displayed on the controllers display. Windfarms: dedicated impact studies and implementation of optimal mitigation, among a large panel of solutions Reference 2	None
5	*Mitigation for the primary clutter would degrade the performance of the Shannon primary radar*	Thales STAR 2000 was designed to work in areas with wind turbines without degradation of coverage. If required upgrade options are available from Thales. A list of upgrade options has been provided. Reference 6	None
6	*Not mitigating for the clutter would be operationally unacceptable and unsafe for Air traffic control*	Clutter would be processed out by the Thales STAR 2000 SDP. If required upgrade options are available from Thales. A list of upgrade options has been provided. Reference 6	None
7	*Taking the Woodcock Hill radar out of service for the many months required to mitigate reflections is not acceptable to IAA operations and would compromise the safety of Air Traffic in Irish airspace.*	The Woodcock Hill radar would not require to be taken out of service for any significant periods. Only minor optimisation should be required. Thales RSM970 MSSR has inbuilt two stage reflection processing to eliminate reflections. Reference 3 – 1.2.2.3	None

8	*Radar reflection mitigations are bypassed when the radar detects aircraft squawking Emergency, Hijack or Comms failure codes.*	This is not correct. The radars SDP will still mitigate against reflections. Thales RSM970 MSSR has inbuilt two stage reflection processing to eliminate reflections. Reference 3 – 1.2.2.3	None
9	*Due to the proximity of the proposed Ballycar wind turbine development to Woodcock hill, the scale of the non-initialisation area required to mitigate for the Ballycar generated deflections would in effect remove almost 30-degrees of the radars 360-degree coverage, reducing its performance below mandated requirements*	This is not correct, any deflections generated by the Ballycar wind turbines will be eliminated by the DE-FRUITER. A non-initialisation area should not be required. Thales RSM970 MSSR has inbuilt DE-FRUITER to eliminate deflected targets. Reference 3 – 3.1.3.1.1, Thales description of how the system automatically deals with deflections (FRUIT).	None
10	*Shadowing from the turbines results in a degradation of the probability of detection of aircraft flying behind the proposed turbines*	Shadowing from Ballycar Windfarm will be below the published ATC surveillance minimum altitudes and should therefore be operationally tolerable. Reference 1 – 5.9.5	None

Table 1: IAA Concerns v Impact

Conclusion

The development of the Windfarm at Ballycar would require minimal optimisation of the Woodcock Hill and Shannon Airport radars. The systems in place have the capacity to provide a service even if a large number of turbines were developed in the coverage area. Thales can also provide upgrades and enhancements to both systems should they be required in future.

Abbreviations

AIS	Aeronautical Information Service
AIP	Aeronautical Information Publication
IAA	Irish Aviation Authority
MSSR	Monopulse Secondary Surveillance Radar
PSR	Primary Surveillance Radar
SDP	Surveillance Data Processor

References

[1] CL-5715-RPT-002 V1.0 Ballycar Wind Farm Aviation Technical Assessment

[2] Thales Star 2000 Datasheet

[3] Thales RSM970 Technical Description

[4] Thales Windfarm Mitigation Presentation

[5] IAA email detailing their concerns

[6] Thales structured list of upgrades

[7] Eurocontrol Mode S station Functional Specification (EMS 3.1.1)

[8] ICAO annex 10 vol IV

[9] AIS AIP Newcastle Airport

[10] An in-depth look at Project Marshall | Thales Group

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1. Introduction

1.1. Overview

1.1.1. Cyrrus have been requested by AI Bridges to provide Aviation support for the Ballycar Windfarm proposal. Previously Cyrrus issued a report [1] which provided the technical evidence demonstrating that both the Shannon Airport and Woodcock Hill radars would have Radar Line of Sight with the Windfarm.

1.2. Aim

1.2.1. This report provides evidence that current systems at Woodcock Hill and Shannon Airport can mitigate the proposed Ballycar Windfarm with minimal intervention.

1.2.2. The following sections address the concerns raised by the IAA in email [5].

1.3. Woodcock Hill Radar

1.3.1. The Woodcock Hill RSM 970 Radar is a tried and tested system used throughout the UK and Europe. The Thales datasheet detailing the systems technical characteristics and ability to meet the Eurocontrol Mode S station Functional Specification (EMS 3.11)[7] and ICAO annex 10 vol IV latest edition standards[8] which have been included for reference.

1.3.2. The IAA have raised concerns that reflections, deflections, and shadowing will cause unacceptable issues. Evidence is provided to constructively address each of these concerns, including confirmation from Thales of the System's ability to address these issues with minimal intervention.

1.3.3. To address the issue of reflections, the Thales RSM970 technical submission details how the system can automatically process sporadic reflections, also known as dynamic reflections, to prevent degradation of the radar picture. The system utilises a second stage of reflection processing which is used to address repeated reflections from one area, these are placed in the static reflector file and automatically processed out by the system. A full explanation of how the radar does this is provided in the Thales RSM970 technical description [3].

1.3.4. The IAA's 2nd concern was that Beam deflection can take place on the Woodcock Hill MSSR. Cyrrus investigated the processing used to prevent deflected targets being displayed. The false returns from deflected targets are known as False Returns Uncorrelated in Time (FRUIT). The Surveillance Data Processor (SDP) within the Woodcock Hill MSSR will use a De-FRUITER to remove these false targets. This technique is used in most MSSR systems. A detailed explanation of how this is done is provided in reference [3].

1.3.5. The IAA's 3rd concern, that shadowing would degrade the area behind the windfarm. Cyrrus and Thales are confident that any effect would be minimal and have no impact on aeronautical operations.

1.4. Shannon Airport STAR 2000 Radar

1.4.1. The Shannon Airport radar is a Thales Star 2000 PSR with co-mounted MSSR.

1.4.2. Rotating wind turbine blades will be processed as moving targets by the PSR and will be displayed as clutter. Modern SDP systems can use advanced techniques prevent this clutter from the Wind turbines from being displayed.

1.4.3. The Thales datasheet [2], confirms the STAR 2000 was designed to operate in areas with wind turbines. Thales have confirmed that the STAR 2000 systems at both Schiphol Airport in the Netherlands and Newcastle Airport in the UK, both operate successfully with multiple windfarms within close proximity of the radars. The Aeronautical Information Service (AIS) for Newcastle Airport [9] has been provided for reference.

1.4.4. The UK MoD have under project Marshall contracted for the supply of a large number of these systems due to their inbuilt capability to operate alongside windfarms.

1.4.5. Thales have undertaken extensive trials documented in their Windfarm Mitigation presentation [4] which concludes the issue of false plots and desensitisation from wind turbines has been solved.

2. IAA Issue Summary

2.1. Table of Results

2.1.1. Table 2 contains a summary of the IAA concerns and if they can be addressed. A traffic Light system has been used to highlight the fact that currently there are no impacts with either the Woodcock Hill or Shannon Airport Radars which cannot be addressed.

	Description of Concern	Mitigation Measure Solution	Residual Impact
1	*no credible and implementable mitigations on the Woodcock hill radar itself to eliminate the Radar beam deflections from the proposed turbines*	Thales RSM970 MSSR has inbuilt DE-FRUITER to eliminate deflected targets. Reference 3 – 3.1.3.1.1, Thales description of how the system automatically deals with deflections (FRUIT).	None
2	*no credible and implementable mitigations on the Woodcock hill radar itself to eliminate the Radar reflections from the proposed turbines*	Thales RSM970 MSSR has inbuilt two stage reflection processing to eliminate reflections. Reference 3 – 1.2.2.3	None
3	*no credible and implementable mitigations on the Woodcock hill radar itself to eliminate the Radar shadowing from the proposed turbines*	Shadowing from Ballycar Windfarm will be below the published ATC surveillance minimum altitudes and should therefore be operationally tolerable. Reference 1 – 5.9.5	None
4	*Ballycar Wind Farm development would introduce false primary targets or clutter on the Shannon Primary radar*	Thales STAR 2000 uses an advanced SDP to prevent wind turbines causing clutter to be displayed on the controllers display. Windfarms: dedicated impact studies and implementation of optimal mitigation, among a large panel of solutions. Reference 2	None
5	*Mitigation for the primary clutter would degrade the performance of the Shannon primary radar*	Thales STAR 2000 was designed to work in areas with wind turbines without degradation of coverage. If required upgrade options are available from Thales. A list of upgrade	None

		options has been provided. Reference 6	
6	*Not mitigating for the clutter would be operationally unacceptable and unsafe for Air traffic control*	Clutter would be processed out by the Thales STAR 2000 SDP. If required upgrade options are available from Thales. A list of upgrade options has been provided. Reference 6	None
7	*Taking the Woodcock Hill radar out of service for the many months required to mitigate reflections is not acceptable to IAA operations and would compromise the safety of Air Traffic in Irish airspace.*	The Woodcock Hill radar would not require to be taken out of service for any significant periods. Only minor optimisation should be required. Thales RSM970 MSSR has inbuilt two stage reflection processing to eliminate reflections. Reference 3 – 1.2.2.3	None
8	*Radar reflection mitigations are bypassed when the radar detects aircraft squawking Emergency, Hijack or Comms failure codes.*	This is not correct. The radars SDP will still mitigate against reflections. Thales RSM970 MSSR has inbuilt two stage reflection processing to eliminate reflections. Reference 3 – 1.2.2.3	None
9	*Due to the proximity of the proposed Ballycar wind turbine development to Woodcock hill, the scale of the non-initialisation area required to mitigate for the Ballycar generated deflections would in effect remove almost 30-degrees of the radars 360-degree coverage, reducing its performance below mandated requirements*	This is not correct, any deflections generated by the Ballycar wind turbines will be eliminated by the DE-FRUITER. A non-initialisation area should not be required. Thales RSM970 MSSR has inbuilt DE-FRUITER to eliminate deflected targets. Reference 3 – 3.1.3.1.1, Thales description of how the system automatically deals with deflections (FRUIT).	None
10	*Shadowing from the turbines results in a degradation of the probability of detection of aircraft flying behind the proposed turbines*	Shadowing from Ballycar Windfarm will be below the published ATC surveillance minimum altitudes and should therefore be operationally tolerable. Reference 1 – 5.9.5	None

Table 2: IAA Concerns v Impact

2.2. Recommendations

2.2.1. The technical documentation provided by the manufacturer (Thales) of the two systems provides assurance that mitigation for the Ballycar Windfarm is possible. Cyrrus would recommend that an onsite condition survey is carried out by Thales on both the Shannon Airport and Woodcock Hill systems to confirm their current operational state and ascertain whether updates or upgrades would be required. A limited operational flight trial may also be prudent at this stage to provide a baseline of the current systems coverage over the area of the proposed Windfarm.

2.2.2. Once the windfarm is built, the systems may require minor optimisation by Thales. Once completed, a further Flight Check would be recommended to confirm the systems performance was acceptable over the Windfarm area.

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Appendix 6

AIRNAV Response Statement Ballycar Wind Farm

Response AIRNAV Ireland

Ballycar Windfarm

Al Bridges

[Date] 25 April 2024

CL-6056-DOC-002 DA

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1.0	Initial Issue	25 April 2024	Initial Issue

Response Statement

This statement has been prepared in response to the concerns raised by AIRNAV Ireland in the letter received Friday 8th March 2024.

The main concerns raised are that the Windfarm could introduce Reflections, Deflections and Shadowing which would compromise the Woodcock Hill radars ability to support 5NM Separation in Enroute Airspace and 3NM Separation in Dublin Airspace.

Previously evidence has been provided that the Thales Monopulse Secondary Surveillance Radar sited at Woodcock Hill can operate safely in area's with high numbers of reflections and deflections as these common issues will be processed out.

Some minor shadowing in the area directly behind the windfarm may occur. Previous secondary radar studies have found the affected area is usually only a few hundred metres and of minimal operational consequence.

A further concern was also raised that a 30-degree sector extending over the Irish sea in which AIRNAV Ireland have responsibilities for Enroute traffic would suffer from degraded performance.

This concern was demonstrated by drawing two straight lines from the radar over the most northern and southern turbines as seen in Figure 1.

Figure 1: AIRNAV Ireland Affected Area

Extensive trials have been done with radars operating in area's with windfarms which show Figure 1 is not indicative of how the radar will perform. The CAA state the following:

“***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.”*

“Low Level Coverage

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 kilometres 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.”

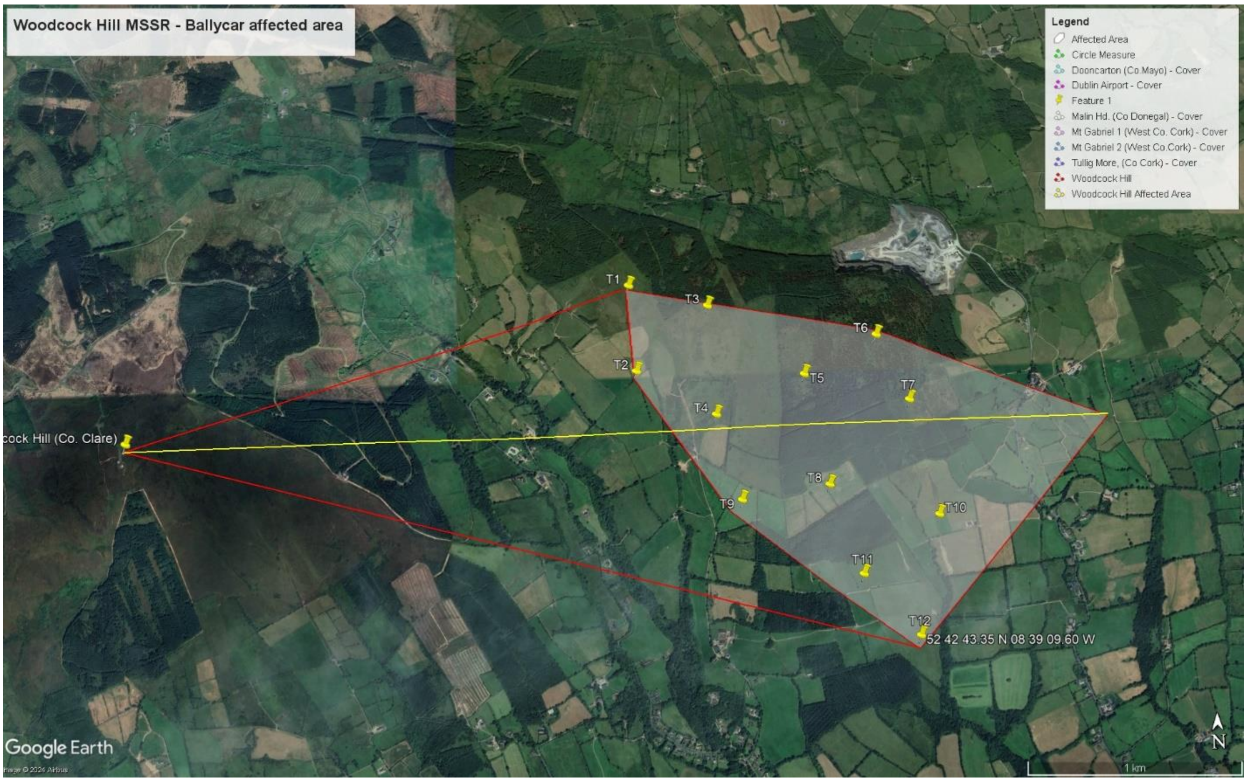

Figure 2: Woodcock Hill - Ballycar Affected Area

Figure 2 shows an indication of the area around the proposed Ballycar windfarm which may be affected.

Enroute traffic is generally expected to be between FL100 and FL400, as only the low-level coverage is likely to be affected there will be no degradation in the radar performance for enroute traffic.

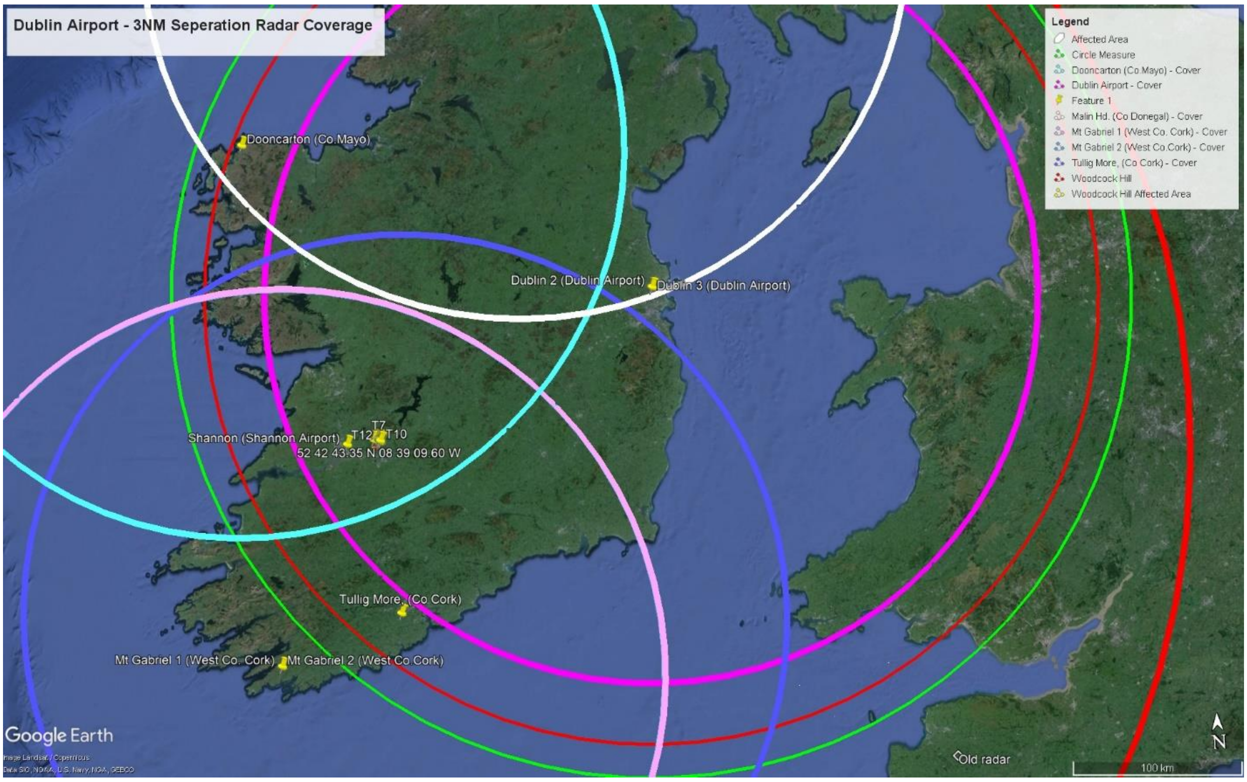

Figure 3: Dublin Terminal Area 3NM Coverage

To further address the concern that the 3NM Separation in Dublin Airspace may be degraded, The coverage from the Airport and Enroute Sensors are shown in Figure 3. As can be seen, the Airspace has overlapping radar coverage from at least 3 Systems closer to the Airport than Woodcock Hill. The AIRNAV Ireland website states: ***"The ARTAS systems merge the radar data and distribute the appropriate air situation picture to our controllers in Shannon, Dublin and Cork."***.

It is unlikely that the Woodcock Hill radar which is > 90NM from the Dublin Airport wood be used for maintaining the 3NM Separation when A minimum of four other systems provide closer cover in this area.

Appendix 7

Aviation Assessment Methodology

7.0 Aviation Assessment Methodology

There are four stages in preparing and compiling an aviation review of the study area which are 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 EUROCONTROL Guidelines.
- Aviation Impact Assessment Report.

7.1 Aviation Consultations

Consultations are commenced with relevant statutory consultees, aviation and 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).

7.2 Aviation Surveys

Desktop surveys of the critical aeronautical infrastructure and 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 en-route navigation, Navigational & Communication Aids including ILS landing system).

7.3 Aviation Desktop Network Analysis & Modelling

Desktop network analysis & modelling are carried out against relevant aviation and 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 and 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 and 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 in the Aviation Review Statement

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

7.4 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.

Appendix 8

Thales RSM970 Technical Description

THALES AIR SYSTEMS

Technical Description of the products

Secondary Surveillance Radar

RSM 970S

Thales Air Systems S.A.S 3, avenue Charles Lindbergh BP20351 – 94628 Rungis Cedex (FRANCE)	Tel.: +33(0) 1 79 61 40 00 Fax: +33(0) 1 79 61 11 78

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1. GENERAL PRESENTATION

1.1. OVERVIEW OF RSM 970 S

1.1.1 General

The RSM 970 S, the latest generation Monopulse SSR designed by Thales, for Approach and En-route surveillance.

Including major improvements:

- Mode S Transmitter
- SSR/Mode S Interrogator and reply processor,
- EMC compatibility,
- Full Mode S capability,
- Mode S / SCF* capability.

Benefiting from the experience gained throughout an impressive number of contracts implemented all over the world (more than 300 RSM 970 S / RSM 970 I / RSM 970 / RSM 870 systems sold), the RSM 970 S fully meets the standards and recommendations of ICAO Annex 10, and its electronics is fully duplicated.

The technical concepts incorporated in the equipment, such as monopulse techniques and Mode S, have been validated through field trials initially carried out as a joint programme with the French Civil Aviation Authorities, and full Mode S operation has been validated by Eurocontrol during the development of the Pre-Operational Mode S station (POEMS), which features the Mode S standard for Europe.

When fitted with the appropriate options (time stamping, dual channel site monitor), the RSM970S fully complies with the Eurocontrol Mode S Specification (EMS).

Thales is the only manufacturer which can propose the full range of SSR/Mode S applications (conventional MSSR, Mode S elementary surveillance, Mode S enhanced surveillance and Full Mode S datalink) with a single product. This feature allows the user to secure his purchase against future requirements.

The RSM 970 S may be operated in a full stand-alone configuration or in conjunction (co-mounted) with a primary radar. It can be interfaced with control centres through a wide range of formats and protocols.

The equipment is designed to be remotely controlled and monitored for all its main functions from a central point (Remote Control and Monitoring System (RCMS)).

* SCF: Surveillance Coordination Function

1.1.2 Global Functionalities of a Mode S Radar Station

1.1.2.1 General

The Mode S is an evolution of the traditional Secondary Surveillance Radar (SSR), which is based upon Mode A/C interrogation/reply scheme. In the Mode S system, this scheme has been enhanced, by uniquely identifying each aircraft using a worldwide unique 24 bit aircraft address, and by allowing the transmission of interrogations selectively addressed to a unique aircraft, instead of being broadcast over the whole antenna beam.

A Mode S radar is able to perform surveillance, i.e. to output the aircraft position, the standard SSR modes (Mode 3/A, Mode C) and the aircraft unique Modes address. It also has data-link capabilities, i.e. the ability to send or extract frames containing binary data. The data-link can operate only on aircraft being tracked by the surveillance processing. From an operational point of view, priority is always given to the surveillance processing (the detection of a target and the transmission of the corresponding information shall never be degraded for any data-link reasons).

In order to provide standard services, ICAO has standardised the Mode S subnetwork, which is the air-ground subnetwork, ATN[*] compatible, making use of the Mode S interrogators data-link features. Such a subnetwork is also able to provide non ATN services, known as Mode S Specific Services.

1.1.2.2 Mode of Operation

For a radar, the surveillance processing is responsible for determining the aircraft position for all aircraft flying in the radar coverage. It is also responsible for transmitting this position information to the users requiring it (usually Air Traffic Control Centres).

The principle of a classical SSR (Secondary Surveillance Radar) is as follows:

- The radar sends an interrogation, asking for aircraft identity (Mode A interrogation) or aircraft altitude (Mode C interrogation).
- This interrogation is detected by all aircraft located in the main antenna lobe.
- These aircraft then reply to the radar with the requested information.

The onboard equipment responsible for the interrogation detection and reply transmission is known as Transponder. A Mode S radar can perform surveillance on both SSR and Mode S transponders. Mode S transponders also behave as SSR transponders when interrogated with a standard SSR interrogation. The Mode S is fully compatible with classical SSR system. In Mode S, the interrogation-reply scheme has been enhanced, as each aircraft can be selectively interrogated, and much more information transferred in both interrogations and replies. Each aircraft is identified with a world-wide unique 24 bit address.

To achieve this selective interrogation scheme, the time has been divided into two short periods respectively called All-Call (AC) and Roll-Call (RC), which are continuously interleaved.

---

[*] ATN: Aeronautical Telecommunications Network

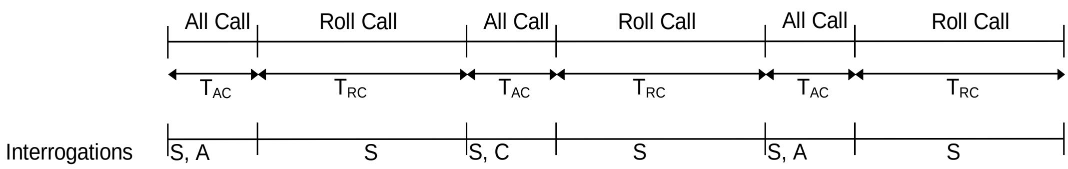
- During the Roll-Call Period, the radar will perform the selectively addressed interrogations, and listen for the associated replies, optimising the Roll-Call time by properly scheduling the interrogations and replies for the aircraft being reachable in the antenna beam at that time. But in order to selectively address an aircraft, the radar needs to know the aircraft address, as well as the approximate aircraft position. Note that the radar will not send a selective interrogation for a given aircraft during the whole scan, because this would highly generate noise in the RF link. Instead the radar will send such interrogations in the direction where the aircraft is expected to fly in.

- During the All-Call period, the radar will ask new aircraft to identify themselves, by returning their Mode S address. Once these address are acquired (i.e. known), the radar will start to perform selective interrogations on the corresponding aircraft, asking these aircraft in Roll-Call interrogations to no longer reply to All-Call interrogations (this is known as lock-out). In order to allow multiple radars to acquire the same aircraft, each radar will be given an II Code (Interrogator Identifier Code). This II Code is put into the All-Call interrogations, and the radar locks out an aircraft only with its own II Code. Note that only 15 II Codes are available. Please refer for details hereafter to the chapter related to the SI codes and II/SI code operation.

- During the All-Call period, in addition to new Mode S aircraft addresses acquisition, the radar also performs surveillance with the standard SSR transponders.

- The IRF (Interrogation Repetition Frequency) is the number of All-Call periods divided by the total All-Call/Roll-Call pattern duration. It is always adjusted, depending on the system configuration (rotation speed, instrumented range, scheduling, etc.) to the lowest practicable value for the specified performance.

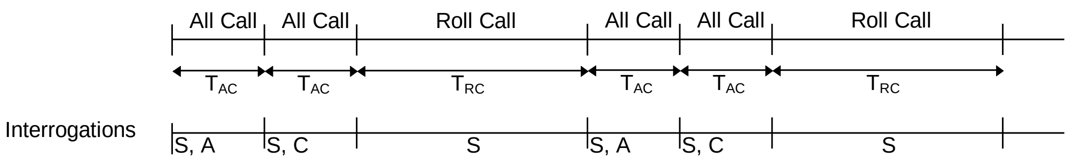
- Two examples of All Call / Roll Call scheduling patterns are shown on following figures:



Type « A » All Call / Roll Call Scheduling

In type A, one All Call occurs for the duration of one All Call and one Roll Call, so:

$$IRF=\frac{1}{T_{AC}+T_{RC}}$$



Type « B » All Call / Roll Call Scheduling

In type B, two All Call occur for the duration of two All Call and one Roll Call, so:

$$IRF = \frac{2}{2T_{AC} + T_{RC}}$$

A/C SSR interrogations are alternated from one All Call to the next.

For an imposed IRF, the Roll Call duration is directly related to the choice of the pattern type. The choice of the most appropriate scheduling is guided by comparison of the Roll Call duration imposed by the IRF, with the minimum RC duration imposed by the operational parameters like range.

1.1.2.3 Elementary Surveillance

The elementary surveillance (ELS) consists in extracting for each aircraft the following information:

- Unique 24-bit aircraft address
- Mode A code
- Aircraft identification (i.e. call-sign): BDS 20

  This feature allows a better flight plan correlation for Mode S capable ATC Centre.

- Flight level in 25 ft increments (depending on aircraft equipment)

  This feature allows a better altitude tracking at ATC level.

- Flight Status (airborne or ground)
- Transponder Capability Report: BDS 10
- Common Usage GICB Capability Report: BDS 17
- ACAS Resolution Advisory: BDS 30

1.1.2.4 Enhanced surveillance

The Mode S transponder contains 256 registers, called BDS (Comm B Data Selector). Note that the first register (register 0) is used for AICB (Airborne Initiated Comm B). Each of these registers is 56 bits long, and can be read at any time by the interrogators. These registers will be filled with aircraft derived information, like aircraft speed, waypoints, meteorological information, call sign, ACAS (Airborne Collision Avoidance System) information, etc. Some of these BDS are useful only when used together with the aircraft position at the time of extraction (like speed, meteorological report, etc.), whereas others (like waypoints, aircraft capability, call sign, etc.) are useful irrespective of the aircraft position.

It is interesting to enhance the usual target report, produced as part of the surveillance processing, with the contents of some of these BDS. This use of BDS is called “Enhanced Surveillance” (EHS).

Today’s defined Downlink Aircraft Parameters (DAP) are:

- BDS 40: Aircraft Intention (Selected Altitude),

- BDS 50: Track and Turn Report (Roll Angle, Track Angle Rate, True Airspeed, True Track Angle, Ground Speed),
- BDS 60: Heading and Speed Report (Magnetic Heading, Indicated Airspeed, Mach Number, Vertical rate).

The extraction of these BDS may be decided by the interrogator, on a simple periodic basis, or based on more sophisticated criteria such as track initiation, turn detection, etc. (routine enhanced surveillance). In a further step, the user may decide additional extraction on its own criteria, and request them to one interrogator (directed enhanced surveillance).

For safety reasons, each radar will extract the BDS involved in routine enhanced surveillance for all targets.

This enhanced surveillance can be considered as a data-link application making use of the GICB (Ground Initiated Comm B) specific service.

For RSM-970S/Mode S, GICB automatic extraction is used to improve track information sent to ATCC.

1.1.2.5 SI codes and II/SI code operation

For a correct operation, all radars interrogating and locking out aircraft in a given geographical area must use a different II code. It means the II code and associated lockout map allocation to radar must be coordinated to avoid multiple coverage using the same II code.

In Europe the II code allocation is performed by Eurocontrol upon ICAO delegation. Today, in the high radar density of the European Core area, shortage of II code is experienced.

An initial solution to II code allocation was to allocate a single code to several radar in the same area, either with a reduction of radar coverage volume, or in conjunction with the implementation of the Surveillance Coordination Network (i.e. Mode S Cluster). The radar coverage volume reduction does not allow to offer a service similar to those of previous SSR systems. The SCN implementation as a strong impact on radar operation and requires a data networking between all radars.

The new graceful solution, which is advised by Thales, is to operate using SI (Surveillance Identifier) code.

SI codes

The SI codes have been defined in the ICAO standard, in order to provide more codes than the 16 II codes. A total of 63 SI codes are available. Radar operation in SI code is similar than in II, and SI is selected using radar parameter in the same way than II code.

Because SI codes were not defined in the first versions of ICAO Annex 10 for Mode S, few aircraft are not yet SI capable. Today in Europe almost all aircraft are SI equipped: in May 2008, 98.36% of Mode S flights were SI capable.

SI and II codes being exclusive, an aircraft not capable of SI code (i.e. II only) would not be detected by a radar using SI code. In order to be able to operationally use SI codes before 100% of aircraft are equipped, a special mode has been defined by Eurocontrol: the “II/SI code operation”.

II/SI code operation

This radar special mode of operation is based on the characteristics of aircraft transponders capable of II codes only. These transponders reply to SI code Mode S All Call interrogation using the “matching” II code (i.e. the II code corresponding to the radical field of the SI code). Thus it can be detected using the appropriate decoding.

This mode allows to process a specific decoding of the All Call replies using this “matching” II code, then to selectively interrogate these aircraft with the II code. All other aircraft replying using SI code are processed using the SI code. It is a solution to correctly detect all aircraft, SI capable and II only capable. To maintain the interoperability between radars using different SI codes, but the same “matching” II code, the non-SI aircraft are not locked-out (in order to enable the acquisition by other radars).

This special mode is specified in the Eurocontrol EMS specification Ed3.11, as an optional requirement in §13.16.1. The SI code operation and the special mode named “II/SI code operation” have been already selected by some ANSPs (e.g. French DSNA). Eurocontrol has started the allocation of SI code, instead of II code.

European Implementing Rule for Mode S interrogator codes

Eurocontrol has prepared an Implementing Rule (IR) in response to a European Commission’s mandate, laying down requirements for the coordinated allocation and use of Mode S interrogator codes for the Single European Sky. These specifications aim to cope with the interrogator code allocation issue concerning the interrogator identifier (II), limited to 16 codes. The increasing number of Mode S interrogators leads to a shortage of available II codes, in the high radar density of European Core area. The allocation of Surveillance Identifier (SI) codes by Eurocontrol allows overcoming this issue without the need to settle a SCN cluster solution.

The related European Commission regulation (EC) No 262/2009 of 30 March 2009 is already entered into force for application from 1st January 2011.

Mode S operators will have to ensure that their Mode S interrogators:

- supports the use of SI codes, in accordance with ICAO Annex 10,
- supports the use of the special “II/SI code operation” mode, in accordance with EMS Ed3.11 requirements of §13.16.1.

The regulation defines Contingency Requirements for Mode S operators, to detect potential interrogator codes conflicts.

At radar level, a measure to prevent code conflicts is to have means to detect any use of a wrong, non-allocated interrogator code.

The RSM970S Thales radar is fully compliant with this EC 262/2009 European Commission regulation.

It already includes the SI code and II/SI code operation features and complies with the Eurocontrol EMS Ed3.11 requirements §13.16.1. It also provides means to detect any use of a wrong interrogator code. The interrogator code (II or SI) is permanently checked at RCMS level by comparison of the expected code value with the one effectively used by radar processing. In case of difference a failure is reported a RCMS operator. The RSM970S SI code and II/SI code operation functions have been fully validated by the French DSNA.

The French civil aviation authority DSNA has validated and operates the Marseille Mode S radar (RSM970S delivered by Thales within the frame of AROMES Mode S programme) in SI code and II/SI mode.

1.1.2.6 Surveillance Co-ordination Network (SCN)

Usually, a radar has an overlapping area with other radars. In such a case, the Mode S system allows the radars to be co-ordinated in these overlapping areas, via the surveillance co-ordination network.

For safety reasons, all radars shall provide track information to ATCC users for all targets flying in their entire coverage, including the overlapping areas.

This surveillance co-ordination network allows radars to exchange track information to allow an aircraft acquisition directly in Roll-Call, in case where radars use the same II code (the group of radars having overlapping coverage and using the same II code is called a “cluster”) or to overcome a potential track miss.

This surveillance co-ordination network may use either a centralised approach (i.e. involving a central controller, which is responsible for maintaining the overall coherence) or a distributed approach (i.e. the interrogators are able to co-ordinate themselves). In both cases, due to failures or other events, a radar may reconfigure its coverage and its II code, to continue fulfilling its surveillance mission, in accordance with the surveillance network policy.

1.1.2.7 Data-Link

The Data link capabilities can be provided by the secondary radar, using its rotating antenna.

The Mode S data-link is defined at two levels.

The first level concerns the dialogue between one interrogator and one transponder, and provides a service comparable to the data-link layer in the ISO scheme, by allowing the exchange of frames of up to 1280 bits. In addition, three additional services are available:

- The uplink broadcast service, which allows an interrogator to send a 84 bit long message to all aircraft in the beam,
- The downlink broadcast service, which allows an aircraft to send a 56 bit long message to all interrogators in view,
- The GICB service, which allows an interrogator to extract one of the BDS registers.

Above this first level, a second level has been defined by ICAO in order to offer a more complete and more inter-operable service. The second level :

- Offers an ISO 8208 service, compliant with the ATN specifications, (called Switched Virtual Circuit (SVC) services)
- Offers Mode S specific services (i.e. data transfer specific to Mode S, making optimal use of Mode S features).
- Allows to manage several interrogators transparently for the user (a flying time in a single interrogator coverage could be very short).

1.2. SYSTEM DESCRIPTION

1.2.1 Radar Design

The RSM 970 S MODE S mainly consists of:

- a Large Vertical Aperture (LVA) AS 909 antenna,
- two electronics cabinets including transmitter, receiver, signal and data processor units.

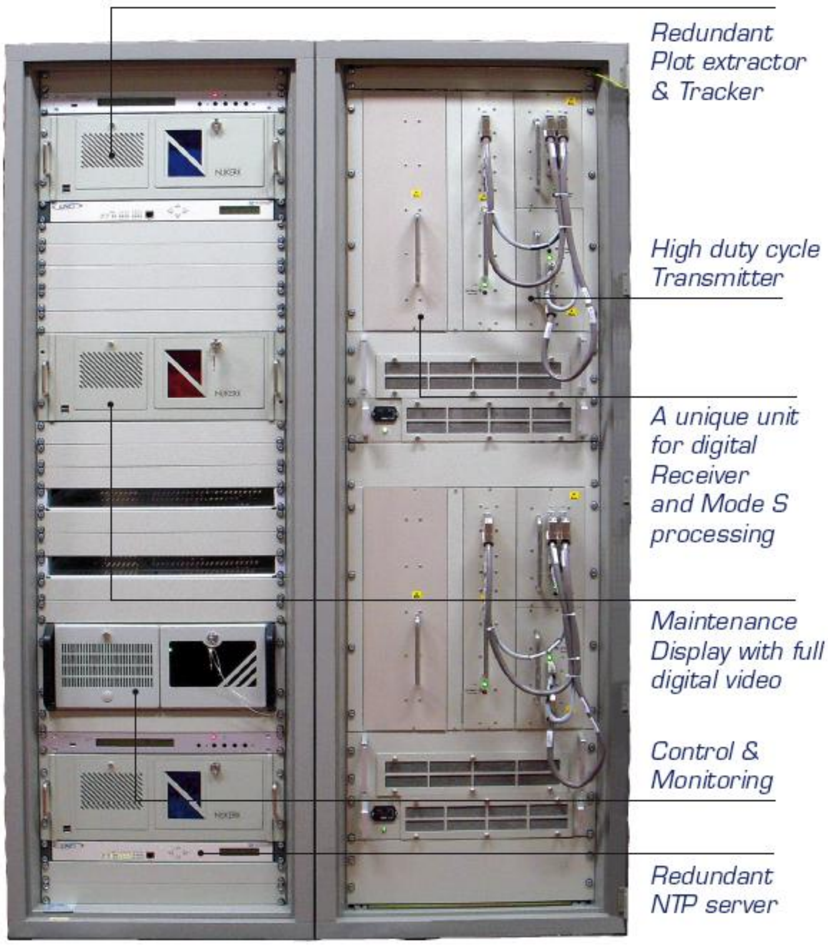


Figure 1 - RSM 970 S electronics cabinets

This equipment can provide full Mode S operation and conforms to or exceeds in every aspect the requirements and recommendations set out in the appropriate subsections of:

- ICAO Annex 10 (up to and including latest amendment),
- EUROCONTROL Standards Radar Surveillance Standards in En-Route Airspace and Major Terminal Areas (March 1997).

The AS 909 antenna provides the Control, Difference and Sum patterns required for the monopulse measurement techniques. The antenna Large Vertical Aperture (LVA) characteristics feature a sharp pattern cut-off at low and negative elevation angles which counteracts ground reflections that affect the pattern of classical antennas.

The Electronic Cabinets, one per channel, are the POEMS designed I/R Mode S cabinets. They are Mode S wired and they house a fully solid state equipment including:

- One high duty cycle Mode S transmitter STX2000 which results from works initiated with the French Civil Aviation Authorities (DSNA/DTI),
- One digital receiver MDR of the latest generation,
- One MSSR / Mode S processor (MMXC),
- One Data Processor (DPC),

All these equipments are qualified within the POEMS programme.

All electronics equipments are duplicated. One channel is connected to the antenna while the other one is connected to a dummy load.

The equipment incorporates the necessary fault detection circuitry and the switching systems to ensure the correct changeover from the main (operational) equipment to the standby equipment.

For co-mounted operation, the DPC can perform PSR/MSSR/Mode S plot combination.

The Data Processor performs adaptative reflection suppression to prevent MSSR unwanted reflection, and tracks PSR/MSSR plots to provide formatted plots or track messages to the Control Centre.

ISLS is always activated. IISLS is provided as a basic feature and may be activated if required.
The RSM 970 S mode S complies with the EEC regulation relative to EMC.

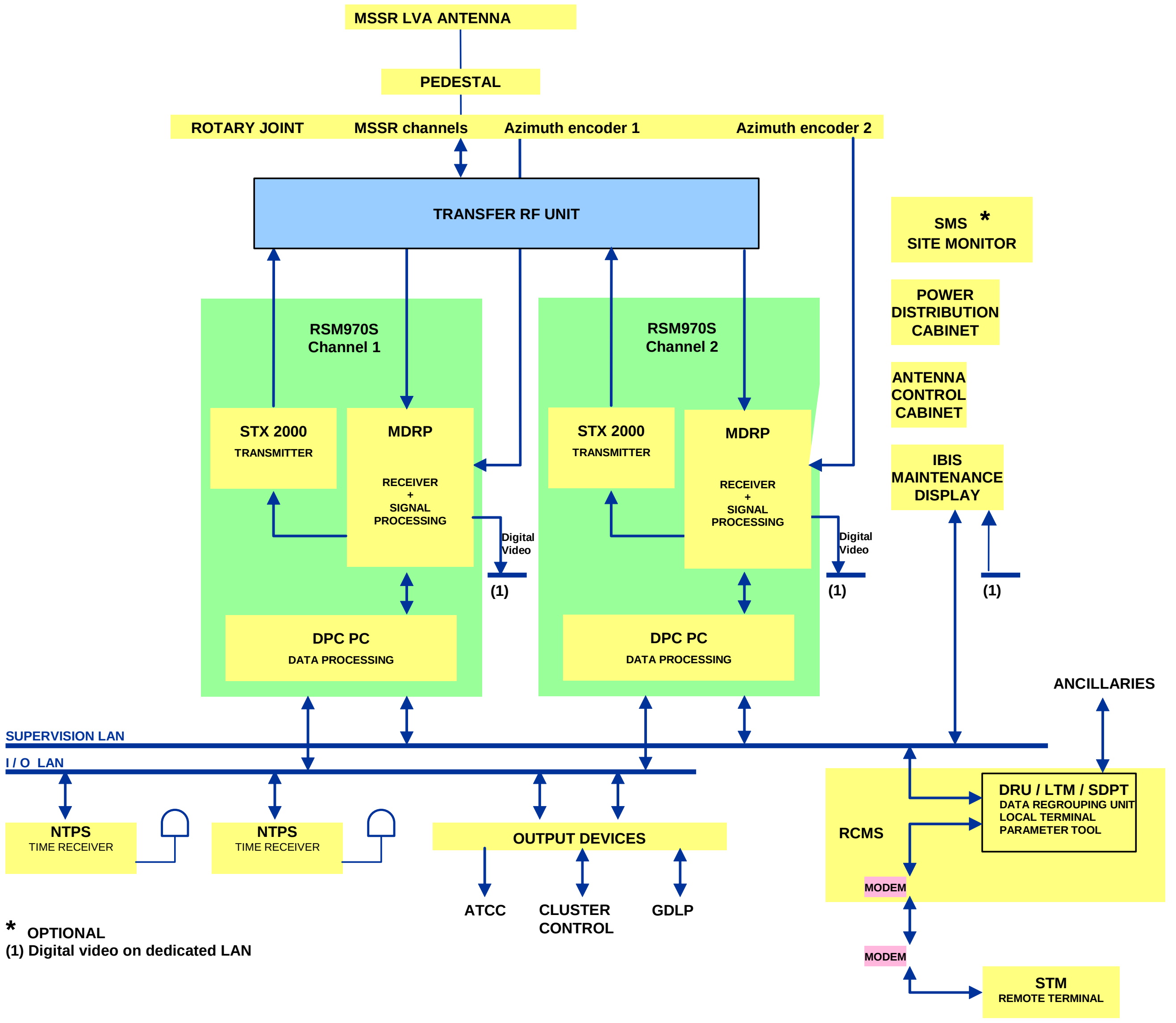


Figure 2 - Stand-alone RSM 970 S – General Configuration

1.2.2 Functional Characteristics

1.2.2.1 Antenna

The open array antenna AS 909 provides a directional sum pattern (Σ), a monopulse difference pattern (Δ) and an omnidirectional pattern (Ω). The gain exceeds 27 dB and the underside cut-off slope is better than 1.8 dB/degree.

Integrated with the rotary joint and mounted directly on the main shaft are the dual optical encoders giving a 14-bit accuracy (or 0.022°) for the azimuth rotation information. The antenna azimuth position is transmitted to both Mode S processing channels.

1.2.2.2 Interrogator and receiver

The RSM 970 S Mode S is capable of MSSR and full Mode S operation (elementary surveillance, enhanced surveillance, data link).

The RSM-970 S fully solid state transmitter is composed of three modules:

- Interface driver module
- Control HPA module
- SUM HPA module

As two separate modules are used for the SUM and Control amplifiers, the transmitter includes the Improved Interrogator Side Lobes Suppression (IISLS) feature.

The fully solid state transmitter has been designed to work with a duty cycle (peak) of 63.7% over 2.4 ms length of time, consistent with the ICAO Annex 10 requirement of transmission of 48 Mode S roll-call Interrogations within 2.4 ms (equivalent to 3 sets of Uplink Extended Length Messages (UELMs) each composed of 16 long messages (112 bits) spaced every 50µs. This requirement can be repeated every 24 ms.

The Interrogator / Receiver has a wide adjustment capability to match any site situation: sectorized output power setting, sectorized ISLS/IISLS operation, selectable RSLS control and attenuation.

The system is able to interrogate in the modes 1, 2, 3/A, C and S and is designed to have a flexible (single, double, triple interlacing) interrogator pattern and mode interlacing capability.

It is possible to change the mode interlacing on a scan by scan basis and on a sector by sector basis.

The system is able to operate in Mixed Mode, in which Mode A/C SSR interrogations are used in All Call periods to trigger Mode A/C SSR replies from SSR and Mode S transponders. This allows detecting faulty Mode S transponders that do not reply to Mode S only All Call interrogations.

The MDR receiver is based on a new digital technology providing a better azimuth accuracy and improved reliability.

1.2.2.3 Signal and Data Processor

The signal and data processing chain performs:

1. MSSR/Mode S Processor (MMXC)
   - MSSR/Mode S scheduling,
   - MSSR/Mode S signal processing,
2. Data Processor Computer (DPC)
   - MSSR/Mode S extractor and
   - PSR/MSSR/Mode S plot combination and tracking.

The MMXC and DPC cope with garbling situations in dense surveillance areas. The Off Boresight Angle measure on each code pulse is associated to the reply message with specific flags and is routed to the monopulse post-processing. The monopulse post-processing performs plot extraction and solves conflict conditions such as garbling, phantoms, saturated presences and specifically processes emergency and distress codes.

Reflections which are common phenomena in SSR systems, are detected and processed using the monopulse information. This reflection may be found either at track level or at plot level. At track level, this function is based on an auto-adaptive process : the reflections are identified as permanent or temporary. This Thales unique feature provides automatic site environment adaptation. At plot level (prior to scan-to-scan correlation), the site environment is taken into account by windows programming.

1.2.2.4 Remote Control and Monitoring

In normal operation the RSM 970 S Mode S is unattended. A Remote Control and Monitoring System is provided so that the major equipment of the RSM 970 S Mode S are monitored and controlled from a remote point. In a co-mounted configuration, the RCMS controls both the RSM 970 S Mode S and the Primary Surveillance Radar (PSR).

1.2.3 Fail Safe Capabilities

Whatever the configuration, the RSM 970 S Mode S consists of a single Antenna/duplicated electronics with automatic changeover of I/R channel should the unit in service fail. Internal fault detection facilities are incorporated into the RSM 970 S Mode S and automatic reconfiguration takes place in case of failure without use of the remote control and monitoring system.

1.2.3.1 Antenna System

The MSSR antenna can be mounted on a stand-alone turntable or at the top of the primary antenna. The antenna system, the drive mechanism and the rotary joint have very high inherent reliabilities and require low preventive maintenance actions.

The azimuth pointing position data is generated by a dual optical encoder, mounted as an integral part of the rotating joint, fixed to the shaft of the turning gear. Thus, there is no back-lash or mechanical play, an essential feature where an angular measurement having an accuracy of 14 bits (0.022°) is required. Each optical encoder, using LED devices, generates a serial message transmitted to the MMXC, using a call/reply protocol for noise and spurious signal rejection.

1.2.3.2 Electronic Equipment

Under normal conditions, one of the two I/R channels (designated as « to Antenna » channel) provides control and interrogation for the MSSR antenna while the other (designated as « To Load » channel) is in a "hot" condition, i.e. ready for immediate transmission.

In the event of the failure of the I/R channel in service, this condition is detected by internal monitoring circuits, and changeover is initiated by the channel Bite function to the « To Load » I/R channel.

1.2.4 Stand-Alone Configuration

The equipment supply as shown in Figure 2 includes:

- An LVA antenna AS 909 comprising 36 radiating elements,
- A pedestal assembly with dual motorization,
- One (3 channels) rotary joint with dual optical encoders,
- One antenna control cabinet,
- One I/R cabinet (TRC) including :
  - Two Mode S transmitters (STX 2000)
  - Two Mode S digital receivers (MDR)
  - Two MSSR/Mode S Processors (MMXC)
- One Processing cabinet (TOM) including :
  - Two Data Processor Computers (DPC)
  - Two Serial lines devices (LINES)
  - Two GPS time stamping
- A Remote Control and Monitoring System RCMS, equipped with:
  - Two computers (Local position (LTM) and Remote position (STM)),
  - Two associated printers (optional),
  - One Data Regrouping Unit/Function DRU in charge of discrete I/O interfaces.
- A radar maintenance monitor display IBIS,

- A Site Dependent Parameter Tool (SDPT) software, allowing operational parameter setting, integrated in the RCMS local position (LTM).
- A Mains Power supply cabinet,
- A dual channel Mode S level 2 Site Monitor SMS may be optionally provided.

1.2.5 PSR Co-Mounted Configuration

When the RSM 970 S Mode S is co-mounted with a Primary Surveillance Radar, some items of the stand-alone configuration are redefined (Figure 3).

The equipment involved are:

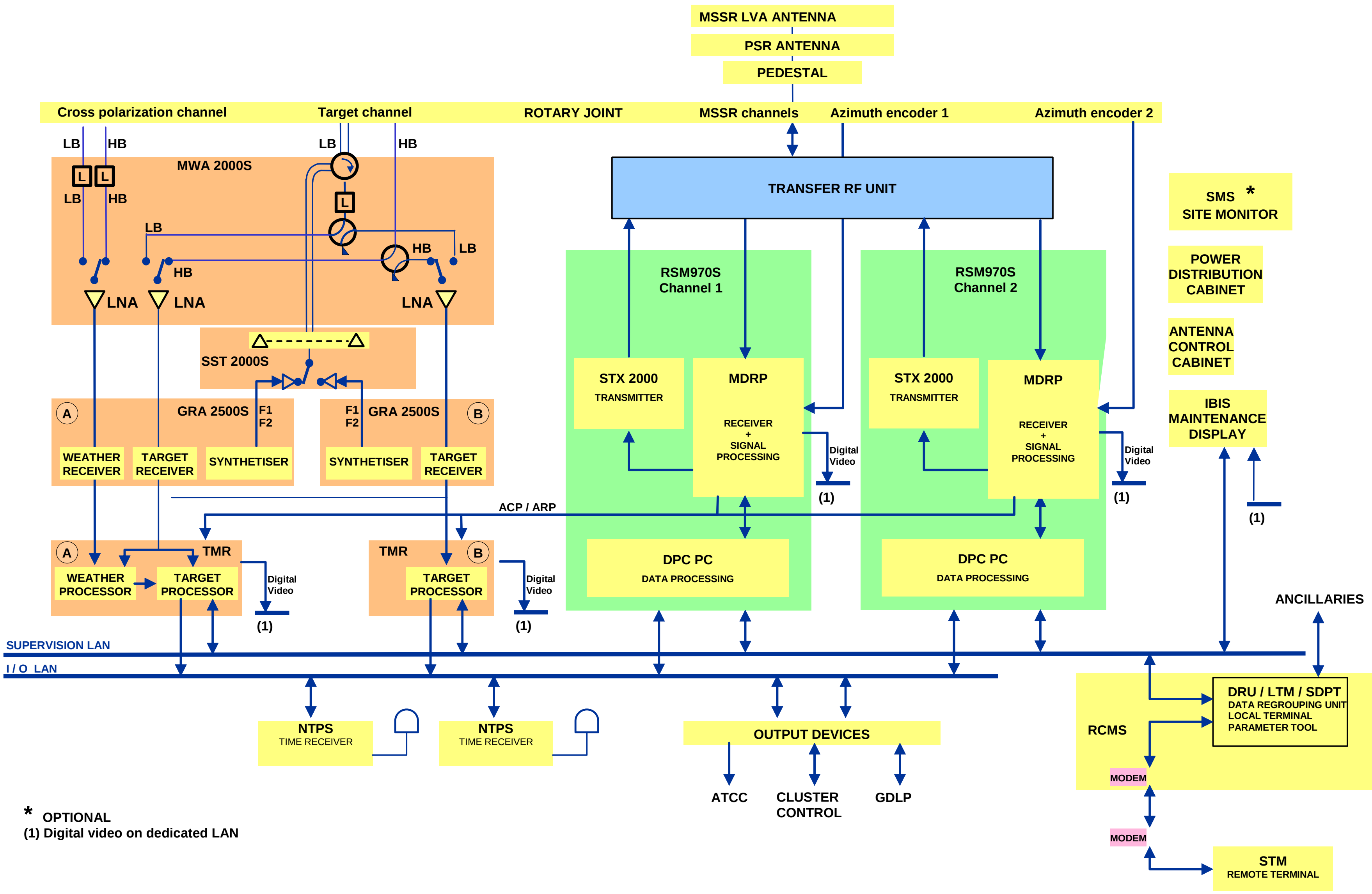
- Pedestal assembly: the PSR antenna is used to support the AS 909 LVA antenna.
- Antenna control unit: The antenna control unit version depends on the Primary radar antenna selected.
- Rotary joint: the rotary joint is designed to duct PSR + MSSR RF links. A 5 or 7-path rotary joint composed of two or four (with weather channel) PSR and three MSSR RF channels is usually selected.

Other parts as:

- Remote Control and Monitoring System (RCMS),
- Radar maintenance monitor display (IBIS),
- Main Power Supply cabinet,

become common equipment to both MSSR and PSR system.

The PSR + MSSR/Mode S plot merging is performed in the DPC when co-mounted with a STAR2000 PSR.



* OPTIONAL
(1) Digital video on dedicated LAN

Figure 3 - Co-Mounted Configuration (Example of STAR 2000)

1.3. PERFORMANCE

1.3.1 General

The RSM 970S Mode S ensures a high quality and reliable coverage to contribute to radar operational separation of 3 NM, 5 NM and 10 NM according to EUROCONTROL standard.

The radar is capable of determining range, azimuth and height positional data, along with the identity, on each target detected, during each revolution of the antenna.

Since the MSSR systems are used in an environment which often includes multiple SSR coverage, the system has been designed in order to cope with a high fruit density (MSSR and/or Mode S fruit). Therefore, the performance will be optimised such that the output of the false data is minimised, while meeting the guaranteed parameters.

The MSSR RSM 970 S Mode S is designed to meet all the guaranteed performance in the presence of a fruit rate of 11,000 replies per second.

The performance of the RSM 970 S MODE S equipment have been confirmed through the various fields and validated by Eurocontrol and French DSNA in the frame of the POEMS pre-operational European Mode S programme. Significant breakthroughs have been achieved in the fields of:

- Discrimination,
- Phantom processing,
- Reflection processing.

Typical performance characteristics are summarised below :

GENERAL	
Modes	1; 2; 3/A; C; S
Output transmitter peak power	2570 W
Transmitter frequency	1030 ± 0.01 MHz
Range	Up to 256 NM
Scan rate	Up to 15 rpm
Antenna:	
- Azimuth beamwidth	2.4°
- Maximum gain	27 dBi
Fruit density	11,000 fruit/sec in the main lobe

DETECTION PERFORMANCE (See Paragraph 1.3.3 for details)	
Target Position Detection	
- Mode A/Mode C Probability of detection	> 99 %
- Mode S Probability of detection	> 99 %
False Target Reports	
- Overall False target report ratio	< 0.1 %
- Overall multiple target report rate over 1 hour	< 1 per scan
Code Detection and Validation	
- Mode A probability of code detection	> 99 %
- Mode C probability of code detection	> 99 %

QUALITY PERFORMANCE (See Paragraph 1.3.4 for details)	
Positional Accuracy	
Systematic errors:	
- Slant range bias	< 14 m
- Azimuth bias (degree)	
- for elevation angles between 0° and +6°	< 0.022°
- for elevation angles between +6° and +10°	< 0.033°
- Slant range gain error	< 1 m/NM
- Time stamp error when not synchronised on external signal	< 20 ms per month
Random errors (standard deviation values) :	
- Azimuth (degree)	< 0.068°
- Slant range	< 30 m (SSR)
	< 15 m (Mode S)
Position Jumps:	
- Overall ratio of jumps	< 0.05 %
False Code Information	
- Overall false codes ratio	< 0.2 %
- Validated false Mode A codes	< 0.1 %
- Validated false Mode C codes	< 0.1 %

RESOLUTION PERFORMANCE in double Mode Interlacing A, C		
Area 1*	Pd Pvcc	98 % 98 %
Area 2*	Pd Pvcc	98 % 90 %
Area 3*	Pd Pvcc	60 % 30 %

* The areas are defined in paragraph 1.3.4.3

CAPACITY for 256 NM instrumented range	
System capacity at 15 RPM	1000
Peak load per 45° wedge	222
Peak load per 3.5° wedge	54

RELIABILITY, AVAILABILITY, MAINTAINABILITY	
Stand-Alone Configuration (including mechanical part):	
• MTBF	>2700h
• MTBCF	>54000h
• MTTR	0.41 h
• Inherent Availability Ai = MTBCF/(MTBCF + MTTR)	0.99999
• Operational Availability Ao = MTBCF/ (MTBCF + MTTR + MLDT) including an assumed Mean Logistic Down Time (MLDT) of 3 hours	0.9999
• BITE Coverage	90 %
Preventive Maintenance:	
• Preventive maintenance and inspection periodicity	90 days
• Antenna oil change periodicity	365 days

ENVIRONMENTAL AND POWER CONDITIONS	
– **Climatic:**	
• Storage indoor:	
- Temperature	-10°C to +60°C
- Relative humidity	93 % at +40°C
- Altitude	0 to 10 000 m
• Operating indoor:	
- Temperature	+10°C to +40°C
- Relative humidity	5 % to 80 % at 40°C
- Altitude	0 to 3 000 m
• Operating outdoor	-40°C to +70°C (including solar radiation)
• Storage outdoor	-40°C to +70°C (including solar radiation)
– **Wind** (including AS 909 antenna):	
• Rotation	160 km/h - 130 km/h (with ice)
• Survival	220 km/h - 180 km/h (with ice)
– **Mains** (3-phase) 230 V/400 V 50/60 Hz	Voltage ± 10 % - Frequency ± 5 %
• Power dissipation	3.6 kW (equipment room) 3.5 kW (drive mechanism)
• Consumption (including the antenna in rotation)	12 kVA (without wind nor ice) 20 kVA (with extreme wind/ice)

1.3.2 Link Power Budget Calculations

The power budget calculation depends on several parameters:

- Antenna speed
- Instrumented range
- Type of scheduling (SSR vs. Mode S)
- Mode S functionality (Elementary vs. Enhanced surveillance, Datalink)
- Tower height
- Presence of a radome
- Etc.

The most usual configurations (instrumented range vs. antenna speed and scheduling) are listed in the following table:

	10 rpm	12 rpm	15 rpm
Conventional SSR, 2-Mode interlace	256 NM	256 NM	256 NM
Mode S, elementary surveillance	256 NM	250 NM	230 NM
Mode S, enhanced surveillance (2 GICB per aircraft)	256 NM	250 NM	200 NM
Mode S, full EMS functionality, including Datalink	256 NM	200 NM	170 NM

Depending on user's needs, other configurations may be proposed.

The typical RSM 970 S configuration is considered in the following calculations:

- 10 rpm antenna speed
- 256 NM instrumented range
- Mode S scheduling
- Full EMS performance
- 25 m RF cables
- Radome

POWER BUDGET CALCULATION WITH BEAM MODULATION

RSM 970 S
Product
Mode S 10 rpm

			Instrumented range	256	NM
Standalone SSR			Antenna speed :	10	rpm
With radome			IRF :	150	Hz
Cable length :	25	m	Tx attenuation:	0	dB
Antenna tilt :	-1,5	deg.	Scheduling type :		Mode S
			Scheduling pattern :		A C S

Up-Link Budget.

Operationnal Range = 256 NM Target elevation = 0,5 °

1	Transmitted power at cabinet output (dBm)	62,80
2	Losses between cabinet output and antenna input (dB)	-2,45
3	Antenna gain (dBi)	27,00
4	Gain decrease at specified elevation angle and tilt (dB)	-5,00
5	Free Space Attenuation (dB)	-146,22
6	Atmospheric and radome (if any) attenuation (dB)	-1,95
7	Transponder antenna gain (dB)	0,00
8	Interrogation beam modulation losses (dB)	-3,00
9	**Total budget at transponder input (dBm)**	**-68,81**
10	Minimum triggering level for 90 % of reply (at transponder antenna end)	-69,00
11	**Power budget uplink margin (9 - 10)**	**0,19**

Down-Link Budget.

Operationnal Range = 256 NM Target elevation = 0,5 °

1	Transponder output power (dBm)	51,00
2	Transponder antenna gain (dB)	0,00
3	Free Space Attenuation (dB)	-146,71
4	Atmospheric and radome (if any) attenuation (dB)	-1,95
5	Antenna Gain (dB)	27,00
6	Gain decrease at specified elevation angle and tilt (dB)	-5,00
7	Losses between antenna and cabinet input	-2,45
8	Reception beam modulation losses (dB)	-3,41
9	**Total budget at receiver input (dBm)**	**-81,52**
10	Minimum processing threshold at cabinet input (dBm)	-82,70
11	**Power budget downlink margin (9 - 10)**	**1,18**

1.3.3 Detection Performance

The RSM 970 S Mode S meets the following requirements for target returns consisting of replies with the specified round reliability from a transponder with capabilities in Mode 3/A, C or Mode S.

A mode interlace pattern of the two modes 3/A and C or the three modes 3/A, C, S is assumed for the performance assessment.

1.3.3.1 Target Position Detection

The probability of detection is measured for traffic of opportunity in the measurement volume (excluding terrain masks and lobbing effects).

It is determined as the ratio of the number of target reports used to calculate target position to the number of total expected reports. Those are the reports contained between the first and the last report from the same aircraft before it leaves the measurement volume.

Mode A / Mode C

The probability of detection of a non Mode S target in the measurement volume, separated from another target in range by more than 2 NM, and in azimuth by more than $2\Theta_{3dB}$ (4.8°), is at least 99 %.

Mode S

The probability of detection of a Mode S target in the measurement volume, is at least 99% when using selective surveillance interrogations

1.3.3.2 False Target Report

The overall false target report rate is the number of false target reports (due to asynchronous or synchronous fruits, and second time around echoes) in relation to the number of detected target reports.

The overall false target report rate is less than 0.1 %.

1.3.3.3 Multiple Target Reports

Multiple target reports are due to:
- Reflections
- Ring around
- In-line multipath
- Splits
- Answers on sidelobes.

The overall multiple Mode S / SSR target reports ratio is less than one target per scan on average.

Discrete Mode 3/A codes are considered for the above figure.

1.3.3.4 Code Detection and Validation

These performances are achieved at Data Processor output (track level).

Mode A / Mode C

The probability of Mode A/Mode C detection is determined by the ratio of the number of target reports with validated correct Mode A/Mode C code data to the number of target reports used to calculate the target position detection.

The Mode 3/A probability of correct and valid code detection for the RSM 970 S equipment is better than 99 % for large samples of opportunity traffic when the aircraft replies are not overlapping (see paragraph 1.3.3.1).

The Mode C probability of correct and valid code detection for the RSM 970 S equipment is better than 99% for large samples of opportunity traffic when the aircraft replies are not overlapping (see paragraph 1.3.3.1).

The above performances are from commonly agreed Eurocontrol requirements.

Mode S

The overall ratio of the number of times a target is detected and output with all reply data correct compared to the number of times a target is detected and output, within the whole radar coverage area, is at least 99% for target replying in Mode S.

1.3.4 Quality

The quality of the data provided is expressed by the following characteristics :

- Positional accuracy,
- False code information,
- Resolution.

1.3.4.1 Positional Accuracy

Azimuth Accuracy

The guaranteed figures for a target located within the coverage volume are:

- Azimuth bias

  - for elevation angles between 0° and +6° : < 0.022°
  - for elevation angles between +6° and +10°: < 0.033°

- Standard deviation ≤ 0.068°
- Azimuth precision 0.0219° (14 bits encoder)

Range Accuracy

The range accuracy is a function of various parameters, some of them independent of the radar system, for example the airborne transponder reply time is specified by ICAO to be accurate to within + 0.5 µs i.e. + 75 m. Fortunately this figure is much smaller on modern equipment.

The MSSR system range accuracy is only limited by the quantization step (50 ns), the (ρ, θ) to (x,y) coordinates conversion and the clock stability.

The guaranteed figures are:

▪ Slant range bias	< 14 m
▪ Slant range gain error	< 1 m/NM
▪ Slant range standard deviation	• Modes A/C ≤ 30 m • Mode S ≤ 15 m

1.3.4.2 False Code Information

Code Information is considered as false, if in a target report, code information is provided which has been wrongly accepted as correct by the radar (validated data).

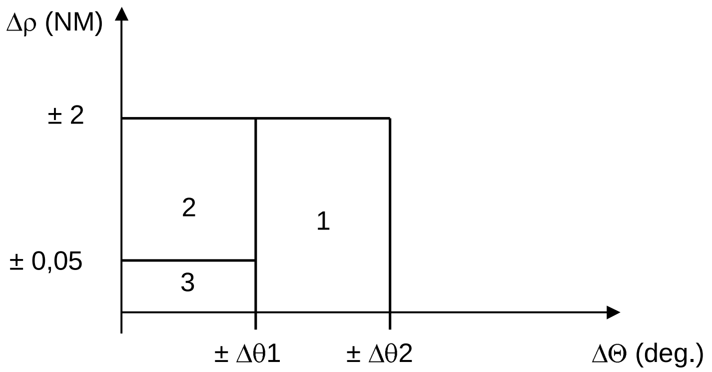
The false code information ratio is the number of target reports with false codes in relation to the number of detected target reports with code information.

Performance of the MSSR are given as :

▪ Validated false Mode A codes	< 0.1 %
▪ Validated false Mode C codes	< 0.1 %.

1.3.4.3 Resolution

The Eurocontrol standards use areas as defined below:



Δρ and ΔΘ are the differences of the two aircraft positions respectively in slant range and azimuth.

ΔΘ1 = 0.6°

ΔΘ2 = 4.8° (i.e. 2 x 3 dB beamwidth).

In the RMS 970 S configurations described in paragraph 1.3.2, the guaranteed detection performances averaged on each specified area are:

Area	1	2	3
Probability of detection	> 98 %	> 98 %	> 60 %
Probability of correct valid Mode A code	> 98 %	> 90 %	> 30 %
Probability of correct valid Mode C code	> 98 %	> 90 %	> 30 %

Assuming the following parameters:

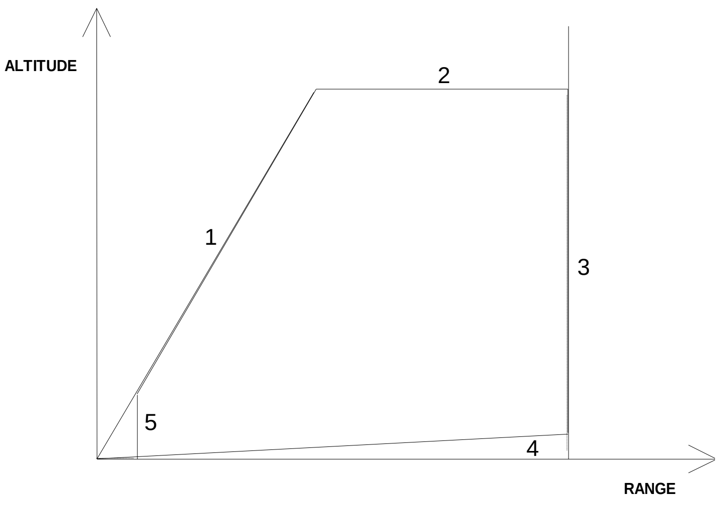
- Round reliability of transponder = 100 % in Mode A and Mode C,
- No FRUIT.

1.3.5 Data Processing Delay

For an antenna rotation rate of 15 RPM, the output delay is better than 1.2 s.

1.3.6 Coverage Area

The volume of coverage is defined by the following figure. It assumes free space detection volume for aircraft carrying ICAO compliant SSR transponders and Mode S transponders.



COVERAGE DIAGRAM

(1) Max. elevation angle : 45 °

(2) Maximum altitude : 66 000 ft

(3) Range	:	256 NM
(4) Min. elevation angle	:	0.5 °
(5) Minimum range	:	0.5 NM

1.3.7 Tracking Performance

1.3.7.1 References

- The tracker implemented in the DPC is the MUST tracker field tested and evaluated by EUROCONTROL in mono and multiradar configurations (RFS) and by French Civil Aviation within the DACOTA programme.

  It has been demonstrated by the French Civil Aviation that the tracker performance level makes possible the application of the following separation between aircraft:

  - 3 NM below 40 NM from the centre of the terminal approach,
  - 5 NM beyond 40 NM.

- The performance of the tracker has been checked on simulated data representing all aircraft trajectories of interest as defined in the Eurocontrol « Standard Document for En-Route Radar Surveillance and Major Terminal Areas » :

  - Uniform motion (radial or transversal position),
  - Uniform speed change up to 1.2 g,
  - Standard turn (2 up to 8 m/s2),
  - Landing and take-off with a combination of uniform speed change, standard turn and climb/descent.

  Mono-radar situation (primary and secondary) as well as for a multi-radar situation (one primary and one secondary) have been taken into account.

- The performance of the tracker has been operationally checked and the results of this evaluation are presented in a report (reference CENA/NT/96 712 June, 1996).

  The operational configuration used for the evaluation has been the approach of Toulouse-Blagnac Airport, with rather stringent conditions:

  - Only two radar sensors are integrated : a primary radar used for approach (100 NM range maximum) and a monopulse secondary radar (256 NM range maximum).

  The distance between radar sensors is small (less than 15 NM) adding difficulties especially for radar observability and radar biases assessment function.

  - Various traffic such as VFR, IFR, low speed, high speed, manoeuvres for approach or not, approach and en-route traffic, military traffic and aircraft testing (for AIRBUS Industries).

The correctness of the Mode C tracking logic has been demonstrated (accuracy, response time, stabilisation time of the tracked Mode C).

1.3.7.2 Typical Features

Track initiation and track continuity performances are supposed to be evaluated using opportunity flights and taking into account all detected plots within the MSSR coverage: PSR only plots, MSSR only plots and combined PSR/MSSR plots.

Track initiation performance, defined in terms of the following time parameters :

- Track initiation delay mean (TIDmn) in seconds or scans,
- Track initiation delay standard deviation (TIDsd) in seconds or scans,
- False track probability (Ftprob) in number of tracks initiated/false target report,

are better than or equal to the values given below :

Track Initiation Requirements

Parameter	Value	Unit
TIDmn	PSR/MSSR => 12.5 (2.5)	seconds (scans)
TIDsd	PSR/MSSR => 2.5 (0.5)	seconds (scans)
Ftprob	PSR/MSSR => 0.001	track/false report

Track continuity, expressed by the following time parameters:

- Track drop rate (Tdr),
- Track swap rate (Tsr),

will be equal or better of the figures presented below:

Track Continuity Requirements

Value for Tracks in MOF (Mode of Flights)			
Parameter	Uniform Motion	Standard Turn & Unit Speed Change	Unit
Tdr	0.01	0.1	/track hours
Tsr	0.01	NA	/swap opportunities

2. INTERROGATOR/RECEIVER

2.1. RF UNIT

2.1.1 Introduction

The RF Unit (RFU) main functions are :

- to perform RF switching between channels 1 and 2,
- to perform, inside each channel, RF decoupling between transmitter and receiver,
- to provide RF DIFFERENCE channel phase adjustment capability.

The elements constituting the RFU are located inside the I/R cabinet. They are accessible through the rear door of the cabinet.

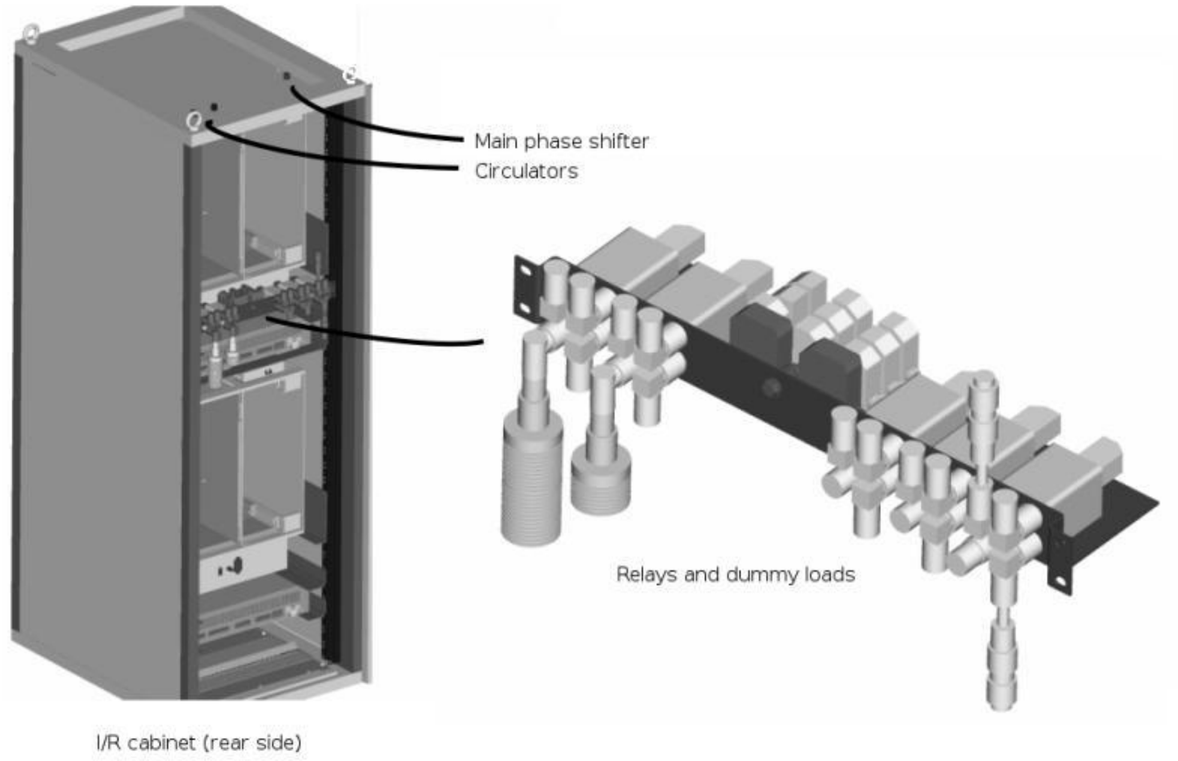


Figure 4 - RF unit view

2.1.2 Interfaces

The RFU is interfaced with the following equipment:

- feeders (FD) which enable RF signals exchange with the aerial,
- transmitter (TX) which transmits RF signals,
- receiver (RX) which receives RF signals,
- MSSR Modulator and Extractor (MMXC) which controls and monitors the RF switches.

2.1.3 Description

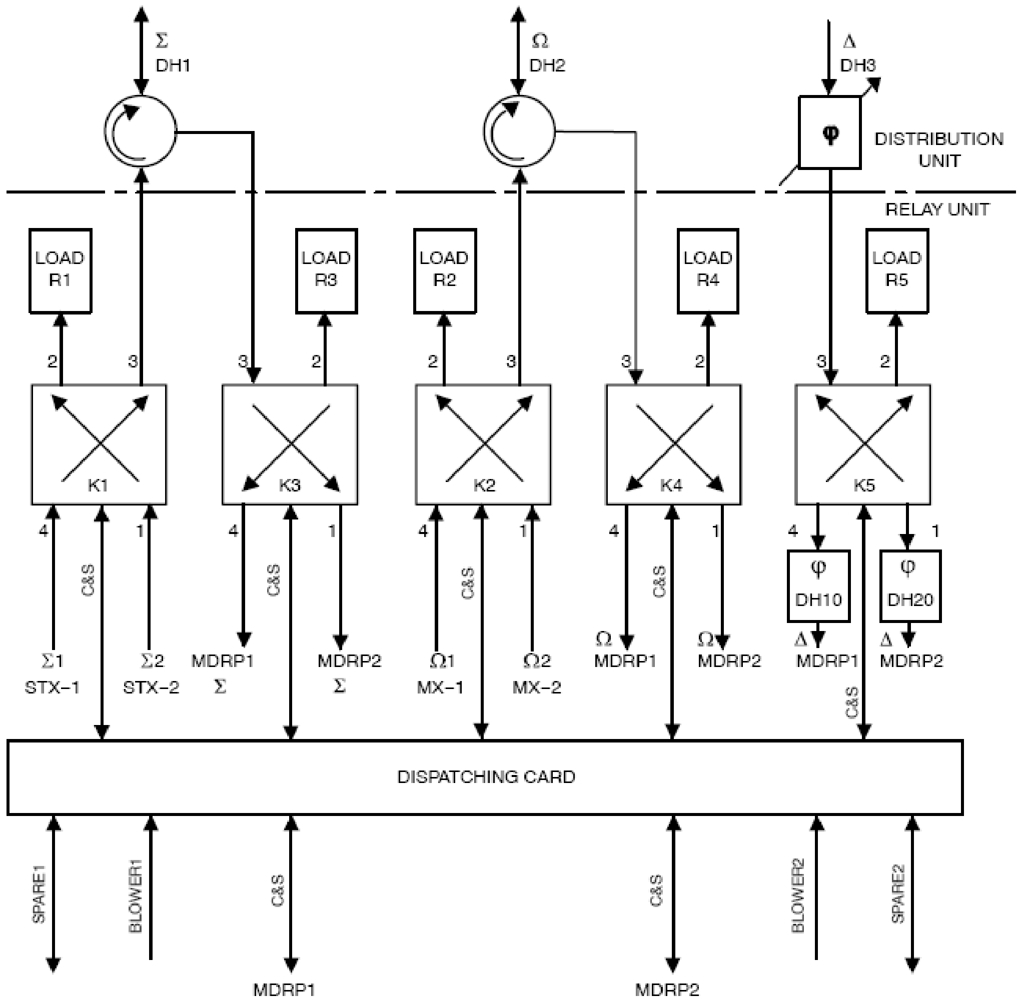
Σ and Ω RF signals coming from the transmitter are driven respectively to the Σ and Ω Tx switches. These switches allow the connection between the antenna and the outputs of the active transmitter. The outputs of the standby transmitter are connected to dummy loads.

Σ, Ω and Δ RF signals coming from the antenna are driven respectively to the Σ, Ω and Δ Rx switches. These switches allow the connection between the antenna and the inputs of the active receiver. The inputs of the standby receiver are connected to dummy loads.

The Σ and Ω duplexers (circulators) perform the separation between transmitting and receiving paths, preventing the transmitted power to be forwarded to the receivers.

The differential phase of the RF path (from antenna to the I/R cabinet) is compensated thanks to a phase shifter (φ1) located at the Δ input of the cabinet. This setting is performed during the on-site installation of the radar.

Two other phase shifters (φ2 and φ3) allow the balancing of RF paths of both radar channels. This setting is performed once for all in factory.



NOTE: C&S means control and status

trc-g006-00-gb

2.1.4 Key Features

- RF path peak power handling on SUM and CONTROL channels:
  - 66 dBm
- RF path mean power handling long term :
  - 53 dBm on SUM channel.
  - 38.5 dBm on CONTROL channel.
- Uplink losses between transmitter output and I/R cabinet output < 1.3 dB.

- Downlink losses between I/R cabinet input and receiver input:

  SUM and CONTROL channel: < ± 1.3 dB.

  DIFFERENCE channel: ≤ 2 dB.

- Difference between channel 1 and channel 2 downlink differential gain SUM/DIFFERENCE, from the RFU input to the receiver input: < ± 0.1 dB.

- Downlink cross channel phase variation between SUM and DIFFERENCE channels from RFU input to the receiver input: < 5 degrees peak to peak.

- Difference between channel 1 and channel 2 downlink differential phase SUM/ DIFFERENCE, from the RFU input to the receiver input: < 5 degrees peak to peak.

- Switching time: < 35 ms

- Isolation between the two channels: > 70 dB at used RF frequencies

- Isolation between any 2 of the 3 RF ports: > 70 dB at used RF frequencies.

- RF signal VSWR on SUM, CONTROL and DIFFERENCE: < 1.3 upstream
  < 1.5 downstream

- Manual phase shift capability for 1090 ± 3 MHz: 270°.

2.2. INTERROGATOR STX 2000

2.2.1 Introduction

The transmitter STX 2000 is designed to be used in RSM-970-S air-traffic control radar stations.

It ensures the modulation and amplification of SSR and Mode S interrogation signals delivered to the "SUM" and "CONTROL" channels of the antenna.

It is mounted in an "Interrogator/Receiver cabinet".

It is made of three modules:

- Interface Driver module (item 1),
- Control HPA module (item 2),
- Sum HPA module (item 3).

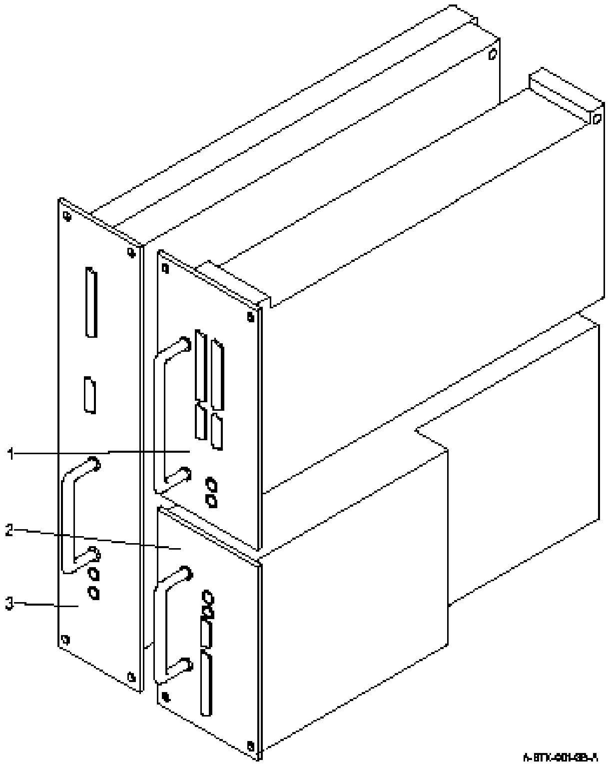


Figure 5 - Transmitter STX 2000 Presentation

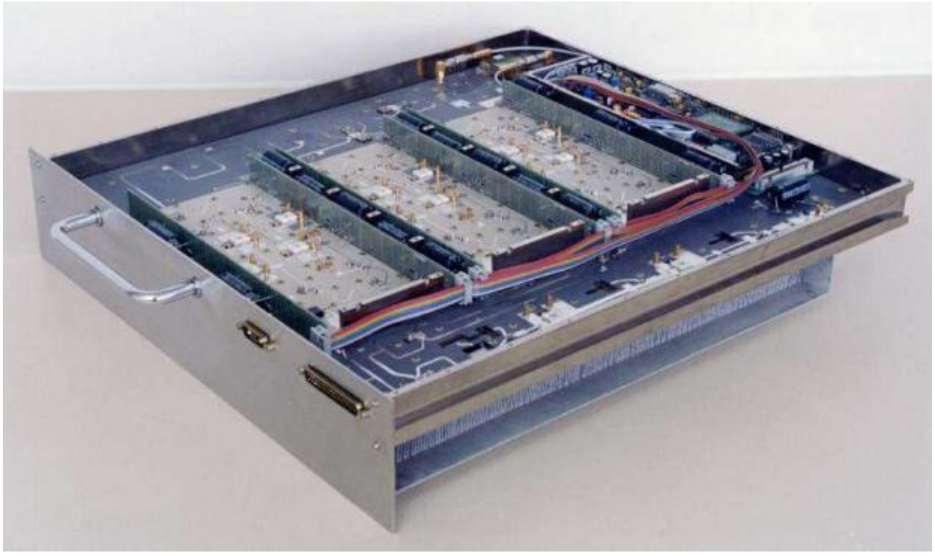


Figure 6 - STX 2000 SUM HPA Module

2.2.2 Interfaces

The STX 2000 is interfaced with:

- The receiver:
  Local Oscillator 1030 MHz CW signal which is generated by the RX, is received by the STX 2000,

- The MSSR Modulator/Extractor (MMXC):
  The function of this interface is to transmit the interrogation modulation commands and the BITE synchronisation commands from MMXC to STX 2000. The BITE reports are sent from STX 2000 to the MMXC.

- The I/R cabinet:

  - Mechanical interface:

    The transmitter is housed by the I/R cabinet.

  - Power supply interface:

    The function of this interface is to provide DC supply (5V, ± 15V, 28V, 50/55V) to the STX 2000.

  - Air flow interface:

    The STX 2000 is cooled by the TX/RX fan unit of the I/R cabinet.

- The RF Unit:
  The function of this interface is to transmit the SUM and CONTROL RF signals to the antenna via the duplexers.

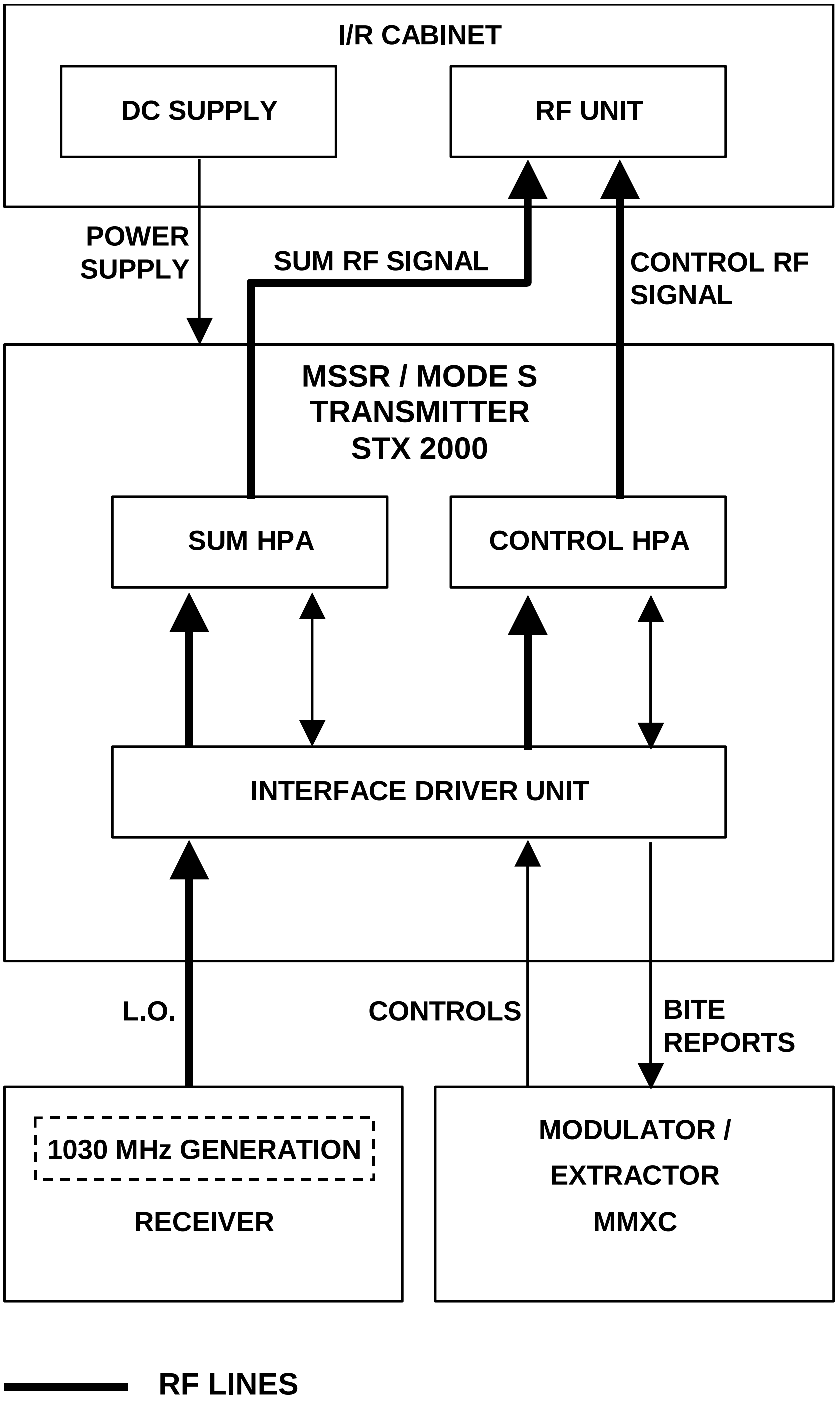


Figure 7 - STX 2000 Transmitter Associated Equipment

2.2.3 Description

The STX 2000 is able to transmit SSR interrogations signals (P1, P2, P3) and also Mode S interrogations signals (P1, P2, P4, P5, long and short P6 with DPSK).

The transmitter is configured such that the P1 pulse can be transmitted on the Control Ω channel so as to implement improved INTERROGATOR Side Lobe Suppression (IISLS).

It is divided into three modules: Sum HPA, Control HPA and Interface Driver.

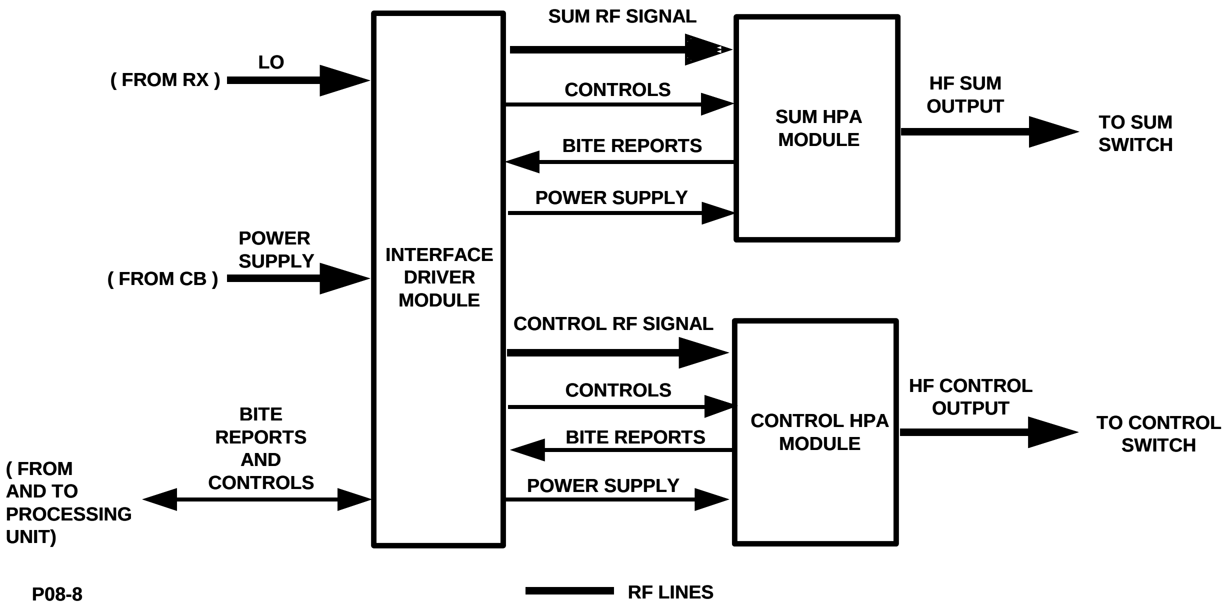


Figure 8 - Main Function of STX 2000

2.2.3.1 Interface Driver Module Functions

The main functions of the Interface Driver module are:

- Interface processing with Processing Unit related to RF modulations, attenuation commands and Built-In Test reports; controls dispatching to HPA modules,
- Storage of all failure reports stemming from BITE functions of HPA modules,
- Power supply dispatching to HPA modules,
- Perform the following RF modulation functions:
  - Differential Phase Shift Keying (DPSK) for the sum channel for Mode S interrogations,
  - Local Oscillator preamplification in order to drive HPA modules,
- Internal interface driver Bite functions.

2.2.3.1.1 RF Modulation Function

The RF signal stemming from the Receiver (LO) is first divided by a 2-way splitter. One output is used to allow a signal detection and a verification of the RF input signal presence. The other drives an amplifier. The LO presence is monitored by an RF detector connected to a coupler located at the interface driver LO input.

The output signal is then divided into a Sum channel and a Control channel.

The Sum channel is composed of amplifiers that ensure an amplification gain and the Local Oscillator shaping according to the interface card control.

In order to realise the DPSK function, a DPSK Modulator shifter is inserted in the Sum channel amplification chain introducing or not a 0/180° phase-shift in pulse P6. The phase modulation control is received from the Processor Unit and transmitted to the DPSK modulator shifter via the interface card.

An output circulator allows to protect the output transistor against reflected power with the help of a dummy load.

The output power is detected via a coupler and an RF detector. The measurement is used by the BITE functions.

The Control channel is identical to the Sum channel but without DPSK system. In this case, the amplifiers are powered according to the Control amplitude modulation stemming from the Processing Unit, via the interface card.

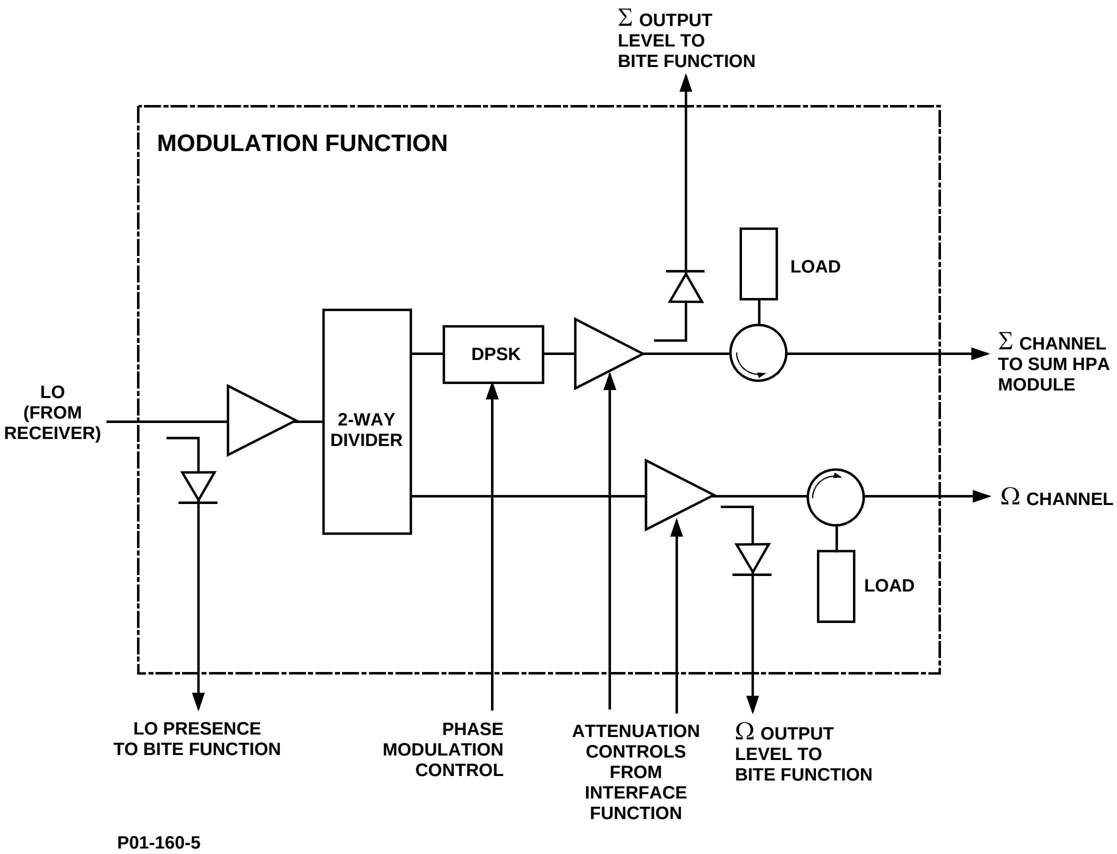


Figure 9 - Interface Driver Module Functions

2.2.3.1.2 Interface Function

The interface function enables to:

- Process the amplitude and phase modulations in order to:
  - ensure consistency of the Processing Unit commands by analysis of SUM and CONT pulse widths, and modulation presence,
  - inhibit modulations in case of alarms detected in HPA module:
    - power reflection at the SUM RF output,
    - power reflection at the CONT. RF output,
    - SUM RF modulation overload detected by junction temperature alarm,
    - ambient over-temperature.

- Transmit controls to the modulation function for the LO shaping and DPSK realise the Management of a command bus which allows to interface with Processing unit for the BITE reports and the attenuation commands.

  The command bus operates with:

  - a selection signal which requires or signals the availability of addresses and data,
  - a bi-directional address bus (4 bits + parity),
  - a data bus (8 bits + parity).

- Interfaces with the HPA modules in order to:

  - transmit the attenuation values to SUM and CONT HPA modules and for the IISLS mode from the data bus,
  - transmit the validation order to authorise the corresponding HPA modules to take into account individually the attenuation values (SUM, CONT, IISLS),
  - receive and memorise the BITE results from the SUM and CONT HPA modules,
  - distribute DC power supply to HPA modules (+ 5V, ± 15V, + 28V, + 50/55V).

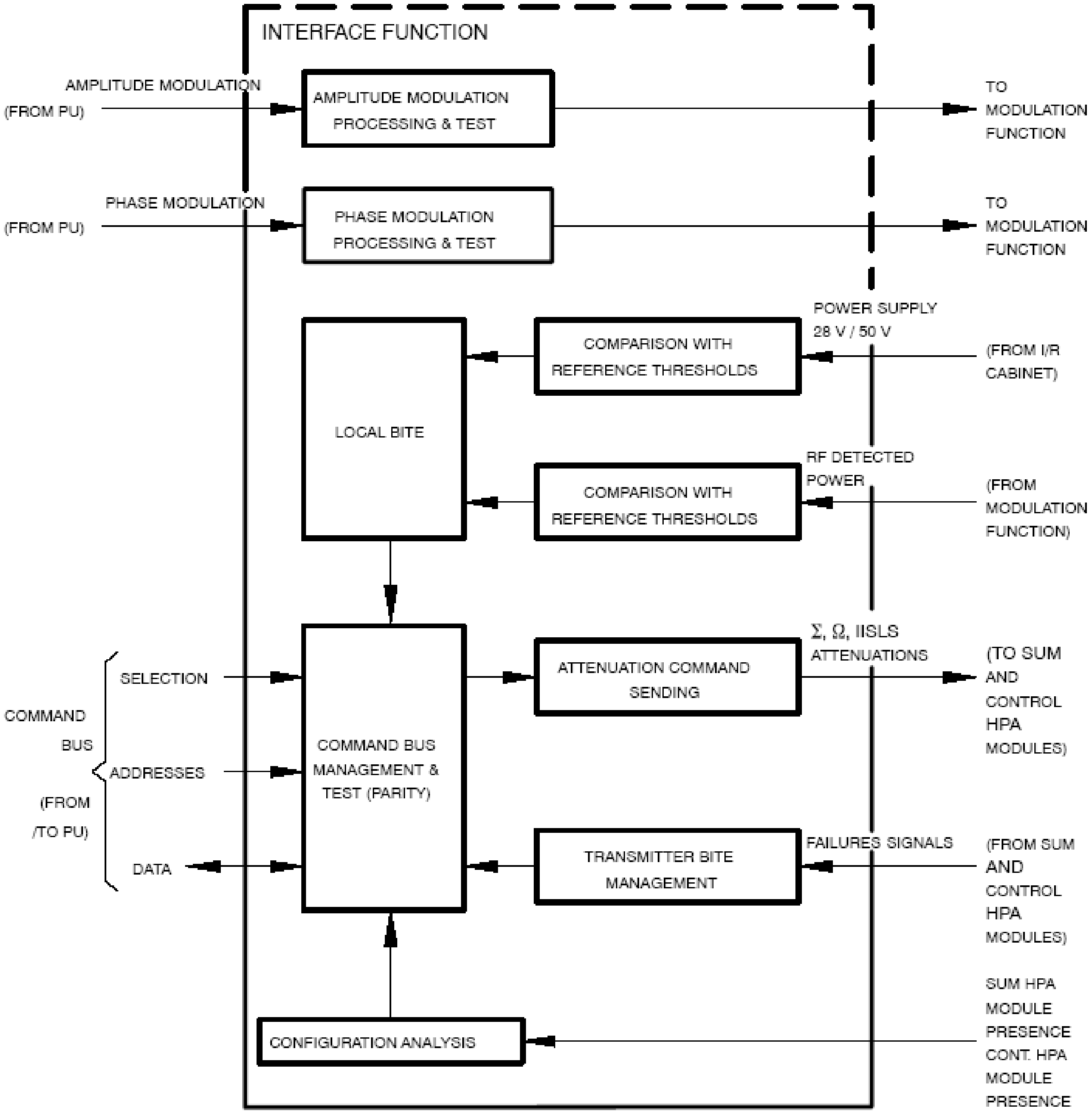


Figure 10 - Interface Function

2.2.3.1.3 Built-In Test Function

Some internal tests are made in the module and for each failure detection, a failure message is prepared to be sent to a Processing Unit (PU) on the bus and a LED on the front panel indicates the failure presence.

These failure signals are related to:

- Ambient temperature,
- Local Oscillator presence,
- Output power,
- Power supply,
- HPA modules presence,
- Time-out on pulse widths,
- Modulation presence.

The LEDs on the front panel give the state of the module:

- The green one is lighting, when the module receives the 5V power supply, otherwise it doesn't light,
- The red one is lighting (with a 1s delay) when an internal failure is detected, otherwise it doesn't light.

Ambient Temperature Measurement

A temperature sensor measures the ambient temperature in the module to detect if the temperature exceeds 70°C (estimated maximum operating temperature). In this case, a failure report is taken into account in the BITE function.

Input Local Oscillator Presence

The Local Oscillator signal is detected by a diode. The detected signal is sent to the Interface card which makes a comparison to a minimum level. Below this level, the Local Oscillator is considered to be off and the failure detection is generated and written into the BITE report.

Output RF Signals

A coupler and a detector at the output of the Sum and Control channels allow to measure the output levels, which are compared to a threshold. Under this threshold, the output is considered as being lost and a failure detection is generated and written into the BITE report.

Power Supply

The presence of the 28V and 55V input voltages is tested and in case of failure, a failure detection is generated and is written into the BITE report.

Time-Out on Pulse Widths

When a Sum or Control amplitude modulation is received from PU, a time counter is started. If the time counter exceeds 2 µs in case of a Control modulation or 40 µs in case of a Sum modulation, the corresponding pulse command is immediately stopped for a pre-determined time. A failure detection is generated and written into the BITE report. Stopping the modulation on the Control channel allows to limit the duty cycle.

Modulation Presence

When the Sum amplitude modulation is not received within 40 µs after a Sum attenuation command, a failure detection is generated and is written into the BITE report.

When the Sum phase modulation is not received within 40 µs after a Sum attenuation command, a failure detection is generated and is written into the BITE report.

When the Control amplitude modulation is not received within 40 µs after a Control attenuation command, a failure detection is generated and is written into the BITE report.

2.2.3.2 Sum HPA Module Functions

The Sum HPA module enables:

- High power amplification to the Sum channel from the RF signal stemming from Interface Drive module,
- Output power attenuation from 0 dB up to 12 dB according to a command received from Interface Driver module,
- BITE functions.

The Sum amplification is performed by a HPA module identical to the Control HPA in the MSSR version, or by a high duty cycle Sum HPA module in the Mode S version.

The description hereafter applies to the Mode S version high duty cycle Sum HPA.

The Sum HPA module function is divided into five sub-functions:

- driving-dividing,
- amplification,
- combination,
- attenuation,
- Built-In Test.

2.2.3.2.1 Driving-Dividing

The Sum driver-divider allows the pre-amplification and the pulse shaping of the RF input signal.

A circulator is inserted after the preamplifier in order to protect it from the power reflected by the 3-way divider. The reflected power is sent to a load.

The RF signals is divided (12-ways) The 12-ways drive their RF signals to the SUM amplification function.

2.2.3.2.2 Amplification

The Sum amplification function is performed by 12 transistors fed from 12-ways of the SUM driving-dividing function. This function enables attenuation controlled by the SUM attenuation function.

The first driver stage is controlled by a pulse shaping system in order to get RF pulses compliant with the requirements for spectral purity and fall time.

The Sum amplification function enables temperature measurement system which is used by the BITE function in order to detect RF modulation overload.

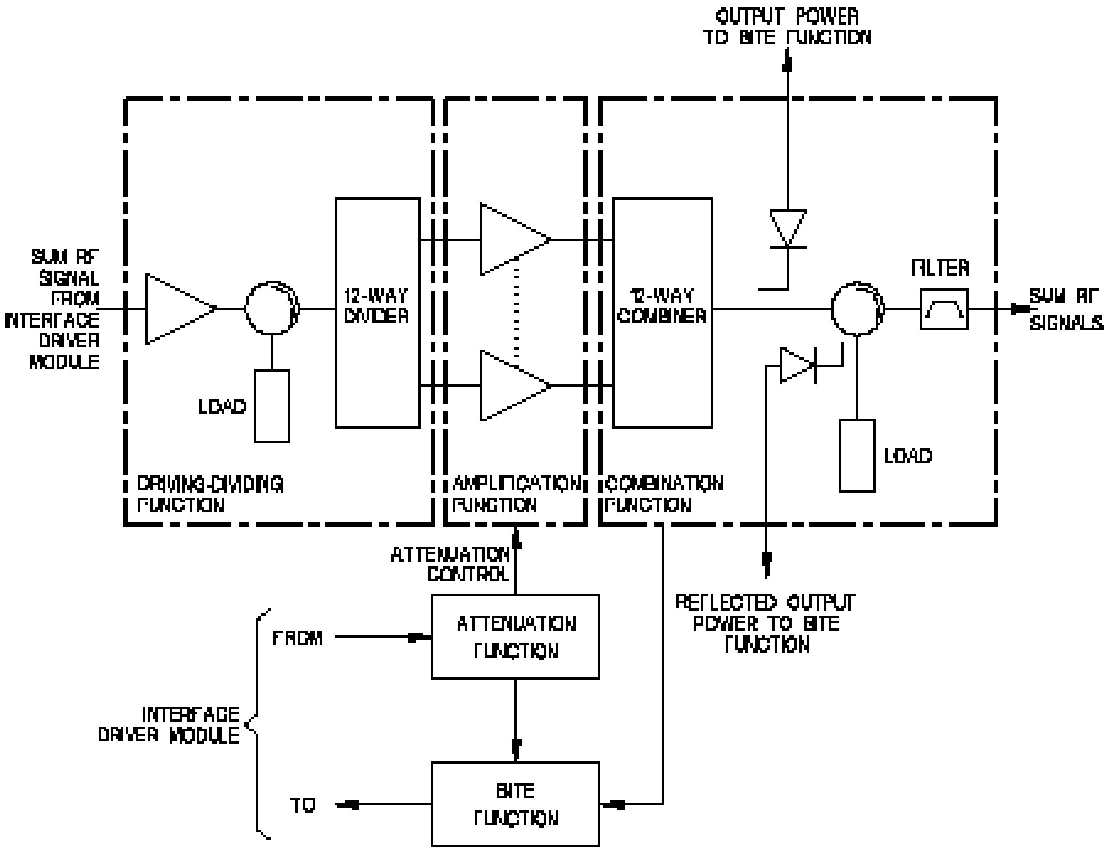
2.2.3.2.3 Combination

The Sum combiner allows to combine the power stemming from the 12 transistors.

An output circulator protects the module against reflected power and infinite VSWR. The reflected power is also detected. The measurement is processed in the BITE function.

A part of the transmit power is measured by a detector. The measurement is processed by the BITE function in order to check if the output power is greater than a minimal value.

A low pass filter reduces the harmonic and spurious level and a band pass filter allows to respect the ICAO standard close to the carrier frequency (± 60 MHz).



P01-160-13.PPT

Figure 11 - High Duty Cycle Sum HPA Module Function

2.2.3.2.4 Attenuation

The Sum attenuation function enables to:

- Process the attenuation code received from the Interface Driver module and generates the control transmitted to the attenuation function,
- Adjust the RF Level for testing of the module.

2.2.3.2.5 Built-In Test

Some internal tests are done in the module and for any failure detection, a failure signal is sent to Interface Driver module and a LED indicates the failure presence. These failure signals are related to:

- Ambient temperature,
- RF modulation overload,

- Reflected output power,
- Output power,
- Power supply,
- Module presence.
- A red LED on the front panel gives the state of the module: it is lighting (with 1 sec. delay) when an internal failure is detected, otherwise it doesn't light.
- Ambient Temperature
- A temperature sensor measures the ambient temperature in the module to detect if the temperature exceeds 70°C (estimated maximum ambient temperature in the module). In this case, a failure report is sent to Interface Driver module and written into the BITE report.
- RF Modulation Overload
- In order to protect the RF a device is used to detect Modulation overload.
- Warning and alarm signals are generated towards Interface Driver module and are written into the BITE report.
- In order to protect RF transistors against Modulation overload, when an alarm signal is generated, the Interface Driver module stops the RF Modulation for a fixed time.
- Reflected Output Power
- The output circulator on the Sum combiner card allows to measure the reflected power with a detector. If the detected power exceeds a fixed value, an error signal is generated to module interface Driver and a failure report is written in the BITE report. In order to protect the RF transistors, the Interface Driver module stops the RF modulation for a fixed time.
- Output Power
- The output power is measured by a detector on the Sum combiner card. The resulting level is compared to reference levels according to the attenuation command and the nominal power P0 (for 0 dB attenuation).
- When for a given attenuation, the output power is outside the reference range, an error signal is generated towards Interface Driver module and is taken into account by the BITE.
- Power Supply
- The presence of the + 28V and + 50/55V input voltages is tested and in case of failure, an error signal is sent towards Interface Driver module and a failure report is written in the BITE report.

Module Presence

The power supply 5V is returned to Interface Driver module.

2.2.3.3 Control HPA Module Functions

The Control HPA module enables:

- High power amplification to the Control channel from the RF signal stemming from Interface Driver module (the same module is also used for the Sum channel in the MSSR version),
- Output power attenuation from 0 dB up to 12 dB according to a command from Interface Driver module,
- IISLS attenuation from 0 dB up to 6 dB,
- BITE functions.

The Control HPA module function is divided into five sub-functions:

- Driving,
- Dividing,
- Control amplification,
- Control combination/attenuation,
- Control Built-In Test.

2.2.3.3.1 Driving

This function enables the pre-amplification and the pulse shaping of the RF input signal.

2.2.3.3.2 Dividing

Preamplified RF signals are divided by a 4-way divider.

2.2.3.3.3 Amplification

The Control amplification function is performed by RF transistors, fed from the 4-ways of the Control dividing function.

2.2.3.3.4 Combination

The Control combination function enables the combination of the power stemming from the 4 RF transistors.

The output circulator protects the module against a too high VSWR.

The output power is measured via a detector. The measurement is used in the BITE function in order to check if the output power is greater than a minimal value.

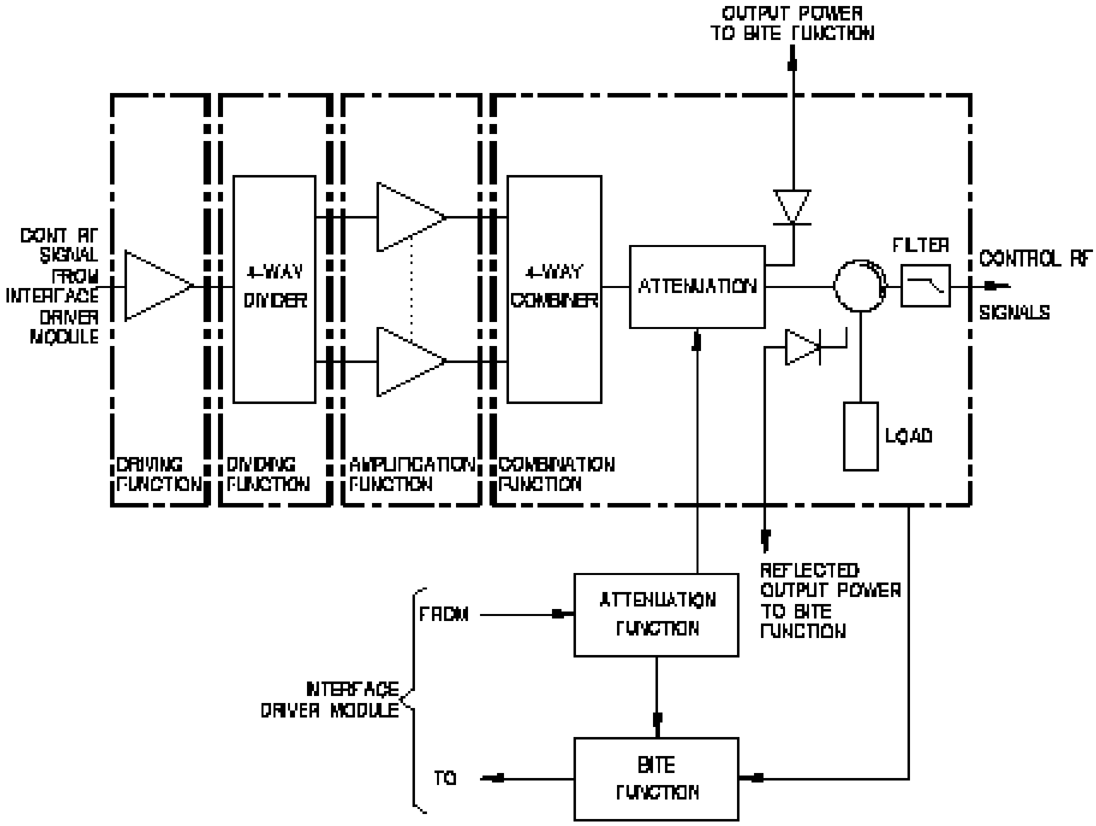
The reflected power is also detected and the measurement is sent to the BITE function.

A low pass filter reduces the harmonic and spurious levels.

2.2.3.3.5 Control Attenuation Function

The Control attenuation function enables to:

- Process the attenuation codes (Cont. and IISLS) received from Interface Driver module and generates the control to the combination function.



P01-160-14.PPT

Figure 12 - Control HPA Module Function

2.2.3.3.6 Built-In Test

Some internal tests are done in the module and for any failure detection, a failure signal is sent to Interface Driver module and a LED indicates the failure presence. These failure signals are related to:

- Ambient temperature,
- Reflected output power,
- Output power,
- Power supply,
- Module presence.
- A red LED on the front panel gives the state of the module: it is lighting (with a 1 s delay) when an internal failure is detected, otherwise it doesn't light.

Ambient Temperature

A temperature sensor measures the ambient temperature in the module to detect if the temperature exceeds 70°C (estimated maximum value). In this case, a failure report is sent to Interface Driver module and is written into the BITE report.

Reflected Output Power

The output circulator on the Control combiner card allows to measure the reflected power with a detector. If the detected power exceeds a fixed value, the signal is generated to Interface Driver module and a failure report is written in the BITE report.

Output Power

The output power is measured by a detector on the Control combiner. The result is compared to reference levels according to the attenuation command and the nominal power P0 (for 0 dB attenuation).

When for a given attenuation, the output power is outside the reference range, the error signal is generated towards Interface Driver module and is taken into account by the BITE.

Power Supply

The presence of the + 28V and + 50/55V input voltages is tested and in case of failure, an error signal is sent towards Interface Driver module and a failure report is written in the BITE report.

Module Presence

The power supply 5V is returned to the Interface Driver module.

2.2.4 Key Features

The following values are typical:

- Operational frequency: 1030 ± 0.01 MHz,
- Output power: 64.1 dBm on Sum and Control channels,
- Mode S version peak duty cycle 63.7% during 2.4 ms on Sum channel. The STX 2000 Mode S duty is compatible with full Data link operation, as defined for the EUROCONTROL POEMS programme,
- Mode S version mean duty cycle: 5% long term. The STX 2000 Mode S duty cycle is compatible with full Data link operation, as defined for the EUROCONTROL POEMS programme,
- RF pulses compliant with ICAO standard,
- IISLS operation on Control channel,
- Output power attenuation from 0 dB up to 12 dB by step of 2 dB (independently on Sum & Cont.).

2.3. MONOPULSE DIGITAL RECEIVER (MDR)

2.3.1 Introduction

The receiver of the RSM 970S radar system performs the digital processing of the signals received from the antenna over the Σ (sum), Δ (difference) and Ω (control) channels in order to deliver the following data needed for the operation of the extractor (part which processes the video data):

- QRSLS: Quantized video generated from the log Σ, log Ω and log Δ videos.
- OBA f(Δ/Σ): Off-Boresight Angle used in Monopulse operation. It defines the angular position of a target detected in the main Sum channel beam.
- Video Log: Log Σ and Log Δ.

The receiver sends the master oscillator frequency signal (1030 MHz) to the transmitter. The master frequency generator is also permanently tested. It is checked using a comparison with the master oscillator frequency generated by the adjacent channel. In the event the frequency of any radar channel exceeds ICAO limits (1030 MHz ± 0.01), a warning is reported at RCMS.

The receiver also contains test circuitry. Internal stimuli are generated from an oscillator at the same frequency as the signals received from the antenna (1090 MHz), via couplers located at the Σ, Δ and Ω RF inputs, these stimuli simulate the various functions of the receiver and detection circuits on the video outputs of the receiver.

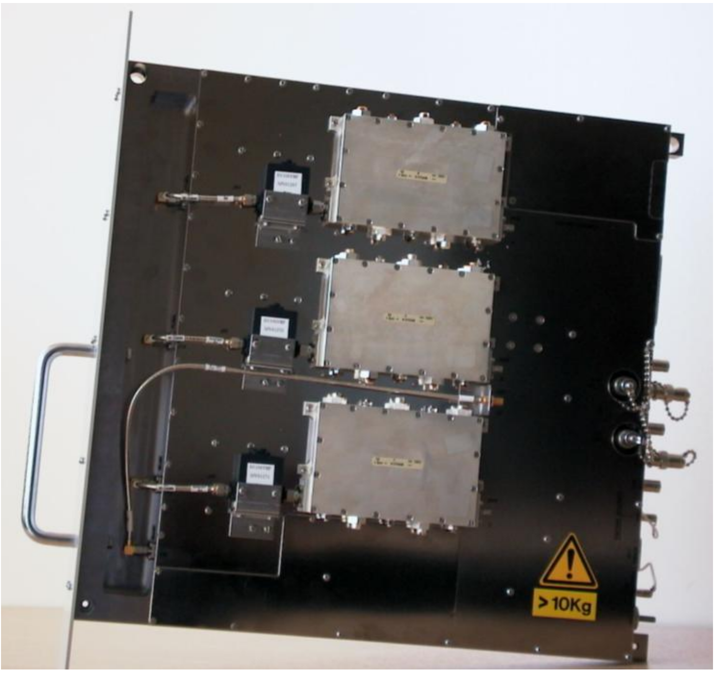


Figure 13 - View of MDR Digital Receiver

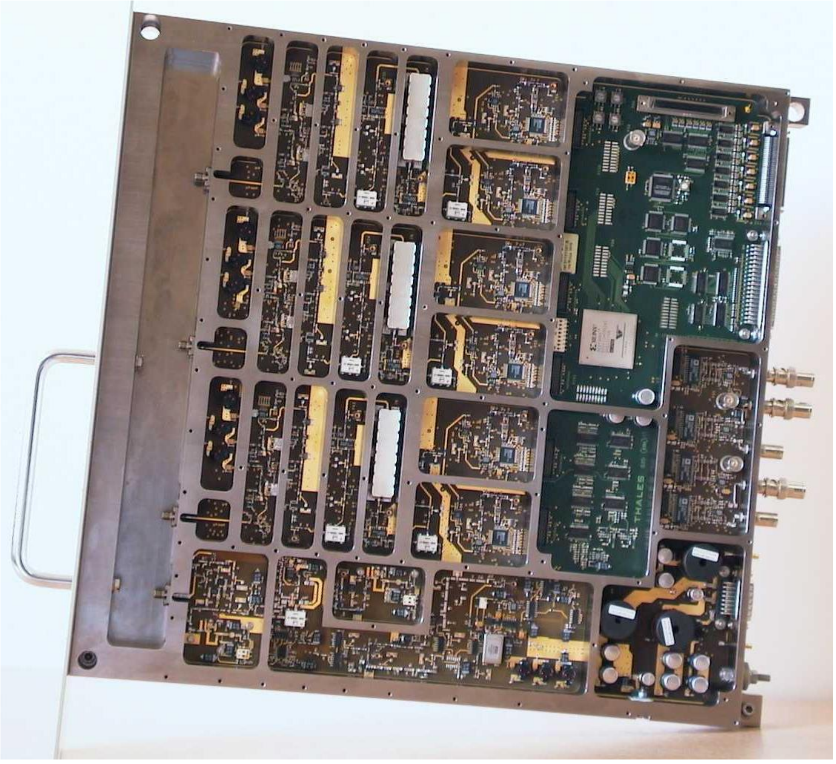


Figure 14 - View of MDR Open Case

2.3.2 Interfaces

The receiver (channel 1 or 2) interfaces with:

- The Interrogator/Receiver cabinet from which it receives DC power supplies and RF signals (Σ, Δ, Ω),
- The transmitter which receives the Local Oscillator from the receiver,
- The processor/control unit :
  - which receives the digital videos and the BITE results from the receiver,
  - which sends operating controls to the receiver,
- The IBIS radar maintenance display in order to display digital videos from either receiver (1 or 2).

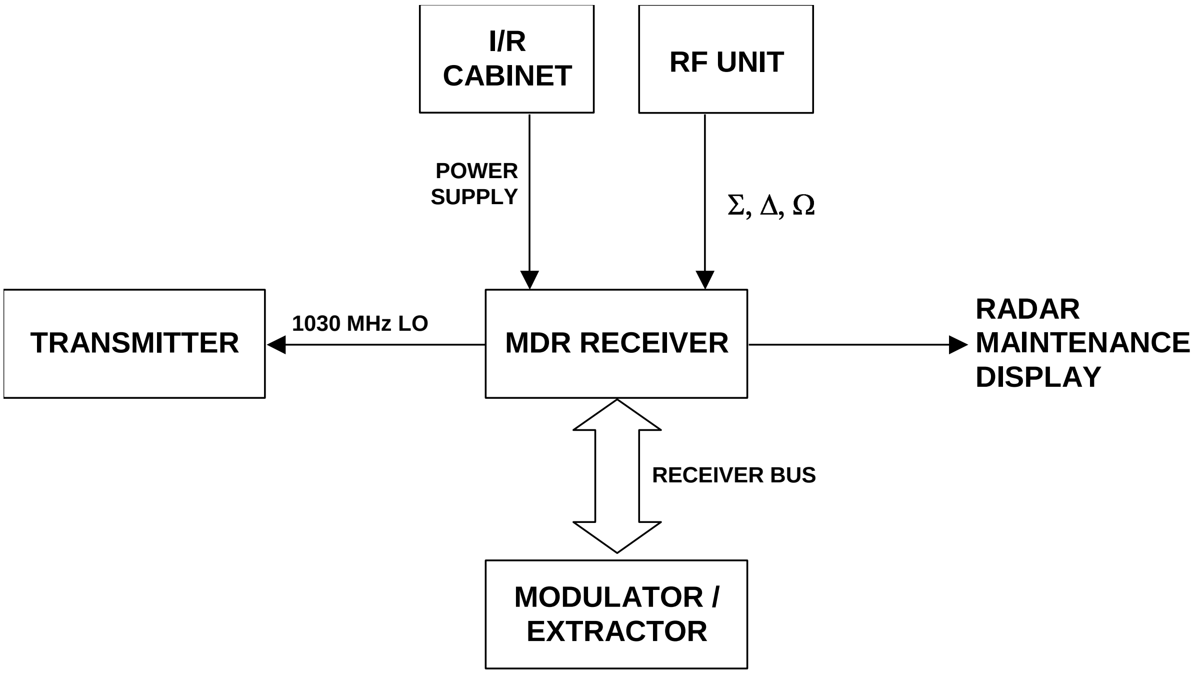


Figure 15 - Associated Equipment

2.3.3 Description

2.3.3.1 General

Signals generated by the receiver are the following:

- the log Σ and log Δ signals are obtained from digital processing.
- the signal QRSLS is determined by digitally comparing the logarithmic video signals:
  - log Σ and log Ω,
  - log Σ and log Δ.

The Σ - Ω comparison allows to suppress signals received within secondary lobes.

The Σ - Δ comparison allows to narrow the received lobe;

- the angle error signal f(Δ/Σ) represents the function $\tan^{-1}\left(\frac{\vec{\Sigma}.\vec{\Delta}}{\Sigma^2}\right)$.

A reduced noise factor is obtained on the three channels by low-noise pre-amplification at the reception frequency.

Filtering is performed upon reception at the RF frequency (1090 MHz) and also at the intermediate frequency (110 MHz) and in digital Amplitude Phase Detection (APD) unit .

The RF signal at 1090 MHz is translated to 110 MHz by mixing with the 1200 MHz Local Oscillator (LO). The LO signal at 1200 MHz is generated by a VCO driven at a crystal oscillator frequency. The signal for the transmitter 1030 MHz is also generated by a VCO.

A bus controls exchanges between the processor unit and the receiver:

- to trigger the receiver BITE tests and to collect BITE reports,
- to set the RSLS thresholds applied in the receiver,
- to set the RSLS validation states in the receiver.

2.3.3.2 Functional description

The receiver can be divided into three sub-functions:

- Analog to digital stages which converts the RF signals coming from transponders after analog amplification, filtering and demodulation into digital signals,
- Local frequency generation which generates the frequency used for down conversion and sent to the transmitter,
- Signal processing which generates the signals intended for the associated equipment and manages the BITE.

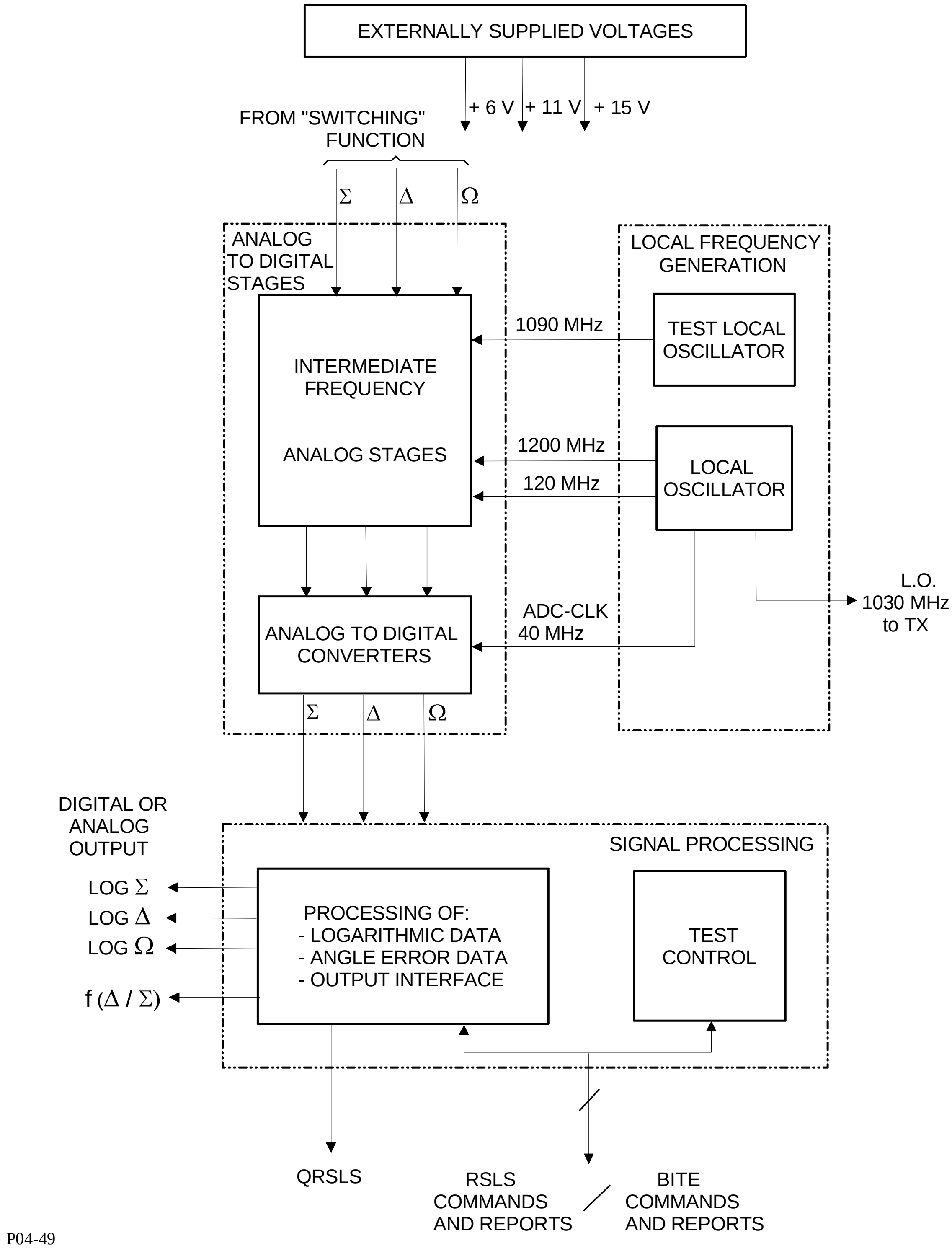


Figure 16 - Reception Function

2.3.3.2.1 Analog to Digital Stages

Analog to digital stages consist of 3 identical linear channels of reception Σ, Δ and Ω. Each one is encoded by two Analog to Digital Converters respectively called MSB chain and LSB chain.

The analog stages function consists of:

- Filtering the 1090 MHz received signal by RF filters.

These filters are fitted on the side panel of the receiver on the Σ, Δ and Ω channels, at the beginning of the demodulation chain. They enable the receiving frequency to be selected at 1090 MHz and they reject the transmitting frequency at 1030 MHz.

The 1090 MHz RF signals from the antenna pass directly to the filters in the Σ, Δ and Ω channels.

- Signals test input:

  - The first signal of test at -20 dBm (generated by Local Frequency Generation) is injected by the first switch, just after the 1090 MHz RF filter, enables the receiver to be tested. The signal of test undergoes all the high dynamic analog chain called MSB (except RF filter);

  - The second signal of test at -53 dBm (also generated by Local Frequency Generation) is injected every second through the switch after the LNA and is going to test all the low dynamic analog chain called LSB (except RF filter and 1st ampli LNA);

  - These signals of test validate also the local frequency generation;

- Preamplifier-mixers and IF filters.

The first stage preamplifier-mixer receives the LO signal (1200 MHz) from the Local Frequency Generation, divided so as to give identical levels on the Σ, Δ and Ω channels. The second stage preamplifier-mixer receives the LO signal (120 MHz) from the Local Frequency Generation. The function of the Preamplifier-Mixer is to perform low-noise amplification, to convert the received signal into 10 MHz IF signals, and to filter them before they are processed in the Angle Error Measurement - Log Amplifier function by the signal processing function.

- Analog to Digital Conversion.

In each reception channel Σ, Δ and Ω, two 14 bits Analog Digital Converters interface the analog chain to the digital chain.

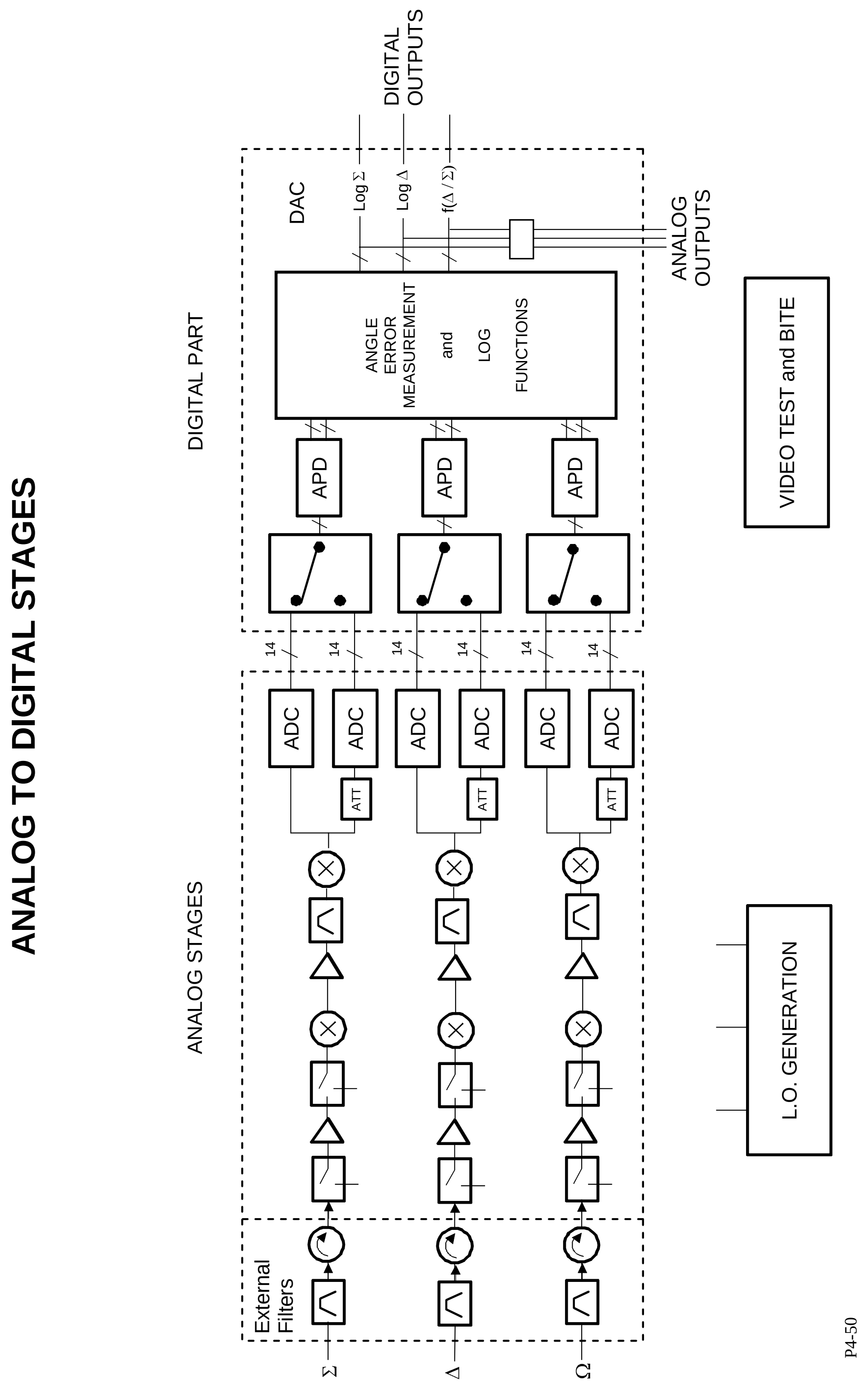


Figure 17 - Analog to Digital Stages

2.3.3.2.2 Local Frequency Generation

The Local Frequency Generation ensures several functions:

- it delivers the LO signal (local oscillator at 1030 MHz) to transmitter,
- it generates the ADC_CLK 40 MHz signal clock for the Analog to Digital Converters,
- it delivers two LO signals (LO 1200 MHz and LO 120 MHz) which when mixed successively with the signal received from the antenna (1090 MHz) and then with the first IF (110 MHz) gives the second IF signal (10 MHz),
- it enables the receiver to be tested by delivering a 1090 MHz signal to the input switches.

The LO 1030 MHz signal is generated by a Voltage Control Oscillator (VCO1) controlled on the 40 MHz source by a phase locked loop PLL1.

The source 40 MHz (TCXO) is a quartz oscillator, compensated in temperature, which delivered also the clock signal ADC_CLK for the Analog to Digital Converter.

The LO 1200 MHz signal is generated by a Voltage Control Oscillator (VCO2) controlled on the 40 MHz source by a phase locked loop PLL2.

The LO 120 MHz signal is generated by multiplying the signal of the TCXO by 3.

LO 1090 MHz signal for test is generated by mixing LO 1030 MHz signal with the LO 120 MHz divided by 2.

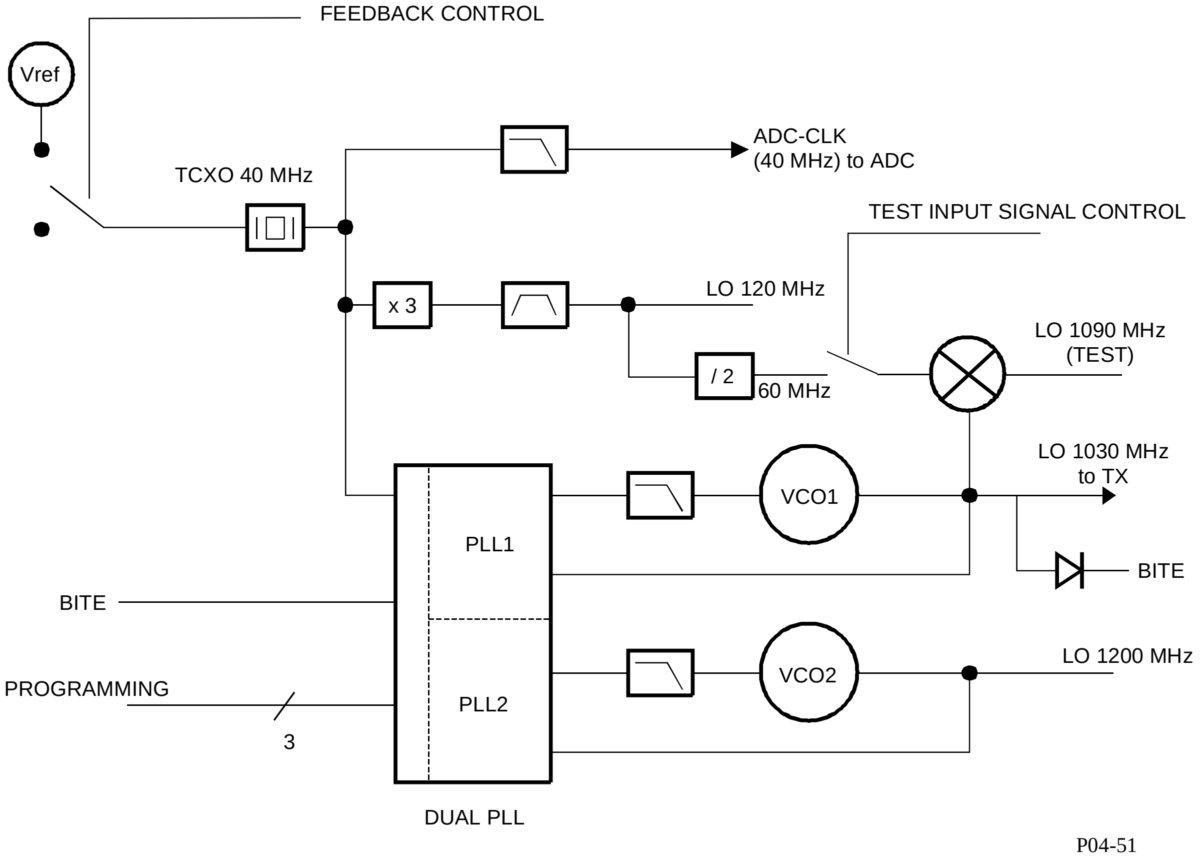


Figure 18 - Local Frequency Generation

2.3.3.2.3 Signal Processing

The purpose of this function is to deliver to the processor unit:

- video QRSLS output. These signals indicate whether the video has been detected on the main lobe of the antenna,
- Log Σ and Log Δ videos,
- Angle error measurement f(Δ/Σ).

It also manages the BITE of the receiver unit.

The processor unit (master) controls all information exchanged between the processor unit and the receiver via a bus. The receiver (slave) executes operations according to processor unit request.

The main functions of the digital chain are:

- Switching between ADC (MSB) and ADC (LSB),

- Amplitude Phase Detection,
- Video signals generation,
- Angle error measurement,
- LOG Conversion,
- Calibrations during operation,
- BITE,
- Digital to Analog Conversion (for maintenance).

Except Digital to Analog Conversions, the other major functions are built in a FPGA circuit.

VIDEO SIGNALS GENERATION

The signal log Ω is assigned a coefficient K1, adjustable between 0 to +10 dB, by step of 1 dB.

The signal log Δ is assigned a coefficient K2, adjustable between -10 dB to +10 dB, by step of 1 dB.

K1 and K2 received on the receiver interface bus is converted in analog signals before assignation to log Ω and log Δ.

The result of comparing log Σ and log Ω + K1 indicates reception on the main (or secondary) lobe. The result of comparing log Σ and log Δ + K2 refines the reception on the main lobe.

Combining these two results gives the video signal QRSLS (Σ).

This system eliminates noise and spurious pulses coming in particular from the area near the secondary radar.

The QRSLS, Log $\sum$, Log Δ and f($\Delta/\sum$). videos are sent to the radar processing unit (for decoding of replies) in digital form (LVDS type).

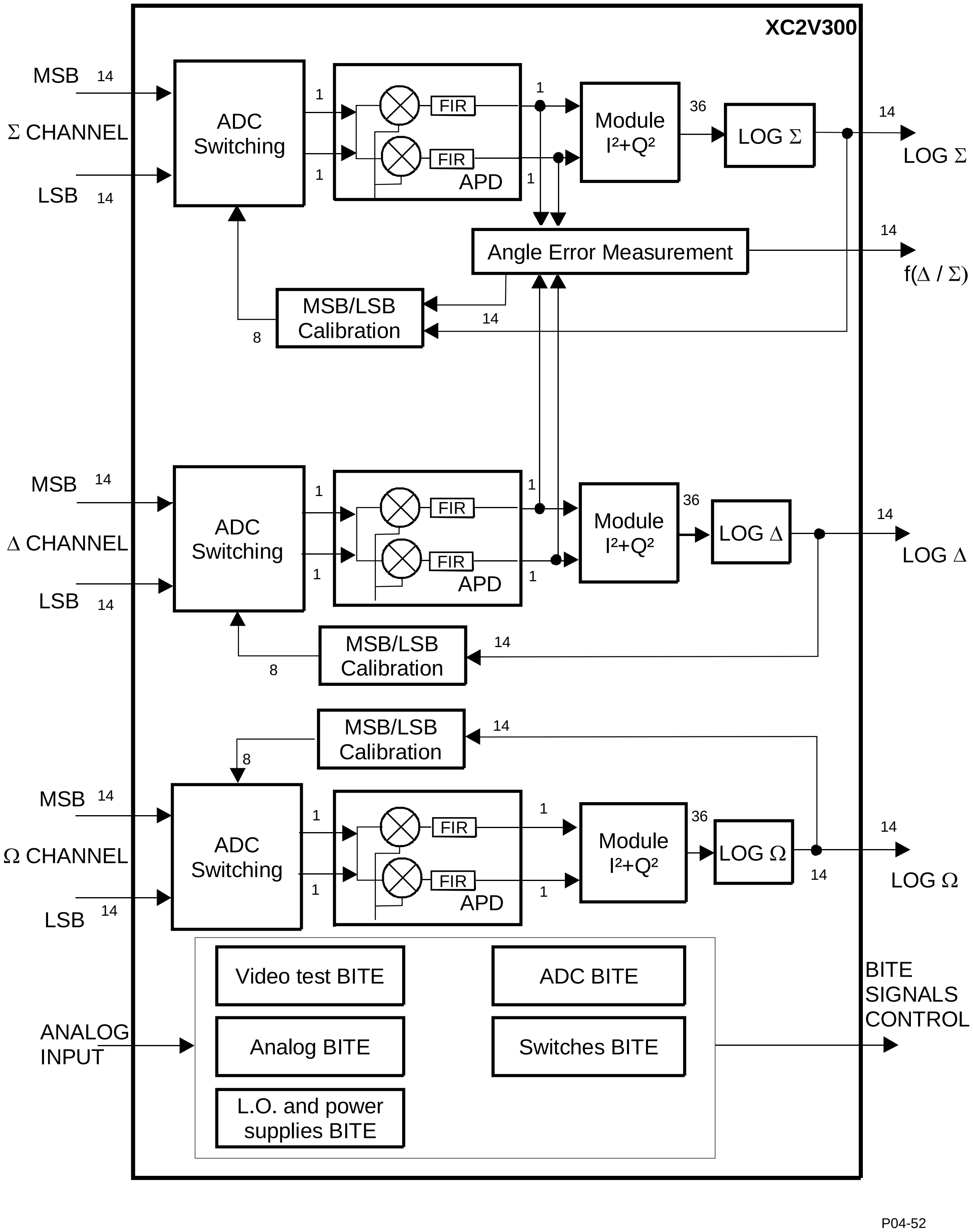


Figure 19 - Signal Processing Function

2.3.3.3 BITE (Built-In Test Equipment)

General

The BITE allows to test the correct operation of the MDR.

A set of tests is made, some of them are performed continuously others upon periodic signals injection.

The main functions BITE are:

- Video test signals,
- Outputs analog and digital LVDS,
- Analog Digital Converters,
- Switches (calibration, injection),
- Local oscillator signals,
- Power supplies.

The BITE report is sent to the processor control/unit via the receiver bus QRSLS/BITE interface. The Processor/Control unit sends the overall BITE report to the Remote and Control Monitoring System.

Angle Error Measurement

The f(Δ/Σ) video is compared to thresholds for 3 Δ/Σ values (-1, 0, +1). The test result is formatted to be sent to the processing unit on the receiver interface bus.

Noise Sensitivity

Each of the signals log Σ, log Δ and log Ω is compared to thresholds so as to check a noise test, a test in the middle of the dynamic range and a test in the high of the dynamic range. The test result is formatted to be sent to the processing unit on the receiver interface bus.

Reception Test Controls

The Controls and Tests function transmits an end-of-range sync signal. From this signal, the Signal Processing function generates the test oscillator control signal and the various attenuation and phase-shift control signals needed by the Σ, Δ and Ω test signals. The test result is formatted to be sent to the processing unit on the receiver interface bus.

2.3.4 Key Features

The following values are typical:

- Received signal frequency: 1090 MHz ± 3 MHz
- Intermediate frequency: 10 and 110 MHz
- Efficient dynamic range: From -20 dBm to -85 dBm
- Pass band at -3 dB: ≥ 8 MHz
- Input impedance on all 3 channels: 50 Ω
- Local oscillator frequency: 1030 MHz ± 10 kHz
- Sensitivity: ≤ -88 dBm

2.4. MONOPULSE MODULATOR AND EXTRACTOR (MMXC)

2.4.1 Introduction

In an RSM 970 S radar channel, the MMXC performs SSR and Mode S radar processing in conjunction with the MSSR Radar Processor (MRP).

The MMXC performs real time processing. Its operational purpose is, according to controls sent by the MRP, to schedule aircraft interrogations and associated listening windows in a succession of all-call periods (for the acquisition of Mode S aircraft and surveillance of aircraft equipped with SSR-only transponders) and roll-call periods (for the surveillance and enhanced surveillance of Mode S aircraft, including data link exchanges in the ATN), in order to:

- generate SSR and Mode S interrogation modulation controls as well as attenuation controls to the transmitter,
- generate RSLS controls to the receiver,
- compute SSR and Mode S replies from the digital videos provided by the receiver, and send the detected replies to the MRP for further processing.

In the dual I/R channel architecture of the Mode S radar, the MMXC of the "to antenna" (i.e.”ON-LINE”) channel processes operational radar data, the MMXC of the "to load" (i.e. “standby”) channel processes test data.

The MMXC controls the switches of the RFU, once it has received an I/R channel switchover control from its associated DPC (MRP part).

For maintenance purpose, the MMXC manages the real time processing of the BITE information gathered from itself and other radar equipment.

The MMXC is housed in a case which is attached to the Monopulse Digital Receiver. The grouping of the MDR and the MMXC is called MDRP (Monopulse Digital Receiver and Processor) and constitutes a single LRU.

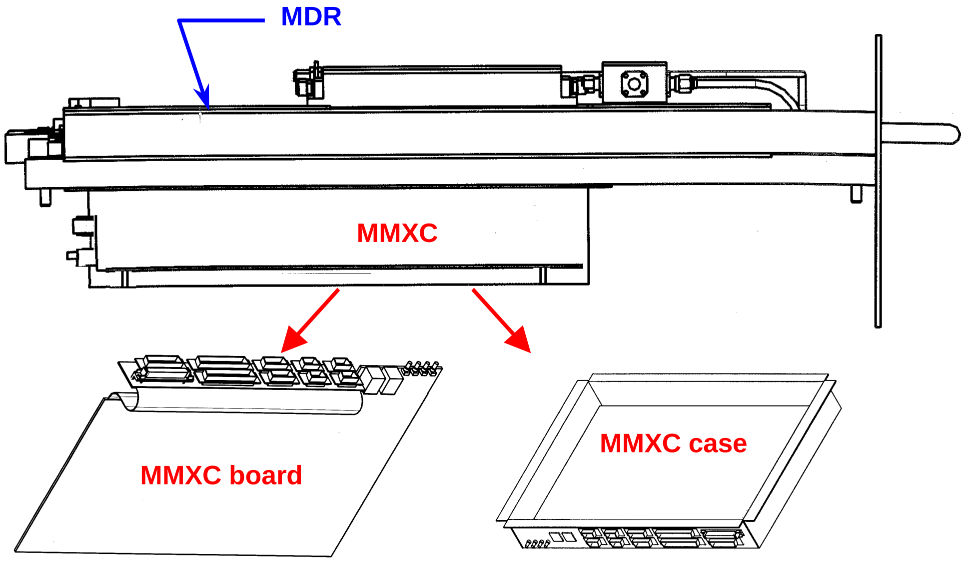


Figure 20 - MDRP configuration

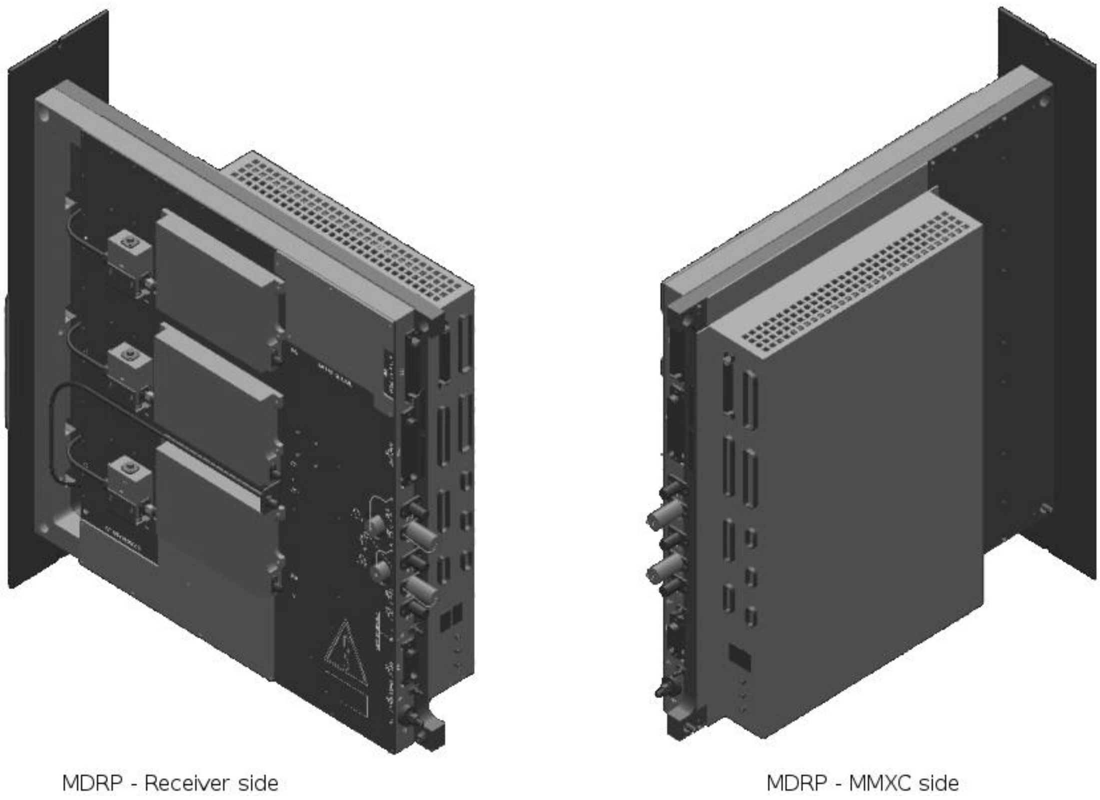


Figure 21 - MDRP view

2.4.2 Interfaces

The MMXC manages the following interfaces:

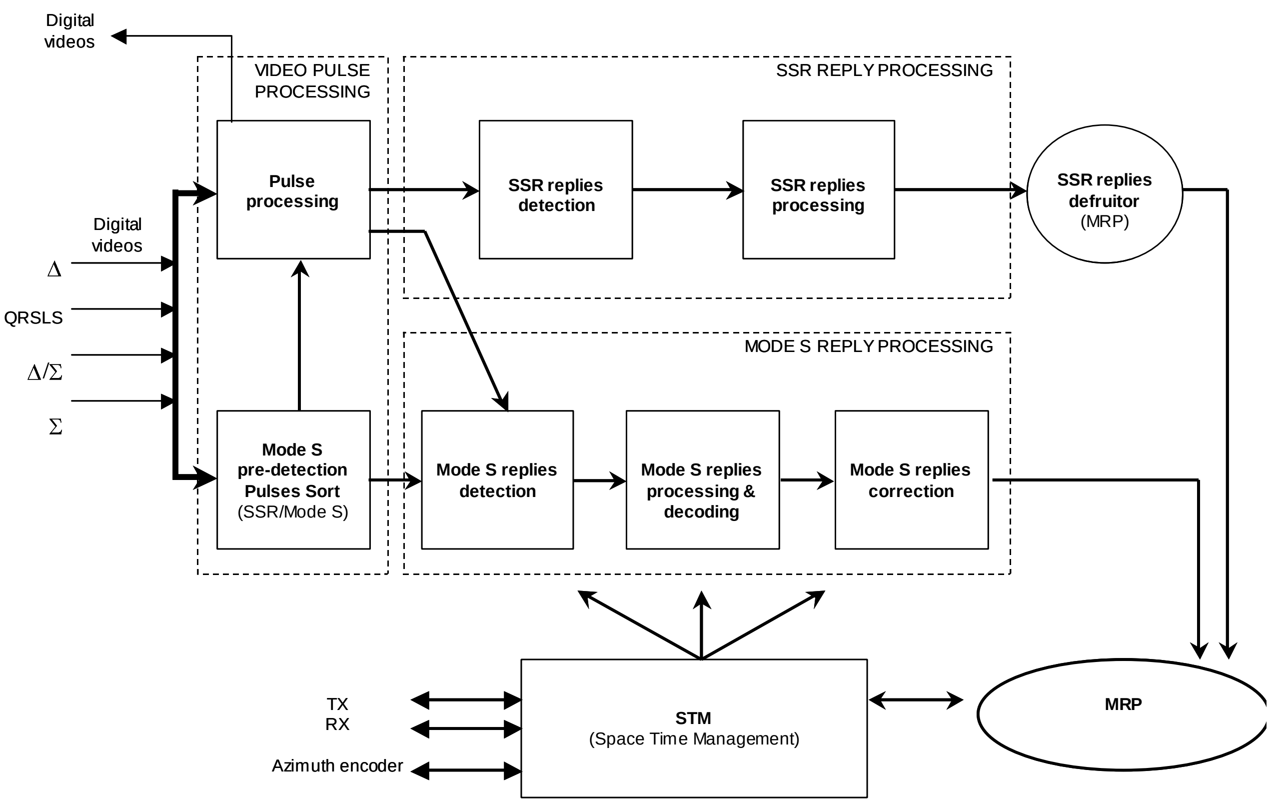
- Transmit data:
    - to the RFU: RF switch controls,
    - to the transmitter: attenuation and modulation controls,
    - to the receiver: RSLS controls and receiver test synchronization control,
    - to the IBIS radar maintenance display: synchronization pulse, pulse presence signals and reply presence signals, digital videos,
    - to the antenna control cabinet: transmission inhibition report
- Receive data:
    - from the RFU: RF switch statuses,
    - from the transmitter: BITE reports,
    - from the receiver: digital videos, QRSLS signal and BITE reports,
    - from the I/R cabinet ancillaries: DC supply, DCS BITE report, fan BITE reports, thermal sensor BITE reports,
    - from the optical encoder: antenna azimuth,
    - from the antenna control cabinet: transmission inhibition control

2.4.3 Description

2.4.3.1 Architecture

The MMXC performs 6 functions distributed on 2 functional blocks :

- Front End Processing (one FPGA + one DSP)
    - MMXC - Cabinet Interface
    - Space Time Management (STM)
    - Video Pulse Processing
    - SSR Reply Processing
    - Mode S Reply Processing
- Ethernet Interface Processing (one FPGA)
    - MMXC - MRP Interface



P08-9

Figure 22 - MMXC functional architecture

2.4.3.2 Front-End functions

2.4.3.2.1 Cabinet interface

The purpose of this function is to convert all the external signals (LVDS digital video, dry contact, ...) into standard digital data.

2.4.3.2.2 Space and time management

This function performs:

- the real time management of the All-Call/Roll-Call pattern,
- the processing of the antenna azimuth and Azimuth Distribution,
- the generation of SSR and mode S interrogation to the transmitter,
- the control and monitoring of the transmitter and the receiver.
- the management of the RF Unit
- the management of the Video and Reply Processing functions.
- the monitoring of the cabinet ancillaries (power supplies, cooling fans…)
- the monitoring of the MMXC Thermal Sensor

2.4.3.2.3 Video pulse processing

This function:

- analyses the shape of video signals sent by RX to detect secondary pulses (SSR or mode S),
- generates TVBC values function of range according to current TVBC law number
- validates pulses according to TVBC values,
- eliminates pulses belonging to Mode S message for SSR Reply Processing,
- computes the characteristics of each detected pulse,
- generates, during test period, test target digital videos.

2.4.3.2.4 SSR reply processing

This function:

- detects SSR replies,
- computes the characteristics of the replies,
- generates an SSR reply message for each validated reply,
- generates an SSR interrogation acknowledgement message for each All-Call SSR interrogation,
- reports the results of the analysis performed during the test period (to the “Space and Time Management” function).

2.4.3.2.5 Mode S reply processing

This function:

- detects Mode S replies:
  - in the range coverage during All-Call period,
  - in each listening window during Roll-Call period

- computes the characteristics of each validated reply,
- detects and corrects, when possible, errors in the data field of the Mode S message,
- generates a Mode S reply message for each listening window,
- generates a Mode S interrogation acknowledgement message for each All-Call or Roll-Call Mode S interrogation
- reports the results of the analysis performed during the test period (to the “Space and Time Management” function).

2.4.3.3 Ethernet interface

This function:

- manages the physical link between MRP and MMXC (Gigabit Ethernet),
- routes the messages between MMXC functions and MRP.

3. DATA PROCESSOR

3.1. DATA PROCESSING COMPUTER (DPC)

3.1.1 Introduction

The Data Processor (DPC) is composed of a Personal Computer (PC) installed in the radar cabinets (one Data Processor per MSSR/Mode S channel).

The online DPC transmits controls to the associated MMXC, in order to schedule SSR, Mode S All-Call and Mode S Roll-Call interrogations. In return, it receives MSSR and Mode S replies elaborated by the MMXC.

In a PSR + MSSR/Mode S configuration, the online DPC also receives PSR plots and weather maps from both PSR radar processors. According to the status of the PSR processors, it selects one of them for processing.

The DPC performs the PSR/MSSR/Mode S plot combination and scan-to-scan correlation (i.e. tracking). Tracks or filtered plots are then transmitted to the ATC Centre via two LINES devices. Eight ATC Center data flows are available with ASTERIX or AIRCAT (Tracks only) formats.

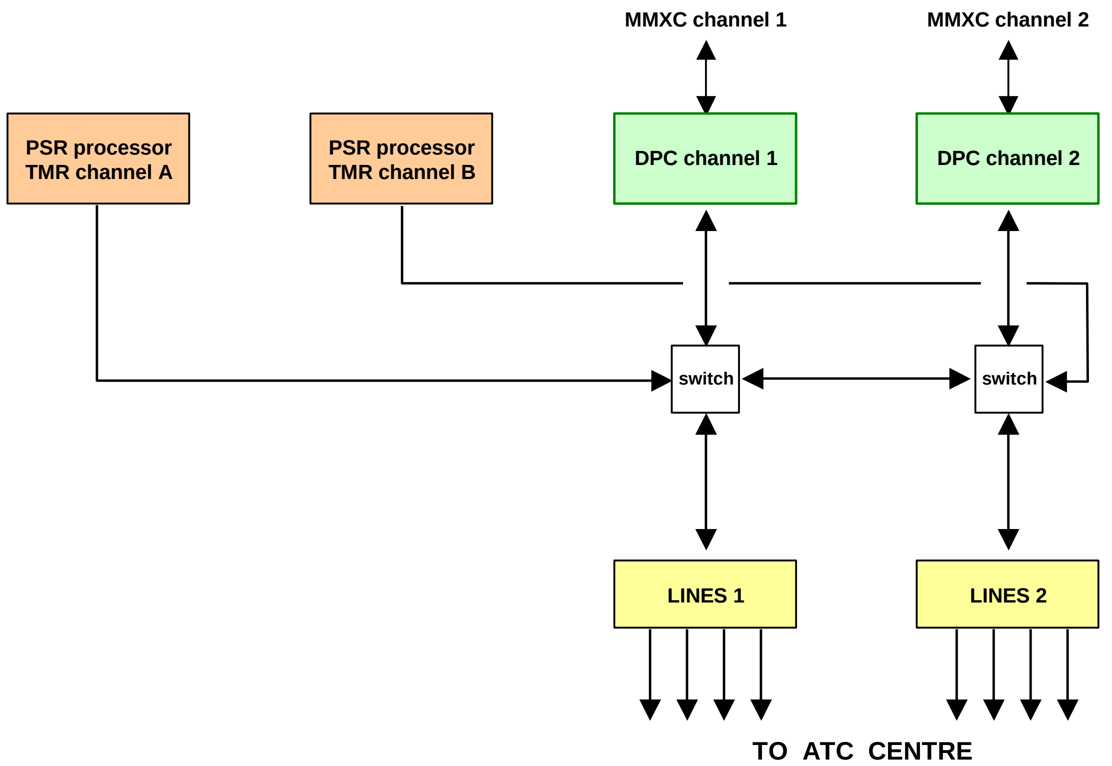


Figure 23 - DPC Environment

3.1.2 Hardware

The Data Processor is composed of a PC (Personal Computer) supporting the GNU/Linux operating system. It is composed of a basic frame and several options, which allow to achieve main requirements.

The chassis is installed horizontally in a standard 19" cabinet, and has a height of 4U (4x44.4 mm).

It is equipped with two front handles in order to be easily extracted from the cabinet.

It is equipped with:

- One 3,5" SATA hard disk drive, with a minimum capacity of 160 GB,
- One IDE DVD drive,
- One 3,5" Floppy disk drive,
- Two Network Interface boards
- One PCIe graphic board ,
- One watchdog PCI board.

3.1.3 Description

The DPC hardware supports two CSCIs:

- MSSR/Mode S Radar Processing (MRP)
- MSSR/Mode S Radar Communications (MRC)

3.1.3.1 MSSR/Mode S Radar Processing (MRP)

The MRP CSCI consists of the following functions:

- Mode S Beam Management (MRP_SBM): this function programs All Call and Roll Call periods, schedules Roll Call interrogations and listening windows for Mode S aircraft within the current beam, processes Roll Call replies and extracts SSR and All Call Mode S plots.
- Scheduling Management (MRP_SM): this function prepares for each 1/64th scan, the list of Mode S and SSR aircraft to be processed by the MRP_SBM function. For each Mode S aircraft, it selects the data link request(s) to be performed. It receives once per sector the aircraft information processed by MRP_SBM and dispatches the detection information to tracking (MRP_TRM) and the data link related information to the data link management function (MRP_DLM). This function also transmits detection information to other MRP channel.

- Tracks Management (MRP_TRM): this function manages aircraft tracking, and transmits appropriate tracks and plots to the MRC CSCI, and to Local Display.

- Datalink Management (MRP_DLM): this function manages the data link requests and results. It prepares data link activity to be performed for each aircraft according to the requests received from internal clients and external clients of MRC CSCI. It transmits appropriate reports and responses to these clients. It transmits data link information to Local Display.

- Channel Bite Management (MRP_CBM): this function manages Built In Tests, Modes, States, Status and Parameters, and monitors the DPC behaviour with RCMS and CBP.

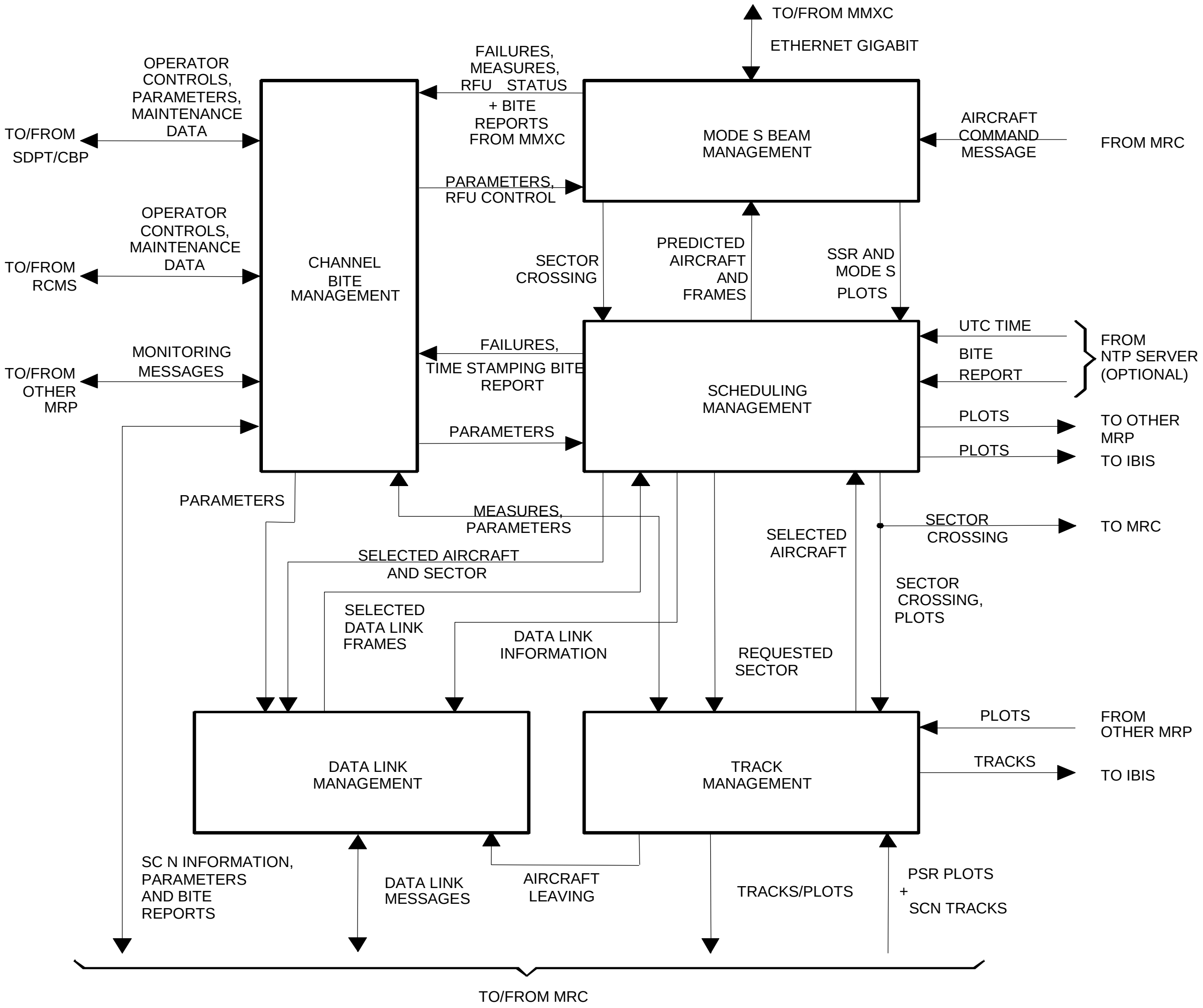


Figure 24 - MRP functions

3.1.3.1.1 MSSR/Mode S beam management

The MRP_SBM function manages all activities that must be performed within the main beam of the antenna and regulates the use of the RF channel. Its main functions are the followings:

- it prepares all information necessary to process All-Call and Roll-Call periods,
- it processes all SSR and Mode S replies received during All-Call periods,
- it manages the real-time scheduling of Mode S surveillance and data link transactions within the Roll-Call periods.

The MRP_SBM function is composed of the following sub-functions:

- Mode S Modulator and eXtractor Control (SBM_MMXC), which manages the interface between MRP CSCI and MMXC,
- Roll Call Period Processing (SBM_RCPP), which manages activities within the Roll Call periods,
- Mode S All Call Period Processing (SBM_MACPP), which manages Mode S activities within the All Call periods,
- SSR All Call Period Processing (SBM_SACPP), which manages SSR activities within the All Call periods. It includes the defruitor function.

3.1.3.1.2 Scheduling management

The MRP_SM function manages the synchronisation of the CSCI.

The MRP_SM function prepares the information to be processed by the MRP_SBM function. For each 1/64th sector, it selects all the Mode S and SSR aircraft of the sector and the data link associated to the Mode S tracks and sends the information to MRP_SBM.

At the end of each 1/64th sector the MRP_SBM sends to MRP_SM the Roll-Call and All-Call information which were processed during the sector. On reception of these released data, MRP_SM dispatches the received information to the concerned users:

- the plot report to the MRP_TRM function, and to the other MRP.
- the data link report to the data link servers (MRP_DLM function),
- the reply report to LD.

The MRP_SM function is composed of the following sub-functions:

- Waiting Aircraft Selection (SM_WAS), which requests aircraft, their surveillance and data link from MRP_TRM and MRP_DLM functions, memorizes them, and places them at MRP_SBM function disposal,
- Aircraft Release Management (SM_ARM), which dispatches the data released by MRP_SBM to MRP_TRM, MRP_DLM, the other MRP and LD.

3.1.3.1.3 Tracks management

The MRP_TRM function is broken down into 5 sub-functions:

- Plot Input (TRM_PIP),
- Tracking (TRM_TRK),
- Data Output (TRM_DOP).
- Reflector Identification (TRM_RFI)
- External Track Correlation (TRM_ETC)

The Plot Input sub-function manages the acquisition of primary and secondary information and associates the primary plots with the secondary plots (SSR + Mode S).

The Tracking sub-function establish the aerial situation. It initialises and maintains tracks. It also computes track windows for Mode S interrogations and SSR detection enhancement.

The Data Output sub-function adds information to the track, sends the tracks to MRC CSCI, sends the tracks and the plots to the Local display.

The Reflector Identification sub-function identifies the dynamic reflectors and sends the static and dynamic reflectors to the Tracking sub-function.

The External Track Correlation sub-function correlates external tracks received from the MRC CSCI with tracks maintained by the radar. According to the result of this correlation, it sends to the Tracking sub-function, commands to create new tracks or to update existing tracks.

3.1.3.1.4 Datalink management

The Datalink Management function manages all data link activities. This function is a server achieving the data link service and will be referred to as the data link server. It can also be seen as a group of servers, each one dedicated to a specific type of Mode S data: broadcast server, GICB server, packet server.

The data link server works for clients which have subscribed to the data link service. Each client declares itself to the data link server. Once known by the data link server, a client can send uplink data link and GICB extraction request to the server. During the subscription, the client indicates to the data link server which downlink data it is interested in: downlink broadcast, downlink packet. The downlink data are only sent to the clients which have requested their transmission.

The data link server collects data link requests from its clients. These request are stored in the DATALINK_DB database. On request from the MRP_SM function, it decides which requests imply a data link exchange with aircraft and sends them to MRP_SM.

Upon reception of data link reports from MRP_SM, uplink data link transmission reports and extracted GICB are sent to the clients which requested it, downlink broadcast and downlink packet are sent to the clients which subscribed to this type of information. The DATALINK_DB is updated according to the data link reports.

This function is composed of the following sub-functions:

- Broadcast Server (DLM_BCSTS),
- GICB Server (DLM_GICBS),
- Packet Server (DLM_PKTS).

3.1.3.1.5 Channel BITE management

The purpose of the Channel Bite Management is to evaluate the ability of the radar channel to perform its mission. The specific functions are:

- to co-ordinate the start-up and initialisation of the DPC,
- to manage the on-line and off-line Built In Tests of the radar channel equipment and establish the operability of component for RCMS Operator,
- to synthesize the states of the radar channel, and decide the switching between To Antenna and To Load channel,
- to co-ordinate the parameters updating, dialoguing with SDPT terminal (CBP CSCI).

On-line BITE testing is defined as BITE tests performed while the radar channel is in the OPERATIONAL or MAINTENANCE operating mode. Such tests are conducted with normal operating signals or internally injected stimuli that do not interfere with normal operation.

Off-line BITE tests are tests conducted while the system is in the maintenance mode using internal test checks and routines. The Off-line tests managed by the CSCI concern the Data Processing Computer. They are performed by rebooting the Computer.

This function is composed of the following sub-functions:

- Data Processing Monitoring (CBM_DPM),
- Built In Test (CBM_BIT),
- States and Modes Management (CBM_SMM),
- Control Management (CBM_CM),
- Monitoring Interface (CBM_MI).

3.1.3.2 MSSR/Mode S Radar Communications (MRC)

The MRC CSCI consists of the following functions:

- Site Monitor Management (SMM): this function tests the system using site monitors.
- Enhanced Surveillance Management local application (ESM): this function programs the automatic extractions of GICBs in order to enhance the data transmitted to the ATCC.
- Air Traffic Control Centre Interface (ATCC_INT): this function relays MRP tracks and tracked plots to the ATCC. It manages up to eight independent logical links to the ATCC.
- Primary Surveillance Radar Interface (PSR_INT): this function relays PSR data to the MRP CSCI. It manages two independent logical links.
- Ground Data Link Processor and Local User Interface (GDLP_LU_INT): this function manages the communications between the MRC CSCI, the GDLP and the Local User. It manages two independent logical links for GDLP and one for LU.
- Surveillance Coordination Network Interface function (SCN_INT): this function manages two independent physical lines and up to five independent logical links on the same physical line.

3.1.3.2.1 Site Monitor Management

The purposes of this function are:

- to carry out on-line tests using site monitors located in the vicinity of the Mode S station,
- to compute and report to the MRP CSCI the corresponding BITE information

These tests may be performed simultaneously on two site monitors, as follows:

<u>First site monitor : Dual channel SMS</u>

The SMS is the Mode S (level 2) site monitor which may be delivered in option with the RSM970S.

The SMS has a dual channel architecture which allows the test of the Mode S station through the following main tests: checks of the SMS position, codes, etc. on each SMS track received.

The BITE status of each SMS channel is gathered by the radar through:

- the extraction of a dedicated BDS E1 register, in Mode S scheduling, or
- the 4 LSBs of the Mode C replies, in SSR (A,C) scheduling.

In Mode S scheduling, additional tests (called “long loop tests”) can be performed. These tests are periodically triggered by the transmission of specific short form MSP packets from the RSM970S to the SMS.

The following table shows type of each test and the associated action performed by the SMS:

Test name	Action of the SMS
II/SI codes delivery	Report the II codes being set.
Alert bit	Temporarily change its Mode A code from standard to test value, which triggers the alert bit.
Downlink capability report	Temporarily change its BDS 10 from standard to test value, which triggers downlink broadcast.
Flight identity change	Temporarily change its BDS 20 from standard to test value, which triggers downlink broadcast.
Unlocking	This test does not correspond to any specific action from the SMS, but to a track unlocking performed by the MRP CSCI.

Second site monitor : Generic SSR / Generic Mode S

The following types of legacy site monitors are supported by the RSM970S:

- SME974: SSR (A, C) dual channel, with BITE status reporting,
- Generic SSR (A, C), single or dual channel,
- Generic Mode S (level 1 or above), single or dual channel.

3.1.3.2.2 Enhanced Surveillance Management

The purpose of this function is to extract GICB registers for all tracks, in order to enhance the information transmitted to the ATCC.

Whenever the MRP CSCI signals a track entry, the functions capability sends back GICB requests for the extraction of the registers:

- which are necessary for Mode S elementary surveillance: Aircraft capabilities and Call-Sign (BDS 10, 17 and 20),
- which are defined by the user (through an operational parameter) for Mode S enhanced surveillance (up to five additional registers may be extracted this way).

3.1.3.2.3 Air Traffic Control Centre Interface

The purposes of this function are:

- to format tracks in the Asterix or Aircat-500 format and to output them to the ATCC logical links
- to detect output overloads on any of the ATCC logical links
- to suppress some data on the overloaded ATCC logical links

3.1.3.2.4 Primary Surveillance Radar Interface

The purpose of this function is to relay primary radar detection data received from a Primary Surveillance Radar (PSR) to the MRP CSCI.

The Weather data received from PSR are directly provided to the ATCC interface function.

The PSR information may be received through a serial line, or from the TMR processor connected on the radar communication LAN.

The function manages an active and a standby logical link. While the messages received on the active link are relayed to the MRP CSCI, the messages received on the standby link are discarded.

3.1.3.2.5 Ground Data Link Processor and Local User Interface

The purposes of this function are the following:

- to establish, maintain and monitor connections with the GDLP,
- to establish, maintain and monitor connections with the LU,
- to relay the GDLP and LU messages to the MRP CSCI
- to relay the MRP CSCI messages to the GDLP and LU

3.1.3.2.6 Surveillance Coordination Network Interface

The purpose of this function is to enable the mode S station to be coordinated with up to six other mode S stations with which it is connected into a cluster. This coordination is used in order to reduce FRUIT and cater for the limited number of II codes available within mode S, since it enables all mode S stations from a given cluster to share the same II code.

The function is in charge of three protocols: NMP, TASP and NNCOP.

- NMP is the Network Monitoring Protocol, it enables the mode S station to determine the network topology, i.e. the list of mode S stations from the cluster which operate network-aided, and the cluster mode (distributed mode or central mode, depending on the presence of a cluster controller within the network topology).

- TASP is the Track Acquisition and Support Protocol, it enables the mode S station to acquire tracks locked by other mode S stations from the cluster and located in the station surveillance coverage. It also enables the mode S station to request track support from the cluster mode S stations in case of miss. TASP is only active when the cluster operates in distributed mode.

- NNCOP is the New Node and Change-Over Protocol, it enables a mode S station to prevent useless exchanges of messages by TASP by sending to the other mode S stations in the cluster the list of unique mode S addresses it knows. This is done either when entering a cluster or when executing a channel switch-over. NNCOP is only active when the cluster operates in distributed mode.

3.2. INTERFACE MANAGEMENT (LINES)

3.2.1 Introduction

The RSM970S is equipped with two external devices ("LINES") in charge of external interfaces (ATC centres, Mode S Datalink, Mode S Surveillance Coordination…)

According to user's needs, two additional LINES devices may be delivered in option.

At a given time, each LINES device performs data routing between the active radar channel and the output lines. All lines carry the same data (i.e. target reports processed by the active channel).

Switch-over between radar channels (i.e. Interrogator and reply processors) is transparent for the ATC centres, i.e. the physical and logical (at protocol level) connections are maintained. This event may influence track numbering.

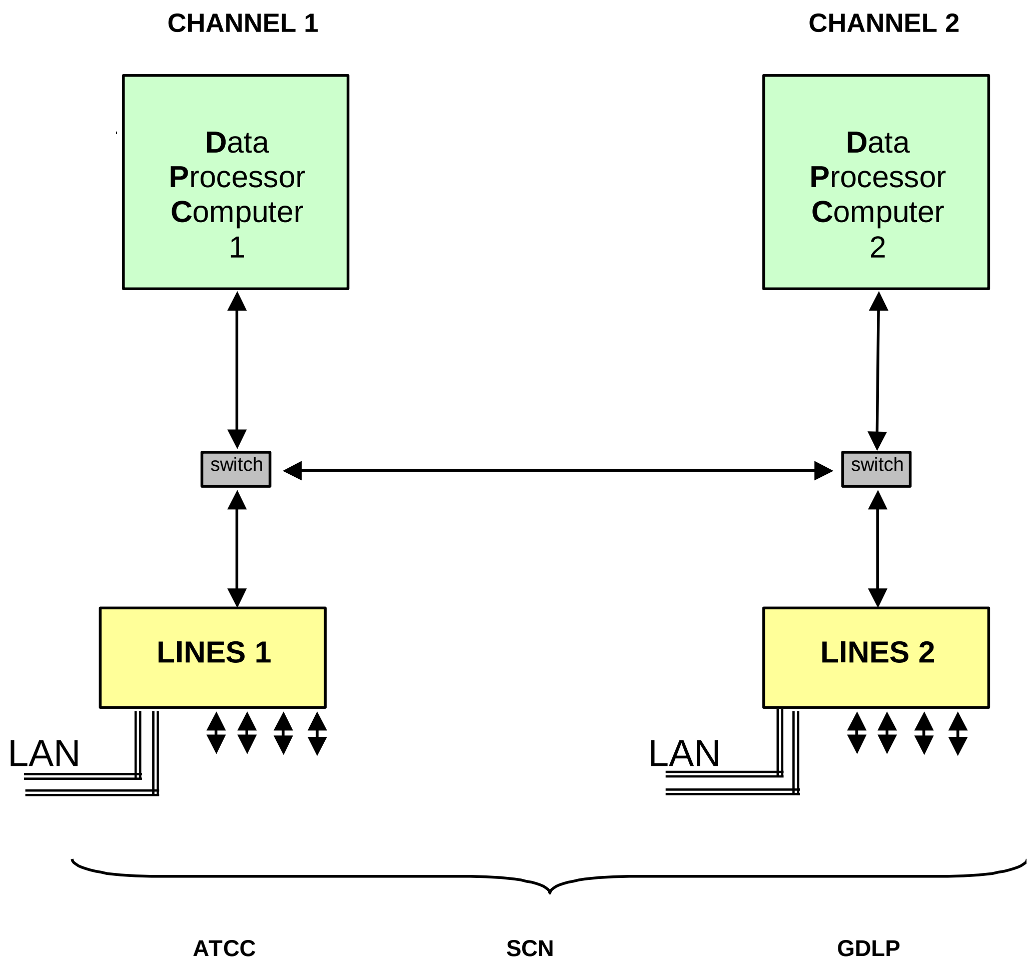


Figure 25 - Interface Architecture

3.2.2 Hardware

The pLINES-E4 box is equipped with:

- 3 Ethernet ports (one for internal use)
  - 10/100bT Ethernet interfaces
  - Auto-negotiation, auto-sensing, half or full duplex mode
- 4 Serial ports
  - DTE multiprotocol (Async/Sync)
  - RS232/422/485/EIA530A/X21 ports, speed up to 250 kbps,
- Processor
  - MPC8250 master CPU & communication processor at 200 MHz (280 MIPS)
- Memory
  - 32 Mbytes of DRAM
  - 8 Mbytes of FLASH EEPROM
  - 128 Kbytes SRAM
- Backlight screen and keyboard

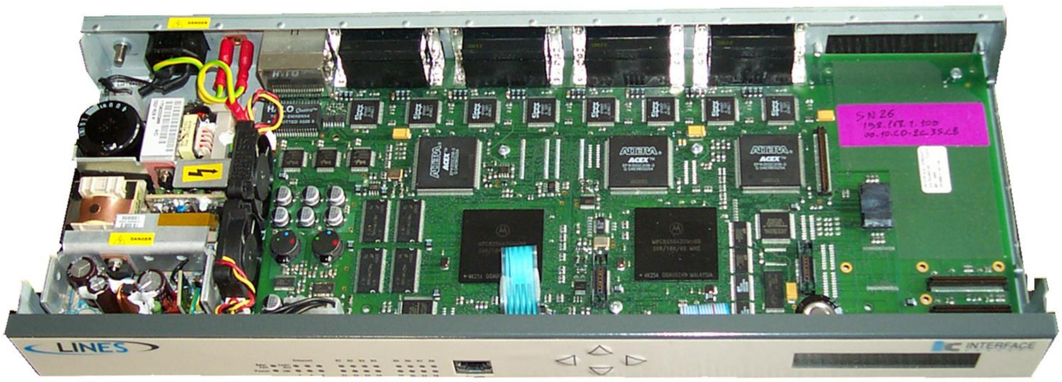


Figure 26 - pLINES-E Internal View

3.2.3 Description

In addition to the delivery of operational data (target reports) to the ATC centres, the external interfaces of a Mode S station may include Datalink (from/to a GDLP – ground Data Link Processor – and/or a local user) and Surveillance Coordination (from/to a Cluster Controller or neighbouring Mode S stations).

Each possible logical link can be mapped onto a physical link, according to the following table:

External Interface	Role	Number of logical links	Protocol	Format
ATCC	Target reports Weather maps	8 (simultaneously)	HDLC-UI HDLC LAP-B X25.3-88 Aircat-500 TCP/IP(**) UDP/IP (***)	Asterix CAT 1, 2, 8 Asterix CAT 48, 34, 8 Aircat-500 tracks
PSR (*)	PSR plots	2 (one active, one stand-by)	HDLC-UI HDLC LAP-B	Asterix CAT 1, 2, 8 Asterix CAT 48, 34, 8
SCN	Surveillance coordination	up to 6	X25.3-88	Asterix CAT 17
GDLP	Mode S Datalink	2 (one active, one stand-by)	HDLC LAP-B X25.3-88	Asterix CAT 18
LU	Mode S Datalink	2 (one active, one stand-by)	HDLC LAP-B X25.3-88	Asterix CAT 18

(*) These interfaces are used for interfacing legacy PSRs only. THALES radars with TMR processors (e.g. STAR2000) use a LAN for exchanging data with the DPCs, without routing through the LINES.

(**) Client or Server; Complies with IP V4 and IP V6.

(***) Unicast or multicast; Complies with IP V4 and IP V6.

3.3. TIME STAMPING

The time stamping is constituted by two NTP servers.

Each server includes:

- one GPS receiver providing an accurate UTC time source,
- one internal clock,
- one Ethernet interface for exchanging time information with external equipment.

Each server is connected to the I/O LAN of the radar (also used for exchanges between the DPC and the LINES and for PSR plots acquisition).

The protocol used is NTP (Network Time Protocol) which allows the automatic synchronization of the DPC, thanks to the built-in service of the GNU/Linux operating system.

In case of a missing GPS signal (e.g. due to too few visible satellites), the internal clock of the NTP server maintains the time information until the recovery of GPS signal. The maximum drift of the NTP internal clock is 20 ms per month.

Additionally to the time messages, the DPC gathers the status of the NTP server in order to compute the availability of the Time stamping function.

Furthermore, the DPCs exchange their time information in order to make a consistency check between both NTP servers.

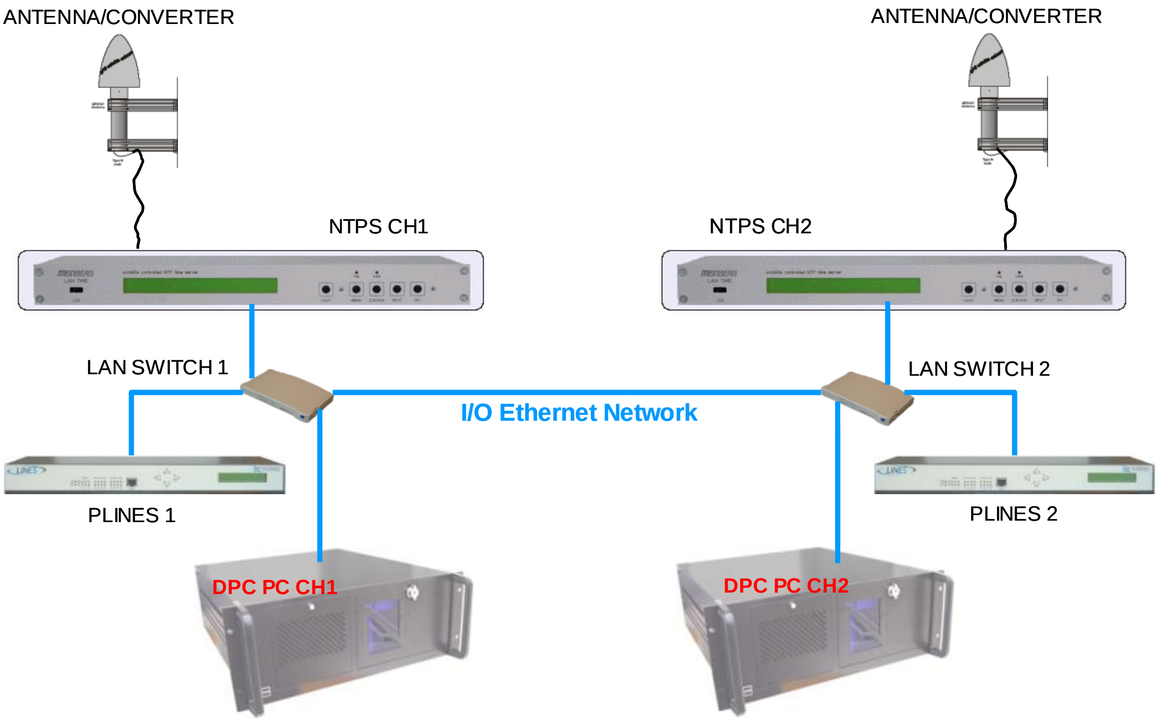


Figure 27 - Time stamping block diagram

4. MAINTENANCE EQUIPMENT

4.1. SITE DEPENDENT PARAMETERS TOOL

4.1.1 General

The Site Dependent Parameter Tool (SDPT) software (called **CBP** for Cabinet Parameters tool) enables the operator to display and change all the operational parameters of each radar channel (setting up purpose) when it is in local control. The operational parameters are all parameters of the radar channel which are software adjustable for installation, operation and maintenance of the system.

The CSCI CBP runs either on the RCMS local terminal (as a separate application) or on an optional dedicated PC.

The purpose of this CSCI is to:

- set up or display operational parameters of the radar channel,
- display measurements and other variables (states, failure codes) within the radar channel,
- send local operator commands.

The programming from SDPT requires the equipment to be switched to the local mode (called "SDPT control"), inhibiting the RCMS orders.

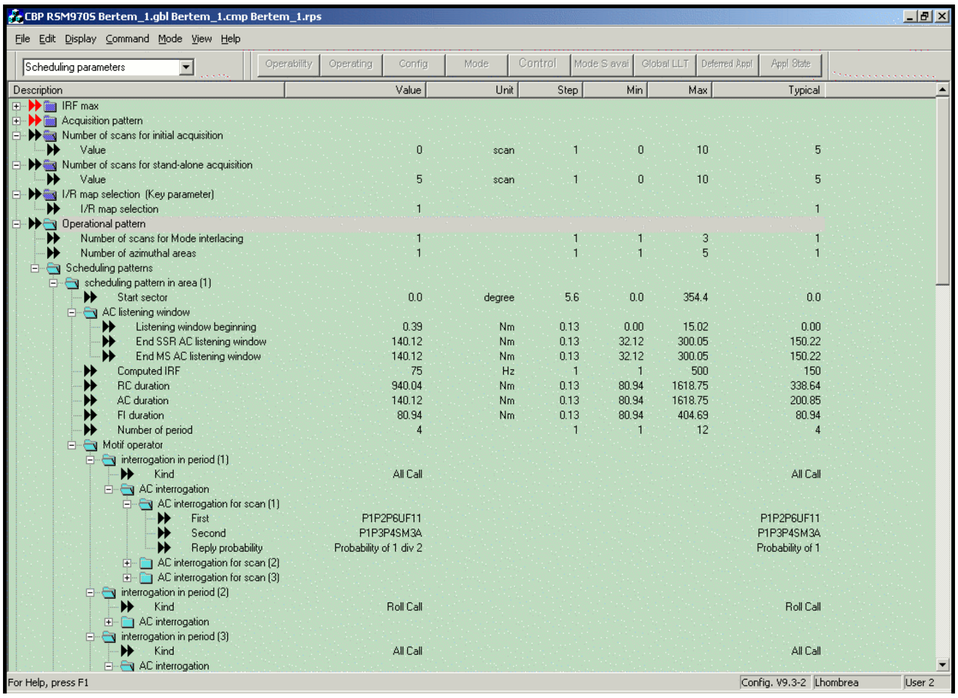


Figure 28 - Example of CBP Display

4.1.2 CBP functions

The CBP CSCI performs the following functions:

- management of the CBP mode of operation,
- edition of MSSR/Mode S parameter sets in SDPT (creation, display, modification, copy of parameter set content),
- generation of coverage map files in MRP (local cartesian cells) format, conversion of coverage map files from Eurocontrol format to MRP format,
- creation and sending of commands to one MSSR/Mode S channel (operator command, direct parameter read/write command),
- management of the parameter set transfer from/to one I/R cabinet channel (parameter set sending to one MSSR/Mode S channel, parameter set reading from one I/R cabinet channel),
- real-time display of monitoring data from one MSSR/Mode S channel (measurements, states and failure codes),
- comparison of parameter sets stored on SDPT disk,
- transmission of coverage map files to the IBIS maintenance display.

4.1.3 Controls

The following controls are available for each radar channel, from the SDPT:

- Failure code reset
- Off line test activation
- SDPT control release/request
- Operational operating state
- Maintenance operating state
- Stand alone / Network aided mode (SCF)
- I/R channel switchover
- Transmission on/off
- I/R map selection, allowing to select the map 1 or map 2 for TVBC law divided into sectors, ISLS / IISLS, transmitted power attenuation
- PSR channel selection (if present).
- Site monitor presence.

These controls are also available from the RCMS, when the equipment is switched to the remote mode (called “RCMS control”).

4.1.4 Parameters

The SDPT allows the setting of the following operational parameters:

- Antenna scan duration
- RSLS control and attenuation values
- I/R map 1 and map 2 definition
- Defruiter correlation choice
- Extraction criteria
- TVBC laws (up to 8 user programmable laws)
- Operational interrogation mode pattern
- Staggering
- Off Boresight Angle (OBA) table
- PSR/SSR bias adjustment
- Anti reflection parameters
- Optional Mode S Site Monitor parameters.

4.2. IBIS MAINTENANCE DISPLAY

4.2.1 Introduction

The proposed Indicator of Radar Information System (IBIS) is a display equipment, featuring radar picture, used for the maintenance operation.

The maintenance display is used for display of plots on tracks and of geographical maps. It also provides windowing of the radar video.

Plots/tracks are superimposed on the radar video, with a geographical maps background. IBIS also enables the display of radar adjustment patterns (OBA).

IBIS can display up to-1000 tracks and 1000 plots simultaneously.

4.2.2 Radar Interfacing

The purpose of the IBIS display is to provide engineers with the means to assess the operational performance and serviceability of the radar system.

The following different types of data can be displayed (if present):

- Digital PSR Video (aircraft and maintenance video), for co-mounted radars
- Digital Log SUM secondary Video.
- Digital Log DELTA secondary Video.
- Digital f(DELTA/SUM) secondary Video
- Digital SSR and Mode S pulse presence video
- Digital SSR and Mode S reply presence video
- PSR / MSSR / Combined plots and tracks (ASTERIX Category 1, 48).
- System status (ASTERIX Category 2, 34).
- Weather data, for co-mounted radars with weather channel (ASTERIX Category 8)
- Specific processing areas (ASTERIX category 245)
- Mode A/C and Mode S Reply-report Data (ASTERIX category 242)
- Datalink information (ASTERIX category 243)
- Surveillance Co-ordination Network data (ASTERIX category 244 if present)
- Coverage maps
- List of Mode S aircraft currently surveyed
- Anomalous data (plots flagged as anomalies)
- Geographical map
- User-defined graphical items
- Range and Bearing lines

The tracks and plots are available on an ETHERNET LAN, the “SUPERVISION" LAN. The video is distributed on a dedicated ETHERNET LAN, the “VIDEO" LAN. The operator has selection devices on IBIS screen to choose the displayed data and the sensor data channel. The status of the selected lines is displayed using a colour code.

The IBIS is designed such that the various categories of data are presented in a manner which allows the data to be viewed simultaneously. For example, the analogue video signals are presented as a backdrop to the target symbols which in turn have labels attached to them containing further track data. This data is refreshed every radar scan.

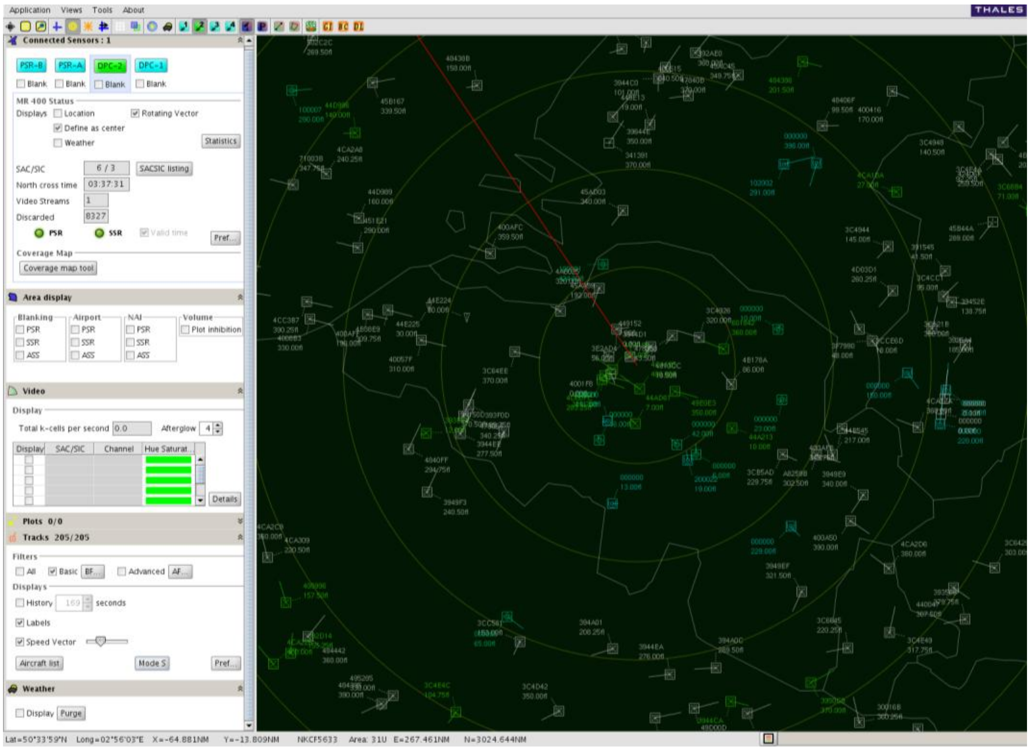


Figure 29 - Example of IBIS Display

4.2.3 Recording and replay

The IBIS features a function to record the received radar data and to replay them afterwards.

The replay can be performed on the same IBIS display or on another IBIS (option). The replay function allows to select a timeframe within the recording and the speed of playback.

All real-time presentation preferences and filtering are also available during play back.

4.3. REMOTE CONTROL AND MONITORING SYSTEM (RCMS)

4.3.1 Basic Principles

The Remote Control and Monitoring System (RCMS) enables the operator, through graphical synoptics and text pages to assess the status of the equipment and identify faults quickly. It also enables the monitoring or the control of a restricted set of operational parameters (supervision and maintenance purpose).

The RCMS is monitoring all the functions of the radar system and provides means for controlling major system elements (on/off, rotation, etc...)

Whereas, the following functions are performed at the level of the BITE of each equipment:

- Acquisition of digital and analogue status,

- Processing of this information to verify the correct operation or, in the event of failure, the determination of the faulty unit,
- Management of front panel indicators,
- Continuous monitoring of the configuration status,
- Management of controls from/to remote control function,

Equipment test and control information is transmitted to/from the Data Regrouping Unit function (DRU) of RCMS via a Local Area Network (LAN) carrying the following information:

- Correct operation codes,
- In case of a failure, code corresponding to the faulty function,
- Command and acknowledgement of remote control orders,
- Any equipment status or parameter requested through the local or remote monitoring position.

The DRU function interfaces ancillary units such as mains and antenna control cabinets and possibly, air cooling system, UPS and other safety devices using opto-couplers and relays.

The RCMS uses basically two consoles, one local, the other remote.

Either console can be declared master or slave. The same information is displayable on both the local and the remote station consoles.

The system hard disk is used for log files storage. The files are in standard text format and list all the monitoring and control action previously done. The files download can be done either on the local position or on the remote position.

Note:

The availability of radar surveillance data is monitored through the monitoring of the data distribution function of the radar data processors. Due to the fact that the RCMS data link is separated from the radar data link(s), in case of failure of radar data links, the monitoring of the radar system, and of the radar data distribution, is still possible.

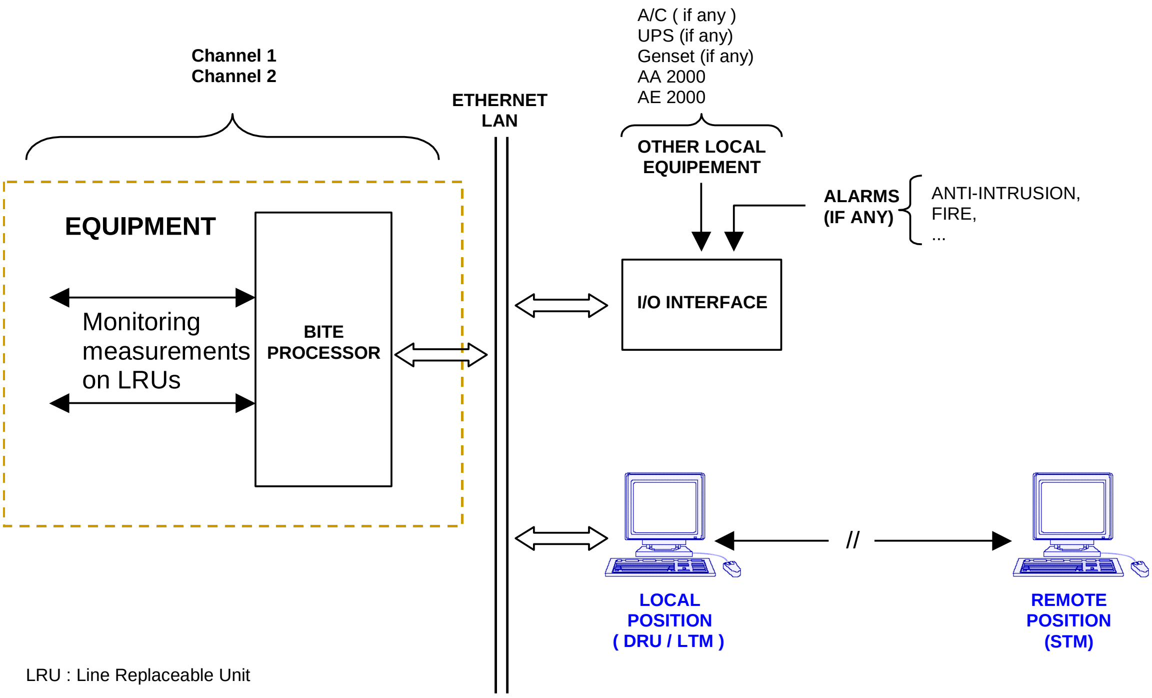


Figure 30 - RCMS Architecture

Figure 31 - Example of RCMS Display for a co-mounted version

4.3.2 RCMS Operation

RCMS provides its functions:

- at station level during system optimisation and preventive / corrective maintenance;
- at Remote Maintenance Room level for the remote system control and monitoring.

The corresponding control and monitoring consoles are provided with a multi-function keyboard and a mouse.

4.3.2.1 Monitoring

A synopsis of the station status is presented, in the form of a block diagram. The selection of any system element is possible from the block diagram using pull out menus for presentation of more detailed status monitoring.

The console provides:

- a graphic coloured indication of the status of a designated equipment element, particularly faults, unavailability,
- pull out menus showing functions and parameters monitored, where appropriate indicating the actual value,
- the indication of a system status as mentioned above.

4.3.2.2 Control

The operator position has the possibility, by selection of a special operating mode, of controlling all major system elements. This is done by means of keyboard and mouse.

This remote control facility will only be operational if the equipment in question, for control, is set to the "remote control" mode of operation. Selection of "local control" on the equipment will inhibit all remote control actions from all remote control consoles. It will not inhibit the feasibility to monitor system status. All control actions are recorded.

4.3.2.3 Description of the RCMS windows

<u>Configuration and remote control windows</u>

The configuration signals are binary data that refer to the operational state of a system or equipment (for example: operational/maintenance, on-line/stand-by, equipment ON/OFF, etc.). The state of the configuration signals generally results from an automatic action of the system or equipment or from a locally or remotely controlled action.

There is one window of text for each equipment or system comprising a title (name of equipment or system). Each configuration is defined with a name and a text corresponding to a binary value (such as true/false). Controls will be issued from this window through direct selection on the screen.

Parameter and Remote Control Window

This window contains discrete or numerical values which may define:

- Nominal settings (frequency of operation),
- Threshold limits (warning, alarms limits),
- Operation modes (channel in use for a receiver).

The parameters may be locally or remotely controlled. Each parameter is identified by a name and its value.

Parameter entry may be selected. A new value may then be entered using the entry window that is presented. This entry window contains a list of valid selections or the limits and a default value for the parameter.

Status and measures windows

These windows can be selected for the display of data that cannot be classified as configuration or parameter data but is relevant to operational or maintenance use.

The status information displayed indicates the current state of equipment and cannot be remotely controlled (e.g. breaker ON/OFF, equipment FAULT/OK, etc.).

The measurements are numerical information generally used for the system's maintenance.

Each window contains a title and the list of status or measures. Each status item is defined with a name and an indication such as "yes" or "no". Each measure is provided with a title, its value, and its unit of measure.

Special control window

Unlike configuration and parameter, which are modifiable data, this window allows the operator to execute other controls.

Alert Window

This window displays information regarding currently active alerts, i.e. those not discarded by the operator.

Failure window

This window groups all the current failures of a given equipment item, and identifies when possible the faulty unit and the failure identification in the functional unit.

Help window

Help indications are displayed at the level of each useful window, and provide the user with information on the use of the RCMS functions.

4.3.2.4 Screen and Peripheral Management Commands

The following commands are available to an operator:

- Designation capability by means of the keyboard or the mouse,
- Block diagram call,
- Upstream - downstream window,
- Return to the highest level window of the group,
- Window management: Scrolling, Sizing, Windowing,
- Enable/Disable printer (if any),
- Audible alarm ON/OFF,
- Pop-up display ON/OFF.

4.3.2.5 Alert Logging and Display

When an alert condition is detected on a supervised equipment, the DRU or its equivalent sends, if relevant, the corresponding information to the operator position(s) that supervise this equipment. Depending on the alarm and the operator position off-line configuration, the alarm may be:

- stored in the daily log file,
- stored in the alert window,
- stored in the failure window,
- displayed in a pop-up window (if enabled),
- printed (if the printer is enabled).

An audible signal on the operator position is activated (if enabled).

4.4. SITE MONITOR – FIELD TEST TRANSPONDER

A single or dual channel MSSR/Mode S site monitor (SMS) can be proposed in option.

In Mode S scheduling, the “long loop test” functionality described in para. 3.1.3.2.1 requires that one Dual channel SMS is dedicated to the radar station.

The SMS-2 site monitor is a solid-state dual channel test beacon. The two channels are operating simultaneously, each channel being fitted with one directional antenna. The two SMS antennas are the Log-periodic antenna ref 2155.

Transmitted power and reply delay are adjustable independently on each channel in order to simulate range.

The SMS-2 operates like an ICAO Mode S aircraft transponder, with additional capabilities, such as programmable attenuation and range. It operates on Modes 3/A, C and S. It complies with the latest Amendment of ICAO Annex 10, concerning pulse and reply characteristics, and Mode S protocols. It acts as a Mode S level 2 transponder.

Figure 32 - View of SMS Dual Channel Equipment

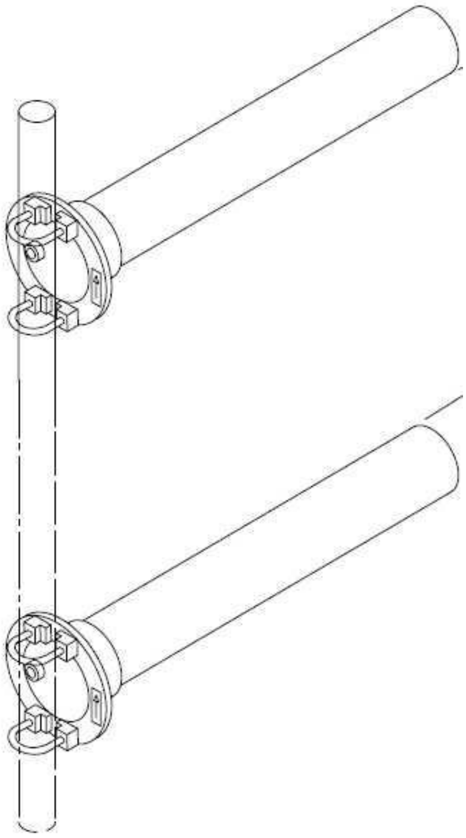


Figure 33 – SMS Directional Antennas

5. ANCILLARIES

5.1. ANTENNA CONTROL UNIT

The Antenna Control Unit is housed in a cabinet installed in the equipment room.

It is used to switch on or off the antenna rotation by controlling the power supply of the motor.

At start-up, the motors are supplied through a 'star' connection and after a delay the connection is automatically switched to a 'delta' connection.

The Antenna Control Unit also generates the DC power supply used for the security checking circuitry.

The security circuits stop the antenna in case of problem detection on the pedestal (temperature, oil level, etc.) It also ensures rotation stops when an emergency push button is activated, when the access door to the antenna platform is opened, or when the motor brake is on.

5.2. POWER DISTRIBUTION UNIT

The functions of the Main Power Cabinet are:

- to ensure mains power distribution to the radar parts of equipment,
- to protect the parts of equipment,
- to ensure human safety.

The power distribution cabinet is equipped with:

- Central breaker,
- Phase order detector,
- Earth leakage protection device,
- Thermomagnetic breaker for each equipment.

6. INSTALLATION

6.1. PHYSICAL CHARACTERISTICS

The RSM 970 S Mode S radar comprises mainly two radar electronic cabinets. EMC cabinets are used where necessary (RF elements).

These cabinets are standard 19" wide and can be installed separately in the radar room or factory mounted on a skid (**1**) thus reducing time and the installation works.

The following figures show the standard layout of the Mode S cabinets and radar room :

- One cabinet housing the duplicated interrogator/receiver and signal processor (**5**);
- One cabinet housing the duplicated data processor, the RCMS and IBIS computers (**4**);
- One power supply cabinet and one antenna control cabinet (installed back-to-back) (**2**), for a standalone MSSR/Mode S configuration.

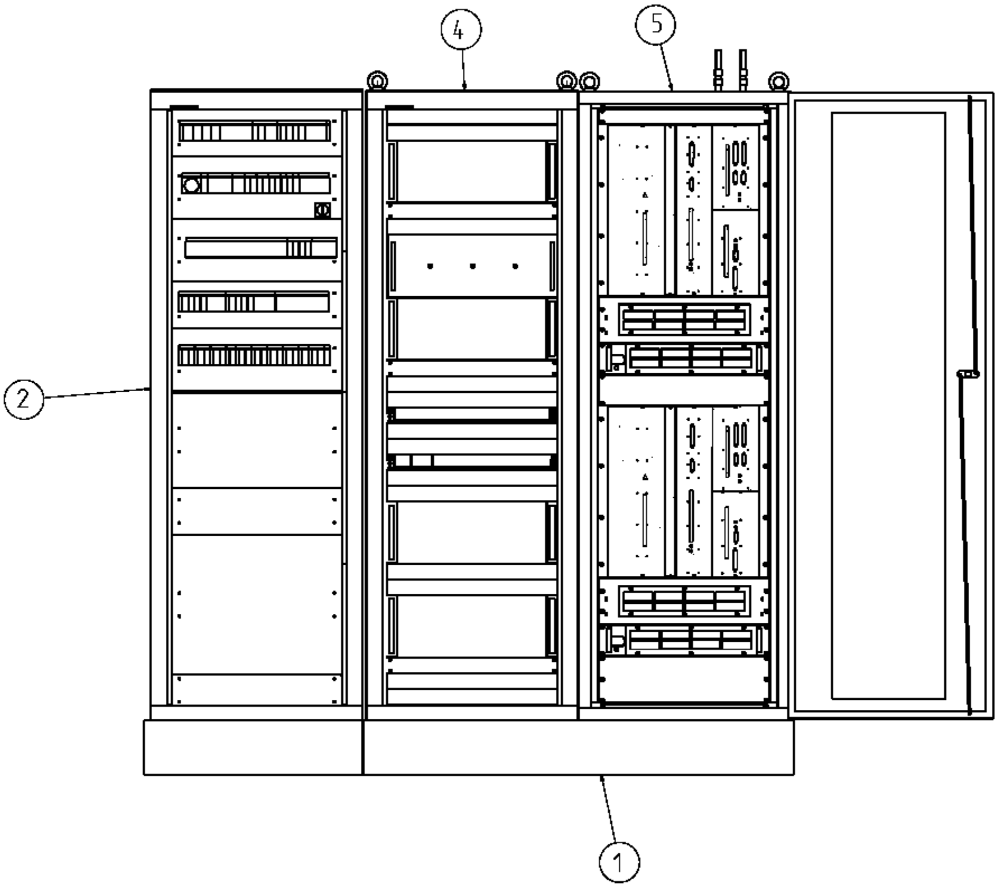


Figure 34 - RSM970S Cabinet Layout (standalone configuration)

The Cabinets skid for a standalone configuration has the following dimensions:

	Cabinets skid
Length	1.80m
Width	1.20m
Height	1,94m
Weight	1.03 t

The RCMS and IBIS displays (including LCD screen, keyboard and mouse) are installed on a separate table (not part of the delivery).

The following figures show an example of installation layout:

Figure 35 - RSM 970 S – Front View

Figure 36 - RSM 970 S – Rear View

6.2. ELECTRICAL CHARACTERISTICS

OVERALL RADAR POWER CONSUMPTION AND DISSIPATION

The following figures are given for a standalone configuration, with a pedestal equipped with 2 motors:

Unit	Power Consumption (kVA)	Power Dissipation (kW)	Power Supply
Aerial system (steady/extreme)*	8/16	3.5	400V 3-phase
RSM 970 S radar cabinets	4	3.6	230V
Total RSM 970 S	12/20		

* Note: steady: without environmental effects or under the protection of a radome (if any).

extreme: 15 rpm, extreme environmental conditions as defined in paragraph 1.3.

Start-up: The peak current at motor start-up is limited to 60 A per phase.

The Main Power Cabinet must be fed by a three phases four wire mains supply:

- 230V/400V ± 10% 50Hz or 60Hz ± 5%

Mechanical and electrical grounds

Cabinet ground and signal ground are separated in most units. The mechanical and electrical grounds of each equipment are grouped together at the outside of the equipment.

Strips are used insofar as possible because they present less impedance at high frequencies than circular section cables. Otherwise 10 square mm yellow/green cable is used. The links are the shortest possible. Each cabinet is equipped with a single vertical copper ground bar. The ground of each equipment of this cabinet is connected to this single bar.

The vertical bar of each cabinet is connected to the horizontal copper ground bar of the skid. The horizontal bar of the skid is linked to the external ground network of the technical building.

6.3. RADAR EQUIPMENT INSTALLATION

Radar equipment installation consists in:

- Aerial system installation,
- Technical room equipment,
- Cable laying and interconnection.

Once the antenna and cabinets have been installed, cables from the antenna to the cabinets are installed and fixed. Mains input is then checked and connected to the mains distribution cabinet. Ground link is connected to the skid assembly. Output data lines are connected to the data transmission devices.

Location and fixing

The skid which supports the equipment cabinet and inter-cabinet cabling is fixed to the floor.

The outside cabling is laid either in false floor or in cable trays trunks.

Interconnection of the equipment

Thales standards for cables identification and marking enables cabling to be separated in groups and functions.

Power supply and signal cables are separately routed in the skid cable duct.

All cables are equipped with plugs and connectors with suitable locking devices.

Air-cooling

The equipment are equipped with their own fans for air-cooling and dust filtering (when applicable) is done at the air inlet.

Electrical

An emergency cut-off device is provided near the entrances of the radar room. It must cut-off the distribution of electric power immediately. Other emergency breakers are usually located in the radar room and at the antenna tower access door for safety reasons.

UPS equipped with an automatic by-pass (changeover) may be optionally connected to the power distribution cabinet. This COTS equipment may be supplied by Thales or by the Customer.

6.4. ENVIRONMENT AND SAFETY

The RSM 970 S Mode S is designed for round the clock operation. The redundant configuration allows for maintenance operation on the stand-by channel without affecting on-line operational data.

Redundant parts can be put off-line at the same time as normal operation is going on.

6.4.1 Environment Requirements

Operational Conditions

- Ambient temperature:
  - Indoor: + 10°C to 40°C
  - Outdoor: -40°C to + 70°C (including solar radiation)
- Change of outdoor temperature: ≤ 10°C / hour
- Relative indoor humidity: ≤ 80 %
- Change in ambient humidity: 20 % / hour

Storage (indoor equipment)

- Temperature: --40°C to 70°C *(in dry atmosphere and under cover)*
- Humidity: ≤ 93 %

6.4.2 Electromagnetic Compatibility

Compliance with European Directive R&TTE 1999/5/CE and with following standards.

ETSI EN 301 489-1 V1.2.1	Electromagnetic and Radio spectrum Matters (ERM) Electromagnetic Compatibility (EMC) standard for radio equipment and services Part 1: Common technical requirements
CEPT/ERC/74-01	SPURIOUS EMISSIONS “unwanted emissions in the spurious domain”
Rec ITU-R SM.329-10	Rayonnement non désirés dans le domaine des rayonnements non essentiels *Union Internationale des Telecommunications
ICAO Annex 10 volume 4	Para 3.1.2.1 and 3.1.2.11

6.4.3 Safety

6.4.3.1 Development Safety

A hazard identification, analysis and risk assessment has been carried out for the RSM970S. The objective of this analysis is to expose any hazards that will require additional design work to incorporate mitigating features. The analysis has not only considered reasonable use, but also reasonably identifiable misuse, manufacture, testing, installation, commissioning, operational failure and fallback modes and maintenance.

6.4.3.2 Product Safety

Compliance with 73/23/CEE Low Voltage Equipment Directive and with following standards:

- EN60950
- Directive 2004/40/CE
- Recommandation 1999/519/CE

Compliance with 98/37/EC Machinery Directive annex 1 and with following standards:

- EN60204-1
- EN292-1
- EN292-2
- EN294
- EN349
- EN418
- EN457

6.4.3.3 Site Installation Safety Considerations:

The Air Navigation Service Provider as owner, has charge of civilian radar sites, as a consequence, he is legally responsible for any harm towards all the people which are physically present, with an authorised access, on these sites. This includes all the workers present on provisional work installation site.

On the other hand, Thales has the responsibility to check that exposure of his workers to risk is compliant with French law.

7. ACRONYMS

AC	All-Call
ACAS	Airborne Collision Avoidance System
AICB	Airborne Initiated Comm B
ADC	Analog to Digital Converter
ANSP	Air Navigation Service Provider
ASTERIX	All Purpose Structured Eurocontrol Radar Information Exchange
ATCC	Air Traffic Control Centre
ATN	Aeronautical Telecom Network
BDS	Comm B Data Selector
BITE	Built In Test Equipment
CBP	Cabinet Parameters
COTS	Commercial Off The Shelf
CSCI	Computer Software Configuration Item
DAP	Downlink Aircraft Parameters
DPC	Data Processor Computer
DCS	Data Communication System
DPSK	Differential Phase Shift Keying
DRU	Data Regrouping Unit
DSNA	French Civil Aviation Authorities
DTE	Data Terminal Equipment
EEC	European Economic Community
EHS	Enhanced Surveillance
ELS	Elementary Surveillance
EMC	Electro Magnetic Compatibility
EMS	Eurocontrol Mode S Specification
FPGA	Field Programmable Gate Array
GDLP	Ground Data Link Processor
GICB	Ground Initiated Comm B
GPS	Global Positioning System
HDLC	High level Data Link Control
HPA	High Power Amplifier
IBIS	Radar maintenance monitor display
ICAO	International Civil Aviation Organisation
I/R	Interrogator / Receiver
IRF	Interrogation Repetition Frequency
ISLS	Interrogator Side Lobe Suppression
II/SI	Interrogator Identifier/Surveillance Identifier
IISLS	Improved Interrogator Side Lobes Suppression
I/O	Input / Output
LAN	Local Area Network
LD	Local Display
LO	Local Oscillator
LNA	Low Noise Amplifier
LRU	Line Replaceable Unit
LSB	Less Significant Bit
LTM	Local Terminal Monitor
LU	Local User
LVA	Large Vertical Aperture
LVDS	Low Voltage Differential Signaling
MDR	Monopulse Digital Receiver
MDRP	Monopulse Digital Receiver and Processor

MLDT	Mean Logistic Down Time
MMXC	Monopulse Modulator and Extractor
MRC	Mode S Radar Communication
MRP	MSSR Radar Processor
MSB	Most Significant Bit
MSSR	Monopulse Secondary Surveillance Radar
MTBF	Mean Time Between Failure
MTBCF	Mean Time Between Critical Failure
MTTR	Mean Time To Repair
NTP	Network Time Protocol
OBA	Off Bore-sight Angle
PSR	Primary Surveillance Radar
PU	Processing Unit
POEMS	Pre-Operational European Mode S station
QRSLS	Quantized Received Side Lobe Suppression
RFU	RF Unit
RCMS	Remote Control and Monitoring System
RC	Roll-Call
RPM	Rotation Per Minute
RSLS	Received Side Lobe Suppression
SCN/SCF	Surveillance Co-ordination Network / Surveillance Co-ordination Function
SDPT	Site Dependent Parameter Tool
SSR	Secondary Surveillance Radar
STM	Space Time Management
SVC	Switched Virtual Circuit
TOM	Tracking-Output-Miscellaneous
TRC	Transmitter Receiver Cabinet
TCXO	Temperature Compensated Crystal Oscillator
TVBC	Time Variation Base Clipping
UELM	Uplink Extended Length Message
UTC	Coordinated Universal Time
VCO	Voltage Control Oscillator
VSWR	Voltage Standing Wave Ratio

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Appendix 9

Thales Windfarm Mitigation Presentation

WINDFARM MITIGATION

Maintain air surveillance around windfarms

Enabling the wind of change safely

The wind is changing in the energy industry, and is doing so fast. Nations across the world are taking important steps to transition into renewable energies, seeking to cut emissions and, over the long term, curb global warming. In this context, the implementation of windfarms – whether offshore or onshore – has emerged, over the past decade, as one of the key elements to facilitate this transition.

Yet what may constitute a solution to one problem may in fact, become a problem in a different context: the development of windfarms across the world interferes with radars' detection capabilities, making the mission of air surveillance more complex. Working closely with diverse partners across a global industry, Thales offers solutions and services that can mitigate windfarms' impact on radars – whether civil or military – saving time and cost while safeguarding required safety levels.

Thales offers a dedicated field-proven innovative windfarm mitigation solution, providing improved safety as well as facilitating windfarm developments.

Thales Windfarm Mitigation – Video Presentation :

https://youtu.be/G0rSns9ILns

Thales offers a dedicated field-proven innovative wind farm mitigation solution, providing improved safety as well as facilitating wind farm developments.

Disruptive winds

The development of windfarms – groups of wind turbines – around the world to address the need for renewable energy sources has to be done in cooperation with civil aviation authorities when required. Wind turbine blades' radar reflections can either appear as false aircraft detections on radar displays or mask the real aircraft tracks, increasing the probability of real targets being lost. The slightest uncertainty regarding an aircraft position in the sky, even for just a few seconds, can have significant consequences on air traffic safety and security in countries with a growing wind industry can be significant.

Addressing this issue, however, is a challenge in itself. It requires careful adjustments to the radar's signal processing capabilities so that sensitivity is not too high – creating too many false alerts – or too low – decreasing false alerts to the detriment of real targets.

Windfarm mitigation in civil air surveillance

Leveraging years of experience in the development of radars for various threats, missions and purposes – whether civil or military – Thales offers the STAR NG (S-band up to 100nm) and the TRAC NG (L-band up to 250nm) radars, both including a feature enabling a proper a windfarm mitigation.
The Windfarm Filter is a dedicated algorithm that uses a specific adaptive Constant False Alarm Rate (CFAR) mechanism designed to minimize track loss and reduce false alarms above and around windfarms. It can be integrated to address both civil and military needs and, as a software capability, can also be activated into other Thales ATC radars already in service.

Finding the most appropriate solution, and the most accurate balance for the algorithm, is specific to every client's needs. What works for one radar, operating around one windfarm characterised by a certain type of wind turbines, may not work for another radar in a different context. Evaluating the impact of each windfarm on potential radars is therefore crucial to de-risking investments.

To this end, Thales has developed a unique simulation tool, WINRAD, for evaluating the impact of proposed windfarms on its radars. Combining environment characteristics – terrain and windfarm visibility, windfarm boundary and layout, wind turbines – with radar behaviour, WINRAD can confirm the windfarm's impact on radar performances. On this basis, it can then predict achievable performance criteria over and around the windfarm area, supporting the identification of the most appropriate radar solution to maintain required detection performance while reducing the false alarm rate.

Windfarm mitigation in military air surveillance

Thales' military air surveillance are all 3D radars using AESA technologies and sophisticated doppler analysis. This enables the radars to separate the target signal from wind turbine signal and discriminate between wind turbines and targets. As a result no plots and tracks are reported on wind turbines and at the same time minimize performance effects on real targets.

Working closely with all stakeholders

Thales works closely with all the stakeholders in the aviation sector, ministries of defence and the wind energy industry to provide an end-to-end service to identify and deliver the optimum solution for each circumstance. Through our windfarm tolerant radars, our radars not only continue to ensure sky safety; they also contributes to unlocking the development of windfarm, increasing their contribution towards a greener future.

Did you know?

- The Thales Wind Farm Filter is field proven, with several dedicated flight trials performed in difficult circumstances, such as low Radar Cross Section (RCS) targets, ground and sea clutter, and low altitudes.
- The Wind Farm Filter is already operational in Europe and Africa

Reference : https://www.thalesgroup.com/en/windfarm-mitigation

Appendix 10

Thales structured list of upgrades

THALES
Building a future we can all trust

NATS

Air Traffic Management for Air Surveillance & Airports

RADAR upgrade presentation to NATS

22 November 2022

www.thalesgroup.com

THALES GROUP LIMITED DISTRIBUTION

Agenda

THALES

Building a future we can all trust

1. Introduction
Surveillance Radar Portfolio

ATM & Surveillance Radar Portfolio

ATC RADAR Portfolio

RSM NG
Approach &
En-Route Mode S

Full range of products for Approach and En-Route

- Air Traffic Management (Civil & Military)
- Air Surveillance of Illegal Traffic

Largest surveillance installed base

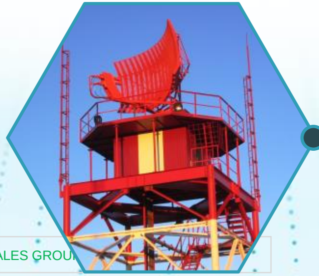
Portfolio recently renewed with lot of commonalities

STAR NG	June 2015	(≥ **60** radars already sold)
TRAC NG	June 2017	(≥ **26** radars already sold)
RSM NG	March 2021	(≥ **20** radars already sold)

Development focused on

- Performances improvement
- Extended & New Features
- Life Cycle Cost reduction & maintenance easiness

TRAC NG
En-Route PSR



STAR NG
Approach PSR

THALES GROU

THALES
Building a future we can all trust

Thales radar – Worldwide References

50 years experience in Air Traffic Management
1000+ radars awarded

Track records – Recent installation examples

2. STAR NG – Key Benefits

Non-Cooperative Approach Primary Surveillance Radar

2.1 Star NG – The new STAR 2000

STAR NG – The improved STAR 2000

Aerial system

- Antenna, pedestal, motors, rotary joint, encoders…
  - *Unchanged*

SST Cabinets — reduction of one cabinet

- Power Amplifiers and Pre-Amplifiers Modules
  - *Unchanged*
- Divide by 2 number of TX modules
- TCC integrated into new GR rack

AA/AE & MWA — reduction of one cabinet

- Antenna Control (AA) & Power Distribution (AE) cabinets merged into single cabinet.
  - ***Unchanged*** (same configuration than stand alone RSM 970S)
- MicroWave Assembly (MWA) repackaged to reduce size
  - ***Reuse*** of existing RF Line equipment (duplexer, coupler, guide limiter…)
  - ***Reuse*** of existing PRFU equipment (A/B switch, coaxial limiter…)
- RF822 (LNA & STC) integrated in new GR rack (new QuadRF board)

STAR NG – The improved STAR 2000

PRP Cabinet — reduction of one cabinet

- New Generator/Receiver including
  - TCC, TMR Unit, PSU, GRU & RF822
  - New boards developed: CIRA, S-CONV & S-QuadRF
- Technology partially coming from other radars
  - ***Limited technical risks***
- Radar Processing
  - ***Minor evolutions*** due to improved characteristics

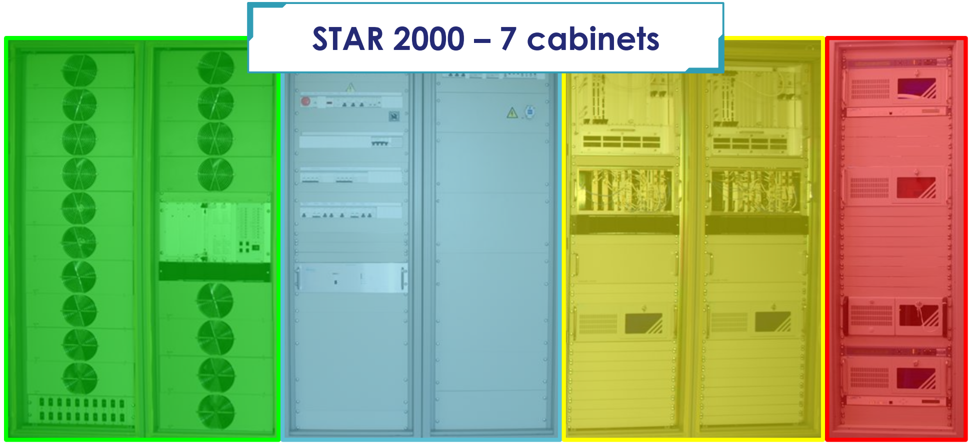
TOM Cabinet — Unchanged

- RCMS & IBIS SW
  - ***Unchanged***
- Time Stamping & P-Lines
  - ***Unchanged***
- Data Processing (plots & tracks, combination)
  - ***Unchanged***

Maintenance strategy and optimization tools

- ***Unchanged***

STAR NG – The improved STAR 2000



- SST Cabinets
- AA/AE & MWA
- PRP Cabinet
- TOM Cabinet

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2.2 Star NG
Performance improvements & new features

STAR NG – Overview

S-Band Primary Surveillance Radar for Civilian Airports & Military Air Bases

Scalable configuration for Approach Surveillance

- ***Adapted rotation speed***
  - 15 RPM ⇔ 60 NM
  - 12 RPM ⇔ 80 NM
  - 10 RPM ⇔ 100 NM
- ***Optimized peak power***
  - 4 Tx Modules ⇔ 8 kW
  - 8 Tx Modules ⇔ 15 kW
  - 16 Tx Modules ⇔ 28 kW
- ***High detection capability*** to achieve target separation within Major Terminal Maneuvering Areas

High detection performance even in harsh environment

- Under adverse conditions: 4G/5G telecommunication stations, WindFarms, electromagnetic interferences…
- Innovative dynamic clutter suppression: ground, sea & atmospheric clutters
- ***High Resolution/Accuracy***

High reliability 24/7 radar

- ***Redundant design*** with automatic switchover
- ***High level of Reliability, Availability & Maintainability***

Provide Approach radar data to ATCC and/or Military Operation centers

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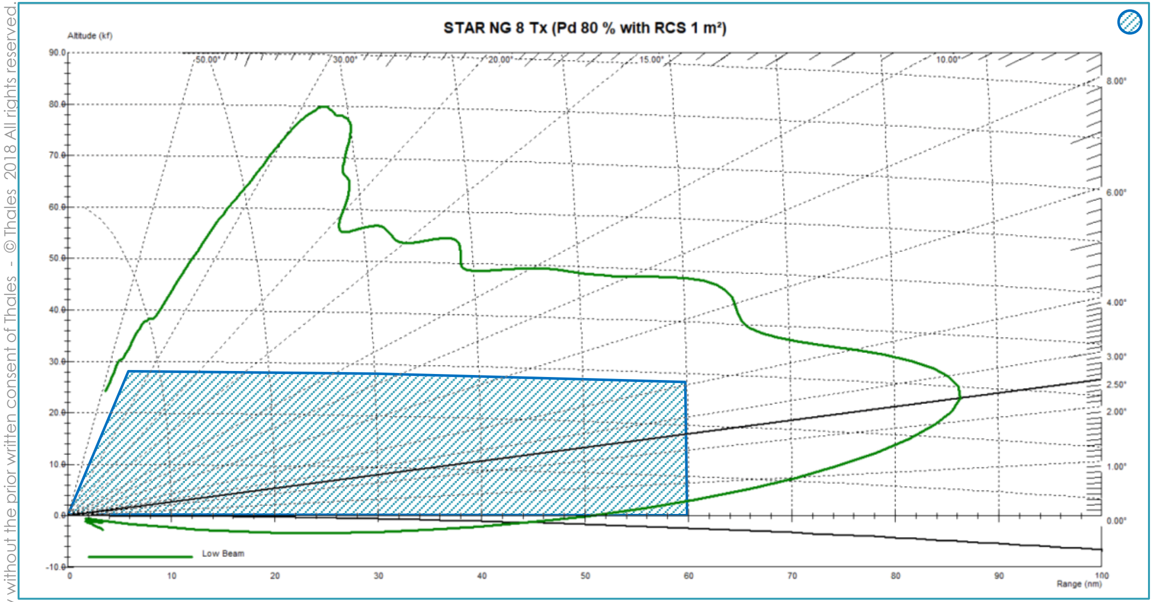
STAR NG – The improved STAR 2000

Characteristics	STAR NG	STAR 2000
Faulty Tx Modules	• N-1 without stopping radar operation • Graceful degradation design	• 1 without stopping radar operation • Graceful degradation design
Range Cell	• 30 m	• 115 m
Instantaneous Bandwidth	• 4 MHz	• 1.5 MHz
Accuracy	• 50 m • 0.15°	• 60 m • 0.15°
Discrimination (@ 80 %)	• 90 m • 2.6°	• 230 m • 2.8°
Analog to Digital Converter	• 16 bits	• 12 bits
Cybersecurity	• By design	• antivirus

(*) Dual Use classification

STAR NG – Improved Coverage Performances

15 RPM / 60 NM



Required Coverage

- Altitude 28 kft
- Coverage 60 NM
- Pd 80 %
- RCS 1 m²
- P_{fa} 10^{-6}

STAR NG configuration

- Rotation speed 15 RPM
- Instrumented Range 60 NM
- Maximum Coverage **86 NM**
- **8 Tx** Modules **15 kW**

STAR NG$_8$ ⇔ 15 RPM / 60 NM (80 % & 1 m²)

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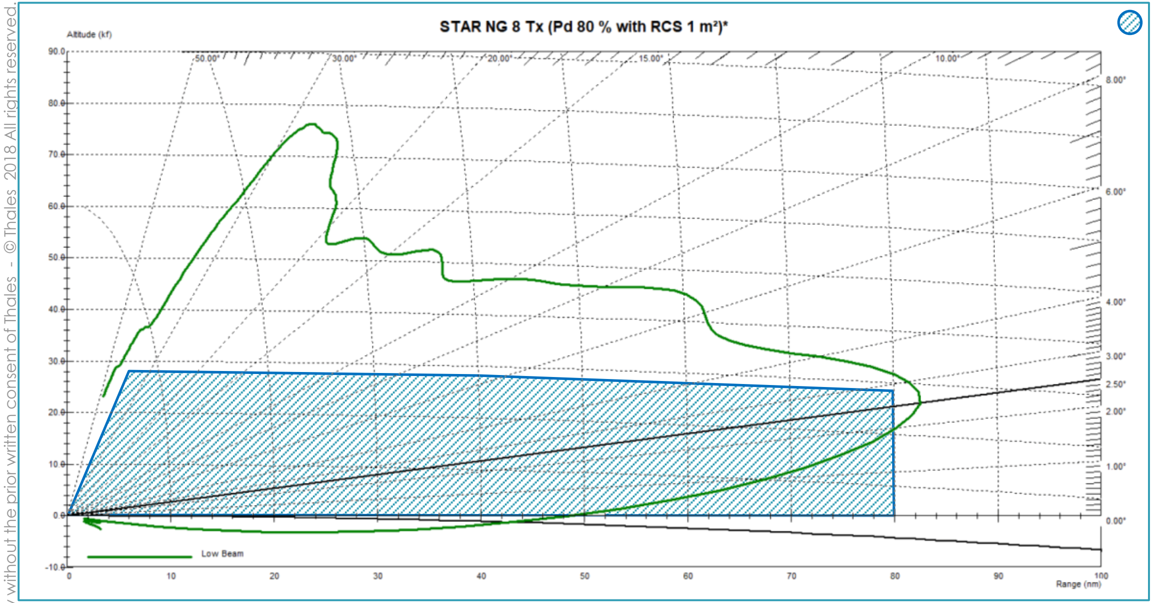
STAR NG – Extended Coverage Performances

15 RPM / 80 NM



Required Coverage

- Altitude 28 kft
- Coverage 60 NM

- Pd 80 %
- RCS 1 m²
- P_{fa} 10^{-6}

STAR NG configuration

- Rotation speed 15 RPM
- Instrumented Range ***80 NM***

- Maximum Coverage **83 NM**
- **8 Tx** Modules **15 kW**

STAR NG$_8$ ⇔ 15 RPM / 80 NM (80 % & 1 m²)

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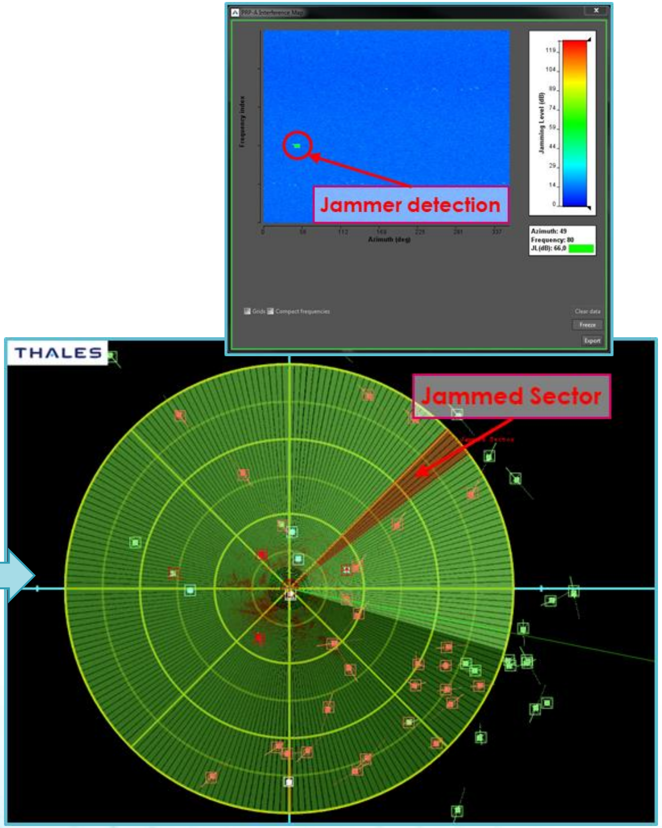
STAR NG – Main Performances

Characteristics	STAR NG
System Stability	• ≥ 65 dB
Minimum Detectable Signal (for Long Pulse)	• - 127 dBm
Dynamic range	• 163 dB
Doppler Filters Banks	• Automatic selection via adaptive map • 8 Filter Banks
Included features	• 4 reception channels processing • Vertical & circular polarization • Redundant weather channel with automatic polarization switch • Interference Map on the local & Interference Report via ASTERIX



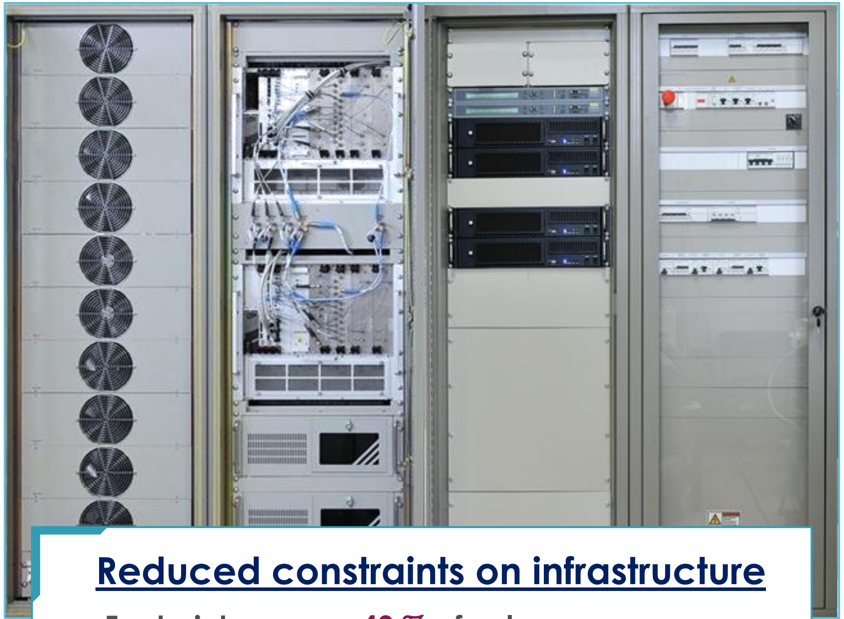
(*) Dual Use classification

STAR NG – New Features and options

Function / Characteristics	Description
4G/5G Filter	• 1 x Waveguide (Rx/Tx) • 3 x Coaxial (Rx)
Improved WindFarm Filter(*)	***Dedicated radar processing*** • Reduce false alarms from wind turbines • Optimize detection of aircraft flying above wind farms

(*) Dual Use classification

STAR NG – Life Cycle Cost improvement



High availability & Reliability

- MTBCF 58 000 h to 66 000 h (vs 40 000 h)
- MTBF 1 800 h to 2 200 h (vs 1 000 h)
- Reliability 99.99 %

Reduced constraints on infrastructure

- Footprint -40 % of volume
- Weight -15 % of the electronics
- Consumption -20 % of power consumption

The lowest Life Cycle Cost of the market

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Carbon footprint reduction

Main actions

- *The improvements already made on NG versions*
  - *STAR NG scalability 8 kW, 15 kW or 28 kW*
  - *Only 8 Tx Modules are sufficient for most cases*

Example

- *Hypothesis*
  - *Using a 8 modules instead a 16 modules : 5kW saved*
  - *Cost of energy in coming years: 1kWh = 1,6€ (was 0.16€ in 2020)*
  - *If electricity is produced with coal: 1KWh eq. 1k*
  - *Life cycle of 10 years = 87 600h*
- *Conclusion*
  - **Saving**= 700k€ + 428 tons eq. CO_2

Carbon footprint reduced by 40% compared to previous generation

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STAR NG at a glance

New *Approach* Control Primary Radar for Medium-Range *Air Surveillance*

Increased detection & tracking performances
- High range resolution
- Dynamic clutter suppression
- Wind Farm mitigation

Dual-Use Primary Radar for Civil & Military Cooperation (as option)
- 3D Function
- Fighter & helicopter detection
- Frequency Agility & ECCM

Cybersecured by design
- Based on NIST framework
- Cybersecurity Virtual Machine

Optimized Maintenance
- High Reliability & Availability
- Limited cost of ownership

ICAO & **EUROCONTROL** compliant

Solid State & **Digital** technology

S-Band	2 700 MHz – 2 900 MHz	
Scalable	8 kW, 15 kW or 28 kW	
Range	110 – 185 km	(60 to 100 NM)
Update rate	4 – 6 s	(10 to 15 RPM)
MTBCF	66 000 h	

185 STAR in operation (24/7) since 2000
60 countries worldwide

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2.3 Star NG – Upgrade benefits

Upgrade benefits

Characteristics	STAR NG	STAR 2000
Faulty Tx Modules	• N-1 without stopping radar operation • Graceful degradation design	• 1 without stopping radar operation • Graceful degradation design
Instantaneous Bandwidth	• 4 MHz	• 1.5 MHz
Accuracy	• 50 m • 0.15°	• 60 m • 0.15°
Discrimination (@ 80 %)	• 90 m • 2.6°	• 230 m • 2.8°
Range Cell	• 30 m	• 115 m
Analog to Digital Converter	• 16 bits	• 12 bits
Increased availability	• MTBCF 58 000 h to 66 000 h • MTBF 1 800 h to 2 200 h	• MTBCF 40 000 h • MTBF 1 000 h
Reduced footprint	• Footprint -40 % • Weight -15 % • Consumption -20 % • Carbon footprint -40%	
Cybersecurity	Cybersecured by design	
Increased Lifetime	**Product end of life ~ 2040 (+16 years)**	**Product end of life in 2034**

(*) Dual Use classification

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3. RSM NG upgrade

Cooperative Approach & En-Route Mode S Radar

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3.1 RSM NG
The latest RSM 970S Tech Refresh

The latest RSM 970S Tech Refresh

RSM main evolutions

Product	Evolution	Year
RSM 870		1985
RSM 970		1990
RSM 970I		1995
RSM 970S (POEMS)		2000
RSM 970S (POEMS)	Receiver (MDR - RF)	2003
RSM 970S (Cirius)	Receiver (MMXC - digital)	2006
RSM 970S (Cirius)	Transmitter (STX NG)	2012
RSM 970S (Cirius)	RCMS V5 upgrade	2016
RSM 970S (Cirius)	Updated PC (DPC, IBIS, RCMS)	2019
RSM NG	***New MDR & ADS-B***	**2021**







Software releases following evolutions & new functionalities from ICAO & EUROCONTROL

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RSM NG – Latest RSM 970S Tech Refresh

New TOM-M Cabinet

- Reuse of STX NG, NTP Servers & P-Lines
- MDRP replaced by a new MDR-M and Front-End in PC
- New PSU & FAN units
- Data processing with new powerful PC
- RCMS & IBIS Merge in single PC (redundant in option)
- Cybersecurity Virtual Machine included

Reuse of AA & AE

Compact design

- 2 cabinets instead of 3
- 30% reduction in weight & volume

RSM NG – Latest RSM 970S Tech Refresh

RSM NG – Latest RSM 970S Tech Refresh

Characteristics	RSM NG	RSM 970S
Instrumented Range @ 15 RPM • SSR – 2 interlaced modes • Mode S – ELS • Mode S – EHS • Full EMS with Datalink	• 256 NM • 256 NM • 256 NM • 170 NM	• 256 NM • 230 NM • 200 NM • 170 NM
Mode of interrogation	• Mode 1, 2, 3 • Mode 5 predisposed • Mode A/C • Mode S • ADS-B Extended Squitter reception	• Mode 1, 2, 3 • - • Mode A/C • Mode S -
External interface	• 64 logical links simultaneously • Full IP links using routers • Serial link optional with pLines	• 8 logical links simultaneously • 4 IP links • 8 serial links

(*) Dual Use classification

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3.2 RSM NG
Performance improvements & new features

RSM NG – Overview

L-Band Secondary Surveillance Radar for Civilian Airports & Air Bases

Digital Meta Sensor

- Mode 1, 2, 3, A/C
- ***Mode S*** Elementary (ELS) & ***Enhanced (EHS)*** including datalink
- ***ADS-B*** Extended Squitter detection over 360°
- Compatible with distributed and centralized ***Cluster Mode*** (SCN)

Enhanced Performances for Approach & En-Route Surveillance

- Rotation speed 5 to 15 RPM
- Instrumented Range up to 256 NM (even @ 15 RPM)
- Stand-alone or co-mounted with PSR

High reliability 24/7 radar

- ***Redundant design*** with automatic switchover
- ***High level of Reliability, Availability & Maintainability***

Full Mode S functionalities validated by EUROCONTROL since early 2000's

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Digital Meta Sensor

SSR & Mode S Main Performances

Transmitted Peak Power

- 3 000 W

Probability of Detection

- > 99 % (international regulation)
- > 99.5 % (typical)

Accuracy (1 σ)

- In SSR Mode
  - Range 30 m
  - Azimuth 0.068° (0.040° typical)
- In Mode S
  - Range 15 m
  - Azimuth 0.068° (0.040° typical)

Up to 2 000 tracks per scan

Compliant with latest version of EUROCONTROL Mode S Station

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Digital Meta Sensor

RSM NG is able to receive the 1090 Extended Squitter

- Via the three channels Σ, Δ, Ω of the LVA antenna
- 360° detection without additional hardware

ADS-B reception & processing

- Integrated ADS-B receiver without additional hardware
- Same degarbling algorithm as the one for Mode S All-Call
- Digital receiver filters adapted for ADS-B functionality

ADS-B reports allow

- Faster track initialization (direct Roll-Call without All-Call)
- To maintain Mode S and combined Mode S tracks
- Reduction of Cone of Silence
- Reduce RF pollution by removing useless All-Call phases

Reports

- ADS-B reports in ASTERIX Cat 021 using specific data stream
- Service data in ASTERIX Cat 025

RSM NG ADS-B is compliant with the non-physical requirements of ED-129B

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Ready for tomorrow

Detection of II/SI Code conflict due to proximity of other radars

- Error in the radar station code
- Error in the coverage map setting
- Presence of a mobile radar

Interference & Jamming analysis

- Strobe detection in case of sectorized Signal Processing overload
- Automatically alert on the presence of jammer

Interference map

- Real time monitoring of FRUITS in each azimuth
- Display FRUITS counting on IBIS

Robustness to jammer

- Adaptation of processing sensitivity to the level of RF pollution
- Maintain the best detection in presence of CW jammer

Local pollution is monitored to optimize radar processing

RSM NG

Approach & En-Route Control radar for Mode S Secondary Surveillance

New digital metasensor

- Military Modes 1, 2 & 3
  Mode 5 predisposition
- Civil Modes A/C
- Mode S Elementary (ELS)
  Enhanced (EHS)
- Integrated 360° ADS-B detection

Cybersecured by design

- Based on NIST framework
- Cybersecurity Virtual Machine

Optimized Maintenance

- Improved Reliability & Availability
- Limited number of spares required
- Reduced cost of ownership

ICAO & **EUROCONTROL** compliant

Digital technology

L-Band	1 030 MHz & 1 090 MHz	
Peak Power	3 000 W	
Range	460 km	(256 NM)
Update rate	4 – 12 s	(5 to 15 RPM)
MTBCF	81 000 h	

400 RSM in operation (24/7) since 2000
70 countries worldwide

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3.3 RSM NG – Upgrade benefits

RSM NG – Upgrade benefits

Characteristics	RSM NG	RSM 970S
***Instrumented Range* @ 15 RPM** • SSR – 2 interlaced modes • Mode S – ELS • Mode S – EHS • Full EMS with Datalink	• 256 NM • 256 NM • 256 NM • 170	• 256 NM • 230 NM • 200 NM • 170 NM
Mode of interrogation	• Mode 1, 2, 3 • Mode 5 predisposed • Mode A/C • Mode S	• Mode 1, 2, 3 • - • Mode A/C • Mode S
External interface	• 64 logical links simultaneously • Full IP links using routers • Serial link optional with pLines	• 8 logical links simultaneously • 4 IP links • 8 serial links
ADS-B integration	• ADS-B data output (ASTERIX Cat 021) • Radar performances improvement	
Increased availability	• MTBCF 81 000 h • MTBF 3 100 h	• MTBCF 54 000 h • MTBF 2 700 h
Reduced footprint	• 2 cabinets instead of 3 • 30 % reduction in weight & volume	
Cybersecurity	Cybersecured by design	
Increased Lifetime	**Product end of life ~ 2047 (+7 years)**	**Product end of life in 2040**

(*) Dual Use classification

4. STAR NG/RSM NG

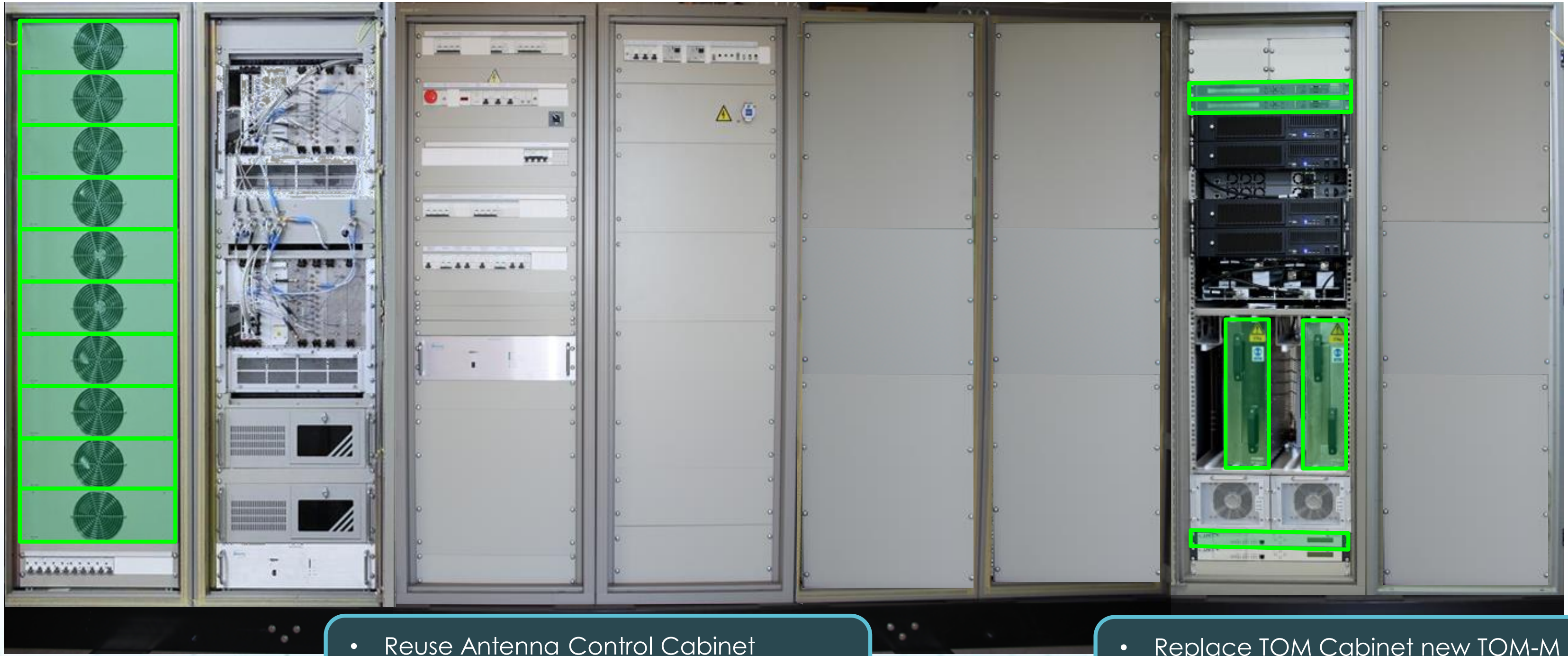
Perfect solution for Approach Surveillance

STAR NG/RSM NG – Upgrade proposal N°1

Up-to-date solution

- Remove the SST Cabinets
- Replace with new SST & PRP Cabinets
- Reuse MES 1400 & MES 110 after refresh

- Remove the LRU from PRP Cabinets
- New GR & Signal Processing in new PRP
- Cover the empty slots



- Reuse Antenna Control Cabinet
- Reuse Power Distribution Cabinet
- Modify MicroWave Assembly

- Replace TOM Cabinet new TOM-M
- Reuse STX NG, NTP & pLines
- Remove the LRU from TRC Cabinets

STAR NG/RSM NG – Upgrade proposal N°3

After the upgrade

Maintenance Console

Integrated in the TOM-M cabinet and equipped with

- 2 wide LCD screens of 24” (1920x1200 resolution)
- 3-buttons mouse & QWERTY keyboard
- 19’’ rackable workstation
  - Powerful processor & 3D graphic board
  - 4 GB SDRAM
  - 1 TB Hard Disk
  - 4 Gigabit Ethernet

It includes the following functions

1. Control & Monitoring System (LTM Local position)
2. Radar Display (IBIS)
3. Parameter Tool (CBP)
4. Cybersecurity Virtual Machine (CVM)

Redundant design proposed as an option

Maintenance Console

Cybersecured by design

- Cybersecurity based on NIST framework
  - ***Protect*** the radar against modification of reference configuration
  - ***Verify*** periodically the system integrity
  - ***Enforce the access right*** policy
  - ***Prevent*** intrusion in the radar cabinets
  - ***Protect*** the physical access even when off-line

Cybersecurity strategy

- System OS hardening
  - Secured BIOS
  - Updated OS with limited packages & services
  - Antivirus & Firewalls
  - Access control with passwords & security logs
  - Encrypted Hard Drive Disks
- Internal network hardening
  - Only required ports, protocols and services activated
  - Switch hardening

Maintenance Console

Single interface to control the cybersecurity functions

- Manage users Login & Password via LDAP directory server
- Prevent from installing unauthorized software
- Allow to perform Cybersecurity checks on the channel under maintenance
- Only USB port of entry to collect data or deploy software upgrades

Maintain cybersecurity without disturbing radar operational behavior

Radar operational availability & operational safety are not impacted

2021 Thales Data Threat Report
https://cpl.thalesgroup.com/data-threat-report

Thank you for your attention

Antoine Chapelon

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Appendix 11

Eurocontrol Mode S station Functional Specification (EMS 3.11)

EUROPEAN ORGANISATION FOR THE SAFETY OF AIR NAVIGATION

EUROCONTROL

European Mode S Station Functional Specification

SUR/MODES/EMS/SPE-01
(form. SUR.ET2.ST03.3114-SPC-01-00)

Edition	:	3.11
Edition Date	:	9 May 2005
Status	:	Released Issue
Class	:	General Public

EUROPEAN AIR TRAFFIC MANAGEMENT PROGRAMME

DOCUMENT IDENTIFICATION SHEET

DOCUMENT DESCRIPTION

Document Title

European Mode S Station Functional Specification

EATMP INFOCENTRE REFERENCE: 05/05/29-03

PROGRAMME REFERENCE INDEX:	EDITION:	3.11
SUR/MODES/EMS/SPE-01 (form. SUR.ET2.ST03.3114-SPC-01-00)	EDITION DATE:	9 May 2005

Abstract

Keywords

Mode S	SSR	Monopulse	Radar
Surveillance	Datalink	Station	PILOT
Cluster	ATN	GDLP	SCN

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DOCUMENT STATUS AND TYPE

STATUS		CATEGORY		CLASSIFICATION	
Working Draft	☐	Executive Task	☐	General Public	☑
Draft	☐	Specialist Task	☑	EATMP	☐
Proposed Issue	☐	Lower Layer Task	☐	Restricted	☐
Released Issue	☑				

ELECTRONIC BACKUP

INTERNAL REFERENCE NAME:

HOST SYSTEM	MEDIA	SOFTWARE
Microsoft Windows NT4	Type:	Microsoft Word 97
	Media Identification:	

DOCUMENT APPROVAL

This version (3.11) of the Mode S Ground Station specification represents the best-available state of requirements at the time of issue and it may be used for the purposes of procurement at the risk of the procuring agency only. In the event of changes to this specification, every effort will be taken to ensure that such changes are brought to the attention of those who have formally been issued with a copy.

The following table identifies all management authorities who have successively approved the present issue of this document.

AUTHORITY	NAME AND SIGNATURE	DATE
Author	Nicolas EERTMANS	9/05/05
Mode S System TF Chairman	Eric POTIER	18/05/05
Mode S Programme Manager	John LAW	10/08/05

DOCUMENT CHANGE RECORD

The following table records the complete history of the successive editions of the present document.

EDITION	DATE	REASON FOR CHANGE	SECTIONS PAGES AFFECTED
2.00	13 Dec 1996	POEMS Functional Specification, baseline version for POEMS contract (was SUR.ET2.ST03.3110-SPC-01-00).	
2.01-2.19	12/96-10/99	POEMS TSC internal working drafts of European Mode S Station Functional Specification.	All
2.99	21 Oct 1999	Proposed Issue of European Mode S Station Functional Specification.	All (mostly editorial)
3.00	25 Oct 1999	Inclusion of comments from DFS, NATS and STNA.	
3.01	13 Dec 1999	Released Issue	
3.02	24 Jul. 2000	Technical additions from POEMS TSC	All
3.03	27 Sep 2000	Review of 3.02 and additional modifications during TSC13.	4,7,8,9
3.04	22 Nov 2000	Additional modifications resulting from TSC13	All
3.05	29 Nov 2000	Additional modifications resulting from TSC14	All
3.06	29 Jan 2001	Additional modifications resulting from TSC15	All
3.07	6 Mar 2001	Inclusion of comments from STNA.	All
3.08	19 April 2001	Released issue. References updated.	
3.09	30 March 2005	Correction of typos. Addition of optional SPI, position reports processing & Internet Protocols.	4.2.4.2.3, 4.9.2.1, 4.9.4.2, 7.2.1, 7.3.2.8, 13.2.2.5, Annex B new sections 13.18 and 13.19.

3.10	27 April 2005	Proposed issue following review by MSTF#22. SPI processing becomes advisory. GICB extraction limited to datalink map removed.	7.2.1 changed and 13.19 removed.
3.11	9 May 2005	Released Issue.	-

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The present document describes the functional specification for the European Mode S Ground Station.

European Administrations who wish to take part in the initial implementation programme may use this document as a kernel for their procurement specification.

CHAPTER 1

INTRODUCTION

1.1 Overview

1.1.1 This chapter provides an overview to the implementation of an European Mode S ground station.

1.1.2 Europe currently operates Secondary Surveillance Radar (SSR) stations for the surveillance function. These stations act autonomously, each providing a radar service to the Air Traffic Control Centre (ATCC). The radar systems are required to operate unattended and must therefore rely on control and monitoring information via a Control And Monitoring (CAM).

1.1.3 The Mode S ground station detailed in this document is described as a ‘PILOT’ system. ‘PILOT’ systems may be procured by Administrations in the core area who wish to take part in the initial implementation programme. The term ‘PILOT’ is used to describe a production standard equipment offered for operational implementation. This implementation will introduce Enhanced Surveillance Services to ATC through use of data link services known as the Mode S Specific Services.

The necessary functionality to support the Mode S Specific Services shall be resident in the ground station. These shall be capable of automatically extracting aircraft derived data which may be selected by programmable criteria (e.g. periodic, on initiation of track, within an azimuth window etc.). Extracted aircraft data shall be transmitted to the requesting application and could be included in Mode S extended report messages. Examples of such data are aircraft address, capability, altitude, aircraft identity, ACAS resolution data and aircraft intention data.

The Airborne Data Link Processor (ADLP) will link various aircraft systems to the Mode S transponder and will provide a means for avionics data to be transmitted to the ground via 'Mode S Specific Services'. The ADLP also provides the necessary functionality to support the full Mode S sub network.

1.1.4 A further stage of development in Mode S implementation is expected to be the addition of the Ground Data Link Processor (GDLP) to provide the full functionality of the Mode S Subnetwork.

The Mode S subnetwork provides a reliable point-to-point Switched Virtual Circuit (SVC) communication service across the Mode S air-ground link. It is fully compatible with the Aeronautical Telecommunication Network which provides complete inter-operability between alternative air-ground data-links. The SVC service of the Mode S Subnetwork may also be used by stand-alone applications outside or alongside the ATN environment (see Figure 1).

The Mode S interrogator includes the necessary functionality to interface to the GDLP (including the frame processing function of the Subnetwork).

1.1.5 The Mode S station can operate in a co-operative way with other Mode S stations (see Figure 2).

This makes it possible:

(a) To reduce the Mode S FRUIT rate, by allocating the same II code to all the stations of a cluster; in this case, the aircraft acquisition can be performed, via the ground network;

(b) To compensate for a possible detection miss, by getting additional Mode S data originating from neighbouring stations.

This mode requires an interconnection between the involved stations.

In the event of a radar failure, the adjacent stations can re-configure their coverage area, according to a pre-programmed scheme, so as to limit the uncovered areas.

1.2 Specification Status

1.2.1 Compliance with the specification is required unless departure from the specification requirements can be demonstrated during the call for Tenders to provide advantages technically or to provide advantages in cost terms without any degradation of performances.

1.2.2 The response to the specification is required to be comprehensive with a completed Compliance Summary as set out below.

The identification or referencing of each paragraph or set of paragraphs is standardised to enable a concise compliance status summary to be provided in the proposals. Each paragraph or set of paragraphs has a suffix in square brackets which is one of:

(a) [An] indicating that the immediately preceding paragraphs contain information for the Contractor and is therefore ADVISORY;

(b) [En] indicating that the requirements of the immediately preceding paragraphs are considered ESSENTIAL;

(c) [On] indicating that the requirements of the immediately preceding paragraphs are considered OPTIONAL;

(d) [In] indicating that the immediately preceding paragraphs are requesting essential INFORMATION.

1.2.3 The compliance summary provided shall be completed and returned with the proposal. This compliance summary is in the form of a table, constructed from the following column headings:

Chapter:	Paragraph:	Item:	Compliance:	Proposal Ref:

Each row of the table uniquely identifies each paragraph requiring response in this specification by the Chapter, Paragraph (and sub paragraph) and Item references in the consecutive order in which they appear in this specification, where the Item reference is in the specification paragraph suffix in square brackets referred to above.

The Tenderer compliance status shall be indicated against each paragraph and Item of this specification in the 'Compliance' column with a C for Compliance or an N for Not Compliant. No other response will be recognised during the evaluation and absence of C or N will be counted as Non-Compliant, as will statements such as 'Read and Understood'. This includes Item references [An], [En], [On] and [In] where:

(a) For [An] 'C' indicates that the paragraph has been read, understood, agreed and accepted;

(b) For [En] 'C' indicates that the requirement is fully met in all respects, exactly as stated in this specification;

(c) For [On] 'C' indicates that the option is offered, it will meet the requirements in all respects, exactly as stated in the specification, and is itemised and priced separately in the commercial response and

(d) For [In] 'C' indicates that the information is supplied complete as requested in the specification and the information shall become contractual after the signature of the contract.

Each response to any of [An], [En], [On] or [In] requires a readily identifiable full qualification in the proposal, otherwise it will be counted as unconditionally Non-Compliant.

If an option [On] is offered as a standard without additional cost, and is fully compliant with the requirement as specified, then this must be clearly stated by 'C STANDARD' in the compliance summary, and itemised as a zero cost option in the commercial response.

All reference to cost implications and specific cost details shall be confined to the Commercial response and shall not appear in the technical response. **[E1]**

The information or the data provided in the proposal descriptions and specifications pertinent to each of the paragraphs of this specification shall be cross referenced via the Proposal Ref column in the Compliance summary. **[E2]**

It should be noted that compliance information not included, or included but in error, in the compliance status summary will be counted as a Non-Compliant statement. **[A1]**

1.2.4 The operational and technical facilities defined by this Specification shall be regarded as essential. Within the defined limits of the specification the Contractor has the freedom of design on the condition that the Eurocontrol Agency and the participating States agree that the system meets the requirements. **[E1]**

1.2.5 In the event of conflict between any of the requirements expressed for the Mode S ground station in any reference documents, the requirements expressed in ICAO Annex 10 ([Ref.1.]), and STANAG 4193 ([Ref.2.]) and the Mode S subnetwork SARPS ([Ref.3.]) shall take priority, followed by the requirement in this Specification. **[E1]**

Where conflict occurs between this specification and any other specification or document, the Agency shall be notified. **[E2]**

1.3 Specification Language

1.3.1 Throughout this document, the word 'shall' denotes a mandatory requirement, 'may' a preferred requirement and 'will' a statement of intent. **[A1]**

'The Tenderer' means the company submitting the Tender and 'the Contractor' means the successful Tenderer to whom the contract arising from the Tender has been awarded. **[A2]**

1.3.2 The Contractor shall be wholly responsible for the consistency and correct working of all interfaces between equipment and subsystems within the complete radar systems, including all the interfaces between and within SSR, Mode S and remote control subsystems as specified within this document. **[E1]**

Therefore, as part of the Tender response, the Tenderer shall advise the Agency of any amendments to any of the interface specification material included in this document which is either considered desirable or necessary. **[E2]**

1.3.3 In the absence of any agreed amendments or relaxations, the specification and associated attachments and other documents or specifications referred to, herein shall be the definitive document(s) for all equipment supplied. **[E1]**

1.3.4 Note that throughout this document the term ‘Agency’ is used to mean EUROCONTROL or the National Administration responsible for procurement. **[A3]**

CHAPTER 2

SCOPE

2.1 General

2.1.1 The Contractor shall develop, supply, install and commission a working system that is complete in every respect, provides specified outputs and meets the performance requirements to the full specification detailed in this document and referenced documents. **[E1]**

Acceptance of the ground station equipment will comprise the full system up to and including all the interfaces described in this specification. **[A1]**

For guidance the following issues are anticipated to be confirmed during the 12 month Interoperability Validation exercise:

(a) Interoperability with an ATCC for Enhanced Surveillance services (data requests and delivery) **[A2]**

(b) Interoperability with an ATCC during Network-Aided cluster operation (surveillance integrity) **[A3]**

(c) Interoperability with an adjacent station during cluster co-ordination (failure modes and effects) **[A4]**

2.1.2 The station shall be functionally modular and include facilities to evaluate the performance of individual processes (as described in [Ref.12.]) for the specified operating conditions of Annex G. **[E1]**

2.1.3 Tenderer shall provide a proposal and separate quotation for all options specified in this document. **[E1]**

2.1.4 The Tenderer shall provide all proposal material on a CD-ROM and in a hard copy form. **[E1]**

2.2 Equipment to be Supplied

2.2.1 The Mode S system will be installed on a site to be decided. **[A1]**

2.2.2 The following items shall be supplied with the Mode S system:

(a) Antenna and turning gear system (optional) **[O5]**

(b) 20m tower (optional) **[O1]**

(c) Shelter (optional) **[O2]**

(d) Interrogator **[E2]**

(e) Processing (SMF, DLF, SCF) **[E3]**

(f) Local display **[E4]**

(g) Local playback and recording (optional) **[O3]**

(h) Control and Monitoring **[E5]**

(i) Far field site monitor **[E6]**

(j) Cluster Controller (optional) **[O4]**

(k) Dual GPS Receiver (optional) **[O7]**

(l) All Dedicated Terminals required for parameter configuration **[E8]**

2.2.3 The system shall be provided with dual channel functionality for items (d),(e) and (i) above. **[E1]**

The Tenderer shall advise where an alternative approach to dual functionality may be more appropriate. **[E2]**

2.2.4 The system shall be designed to be located in a building which has been constructed for the purpose of containing the Mode S system. **[E1]**

2.2.5 The Tenderer shall provide the necessary interface functionality to support the Mode S system to be collocated with a primary surveillance radar. **[E1]**

"Collocated" includes both co-mounted and off-mounted configurations. **[A1]**

2.2.6 The Tenderer shall provide in the proposal details of the ground station's modularity. This shall include the design philosophy regarding technological updates and functional upgrade of the hardware and software. **[I1]**

The Tenderer may refer to Ref 13 regarding modular design. **[A1]**

In particular the Tenderer shall indicate how their design approach can accommodate subsequent updates to [Ref.5.] and [Ref.6.]. **[I2]**

CHAPTER 3

SYSTEM DESCRIPTION

3.1 General

3.1.1 As expressed in 1.2.5, the Mode S ground station shall primarily meet all the requirements of [Ref.1.] and those described in the Mode S Subnetwork SARPS followed by the requirements as detailed in this document. **[E1]**

The Mode S ground station shall meet the requirements of Military SPI, Military Emergency train and Mode 3 as defined in STANAG 4193 [Ref.2.]. **[E2]**

The Tenderer shall provide equipment as described in [Ref.2.] which includes Mode 1 and 2. **[E3]**

There is no requirement to include Mode 4. **[A1]**

3.1.2 Each ground station shall support the following functions:

(a) interrogation, detection and acquisition of Mode S, 3/A and C to comply with [Ref.1.]:

- (i) Mode 3/A,C,S All-Call interrogation;
- (ii) Mode A/C only All-Call;
- (iii) Mode S only All-Call. **[E1]**

(b) addressed surveillance and standard length communication transactions as described in [Ref.1.] which include:

- (i) Surveillance, altitude request;
- (ii) Comm A altitude request;
- (iii) Surveillance identity request;
- (iv) Comm A identity request;
- (v) Surveillance altitude reply;
- (vi) Comm B altitude reply;
- (vii) Surveillance identity reply;
- (viii) Comm B identity reply;
- (ix) Lockout protocols;
- (x) Basic data protocols including:
  - Flight status;
  - Capability reporting.
- (xi) Standard length communication protocols:

- Comm A
- Comm A broadcast
- Ground initiated Comm B
- Air initiated Comm B
- Comm B broadcast
- Enhanced Comm-B protocol for Level 5 transponders **[E2]**

(c) Extended length communication transactions as defined in [Ref.1.], including:

(i) Comm C

(ii) Comm D

(iii) Multisite uplink ELM protocol

(iv) Non selective uplink ELM

(v) Multisite downlink ELM protocol

(vi) Non selective downlink ELM

(vii) Enhanced ELM protocol for Level 5 transponders **[E3]**

(d) Aircraft Identification Protocol including:

(i) Aircraft identification reporting

(ii) Aircraft capability reporting

(iii) Change of aircraft identification **[E4]**

(e) Data link function including:

(i) Frame processing;

(ii) Mode S specific services processing. **[E5]**

3.1.3 The station shall manage the following:

(a) Mode S specific services to minimise the use of the RF channel e.g. combining identical requests; **[E1]**

(b) The Mode S packets (e.g. prioritise packets, delay the frame processing in order to achieve maximum benefit from multiplexing); **[E2]**

(c) Uplink and downlink broadcasts. **[E3]**

3.1.4 The grouping of functional elements as described in chapters 6 through 9 does not impose any physical implementation. **[A1]**

3.2 Cluster Operation

3.2.1 The number of interrogator identity (II) codes available is limited and therefore unique codes cannot be allocated to each Mode S ground station. A Surveillance Co-ordination Network (SCN) will allow a common II code structure to be implemented for clusters of ground stations. **[A1]**

The Surveillance Identifier (SI) codes described in [Ref.1.] provide additional codes that can be allocated to interrogators which only perform a surveillance function. **[A2]**

The capability to interrogate and set lockout for an SI code and decode and process replies from an SI capable transponder shall be provided in the ground station. **[E1]**

3.2.2 The objective of Surveillance Co-ordination is to allow any Mode S ground station to operate effectively within any radar siting plan while keeping the levels of RF pollution as low as possible. This means preventing interference between stations by the correct use of II/SI codes, Mode S protocols, transponder all-call lockout, coverage map configuration and target handover. **[A1]**

3.2.3 A Surveillance Co-ordination Function (SCF) shall be incorporated into each ground station, as described in chapter 8, and shall provide:

(a) Network control and management including failure detection and resolution; **[E1]**

(b) Co-ordination procedures, as defined in [Ref.1.], between coverage areas of networked ground stations to allow targets to be acquired without need for All-Call; **[E2]**

(c) Track data to adjacent stations upon request. **[E3]**

3.2.4 When operating as part of a cluster the stations operation is termed ‘network-aided’. This operation shall support the following modes which are described more precisely in subsequent chapters:

(a) Central mode where the coverage map and II/SI code are determined by a cluster controller (CC) as described in Appendix A of [Ref.1.]; **[E1]**

(b) Distributed mode where the Ground station SCFs co-ordinate to ensure correct cluster operation, as defined in [Ref.1.]. **[E2]**

In addition to ‘network-aided’ operation the SCF shall also support ‘stand-alone’ operation where each station shall operate independently from cluster. **[E3]**

3.2.5 The data format to be used over the Surveillance Co-ordination Network shall be as described in [Ref.6.]. **[E1]**

3.2.6 The Mode S ground station shall be capable of forming a cluster with any Mode S ground station whose network interface comply with [Ref.1.]. **[E1]**

The Surveillance Ground Network will provide the infrastructure to support communications between the Mode S ground stations and the Cluster Controller. **[A1]**

CHAPTER 4

GENERAL EQUIPMENT AND PERFORMANCE REQUIREMENTS

4.1 Scope

4.1.1 This chapter details the equipment functional and performance requirements which shall be met to satisfy the requirements for the provision of the Mode S system. **[A1]**

4.1.2 Where performance parameters are specified as a standard deviation, this shall always refer to the standard deviation of a Normal Distribution, unless it is specifically stated otherwise. Also the terminology root mean square shall be taken as synonymous with standard deviation (σ1), unless it is specifically stated otherwise. **[A1]**

4.2 Performance Requirements

4.2.1 General

The following paragraphs specify the coverage requirements and specify the system performance parameters. **[A1]**

The performance requirements specified in the following paragraphs are the minimum operational performance requirements. They shall be met with all site dependant operational parameters set following commissioning including antenna tilt, gain time control and any other variable thresholds. **[E1]**

To ensure that the performance requirements are met the system will be subjected to Factory Acceptance Tests (FAT), Site Acceptance Tests (SAT) along with system performance evaluations, flight trials and live traffic performance evaluations to cover Mode 3/A,C operation and Mode S operation prior to acceptance. In addition to coverage confirmation, targets of opportunity will be used to establish accuracy performance. **[A2]**

Tools approved by the Agency shall be used to check compliance to the required performances. In particular, the Contractor shall obtain and use, where appropriate, the PTE tools for acceptance testing. Characteristics of this equipment are included in Annex I, and a fuller description is available from the Agency. **[E2]**

Supplementary or alternative tools may be proposed to satisfy the compliance and safety requirements of the individual member states, the use of which shall be agreed by the Agency. **[E3]**

The contractor shall fund all costs associated with the provision and use of whichever test tool is selected. **[E7]**

Full coverage and performance details compliant with this specification shall be supplied with the proposal. **[I2]**

It is assumed that SSR Mode 3/A, C and S transponders conform to all the requirements of [Ref.1.]. **[A3]**

The Mode S sensor shall process transponders compliant with ICAO Annex 10 Amendment 69, 71 and 73. **[E4]**

The Tenderer shall clearly describe how he intends to fulfil the previous requirement, and more specifically the determination of transponder's communication capability. **[I3]**

The Tenderer shall in particular indicate the effects on the acquisition processing, internal application list, DLF,GDLP/LU, the use of the continuation subfield/flag, on RAs, and on Asterix reporting. **[I4]**

The Mode S sensor shall solicit and detect replies from Mode 3/A,C only and Mode S transponders within the specified coverage subject to the system performance requirement detailed in this Chapter. **[E5]**

For aircraft tracked with selective Mode S interrogations the Mode S ground station shall extract Mode C information from those Mode S transponder equipped aircraft on every scan, in addition to any Mode 3/A code update subject to the system performance requirement detailed in this Chapter. **[E6]**

In addition to the general operating model of Annex G, the performance requirements shall be met for the operational configurations (IRF vs. range/turning rate) of the sites to be commissioned. **[E8]**

The Tenderer shall define how many re-interrogations, in function of range, are assumed to achieve the Mode S performance requirements for all configurations given in Annex G, and target velocity limits specified in 4.6.10. This shall be supported by field data. **[I5]**

It is a goal for the system to minimise the re-interrogation rate while meeting all required performances. **[A4]**

The Tenderer shall describe in detail how non-discrete Mode A codes are handled by the station. **[I6]**

4.2.2 Radar Coverage

4.2.2.1 The Mode S Radar shall provide continuous, gap-free cover through 360° of azimuth and over a range of 0.5 NM to at least 256 NM. **[E1]**

The upper limit of cover shall be at least 66,000 ft. **[E2]**

It is expected that, due to site conditions and earth curvature the lower limit of coverage shall not be horizontal all the way to 256 NM. **[A1]**

The Tenderer shall state the lower limit of coverage in elevation and under what conditions this lower limit shall be achieved. **[I1]**

The zenithal gap, shall not extend below an elevation angle of 45° above the horizontal. **[E3]**

4.2.2.2 The Tenderer shall provide horizontal and vertical polar diagrams for the ICAO defined transponder frequency bands to achieve the accuracy and detection performance of 4.2.3 and 4.2.6 throughout cover. **[I1]**

The vertical polar diagrams shall include the following conditions:

(a) Free space; **[E1]**

(b) Antenna height 20m, medium dry ground with a Relative Permittivity of 15 and Conductivity of 0.04 Siemens per metre; **[E2]**

(c) Antenna height 20m, sea water with a Relative Permittivity of 70 and Conductivity of 5 Siemens per metre. **[E3]**

For the purposes of calculation the reflection surfaces of (b) and (c) may be assumed to be spherical and optically smooth and conform to the WGS 84 Earth Model. **[A1]**

The Mode S equipment provided by the Contractor shall meet the requirements detailed in the polar diagrams as agreed by the Contractor and the Agency prior to the award of the Contract. **[E4]**

The Tenderer shall state in their proposals any non compliance with the performance requirements of 4.2.3 and 4.2.7 within the first null above the horizontal. **[I2]**

4.2.2.3 The Tenderer shall also clearly explain the technique used and the effects on the performance of sensitivity time control (STC) and any other thresholding in the system (e.g. short pulse elimination and received signal strength), specifically stating the STC levels assumed. **[I1]**

The antennas performance shall be such that with a receiver STC of 42dB at 0.25 NM, the zenithal gap shall not extend below an elevation angle of 45°. **[E1]**

4.2.2.4 During the commissioning phase, the Contractor shall analyse the radar sensor performance in order to define the Commissioning Volume where the radar sensor can provide radar services according to local environmental and operational constraints. This Commissioning Volume shall be agreed between the Contractor and the Agency. **[E1]**

The Measurement Volume is defined as the area below the flight level 500, above the flight level 100 until 100 NM, above the flight level 200 between 100 NM and 135 NM, above the flight level 300 between 135 NM and 170 NM. **[A1]**

The Measurement Volume is defined for a normal site, however in certain cases (e.g. area of mountains) this volume should be adapted by using the Eurocontrol RASCAL tool in order to define the volume which is not subject to terrain screening. **[A2]**

Annex G provides the volumes (Commissioning or Measurement Volume) against which the site performances requirements shall be tested. **[E2]**

All theoretical or required site performances can be verified in factory with simulated targets and without any volume restriction. **[A3]**

4.2.3 Position Detection Performance

4.2.3.1 General

The Probability of Detection (Pd) shall be determined by the ratio of the number of target reports with measured position to the number of total expected reports. **[A1]**

The expected reports are the reports contained between the first and the last report from the same aircraft before it leaves the volume to be analysed. The method of chaining will be that which is defined in PTE tool. **[A2]**

The Tenderer should anticipate that the verification of probability of detection will be undertaken using the PTE tool set for a monoradar analysis. **[A3]**

The European Surveillance Standard recommends that the SSR probability of detection for surveillance should be greater than 97% and code validations of 98% and 96% for Modes 3/A and C respectively. **[A4]**

The above figures shall be met by the Mode S equipment for the overall coverage area. **[E1]**

‘Overall’ means that the measurement method shall be applied without further geographical restrictions to the whole sample of the recorded data obtained from opportunity traffic within the Commissioning Volume. **[A5]**

The performance characteristics for existing operational Monopulse sites shall be the benchmarks against which the detection and code validation of Mode S operational stations will be validated. **[A6]**

The Tenderer shall state, for each performance justification, the values for All Call and Roll Call period durations, Mode 3/A,C and Mode S All Call IRF using the values for antenna rotation speed given in the Annex G. **[I1]**

The Tenderer shall provide, as part of the Tender response, evidence that his proposed system can fully meet the performance requirements, and stating under what conditions (e.g. site, garbling, FRUIT rate). **[I2]**

The Tenderer shall detail in the proposal the effect of an increase of FRUIT rate to 20 000 FRUIT/s in the 3dB beamwidth on the Probability of Detection **[I3]**

In order to provide an adequate sample size for performance verification, the data collected for peak traffic hours will include at least 50000 reports. **[A7]**

The Tenderer shall state and justify the round trip reliability for all surveillance Mode S transactions. **[I5]**

The Tenderer shall state all assumptions made in response to paragraphs 4.2.3.1 to 4.2.3.3, and shall also indicate any circumstances where the values given will be modified. **[I6]**

4.2.3.2 SSR Detection without synchronous garbling

4.2.3.2.1 SSR Theoretical Detection

The Tenderer is advised that in addition to transponders which operate with 21dBW, SSR transponders having power outputs of 18.5 dBW are permitted for aircraft not flying above 15000 ft. **[A1]**

The Tenderer shall provide a downlink power budget for transponders having a power output of 18.5 dBW, stating the maximum detectable range at 15000 ft. **[I1]**

The Tenderer shall state any deviation from the accuracy and detection performance of 4.2.3 and 4.2.6 for transponders having power outputs of 18.5 dBW. **[I2]**

The Tenderer shall provide detection analysis, including uplink and downlink budgets for 256 NM range; 150 Hz IRF, vertical polar diagrams for the conditions of Annex G and for each of the following transponder reply frequencies:

(a) 1090 MHz

(b) 1087 MHz

(c) 1093 MHz **[I3]**

The Tenderer shall state, for each detection analysis, the All Call and Roll Call period durations, Mode 3/A,C and Mode S All Call IRF. **[I4]**

The Tenderer shall state the achievable plot detection and correct code validation figures for each transmitted mode (3/A, C) for the conditions stated in **[I3]**, assuming that the transponder code responses conform to [Ref.1.] and [Ref.2.]. **[I5]**

The Tenderer shall also include in the proposal details of the minimum number of replies required at the receivers' inputs to detect a target and output a report with an agreed accuracy and level of confidence when interrogating on the following:

(a) Mode 3/A only; **[I6]**

(b) Mode C only; **[I7]**

(c) 3/A, C mode interlace. **[I8]**

For the above, assume that the detected target is subjected to the full target processing in the system, and that it shall be output as a confirmed report. **[A2]**

The Tenderer shall provide in the proposal an analysis of how the system will achieve a theoretical SSR probability of detection better than 99%, for aircraft which are not close (slant range > 2 NM, azimuth > 2 * nominal 3dB interrogation beamwidth), with the following hypotheses:

- 4 interrogations in the 3 dB beam (2 mode A and 2 mode C);
- a transponder probability of reply equal to 90%;
- a target and FRUIT rate as defined in Annex G;
- Mode A/C transponder. **[I9]**

The Tenderer shall detail in the proposal how this probability of detection will be tested in FAT. **[I10]**

4.2.3.2.2 SSR Site Performance

On a site, with the parameters used for the commissioning of the radar, the SSR probability of detection shall be at least 99% for the set of aircraft:

(a) Which are in the Measurement Volume;

(b) Which are not in the zenithal gap (elevation angle below 40);

(c) Which are not in close proximity (slant range > 2 NM, azimuth > 2 * nominal 3dB interrogation beamwidth). **[E2]**

The definition of the above filter is made in order to avoid taking into account problems due to the site or due to the distribution of the traffic between this clear area and the remainder of the radar coverage. **[A1]**

The probability of detection shall be verified at FAT & SAT as defined in section 14.15 **[E4]**

4.2.3.3 Mode S Detection in Selective mode

4.2.3.3.1 Mode S Theoretical Detection

The Tenderer shall provide detection analysis, including uplink and downlink budgets for 80, 150, 200 and 256 NM ranges, vertical polar diagrams for the conditions of Annex G and for each of the following transponder reply frequencies:

(a) 1090 MHz

(b) 1087 MHz

(c) 1093 MHz **[I1]**

The Tenderer shall state, for each detection analysis, the values for antenna rotation speed, range, All Call and Roll Call period durations, Mode 3/A,C and Mode S All Call IRF. **[E1]**

The Tenderer shall state the achievable plot detection and correct Mode S address validation figures for each transmitted Mode S surveillance/SLM replies (Downlink Formats 4, 5, 20 and 21). **[I2]**

The Tenderer shall provide in the proposal an analysis of how the system will achieve a theoretical Mode S probability of detection better than 99%, with the following hypotheses:

- A transponder probability of reply equal to 90%,
- A target and FRUIT rate as defined in Annex G,
- Mode S transponder. **[E2]**

The Tenderer shall explain how, during handover, the probability of detection will be maintained in a cluster whereby each station will share the same II/SI code. **[I4]**

The Tenderer shall detail in the proposal how the probability of detection and the number of re-interrogations will be tested in FAT. **[I5]**

The Tenderer shall detail in the proposal how the probability of detection, during handover, will be tested in the case of operation as part of a cluster whereby each station will share the same II/SI code. **[I6]**

4.2.3.3.2 Mode S Site Performance

For Mode S targets, track reports using external data coming from an adjacent sensor will be considered as extrapolated data and shall not be taken into account as a target report with measured position. **[E1]**

On site, the probability of detection shall be measured when the station does not operate network aided. **[E2]**

On a site, with the parameters used for the commissioning of the radar, the Mode S probability of detection shall be at least 99% for the set of aircraft:

- Which are in the Measurement Volume;
- Which are not in the zenithal gap (elevation angle below 40);
- Which are not in close proximity to each other (slant range > 5.3 NM, azimuth > 2 * nominal 3dB interrogation beamwidth). **[E4]**

The definition of the above filter is made in order to avoid taking into account problems due to the site or due to the distribution of the air traffic between this clear area and the remainder of the radar coverage. **[A1]**

The 99% of probability of detection (defined in **[E4]**) shall be achieved in roll call with, on average, 2 GICB requests per aircraft. **[E6]**

With the probability of detection measured in the volume described above, the Contractor shall provide the average number of interrogations per aircraft. **[I1]**

The probability of detection shall be verified at FAT & SAT as defined in section 14.15. **[E7]**

The Tenderer should anticipate that the verification of probability of detection as defined above will be undertaken for each site using a long duration recording (more than 50,000 reports) and the PTE tool set. **[A3]**

4.2.4 Code Detection without Synchronous Garbling

4.2.4.1 Code Detection and Validation for SSR

4.2.4.1.1 The Mode S system shall detect all Mode 3/A, C, as defined in [Ref.1.] and shall perform a credibility check to remove the possibility of delivering erroneous data to the surveillance users. **[E1]**

4.2.4.1.2 All of the height codes defined in Appendix 1 of [Ref.1.] shall be translated from the corresponding mode C responses and any codes outside the range of values in Appendix 1 shall not be translated from any mode C responses. **[E1]**

4.2.4.1.3 The special civil codes 7500, 7600 and 7700 shall be detected and recognised, as defined in [Ref.1.]. **[E1]**

The special Military Emergency reply train, as defined in [Ref.2.], shall be detected, recognised and the appropriate fields set in the target report. **[E2]**

The special Military Identity reply train, as defined in [Ref.2.], shall be detected, recognised and the appropriate fields set in the target report. **[E3]**

The above codes shall be output immediately upon detection, and not subject to any delay. **[E4]**

The appropriate identifier bits as specified in Ref 5a shall be set in the output message. **[E5]**

4.2.4.1.4 The probability of code detection is defined as, at each scan, for a given target, a radar target report with correct and validated code data, corresponding to the interrogation modes, is produced. **[A1]**

The probability of Mode A/Mode C code detection is determined by the ratio of the number of target reports with correct Mode A/Mode C code data to the number of target reports used to calculate the target position detection. **[A2]**

As a minimum, the overall Mode 3/A probability of correct and valid code detection shall be better than 98% for large samples, without any geographical restrictions, of opportunity traffic. **[E1]**

As a minimum, the overall Mode C probability of correct and valid code detection shall be better than 96% for large samples, without any geographical restrictions, of opportunity traffic. **[E2]**

4.2.4.1.5 It is expected that achieved performance figures will be higher than in 4.2.4.1.4 above. The Tenderer shall provide in the proposal details of the performance figures which the equipment shall be able to meet and state under what conditions. **[I1]**

4.2.4.1.6 The Tenderer should anticipate that the verification of code detection and validation as defined above will be undertaken for each site using large live traffic samples and the PTE tool set. **[A1]**

4.2.4.1.7 As a maximum the percentage of incorrect but validated Mode A codes shall be lower than 0.1%. **[E1]**

4.2.4.1.8 As a maximum, the percentage of incorrect but validated Mode C codes shall be lower than 0.1%. **[E1]**

4.2.4.2 Code Detection and Validation for Mode S

4.2.4.2.1 As a minimum, the ratio of the number of times a target is detected and output with all reply data correct compared to the number of times a target is detected and output shall be at least 99% for all targets replying in Mode S. **[E1]**

4.2.4.2.2 The Tenderer shall provide in the proposal details of the performance figures which the equipment shall be able to meet and state under what conditions. **[I1]**

The Tenderer should anticipate that the verification of code detection and validation as defined above will be undertaken for each site using large live traffic samples and the PTE tool set. **[A1]**

4.2.4.2.3 No more than one message segment containing false data of a Comm-B or Comm-D reply shall be delivered from the Mode S system in 10^7 messages. **[E1]**

4.2.4.2.4 The special civil codes 7500, 7600 and 7700 shall be detected and recognised, as defined in [Ref.1.]. **[E1]**

The above codes shall be output immediately upon detection, and not subject to any delay. **[E2]**

The appropriate identifier bits as specified in Ref 5a shall be set in the output message. **[E3]**

4.2.5 False and Multiple Target Processing (Mode 3/A,C,S)

4.2.5.1 False Target Processing

SSR Target reports generated by one or more of the following shall be classified as false target reports:

(a) FRUIT;

(b) Second time around echoes. **[E1]**

The false target report ratio is the number of false target reports in relation to the number of detected target reports. **[A1]**

The overall false target report ratio shall be less than 0.1%. **[E2]**

The Tenderer shall provide full analysis of the false target processing subject to the FRUIT rates and distribution of Annex G and state the maximum False Target Rate likely to be incurred under the operating conditions described in Annex G paragraphs G.2 and G.4. **[I1]**

The Tenderer shall anticipate that the verification of the false target rate as defined above will be undertaken for each site using the PTE tools set. **[A2]**

4.2.5.2 Multiple Target Processing

Multiple Mode S/SSR target reports shall include all those target reports generated by:

(a) Replies from an aircraft interrogated by the radar via an indirect path (reflection);

(b) Replies from an aircraft interrogated through a sidelobe of the directional antenna pattern and which are not inhibited by the sidelobe suppression antenna pattern (sidelobes);

(c) Target split in several sequences either in azimuth or in distance (splits). **[E1]**

The overall Multiple Mode S/SSR Target Rate, measured over one hour, shall be less than one target per scan on average. **[E2]**

The multiple target processing shall discriminate between false and real, non-unique addressed Mode S targets. The latter shall be flagged in the ASTERIX data item I048/030 Warning Error/Conditions bit 16 "Duplicated or Illegal Mode S Aircraft Address”. **[E3]**

The Tenderer shall provide details in the proposal of candidate methods to achieve such discrimination when targets are detected in the same beam-dwell. **[I1]**

The Tenderer shall provide full analysis of the multiple target processing subject to the FRUIT rates and distribution of Annex G and state the maximum

Multiple Target Rate likely to be incurred under the operating conditions of Annex G. **[I2]**

The Tenderer shall anticipate that the verification of the Multiple Target Rate as defined above will be undertaken for each site using the PTE tools set. **[A1]**

4.2.6 Surveillance Position Accuracy

4.2.6.1 General

The range and azimuth accuracy requirements specified herein shall be the minimum requirements. The Tenderer shall provide as part of the technical proposal:

(a) Detailed accuracy performance characteristics of the proposed equipment; **[E1]**

(b) Any conditions which impact the proposed performance characteristic; **[E2]**

(c) Detailed system level accuracy error budget analysis as described in Annex H. **[E3]**

Existing monopulse SSR system performance characteristics will be used as a benchmark for evaluating the Tenderers proposal. **[A1]**

The conditions, under which the random errors (azimuth and slant range error standard deviation) and systematic errors (azimuth and slant range bias) will be measured, shall be: **[E4]**

(a) Plot position data measured at the output interface to the Surveillance users;

(b) Non garbled pulse reply conditions;

(c) Aircraft within the Commissioning Volume;

(d) Interrogation conditions, received power and frequency levels as stated in Annex G;

(e) Separate measurements for:

  (i) Mode 3/A, C reports;

  (ii) Mode S all call reports;

  (iii) Mode S roll call reports.

(f) Long term effects (i.e., stability with time);

(g) Any combination of units/subsystems which are configured to meet redundancy requirements;

(h) Measurements using the conditions for accuracy test requirements stated elsewhere in this document and as stated by the Tenderer in his proposal.

The Tenderer should anticipate that the verification of accuracy as defined above will be undertaken for each site using some combination of live traffic, the fixed far field monitor, a Target/FRUIT generator and the PTE tool set. **[A2]**

4.2.6.2 Range Accuracy

The Mode S sensor slant range errors, for any modes (3/A, C or S), shall be within the following limits:

(a) Systematic Errors

(i) The slant range bias shall be < +1/128 NM (+14 metres). **[E1]**

(b) Random Errors

(i) All SSR Random errors shall be less than 30 m RMS (1 sigma) **[E2]**

(ii) All Mode S Random errors shall be less than 15 m RMS (1 sigma) **[E3]**

The speed of light value shall be a Site Dependant Parameter programmable, providing 2 values:

(a) The vacuum value (the only internationally recognised one): c = 299,792,458 m.s^{-1};

(b) Another value (to be specified by the Agency) **[E4]**

The programming of this site-dependant parameter shall be possible at the CAM or at the Dedicated Terminal to be delivered. **[E5]**

The Tenderer shall clearly describe the effects of this SDP on the systematic and random range errors. **[I1]**

4.2.6.3 Azimuth accuracy

All detected targets within the stated coverage volume for any modes (3/A, C or S), measured using live traffic or controlled test transponders shall be within the following limits:

(a) Systematic Errors

(i) The azimuth bias for elevation angles between 0 and +6° shall be less than 1 AU (0.022°) where 1 AU represents 360/16384°). **[E1]**

(ii) The azimuth bias for elevation angle values between 6 and +10° shall be lower than 0.033° (excluding ice and wind effects on the antenna). **[E2]**

(b) Random Errors

(i) All azimuth random errors shall be less than 0.068° (one sigma) **[E3]**

The azimuth bias shall not increase at elevation angles more than 10° by an amount attributable to the antenna (e.g. beam widening effects -normally the inverse cosine of the elevation angle). **[E4]**

The system azimuth bias elevation changes attributable to the antenna beam widening at large elevation angles shall be stated by the Tenderer in his proposal. **[I1]**

This value shall be verified by tests of the antenna as part of the overall system test. **[E5]**

4.2.6.4 Bias Adjustment and Stability

The bias null adjustment in range and azimuth shall be applied by site dependent adaptation values. **[E1]**

The bias adjustments for the redundant channels shall be capable of being applied separately and independently such that the system bias requirements are met irrespective of the channel in use. (e.g., the data from either channel must meet the system requirement.). **[E2]**

Operationally compatible calibration procedures, employing these capabilities, shall be developed and used as part of accuracy tests. **[E3]**

Once the system bias values are nulled, the long term measured bias value (bias drift) shall remain within the specified limits, irrespective of the channel in use. **[E4]**

The angular offset shall be adjusted in order to calibrate the angular measurement of the Mode S system to within 1AU (i.e. AU = 0.022°) **[E5]**

4.2.6.5 Range and Azimuth precision

Target range shall be reported to a precision of at least 1/128 NM at all ranges. **[E1]**

Target azimuth shall be reported to a precision of at least 360/16384 (0.022)° at all ranges and azimuths. **[E2]**

The Tenderer should anticipate that the verification of range and azimuth precision as defined above will be undertaken for each site using a Target/FRUIT generator and the PTE tool set. **[A1]**

4.2.6.6 Jumps

Jumps are defined in [Ref.11.] as being reports with positional error higher than 1° in azimuth or 700 m in range. **[A1]**

The overall jump rate, defined in [Ref.11.] as being the number of jumps divided by the number of detected reports, shall be less than 0.05%. **[E1]**

4.2.7 Target Processing

4.2.7.1 Performance with Garbling Targets

4.2.7.1.1 General

4.2.7.1.1.1 It is expected that the achieved performance figures will be higher than the following minimum requirements of 4.2.7.1.2 to 4.2.7.1.5. **[A1]**

It is anticipated that the figures below are achieved for all operational ranges and associated turning rates and IRF specified in Annex G. **[A2]**

The Tenderer shall provide in the proposal details of the performance figures which the equipment shall be able to meet and state under what conditions. **[I1]**

4.2.7.1.1.2 The Tenderer shall include in the proposal a detailed analysis of the resolution and garble performance of their system (including Mode 3/A, C codes and Mode S addresses), stating any conditions for which the requirements of 4.2.7.1 will not be achieved including the limits of relative amplitudes and relative off boresight angles of interfering replies. **[I1]**

4.2.7.1.1.3 The Tenderer shall detail in the proposal how the azimuth's accuracy of the reply is determined. **[I1]**

4.2.7.1.1.4 The system shall be capable of processing up to four discrete, mutually overlapping replies simultaneously rejecting all possible phantoms produced by them, including C2/SPI phantoms. **[E1]**

Genuine targets, including relative targets with C2/SPI spacing, shall not be rejected as phantoms. **[E2]**

The Tenderer shall provide details in the response on his proposed method of handling phantom replies. **[I1]**

4.2.7.1.1.5 The Tenderer shall include in the Power Up Checks a test with simulated targets generated by the TTG function (Test Target Generator). This function shall generate artificial plots within a complete scan to test the basic functionalities of the Link Control (LC). This test process will not result in a plot delivered off the site. **[E1]**

The Tenderer shall provide details in the response of the proposed method of TTG. **[I1]**

4.2.7.1.2 SSR Positional Detection with Garbling Target

4.2.7.1.2.1 Within a separation window area of 0 NM to less than 0.05 NM in range and 0 to 0.6° in azimuth, the overall probability of detecting two SSR targets shall be at least 60%. **[E1]**

4.2.7.1.2.2 Within a separation window area of greater than 0.05 NM to less than 2 NM in range and by less than 0.6° in azimuth, the overall probability of detecting two SSR targets shall be at least 98%. **[E1]**

4.2.7.1.2.3 Within a separation window area less than 2 NM in range and by more than 0.6° and by less than 4.8° in azimuth, the overall probability of detecting two SSR targets shall be at least 98%. **[E1]**

4.2.7.1.2.4 Outside the separation window areas as defined in 4.2.7.1.2.1 to 4.2.7.1.2.3, the probability of detection shall be the same as described in paragraph 4.2.3.1. **[E1]**

The Tenderer should employ a Target/FRUIT Generator and the PTE tool set to verify the average Pd of two SSR Mode 3/A,C targets as defined above. **[A1]**

The Tenderer shall provide guaranteed values for the probability of detecting an SSR target for each of the above defined areas. **[I1]**

4.2.7.1.3 Mode S Detection with Garbling Reply

4.2.7.1.3.1 Whatever the relative position of both targets, the radar shall maintain the Probability of detection specified in 4.2.3 when using selective surveillance interrogations. **[E1]**

The Tenderer shall state in the proposal the expected acquisition performance for both targets when using stochastic acquisition. **[I1]**

4.2.7.1.3.2 If two replies were to be received simultaneously by the radar, The Tenderer shall provide in the proposal details of the probability of detection for a Mode S short and long reply garbled over an overlapping time ‘ t’ as listed below with an SSR or Mode S reply.

(a) t =< 20 microseconds **[I1]**

(b) 20 < t =< 32 microseconds **[I2]**

(c) 32 < t < 64 microseconds **[I3]**

(d) t => 64 microseconds **[I4]**

The Tenderer should anticipate that the verification of Mode S detection with a garbling target as defined above will be undertaken for each site using a Target/FRUIT generator and the PTE tool set. **[A1]**

4.2.7.1.4 SSR Correct Code Detection with Garbling Targets

4.2.7.1.4.1 Within a separation window area of 0 NM to less than 0.05 NM in range and 0 to 0.6° in azimuth, the overall probability of detecting two SSR targets with correct and valid Mode 3/A, Mode C codes shall be at least 30%. **[E1]**

4.2.7.1.4.2 Within a separation window area of greater than 0.05 NM to less than 2 NM in range and by less than 0.6° in azimuth, the overall probability of detecting two SSR targets with correct and valid Mode 3/A, Mode C codes shall be at least 90%. **[E1]**

4.2.7.1.4.3 Within a separation window area less than 2 NM in range and by more than 0.6° and by less than 4.8° in azimuth, the overall probability of detecting two SSR targets with correct and valid Mode 3/A, Mode C codes shall be at least 98%. **[E1]**

The Tenderer should anticipate that the verification of SSR code validation with a garbling target as defined above will be undertaken for each site using a Target/FRUIT generator and the PTE tool set. **[A1]**

4.2.7.1.5 Mode S Decoding Performance with Garbling Replies

4.2.7.1.5.1 Whatever the relative position of both targets, the radar shall maintain the decoding probability and reply integrity specified in 4.2.4.2 for all Mode S selective interrogations. **[E1]**

4.2.7.1.5.2 If two replies were to be received simultaneously by the radar, The Tenderer shall provide in the proposal details of the decoding probability for a Mode S short and long reply garbled over an overlapping time 't' as listed below with an SSR or Mode S reply.

(a) t =< 20 microseconds **[I1]**

(b) 20 < t =< 32 microseconds **[I2]**

(c) 32 < t < 64 microseconds **[I3]**

(d) t => 64 microseconds **[I4]**

The Tenderer should anticipate that the verification of Mode S code validation with a garbling target as defined above will be undertaken for each site using a Target/FRUIT generator and the PTE tool set. **[A1]**

4.2.7.2 Target Loads

4.2.7.2.1 The number of targets to be processed will depend on the operational range of the radar and the range distribution of the targets. For modelling and test purposes the target load shall be assumed to vary with range as shown in G.4. **[A1]**

4.2.7.2.2 The radar systems offered shall be capable of processing at least the following number and distribution of targets from 0.5 NM to 256 NM instrumented range with a rotating antenna turning rate of at least 10 rpm:

(a) A steady state maximum of 900 transponder equipped aircraft in cover; **[E1]**

(b) A large sector peak of 45° containing 25% of the total number of aircraft. Only one large sector peak shall be present in each 90° quadrant; **[E2]**

(c) A small sector peak of 3.5° containing 6% of the total number of aircraft. Two small sector peaks, centrally located within each of two large sector peaks separated by 180° shall be the maximum number of small peaks occurring. **[E3]**

The numbers of targets specified above are considered to be numbers of real targets and do not include false target replies. **[A1]**

The distribution of sectors, described above, is illustrated in Figure 16. **[A2]**

The Tenderer shall state in the proposal details of the minimum processing capabilities for the sectors defined above for each of the scenarios of the following:

(a) All transponders shall be Mode S. **[I1]**

(b) 50% of transponders shall be Mode 3/A,C and 50% shall be Mode S. **[I2]**

(c) 25% of transponders shall be Mode 3/A,C and 75% shall be Mode S. **[I3]**

4.2.7.2.3 The Interrogator-Receiver and System Management Function shall EACH be demonstratively capable of processing without data loss or corruption or overload, and within the maximum system delay (refer to 4.2.7.3.2), the target and FRUIT loads defined by the models in paragraph 4.2.7.2.2 and Annex G with the following additional condition:

(a) The system shall be able to maintain the tracks of up to 12 targets simultaneously through the "Cone of Silence" using historical data, so as to facilitate target to track correlation following the targets exit from the Cone of Silence; **[E1]**

The Tenderer shall provide in the proposal an outline test specification and procedure as part of the Test Strategy, including a description of load models to demonstrate the load capability, taking account of both main beam and sidelobe received replies. **[I1]**

Equipment acceptance testing will be required to demonstrate load processing capability based on the models of this section. **[A1]**

4.2.7.2.4 The Mode S station shall be designed to optimise the number of transactions (i.e. minimising the number of interrogations/replies required for the particular protocol whilst also making most efficient use of the available channel time) by using techniques such as interleaving, azimuth offset and interrogation combination. **[E1]**

The Tenderer shall provide in the proposal details of the methods used in the scheduler to optimise the number of transactions. **[I1]**

If the aircraft indicates in a surveillance reply that data (including Mode A code and Flight ID) is waiting to be extracted from the transponder, the ground station shall be able to extract the data during the same beam dwell, unless the surveillance reply is received in the last roll-call period of the beam dwell. **[E2]**

In the case of absence of a reply to a Comm-A interrogation also used for surveillance purpose, the system shall re-interrogate the aircraft with separated surveillance (UF4, 5) and Comm-A interrogations (UF20, 21), and shall attempt to schedule these new interrogations in the same scan. **[E3]**

The Tenderer shall describe how the above function will be implemented. **[I6]**

For Mode S targets, the system shall extract the Mode A code and BDS 2,0 on acquisition and on change. **[E4]**

Mode A code and BDS 2,0 shall automatically be extracted by the station when the last measured position of the track is older than 18 seconds. **[E5]**

The Tenderer shall include in his proposal details of the Mode S radar's processing capabilities for the uplink and downlink transfer of SLM and ELM, including details of how messages are prioritised. **[I4]**

For the purposes of modelling it shall be assumed that:

(a) The target load distribution conforms with that described in G.4

(b) The interrogation limits for Mode S interrogators are at the maximum as defined in [Ref.1.].

(c) The performance level of Mode S transponders is as defined in [Ref.1.]. **[A2]**

The Tenderer shall clearly state any assumptions made in the response. **[I5]**

4.2.7.3 Processing Delays and Overload Conditions

4.2.7.3.1 The Mode S system shall combine PSR, SSR and Mode S target reports for all instrumented ranges up to 256 NM. **[E1]**

The Input Angle is defined as the angle at which the antenna is pointing when a plot is received by the PAF. **[A1]**

The Output Angle is defined as the angle at which the antenna is pointing when a plot is queued for output to the data transmission system. **[A2]**

The Overload Angle is defined as the maximum angular delay between the input and output angle that can be tolerated. Plots still queued for output to line after the overload angle are subject to data rate control. **[A3]**

The Tenderer shall provide all necessary information about the combination processing:

(a) Criteria used (proximity, quality,.....)

(b) Correlation window (size,....)

(c) Measured position definition for combined plots (weighting,.....)

(d) Processing time **[I1]**

The Tenderer shall state how many SSR/Mode S targets and PSR targets can be combined per second. **[I2]**

The Tenderer shall state how the following cases are processed:

(a) There are multiple PSR targets candidates for combination with one SSR/Mode S target;

(b) There is only one PSR target candidate for combination with several SSR/Mode S targets;

(c) There is one SSR target report candidate for combination with one Mode S target. **[I3]**

4.2.7.3.2 The target delays from the time of illumination by the antenna boresight to the input of the target report to the PAF under full load conditions shall be, for normal continuous scanning, in azimuth order within the equivalent of 45° scanning time. **[E1]**

The total system delay from illumination of the target by the antenna boresight to transmission of the target report from the PAF under full load conditions shall not exceed a time equivalent to 120° of an LVA antenna rotation and shall not exceed more than 2 seconds independent of the turning rate as defined in [Ref.11.]. **[E2]**

The overall Mode S system delay for a co-located system, defined as the overload angle shall be programmable between 0°-120°, but it shall not exceed more than 2 seconds independent of the turning rate. **[E3]**

This will enable the waiting time to be programmed. A larger value will increase the probability of combination. **[A1]**

The Tenderer shall state in the proposal the maximum target and system delays accounting for plot processing delays and full loads, but not accounting for data delays due to output clock rates. **[I1]**

4.2.7.3.3 The Tenderer shall provide in the proposal a budget of the delays incurred by each part of the processing for the load conditions of paragraph 4.2.7.2, Annex G. **[I1]**

4.2.7.3.4 The system shall be able to 'manage' overload or potential target processing delays in excess of the target and reply rates specified in paragraph 4.2.7.2, and Annex G, in particular minimising loss and preventing corruption of target data at the output. **[E1]**

4.2.7.3.4.1 Plot Output Overload

A priority scheme has been defined, from the highest priority information (a) to the lowest (e):

(a) Any Real Time Quality Control* messages, Status, Sector messages, Military and SSR emergencies (7500, 7600, 7700), Mode S alert flags, Military Identity;

(b) Mode S/SSR plots (combined plots if the primary option has been chosen) in the area of interest;

(c) Mode S/SSR plots (combined plots if the primary option has been chosen) not in an area of interest;

(d) Primary only data (if the primary option has been chosen);

(e) Enhanced Surveillance transactions only (inclusive ACAS broadcast). **[A1]**

* Real Time Quality Control messages are delivered each scan to report the system status and health to the Air Traffic Control Centre.

When these Real Time Quality Control messages (test targets) are output to the ATCC users, the corresponding Asterix Category 48 target reports shall be labelled accordingly with the bit "TST" set within the field I048/020" Target Report Descriptor ". **[E1]**

A site-dependant parameter shall enable:

(a) Either to output the RTQC (test targets) to the ATCC users;

(b) Or not to output these RTQC (test targets). **[E2]**

The programming of this site-dependant parameter shall be possible either at the CAM locally or remotely **[E3]**

If processing delays or overloads occur due to limitations at the plot output (eg data transmission link) then reduction shall use the above priority scheme. **[E4]**

The above priority scheme shall reference to an area of interest which shall be defined in data rate control maps. **[E5]**

'Areas of Prime Interest' (a maximum of 1 per sector) are defined in the system in which plots are raised to a higher priority level than those plots not in the 'Area of prime Interest'. The plots which attain the highest priority will be selected for transmission first. **[A2]**

The Tenderer shall describe in the proposal operationally acceptable methods of overload management employed and detail the effects of overload, in particular on the performance of the system, and state the conditions under which data may be lost. **[I1]**

4.2.7.3.4.2 Internal Overloads

Each part of the system processing shall be monitored for overload conditions which shall be reported locally and remotely. **[E1]**

On completion of overload conditions the event shall be reported locally and remotely. **[E2]**

When conditions are such that an overload of the system occurs, the subsequent removal of the overload shall allow the system to recover and to function normally without the need for any manual intervention. **[E3]**

The system shall be able to cope with, and to recover from, any overload caused by an out of specification input loading of PSR plots. **[E4]**

The Tenderer shall describe in the proposal any form of dynamic thresholding or limiting employed to manage overloads by reducing the detection and output of pulses, replies or target reports including:

(a) The point of application of the threshold ie receiver output, reply output. **[I1]**

(b) The conditions under which the threshold is activated. **[I2]**

(c) The effect of the threshold on target detection. **[I3]**

(d) The indications that are provided to show that the threshold is in operation. **[I4]**

(e) The effect on the Surveillance Co-ordination Function **[I5]**

4.2.7.4 Datalink Scenarios

4.2.7.4.1 General

The radar system offered shall be capable of processing the two following data link models. **[E1]**

The Tenderer shall include in the response details of the proposed methods to test the models outlined below, detailing all the assumptions and calculations. **[I1]**

4.2.7.4.2 Datalink Model ‘A’

The aim of this model is to prove the capabilities of the Interrogator Transmitter. **[A1]**

12 aircraft are to be serviced by 5 Mode S scheduling periods in a 40 ms beamwidth. Each schedule is allocated a 5 ms period. The data link transactions which occur are as follows:

(a) Schedule 1: 12 short interrogations (i.e. an UELM reservation is transmitted to each aircraft and assume that the reply from each aircraft includes the DELM announcement);

(b) Schedule 2: 48 Comm Cs are transmitted (i.e. 4 Comm-Cs to each aircraft);

(c) Schedule 3: 12 short interrogations (i.e. a combined DELM reservation and surveillance to each aircraft);

(d) Schedule 4: 12 Comm C (i.e. Extract a single DELM from each aircraft);

(e) Schedule 5: 12 short interrogations are transmitted (i.e. an interrogation combining Comm C and Comm D closeout functions for each aircraft). **[A2]**

The Contractor shall test the above scenario for a defined number of random runs (minimum 250) each using a different time distribution. **[E1]**

The minimum probability of success for each scenario shall be 90%. **[E2]**

Between each of the above Roll-Call schedules, there shall be an All-Call period with a UF11 and a Mode A or C interrogation. **[A3]**

4.2.7.4.3 Datalink model 'B'

The aim of this model is to prove the ability of the RTCC to optimise the scheduling sequence for interrogations and replies subject to constraints of [Ref.1.] on Mode S transponders and Mode S interrogators. **[A1]**

In order to reflect the current strategy for Mode S, to perform Enhanced Surveillance in the early years, the scenarios assume a background rate for GICB on each aircraft. **[A2]**

For each scenario the traffic shall be considered as equally distributed in azimuth, and distributed in range as follows:

(a) Scenario 1

Range NM	5-10	10-20	20-40	40-60	60-80	80-90	90-130	130-150
Distribution	1	3	12	7	7	2	6	10

(b) Scenario 2,3,4

Range NM	5-10	10-20	20-40	40-60	60-80	80-90	90-130	130-150
Distribution	1	1	6	4	3	1	3	5

(c) Scenario 5

Range NM	5-10	10-20	20-40	40-60	60-80	80-90	90-130	130-150
Distribution	0	1	3	2	2	1	1	2

Note: The above definition shall be applicable for a random distribution in each range band. **[A3]**

The site parameters are assumed to be:

(a) Min range: 5 NM

(b) Max range:150 NM

(c) Scan rate: 4 seconds **[A4]**

The normal (background) traffic density is 6 aircraft distributed in all 3.5° sectors, except in two adjacent peak sectors, for scenario 2-5 and a single peak sector for scenario 1. The density of these peak sectors is defined in each scenario. The peak sectors are met only once per scan. The background load can be considered as 1 aircraft every 0.6° **[A5]**

The aircraft involved in the datalink transactions shall always be those aircraft encountered in the first peak sector. **[A6]**

The station operates in multisite mode and each datalink transaction includes all consequent protocol (reservation, closeout etc.). **[A7]**

All requested BDS registers end in '0', and all interrogations elicit a decodable reply. **[A8]**

(a) Scenario 1

   (i) Traffic density: 48 aircraft in 3.5° sector;

   (ii) GICB rate: 1 GICB per aircraft;

   (iii) Datalink transactions: 4 Comm-C and 4 Comm-D on three of them.

(b) Scenario 2

   (i) Traffic density: 24 aircraft in 3.5° sector;

   (ii) GICB rate: 3 GICBs per aircraft.

(c) Scenario 3

   (i) Traffic density: 24 aircraft in 3.5° sector;

   (ii) GICB rate: 2 GICBs per aircraft;

   (iii) Datalink transactions: 16 Comm-C on only two aircraft.

(d) Scenario 4

   (i) Traffic density: 24 aircraft in 3.5° sector;

   (ii) GICB rate: 2 GICBs per aircraft;

   (iii) Datalink transactions: 16 Comm-D on one of them.

(e) Scenario 5

   (i) Traffic density: 12 aircraft in 3.5° sector;

   (ii) GICB rate: 3 GICBs per aircraft;

   (iii) Datalink transactions: 16 Comm-C on three aircraft and 16 Comm-D on three other aircraft.

The Contractor shall test each scenario for a defined number of test runs (minimum 250) with a different range distribution for each test run. **[E1]**

These tests will provide an overall probability of success for the scenario. **[A9]**

A test run will be considered as successful if all the transactions are achieved in one scan. **[A10]**

The minimum probability of success to complete transactions in one scan for each scenario shall be 90%. **[E2]**

4.2.8 Data Link Delays

4.2.8.1 All SVC/MSP packets delivered by an aircraft shall not be delayed more than 2/16th of a scan period (i.e. 44°) from the time of receipt i.e. the reception of the last segment of a frame at the receiver input until the contents of the frame is ready to be transmitted through the GDLP/Local User interface. **[E1]**

The Tenderer shall include in the proposal details of the calculations of what delays would be incurred for the transmission of downlink messages. **[I1]**

All SVC/MSP packets arriving at the GDLP/Local User interface, and not subject to any congestion due to priority management, shall not be delayed for more than 2/16 of a scan period (i.e. 44°) from receiving the last bit in the message from the GDLP/Local User interface, until they are available in the transmitter for transmission to the aircraft. **[E2]**

The Tenderer shall include in the proposal details of the calculations of what delays could be incurred for the transmission of uplink data messages, i.e. from the time of receipt from the GDLP/Local User interface until they are available for transmission to the aircraft. **[I2]**

4.2.8.2 The Mode S station shall be capable of performing the extraction of the ACAS broadcast, not later than one antenna revolution after its announcement subject to the probability of detection described in 4.2.3.1. **[E1]**

4.2.8.3 The Mode S station shall be capable of retrieving the new Mode A code not later than one antenna revolution after detecting the alert flag subject to the probability of detection described in 4.2.3.1. **[E1]**

4.3 SSR Monopulse upgrade

4.3.1 Some states might choose to go to Mode S by upgrading their existing monopulse ground stations. **[A1]**

The Tenderer shall provide details in the proposal of their development plans to upgrade their monopulse systems to Mode S. **[I1]**

The Mode S system shall be designed in such a modular way that by using part of the Mode S system it will be possible to upgrade an SSR monopulse sensor. **[E1]**

4.4 Spare

4.5 Provision for E-SCAN communication only antenna collocation

4.5.1 It is anticipated that E-SCAN will not be used for the first step of the Mode S implementation. **[A1]**

4.6 General Requirements

4.6.1 Equipment Qualification

4.6.1.1 The Mode S Interrogator Receiver, Antenna, System Management Function, Surveillance Co-ordination Function, Data Link Function, Control Monitoring and Local Display System shall be supplied as a fully integrated system. **[E1]**

4.6.1.2 Information shall be included in the proposal on current operational identical equipments and/or field trials previously carried out on the same type and functionally identical equipments to those offered. **[I1]**

4.6.1.3 The statement of compliance and the proposal shall indicate the development stage of the relevant item against the Specified paragraph number. **[E1]**

The Tender Response shall include a complete description of the equipment design along with a development plan for completion of the equipment design. **[E2]**

The Tenderer shall identify in the Tender Response the main elements of the proposed system and whether they are readily available. **[I1]**

The subsystems and equipment which are to be developed shall be identified in the Tender Response and the proportion of development, hardware and software, shall be indicated with timescales in the development plan. **[I2]**

The appointed Contractor shall be required to prove the equipment by factory and site acceptance testing (times and frequency to be decided). **[E3]**

4.6.1.4 The Tenderer shall provide full information on:

(a) The stability of the proposed system, particularly with regard to amplitude and phase variations. **[I1]**

(b) The maintenance requirements of the proposed system **[I2]**

4.6.1.4.1 The Tenderer shall describe in the proposal the setting up and calibration procedures to obtain range and azimuth registration (i.e. north alignment and range zero relative to P3 or P6 synch phase reversal) and quote the accuracy obtainable. **[I1]**

4.6.2 Configuration

4.6.2.1 The system to be supplied shall be dual channel, complete with changeover capability, controlled both locally and remotely by the CAM. **[E1]**

4.6.2.2 Each channel of the dual channel Mode S station shall operate in any of the three operating modes as follows:

(a) Active: the equipment is used for the operation of the station **[E1]**

(b) Stand-by: the equipment is switched on and normally available for operation, i.e. a reconfiguration, automatic or controlled, can take place. **[E2]**

(c) Only the redundant equipment can be in the stand-by mode. **[A1]**

(d) Maintenance: the equipment is under maintenance and is not available for operation. **[E3]**

For dual channel configurations any fault state shall be reported to CAM. **[E4]**

4.6.2.3 In a dual channel system there is only one channel which shall be Active. **[E1]**

Switching from a Stand-by mode to an Active mode is performed according to a 'cold switch-over' procedure by an operator command or by a 'hot switchover ' when the Active equipment fails. **[E2]**

Switching from Active to Stand-by mode is performed by a 'cold switch-over' procedure, by an operator command. **[E3]**

The normal procedure for switching to Maintenance mode is performed from the Stand-by mode, by an operator command. When exiting the Maintenance mode, switching is always performed to Stand-by. **[E4]**

Exiting the Maintenance Mode shall be possible by two mutually exclusive modes: 1) remotely via the CAM; or 2) locally by operator command authorised from the front panel. **[E5]**

4.6.2.4 The 'hot switch-over' procedure shall correspond to a failure of an Active equipment, where an automatic reconfiguration of the processing occurs through switching. **[E1]**

In case of 'hot switch over' the failing channel shall be automatically switched to Maintenance mode. **[E2]**

In the case of failure a 'hot switch-over' shall be inhibited in case of additional failure of the now active channel. **[E3]**

The Tenderer shall include in the proposal details of how the automatic configuration occurs and the effect on the overall system performance. **[I1]**

The switching shall be effective within one antenna revolution after the fault has been detected and comply with the requirements of 6.5.2. **[E4]**

The tenderer shall describe how the failures from the different LRUs and/or functions (Surveillance, SCF, DLF) are managed by the BITE and taken into account for switching decision. **[I2]**

4.6.2.5 The 'cold switch-over' procedure corresponds to the controlled switching of all the processing chains (in local or remote mode). It shall guarantee that no data, essential for surveillance, is lost during the switching. **[E1]**

The 'cold switch-over' shall take one antenna revolution to perform from operator input. **[E2]**

The Tenderer shall provide details in the proposal how the 'cold switch-over' is performed and how it affects the operation of the system. **[I1]**

4.6.3 Equipment Cabinets

4.6.3.1 The Tenderer shall describe in the proposal the means of maintenance and cable access. **[I1]**

Installed cabinets will generally be grouped on a channel basis. **[A1]**

4.6.3.2 The Tenderer shall state in the proposal the height, width, depth and weight of all the major equipment units, including equipment cabinets, identifying their location with respect to each other. **[I1]**

The Tenderer shall state in the proposal the height, width, depth and weight of all additional peripheral devices required to support the system. **[I2]**

The Tenderer shall give power consumption and heat dissipation figures for all the preceding equipment units. **[I3]**

4.6.3.3 The equipment installation shall be such that access to any equipment cabinet, the removal of any sub-unit, PCB, and the use where required of extender cards, external test equipment etc. is not impeded by any adjacent cabinets, units etc. **[E1]**

4.6.3.4 The Tenderer shall state in the proposal where forced air cooling is employed. **[I1]**

4.6.4 Interference

4.6.4.1 The Interrogator Receiver and the System Management Function shall both withstand and recover, with minimum delay, from the effects of cw interference. **[E1]**

At no time shall cw interference saturate or overload any part of the Mode S Ground System. **[E2]**

The receiver shall be capable of operating in the presence of cw (from -95dBm to -20dBm) and pulsed cw interference (illustrated as two overlapping pulse trains (with characteristics of Mode 3/A replies and Mode S preambles, except pulse width from 0.50 to 0.55 us). The first at -40dBm at the RF port, the second at -60dBm and lagging the first with a 0.7 us delay. The quantised output due to the second pulse train must be present); both types of interference may be received over the range 1080 MHz to 1100 MHz. **[E3]**

Following the removal of the detected cw interference replies shall be detected, decoded and processed, 2ms after the end of the interference. **[E4]**

The Tenderer shall provide information on the level and effects of interference that the Mode S ground system can tolerate. **[I1]**

The Tenderer shall state the modes accommodated and specify the level of protection from both ground and airborne IFF/SSR frequency systems that will be achieved. **[I2]**

The Tenderer shall state the reaction and recovery times of the protected system. **[I3]**

4.6.5 Peripheral Devices

4.6.5.1 The number of peripheral equipments required to support the system shall be minimal. **[E1]**

4.6.5.2 The Tenderer shall provide in the proposal a list of the peripheral equipments required to support the system. **[I1]**

All peripheral equipment required to support the operation of the system shall be included in the delivered equipment. **[E1]**

The Tenderer shall provide in the proposal details of all peripheral equipments, including any required for commissioning of the system such as PROM Programmers, special measurement tools, data recording devices etc. **[I2]**

The Specification for any peripheral equipment requirements (e.g. MMI, printer etc) shall be agreed with the Agency. **[E2]**

4.6.5.3 Common and internationally recognised interface standards shall be employed for all peripheral devices. **[E1]**

Wherever possible, the use of common peripheral equipments between different functions is preferred. **[A1]**

4.6.6 Processing Capacity

4.6.6.1 For the maximum loading conditions and for the FRUIT and reflection rates specified in Annex G,

(a) each single processor shall not be utilised for more than 50% of the time when this time stands for a complete antenna revolution. **[E1]**

(b) each single processor shall not be utilised for more than 80% of the time when this time stands for a small sector peak of 3.5°. **[E2]**

The Tenderer shall describe the maximum utilisation of each single processor for a scanning time corresponding to a large sector peak of 45°. **[I1]**

The Tenderer shall state in the proposal the processor utilisation contingencies over and above the maximum loading defined in Annex G **[I2]**

4.6.6.2 The system software shall not take up more than 50% of the available memory allocated for the system software. **[E1]**

The Tenderer shall state in the proposal the available storage contingency for the software for each part of the system. **[I1]**

4.6.6.3 For the maximum loading conditions of Annex G, the amount of Random Access Memory and disc storage in use at any time shall not exceed 50% of that available. **[E1]**

The spare random access memory above shall apply independently to global memory, and all individual processors within the proposed system. **[E2]**

The contingencies above shall be demonstrated and proved to be met during Factory Acceptance Testing of the systems, under maximum load conditions. **[E3]**

The Tenderer shall provide in the proposal an outline of how the achievement of the above contingencies will be demonstrated. **[I1]**

4.6.7 System Response Time

4.6.7.1 The response times of the Mode S system and any associated control and changeover equipment shall be as follows:

(a) For an off-mounted Mode S system, the maximum time between the start-up command of a ground station and the sending of a report on the surveillance line, regardless of the ON/OFF power states of the turning gear and electronics, shall not exceed one minute + two scans period after passing North. **[E1]**

(b) For a off-mounted Mode S system, the maximum time between the start-up command of a ground station and the sending of a report on the surveillance line, with the antenna rotating at its operational rate and with no power applied to the rest of the Mode S system, shall not exceed 21 s + three scans period after passing North. **[E2]**

The Tenderer shall provide in the proposal the maximum system response time for each of the requirements a) to b) above, where "passing North" is assumed to mean "first North crossing after azimuth data is reported as correct by CAM". **[I1]**

4.6.8 System Recovery

4.6.8.1 Upon the restoration of any of the inputs listed below, following a failure of that input, and irrespective of the duration of the failure, the ground station shall be fully restored to the operating conditions that applied before the failure occurred, without the need for any manual intervention:

(a) Azimuth data; **[E1]**

(b) External data clocks; **[E2]**

(c) Mains power supply; **[E3]**

(d) RF and SMF interfaces; **[E4]**

(e) Station CAM. **[E5]**

The Tenderer shall state in the proposal the maximum duration of any interruption of the above external inputs that can occur without affecting or impairing the operational status of the system. **[I1]**

The Tenderer shall state in the proposal for every external input, the effect on the plot assignor function of failure of that input, and the recovery state and recovery time following restoration. **[I2]**

4.6.9 System Expansion

4.6.9.1 It is essential that any proposed system is not only capable of fully meeting the load requirements defined in this Chapter but is also capable of meeting the indicated increases in loading during the life of the equipment. **[A1]**

The Tenderer shall state in his proposal the cost and the possible additional boards that are required to achieve the safety margin described in all the following requirement. **[I1]**

The systems load capacities shall be expandable to accommodate further growth in air traffic movements. **[E1]**

Traffic growth to 120% of the SSR and Mode S target figures specified in the model for target processing capacity shall be attainable without extension of the system delays of 4.2.7.3 and 4.2.8. **[E2]**

The design architecture shall be capable of supporting the above expansion requirements. **[E3]**

The Tenderer shall advise how the above expansion can be achieved. **[I2]**

This increase in capacity shall be attainable for a conventional rotating antenna scan rate of up to 15rpm or background surveillance update rate of 4 secs. **[E4]**

The Tenderer shall state in the proposal the maximum Mode S target, secondary target, and combined target capacities of the proposed system for delays not exceeding those above. **[I3]**

It is assumed that primary echo returns, secondary transponder replies, FRUIT and false target rates should increase in the same proportion as the traffic expansion. **[A2]**

4.6.10 Target Velocity Limits

4.6.10.1 The aircraft population to be controlled includes rotary winged and high performance fixed wing aircraft. Therefore the Mode S radar shall be capable of detecting and processing aircraft operating to the following performance parameters, in any combination. **[E1]**

(a) A steady state speed from 0 kn to 2000 kn; **[E2]**

(b) Spare;

(c) A vertical rate of climb or descent, as reported by the received Mode C data from 0 ft/min to 25000 ft/min; **[E4]**

(d) A vertical rate of climb as in (c) above with no horizontal displacement; **[E5]**

(e) A straight line acceleration/deceleration from any initial velocity in the range 0-2000 kn, from 0.01g to 5g, to achieve a steady state speed of between 0-2000 kn e.g. from 300 kn steady state, accelerating at 2g to 2000 kn. **[E6]**

The Tenderer shall advise what impact a combination of these parameters will have on the Mode S surveillance and datalink performance, particularly for aircraft at less than 25 NM range. **[I1]**

Provision shall be made for the values of the above parameters to be set to any value within the ranges specified. **[E7]**

Civil traffic is defined with the vertical rates and maximum speed defined above and accelerations (transversal and/or longitudinal) up to 2g. **[A1]**

Military traffic is defined with the vertical rates and maximum speed defined above and accelerations (transversal and/or longitudinal) up to 5g. **[A2]**

By default, all performance verifications shall be performed with a station configured to track at least civil traffic **[E8]**

The Contractor shall demonstrate, when configured for military traffic, that the system is capable of meeting the Probability of detection and the accuracy requirements for trajectories covering the military traffic velocity limits. **[E9]**

The Tenderer shall describe in the proposal how this range of aircraft performance will be accommodated and how the values of the above parameters are preset. **[I2]**

4.6.11 Power Up Checks

4.6.11.1 The following requirements will ensure that the radar system is not knowingly returned to service without the correct software/hardware build state or site default parameter settings. **[A1]**

(a) The Mode S system shall confirm the serviceability of RAM on power-up **[E1]**

(b) Each sub-system shall verify that the software issue of each board and prom on power up or reset is current. **[E2]**

(c) The Tenderer shall advise how each sub-system can verify that the hardware issue of each board on power up or reset is current. **[I1]**

(d) The Tenderer shall advise how each sub-system can verify that the site dependent default parameters on power up or reset is current. **[I2]**

In each of the requirements above an error message shall be produced if the test fails, but not cause a reset or shutdown. **[E3]**

The Tenderer shall include in the proposal details of the power up and reset checks. **[I3]**

4.6.12 Site Dependent Parameters

4.6.12.1 Site Dependent Parameters (SDPs) shall, wherever practical, be set by link settings, switches or stored in a suitable non-volatile medium (eg PROM). **[E1]**

SDPs shall not be hard-coded within any software of the system. **[E2]**

The adjustment of any SDPs shall not require any alteration or recompilation of the software. **[E3]**

SDPs contained in a PROM or other suitable medium shall be easily adjustable, for example via a connected terminal, or the local display facility. **[E4]**

It shall be possible to display all operational and ‘key’ site dependent parameters. **[E5]**

The CAM facility shall be employed to re-configure Agency designated operational parameters at the ground station. **[E6]**

Parameters that may be altered via a connected terminal, such as described in 4.6.5, require protection as follows:

(a) It shall only be possible to change parameters with the relevant system in ‘local mode’; **[E7]**

(b) It shall not be possible to configure to ‘remote’ mode with temporary changes present, except by special action which shall ensure that the ATCC is advised of this special status via the CAM for as long as the condition exists; **[E8]**

(c) Unauthorised or inadvertent alterations shall be prevented, e.g. by password entry; **[E9]**

Details of the protection method shall be supplied in the Tender response. **[I1]**

The design approach shall be capable of ensuring that SDPs will not change in the event of a 'switch-over' of the active channel. **[E10]**

4.7 Environmental Conditions

4.7.1 Internal Conditions

4.7.1.1 Any equipment housed within the radar station equipment room(s) shall operate and maintain its full operational performance under the following conditions:

(a) Temperature: 0°C to +40°C **[E1]**

(b) Relative Humidity: 90% (non-condensing at +25°C) **[E2]**

Where it is agreed that COTS equipment may be employed in the radar station equipment room, the following condition is considered acceptable for that equipment:

(a) Humidity 80% (non-condensing at +25°C);

(b) Temperature +10 to +40°C. **[A1]**

4.7.2 External Conditions

4.7.2.1 Any equipment not housed within the radar station equipment room(s) or remote equipment shelter including Far Field Monitor, LVA antenna, turning gear together with any pedestal mounted electronics shall operate and maintain its full operational performance under the following conditions:

(a) Ambient Air Temperature: -40°C to +50°C; **[E1]**

(b) Relative Humidity: Up to 100% (Lower than 90% at 40°C); **[E2]**

(c) Driving Rain: Up to 60 mm/h; **[E3]**

(d) Snow load: Up to 200 kg/m^2 (in or out of operations and in transport); **[E4]**

(e) Solar radiation: 1135 W/m^2h during 4 hours; **[E7]**

(f) Hail: Up to 10 mm at 18 m/s; **[E5]**

(g) Wind resistance:

(i) In operation, bursts up to 160 km/h without frost or ice, up to 130 km/h with 12 mm frost or ice;

(ii) In survival, bursts up to 220km/h, without frost or ice, up to 180 km/h with 12 mm ice or frost. **[E6]**

4.7.2.2 All external equipment antennas and turning gear shall be resilient to salt atmospheres. **[E1]**

DEF-STAN 07-55 Test C6 provides guidance to the salt resilience to be attained. **[A1]**

4.7.2.3 The Tenderer shall provide in the proposal information on the effects on the detection and accuracy performance of 4.2.3 and 4.2.6 for a Mode S radar subject to severe fresh and salt water rime ice formation on the antenna. **[I1]**

The Tenderer shall provide in the proposal information on the effects listed above on the array gain and beam patterns. **[I2]**

The Tenderer shall provide in the proposal information on prevention of rime ice formation and/or recommendations to reduce the effects of these climatic conditions. **[I3]**

4.7.2.4 Full, individual environmental specifications for all external equipment shall be provided in the proposal. **[I1]**

4.7.3 Storage Conditions

4.7.3.1 All types of equipment, including spares, shall be capable of being stored under cover for a period of up to two (2) years at varying temperatures from -40°C to +60°C with an ambient relative humidity ranging from 40% to 90%, damp heat lower than 93% at 40°C without affecting either their operation and performance to specification, or their normal expected operational life. **[E1]**

Where it is agreed that COTS equipment may be employed, the following condition is considered acceptable for that equipment: Humidity 80% (non-condensing at +25°C); Temperature -10 to +60°C. **[A1]**

4.7.3.2 Any equipment with components whose operational life could include time in storage, for example memory devices dependent upon batteries, shall be identified and the appropriate precautions to be taken shall be described in the proposal, together with the maximum storage life. **[I1]**

The equipment items shall be capable of undergoing, in their package, the constraints related to the transport by air, sea or land. **[E1]**

4.8 Radar System Overview

4.8.1 System Interconnections

4.8.1.1 The Tenderer shall provide in the proposal system diagrams for the Mode S system showing the offered system configurations, equipment types and interconnections. **[I1]**

4.8.1.2 Where appropriate, specific details shall be given for signals, data formats etc., particularly where an interface is required between the Mode S system being provided against this specification, and another system outside the scope of this specification. **[I1]**

In other areas, where interface details have yet to be decided, general information shall be given by the Tenderer. The specific details of these interfaces will be defined and agreed with the Agency after contract award. **[I2]**

4.8.1.3 For the rotating antenna the Tenderer shall provide, in the proposal, detailed specifications of the rotating joints, with drawings, to meet the Mode S performance and interface requirements. **[I1]**

4.8.2 System Interfaces

4.8.2.1 The Mode S system shall provide interfaces for:

(a) Surveillance users; **[E1]**

(b) Networked Mode S stations; **[E2]**

(c) Datalink users; **[E3]**

(d) The Control and Monitoring System remote terminal; **[E4]**

(e) Primary Surveillance Radar; **[E5]**

(f) A playback and recording facility; **[E6]**

(g) An RF analysis facility. **[E7]**

4.8.2.2 In accordance with the above the Mode S system shall conform to the requirements of:

(a) [Ref.5.] **[E1]**

(b) [Ref.6.] **[E2]**

(c) [Ref.9.] **[E3]**

(d) [Ref.1.] **[E4]**

(e) [Ref.17.] **[E8]**

The ASTERIX formats described in [Ref.5.] and [Ref.6.] are likely to evolve; the current agreed version shall be used. **[E5]**

Design precautions shall be taken to minimise the impact of, and the effort necessary, to accommodate the introduction of ASTERIX format modifications; in particular to avoid any re-compilation when upgrading these formats. **[E6]**

The contents of the PSR-related data received in Asterix Category 1 and Category 2 shall be translated into the corresponding fields of the data to be delivered to ATCC users (Asterix Category 48 and Category 34) **[E7]**

4.9 Data Transmission

4.9.1 Time Function

4.9.1.1 The equipment shall include a Time Function to provide time to the system (including CAM) for the purpose of synchronisation and time-stamping. **[E1]**

The Time Function shall time-stamp the information using the information provided either by an external source or by an internal clock. **[E2]**

The system shall be capable to be interfaced with two external time sources. **[E3]**

In the event that the external source fails to deliver a time reference, the Time Function shall revert to the internal clock. This condition shall be reflected in the Time Source Status as part of the Station Configuration Status item of the ASTERIX Category 34 messages. **[E4]**

The maximum drift of the internal clock shall be less than 20ms per month. **[E5]**

The Tenderer shall state in the proposal the accuracy, resolution and drift of the internal and external time sources which are used for time-stamping. **[I1]**

The time-stamping process accuracy shall be such that measured position accuracy requirements defined in 4.2.6 are met for all aircraft speeds specified in 4.6.10 (i.e. position errors include those due to time-stamping inaccuracies). **[E6]**

The Tenderer shall state in the proposal at which level and how the time stamping information is effectively derived and output in the following target reports:

(a) For Mode S solo targets;

(b) For SSR solo targets;

(c) For PSR solo targets;

(d) For combined targets. **[I2]**

The Tenderer shall explain clearly in the proposal how the TSV bit of the data item I034/050 will be set, in particular for the following cases:

(a) At start-up;

(b) When the external time signal (e.g. GPS satellites signal) fails;

(c) When the time receivers (e.g. GPS receivers) fail;

(d) When the internal clock fails or drifts out of specification. **[I3]**

The Tenderer shall also state the consequences on the system behaviour (switch-over, data output...). **[I4]**

The Tenderer shall provide detailed information on the protocol and data format used between the external time sources and the Interrogator. **[I5]**

4.9.2 Transmission Network

4.9.2.1 The ground station shall be capable of processing continuously:

(a) Output of ASTERIX Cat 34 and Cat. 48 messages on up to three simultaneous, independently configurable, channels at an average rate of 250 messages/second each; **[E1]**

(b) Time stamping and merging of 32 Sector Messages per 360° rotation; **[E2]**

(c) Conversion of all equipment status messages into the Station Configuration Status message; **[E3]**

(d) Exchange of ASTERIX Cat. 17 messages to/from Surveillance Co-ordination Network at an average rate of 150 messages/second; **[E4]**

(e) Exchange of ASTERIX Cat. 18 messages to/from each of the GDLP/Local User interfaces at an average rate of 150 messages/second. **[E5]**

The Tenderer shall state in the proposal the maximum number of combined plot messages per second that can be processed and output, and under what conditions. All assumptions shall be stated. **[I1]**

Each channel shall be configurable independently in terms of data rate (9.6 to at least 128 Kbps for WAN interfaces and at least 100 MB for LAN interfaces), protocol (X.25 or HDLC Lap-B for WAN and TCP/IP, UDP/IP, IP v4 and v6 for LAN) and physical interface (RS-232/V.24 and a standard supporting RS-422/V.11 balanced circuits for WAN and IEEE 802.3 100BASE-T for LAN). **[E6]**

The type of standard supporting RS-422/V.11 balanced circuits shall be agreed with Agency prior to contract let (e.g. X.21, RS-449, RS-530...). **[E15]**

Channel throughput and protocol requirements differ from application to application (ATCC output, SCN or datalink connection) and are detailed in paragraphs 7.3.2.8, 8.3.1 and 9.2.1. **[A1]**

The HDLC Lap-B data link layer protocol and X.25 packet layer protocol implementations shall comply with the ITU-T/CCITT Recommendation X.25 1988. **[E8]**

The IPv4, IPv6, TCP, and UDP protocols shall comply respectively with the IETF RFC 791, 2460, 793 and 768. **[E16]**

The following restrictions shall be applied to X.25 connections used for the PILOT station:

(a) For SCN connections, only SVCs shall be allowed; **[E9]**

(b) The system shall support SVCs for all other connections; **[E10]**

(c) The address shall conform to the ITU-T X.121 Recommendation (non-TOA/NPI format); **[E12]**

(d) No optional X.25 user facility shall be used unless otherwise agreed with the Agency. **[E13]**

The Tenderer shall provide a completed ISO/IEC PICS Proforma to the Agency for the X.25 (ISO/IEC 8208) and the HDLC Lap-B (ISO/IEC 7776) implementations as part of their proposal, according to [Ref.15.] and [Ref.16.]. **[I3]**

The Tenderer shall provide information on the adaptation of channels to other communication protocols (such as TCP/IP), and other Wide Area Networks (such as frame relay, ATM...). **[I4]**

The Contractor shall provide external conformance certificate of the X.25 and HDLC Lap-B interfaces, by an independent 3rd party, to confirm compliance to the ISO/CCITT/ITU-T standards. **[E14]**

The size of the X25 packets should preferably be up to 512 bytes. **[A2]**

4.9.3 Cross Site Data Transmission

4.9.3.1 Digital and video signals transmitted within the confines of the off-mounted collocated site shall utilise high integrity data transmission methods. **[E1]**

4.9.3.2 The immunity to lightning strike shall be specified and detailed information on the protection methods employed shall be provided in the proposal. **[I1]**

4.9.4 Output Link Management (OLM)

4.9.4.1 The Contractor shall provide each Mode S ground station with a facility to manage the following services: communication to ATCC, SCN, PSR, Local User and GDLP. **[E1]**

A number of physical interfaces, to be defined by the Agency, shall be available to the communication services. **[E2]**

The Agency may choose, for some site configurations, not to have a physical PSR interface. **[A1]**

4.9.4.2 The OLM functionality shall:

(a) Ensure that no single failure condition has a critical consequence on communication services; **[E1]**

(b) Allow physical interface switchover without any resulting radar channel switchover; **[E2]**

(c) Allow radar channel switchover without any resulting physical interface switchover; **[E3]**

(d) Be monitored and controlled by the CAM; **[E4]**

(e) Be monitored by both radar channels; **[E5]**

(f) Allow to assign any communication service to any physical interface; **[E6]**

(g) Allow to assign several communication services to the same physical interface; **[E7]**

(h) Allow to assign several physical interfaces to the same communication service:

(i) To allow diverse routing of the same ATCC data through different physical interfaces;

(ii) To offer to use either two X.25 connections or two TCP/IP connections to access to the SCN;

(iii) To allow each radar channel to be connected to both PSR channels. **[E8]**

The provisions of (g) and (h) are intended to reduce the total number of physical connections, whilst still supporting diverse routing of the ATC outputs and meeting throughput requirements. **[A1]**

When several communication services are assigned to the same physical interface (i.e. multiple SVCs on a DTE-DCE link), the routing of each communication data flow to the right application should be done according to one of the following criteria:

(a) Distant DTE address;

(b) Content of the USER DATA field in Call Requests and Incoming Calls;

(c) Content of the X.121 sub-address. **[A2]**

The Contractor shall perform the above routing according to the criteria to be chosen by the Agency. **[E9]**

The provisions of (h) would still facilitate pre-configurable mapping of DTE or IP addresses to particular services (e.g. SCN). **[A3]**

An example configuration could be:

(a) 2 ATC services (all active);

(b) 1 GDLP service (only one active communication port);

(c) 1 Local User service (only one active communication port);

(d) 1 SCN service for each other node of the cluster (only one active communication port); and

(e) 2 PSR services. **[A5]**

4.10 Test Equipment

4.10.1 The Tenderer shall provide details of all equipment considered necessary to provide analysis of the ground station functionality and interfaces that cannot be achieved using PTE or an equivalent tool. This shall identify which items are available at no cost, and those requiring development. Where development is anticipated an associated plan, describing the proposed timescales, qualification and cost (quoted separately in the Commercial Response) shall be presented in the Tender Response. **[I1]**

4.11 Power

4.11.1 The equipment items shall be connected to a power distribution network supplying a nominal line voltage of 3 phase 400V -6%, +10% of frequency 50Hz +/-2%. **[E1]**

CHAPTER 5

ANTENNA SYSTEM

5.1 LVA Requirements

5.1.1 The requirements for the LVA antenna are specified in Chapter 13. **[A1]**

CHAPTER 6

INTERROGATOR SYSTEM

6.1 General

6.1.1 Introduction

6.1.1.1 The interrogator (Figure 5) shall consist of:

(a) A transmitter, providing sum and control channel output **[E1]**

(b) A monopulse receiver, accepting sum, difference and control channel input. **[E2]**

(c) A video signal process that provides processed Sum, RSLS and OBI signals **[E3]**

(d) An RF changeover unit to allow the standby channel to become the active channel. **[E4]**

The transmitter shall issue Mode S, Mode 3/A,C and Mode 1/2 interrogations and the receiver shall accept the Mode S, Mode 3/A,C and Mode 1/2 replies. **[E5]**

6.1.2 Functions

6.1.2.1 The interrogator shall have the following capabilities:

(a) Interrogation and reception on Modes 3/A, C, S and Modes 1/2; **[E1]**

(b) Mode S only all-call preceding either a Mode 3/A or Mode C interrogation by between 45 microseconds and 128 microseconds timed from the sync phase reversal to the leading edge of the P3, Mode 3/A,C. **[E2]**

(c) Operation on 3 mode interlace programmes, including stochastic All-Call and lockout override as shown in Figure 12; **[E3]**

(d) Operation in azimuth selectable improved interrogator sidelobe suppression (IISLS) for Mode 3/A,C or intermode; **[E4]**

(e) Operation of receiver sidelobe suppression (RSLS); **[E5]**

(f) Output of data suitable for plot processing; **[E6]**

(g) Control of all main functions of the interrogator shall be provided locally and remotely via the CAM interface; **[E7]**

(h) To receive interrogation modulation commands from the RTCC or external test equipment. **[E8]**

6.2 Transmitter

6.2.1 The transmitter shall provide:

(a) One sum channel (Pulse P1, P2, P3, P4 and P6 (with DPSK modulation) transmissions); **[E1]**

(b) One control channel (pulse P2, and P5 transmissions). **[E2]**

The P5 shall be transmitted on the control channel, in the case of Mode S All-Call or selective interrogations. **[E3]**

A detailed description of the interrogator transmitter with block diagram and specification shall be provided in the proposal. **[I1]**

6.2.2 The transmitter shall not require any adjustment or setting up following replacement of any unit. **[E1]**

6.2.3 The transmitter shall not require any regular or preventative maintenance of any unit. **[E1]**

6.2.4 As a minimum, the transmitter shall be capable of operating at a peak duty cycle of 63.7% over 2.4ms length of time. **[E1]**

It is expected that the above requirement can be repeated every 24ms. **[A1]**

The transmitter shall be capable of operating at a duty cycle of at least 5% over a whole scan. **[E2]**

The Tenderer shall include in the proposal information on the Mode S duty cycle capability, including Mode S modes of operation, intermode interlace, power and range performance and transmitter modularity. **[I1]**

6.2.5 The SSR/All-Call period shall be used for the surveillance of Mode A/C transponder equipped aircraft and the acquisition of Mode S transponder equipped aircraft. **[E1]**

The Selective Interrogation period shall be used for the Mode S Roll-Call surveillance and data link transactions. **[E2]**

The internal IRF for the SSR/All call period shall be adjustable from 50Hz to 250Hz with increments no greater than 1Hz. **[E3]**

The SSR/All Call period shall be constant or staggered. The stagger may be a fixed sequence, random or pseudo random (eg 64 stagger periods which are selectable and a deviation of 0% up to +10% in 1/2% steps from the mean IRF). **[E4]**

The Tenderer shall describe the method of stagger generation. **[I1]**

A Mode S only All-Call interrogation shall occur once every ‘m’ SSR/All-Call periods, where ‘m’ shall be a site configurable parameter between 1 to 9 in steps of 1. **[E5]**

6.2.6 Stochastic lockout over-ride shall be selectable to acquire aircraft (see Figure 12 for examples). **[E1]**

The Tenderer shall provide details on how stochastic lockout override shall be implemented in their proposal. **[I1]**

6.2.7 A number of mode programmes shall be selectable on an antenna scan basis. It shall be possible to set-up at least the following mode programmes:

(a) Single SSR Mode; **[E1]**

(b) Dual SSR Mode Interlace; **[E2]**

(c) Triple SSR Mode Interlace (eg A,A,C); **[E3]**

Antenna scan interlace, whereby different triple mode interlaces may be transmitted, each on up to three alternate antenna revolutions shall be available. **[E4]**

Change in interlace shall be applied on the North crossing. **[E5]**

The Tenderer shall state in the proposal the modes and interlace programmes available as standard and as options, including Mode S. **[I1]**

The Tenderer shall describe in the proposal how Mode S interrogations may be selected, interlaced and transmitted. **[I2]**

The triple mode interlace shall include Mode 1 and Mode 2. **[E6]**

6.2.8 A number of programmes shall be selectable on a per sector basis (each sector representing 1/32 antenna revolution). The illumination period for an aircraft by the beam shall be divided into a defined number of intervals. Each interval shall represent one All Call or one Roll Call period. The minimum number and the content of All Call periods shall be defined according to the previous selected antenna scan mode programme, i.e. for two hits per SSR mode:

(a) Single mode: two All Call periods,

(b) Dual mode: four All Call periods

(c) Triple mode interlace: six All Call periods

The interlace of the modes is defined in 6.2.7, and the minimum duration of each All Call period shall be adjustable to the operational range in the particular sector. The total number of intervals shall not exceed 12; and the duration and type of each interval shall be defined separately, but consistently. All parameters associated to the sector scan programme shall be considered as Site Dependent Parameters. **[E1]**

6.2.9 The peak transmitter power output on both the sum and control channels shall be determined from the max. range requirement described in 4.2.2.1. **[E1]**

The Tenderer shall submit uplink and downlink power budget calculations to support the above requirement. **[I1]**

The Tenderer shall state in the proposal the peak output power available. **[I2]**

It shall be possible to vary the output power of the interrogator and control pulses. **[E2]**

Variation of the interrogate and control output powers shall allow a power variation at least over the range from maximum power to 12dB below maximum power. **[E3]**

Output power variation for both interrogate and control outputs shall be in increments no greater than 2.0dB and to an accuracy of at least +1.0dB. **[E4]**

The Tenderer shall state in the proposal the minimum independent power variation between the interrogator and the control pulses, the incremental steps and the accuracy of the incremental steps. **[I3]**

The Tenderer shall provide details in the proposal of the method to vary power depending upon the range of the Mode S transponder equipped aircraft. **[I4]**

6.2.10 It shall be possible to vary the interrogate and control output power, on each selective interrogation, according to the range of the target. **[E1]**

It shall be possible to programme as a function of azimuth over a number of unequal sectors, not less than 32, over 360°, the interrogate and control powers pertinent to both Mode S All Call and SSR operation. **[E2]**

The Tenderer shall describe the method of achieving power variation with azimuth and range. **[I1]**

6.2.11 A system limiting the number of interrogations shall protect the transmitter against overloads and shall guarantee that the requirements as specified in [Ref.1.] para 3.1.2.11.1.2 are not exceeded. **[E1]**

If the limits are exceeded then the surveillance interrogations shall have priority. **[E2]**

The Tenderer shall provide in the proposal details of the protection of the transmitter. **[I1]**

6.2.12 IISLS shall be available for interrogations by transmitting both pulses P1 and P2 on the control channel. **[E1]**

When IISLS is enabled it shall be possible to manually adjust the power of pulse P1,in steps of 1.4° for the azimuth and in steps of 2dB for the power till the decrease does not exceed the level of 6dB below the power of pulse P2. **[E2]**

The Tenderer shall provide in the proposal information on IISLS to clearly show its method of implementation and performance, including the radar range over which it is available, effects on transmitted powers, detection and false targets, particularly in a congested Mode S/SSR environment. **[I1]**

6.3 Receiver

6.3.1 Configuration

6.3.1.1 The receiver shall provide:

(a) Sum, difference and control channels; **[E1]**

(b) Outputs to the receiver video process utilising data from the sum, difference and control channels. **[E2]**

The Tenderer shall provide a detailed description of the receivers with block diagrams and specification in the proposal. **[I1]**

6.3.2 Functions

6.3.2.1 The receiver shall perform the following functions:

(a) RF filtering **[E1]**

(b) RF amplification if necessary **[E2]**

(c) IF conversion, IF filtering and logarithmic IF amplification. **[E3]**

6.4 Receiver Video Processing

6.4.1 Functions

6.4.1.1 The azimuth data, received from the azimuth data generator, shall be decoded and used to determine boresight. **[E1]**

Processed Sum Video, RSLS and Off Boresight Indication signals shall be provided to the RTCC. **[E2]**

SSR and Mode S All Call Processed Sum video, together with OBI, shall be provided for local monitoring. **[E3]**

6.4.1.2 The detected pulse output, following pulse detection and quantisation, shall accurately reflect the received pulse. **[E1]**

The Tenderer is referred to the definition for quantised video for monopulse systems in [Ref.12.]. **[A1]**

6.4.1.3 STC, or an equivalent thresholding method, shall be provided and it shall be possible to select either a linear or programmable action. **[E1]**

6.4.1.4 The off-boresight angle (OBA) look up table shall be site dependent. **[E1]**

The off-boresight angle precision shall be within 0.022°. **[E2]**

6.4.1.5 Monopulse data from received pulses shall be accumulated and checked for long term consistency against the conversion facility, so as to detect any change or drift in the system monopulse azimuth accuracy. **[E1]**

The Tenderers proposal shall include details of any on-line monitoring of monopulse accuracy. **[I1]**

6.4.1.6 The Tenderer shall provide in the proposals details on the receiver channel amplitude and phase response matching requirements of the system offered stating the required tolerances to be maintained in the matching of the channels. **[I1]**

Systems that automatically compensate for any mismatch of channels are preferred. **[A1]**

6.4.1.7 The system maintenance shall not require any adjustment or setting up following the replacement of a unit. **[E1]**

6.5 RF Change-over Unit

6.5.1 The RF Changeover Unit shall enable the in service interrogator to be connected to the antenna and the standby interrogator to be connected to the dummy load. **[E1]**

6.5.2 During changeover the system shall provide uninterrupted service without any corruption to the output surveillance data. **[E1]**

An example of how this could be achieved is to enable the receive signal to be fed to both channels of the dual system. i.e. The standby receiver and processor sub-systems are fed with the same receive signals as the main in service receiver. **[A1]**

For the purpose of this paragraph, “uninterrupted service” is assumed to neglect the finite switching time (<100ms). **[A2]**

6.5.3 The RF Changeover Unit shall only be powered by low voltage d.c. supplies, derived from both channels of the system. **[E1]**

6.5.4 A remote indication of the RF Changeover selection shall be available. **[E1]**

This will enable verification that the channel selected for output is that actually connected to the antenna. **[A1]**

6.5.5 The interruption of transmissions to the antenna when changing over interrogation channels shall meet the requirements of 4.6.2. **[E1]**

6.5.6 The RF Changeover Unit shall retain its selected state in the absence of control signals and power supplies. **[E1]**

An indication to determine which is the Active channel shall be provided. **[E2]**

This will ensure that in the event the equipment is switched off, and there is no further controlling or switching action, the same channels will be connected to the antenna or dummy load when power is returned. **[A1]**

6.5.7 The equipment shall be of passive design and require no routine maintenance. **[E1]**

6.5.8 The design shall include a 20dB bi-directional high power precision coupler in each of the SUM / Difference and control channels to facilitate RF injection and measurement of downlink polar diagrams on Sum, Difference and Control channels. **[E1]**

6.5.9 The Tenderer shall state the Insertion Loss for Transmit and Receive frequencies **[I1]**

6.5.10 The Tenderer shall state the VSWR and Phase shift between Sum and Difference channels **[I1]**

6.5.11 The isolation between ports and channels shall be:

(a) >40dB between channel 1 and channel 2 ports; **[E1]**

(b) >70dB between ports of the same channel (i.e. with the receiver disconnected). **[E2]**

Isolation shall be measured at the RF Changeover Unit with the receiver disconnected, i.e. the test will be performed with sigma, delta and omega disconnected. **[A1]**

CHAPTER 7

SYSTEM MANAGEMENT FUNCTION

7.1 General

7.1.1 Configuration

7.1.1.1 The System Management Function (SMF, Figure 6) controls all the activity on the RF channels. **[A1]**

The SMF shall be considered as containing the following sub-functions:

(a) Real Time Channel Controller (RTCC) containing:

- (i) a Mode A/C reply processor
- (ii) a Mode S reply processor
- (iii) an interrogation scheduler

(b) Link Controller (LC) containing:

- (i) Plot Assignor Function (PAF)
- (ii) Station Roll-Call lists
- (iii) Mode S Link Management Processor (LMP)
- (iv) Communications Management Processor (CMP) **[E1]**

The Tenderer shall include in the proposal a block diagram showing the functionality and input/output ports of the SMF and detail any differences and the reason for the different approach. **[I1]**

7.1.2 General Requirements

7.1.2.1 The SMF shall be able to receive and process reply data from the interrogator when it is receiving replies consistent with the requirements of G.4. **[E1]**

It shall form plots for all aircraft and output them to ATC and to the monitor display. **[E2]**

The SMF shall be able to take in uplink data link transactions from the DLF, process and output them to the interrogator, at a rate which equals the maximum interrogation rates specified in [Ref.1.] when combined with the surveillance update interrogations. **[E3]**

The surveillance update interrogations shall have had priority over the data link interrogations should the interrogation rates exceed the defined limits. **[E4]**

It shall also be able to process downlink data link transactions generated both by requests from the ground system and by transactions initiated by the airborne system. **[E5]**

The Tenderer shall include in the proposal details of the SMF. **[I1]**

7.1.3 Interfaces

7.1.3.1 The SMF will have interfaces to:

(a) The antenna system, to receive information on the azimuth of the boresight of the beam when replies are received; **[E1]**

(b) The interrogator:

(i) To send interrogation modulation commands (including power level, probability of reply and Lockout flags) and data content; **[E2]**

(ii) To obtain processed video and Off Boresight Information (OBI) for all reply pulses. **[E3]**

(c) ATCC, to provide ASTERIX. Cat 34, Cat 48 data (each interface being dual channel); **[E4]**

(d) The DLF to obtain data link transactions for sending to the aircraft, and to send received downlink data link transactions to the DLF; **[E5]**

(e) The SCF to obtain information on aircraft acquired through SCN, and details of aircraft for which the ground station is responsible for surveillance and data link; **[E6]**

(f) Control and Monitoring to enable the control and monitoring functions to be performed; **[E7]**

(g) External time source to serve as a time reference and permit time stamping of plots etc... **[E8]**

The Tenderer shall include in the proposals details of any changes/additions/deletions etc... to the interfaces outlined above, stating the reasons for the different approach. **[I1]**

7.2 Real Time Channel Controller (RTCC)

7.2.1 The RTCC (Figure 7), by using interrogation algorithms, employing interleaving and azimuth off-set techniques (where message delivery azimuth is optimised with respect to interrogation type and priority) combined with the data-link and Mode S specific services interrogation requests from the LC, shall schedule the interrogations to be sent to the transmitter. **[E1]**

The resulting replies received from the video processor function are processed by the Mode A/C reply processor and the Mode S processor to create a report for each reply before it is sent to the LC. **[E2]**

A Mode S Reply Report is defined as a Mode S summary report with, as a minimum, Address, associated position, message data and status (eg reservation) for all successful transactions to a given target in the beam-dwell. **[A1]**

An SSR Reply Report is defined as an SSR report with, as a minimum, positional information correlated from all the decoded replies associated with the target received during the beam-dwell. **[A2]**

The tenderer shall provide information on how the system will proceed if a valid Mode 'S' reply is not decoded in the expected listening period. **[I3]**

The RTCC shall also perform automatic extraction for Air Initiated Comm B (AICB). **[E4]**

The overall rate of (re-)interrogation required to obtain a valid selective reply shall be used as a performance monitoring indicator. This indicator shall be obtained by dividing the number of roll-call interrogations actually performed by the number of expected roll-call interrogations. **[E5]**

As an example, there will be 1 expected interrogation if 0 or 1 GICB extraction per scan is programmed and 2 expected interrogations if 2 GICBs are required per scan. **[A3]**

The Tenderer shall provide detailed information on how this performance monitoring indicator will be computed and reported. **[I3]**

As a minimum, the Mode S Reply Processing shall perform preamble detection and error detection and correction **[E6]**

The Tenderer shall include in the proposal details of the operation of the RTCC, including details of the Mode A/C Reply Process, Mode S reply process, scheduler and performance monitoring indicator.. **[I1]**

As part of the acquisition process, the system shall extract:

(a) BDS 1,0; and

(b) if bit 33 of BDS 1,0 is set then extract BDS 2,0; and

(c) if bit 25 of BDS1,0 is set then extract BDS 1,7 and BDS 1,D **[E7]**

The Tenderer shall provide detailed information on the Acquisition Processing of Mode S targets (in particular the delay in completing the acquisition process; algorithms used in the form of pseudo-code, extraction of CA field, BDS 1,0, BDS 2,0, BDS 1,7, BDS 1,D, and impact on the Asterix output data.....) **[I2]**

The Tenderer is advised that the following modification has been proposed, in combination with a procedure where the ATCO would request the pilot to transmit an SPI, to mitigate for the potential lack of detection of alert conditions when targets are missed for more than 18s: Upon reception of a

Mode S reply with a FS field equal to 4 or 5 (i.e.,SPI), the system shall for the corresponding target:

(a) restart the acquisition process as defined in 7.2.1 [E7] in order to re-acquire airborne information only acquired at track initialisation or on change (aircraft capabilities, Mode A code, Aircraft Identification), and

(b) optionally re-establish the data-flash contracts previously established if still supported. **[A4]**

The SPI announcement will last for 18 +/- 1s and the acquisition process may last for several scans. It is therefore recommended to complete an acquisition process before starting a new one. **[A5]**

When the SPI remains set for a long period of time the system should foresee to re-acquire data at a given configurable time interval in order to avoid to stay in a continuous acquisition process. **[A6]**

7.2.2 The interrogation scheduler shall:

(a) Control the rate and content of the Mode S only All Call interrogations; **[E1]**

(b) Control variable all call interrogation scheduling (which allows for the concatenation of Roll Call periods for extended datalink activities); **[E7]**

(c) Control the rate of output of intermode A/C/S All Call interrogations; **[E2]**

(d) Control the rate of output if intermode A/C only all Call interrogations; **[E3]**

(e) Control the rate and output of Mode 3/A and C interrogations; **[E4]**

(f) Control the timing of the Mode S selective interrogations; **[E5]**

(g) Provide an interface to record the Mode A/C and Mode S reports. **[E6]**

7.3 Link Controller (LC)

7.3.1 General

7.3.1.1 The LC (Figure 8) shall pass data-link and Mode S specific services requested interrogations to the RTCC for action. **[E1]**

The Mode A/C and the Mode S replies received from the RTCC are sent to the Plot Assignor Function (PAF) in order to track targets. **[E2]**

Correlation with the corresponding PSR shall be performed by the PAF. **[E3]**

Data link information shall be sent to the appropriate interfaces, except some GICB replies which can be passed also directly to plot formatting for delivery as Enhanced Surveillance data [Ref.5.]. **[E4]**

The Tenderer shall provide information on how he will achieve the enhancement of plot data in ASTERIX format. **[I1]**

7.3.1.2 When a reply is not required from the aircraft, the RTCC shall inform the LC whether an interrogation has been sent. **[E1]**

7.3.2 Plot Assignor Function (PAF)

7.3.2.1 The PAF shall include at least the following sub-functions:

(a) False target processing that can discriminate against reflected replies, FRUIT replies, split targets, ring around targets and distinguish between multiple occurrence of targets in the same beam dwell, with the same non-unique address; **[E1]**

(b) Track initialisation, maintenance and prediction; **[E2]**

(c) Track association and combination of primary and secondary radar data; **[E3]**

(d) ASTERIX plot formatting which delivers Cat 48 and Cat 34 data, and for Mode S targets appends plot messages for delivery of Enhanced Surveillance data to the ATC. **[E4]**

7.3.2.2 A track shall be initialised and maintained, both upon detection (SSR and Mode S aircraft) or upon receiving supplementary data (Mode S aircraft only). **[E1]**

The PAF shall track all the aircraft, including aircraft with duplicated addresses and shall maintain the Roll Call list. **[E2]**

Aircraft information shall be sent to the ATCC and a track initiated for a Mode A/C transponder equipped aircraft that has been confirmed to be in the surveillance responsibility area. **[E9]**

The Tenderer shall describe how a report is localised in the coverage map when the report lacks credible altitude information (PSR or Mode S/SSR target without credible altitude code). **[I6]**

Aircraft information shall be sent to the ATCC and a track initiated for a Mode S transponder equipped aircraft that has been confirmed to be in the surveillance responsibility area, and:

(a) At least one All Call reply has been detected and confirmed by a selective surveillance reply or **[E3]**

(b) A selective surveillance reply has been received from a selective interrogation which was initiated by supplementary data from the SCF. **[E4]**

At track initiation, the first roll call reply will normally provide altitude information. As this is the first reply received, then it will not be possible to perform the credibility check. However, it can be assumed that in the majority of cases the altitude information will be valid. For this reason, the altitude information can be used to determine the surveillance responsibility. **[A1]**

When a Mode S aircraft is detected in the lockout map, the station shall apply as soon as possible the all call lockout protocol defined in that map. **[E11]**

The Mode C shall be updated on the track for each antenna revolution. **[E5]**

Aircraft surveillance data and measured position information shall be sent for every antenna revolution until the track is cancelled. **[E6]**

The position information shall originate, by decreasing priority, from a detection (All- Call or a selective surveillance reply), or from an extrapolation (miss). **[E7]**

An operational parameter, when enabled, shall force the output of extrapolated target reports to Local Display and/or ATCC in case of miss. **[E14]**

Position information originating from extrapolation, if sent, shall be flagged accordingly. **[E8]**

An operational parameter, when enabled, shall force the output of target reports to ATCC, containing at least position (range, azimuth and altitude) and identification (Mode A and, if applicable, Aircraft ID), after a user selectable number of scans following first detection (minimum 1, i.e. on the second scan), provided the corresponding target has been confirmed to be in the surveillance responsibility area. **[E12]**

An operational parameter, when enabled, shall force the output of target reports to ATCC (irrespective of the detection type, e.g. 3/A, C, Roll Call and All Call), after a user selectable number of scans following first detection (minimum 0, i.e. on the first scan). **[E10]**

Such forced target output may be preferable for approach radar in order to track as soon as possible taking-off targets. **[A2]**

This mode of operation shall be limited to user defined geographical areas, and the resulting “early reports” reserved to selected ATCC outputs. **[E13]**

The rules stated in [E3] and [E9] may not always be met in the mode described in [E10]. **[A3]**

The Tenderer shall provide detailed information (in particular, algorithms used in the form of pseudo-code, impact on the ASTERIX output data…) on the processing required to initiate a track and deliver an SSR report to the ATCC. This information, supported by field data analysis results, should take the form of a probability of initialising and delivering a SSR report to the ATCC output in function of time. **[I1]**

The Tenderer shall provide detailed information (in particular, algorithms used in the form of pseudo-code, impact on the ASTERIX output data…) on the processing required to initiate a track and deliver a Mode S report to the ATCC. This information, supported by field data analysis results, should take the form of a probability of initialising and delivering a Mode S report to the ATCC output in function of time. **[I2]**

The Tenderer shall provide detailed information (in particular algorithms used in form of pseudo-code, impact on the Asterix output data.....) on the track processing in particular concerning the following points:

(a) Type of filter e.g., Alpha/Beta-filter, Kalman Filter;

(b) Algorithms used;

(c) Slant range correction;

(d) Tracking in rho/Theta or X,Y;

(e) Method of projection used. **[I3]**

The Tenderer shall provide detailed information (in particular algorithms used in form of pseudo-code, impact on the Asterix output data.....) on the following points related to the delivery of a SSR report to the ATCC:

(a) Resolution of multiple assignment;

(b) Combining of Split Plots;

(c) Code Swapping;

(d) Code Validation;

(e) Code Change;

(f) Mode C Credibility Checking. **[I4]**

The Tenderer shall provide detailed information (in particular algorithms used in form of pseudo-code, impact on the Asterix output data.....) on the following point related to the delivery of a Mode S report to the ATCC: Mode C Code Validation and Credibility Checking. **[I5]**

7.3.2.3 A track shall be cancelled when:

(a) An aircraft traverses from a cell with Surveillance Responsibility to one without (there is no need to coast), or **[E1]**

(b) the track is not in the cone of silence and has not been updated within three antenna revolutions and no additional information has been received during that time period from neighbouring stations. **[E2]**

7.3.2.4 Reflection Suppression

Target reports identified as reflections shall not be output as genuine targets but all the tracks including those consisting of false targets shall be initiated and maintained. **[E1]**

7.3.2.5 False targets due to any of the causes listed below shall be identified (marked) as false in the category indicated and shall be rejected (ie not output as genuine targets):

(a) False targets due to multipath; **[E1]**

(b) False targets at similar range to, but at different azimuths from, an originating genuine target at short range shall be identified as 'ringaround'; **[E2]**

(c) False targets at similar azimuths to, but at increasingly longer ranges from an originating genuine target shall be identified as 'in-line multipath'; **[E3]**

(d) False targets split from an originating genuine target due to antenna beam distortion or splitting as a result of multipath or local obstruction diffraction shall be identified as 'splits'; **[E4]**

(e) False targets with angular separations from an originating target due to reflection of the interrogations and/or transponder responses by reflecting surfaces in the signal paths shall be identified as 'reflections'. **[E5]**

7.3.2.6 Mode A/C Reflection Processing

The processing shall continuously and automatically locate and identify the orientation and position of the reflecting objects within range of the radar by analysis of the geometry of reflection data from targets with unique codes. **[E1]**

The reflector data shall be used to maintain dynamic reflector surface data. **[E2]**

It shall be possible to program into the PAF reflector surface position and orientation data for permanent reflectors, such as hangars. **[E3]**

The processing shall employ the reflector data stored in the dynamic and permanent reflector surfaces to identify reflections by analysing the geometry of the real target, the reflections and the stored reflector data. **[E4]**

The Tenderer shall provide detailed information on the methods proposed to eliminate both permanent and dynamic reflection surfaces. **[I1]**

The Tenderer shall state in the proposal the reflector storage capacities and the method of handling both the permanent and dynamic reflecting surfaces. **[I2]**

7.3.2.7 Mode S Reflection Processing

The Tenderer shall include in the proposal details of the Mode S reflection processing. **[I1]**

7.3.2.8 Surveillance Data Output

The network protocol for transmitting the surveillance data to ATCC shall be X.25 or HDLC Lap-B, up to a 128 Kbps maximum output rate for WAN protocols or UDP/IP (unicast or multicast over IPv4 or IPv6), TCP/IP(client or server over IPv4 or IPv6) for LAN protocols. **[E1]**

The type of the protocol used shall be a site dependent parameter. **[E2]**

7.3.3 Station Roll-Call List

7.3.3.1 The Station Roll-Call List shall contain at least identification and positional information on targets that the station is tracking. **[E1]**

7.3.3.2 The PAF will maintain the station Roll Call list and the SCF will update it. The CMP and the SCF will use the station Roll Call list to ensure that requesting applications will be able to send interrogations to the required aircraft via the ground station. **[E1]**

7.3.4 Communication Management Processor (CMP)

7.3.4.1 The CMP processes all requests for data link transactions which are input to it from the DLF. It is responsible for co-ordination of interrogation instructions. **[E1]**

The data packets are passed to the scheduler for transmission and the Mode S downlink information is received from the PAF via the LMP to pass onto the DLF. **[E2]**

An aircraft shall be reported to the GDLP in accordance with [Ref.9.]. **[E3]**

An aircraft shall be reported to the GDLP as leaving when the aircraft is leaving the datalink coverage map or if no reply to a selective interrogation reply has been received for more than three antenna revolutions. **[E4]**

The CMP shall operate flow control procedures when it is unable to process the incoming requests received from the GDLP / Local User Interface. **[E5]**

The operation of flow control shall be reported in the appropriate fields in the ASTERIX Cat. 18 messages of [Ref.6.]b. **[E6]**

7.3.5 Mode S Link Management Process (LMP)

7.3.5.1 The LMP shall control all the Mode S link activities except Mode S All -Call interrogations which are controlled directly by the RTCC. **[E1]**

The LMP shall schedule the interrogations which result in the acquisition of Mode S aircraft from the replies being formed into plots and tracked in the PAF which in turn ensures that they are presented to the Roll Call List. **[E2]**

For each target on the Station Roll Call List that the ground station is responsible for, and for new targets input from the SCF, the LMP shall assemble and send interrogation instructions to the RTCC. **[E3]**

The LMP shall take the Mode S frames from the queues in the CMP, highest priority queue first, and form them into interrogation instructions to send to the RTCC. **[E4]**

They shall be delivered in azimuth order and with control information to ensure that a sequence of interrogations to a particular aircraft (e.g. Linked Comm A or UELM with its reservation and close out) can be maintained. **[E5]**

The LMP shall take Mode S reply status information (e.g. successful or failed delivery) to enable it to perform frame repair by making new attempts at succeeding polling intervals and report the final result to the CMP. **[E6]**

The Tenderer shall include details in the proposal of the functions of the LMP. **[I1]**

7.3.5.2 A transaction shall be considered as a failure if it is not completed within the time delays given below, from the moment when the first interrogation concerning it is transmitted. **[E1]**

Transaction Type	Typical values (in antenna revolutions)
Comm A (1 to 4 segments)	3
Comm B (1 to 4 segments)	3
Comm C (2 to 16 segments)	4
Comm D (1 to 16 segments)	5

These values shall be adjusted separately for each type of transaction between 1 and 20 antenna revolutions. **[E2]**

The Tenderer shall include in the proposal details of how the above is to be managed and implemented. **[I1]**

CHAPTER 8

SURVEILLANCE CO-ORDINATION FUNCTION

8.1 Overall Objective

The overall objective of Surveillance Co-ordination is to allow any Mode S ground station to operate effectively within any radar siting plan, while keeping the levels of RF pollution as low as possible. This means preventing interference between stations by the correct use of II/SI codes, Mode S protocols, transponder All-Call lockout, coverage map configuration and target handover. **[A1]**

The SCF function achieves this by ensuring co-operation between stations operating as part of a networked cluster. **[A2]**

The cluster modes of operation and the interfaces are defined in more detail in the SCN ICD [Ref.1.]. **[A3]**

8.2 Overview

8.2.1 Global Operation

The ground station shall be capable of operating as part of a networked cluster of ground stations as outlined in section 3.2, whereby each station in the cluster will share the same code. **[E1]**

The National Authorities will provide the main communications structure required for the operational Surveillance Co-ordination Network. II/SI code allocation schemes will ensure that Mode S will operate without interference in Europe. These schemes will provide the II/SI code and cluster configurations required to meet operational requirements and siting plans. **[A1]**

When operating as part of a cluster, each station shall advise other cluster stations of the arrival of aircraft in their respective coverage as defined in the ICD for Intersite Co-ordination [Ref.1.]. **[E2]**

The station shall acquire the aircraft by placing it on the Roll-Call List and sending it a surveillance interrogation. (This aircraft is already locked out on the same II/SI code, therefore it does not respond to an All-Call). **[E3]**

The SCF shall provide track data to adjacent stations within a cluster upon request. **[E4]**

The SCF shall be designed to minimise the amount or extent of II/SI code reconfiguration. **[E5]**

The SCF shall be designed to interface with up to 5 other Mode S stations, as well as a Cluster Controller, if present, via the Surveillance Co-ordination Network (SCN). **[E6]**

8.2.2 Description of Cluster Operation and modes

When operating as part of a cluster (i.e. the stations are connected to the SCN) the station's operation is termed 'Network Aided'. This operation will include two 'modes', which are central and distributed. **[A1]**

In central mode, the station shall operate with the coverage map and II/SI code determined by the Cluster Controller (CC). **[E1]**

In distributed mode, the coverage map and II/SI code shall be selected by the algorithm as defined in [Ref.1.] operating at the radar node. **[E2]**

In addition to network aided operation within a cluster, the SCF shall also support 'Standalone' operation, when ground stations are not connected to the Surveillance Co-ordination Network (SCN). **[E3]**

8.2.3 Operation and Mode Transitions

When performed manually by operational staff, the connection or disconnection of the station to the SCN shall be possible either locally or through the CAM. **[E2]**

Transitions shall proceed according to the rules detailed in [Ref.1.]. **[E5]**

The addition of a station to the cluster shall be achieved without disruption to the operational service. **[E6]**

The Tenderer shall describe, in the Tender Response, a method to achieve the above. **[I1]**

8.2.4 Failure recovery

The handling and recovery of failures shall proceed according to the rules detailed in [Ref.1.]. **[E1]**

For node failure, the Tenderer is referred to the method used to set the NOGO bit in ASTERIX item I034/050 ([Ref.5.]). **[A1]**

If the node is NOGO then it shall not be part of the cluster. **[E4]**

The node shall be removed from the cluster by disabling the SCN connection. **[E5]**

When a node's NOGO bit is subsequently cleared, its SCN connection shall be re-enabled. **[E6]**

The NOGO bit shall be changed by the node's internal test logic 'BITE'. The NOGO bit in Cat 34/050 is automatically set to 0 whenever the system is active and therefore released for operational use. **[E8]**

All network and nodal failures shall be reported to the CAM. **[E9]**

8.3 Functionality

8.3.1 The SCF shall include the following:

(a) Coverage maps indicating the surveillance, lockout and datalink coverage to be maintained, as defined in [Ref.13.]; **[E1]**

The extent of each cell shall be as defined in [Ref.13.] and the radar coverage limit shall be adapted to the border of the cell; **[E2]**

(b) A means to add or delete targets to the station Roll-Call list in accordance with the SCF state; **[E3]**

(c) A network system status list containing information on the latest SCF state; **[E4]**

(d) A network control and failure control process which contains the processing and protocols required to maintain the station within the cluster; **[E5]**

(e) A communication interface to the SCN. The interface shall support the exchange of ASTERIX messages for surveillance co-ordination as defined in [Ref.1.]; **[E6]**

(f) A track acquisition and support protocol to ensure that any interrogator is aware of any new track entering its coverage, and used by a radar to request track information from a neighbouring node when a track miss has occurred, as detailed in [Ref.1.]. **[E7]**

8.3.2 Provision for intermittent lock-out shall be made in a selected area which shall be detailed in the lock-out responsibility coverage map. In these areas the station shall send lockout instructions for an aircraft on one scan only. The station shall continue to perform surveillance on the aircraft without sending any more lockout instructions until the aircraft responds to an All-Call. Following reception of an All-Call reply, the station shall wait for a given period and then repeat the above procedure. **[E1]**

The above timer value shall be a site dependent parameter (from 0 to 30s, with a step of 1s). **[E2]**

8.3.3 Provision for Lockout over-ride shall be made in selected sectors, determined from the lock-out override coverage map, within which the station shall interrogate the Mode S aircraft during the All Call period by using a value of PR as indicated in the example of Figure 12. **[E1]**

8.3.4 Spare.

8.3.5 The Contractor shall provide a facility to allow the loading of coverage maps compliant with [Ref.13.] into the radar system software. **[E1]**

The coverage maps will be provided, in the format defined in [Ref.13.], by the Agency. **[A1]**

8.3.6 The Tenderer shall provide details in the response of how the following processes operate:

(a) Station Roll Call list; **[I1]**

(b) Periodic Monitoring Process; **[I2]**

(c) Network and Failure Management Process; **[I3]**

(d) Coverage Map; **[I4]**

(e) Network System Status List; **[I5]**

(f) Network Link. **[I6]**

8.3.7 It shall be possible to load another solution list for the ground station without affecting its current operation. **[E1]**

It shall be possible to set the date and time at which the update of a solution list becomes effective. **[E2]**

When this new solution list becomes effective, the radar shall first operate standalone. **[E3]**

8.3.8 The Surveillance Co-ordination Function shall provide a Co-ordinate Transformation as defined in [Ref.6.]a, Annex A, to the local co-ordinate set for the track data received from the connected stations. **[E1]**

The Surveillance Co-ordination Function shall provide a Co-ordinate Transformation as defined in [Ref.6.]a, Annex A, from the local co-ordinate set for track data sent to connected stations. **[E2]**

CHAPTER 9

DATA LINK FUNCTION

9.1 General

9.1.1 The Data Link Function (DLF) provides the functionality to support the air/ground data link and is illustrated in Figure 13. **[A1]**

9.1.2 The DLF shall include the functionality of the Specific Service Entity, as defined by section 5.2.7 of Mode S Subnetwork SARPs [Ref.3.]. It shall support all the Mode S Specific Services, namely Ground Initiated Comm Bs (GICBs), Broadcast Comm Bs, Broadcast Comm As and the Mode S Specific Protocol (MSP). **[E1]**

9.1.3 The DLF shall also include the Frame Processing function as defined by section 5.2.2 of Mode S Subnetwork SARPs [Ref.3.] to support Switched Virtual Circuit communication over the Mode S Subnetwork via the Ground Data Link Processor. **[E1]**

9.2 DLF Functionality

9.2.1 The DLF shall have two interfaces, one to receive/send data to the GDLP and the other an interface to a Local User. **[E1]**

The data formats that shall be used are defined in [Ref.6.](b). **[E2]**

The DLF shall be able to support simultaneous operation with both a GDLP and Local User. **[E3]**

The DLF shall enable the connection to the GDLP and the Local User via X.25 and/or through HDLC Lap-B. The minimum throughput shall be 19.2 Kbps, and shall be configurable up to 128 Kbps. **[E4]**

The type of the protocol used shall be a site dependent parameter. **[E5]**

9.2.2 The DLF shall contain the following:

(a) The DLF-GDLP packet level interface that sends and receives data (i.e. SVC requests and Mode S Specific Services) from the GDLP to the DLF as defined in [Ref.9.]; **[E1]**

(b) The DLF-Local User packet level interface that sends and receives Mode S Specific Service requests from the Local User interface to the DLF as defined in [Ref.9.]; **[E2]**

(c) The Internal Applications that allow pre-configured GICB extractions and Dataflash contracts. These Internal Applications can be accessed locally/remotely via the CAM or a dedicated terminal; **[E3]**

(d) The Broadcast Manager shall process the broadcast requests from the DLF-GDLP interface, the DLF Local User Interface. **[E4]**
The Broadcast Manager shall send all downlink broadcasts to the GDLP, Local User and Internal Applications. **[E5]**

(e) The GICB Manager shall combine duplicated GICB requests onto a single data flow. The GICB Manager shall send the responses to the requesting applications. **[E6]**

(f) The SVC/MSP Manager shall manage the uplink and downlink SVC/MSP data flows, perform the frame processing and multiplexing functions and shall not perform L, M and S bit processing as defined in [Ref.3.]. **[E7]**

GICB and downlink broadcasts shall be extracted from all aircraft in the surveillance responsibility of the ground station. **[E8]**

The Tenderer shall provide details in the proposal of the above functionality and details of how they will be implemented. **[I1]**

9.2.3 The internal applications contain the following pre-configured contracts:

9.2.3.1 Internal GICB Application

The System shall be capable to extract automatically via programmed GICB requests at least 4 BDS registers for all aircraft in surveillance responsibility. **[E1]**

The System shall enable the programmed extraction of any kind of BDS register through these GICB requests. **[E2]**

These GICB requests shall be programmed on a periodic basis. **[E3]**

A priority shall be assigned to each of these GICB requests by the IAL, in consistence with the GICB priority field specified in data item I018/030 (see [Ref.9.]). **[E4]**

The BDS registers to be extracted, the periodicity of extraction of each BDS and their priority shall be site-dependant parameters programmed either at the CAM or at a dedicated terminal. **[E5]**

No GICB extraction programmed internally shall be attempted by the system if the programmed BDS register is not supported by the aircraft installation. **[E6]**

A BDS register shall be detected as supported by the aircraft installation when bit 25 of the BDS register 1,0 is set to 1 as well as the associated bit of register 1,7. **[E7]**

If a BDS register is not listed in BDS 1,7, it is assumed to be available and shall be extracted if requested. **[E8]**

No GICB extraction request received from the GDLP/LU should be accepted by the system if the programmed BDS register is not supported by the aircraft installation. **[A1]**

The Tenderer shall state whether the BDS register extracted as a consequence of an internal GICB request is used to update asynchronous GICB requests received from GDLP/LU. **[I1]**

9.2.3.2 Internal Dataflash Application

Dataflash is a protocol that enables event driven transmission of aircraft information (indicated air speed, selected heading, waypoints...). It is an efficient way for a ground application to receive data that do not change very often and in an unpredictable manner. The Dataflash protocol allows a ground application to retrieve the contents of aircraft registers (BDS). BDS transmission upon register changes is performed as a result of a request from the station. **[A1]**

Dataflash uses MSP packets (Mode S Specific Protocol). The MSP protocol provides a datagram service within the Mode S Sub-Network. The MSP service provides 63 uplink channels and 63 downlink channels. Specific channels have been allocated to the Dataflash application. Ground initiated requests use uplink channel 6 (“ground to air service request”). Aircraft Dataflash information are downlinked on channel 3 (“Dataflash”). **[A2]**

The System shall be capable to manage at least 4 Dataflash contracts for each aircraft in datalink coverage, supporting the Dataflash application. **[E1]**

No Dataflash contract shall be initiated with an aircraft if the related BDS register is not supported by the aircraft installation (see 9.2.3.1 **[E7]**). **[E2]**

The Internal Dataflash application shall determine through bit 6 and bit 31 of BDS 1,D whether the aircraft does support the Dataflash protocol. **[E3]**

When all the above conditions are met for an aircraft entering the datalink coverage, the programmed Dataflash contracts shall be initiated for this aircraft. **[E4]**

The internal Dataflash application shall be able to perform the following functions:

(a) Extract BDS embedded in any MSP Dataflash packets transmitted by aircraft; **[E5]**

(b) Transmit these BDS along with track data of the same scan to the ATCC (using the MB data item of Cat. 48 or specific items for particular BDS); **[E6]**

(c) For each Dataflash packet, transmit a GICB response to the GDLP/LU interfaces for users which requested an asynchronous update of this particular BDS (i.e. either the GDLP or the LU had used the AU flag in a GICB request for this BDS); **[E7]**

The conditions of the contract (BDS register to be monitored, contract number, event, change or time criteria which will trigger the AICB) shall be site-dependant parameters programmed either at the CAM or at a dedicated terminal. **[E9]**

The station shall not attempt to terminate any established Dataflash contract. **[E10]**

The implementation of the Dataflash application shall be compliant with [Ref.3.]. **[E11]**

9.2.4 It is recommended to stop downlink extraction and output queued ASTERIX Cat 18 messages from the DLF before making a cold switch-over. **[A1]**

9.2.5 Spare.

9.2.6 The DLF shall indicate to the SMF whether any BDS data acquired should be appended to the report data to provide Enhanced Surveillance Data to ATCC. **[E1]**

All BDS data requested through category 18 for transmission in category 48, or requested via the IAL (through GICB requests or Dataflash contracts), shall be delivered to ATC (Surveillance Users) using the MB data item of category 48 except were a dedicated data item exists (48/240 & 48/260) and also be provided to the MMI. **[E2]**

9.2.7 The DLF shall be monitored via the control and monitoring system. **[E1]**

The Tenderer shall provide in the proposal details of what is available to the control and monitoring system. **[I1]**

9.3 Data link storage

The DLF shall be able to have a data link storage capacity equivalent to a two scans time period in both uplink and downlink direction in order to avoid immediate application of flow control in case of slight overload. **[E1]**

The Tenderer shall provide details of the data load capacity and the data link storage capability. **[I1]**

CHAPTER 10

CONTROL AND MONITORING (CAM)

10.1 General

10.1.1 The overall objective of the control and monitoring is to ensure that an unattended Mode S ground station shall provide continuous surveillance throughout its required coverage. **[E1]**

The Tenderer shall state in the proposal how the control and monitoring of the following is performed:

(a) Radar sensor, including antenna, turning gear, RF change-over and azimuth data; **[E2]**

(b) Interrogator; **[E3]**

(c) System Management Function (SMF); **[E4]**

(d) Surveillance Co-ordination Function (SCF); **[E5]**

(e) Data Link Function (DLF); **[E6]**

(f) Data transmission facilities (modem, multiplexer and network terminating units); **[E7]**

(g) Far Field site monitor; **[E8]**

(h) General site utilities (fire and intruder alarm, air conditioning equipment); [E9

10.2 Control and Monitoring Interfaces

10.2.1 Provision for interfaces to enable local and remote control and monitoring shall be provided using industry standard interface and protocol. **[E1]**

The Tenderer shall provide a detailed description of the interfaces, protocols and message formats used for the above function. **[I1]**

The Tenderer shall indicate whether the following statistical information (on a Scan or timely basis) are provided by the CAM interfaces (locally or remotely):

(a) Information about the data supplied to the ATCC users:

(i) Number of solo Mode S reports;

(ii) Number of solo SSR reports;

(iii) Number of solo PSR reports;

(iv) Number of combined SSR/PSR reports;

(v) Number of combined Mode S /PSR reports;

(vi) Number of Splits plots;

(vii) Number of code swaps;

(viii) Number of reports with duplicated Mode S address;

(ix) Number of test transponders;

(x) Number of test targets.

(b) Information about the data transferred through the SCN:

(i) Number of Track Initiations sent out;

(ii) Number of Track Initiations received;

(iii) Number of Track Data messages sent out;

(iv) Number of Track Data messages received;

(v) Number of Track Data Requests sent out;

(vi) Number of Track Data Requests received;

(vii) Number of Tracks for which SCN Track Support is being given;

(viii) Number of Tracks for which SCN Track Support is being received.

(c) Information (including the rationale) about the data exchanged with the GDLP;

(d) CPU loading on the different processing boards;

(e) measured data rate on each link (surveillance, SCN and DLF). **[I3]**

Control of every facility and function of the system shall be provided via these interfaces. **[E2]**

A disconnection of the CAM link shall not create an interruption to the operational service. **[E3]**

Under CAM link failure full control shall automatically be provided locally, either through the local CAM interface or through another terminal. **[E4]**

When under control of the remote terminal, all local control of the system shall be inhibited except for the request for local control. Transfer to local control is executed only after permission by the remote terminal. **[E5]**

When under local control at the equipment itself all control via the remote terminal shall be inhibited, however monitoring and recording of all functions shall continue. **[E6]**

The Tenderer shall provide details in the proposal of the list of parameters subject to remote control and monitoring in their proposed system. **[I4]**

10.2.2 The CAM interface shall enable the connection or disconnection of the ground station from the Surveillance Co-ordination Network (SCN). **[E1]**

10.2.3 The Contractor shall supply, at a date to be agreed with the Agency, interface control documents defining the interfaces, protocols and message formats used for the CAM function. **[E1]**

10.3 Built in Test Equipment (BITE)

10.3.1 Comprehensive on-line and off-line BITE shall be provided in the Mode S system. **[E1]**

On-line BITE testing is defined as BITE tests performed while the system is in the operating mode or in the standby mode; such tests would normally be conducted with normal operating signals or internally injected stimuli that did not interfere with normal operation. Off line BITE tests are those conducted while the system is in the maintenance mode using internal test checks and routines. **[A1]**

Off line BITE shall be capable of being initiated locally and remotely. **[E2]**

BITE shall be provided for both on-line and off-line testing of the Mode S systems and shall be able to detect any fault affecting the performance of the system. **[E3]**

The BITE coverage rate (part of the system [including all units, boards and components] monitored by BITE) shall be at least 90%. **[E4]**

The BITE fault finding rate shall be at least 95%. That is, at least 95% of all failures shall be detected and isolated by test to within a three LRU group (In most instances a PCB is defined as a single LRU). The BITE fault-finding rate is algebraically equal to the product of the fault detection rate and the fault isolation rate. **[E5]**

It is anticipated that the above requirement be met by on-line BITE. **[A2]**

The Tenderer shall state in the response the on-line and off-line fault finding rate that shall be achieved. **[I1]**

It is expected that achieved performance figures will be higher. The Tenderer shall provide in the proposal details of the performance figures which the equipment shall be able to meet and state under what conditions. **[I2]**

10.3.2 The on-line and off-line testing of the system shall work without the need for any additional external test equipment. **[E1]**

The on-line fault reporting time shall be less than 2 seconds after detecting the fault. **[E2]**

The on-line and off-line BITE shall register the faulty equipment (LRU) and report the information through the CAM interfaces. **[E3]**

The Tenderer shall provide details in the proposal of the BITE facilities available and what on-line tests the system will be able to perform. **[I1]**

10.3.3 On-line testing shall provide radar performance data through the CAM interfaces, in particular performance degradation providing advance warning of a developing fault condition or the need for maintenance. **[E1]**

In the proposal, The Tenderer shall state the performance parameters and describe the method of reporting the performance data both locally and remotely for the Mode S ground station. **[E2]**

CHAPTER 11

LOCAL DISPLAY

11.1 Local Display

11.1.1 An autonomous, readily moveable and transportable raster scan radar display shall be provided with interfaces as described in Figure 14. **[E1]**

11.1.2 By using the display, maintenance and commissioning engineers shall be able to fully assess the operational performance and serviceability of the Mode S system. **[E1]**

11.1.3 The display hardware shall make use of an industry standard graphics (minimum 1000 line) work station with an industry standard operating system. **[E1]**

Where specialised external processing hardware is proposed, it shall be interfaced to the same operating system as the display. **[E2]**

The display shall be capable of handling the target loads as specified in Annex G. **[E3]**

The Tenderer shall provide details of the hardware which will be supplied. **[I1]**

11.1.4 The display system shall accept and display signals or data from the Mode S radar system (live) or from the optional data recording and playback facility, if any, consisting of at least:

(a) Turning and trigger information (for SSR Mode A/C and Mode S All Call); **[E1]**

(b) SSR/Mode S video signals; **[E2]**

(c) PSR video signals; **[E3]**

(d) Quantised Processed Sum Video (Analogue video converted to digital words synchronised to the monopulse plot extractor master clock timing) Signals (SSR and Mode S All Call); **[E4]**

(e) Reply Report Data (messages output from the Mode A/C and Mode S reply processor); **[E5]**

(f) Plot Assignor data (ASTERIX Cat. 1, 48); **[E6]**

(g) Mode S enhanced surveillance information (ASTERIX Cat. 48); **[E7]**

(h) Status information (ASTERIX Cat. 2, 34); **[E8]**

(i) Track data exchanged on the Surveillance Co-ordination Network (content of ASTERIX Cat. 17 messages); **[E9]**

(j) Presentation of the currently operational local Surveillance Coverage maps, for a user-defined altitude; **[E10]**

(k) Data flagged as Anomalies and false plots in the PAF and NOT sent to ATCC; **[E11]**

(l) A list of the Mode S aircraft under surveillance (Mode S address, height & position); **[E12]**

(m) The data link capability of each aircraft; **[E13]**

(n) The last received message decoded per aircraft; **[E14]**

(o) The Broadcast Comm Bs received; **[E15]**

(p) The GICB's received; **[E16]**

(q) MSPs (for Dataflash); **[E17]**

(r) TCAS resolution advisories. **[E18]**

Data (b), (c), (d), (f), (g), (i), (j) and (k) shall be displayed in a geographical representation. **[E19]**

The Tenderer shall provide information on the subset of these signals that can be displayed simultaneously. **[I1]**

The Tenderer shall provide detailed information about the editing and display of border and coastline maps. **[I2]**

The Tenderer shall provide detailed information about the editing and display of other geographical maps (other radar positions, airways, runways…). **[I3]**

The Tenderer shall provide detailed information about the display of the coverage maps (surveillance, lockout and datalink). **[I4]**

The Tenderer shall provide detailed information about the display of Asterix Cat 17 data. **[I5]**

The system shall provide the operator with the ability to select any combination from the above list for display. **[E20]**

The Tenderer shall provide detailed information on how the above data is selected and retrieved from the station (software or hardware selection…). **[I6]**

11.1.5 The system shall be able to display the content of the ASTERIX data sent on the ATCC output specified in 4.9.2.1. **[E1]**

11.1.6 The display system shall recognise, process and interpret all message types in ASTERIX and display the data from these messages [Ref.5.]b,c and [Ref.6.]a. **[E1]**

11.1.7 The Contractor shall supply any peripherals and/or ancillary equipment that are necessary for the operation of the display **[E1]**

11.1.8 The symbology (and/or colour) shall be such as to distinguish between different plot types. **[E1]**

A background map facility shall be provided for up to 300 NM radius of the origin. **[E2]**

It shall be possible to import the map parameter co-ordinate set. **[E3]**

11.1.9 The Tenderer shall include in the response details of how all the information for selected plots could be displayed (including additional data such as GICB reply data, status information). **[I1]**

11.1.10 There shall be a facility to record the data defined in 11.1.4, (l) to (r), and to display this stored information. **[E1]**

The Tenderer shall provide details in their proposal of the method used to store the above data. **[I1]**

CHAPTER 12

FAR FIELD MONITOR

12.1 General

12.1.1 The far field site monitor shall be a self contained unit acting as a Mode S level 3 transponder (as defined in [Ref.1.] 2.1.5.1.3) located externally to the ground station site. **[E1]**

12.1.2 It shall be a dual channel system with redundant capacity in the event of a single channel failure. **[E1]**

The radar processing shall enable the definition of multiple far field monitors and provide the capability to suppress their reports from delivery to ATC. **[E2]**

12.1.3 The Mode S site monitor shall include the following features:

(a) Operation on Modes 3/A,C, intermode and Mode S (II and SI codes); **[E1]**

(b) Simulated range and flight level reporting; **[E2]**

(c) Robustness to common-mode failure (i.e. one channel shall transmit in the event of failure in the other channel); **[E3]**

(d) Comprehensive BITE facilities to enable fault diagnosis to module level; **[E4]**

(e) Modular construction with plug/socket connections on all modules; **[E5]**

(f) Fully solid state; **[E6]**

(g) BITE status and configuration status shall be reported to CAM; **[E7]**

(h) Configuration shall be controlled by CAM; **[E8]**

(i) User definable data as described in 12.2.1. **[E9]**

The far field monitor shall comply with all the requirements of [Ref.1.]. **[E10]**

The Tenderer shall advise what additional features could enhance the capability of the far field monitor (e.g. external frequency selection, battery back-up, power attenuation adjustment) **[I1]**

The Tenderer shall include in the proposal details of the Mode S site monitor configuration and how the changeover action is reported to the CAM. **[I2]**

12.2 Reply Processing

12.2.1 User definable data shall include:

(a) The Mode S technical address for each channel shall be selectable as a 6 character Hexadecimal address. **[E1]**

(b) Separate altitude and identity information for each channel shall be selectable (in terms of octal Mode A code and FL respectively). **[E2]**
Each code shall remain configured during periods of power interruption. **[E3]**

(c) Separate Flight Identity (or call-sign) information for each channel shall be selectable. During switch-over (due to equipment failure) the change of Flight ID shall be announced by the use of the standard Mode S broadcast protocol. Such a facility will provide the ground station with an indication of site monitor failure. **[E4]**

(d) Separate range offset parameters for each channel shall be selectable.

(e) It is anticipated that the data defined in a, b, c and d are all selectable via portable test equipment (e.g. lap top computer). **[A1]**

(f) The portable test equipment shall be provided with each site monitor equipment **[E5]**

12.2.2 In addition the following test functions shall be provided:

(a) Delivery of "active" II/SI code; **[E1]**

(b) Remote Setting Failure. That is the ground station shall be able to set remotely (or "trigger"):

(i) The Alert bit; **[E2]**

(ii) The Downlink Capability Report announcement; **[E3]**

(iii) Change of Flight Identity; **[E4]**

(iv) Test RA broadcast. **[E5]**

The use of MSP uplink channel 6 (ground to air service request) allows the ground station to be able to set remotely (or " trigger") such features. **[A1]**

The Tenderer shall provide in the proposal implementation details of the test functions which have been listed above. **[I1]**

12.2.3 The equipment shall function on a power supply consistent with the requirements of 4.11. **[E1]**

12.2.4 The Tenderer shall provide power budget calculations to support a ‘typical’ far field monitor installation. **[I1]**

The equipment supplied shall include all ancillary equipment including antenna, cabling power supplies and any necessary mounting hardware. **[E1]**

CHAPTER 13

OPTIONAL REQUIREMENTS

13.1 General

This chapter contains a number of optional requirements that, if exercised by the customer, will be identified as deliverable items in the List of Price & Deliverables (under 'Optional Deliverables') that accompanies any call for tender. **[A1]**

13.2 Cluster Controller

13.2.1 Surveillance Co-ordination Network

The objective of surveillance co-ordination is to allow any Mode S ground station to operate effectively within any radar siting plan as was stated in Chapter 8. **[A1]**

Figure 11 shows the overall layout of a typical Surveillance Co-ordination Network Cluster. It consists of a number of nodes which are all using the same limited set of II codes. A Cluster Controller (CC) is connected via a network to a number of ground station SCFs in order to provide centrally controlled mode of operation. The ground station SCFs are also connected via the network so as to provide a distributed mode in the event of the CC not being available. **[A2]**

The central controlled mode has been designed to take advantage of the central and therefore global view of the cluster. This view can be established in one of two ways:

(a) by passing track information from the connected cluster radars to the CC using track data messages in ASTERIX Category 17. This information is then processed by the CC to construct a CC global roll-call.

(b) by using system track data already available and processed in Radar Data Processing (RDP) systems. This option allows the CC and RDP systems flexibility in configuring the cluster to optimise the overall surveillance performance. The CC can take advantage of this pre-processing if a suitable interface is provided between the CC and the RDP system. **[A3]**

13.2.2 Functionality

The Cluster Controller is an optional item and as such the act of exercising this option shall not require a modification to the basic functionality of the ground station equipment. **[E1]**

The functions of the CC SCF are designed to optimise the Surveillance Co-ordination Network. They are illustrated in Figure 10, referred to in [Ref.1.] and described below. **[A1]**

13.2.2.1 Global Roll-Call

The CC SCF's function is to maintain the global roll-call by using knowledge of all the solution lists for each connected ground station. Three types of target lists shall exist:

(a) The Global Tracked Target list which contains information on every aircraft currently tracked by the connected ground stations. **[E1]**

(b) For each connected station, a Station Tracked Target List containing only those targets that are fully tracked (ie successfully added to the roll call list) by the station. **[E2]**

(c) For each connected station, a Station Potential Track List containing targets that the station is capable of tracking. **[E3]**

13.2.2.2 Track Data and Surveillance Processing.

Track information to maintain the Global Roll-Call lists can be received from:

(a) The SCF via the SCN, or **[E1]**

(b) The Radar Data Processing system (in the future). **[E2]**

The surveillance processing function maintains the Global Tracked Target List. Track data received from connected stations shall also be inserted into the respective Station Tracked List to which they are associated. **[E3]**

The Surveillance Processing Function shall be responsible for the deletion of Roll-call entries when no further track data is received. **[E4]**

The Surveillance Processing Function shall provide a Co-ordinate Transformation to the local co-ordinate set for the track data received from the connected stations. **[E5]**

The particular algorithms required for the Co-ordinate Transformation will be provided to the Contractor by the Agency. **[A1]**

13.2.2.3 CC Surveillance Co-ordination function.

13.2.2.3.1 The CC SCF shall contain the following functions:

(a) A pre-defined cluster coverage map indicating all ground station responsibilities for providing lockout and handover on targets located in different regions of the cluster. The map structure shall be defined as in [Ref.1.] and shall be at least capable of mapping a cluster covering an area of 600 NM by 600 NM; **[E1]**

(b) A network system status list containing the cluster topology determined by the Network Monitoring Protocol (NMP) running in the `Network Failure and Control' function of the CC. It shall consist of a table containing the status of all connections between the network nodes; **[E2]**

(c) A periodic monitoring process shall be responsible for the routine monitoring of the global roll-call, the coverage map and the network system status list. The process shall ensure that status changes result in the appropriate cluster handover activity; **[E3]**

(d) A network and failure control process which runs the protocols required to maintain the central mode of operation within the cluster. The acquisition and lockout responsibilities shall also be noted in the Station Potential Track list for subsequent processing and monitoring of cluster, station and target status. **[E4]**

13.2.2.3.2 The Periodic Monitoring Process (PMP) shall:

(a) Monitor the network system status list; **[E1]**

(b) Monitor the CC global roll-call; **[E2]**

(c) Based on the cluster topology, select the coverage map and maintain the global roll-call based on that map. **[E3]**

When the PMP detects a change of target status in global roll-call, or of cluster topology in the network system status list, it shall update the global roll-call target lists and ensure that the Network and Failure control process is made aware of the targets to which this change applies. **[E4]**

The PMP shall check the consistency between the Station Potential and Station Tracked target lists and ensure that inconsistencies which could indicate a cluster fault (e.g. Targets which should be being tracked but which are not and which are not subject to a lost track request) are resolved consistent with the cluster system configuration. **[E5]**

The Tenderer shall provide information in the Tender Response on the inconsistencies that shall be checked. **[I1]**

The simplest solution to be adopted in these cases is for a CC failure to be declared and actioned as in 13.2.2.3.3 below. **[A1]**

The PMP shall handle at least the following changes of status:

(a) Newly acquired targets - those targets which have flown into the cover of the CC cluster coverage area; **[E6]**

(b) Targets flying into the surveillance coverage of cluster radars; **[E7]**

(c) The network system status list indicates a change of cluster topology. In this case the PMP shall select the appropriate coverage map and amend target details on the global roll-call to reflect the new target status. **[E8]**

The Tenderer shall propose in the Tender Response a method used to select the appropriate coverage map. **[I2]**

The method to be used shall be agreed between the Contractor and the Agency. **[E9]**

13.2.2.3.3 The Network and Failure Controller shall perform: **[E1]**

(a) Handover management - which shall include running the following protocols defined in [Ref 10]:

(i) Track acquisition protocol to ensure that any interrogator is aware of any new track entering its coverage; **[E2]**

(ii) Track support protocol used when a radar requests track information from the CC on targets where a track miss has occurred. **[E3]**

(b) Cluster topology and state determination: **[E4]**

(i) This shall be achieved using the network monitoring protocol (NMP). **[E5]**

(ii) The NMP derived cluster topology shall then be communicated to the cluster stations as defined in [Ref 10]; **[E6]**

(c) Failure management, where: **[E7]**

(i) The SCF shall be able to safely reconfigure the cluster in the event of failures. **[E8]**

(ii) The reconfiguration shall ensure the fault is isolated and that the remaining cluster can continue to provide for correct Mode S operation. **[E9]**

(iii) The SCF shall reconfigure the cluster in the case of CC failure and network failures as described in [Ref 10]. **[E10]**

The Network and Failure Control process shall determine the cluster response to the changes in target status. **[E11]**

The Tenderer shall provide in the proposal details of all the functions defined below:

(a) The coverage map, and adaptations of it **[I1]**

(b) The network system status list. **[I2]**

(c) The periodic monitoring process. **[I3]**

(d) The network and failure controller. **[I4]**

13.2.2.4 Cluster Size

The cluster is normally considered to consist of up to six ground stations. **[A1]**

The Cluster Controller shall be able to handle at least 4000 targets. **[E1]**

The Tenderer shall provide information on the upgradeability of the CC functionality to support a larger cluster size. **[I1]**

13.2.2.5 Network Link

The link shall be able to provide a communication interface with the SCN and the CAM and optionally a local RDP system. **[E1]**

The SCN interface shall support X.25 at a minimum data rate of 19.2 Kbps for out going and incoming data. **[E2]**

The SCN interface shall support TCP/IP connections (client and server over IPv4 or IPv6). **[E3]**

The interface shall support the ASTERIX formats for surveillance co-ordination data defined in [Ref.6.]a. **[E4]**

Note that if an optional RDP connection is not provided additional bandwidth will be required. **[A1]**

The Tenderer shall propose information on the data rate to be used, and how it has been calculated. **[I1]**

13.2.2.6 Control and Monitoring (CAM)

The Cluster Controller shall be provide with local and remote control and monitoring. **[E1]**

The Tenderer shall provide details of the CAM capabilities provided with the CC. **[I1]**

13.3 LVA Antenna Requirements

13.3.1 The Tenderer shall propose a Large Vertical Aperture (LVA) antenna, providing monopulse sum and difference channels with an additional omnidirectional control channel, suitable for SSR and Mode S, that enables the requirements of this specification (Chapters 4 and 6) to be met in all respects. **[E1]**

13.3.2 The Tenderer shall detail in their proposal where they consider their antenna will not enable the requirements of this specification (Chapters 4 and 6) to be met in all respects. **[I1]**

13.3.3 The Tenderer shall provide details in their response of the antenna characteristics, with guaranteed parameter limits, and supported with measured antenna polar diagram. **[I1]**

13.3.4 As a minimum the following information shall be supplied by the Tenderer in their response:

(a) Vertical sum polar diagrams (field strengths, -3dB beamwidth, sidelobes, underside rolloff rate, etc.); **[I1]**

(b) Sum horizontal polar diagrams (peak forward gain, beamwidth at -3dB, -10dB, -20dB, symmetry/alignment of sum peak and beamwidths over elevation, sidelobes, etc.); **[I2]**

(c) Control pattern (coverage of sum sidelobes, crossover points, notch/minimum, symmetry/alignment over elevation, etc.); **[I3]**

(d) Difference pattern (crossover points, peak gain, difference null, symmetry/alignment over elevation, etc.); **[I4]**

(e) Fully dimensioned drawings; **[I5]**

(f) Safety (maintenance personnel, lightning strike protection); **[I6]**

(g) Mechanical requirements (dismantling/reassembly of columns, transportation, lifting); **[I7]**

(h) Environmental protection; **[I8]**

(i) Maximum operational wind speeds and ice depth such that the antenna can function within the conditions of 4.2; **[I9]**

(j) Maintenance requirements and lifetime of the array. **[I10]**

13.3.5 Prior to acceptance and delivery of each antenna the Contractor shall provide measured azimuth and elevation patterns for the antenna supplied, according to an agreed test procedure. **[E1]**

13.4 The LVA Turning Gear Requirements

13.4.1 The Tenderer shall propose in their response turning gear and azimuth take off equipment for the ground station that enables the requirements of this specification to be met in all respects. **[E1]**

The radar gear and associated components, i.e. rotating joint, slip ring assemblies, etc. shall be based on proven equipment of established mechanical accuracy and reliability. **[E2]**

The turning gear shall have dual azimuth take off to a resolution of 360/16384°. **[E3]**

The Tenderer shall provide in the tender response information on the format of the azimuth data. **[I1]**

The Tenderer shall provide detailed information on the turning gear and the associated pedestal mounted electronics on the following configurations:

(a) 1 Motor Drive **[I2]**

(b) 2 Motor Drives **[I3]**

The Tenderer shall describe in detail the behaviour of the system when the turning gear speed fluctuates too much due to excessive loading (due to the wind for example). In particular the Tenderer shall indicate the consequences of such conditions on the output of the data to the ATCC users. **[I4]**

The Tenderer shall detail in their response where their proposed turning gear will not enable the requirements of this specification to be met in all respects. **[I5]**

13.4.2 As a minimum the following information shall be supplied by the Tenderer in their response:

(a) LVA weight and details of the on mounting interfaces **[I1]**

(b) Details of the tilt and horizontal mechanisms **[I2]**

(c) Rotation speeds and speed variations under the worst conditions of 4.7.2 (include effects on system performance, tracking, etc.) **[I3]**

(d) Details of braking and locking the antenna **[I4]**

(e) Details of safety interlocks to immobilise the antenna during maintenance **[I5]**

(f) Horizontal stability of the antenna/tower interface and the main antenna drive Dearing over the full turning rate and tilt range of the antenna **[I6]**

(g) Details of the azimuth take off systems **[I7]**

(h) Details of alignment and maintenance of the azimuth data and north marker **[I8]**

(i) Details of how the turning information is to be validated **[I9]**

(j) Details of the rotating joint including power handling capabilities **[I10]**

(k) Details of the drive assembly and couplings **[I11]**

(l) Details of the lifting points for each major component **[I12]**

(m) Details of the turning gear lubricating system **[I13]**

(n) Details of the maintenance of the turning gear system **[I14]**

(o) Detailed list of the tools being delivered in order to perform the preventive and corrective maintenance operations for the LVA and the turning gear (including lifting devices) **[I15]**

13.5 Shelter

13.5.1 This section details the requirements which a shelter holding the Mode S ground station shall meet if this option is accepted. **[A1]**

13.5.2 The structure of the shelter shall be of metal construction designed in accordance with the accepted practices. The structure shall meet the building codes and other relevant regulations of the country in which it is situated. **[E1]**

The Tenderer shall state any specific exceptions. **[E2]**

The Tenderer shall provide in the proposal details of the shelter's structure. **[I1]**

The shelter shall have a design life of 25 years with a time to first maintenance of 10 years **[E3]**

The shelter shall have two access doors, separated for fire safety purposes. One of the doors shall be of sufficient size to permit all equipment to be loaded or removed from the shelter. **[E4]**

It is anticipated that the main personnel door has a lobby area (foyer) and internal door. **[A1]**

The shelter shall be provided with suitable fixings at each corner to allow the shelter to be secured to the concrete foundations so as to prevent movement (or structural damage)in wind speeds up to the specified wind load environment. **[E5]**

13.5.3 The shelter, building services and equipment shall be designed to meet all current planning requirements and provide an environment that enables staff to carry out their work in a manner that it acceptable to the Agency and permits the delivered equipment to be installed and operated without modification to the shelter or equipment. **[E1]**

The shelter shall be capable of housing all technical equipment required for the system and the following items of furniture, desk, chair, filing cabinet (4 drawer) and stationery cupboard. **[E2]**

The Tenderer shall provide in the proposal details of the layout of the shelter. **[I1]**

13.5.4 The shelter shall be approved by the Agency for fire protection and security. **[E1]**

13.5.5 The shelter shall have suitable lifting points at each corner to allow for cranage on and off a lorry and be capable of transportation in the EC area without police escort. **[E1]**

The shelter shall be capable of being transported with the full technical load installed. **[E2]**

The above is not a requirement for the equipment to be ruggedised for transportation; delicate equipment may be removed for subsequent transportation. **[A1]**

The shelter roof shall be capable of supporting the necessary snow and maintenance loads **[E3]**

13.5.6 The 3 phase 400V 50Hz distribution system shall comprise of at least the following:

(a) Main incoming fuse switch for isolation and protecting the full installation; **[E1]**

(b) Domestic distribution board with circuit breaker protection for:

- (i) Lighting;
- (ii) Domestic ring main;
- (iii) Heating/cooling plant;
- (iv) Obstruction light and tower power;
- (v) Fire alarm system;
- (vi) Intruder alarm system; **[E2]**

(c) Technical distribution board with circuit breaker protection for the technical equipment; **[E3]**

(d) Connection for mobile 3 phase 400V 50Hz generator, with change-over switch for selection between mains and generator for supplying the full load requirements of (b) and (c) above. **[E4]**

The Tenderer shall provide details in the proposal of the electrical components of the shelter. **[I1]**

13.5.7 The shelter should be considered in two modes of operation occupied and unoccupied. **[A1]**

In either mode the shelter shall be maintained at a temperature of 21° +/- 5° of the selected temperature for the period at the limit of the hot (with sun loading) and cold soak specified extremes. **[E1]**

A spare (redundant) heating and cooling system shall be provided. **[E2]**

The Tenderer shall detail in the proposal how the air temperature shall be maintained within the shelter. **[I1]**

13.6 Tower

13.6.1 This section details the tower requirements which shall be met if this option is accepted. **[A1]**

The tower is not considered as a mobile facility. **[A2]**

13.6.2 The aerial support shall be designed to meet the operational needs of the system proposed including structural requirements at the environmental extremes and access for maintenance of all antenna elements. The tower shall be capable of providing a mount for the standalone designated LVA antenna type (i.e. no co-located primary antenna) **[E1]**

The torsional deflection shall not exceed 1.5 minutes of Arc. **[E2]**

Deflection in the vertical plane shall not exceed 2.0 minutes of Arc. **[E3]**

Both of these are measured with the antenna installed and at the aerial/tower interface level over the specified operational wind speeds. **[A1]**

The required tolerance of horizontal level shall not to exceed +/-2 minutes of Arc through the azimuth of 360°. **[E4]**

The design of the structure shall be such that this tolerance shall not be subject to deterioration with age. Alternatively the design shall allow for easy adjustment of the level. **[E5]**

13.6.3 The steelwork of the tower shall be to BS4360 (or equivalent). **[E1]**

All steelwork of the tower shall be galvanised in accordance with BS 729 (or equivalent) after fabrication. **[E2]**

The tower shall comply with the requirements of BS CP3 Chap V:Part 2: 1972 including amendments AMD 4952, 5152, 5343(or equivalent). **[E3]**

13.6.4 The tower shall have a design life of 25 years, allowing for preventative visits every year, and a time to first maintenance of 10 years. **[E1]**

13.6.5 The tower shall have staircase access to the top inspection/working platform. **[E1]**

The staircase shall have suitable lighting. **[E2]**

The top inspection/working platform shall have all necessary handrails and toeboards. **[E3]**

The top platform shall have an access hatch with lifting beam over capable of lowering the elements of the array necessary for maintenance to the ground. **[E4]**

The top of the staircase on to the platform shall have a lockable door to prevent unauthorised access to the top platform. **[E5]**

The tower shall be fitted with obstruction lights of 2000 candela (steady red light) in such a way that they are visible for 360° of the azimuth. **[E6]**

The Tenderer shall include in the proposal details of the design of the tower. **[I1]**

13.6.6 The Contractor shall design, supply and install a lightning protection system to cover the tower and antenna system in accordance with BS6651(or equivalent). **[E1]**

13.7 Data Recording and Playback

13.7.1 The Tenderer shall provide in the proposal details of the record/replay facilities which shall be used to evaluate radar data and details of how these facilities shall be connected with the Mode S ground system, as indicated in [Ref.12.]. **[I1]**

13.7.2 The system shall be capable of selective and full data recording and replaying of the following time-stamped data:

(a) Plot Assignor Data (inc. SSR/PSR/combined RDIF/ASTERIX Cat. 001, 2, 34, 48 data); **[E1]**

(b) Mode S enhanced surveillance information (ASTERIX Cat. 48 data); **[E2]**

(c) Status information (time, date, scan no.); **[E3]**

(d) Data flagged as Anomalies and false in the PAF and NOT sent to ATC; **[E4]**

(e) Interrogation instructions; **[E5]**

(f) Mode A/C and Mode S reply report data; **[E6]**

(g) Data from the Surveillance Co-ordination Network. **[E7]**

The bulk data recording capability shall be capable of recording up to four of the above simultaneously. **[E8]**

In addition it shall be capable for up to four of the above to be selectively recorded with time-stamp for up to eight hours without interrogation instructions (2 hours with interrogation instructions) with all radar systems operating at full capacity. **[E9]**

The selection of inputs shall be independent of the data being displayed. **[E10]**

The Tenderer shall provide in the response the proposed method for data recording and playback, stating the expected duration for the above signals. **[I1]**

13.7.3 It shall be capable to record full data of a given type and selectively record in order to replay, the following information together with azimuth information where appropriate:

(a) SSR quantised processed sum video signals; **[O1]**

(b) Mode S All-Call quantised processed sum video signals. **[O2]**

The Tenderer shall provide information in the response of the preferred approach. **[I1]**

13.7.4 Control of full and selective data recording shall be via the operator interface. **[E1]**

13.7.5 The medium to be used for bulk and selective digital recording shall allow recordings to be replayed for analysis on another computer. **[E1]**

13.7.6 Selection of digital recording shall be by any logical and/or combination of the following criteria:

(a) All aircraft within a static volume bounded by any azimuth and altitude interval. **[E1]**

(b) Aircraft with selected Mode 3/A codes (from a definable list of up to 20 Mode 3/A codes) **[E2]**

(c) All aircraft Mode S addresses selected (from a definable list of up to 20 Mode S addresses). **[E3]**

(d) All plot data which falls within a dynamic log box (size defined by the user). The centre of the box to be given by an aircraft defined as in (b) or (c) above. **[E4]**

(e) All data described as ‘anomaly’ or ‘false’. **[E5]**

13.8 RDIF Requirements

13.8.1 As an option, Data Rate Control and Real Time Quality Control shall be implemented in the RDIF format as described in CAA Paper 87002 § 5.1.2 and 5.1.4. **[O1]**

13.8.2 Each input port shall receive filtered primary plot data in RDIF/ASTERIX format, HDLC protocol, synchronous and simplex; at a rate in the range 7.2 to 38.4 Kbps in increments of 2.4 Kbps. **[E2]**

13.8.3 For Surveillance data, there shall be 3 interfaces per SMF and each interface shall be dual channel. Thus, each interface should be software configurable to be either both ASTERIX (or optionally both RDIF) **[A1]**

13.8.4 As an option, output of RDIF messages on three simultaneous, independently configurable, channels at an average rate of 250 messages/second **[O1]**

13.8.5 As an option, the SMF shall have an RDIF interface. **[O1]**

13.8.6 As an option the PAF shall include RDIF plot formatting. **[O1]**

13.8.7 As an option the data shall be provided at the same rate to the local display in RDIF. **[O1]**

13.8.8 As an option, the display system shall recognise, process and interpret all messages types in RDIF including the extensions as defined in (CAA Paper 87002) and display the data from these messages. **[O1]**

13.8.9 The system shall be capable of selective and full data recording and replaying of time-stamped data Plot Assignor Data (inc. SSR/PSR/combined RDIF/ASTERIX Cat. 001, 2, 34, 48 data) **[E1]**

13.9 FFM Optional Requirements

13.9.1 The Tenderer shall provide a detailed proposal for the following FFM optional items:

(a) Power Attenuator **[O1]**

(b) Battery back-up **[O2]**

(c) Outdoor packaging **[O3]**

13.9.2 The test functions described in 12.2.2 [E2] to [E5] shall independently be selectable through dedicated SDPs. **[E1]**

13.10 Test and Development System

A Test and Development System may not be appropriate for this project but the Agency may wish to support a tool for the operational implementation of Mode S. **[A1]**

To ensure that the Agency always has access to hardware to enable testing of new versions of software to be performed, the Tenderer shall provide as an option a proposal for the following: A test system comprising a representative sub-set of all the hardware in the system that can be used to perform system tests of the software. Sufficient hardware shall be provided to ensure that all fall-back, fail-safe and automatic switchover mechanisms can be tested. **[O1]**

The Tenderer shall state in his proposal what constitutes a representative sub-set and give reasons why this is sufficient. **[I1]**

13.11 Software Development System

A Software Development System may not be appropriate for this project but the Agency may wish to support a tool for the operational implementation of Mode S. **[A1]**

This Software Development System shall be separate from the Test and Development system specified above. **[E1]**

The Tenderer shall provide as an option a Software Development system to hold all of the source code under control of CM software, and on which compilation, linking etc. is carried out. **[O1]**

The Tenderer shall state the processing power and disc capacity for this bureau and provide performance figures for the following:

(a) An estimate of the time to complete a single complete rebuild of the system software. (assuming that no other build/compilation processes are running). **[I1]**

(b) Development System Storage capacity. **[I2]**

(c) Storage capacity required for one build. **[I3]**

The Build software shall allow for a minimum of 5 software engineers to generate different versions of a complete set of system software simultaneously. **[O2]**

The first item in an acceptance test of a Software Development System would commence with an 'empty' machine and load all operating systems, applications programs and source code onto it, to arrive at a working system. **[A2]**

13.12 Control and Monitoring Terminals

13.12.1 General

13.12.1.1 The Tenderer shall state how the following data is displayed on the local and remote terminal:

(a) Radar sensor, including antenna, turning gear, RF change-over and azimuth data; **[E1]**

(b) Interrogator; **[E2]**

(c) System Management Function (SMF); **[E3]**

(d) Surveillance Co-ordination Function (SCF); **[E4]**

(e) Data Link Function (DLF); **[E5]**

(f) Data transmission facilities (modem, multiplexer and network terminating units); **[E6]**

(g) Far Field site monitor; **[E7]**

(h) General site utilities (fire and intruder alarm, air conditioning equipment); **[E8]**

The Tenderer shall indicate whether the following statistical information (on a Scan or timely basis) are provided for display at the CAM terminals (locally or remotely):

(a) Information about the data supplied to the ATCC users:

- (i) Number of solo Mode S reports;
- (ii) Number of solo SSR reports;
- (iii) Number of solo PSR reports;
- (iv) Number of combined SSR/PSR reports;
- (v) Number of combined Mode S /PSR reports;
- (vi) Number of Splits plots;
- (vii) Number of code swaps;
- (viii) Number of plots with duplicated Mode S address;
- (ix) Number of test transponders;
- (x) Number of test targets.

(b) Information about the data transferred through the SCN:

- (i) Number of Track Initiations sent out;
- (ii) Number of Track Initiations received;
- (iii) Number of Track Data messages sent out;
- (iv) Number of Track Data messages received;

(v) Number of Track Data Requests sent out;

(vi) Number of Track Data Requests received;

(vii) Number of Tracks for which SCN Track Support is being given;

(viii) Number of Tracks for which SCN Track Support is being received.

(c) Information (including the rationale) about the data exchanged with the GDLP;

(d) CPU loading on the different processing boards;

(e) measured data rate on each link (surveillance, SCN and DLF). **[I1]**

13.12.1.2 The CAM terminals shall enable the connection or disconnection of the ground station from the Surveillance Co-ordination Network (SCN). **[E1]**

13.12.1.3 The Tenderer shall provide detailed information about the BITE of the CAM terminal (local or remote). **[I1]**

Each CAM terminal shall be delivered with a printer capable of printing all controlled and monitored data. **[E1]**

13.12.2 Local Terminal

13.12.2.1 Control and monitoring of the system and all subsystem shall be provided through a local (i.e. local to the equipment) terminal. **[E1]**

The Tenderer shall provide details on the HMI, including screen layout, used in the local terminal. **[I1]**

The Tenderer shall provide details on the platform used in the local terminal. **[I2]**

The Tenderer shall state the number of days over which the local terminal can store the control and monitoring messages received and sent. **[I3]**

13.12.3 Remote Terminal

13.12.3.1 Control and monitoring of the system and all subsystem shall be provided through a remote terminal. **[E1]**

The Tenderer shall provide details on the HMI, including screen layout, used in the remote terminal. **[I1]**

The Tenderer shall provide details on the platform used in the remote terminal. **[I2]**

The Tenderer shall state the number of days over which the remote terminal can store the control and monitoring messages received and sent. **[I3]**

13.13 GPS Receiver

As an option, the system shall be fitted with two GPS receivers acting as the external source. **[E1]**

13.14 Mode S interrogator with primary radar collocation

13.14.1 Some states might choose to collocate primary L-band or S-band radar with Mode S interrogators as defined below. **[A1]**

The Tenderer shall provide interfaces for the L-band 23cm HSA primary radar and co-locating with the L-band SRE-M5 AEG or Alenia/Thomson S-band: **[A2]**

Each channel of the Mode S ground station shall have a configurable primary interface to each primary channel, which may be selectable locally and remotely. **[E1]**

Each input port shall receive filtered primary plot data in RDIF/ASTERIX format, HDLC protocol, synchronous and simplex; at a rate in the range 7.2 to 38.4 Kbps in increments of 2.4 Kbps. **[E2]**

Each input port data rate shall be independently set to any output data rate in the range 7.2 to 38.4 Kbps in increments of 2.4 Kbps. **[E3]**

Each input port shall be able to be independently synchronised with either an external or internal clock, where the internal clock accuracy shall be better than one part in one million. **[E4]**

The clock and data levels shall conform to RS232-C or RS422. **[E5]**

The Mode S ground station shall perform plot combination with the primary radar data that is found to be associated with an SSR/Mode S target. **[E6]**

The Tenderer shall provide all necessary information of how it is intended to solve the problem of mutual interference. **[I1]**

The Mode S system shall be capable of operating asynchronously with the co-located radars. **[E7]**

The Tenderer shall provide details in the response of the proposed PSR interface. **[I2]**

13.15 Additional equipment and performance requirements

The system shall support PVCs for all connections except the SCN ones **[E1]**

In the case of repeated absence of a reply to a UF 4 or UF 5 interrogation containing a RR field higher or equal to 17, the system shall re-interrogate the aircraft with a UF 4 or UF 5 interrogation containing a RR field lower or equal to 16, and shall attempt to schedule this new interrogation in the same scan. **[E2]**

The Tenderer shall provide details on how the above function will be implemented. **[I1]**

13.16 Additional System Management Function requirements

An operational parameter shall be available to override the check of bit 33 of BDS 1,0 for the extraction of BDS 2,0 during the acquisition process. **[E1]**

An operational parameter shall be available to override the check of bit 25 of BDS 1,0 for the extraction of BDS 1,7 and BDS 1,D during the acquisition process. **[E2]**

An operational parameter shall be available to override the check of BDS 1,7 for the extraction of BDS registers. **[E3]**

13.16.1 II/SI code operation

An SI code, defined in [Ref.1.], is composed of the IC field and the CL field. Only transponders complying with Amendment 73 of Annex 10 will decode the CL field in order to determine if the content of the IC field is an II code or an SI code. Transponders which have not been upgraded to handle SI code will, by default, consider the content of the IC field as being an II code value. Therefore, if CL is not equal to zero (meaning that the IC field contains a SI code), the non-upgraded transponders will encode the parity sequence of the reply using the "matching" II code rather than the SI code contained in the interrogation. **[A1]**

The system, when operating with an SI code and if enabled by an operational parameter, shall also acquire targets through all-call replies which are encoded using the "matching" II code. This transponder shall be considered as a non SI equipped transponder. **[E1]**

Even if the content of BDS 1,0 states that the transponder has the SI capability, if this transponder is detected as using the "matching" II code to encode the parity sequence of the replies, it shall be considered as a non SI equipped transponder. **[E2]**

The system, if operating with an SI code and if enabled by an operational parameter, shall interrogate targets equipped with non SI transponders using the Mode S selective protocols foreseen for II code operation. The II code to be used shall be the "matching" II code. **[E3]**

The system, if operating with an SI code and if enabled by an operational parameter, shall be configurable by the user to either:

(a) not lockout non SI transponders on the "matching" II code ; **[E4]**

(b) use intermittent lockout for this "matching" II code. **[E5]**

The system, if operating with an II code and if enabled by an operational parameter, shall be configurable by the user to either:

(a) not lockout Mode S transponders which do not report the SI capability in BDS 1,0 ; **[E6]**

(b) use intermittent lockout for Mode S transponders which do not report the SI capability in BDS 1,0. **[E7]**

The above requirements are to allow neighbouring stations operating with an SI code and the “matching” II code to acquire the non SI targets. **[A2]**

When this additional system management function is activated, the lockout maps are not taken into account for non SI equipped transponders. **[E8]**

This additional system management function will only be activated when the aircraft population consists of a significant proportion of SI equipped transponders. **[A3]**

13.17 Additional DLF requirements

When the station extracts a downlink Dataflash message following the announcement of the event, the station shall check if the message is associated to a contract that has been set-up by the station's IAL and if so, shall identify the register which is subject to monitoring. **[E1]**

If the Dataflash contract was set-up by the Internal Application List, the station shall program a GICB extraction for the monitored register during the same scan as the reception of the downlink Dataflash message. **[E2]**

This function shall be selectable by an SDP, for each contract independently. **[E3]**

The above option does not modify the normal operation of the station Dataflash application. Consequently, the operator should normally not select this function for a two-segments contract. **[A1]**

13.18 Processing of Position Reports

Mode S ground stations, when not clustered, exclusively rely on All Call interrogations and replies for Mode S targets acquisition. The processing of additional, indepedent target reports could support Mode S targets acquisition, anti-reflection processing as well as identifying Mode S detection failures. Such independent target position reports could come from Extended Squitters decoded on the omni antenna, or from target reports decoded on an external interface (e.g. ADS-B ASTERIX target reports). **[A1]**

The Tenderer shall provide details on the extensibility of their design to accommodate such enhancements, and the expected benefits. **[I1]**

CHAPTER 14

GENERAL EQUIPMENT CONDITIONS

14.1 Logistic Support

14.1.1 General

All parts of the ground station to be provided under this contract shall be designed and constructed in order to withstand possible operations of 24 hours per day, 7 days per week, 52 weeks per year for a minimum 10 year life cycle. **[E1]**

A modular approach, with easy access to each LRU and test point, shall be employed. The approach shall facilitate rapid replacement of faulty units, in order to satisfy the availability and maintainability requirements, whilst minimising impact on personnel and equipment safety. **[E2]**

It is preferred that duplicated items in the antenna turning gear can be replaced without the need to stop the antenna rotating. **[A1]**

The Tenderer shall state in his response the antenna turning gear items that require the antenna to be stopped when replaced. **[I1]**

It is preferred that no rear access is required for maintenance purposes. **[A2]**

It is required that related equipment maintenance actions shall be carried out from the same side of the equipment. **[E3]**

Maintenance philosophy for the ground station shall be consistent with unattended operation and shall be as follows:

(a) Restoration of service by Line Replaceable Unit (LRU) exchange at Organisational level. This may be carried out by appropriately trained Contractor, Agency or National personnel. **[A3]**

(b) Further diagnosis and exchange of Field Replaceable Units (FRU) to be carried out by engineering staff, either Contractor, Agency or National, utilising Intermediate or Depot level facilities. **[A4]**

(c) Defective LRU/FRU shall be returned for appropriate action (e.g. repair, recalibration, replacement) to the Contractor or a designated National Repair Centre. **[A5]**

A Logistic Support Plan shall be provided by the Tenderer with his Proposal regarding cost efficient approaches to Engineering, Logistic Support and Maintenance of the system(s), equipment(s) and software. This shall cover the entire planned life cycle of the system(s). **[I2]**

The Plan shall detail the methods & standards to be employed to achieve the Availability, Reliability and Maintainability objectives (including safety aspects) contained in this Specification. **[E4]**

The Plan shall also provide outline details of types of personnel, training, Support & Test Equipment requirements, Spares availability and Corrective & Preventative maintenance tasks (particularly those expected to exceed 30 minutes in length). **[E5]**

The Tenderer shall indicate in his Tender response the level of support available from their own resources to provide backing for the Agency or the National organisation's support facilities. **[E6]**

The Commercial Response shall include appropriate cost scales for:

(a) Maintenance Support Contract set-up and renewal **[E7]**

(b) Manufacturer's repair of LRUs and FRUs **[E8]**

(c) Post Design Services contract to provide technical information and assistance to component level and to allow any changes or improvements resulting from the test and validation period to be accommodated **[E9]**

Examples of the above, where available, shall be included in the Tender Response. **[E10]**

The Agency, or the National organisations may be required to perform Logistic Support Analysis to MIL STD 1388-1A. **[A6]**

The Tenderer shall indicate in the Tender Response his ability to comply with the objectives of this Standard (or equivalent) by citing previous examples of deliveries using Logistic Support Analysis. **[I3]**

The Tenderer shall guarantee the availability of all items required to support the system(s) supplied for at least 10 years after final acceptance of the last station to be installed. **[E11]**

Advance warning of at least 12 months shall be required for inability to meet this commitment to allow the Agency the option of a Lifetime spares procurement. **[E12]**

All components used in the Mode S system shall be available from more than one source, except with the prior written agreement of the Agency. **[E13]**

The Agency retains the right to purchase items required to support the system(s) supplied directly from the original equipment or component manufacturers. **[A7]**

Software maintenance, including PROM/EPROM programming shall be addressed specifically by the Tenderer who shall include details of his intended software Maintenance Policy in his Tender Response **[E14]**

14.2 Reliability, Availability, and Maintainability (RAM)

14.2.1 General

Availability, Reliability and Maintainability are characteristics of the overall system which shall be specified, designed, implemented, tested, validated and documented. **[E1]**

The methodology, techniques, processes and tools The Tenderer intend to use to achieve the specified RAM objectives shall be described or referenced in specific plans addressing architecture, hardware and software aspects. **[I1]**

The Military Standards Referenced in Annex C provide the preferred methodology. **[A1]**

14.2.2 Availability

For the purposes of this specification, Availability is defined as a ratio of the total time the system is capable of performing it's mission, against the time for which it is required to perform that mission, expressed as a percentage. **[A1]**

The availability calculation excludes all planned downtimes. **[A2]**

The figures for Availability quoted in this Specification are for Operational Availability (Ao) and shall be calculated using the following equation:

$$A(o) = \frac{MTBF}{MTBF + MTTR + MRT}$$

MTBF = Mean Time Between Failures in hours.

MTTR = Mean Time To Repair in hours.

MRT = Mean Response Time in hours (i.e. the average time from notification of failure for a technician to be ready to commence repair action). **[A3]**

14.2.2.1 Failure Definition

The Mode S System is to be considered as failed when coherent and full radar data is no longer provided by that system to Air Traffic Control. **[A1]**

The Mode S System is defined in Chapter 2 of this specification. **[A2]**

14.2.2.2 System Availability

The operational availability of coherent and full radar data from the Mode S ground station site shall be greater than 99.98%. **[E1]**

The Tenderer shall use availability figures for the customer-supplied components in order to predict the overall system availability. **[E6]**

The system reliability requirement for each Mode S ground station as described in Figure 3 (excluding Local Display and Recording/Playback facility) shall be greater than 20,000 hrs MTBF. **[E2]**

MTTR at Organisational Level shall be 30 (thirty) minutes. **[E3]**

The following figures are given for Tender Evaluation purposes:

(a) The MRT shall be 3.5 hours;

(b) The maximum time to repair shall not exceed 8 (eight) hours for 95% of all repairs;

(c) The maximum response time shall not exceed 8 (eight) hours. **[A2]**

When procuring equipment during the operational implementation phase of Mode S the Agency will provide the MRT based on their individual maintenance philosophy. **[A3]**

If the option is taken, the operational availability of the cluster controller shall be greater than 99.99% using the MTTR and MRT above. **[O1]**

The operational availability of the site monitor shall be greater than 99.995% using the MTTR and MRT above. **[E5]**

14.2.3 Reliability

Reliability is the probability that an item will perform it's intended function without error, under stated conditions, for a specified period of time. **[A1]**

14.2.3.1 Reliability Model

The Tenderer shall substantiate his ability to meet the specified RAM by providing in his response a reliability model consisting of reliability block diagrams covering all functions of the system. **[E1]**

The MTBF and MTTR in hours and the Availability shall be clearly shown in either the block diagram or in a list showing the equipment breakdown to functional unit level, with identification of specific common failure mode (e.g. switch over equipment). **[E2]**

14.2.3.2 Reliability Goals

Where appropriate hardware and software shall be separately identified and included in the Reliability predictions. **[E1]**

The Tenderer shall state the individual MTBF's of the equipment listed below and identify which items are duplicated to achieve the required availabilities of 14.2.2.2:

(a) SSR Antenna and cabling; **[I1]**

(b) Main bearing and drive ring; **[I2]**

(c) Rotary Joint and slip rings; **[I3]**

(d) Drive Motors and clutch; **[I4]**

(e) Antenna controllers; **[I5]**

(f) Azimuth Encoders; **[I6]**

(g) Control and Monitoring (Single Channel); **[I7]**

(h) Mode S Electronics (Single Channel); **[I8]**

(i) Monitor Display; **[I9]**

(j) Site Monitor; **[I10]**

(k) Cluster Controller. **[I11]**

The above info is required only if the corresponding equipments are being procured. **[A2]**

The Tenderer shall ensure the design minimises system outage due to preventative maintenance. **[E2]**

The Tenderer shall state in the Tender Response all expected outages. **[I12]**

14.2.3.3 Reliability Prediction

The Tenderer shall provide in his Response reliability predictions and analysis for each site as per MIL-HDBK-217 using exclusively a generic parts count method. **[I1]**

A Ground Fixed environment shall be used for all calculations. **[E1]**

Predictions for single channel MTBF and System MTBF shall be provided for the following:

(a) Line replaceable units; **[I2]**

(b) Each major equipment group; **[I3]**

(c) Each single channel of the system. **[I4]**

Where existing equipments are being offered to fulfil the contractual requirements then field failure rates and MTBF data shall be provided to substantiate the predicted data. **[E2]**

The Tenderer shall indicate the condemnation rate for the following:

(a) Line replaceable unit; **[I5]**

(b) Each major equipment group; **[I6]**

(c) Each single channel of the system. **[I7]**

14.2.3.4 Reliability Predictions Update

Reliability Predictions shall be provided within ninety (90) days of contract award and at agreed intervals thereafter for approval by the Agency. **[E1]**

14.2.3.5 Reliability Demonstration

The Contractor shall conduct a Reliability Demonstration. **[E1]**

The preferred methodology is described in MIL STD 785. **[A1]**

The Tenderer may propose an alternative methodology, to be described in the SAT Test Strategy, subject to Agency approval. **[I1]**

14.2.4 Maintainability

Maintainability is the measure of the ability of an item to be retained in or restored to a specified condition when maintenance is performed by personnel having specified skill levels, using prescribed procedures and resources, at each prescribed level of maintenance and repair.. **[A1]**

MTTR is the sum of corrective maintenance times at any specified level of repair, divided by the total number of failures within an item repaired at that level, during a particular interval under stated conditions. **[A2]**

14.2.4.1 Maintainability Goals

The Contractor shall meet or improve on the MTTR targets for the following functional areas:

(a) Mode S Antenna - 4 hrs; **[E1]**

(b) Main Bearing - 8 hrs; **[E2]**

(c) Motors & Encoders - 4 hrs; **[E3]**

(d) Mode S Electronics - 0.5 hrs; **[E4]**

(e) CAM - 0.5 hrs; **[E5]**

(f) Monitor Display - 1 hr; **[E6]**

(g) Site Monitor - 0.5 hrs; **[E7]**

(h) Cluster Controller - 0.5 hrs. **[E8]**

The above info is required only if the corresponding equipments are being procured. **[A1]**

The Tenderer shall provide in Tender response the MTTR estimates for each of the following:

(a) Line Replacement Unit; **[I1]**

(b) Each major equipment group; **[I2]**

(c) Each single channel of the system; **[I3]**

14.2.4.2 Maintainability Predictions

The Tenderer shall provide in the Tender response Maintainability Predictions for the following equipments:

(a) Line Replaceable Unit; **[I1]**

(b) Each major equipment group; **[I2]**

(c) Each single channel of the system. **[I3]**

MTTR predictions shall be in accordance with MIL HDBK 472. **[E1]**

The Tenderer shall conduct a Maintenance Task Analysis in accordance with MIL STD 470. **[E2]**

14.2.4.3 Maintainability Prediction Updates

Maintainability Predictions shall be provided within ninety (90) days of contract award and at agreed intervals thereafter for approval by the Agency. **[E1]**

14.2.4.4 Maintainability Costs

The Tenderer shall provide in the Tender response the average material cost of repair, the average cost per repair and the depot response time for the following:

(a) Line Replaceable Unit; **[I1]**

(b) Each major equipment group; **[I2]**

(c) Each single channel. **[I3]**

14.2.4.5 Maintainability Demonstration

The Contractor shall conduct a Maintainability demonstration in accordance with MIL STD 471. **[E1]**

14.3 Life Cycle Aspects

The ground station equipment shall be designed to have an in-service life of at least 10 years and shall be designed in such a manner that it may be progressively upgraded in functionality and performance. **[E1]**

The Tenderer shall indicate in the Tender Response the expansion capability of his proposed equipment (processor power, memory capacity, etc.). **[I1]**

The Tenderer shall be prepared to provide data for life cycle costing (Refer to Annex F for Data Requirements List). **[A1]**

To enable the Agency to fully calculate Life Cycle Cost implications, the Tenderer shall include as part of his proposal a provisional Build List of all repairable items. **[I2]**

The following information shall be provided for each item listed:

(a) Mean Time Between Failure, **[E2]**

(b) Mean Time To Repair, **[E3]**

(c) Original Manufacturer (Name, Address & Telephone Number) (include Alternative Manufacturer if available) **[E4]**

(d) Manufacturer's Part Number and Designation, **[E5]**

(e) Supply Price (including volume discount if any) and initial escalation rate. **[E6]**

The sources for all data shall be quoted. **[E7]**

Where any item of data is not supplied, the reason for non inclusion is to be stated. **[E8]**

All data shall be supplied by the Contractor within 12 months of Contract Let. **[E9]**

The Tenderer shall provide as part of the Commercial Response a Life Cycle Cost analysis. **[E10]**

14.4 Documentation

14.4.1 General Requirements

The Tenderer shall provide a detailed list of technical documents to be delivered, which include, but is not limited to, the following documents:

(a) System Overview; **[E1]**

(b) List of Deliverable Items; **[E2]**

(c) Statement of Compliance; **[E3]**

(d) Project Management Documentation:

- (i) Project Management Plan (PMP); **[E4]**
- (ii) Configuration Management Plan (CMP); **[E5]**
- (iii) Quality Plan (QP); **[E6]**
- (iv) Software Development Plan (SDP); **[E7]**
- (v) Verification and Validation Plan (VVP); **[E8]**

(vi) Installation and Commissioning Plan. **[E9]**

(e) Reliability, Maintainability and Availability Predictions (RMA). **[E10]**

(f) Lifecycle Documentation:

(i) System Requirement Specification (SRS or DOD-2167 SSS). **[E11]**

(ii) System Architecture Design Document (SAD or DOD-2167 SSDD). **[E12]**

(iii) Software Requirement Documents (SRD or DOD-2167 SRS), for each CSCI. **[E13]**

(iv) Software Architectural Design Documents (ADD or DOD-2167 SDD), for each CSCI. **[E14]**

(v) Interface Control Documents (ICD) for internal and external interfaces. **[E15]**

(vi) Hardware Development Specifications, for each HWCI. **[E16]**

(vii) Hardware Architectural Design Documents, for each HWCI. **[E17]**

(viii) COTS customisation documents. **[E18]**

(ix) Operator Handbooks. **[E20]**

(x) Verification and Validation Documents (for the system, the hardware and software components). **[E21]**

(g) COTS standard documentation. **[E22]**

(h) Training and Maintenance documentation. **[E23]**

(i) System Documentation **[E24]**

The Tenderer shall state when these documents will be delivered. **[I1]**

The exact delivery schedule shall be subject to agreement with the Agency. **[E25]**

The Tenderer shall deliver preliminary versions of the documents listed in (a), (b), (c), (d) and (e). **[E32]**

The Contractor shall deliver the documents identified in the Tenderer's list. **[E26]**

All deliverable documentation shall be written in English, using standardised presentation and notation. **[E27]**

All deliverable documentation shall be provided as paper and computer readable in a format to be agreed with the Agency prior to contract let. **[E28]**

The Contractor shall ensure that the Agency has the right to a free licence to copy the deliverable documentation called for under the contract, and to circulate or use the copies within the establishments of the Agency. The Agency will not disclose such documents outside its establishments without the prior written consent of the Contractor which shall not be unreasonably withheld. **[E29]**

The Tenderer shall identify in their Tender Response any deliverable documentation which will not be subject to the licence above. **[I2]**

Delivered documentation shall always be identified on the cover page with the assigned code referred to in the List of Deliverables. **[E30]**

In addition to the requirements above; flow charts, block diagrams and preventative/ corrective procedures (including diagnostics) shall be required. **[E31]**

These may be provided as a separate document or included in the main document. **[A1]**

14.4.2 Requirements Traceability

Traceability through cross references of the functional requirements shall exist throughout all levels of the documentation produced, including maintenance phases documentation. **[E1]**

14.4.3 Operator Handbooks and Maintenance Documents

The purpose of the Operator Handbooks and Maintenance Documents is to enable operation, maintenance, fault diagnosis and repair of the equipment by trained personnel in the Agency . **[A1]**

Although service restoration will be effected by replacing faulty LRUs with serviceable items, all the data needed to enable staff to locate faults to LRU level is required. **[A2]**

14.4.4 Cable Schedules

The System Cabling Schedule shall form part of the System Documentation. **[E1]**

The system cabling comprises all the cables used to interconnect the complete system. **[A1]**

14.4.5 Lifecycle Documentation

Either a component needs to be newly developed, or it exists already as a product or as part of a product. Those existing products are Off The Shelf products. They can be classified into Commercial Off the Shelf products (COTS) and Non Commercial Off The Shelf products (OTS). **[A1]**

A component shall only be categorised as COTS if it satisfies the following conditions:

(a) It has been developed ready for sale (in stock) by a third party, prior to receiving the contract (e.g. standard PC…);

(b) It is available to the market;

(c) It has an established history of use by different customers;

(d) It is a product of a reputable, well-established company;

(e) It is maintained by the vendor;

(f) The vendor possesses the source (in case of a software component);

(g) It is not modified for the contract (customisation in the form of setting/tuning parameters is not considered a modification). **[E1]**

A component shall only be categorised as OTS reused component if it satisfies the following conditions:

(a) It has been developed by the Tenderer and used outside the current contract;

(b) The product is developed according to an acceptable QA system, the complete lifecycle documents belonging to the product are available;

(c) It needs minor modifications (no more then 30 % of the original source code is to be modified/extended for the contract, in case of software) **[E2]**

Full lifecycle documentation shall be produced and delivered for newly developed components. **[E3]**

The existing lifecycle documents belonging to the OTS products shall be provided, updated if they were modified to fit in the procured system. **[E4]**

The COTS standard documentation (User Manual, Reference Manual…) shall be provided, together with documents describing how they were customised to fit in the procured system. **[E5]**

The Tenderer shall state, for each Configuration Item, whether it classifies as COTS, OTS or needs to be developed. **[E6]**

In addition to the above requirements, all source code listings of new and OTS reused software modules shall be provided in hardcopy and an appropriate computer readable format and provide the full definition and identification of the software development environment used (compilers, testing tools, simulator). **[E7]**

14.4.6 Amendments

The Tenderer shall advise the Agency in the Tender response on the exact procedures that will be employed to amend the documentation to include subsequent updates. **[I1]**

Specific Procedures shall be defined to control the various status of documentation, its approval and to ensure that the pertinent issues of appropriate documents are available at the appropriate locations, particularly when computerised documentation is used distributed and archived. **[E1]**

14.5 Training

Training for the delivered equipment shall be sufficient to enable Agency engineers to efficiently undertake the necessary trials to evaluate the ground station. **[E1]**

The following 'minimum training requirements' are identified for the ground station system:

(a) System description, including data flows;

(b) Interpreting system status;

(c) Initiate changes to system configuration;

(d) Reinstating equipment after failure/maintenance;

(e) Routine maintenance;

(f) Fault location;

(g) Restoration of service by module changing;

(h) Running and interpreting diagnostic software. **[A1]**

The Tenderer shall provide in the Tender responses a Training Plan for the ground station equipment as part of the Tender response. **[I1]**

The Training Plan shall describe the objectives, pre-requisites, duration and approach for training personnel involved with the delivered equipment (both hardware and software). **[E2]**

The Tenderer shall provide as part of the Commercial Response a separately cost proposal for the training of staff, stating how they intend to comply with the Training Plan objectives. **[I2]**

It is anticipated that all Training Courses shall be held at the Contractors premises. **[A3]**

The Contractor's training personnel shall utilise a complete and fully functioning system for all practical training. **[E3]**

To ensure a good standard of training, the Contractor shall employ Instructors who are fully trained in Instructional Techniques. **[E4]**

14.6 Safety Requirements for Personnel and Environment

14.6.1 Safety Regulations and Standards

The Contractor shall meet all International, European and National Health and Safety standards, rules and practices and the legislation that has relevance to the equipment being supplied. **[E1]**

'National' Health and Safety standards, rules and practices in this context is considered to be the standards of the country in which the equipment is to be installed, as specified in the local language. **[A1]**

The Tenderer shall state the National Health and Safety at Work requirements which will be adhered to. **[I1]**

The Tenderer shall state the standards relevant to the equipment being supplied. **[I2]**

The Contractor shall at all times observe the local rules regarding health and safety at work, relative to the personnel in his service The expenses which arise from this obligation (including any necessary translation of documentation) shall be borne by the Contractor. **[E2]**

The Tenderer shall show his understanding of the rules in force for the sites selected for the implementation of the Mode S ground system. **[E3]**

The Tenderer shall provide in Tender response details of their management system for Health and Safety and demonstrate the processes used to ensure compliance. **[I3]**

The Tenderer shall provide in Tender response details of the acoustic noise level of the proposed equipment. **[I4]**

14.6.1.1 Pre-Contract Audit

The Agency shall have the right to carry out a Pre-Contract Audit to confirm that the standards and the management system detailed by the Tenderer fully meet the Agency's requirements. **[E1]**

The audit will confirm that the Tenderer is operating to the standards defined in the Tender Response. **[A1]**

14.6.1.2 Climbing Devices

All ladders that may be required to gain access to areas that are out of reach from ground level in areas where particular hazard may exist shall be fitted with "Railok" to prevent personnel falling. **[E1]**

All installations shall require the approval of the Agency’s delegated Safety Officer. **[E2]**

14.7 Air Traffic Service Safety

14.7.1 Introduction

14.7.1.1 The Agency's safety policy is to secure high standards of safety within the air traffic services and systems it plans, provides and operates by minimising those risks which contribute to aircraft accidents as far as reasonably practicable. Safety is afforded the highest priority and it is an integral part of the Management function. **[A1]**

14.7.1.2 The Contractor shall demonstrate his understanding of the safety requirements and that their design and implementation plans will meet all of the safety criteria. The necessary demonstrations shall be through analysis of the design, components and maintenance procedures. **[E1]**

14.7.1.3 The safety activities and analysis present the evidence, arguments and assumptions, at significant points in the system life cycle, to provide assurance that:

(a) The Safety Requirements of the system are either met or that any shortcomings, limitations or unresolved hazards are understood and accepted. **[A1]**

(b) When introduced into operational service the new system does not, of itself, exhibit any hazards due to installation, commissioning and integration activities. **[A2]**

(c) The introduction of the new system does not adversely affect the safety of the existing ATS. **[A3]**

14.7.1.4 The safety assurance activities provide the necessary confidence that the following objectives have been met:

(a) The Safety Requirements of the system have been correctly identified. **[A1]**

(b) The procedures and standards used to design, develop and analyse the system are adequate and have been implemented correctly. **[A2]**

(c) There is sufficient evidence available to show compliance with the Safety Requirements, and to allow the system to proceed to the next life cycle phase or continue in operation, as appropriate. **[A3]**

14.7.2 Safety Plan

14.7.2.1 The Safety Plan shall define the safety management, safety analysis and assurance activities to be performed by the Contractor. **[E1]**

14.7.2.2 The Tenderer shall provide a preliminary Safety Plan. **[E1]**

The Tenderer's Safety Plan shall, as a minimum, address the items detailed at Annex D and shall confirm that they are commensurate with ensuring the Safety Plan deliverables are met. **[E2]**

14.7.2.3 The Contractor shall provide a Safety Plan. **[E1]**

14.7.3 Safety Plan Deliverables

14.7.3.1 The Contractor shall deliver the following documented deliverables resulting from the activities defined in their Safety Plan:

(a) Design Process and Assurance Deliverable; **[E1]**

(b) Installation, Commissioning, Integration and Test and Evaluation Deliverable. **[E2]**

14.7.3.2 The Design Process and Assurance deliverable shall:

(a) Provide a summary description of the Mode S functions, supported with diagrams, showing their physical location(s) and role. The boundaries of the Mode S System and its interface with other systems or facilities should be clearly identified. **[E1]**

(b) Identify or reference the Safety Requirements of the Mode S System. **[E2]**

(c) Describe the physical configuration of Mode S, including permitted variations of the configuration during operation. **[E3]**

(d) Identify the documentation and its status, which records the system build state for Mode S. **[E4]**

(e) Provide a description of the design process used for the development of the hardware and software aspects of Mode S. **[E5]**

(i) This description shall show the design, coding, verification and validation methods to be employed that will allow the software to meet the Safety Requirements. **[E6]**

(ii) This description shall provide evidence, arguments and assumptions for claiming that the hardware design has been implemented to a level consistent with the Safety Requirements. **[E7]**

(f) Identify any dependencies on other systems or facilities that affect the ability of Mode S to meet its Safety Requirements. **[E8]**

(g) Address each Safety Requirement: **[E9]**

(i) Providing arguments to support the claim that the Mode S design will meet the Safety Requirement; **[E10]**

(ii) Summarising, and referencing, any evidence available that supports the arguments that the design will meet the Safety Requirement; **[E11]**

(iii) Identifying the current compliant status of the Safety Requirement (met, not met, not proven); **[E12]**

(iv) Identifying any further verification and subsequent validation that is to be performed during the Installation, Commissioning and Integration activities; **[E13]**

(v) Identifying any features in the design that specifically address the Safety Requirement. **[E14]**

(h) State any limitations on the use, or maintenance, of Mode S or other shortcomings identified in the design. **[E15]**

(i) Specify any aspects of the Mode S performance that should be monitored in service to provide assurance that the Safety Requirements continue to be met in operation. **[E16]**

(j) Detail the confidence that has been gained that the Installation, Commissioning and Integration activities will not have an adverse effect on the safety of the existing ATS. **[E17]**

14.7.3.3 The Installation, Commissioning, Integration and Test and Evaluation Deliverable shall:

(a) Describe the installation, commissioning, integration and test and evaluation process and provide evidence, arguments and assumptions for claiming that this process was effective in maintaining the safety of Mode S and the existing ATS. **[E1]**

(b) Identify any dependencies on other systems or facilities that affect the ability of the Mode S System to meet the Safety Requirements. **[E2]**

(c) State any limitations on the use, or maintenance, of Mode S or other shortcomings identified in the design. **[E3]**

(d) Address each Safety Requirement: **[E4]**

(i) Identifying the compliant status of the Safety Requirement. **[E5]**

(ii) Identifying and reference the results of any other evidence that confirms or otherwise that the Safety Requirement will be met, and revise the status of the Safety Requirement accordingly. **[E6]**

(iii) Where it has not been concluded that a Safety Requirement will be met provide information about the possible impact to ATS. **[E7]**

(e) Declare and identify any other deficiencies in Mode S that may affect the safety of the ATS. **[E8]**

(f) Identify any aspects of the Mode S performance that should be monitored in service to provide assurance that the Safety Requirement continue to be met in operation. **[E9]**

(g) Identify any Mode S operation and maintenance requirements necessary to preserve the safety, including the identification and provision of relevant training. **[E10]**

(h) Detail the confidence that has been gained that the transition to operational use will not have an adverse effect on the safety of the existing ATS. **[E11]**

(i) Identify the documentation and its status, which records the Mode S build state. **[E12]**

(j) Identify or reference the process and responsibilities for initiating, performing and approving changes to Mode S. **[E13]**

14.7.4 Mode S Safety Requirements

14.7.4.1 A provisional analysis has been undertaken for the Mode S Safety Requirements and was derived by consideration of the failure modes on Air Traffic Operations. Annex E provides the target figures for the Mode S system in the operational phase, for a limited list of failure modes. The contribution of Radar Data Processing Systems, communication links and ATC workstations to the Mode S system are not included in Annex E. **[A1]**

The list of failure modes for the ground station shall be developed and refined by the Contractor, in consultation with the Agency. **[E1]**

Note that the strategy for the initial implementation of Mode S across the core area of Europe is defined as dual coverage (derived from two independent sources working simultaneously), wherever possible. **[A2]**

The Contractor shall demonstrate that ground stations based on their design can meet the refined Mode S System Safety Requirements. **[E2]**

Loss of radar data is defined as radar information that is not available from the ground station. **[A3]**

The loss of radar data for less than 10 seconds is considered to have no safety effect. **[A4]**

Corruption is defined as radar information that is available from the ground station(s) that is incorrect. **[A5]**

Detected corruption is defined as corrupt radar information available from the ground station(s) that has been identified as corrupt. **[A6]**

Undetected corruption is defined as corrupt radar information available from the ground station(s) that has not been identified as corrupt. **[A7]**

The corruption of any sequence of reports from the same aircraft for less than 10 seconds is considered to have no safety effect. **[A8]**

Height and Identity data is used to define the surveillance information of both Modes A/C and S. **[A9]**

14.7.5 Mode S Safety Analysis

14.7.5.1 General

In support of the Safety Plan deliverables the following specific safety activities shall be conducted by the Contractor. The product of these analyses, where appropriate, are deliverables to the Agency. **[E1]**

14.7.5.2 Standards

Relevant standards for the conduct of Mode S safety activities are indicated at Annex C. **[A1]**

The Tenderer shall state in his response the standards they will be using for each safety activity. **[I1]**

14.7.5.3 Hazard Log

14.7.5.3.1 The Contractor shall:

(a) Produce and maintain a Hazard Log; **[E1]**

(b) Ensure that all changes initiate a review of existing and new hazards that may arise as a result of such changes; **[E2]**

(c) Use a common tool (Word, Excel etc.) to maintain the Hazard Log (Refer to Section 14.13.3). **[E3]**

14.7.5.3.2 The Contractor's Hazard Log shall be provided as soon as it is updated throughout the life cycle of the product, including updates resulting from third contracts. **[E1]**

14.7.5.4 Hazard Identification and Analyses

14.7.5.4.1 The Contractor shall conduct a programme of Hazard Identification and Analyses, building on that of Annex E, and stating any assumptions about other systems; to ensure that the identification of hazards within Mode S are both refined and extended. **[E1]**

14.7.5.4.2 The ground station Safety Requirements shall form the initial assessment of the safety criticality of Mode S. The Contractor shall use this assessment as the basis for the subsequent hazard analysis as the design progresses. **[E1]**

14.7.5.4.3 The Contractor shall incorporate the results of the Hazard Identification and Analyses into the Hazard Log. **[E1]**

14.7.5.4.4 The Hazard Identification and Analyses shall include, but not be limited to:

(a) A system FMECA (Failure Modes Effect and Criticality Analysis) for Mode S hardware and software updating it regularly during system development. In the case of hardware, the FMECA shall decompose Mode S to Line Replacement Unit level. Where the FMECA has identified a safety significant failure, the Contractor shall take steps to eliminate, mitigate, circumvent, or otherwise reduce the safety significance of the failure. **[E1]**

(b) A Fault Tree Analysis (FTA) to complement the FMECA and to derive quantitative probabilities of occurrences of all hazards and to demonstrate that the Safety Requirements have been met. The FTA shall explicitly state the source and justification of all failure probabilities used in the derivation of quantitative probabilities for each hazard. **[E2]**

The Tenderer shall provide in the Tender Response his approach to the above with respect to software. **[I1]**

14.7.5.5 Spare.

14.7.5.6 Independent Safety Assessment

14.7.5.6.1 The Contractor shall carry out an Independent Verification and Validation (IV&V) of the implementation of the Contractor Safety Plan and its products. Suitably qualified personnel independent of the development team shall be used. **[E1]**

14.7.5.7 Safety Assurance Traceability

14.7.5.7.1 The Contractor shall document, implement and maintain traceability procedures to allow for full forward and backward traceability of all documents, components, materials, designs, reviews, records pertaining to the safety assurance activities. **[E1]**

14.8 Hardware Requirements

14.8.1 General Hardware Requirements

The construction of the system and all its components shall be in accordance with the best current practices and standards in force at the International and European levels. **[E1]**

As part of the Tender Review Process the Agency will carry out an on-site audit of the Tenderers Hardware Design and Management processes. **[A1]**

The audit will involve an assessment of the controls used in the hardware design and management process and an evaluation of their effectiveness. **[A2]**

14.8.2 Hardware Standards and Codes of Practice

The Tenderer shall state in the Tender Response the Hardware Standards and Codes of Practice which will be applied to the system. **[I1]**

Copies of these standards and codes of practice shall be made available on request. **[E1]**

The Tenderer shall identify where each of the following hardware aspects are defined in the standards quoted:

(a) Component Selection, including, but not limited to, semiconductor devices, fuses, fans etc; **[I2]**

(b) Circuit Design; **[I3]**

(c) Electrical Wiring; **[I4]**

(d) Connections; **[I5]**

(e) Printed Circuits and Wiring; **[I6]**

(f) Circuit and Equipment Layout; **[I7]**

(g) Circuit and Equipment Assembly; **[I8]**

(h) Protective Devices; **[I9]**

(i) Interchangeability of equipments, sub-assemblies and components; **[I10]**

(j) Full accessibility of components for maintenance, with easily accessible connection, testing and fixing points; **[I11]**

(k) Replaceable parts located and secured so as to permit inspection, servicing and replacement without damage to, or interference with adjacent part of wiring; **[I12]**

(l) Fail safe characteristics for each component, circuit and equipment; **[I13]**

(m) Use of autotest and automatic detection and indication of failed components; **[I14]**

(n) Protection of cables, wiring, and board against damage from liquids, heat, shock and vibration; **[I15]**

(o) Marking and labelling of the various components, boards, equipment, cables and wiring; **[I16]**

(p) Use of warning and instruction labels for any risk of danger. **[I17]**

14.8.3 Spares Availability

The Tenderer shall undertake to ensure that spares will be available for at least 10 years after acceptance of the equipment. **[E1]**

14.8.4 Modification After Delivery

Modification to the type of equipment supplied under the Contract made by the Contractor subsequent to delivery shall be notified to the Agency in order that consideration may be given to the embodiment of such modifications in ancillary equipments. **[E1]**

Post Contract Support shall be available for a minimum of five years after acceptance of the equipment. **[E2]**

14.8.5 Handling Requirements

Panels, units and chassis which require removal for maintenance should not normally exceed 10 kg in weight (including the weight of the transit case). **[E1]**

Units exceeding 10 kg in weight shall be provided with suitable lifting facilities. **[E2]**

Such equipment shall be clearly labelled as being heavier than 10 kg with a warning label. **[E3]**

The Tenderer shall identify in the proposal any special handling requirements. **[I1]**

The design of panels, units, chassis etc. shall be such that they can be safely set down without damage. **[E4]**

Fragile components shall not be positioned in exposed places, but should be protected in the best way possible (e.g. guard rails). **[E5]**

The Contractor shall bring to the Agency's notice components or devices supplied under the Contract that could be in any way affected by electrostatic discharge and which might as a consequence be damaged by incorrect handling or storage. **[E6]**

14.8.6 Air Conditioning

Air Conditioning shall be provided as required by National Administration regulations. **[E1]**

14.9 Software Requirements

14.9.1 General

For the purpose of this specification, firmware is defined as software burned in hardware devices. **[A1]**

The following software requirements shall apply for firmware and software. **[E1]**

The software shall be designed to preclude abnormal behaviour and to limit the consequences of system failure conditions through appropriate fault avoidance techniques, fault tolerant design architecture, verification and validation methodologies. **[E2]**

Software design, development, verification, validation and maintenance shall be carried out according to methodical and rigorous procedures to ensure that the system fully complies with the specification, and to ensure that performance, safety and quality objectives allocated to the software are met. **[E3]**

The Tenderer shall list the software deliverables in a preliminary Configuration Management Plan, to be provided as part of the Tender Response. **[I1]**

As part of the Tender Review Process the Agency will carry out an on-site audit of the Tenderers Software Development and Management processes. **[A2]**

This audit will involve an assessment of the controls used in the software development and management process and an evaluation of their effectiveness. **[A3]**

14.9.2 Software Standards

The software deliverables shall be produced in accordance with the best current practices and standards in force at the International and European levels. **[E1]**

High order languages conforming to a recognised ISO or ANSI standard shall be used. **[E2]**

The Tenderer shall state in his response the software language to be used. **[I1]**

The Tenderer shall identify in the Tender Response the Software Standards and Codes of Practice which will be applied to the Project. **[I2]**

The Contractor shall review with the Agency the appropriate software standards for this Project. **[E3]**

14.9.3 Design Methods

An important factor in an orderly software development program is an early establishment of a design discipline which makes the software traceable, testable, maintainable and understandable to persons other than the developers. **[A1]**

An industry standard method of software design shall be employed. **[E1]**

If new software developments are needed, the Tenderer shall state in a preliminary Software Development Plan the software development environment in terms of hardware and software including as a minimum:

(a) Software development objectives (criticalities of the software functions, quality, safety, etc.); **[E2]**

(b) Team organisation; **[E3]**

(c) Interfaces; **[E4]**

(d) Design methodology and all tools which will be employed; **[E5]**

(e) Standards and activities with regards the software life cycle; **[E6]**

(f) Technical milestones; **[E7]**

(g) Support environment to be used or implemented (tools, simulator, etc.); **[E8]**

(h) Hardware platform(s) for the tools to be used. **[E9]**

The standard for airborne software embedded system RTCA DO 178B/EUROCAE 12B may be used as guidelines for coping with the software requirements and tailoring the effort of development, verification and validation versus the criticality of the software functions. **[A3]**

14.9.4 Software Safety

The required Safety Requirements are defined in 14.7. In order to meet these requirements it is essential that the software processes shall be examined as part of the FMECA. The criticality of each software module/process shall be identified according to the role carried out by the process within the system. **[E1]**

The Tenderer shall identify in the Software Development Plan the various criticalities of the tasks carried out by the software functions and the measures (in terms of developments, verification, validation and assurance activities and techniques) to ensure that the characteristics of the software, in particular its failure modes, do not impact on the overall system safety level as defined in 14.7. **[E2]**

The Tenderer shall state the levels according to which they have developed, or intend to develop the software components in terms of the Mode S ground station (see RTCA DO 178). **[I1]**

14.9.5 Operating System Standards

The Tenderer shall provide in the Tender response details of the Operating System to be used. **[I1]**

The Contractor shall ensure that the Operating System design shall allow for future hardware, software and communication enhancements. **[E1]**

The Tenderer shall state the level to which the Operating System can analyse the type and cause of detected system errors. The level of ability to record data concerning the error and its cause for error notification and subsequent investigation from a maintenance position shall be stated. **[I2]**

Where an Operating System has been written by, or is owned by the Tenderer, the source code for the operating system shall be defined as a deliverable item in the Contract. **[E2]**

The Tenderer shall state the system reload time. **[I3]**

14.9.6 System Compatibility

Where any form of distributed processing architecture is used, the Contractor shall provide details of procedures and specific techniques to ensure that the software that runs in each processor is compatible with the software running in all the other processors that make up one channel of the overall system. **[E1]**

Suitable recovery mechanisms shall be coded for the case where incompatible versions are found to be running in different processors. **[E2]**

14.9.7 Upgrades and Reversion

Unless a version of software for a processor is to be kept on removable media, where changing the version of software that is running is performed by changing the media and reloading the system, the storage medium built into the system is to be capable of holding two versions of the system software. **[E1]**

The time taken to switch between software versions shall be no more than 3 minutes plus the system reload time as given in 14.9.5. **[E2]**

14.9.8 Adaptation

For flexibility of operation and ease of maintenance it is essential that all variables within the software that control site configurable parameters can be modified without the need for software recompilation/rebuild. **[E1]**

All such operational parameters shall be referred to as adaptation parameters, which are a software adjustable, agreed subset of the SDPs. **[A1]**

All adaptation parameters within the system shall be stored in a manner that allows for any parameter to be easily changed without any impact on the operational software and system safety. **[E2]**

A method shall be provided for changing the content of adaptation file(s). The method provided shall be capable of range checking the variable(s) to be changed and of providing a plain language description of each parameter that can be changed. This method shall be separate from any commands used to change the values of these parameters while the system is running. **[E3]**

The site configuration parameters shall be defined in a logical manner in units which relate to the parameter concerned. (e.g. Range in NM; azimuth in degrees or Azimuth units etc.). **[E4]**

All parameters shall be accessible and/or modified through the CAM interfaces or a dedicated terminal. **[E5]**

In case a dedicated terminal is necessary to fulfil these requirements the Tenderer shall include this terminal within the bid. **[E7]**

The Tenderer shall provide detailed information on this dedicated terminal **[I1]**

The Contractor shall deliver a special document:

(a) Listing all the software parameters that could be accessed and/or modified via the CAM or any dedicated terminal;

(b) Indicating for each parameter the default value, increment, minimum & maximum values, units, etc;

(c) Listing all the hardware parameters (switches, jumpers, DIP,......) that are accessible and/or configurable;

(d) Indicating for each hardware parameter the default configuration, the possible ones and the physical location on concerned PCB by means of a lay-out diagram;

(e) Describing for each parameter the impact of a change at the component, LRU, sub-system and system levels, especially from the point of view of the functionality being modified, and the effects on the output and input data. **[E8]**

14.9.9 Verification

The Contractor shall define in a Verification and Validation Plan the verification process being used to ensure that the results of a particular phase/activity in the software development has met the requirements of the previous phase. **[E1]**

Verification shall be carried out according to methodical and rigorous procedures to ensure that performance, safety and quality objectives allocated to the software are met. **[E2]**

14.9.10 Validation

The Contractor shall define in the Verification and Validation Plan the validation process being used to ensure that the results of the software development has met the requirements of the project. **[E1]**

Validation shall be carried out according to methodical and rigorous procedures to ensure that performance, safety and quality requirements are met. **[E2]**

There the Contractor identifies the use of simulation as appropriate to the validation process the level of simulation shall be identified. **[E3]**

Any testbeds etc. used for module/sub-system testing shall be retained under configuration control for the duration of the Contract (including maintenance period). All such software and associated test specifications shall be maintained so that any test performed at any time during system development may be re-performed on the versions of software modules that form the final delivery of software. **[E4]**

The Contractor shall state what special arrangements will be undertaken to test and validate critical software. **[E6]**

The above information is essential from the safety aspect. **[A1]**

The Test Specification shall detail and identify the test harnesses used. **[E7]**

The Contractor shall identify in the Software Development Plan the verification and validation processes used to integrate the operating system and software with the hardware. **[E8]**

Results of all tests shall be recorded for subsequent audit. **[E9]**

14.9.11 Software Development Environment

The Software Development and Verification Environment is a significant factor in the production of high quality software. **[A1]**

Qualified or intensively validated tools shall be used to achieve the necessary level of confidence for minimising potential environment related errors. **[E1]**

The development and verification environment shall be subject to Configuration Management. **[E2]**

If the Software Development and Verification environment is changed during the software life cycle, the validity of previous tests and coverage analyses shall be reconsidered by the Agency. **[A2]**

The Agency reserves the right to request the re-verification of modules in the event of changes to the Software Development and Verification Environment. **[E3]**

14.10 Design

14.10.1 General

Fault tolerant design shall be applied wherever the potential for critical consequences results from the design or operation of the Mode S ground station and associated equipment. **[E1]**

The following deterministic safety design principles shall be implemented as a minimum:

(a) No single failure condition shall have a critical consequence for ATC Services; **[E2]**

(b) No single operator error shall have a critical consequence for ATC services and the operator; [E3;

(c) Hardware or software failures shall not cause additional failures with hazardous effects; **[E4]**

(d) Safety-critical functional paths (both hardware and software) shall be isolated or partitioned from non safety-critical functions, in order to prevent propagation of errors and failures; **[E5]**

(e) Alternate or redundant safety critical functional paths shall be separated or protected in such a way that any event that causes the loss of one functional path will not result in the loss of alternate back-up, or redundant paths; **[E6]**

(f) Parametric operating ranges and performance limits for safe operation shall be established for the design and shall be specified by the Contractor; **[E7]**

(g) The design shall provide protection to avoid the erroneous acceptance of commands that may affect personnel safety or cause hardware or software damage. **[E8]**

Multiple failures that result from common cause or common mode failure mechanisms shall be considered as single failures for the purpose of determining and designing the fault tolerant system. **[E9]**

Failures modes shall be considered to originate from:

(a) Hardware; **[E10]**

(b) Software; **[E11]**

(c) Firmware; **[E12]**

(d) Procedures as the result of design error; **[E13]**

(e) Random failure due to environmental effects. **[E14]**

The Design shall allow expansion to accommodate future growth (in functional and performance requirements to achieve full Mode S) through scalable, modular design, built on structured techniques that ensure traceability and consistency between the functional requirements and the ultimate design specifications. **[E15]**

The Tenderer shall define the methodology, techniques and tools employed to achieve the system design objectives. **[I1]**

The Tenderer shall demonstrate that they are compliant with the requirements in chapters 14.2, 14.4, 14.6 and 14.7 of this specification, by delivery of sample design specification documentation described in MIL-STD-1521. **[I2]**

Traceability, consistency and completeness shall be ensured between design specification and the system requirements. **[E16]**

The system design shall take into account the necessary features for verification and validation testing, and for maintenance. **[E17]**

The Agency believes that it will be in the Projects' best interest for there to be a continuous free exchange of technical information between the Contractor and the Agency's' technical staff, especially in the early stages of the project. **[A1]**

The Tenderer shall state how such relationships will be fostered. **[I5]**

14.10.2 Ongoing technical dialogue

The Agency considers it essential that there is an ongoing dialogue with the Contractor on all technical issues. **[A1]**

If necessary the Agency shall convene additional meetings at short notice to discuss specific problems or technical issues. **[E1]**

14.11 Delivery

The Contractor shall deliver the items as described in the 'List of Deliverables' at the dates agreed and to the locations specified by the Agency. **[E1]**

The Contractor shall deliver the Mode S ground station to site for Site Acceptance Testing as specified in this document, following successful completion of all Formal Acceptance Tests on his factory test bench, in addition to any internal verification and validation testing normally described in the project quality assurance and development plans. **[E2]**

The Contractor shall provide for software, the description and the identification of each delivered version, and the associated source and executable code, the identification of the development and testing tools, the updated corresponding documentation (specifications, design, test plan, test results, listing). Compatibility with the various hardware version shall be indicated. **[E3]**

14.12 Installation and Commissioning

The Contractor shall prepare, deliver and apply an Installation and Commissioning Plan, describing the objectives, the strategy, the milestones, the installation and site testing procedures, acceptance criteria, the respective responsibilities between the Agency, the user and the Contractor. **[E1]**

This shall be subject to a specific planned review, not later than 120 working days before delivery of the Mode S ground station. **[E2]**

The Agency and the user will provide, according to an agreed plan, details of the sites where the Contractor shall install the Mode S ground station. **[A1]**

The Contractor shall provide all necessary studies and equipment to complete installation at the chosen user site, and shall provide all welfare and temporary services in support of their installation team **[E3]**

The installation and commissioning Plan shall be approved by the Agency and shall include, but not be limited to, the following aspects:

(a) Physical dimensions and weight of all equipment; **[E4]**

(b) Power consumption of all equipment; **[E5]**

(c) Heat dissipation of all equipment; **[E6]**

(d) Full wiring schedules, interconnection diagram and routing for power, signal, earthing cables; **[E7]**

(e) Full details of waveguide and RF co-ax connections and fixing including full dimensions and routing; **[E8]**

(f) All details for lifting, assembling and fixing the Antennas; **[E9]**

(g) Alignment Procedures for the PSR and SSR Antennas; **[E10]**

(h) Details of site accommodation requirements; **[E11]**

(i) Details of site plant requirements. **[E12]**

The documentation shall be updated periodically in order to reflect accurately the complete installation. **[E13]**

In order to provide a consistent response for the cost of Installation the following site facilities will be provided by states:

(a) Tower foundation (Contractor shall state size and bearing load);

(b) Equipment cabin foundation (Contractor shall state size and bearing load);

(c) Electricity supply (Contractor shall state requirements);

(d) Data lines and telephone lines (Contractor shall state requirements);

(e) Access to site;

(f) Hardstanding for 2 Agency vehicles. **[A2]**

The Tenderer shall state in the proposal the aspects of the installation to be included in the documentation concerning:

(a) Cabling Arrangements, routing, identification; **[I3]**

(b) Interference, susceptibility to radio frequency; **[I4]**

(c) Earthing arrangements; **[I5]**

(d) Equipment mounting, cooling. **[I6]**

Compliance with the EMC recommendations contained within EEC Directive (89/336/EC) on Suppression of Interference shall be required. **[E14]**

The Contractor will be required to demonstrate that the delivered system conforms to the EMC recommendations. The cost of this demonstration shall be borne by the Contractor. **[E15]**

The Contractor shall be responsible for all transportation and delivery of equipment to the sites where installation shall take place. **[E16]**

Commissioning will be granted after successful on site testing with a specified operational environment and acceptance of the associated deliverables specified in the plans. **[A3]**

14.13 Project Management

14.13.1 Project Management Plan (PMP)

The Tenderer shall provide in their Tender Response a PMP that clearly describes all stages of the project including flight trial, SAT, FAT etc. **[I1]**

The PMP shall include the following list as a minimum:

(a) Project Plan with milestones and timescales. **[E1]**

(b) Resource Schedule, showing the contribution from team members. **[E2]**

(c) A Work Breakdown Structure, showing the work packages, responsibilities, and expected duration. Each work package shall be described with the input needed and expected deliverables. **[E3]**

(d) Delivery Schedule, showing dates and deliverables. **[E4]**

(e) A description of the Tenderer's proposed project team including Curriculum Vitae for the key project team members. **[E5]**

(f) Organisation / Roles and Responsibilities:

The role and the responsibilities of each key member for the various project phases and steps shall be described. **[E6]**

(g) Interfaces with SubContractors and Suppliers:

Any Subcontract and/or Consortium arrangements shall be described, covering the respective involvement and responsibility. **[E7]**

(h) Key risks and jeopardise to satisfactory project progress and how these will be managed. **[E8]**

(i) Methods to manage and control the work performed under the project. **[E9]**

(j) Method used to monitor internal communication and reporting. **[E10]**

(k) Methods and procedures to manage Quality Assurance. **[E11]**

This plan shall be updated throughout the life of the Contract to continually reflect the project team organisation and the work breakdown structure. **[E12]**

Any change in the responsibilities during the project shall be formally reported to the Agency. **[E13]**

The Tenderer shall state in the Tender Response his requirements in terms of resources required from the Agency at all phases of the Project. All Agency resources required shall be scheduled into the plan. **[I2]**

If different development sites are planned, co-ordination links and procedures shall be provided. **[E14]**

14.13.2 Spare.

14.13.3 Project Support Tools

The Contractor shall ensure that it uses PC tools which are compatible with the Agency standards. **[E1]**

The Tenderer shall state any conversion methods that may be necessary for documents produced automatically by CASE tools. **[I1]**

The Agency currently uses the following support tools:

(a) Microsoft Word 97; **[A1]**

(b) Microsoft Excel 97; **[A2]**

(c) Microsoft Project 98; **[A3]**

(d) Windows NT4; **[A4]**

(e) Microsoft Access 97; **[A5]**

(f) Adobe Acrobat Reader 4.0. **[A6]**

In order to reduce the size of electronic documents sent to the Agency, and to avoid the spreading of macro-viruses, the Tenderer is advised to use a lean and safer format such as Rich Text Format (RTF) or Portable Document Format (PDF). **[A7]**

14.13.4 Control and Reporting

The Control and Reporting mechanisms are defined by the Agency responsible for the procurement. **[E1]**

14.13.5 Spare.

14.13.6 Spare.

14.13.7 Spare.

14.13.8 Configuration Management

14.13.8.1 General

Configuration Management (CM) is an essential discipline applying to all deliverable items including documentation, hardware, spares and software (Application software, system software, compilers & testing facilities). **[A1]**

CM identifies the function and physical configuration of an item. **[A2]**

CM controls changes to the item and records and reports those changes as well as implementing the changes into all identical items. **[A3]**

14.13.8.2 Preliminary Configuration Management Plan

The Tenderer as part of their Tender Response shall provide details of the hardware and software CM plans they would implement following contract award. **[I1]**

The Preliminary CM Plan shall include as a minimum:

(a) List of internal and external items of the project established as Configuration Items. **[E1]**

(b) Responsibilities and relevant procedures to be used; **[E2]**

(c) Configuration Management tools and techniques; **[E3]**

(d) Configuration Identification and modification policy; **[E4]**

(e) Configuration Status Accounting; **[E5]**

(f) Configuration Auditing; **[E6]**

(g) Software/Hardware Interface Management; **[E7]**

(h) Configuration Control for spares ranging and maintenance; **[E8]**

Change procedures shall be consistent with the configuration approach. **[E9]**

14.13.8.3 Hardware Configuration Management Plan

The Contractor shall provide a detailed hardware CM Plan for Agency approval. **[E1]**

The CM Plan shall include details of how the configuration of subcontracted hardware is dealt with. **[E2]**

The plan shall describe the Contractor's CM programme that will be used to ensure adequate control of the status of all "configured items", documentation and spares. **[E3]**

The hardware CM plan shall also identify proposals for the Agency to assume the CM responsibility post technical completion from the Contractor. **[E4]**

14.13.8.4 Software Configuration Management Plan

The Contractor shall provide a detailed software CM plan for Agency approval. **[E1]**

The plan shall describe the Contractor's software CM programme that will be used to ensure adequate control of the System software including documentation and deliverable software. **[E2]**

The software CM plan shall identify the participation of the Contractor SQA department in software CM activities. **[E3]**

Key personnel shall be identified using organisation charts. **[E4]**

The software CM plan shall also identify proposals for the Agency to assume software CM authority post technical completion from the Contractor. **[E5]**

14.13.8.5 Audit

A specific Configuration audit can be decided by the Agency e.g. if significant discrepancies are detected. This audit would be carried out by the representatives of the Agency, and/or its partners in the project, and/or a third party. **[A1]**

The Contractor shall then allow access to the necessary information, in conformity with the agreed audit objectives and process. **[E1]**

14.13.8.6 Change Control

Design records shall be maintained by the Contractor as part of his CM programme. **[E1]**

Any changes, which may alter the agreed Contract production baseline shall be referred to the Agency for their approval. **[E2]**

The Tenderer shall propose specific procedures to monitor the project and control change. **[E3]**

Shortcomings and subsequent corrective actions and/or proposed evolutions shall be described in a "Technical Issue Form" and submitted to the Agency. If the proposed amendment is accepted, a "Change Request" shall be raised using an appropriate agreed procedure. **[E4]**

Before a change is made official, its validity shall be confirmed and the effects on other items shall be identified and thoroughly examined. Methods to show the traceability and compatibility between changes and modified parts of system/software shall be provided. **[E5]**

Any change having a contractual impact shall be the subject of a formal Contract amendment. **[E6]**

Where necessary the Agency's representative will attend change control meetings at the Contractor's premises. **[A1]**

The CM Plan shall state the Configuration Management procedures to be used on the project. **[E7]**

The system for identifying the configuration shall be defined and how the identification is allocated should be documented. The Contractor shall maintain a system to ensure that the configuration of each configured item within a system may be identified. **[E8]**

The Configuration Management system should be subject to audits by the Contractor to demonstrate that it is suitable and effective. The audits shall verify the accuracy of the configuration information. **[E9]**

The results of these audits shall be made available to the Agency on request. **[E10]**

Configuration control shall also be applied to spares in the maintenance process if applicable. **[E11]**

The CM Plan shall state how this is achieved. **[E12]**

The Tenderer shall document his controls over software/hardware interfaces **[E13]**

14.13.8.7 Software Configuration Management / Configuration Control

The Contractor shall use configuration management software to ensure that only authorised changes are made to source code modules. **[E1]**

All Modules/files that make up the system and/or the development environment (compilers / linkers etc.) shall be under the control of the CM software at all times. This includes the output files from the compile/link process in addition to the input source files. **[E2]**

Compatibility between various versions of hardware and software of the Mode S ground station shall be permanently addressed in the CM Plan. **[E3]**

14.13.8.8 Operating System Configuration Management / Configuration Control

Where a 3rd party operating system is used, changes to the code shall only be allowed through formal Configuration Control procedures. **[E1]**

All such changes shall allow future operating system upgrades to be provided by the original vendor. **[E2]**

All configuration details for the operating system employed shall be supplied to the Agency. **[E3]**

For an in-house operating system, formal Configuration Control procedures shall be fully applied. **[E4]**

14.13.8.9 Documentation Configuration Management

Shortcomings and subsequent corrective actions and/or proposed evolutions to all documents shall be described in a "Technical Issue Form" and submitted to the Agency. If the proposed amendment is accepted, a "Change Request" shall be raised using an appropriate agreed procedure. **[E1]**

14.13.9 Project Risk

The Tenderer shall provide in their Tender Response a Risk Management Plan (RMP) detailing how they will manage risks associated with this project. **[I1]**

The areas to be covered in the RMP shall be, as a minimum, financial, technical (hardware and software), quality, programme, etc. **[E1]**

The Contractor shall maintain a Risk Register (RR) which shows, as a minimum:

(a) What activities may be affected by each risk; **[E2]**

(b) The probability of risk; **[E3]**

(c) The areas of impact; **[E4]**

(d) Suggested risk reduction measures; **[E5]**

(e) Ownership of the risk. **[E6]**

The Contractor shall report all risk areas, using the agreed reporting procedures. **[E7]**

14.14 Quality Assurance

14.14.1 General

Quality Assurance (QA) is a planned, controlled and systematic programme to ensure the deliverable equipment or service meets specified requirements. **[A1]**

Quality Assurance shall be applied to all activities necessary for the achievement of the Mode S ground station project. **[E1]**

Quality Assurance shall ensure the quality targets, requirements and specifications are correctly and completely fulfilled and ensure traceability and visibility throughout the project. **[E2]**

14.14.2 Quality Standards

The Tenderer shall be approved to BS EN ISO 9001/9002 or to an equivalent standard. **[E1]**

For the software elements of the Contract, approval to ISO 9000-3 or equivalent is preferred. **[A1]**

These approved Quality procedures shall apply to both hardware and software aspects of the Contract. **[E2]**

The terms of the applicable standard shall apply throughout the period of the Contract. **[E3]**

The scope of registration shall also cover the scope of the activities relating to the Contract. **[E4]**

The Tenderer not certified to these standards shall demonstrate that he is working towards such a standard and can be audited against it. **[E5]**

14.14.3 Quality Assurance Authority

The Agency shall nominate one of its representatives as the Quality Assurance Authority for the purpose of the contract. The Agency Quality Assurance Authority shall have unrestricted access during normal working hours to verify at source that the activities, processes and techniques employed in the design and manufacture of the hardware, software and associated documentation conforms to the requirements of the contract, Quality Plan and associated documents. **[A1]**

14.14.4 Quality Plans

14.14.4.1 Preliminary Quality Plan

The Tenderer and his proposed major SubContractors shall submit, as part of their technical proposal, a Preliminary Quality Plan (QP) based on the requirements of this specification and which details the QA programme which would be implemented in the event of a Contract being awarded. **[I1]**

The Preliminary QP shall list all QA related and supporting documents. **[E1]**

A copy of QA manuals and other related documents shall be supplied to the quality authority upon request. **[E2]**

14.14.4.2 Quality Plan

A Quality Plan, in accordance with BS EN ISO 9001/9002, shall be submitted by the successful Tenderer and their major SubContractors, detailing how QA will be applied to the Contract. **[E1]**

This plan shall be submitted for approval by the Agency. The QP shall be implemented immediately. **[E2]**

The QP shall identify the product specified by the Contract and shall state the procedures of the Contractor's Quality Manual that apply to the Contract. **[E3]**

The QP shall identify additional procedures and amplifications to existing procedures that are required to meet the Contract conditions. **[E4]**

The QP shall highlight the critical control and review stages for the whole Quality task from Contract inception to final acceptance of the product by the Agency. **[E5]**

The QP shall identify the entry criteria for these milestones and define how satisfactory completion is recorded. **[E6]**

The QP shall include Quality organisation charts for the Contractor, and all major SubContractors, showing reporting and responsibility lines within the Companies. **[E7]**

Names and designations shall be provided for all staff with responsibilities for the Contract. **[E8]**

All defining documents shall be subject to document control procedures. **[E9]**

The QP shall require Agency approval at all issues. **[E10]**

The QP shall list those documents that will be submitted to the Agency for approval prior to issue. **[E11]**

The Contractor shall pass down to his SubContractors all aspects of his QP necessary to ensure the quality of the product and/or service. **[E12]**

The Contractor shall remain totally responsible for his SubContractors and shall describe how SubContractors have been selected. **[E13]**

The QP shall state which SubContractors have produced their own QP. **[E14]**

14.14.4.3 Software Quality Plan

A Software Quality Plan (SQP), in accordance with ISO 9000-3, shall be submitted by the Tenderer and their major SubContractors detailing how QA will be applied to the Contract. **[E1]**

The SQP shall describe the quality objectives, the methodologies, the quality verification and assurance activities to be implemented and the software and associated documentation to be supplied under the contract. It shall state the general procedures of the Contractor's Quality Manual that apply to the Contract. **[E3]**

The SQP shall identify additional procedures and amplification to existing procedures that are required to meet the Contract conditions. **[E4]**

The SQP shall include, but not be limited to, the following:

(a) Description of software quality objectives; **[E5]**

(b) Definition of software life cycle model to be used; **[E6]**

(c) Software staff and SQA organisation and their relationship to the project team; **[E7]**

(d) Definition of deliverable items and deliverable media; **[E8]**

(e) Verification and Quality Assurance activities throughout the life cycle; **[E9]**

(f) What techniques, notations, languages, methods, standards (internal and national), conventions and tools are to be used during the project and to which activity and deliverable each applies; **[E10]**

(g) How the quality of deliverables is assessed; **[E11]**

(h) Configuration Management and Change Control procedures; **[E12]**

(i) Documentation to be provided and to what standards; **[E13]**

(j) Procedures for subcontracting of software; **[E14]**

(k) Defect and Non Compliance reporting; **[E15]**

14.14.5 Quality Assurance Audits

The Agency reserves the right to audit the Contractor's and all major SubContractor's QA organisations against procedures agreed with the Agency at any time during the Contract. **[A1]**

The Agency will nominate a Quality Assurance Representative (QAR) for the project. **[A2]**

Reasonable access and accommodation at the Contractor's premises shall be provided to the QAR, or his representative, in order to perform assessment activity including:

(a) A Quality assessment of the Contractor's Quality Management System to the relevant standard and to the Quality Plans prior to the start of the Contract work; **[E1]**

(b) Selective Quality surveillance audits against the relevant standard and Quality Plans during the term of the Contract; **[E2]**

(c) Similar access as described above to the premises of the major SubContractors; **[E3]**

(d) Quality Progress statements, required monthly, to be provided as part of the regular project reporting procedures. **[E4]**

14.14.6 Communication and Interfaces

The Tenderer shall state what information is to be recorded to monitor the control of the manufacture and test process. **[I1]**

The Tenderer shall state how the information is to be recorded and how it will be shared with the Agency. **[I2]**

The Tenderer shall state how problems are escalated internally and how these are to be discussed with the Agency, where required, to ensure an agreed solution is reached. **[I3]**

The Tenderer shall state what quality initiatives are in place to ensure that all staff are involved in the quality process. **[I4]**

The Tenderer shall state what Quality Training their staff receive. **[I5]**

14.15 Testing and Acceptance

14.15.1 General

It is particularly important that all Test Specifications used for proving that the system fulfils the requirement shall be generated directly from the overall system requirement specification. Cross references shall be placed in the Test Specification so that any test can be traced back to the requirement that it is proving. **[E1]**

In addition, module and sub-system Test Specifications shall be generated directly from the relevant design document. Cross references shall be placed in these test specifications so that any test can be traced back to the relevant area of the design. **[E2]**

A Verification Cross Reference Index (VCRI) shall be produced to trace continuity from the Specification through the Design Document to the FAT and SAT Acceptance Test Specifications. **[E3]**

It would be acceptable for all such cross references to be placed in a separate document. **[A1]**

In this case the cross reference document shall be updated and re-issued whenever any other document changes. In addition, the cross reference document shall be updated, and distributed with the first draft issue of any other document. **[E4]**

Should a deliverable be non-conformant, the Contractor shall correct it at his own expense, and after rectification, shall resubmit it for acceptance, within a time schedule agreed by the Agency. **[E5]**

The purpose of the testing is to prove the Mode S ground equipment fulfils the performance requirements of this specification. **[A2]**

This Chapter identifies the minimum tests to be performed across all the equipment at sub-system, system, site and network level up to and including Provisional Acceptance of the equipment. **[A3]**

The Contractor shall formulate, arrange and conduct tests to satisfactorily demonstrate, to the Agency, compliance of the deliverable equipment with all the performance requirements of this specification. **[E6]**

The Tenderer shall include in the proposal a preliminary Verification and Validation Plan, as detailed in section 14.15.4, which outlines their test programme. **[I1]**

The Contractor shall develop an overall Verification and Validation Plan, as detailed in section 14.15.4, which will detail how the performance requirements of this specification will be verified, recorded and accepted. **[E7]**

It shall be the responsibility of the Contractor to arrange and perform the acceptance testing. **[E8]**

These tests shall be witnessed by Agency personnel in accordance with an agreed plan. **[E9]**

14.15.2 Test Equipment

The Contractor shall bear the cost of all resources required for testing (including personnel, and premises) to complete SAT as defined in 14.15.12.4. **[E1]**

Where possible, the equipment will be identical to that recommended for field maintenance. **[A1]**

The Contractor shall provide details in the Verification and Validation Plan to show that all resources (test equipment, procedures, personnel and premises etc.) are adequate and available to perform the testing. **[E2]**

Ideally the Contractor shall utilise live data for testing. **[A2]**

If live data is not available at the Contractor's premises the Contractor may use recorded or simulated traffic data. **[A3]**

The Tenderer shall state the methods they intend to use to perform high load testing of the system. **[I1]**

The Performance demonstration may be deferred until live data is available as part of the site acceptance testing. **[A4]**

The Contractor shall provide details in the Verification and Validation Plan of all tests that cannot be performed at the Contractors or SubContractors premises, including the reasons. **[E3]**

Agreement shall be required with the Agency of any tests that are to be deferred. **[E4]**

14.15.3 Accuracy of Testing

The Contractor shall satisfactorily prove to the Agency that the methods of testing provide confirmation that the equipment actually meets the performance requirements of this specification, and that the test procedures provide the required precision and accuracy. **[E1]**

Such proof shall be submitted with the proposed Verification and Validation Plan. **[E2]**

14.15.4 Test Methodology

14.15.4.1 Preliminary Verification and Validation Plan

The Tenderer shall include in the Tender Response a preliminary Verification and Validation Plan for the project. **[I1]**

This plan shall include at least the following:

(a) A list of the systems and sub-systems to be tested; **[E1]**

(b) A list of the types of test to be employed (e.g. QT, FAT, SAT, System) and the tools required at each stage; **[E2]**

(c) A verification matrix that will show for each paragraph of this specification which of the types of tests in (b) applies; **[E3]**

(d) The names, positions, authority, role and interrelationships of the personnel to be involved in the tests stated in (b). **[E4]**

14.15.4.2 Verification and Validation Plan

The Contractor shall develop and supply a comprehensive Verification and Validation Plan which shall include at least all of the following:

(a) List of the systems and sub-systems to be tested with identification of the hardware and software versions for the equipment under test, and for the development and testing support tools; **[E1]**

(b) Identification of all the parameters which will be tested; **[E2]**

(c) A Test Specification for FAT and SAT detailing the methods and procedures that will show compliance with the performance requirements of this specification; **[E3]**

(d) A verification matrix that relates each and every performance requirement of this specification to the specific test(s) that will be performed to demonstrate compliance with that requirement; **[E4]**

(e) A verification matrix that relates each and every requirement of this specification to the specific test(s) that will be performed to demonstrate compliance with that requirement; **[E5]**

(f) The names, positions, authority, role and interrelationships of the personnel to be involved in the tests stated in (c). **[E6]**

Each test specification shall be a standalone document specifically tailored to this Contract and shall not refer to test specifications that the Contractor has used previously for other contracts or development work. **[E7]**

The above requirement does not preclude the Contractor copying relevant test paragraphs from other test specifications into that required by the Agency. **[A1]**

The agreed procedures and test data sheets shall form the basis for the testing of the deliverable items. **[E9]**

14.15.5 Start of Testing

Testing, as identified in 14.15.12, shall not begin until the test specifications have been agreed between the Agency and the Contractor. **[E1]**

After agreement has been reached the Contractor shall provide 10 working days notice of the commencement of scheduled testing. **[E2]**

This will allow the Agency to make the necessary arrangements for witnessing the test. **[A1]**

14.15.6 Preliminary Testing

Test notification shall not be given until the Contractor has carried out preliminary tests to ensure the equipment is fully compliant with the test procedures. **[E1]**

A QA certified copy of the preliminary test results shall be provided 10 working days prior to the commencement of official testing. **[E2]**

14.15.7 Certification of Test Results

Two copies of all test results, certified by an authorised representative of the Contractor's QA organisation, shall be provided to the Agency. **[E1]**

One copy shall be sent to site with the tested equipment, the second copy shall be forwarded to the Agency's designated Project Manager. **[E2]**

The test result sheets shall clearly identify the equipment name, type, serial number, test specification number and the test date. **[E3]**

Each individual test result shall be clearly identified and the test result sheet shall be signed by the Contractor's QA representative and countersigned by the Agency witness. **[E4]**

14.15.8 Test Failures

Any failed units shall be repaired and the cause of failure shall be determined and if necessary processes and/or materials or components changed so that all requirements of the specification are met. **[E1]**

Repaired units, and all other units that may have been affected by the failed unit, shall be re-tested to demonstrate final compliance with the test specification. **[E2]**

All software shall be rectified and the cause of the error determined. All software modules that may have been affected by the failed module should be re-tested. **[E3]**

All test failures shall be logged as Problem Reports by the Contractor's QA Representative and shall be subject to closure, following explanation which shall be agreed by the Agency, or the raising of an approved engineering change order. **[E4]**

All test failures shall be categorised and agreed with the Agency. **[E5]**

14.15.9 Location of Testing

Unless otherwise agreed by the Agency, all factory testing shall occur at the Contractor's or major SubContractor's premises. **[E1]**

To confirm the performance parameters not tested at the factory the Contractor shall make provision for demonstrations of the systems functionality prior to delivering the equipment for SAT. This test site shall be nominated by the Contractor. **[E2]**

14.15.10 Damage to Equipment

Any equipment damage caused as a result of any testing shall be corrected and the equipment refurbished at the Contractor's expense prior to Agency acceptance. **[E1]**

14.15.11 Electromagnetic Compatibility

EMC requirements shall conform to EEC Directive (89/336/EEC with amendments 92/31/EEC and 93/68/EEC). **[E1]**

Each subsystem shall function to specification both in its own environment and in the full system environment. **[E2]**

This requirement shall apply for all combinations of operational and maintenance configurations, and shall include mutual interference between systems and within systems. **[E3]**

14.15.12 Stages of Testing

This section outlines the minimum testing that shall be performed **[E1]**

14.15.12.1 Spare

14.15.12.2 Factory Acceptance Tests (FAT)

Complete and thorough testing shall be conducted to demonstrate compliance with the equipment design criteria. **[E1]**

FAT testing shall be carried out using the deliverable hardware and software. **[E2]**

The FAT shall prove conclusively that the equipment meets all applicable specifications and will meet the operational and performance requirements of this specification. **[E3]**

A representative(s) of the Agency will attend the FAT. **[A2]**

Subject to agreement with the Agency FAT testing may be deferred to testing on site to demonstrate design features that cannot be performed at the Contractor's premises. **[A3]**

The Factory Acceptance Test shall include the following software/operating system aspects:

(a) Configuration Identification of every file/module under test. No file or module used in this process shall be in a development state as reported by the CM software. All files shall be registered/authenticated before the process starts. **[E4]**

(b) Recompilation of every source file to be built into the system software followed by rebuilding the executable software loads. **[E5]**

If a Software Development Facility is one of the deliverables, every file used in the above process, at the version used in this process, shall be delivered to the Agency under the control of CM software. **[E6]**

(c) Recreation of the operating system from either:

(i) The delivery kit and configuration details if a third-party operating system is used. **[E7]**

(ii) The source code and configuration details if an in-house operating system is used. **[E8]**

(d) Validation of operating system performance. **[E9]**

(e) Confirmation that each adaptation parameter can be changed, and that the changes have the required impact on the operation of the overall system. **[E10]**

14.15.12.3 Site Acceptance Tests (SAT)

The following shall be provided to the Agency 10 working days prior to the commencement of SAT testing:

(a) Evidence of closure of all previously raised observations, or agreement of action with respect to outstanding observations. **[E1]**

(b) Records of changes made since the FAT. **[E2]**

(c) The hardware and software build states. **[E3]**

(d) All test documentation to be available and agreed. **[E4]**

(e) Justification and explanation in writing of the choice of site parameters. **[E5]**

The SAT testing shall demonstrate the accuracy, stability, electromagnetic compatibility, availability, reliability and maintainability of the deliverable hardware and software over all parameters to meet all the operational and performance requirements of this specification **[E6]**

The SAT shall utilise all the deliverable hardware and software of all sub-systems, both individually and as a complete system, and will be performed using test equipment and live target data as appropriate. **[E7]**

The SAT specification may be a sub-set of the FAT specification as agreed between the Contractor and the Agency. **[A1]**

A representative(s) of the Agency will attend the SAT. **[A2]**

14.15.12.3.1 SAT Composition

Site Acceptance testing shall comprise the following discrete elements:

(a) Software Generation; **[E1]**

(b) Deferred FAT Tests; **[E2]**

(c) System; **[E3]**

(d) Reliability Demonstration; **[E4]**

(e) Maintainability Demonstration; **[E5]**

(f) Environmental Tests. **[E6]**

In respect of PILOT and production systems to be supplied, provided any changes to the Build Standard of the equipment have been properly taken into account, and that traceability can be assured, then Site Acceptance testing may comprise only elements (b) and (c) above. **[A1]**

14.15.12.3.2 Software Generation

The deliverable Operational, run-time, software (or PROM based firmware) shall be officially generated from the deliverable source code using Agency approved generation procedures. **[E1]**

The generation shall be witnessed by the Contractor's QAR and may be witnessed by the Agency. **[E2]**

It is this build of Operational software that shall be used in all subsequent Site Acceptance Tests. **[E3]**

14.15.12.3.3 Deferred FAT Tests

The Contractor shall conclude the Factory Acceptance Testing by performing all tests deferred to site due to lack of live data or associated facilities **[E1]**

14.15.12.3.4 System

The Contractor shall perform complete and thorough testing of all units, modules and subsystems interconnected to form the whole deliverable System to demonstrate the System's compliance with all the operational and performance requirements of this specification. **[E1]**

The System tests shall include network or site to site interfaces and functional tests as necessary to prove compliance with the requirements of this specification. **[E2]**

14.15.12.3.5 Reliability Demonstration

The Reliability demonstration shall be performed in accordance with 14.2.3.5. **[E1]**

14.15.12.3.6 Maintainability Demonstration

The Maintainability demonstration shall be performed in accordance with 14.2.4.5. **[E1]**

14.15.12.3.7 Environmental Testing

The Contractor shall provide a QA-approved report which ensures that the System continues to operate and meet all the operational and performance requirements of this specification whilst operating in a steady, ambient environment of +40°C with ambient humidity. **[E1]**

14.15.12.4 Acceptance

Following satisfactory completion of all Site Acceptance Tests the Contractor shall offer the System for formal acceptance by the Agency. **[E1]**

A formal Technical Completion (TC) meeting shall be held to consider the Provisional Acceptance of the system. **[E2]**

The TC meeting will examine the following areas to establish their completion or identify outstanding observations that have to be cleared within prescribed timescales:

(a) Equipment - A complete build state will be provided for all deliverable hardware and software. Special to type test equipment and support/test software shall be included as part of the build state. A complete list of all major concessions and production permits shall be provided with their relevant build states. **[E3]**

(b) Training - All training shall be complete to ensure that adequately trained engineers are available to undertake equipment maintenance. **[E4]**

(c) Spares - A build state of all deliverable spares shall be provided. All spares shall have been tested and delivered prior to TC. The build state of spares shall be identical to that of the main equipment. **[E5]**

(d) Documentation- All deliverable documentation shall have been provided. **[E6]**

(e) Test Equipment- All deliverable test equipment including software and hardware support facilities (if applicable) shall have been provided. **[E7]**

All Problem Reports and observations shall be closed or action assigned and agreed. **[E8]**

Completion of the SAT shall be recorded on the SAT Completion Certificate. **[E9]**

Certificate of Conformance documentation shall be provided for all deliverable items (including software). **[E10]**

Technical Completion may occur on a subsystem basis, if this option is chosen then a System Technical Completion meeting shall be held to ensure all System aspects have been completed. **[E11]**

ANNEX A

GLOSSARY

°C	Degree Celsius
ACAS	Airborne Collision Avoidance System
ACP	Azimuth Count Pulses
ADLP	Airborne Data Link Processor
AICB	Air Initiated Comm B
ASTERIX	All Purpose Structured Eurocontrol Radar Information Exchange
ATC	Air Traffic Control
ATCC	Air Traffic Control Centre
ATN	Aeronautical Telecommunication Network
AU	Azimuth Unit
BDS	Comm B Data Selector
BITE	Built In Test Equipment
CC	Cluster Controller
CMP	Communication Management Process
DCE	Data Circuit-terminating Equipment
DELM	Downlink Extended Length Message
DLF	Data Link Function
DRC	Data Rate Control
DUP	Duplicated address
EASIE	Enhanced Air Traffic Management and Mode S Implementation in Europe
EATCHIP	European ATC Harmonisation and Integration Programme
ELM	Extended Length Message
E-SCAN	Electronically Scanned
FAT	Factory Acceptance Tests
FL	Flight Level (1FL = 100 ft)
FRUIT	False Replies Unsynchronised In Time
GDLP	Ground Link Data Processor
GICB	Ground Initiated Comm B
GPS	Global Positioning System
HDLC	High level Data Link Control
ICAO	International Civil Aviation Organisation
ICD	Interface Control Document
IFF	Identification Friend or Foe
II	Interrogator Identifier
IISLS	Improved Interrogator SideLobe Suppression
IRF	Interrogation Repetition Frequency
Kbps	Kilo bit per second
kn	Knot ($NM.h^{-1}$, 1 kn = 0.514444 $m.s^{-1}$)
LC	Link Control
LMP	Link Management Process
LRU	Lowest Replaceable Unit
LVA	Large Vertical Aperture (rotating antenna)

MSP	Mode S Specific Protocol
MSSR	Monopulse Secondary Surveillance Radar
MTBF	Mean Time Between Failures
MTL	Minimum Triggering Level
MTTR	Mean Time To Repair
NM	Nautical Mile (1 NM = 1852 m)
OBI	Off Boresight Indication
PAF	Plot Assignor Function
PCB	Printed Circuit Board
PMB	Project Management Board
PMC	Project Management Cell
PMPP	Project Management Programme Plan
POEMS	Pre Operational European Mode S Station
PRF	Pulse Repetition Frequency
PSR	Primary Surveillance Radar
PTE	POEMS Test Equipment
RA	Resolution Advisory
RASCAL	Radar Sharing Calculation software
RASS	Radar Analysis Support System
RDIF	Radar Data Interchange Format
RDP	Radar Data Processing
RF	Radio Frequency
RMS	Root Mean Square
RSLS	Receiver SideLobe Suppression
RTCC	Real Time Channel Control
RTQC	Real Time Quality Control
SARPs	Standards And Recommended Practices
SAT	Site Acceptance Tests
sd	Standard Deviation
SCF	Surveillance Co-ordination Function
SCN	Surveillance Co-ordination Network
SICASP	SSR Improvements and Collision Avoidance Systems Panel
SLM	Standard Length Message
SMA	System Management Application
SMF	Systems Management Function
SPI	Special Position Identification pulse
SSE	Mode S Specific Service Entity
SSR	Secondary Surveillance Radar
STC	Sensitivity Time Control
SVC	Switched Virtual Circuit
TCAS	Traffic Alert and Collision Avoidance System
UELM	Uplink Extended Length Message

ANNEX B

REFERENCE DOCUMENTS

[Ref.1.] ICAO Annex 10, third edition of Volume IV (incorporating Amendments 70-77 to second edition).

[Ref.2.] STANAG 4193 NATO Technical characteristics of IFF MK XA and MKXII Interrogators and Transponder.

[Ref.3.] Mode S Subnetwork SARPs described as Volume III, Part 1, Chapter 5 to Amendment 77 of ICAO Annex 10, including appendices, November 2002

[Ref.4.] Manual of SSR Systems, third edition (2004): ICAO Doc.9684.

[Ref.5.] Standard STFRDE ASTERIX documents:

(a) EUROCONTROL Standard Document for Radar Data Exchange Part 1 ASTERIX, SUR.ET1.ST05.2000-STD-01-01, Edition: 1.26, November 2000

(b) EUROCONTROL Standard Document for Surveillance Data Exchange Part 2b Transmission of Monoradar Service Messages, SUR.ET1.ST05.2000-STD-02b-01, Edition: 1.26, November 2000

(c) EUROCONTROL Standard Document for Surveillance Data Exchange Part 4 Transmission of Monoradar Target Reports, SUR.ET1.ST05.2000-STD-04-01, Edition: 1.14, November 2000

[Ref.6.] European Mode S ASTERIX Documents:

(a) EUROCONTROL Standard Document For Surveillance Data Exchange Part 5 Category 017 Mode S Surveillance Coordination Function Messages, SUR.ET2.ST03.3111-SPC-02-00, Edition: 1.0, October 2004 + Annex A: Co-ordinate transformation algorithms for the hand-over of targets between POEMS interrogators

(b) EUROCONTROL Standard Document For Surveillance Data Exchange Part 6 Category 018 Mode S Datalink Function Messages, SUR.ET2.ST03.3112-SPC-01-0, Edition: 1.5, March 1999

[Ref.7.] RDIF 'Radar Data Interchange Format' CAA Paper 87002, November 1991.

[Ref.8.] Regional Supplementary Procedures (SUPPs) – ICAO. Doc.7030/4, EUR, Part 1 (Carriage and Operation of SSR Mode S airborne equipment)

[Ref.9.] EATCHIP GDLP/Local User ICD for POEMS, SUR.ET2.ST03.3112-SPC-02-00, Edition: 1.7, Edition Date, 17 March 1999, Status: Working Draft.

[Ref.10.] European Mode S Station Intersite Surveillance Co-ordination Interface Control Document, SUR/MODES/EMS/ICD-01 (form. SUR.ET2.ST03.3110-SPC-02-00), 2.06, 9 May 2005.

[Ref.11.] EUROCONTROL Standard Document for Radar Surveillance in En-Route Airspace and Major Terminal Areas, Edition 1.0, March 1997 RELEASED issue.

[Ref.12.] ICAO "Manual on Testing of Radio Navigation Aids: Volume III (Testing of Surveillance Radar Systems): ICAO Doc.8071

[Ref.13.] European Mode S Station Coverage Map Interface Control Document, SUR/MODES/EMS/ICD-03 (form. SUR.ET2.ST03.3113-SPC-01-00)), 1.16, 9 May 2005.

[Ref.14.] ICAO AIR NAVIGATION PLAN - EUROPEAN REGION DOC 7754/24 Corrigendum 17/2/99

[Ref.15.] International Standard ISO/IEC 8208: 1995 (E): Information Technology-Data communications-X25 Packet Layer Protocol for Data Terminal Equipment.

[Ref.16.] International Standard ISO/IEC 7776: 1995 (E): Information Technology-Telecommunications and information exchanges between systems-High level data link control procedures-Description of the X.25 Lap-B compatible data link procedures.

[Ref.17.] European Mode S Station Surveillance Output Interface Control Document, SUR/MODES/EMS/ICD-04, 1.02, 19 April 2001.

ANNEX C

LIST OF RELATED DOCUMENTATION & STANDARDS

The Contractor will be required to undertake a "Standards Tailoring" exercise with a working group chaired by the Agency. The purpose of this working Group will be to state for each standard whether it is accepted in full; whether they wish to tailor it; or wish to use an alternative. **[A1]**

Agency personnel shall approve the agreed standards to be applied. **[E1]**

The Tenderer shall advise in the Tender Proposal on suitable related or alternative standards. **[I1]**

The Tenderer shall include the issue number and amended state of each document to be applied. **[I2]**

ISO 9001 (1994)	Model for Quality Assurance in design, development, manufacturing, installation and servicing
ISO 9000 3 (1991)	Quality management and quality assurance standards - part 3: Guidelines for the application of ISO 9001 to development, supply and maintenance of software.
ISO/CD 12207	Software engineering organisation.
ISO 10011	Audit of quality assurance
IEEE/EIA 12207.0	Industry Implementation of International Standard ISO/IEC 12207 1995 - (ISO/IEC 12207) Standard for Information Technology - Software Life Cycle Processes
IEEE/EIA 12207.1	Guide for Information Technology - Software Life Cycle Processes, Life Cycle Data
IEEE/EIA 12207.2	Guide for Information Technology - Software Life Cycle Processes, Implementations Considerations
MIL STD 973	Configuration Management.
RTCA DO 178 B(1992)	Software considerations in airborne systems and equipment certification.
IEEE STD 730	Software quality assurance plans
IEEE STD 829,1008 & 1012	Software specification, development, testing and validation
MIL STD 470	Maintainability Program
MIL STD 471A	Maintainability Verification/Demonstration
MIL STD 721C	Definition of Terms for Reliability and Maintainability

MIL STD 785	Reliability Program
MIL STD 1388-1A	Logistic Support Analysis
MIL STD 1388-2B	Logistic Support Analysis Record
MIL STD 1629	Failure Modes, Effects and Criticality Analysis
MIL STD 2165A	Testability Program
MIL HDBK 217F	Reliability Prediction
MIL HDBK 338	Reliability Design
MIL HDBK 472	Maintainability Prediction
MIL STD 454	Standard General Requirements for Electronic Equipment
MIL STD 498	Military Standard for Software Development and Documentation
MIL STD 882B	System Safety Program Requirements
IEC 812/BS 5760 (all parts)	Reliability of systems, equipment and components
IEC 812/BS 5760 Part 5	Guide to failure modes, effects and criticality analysis (FMEA and FMECA)
IEC 812/BS 5760 Part 7	Guide to fault tree analysis
IEC 812/BS 5760 Part 8	Guide to the assessment of reliability of systems containing software
ARP 926A	Fault/Failure Analysis Procedure

ANNEX D

OUTLINE SAFETY PLAN

The following outline shall be used as a basis for the Safety Plan for the Mode S Ground Station Tender response and to form the basis of the subsequent contractual requirements. **[E1]**

D.1 Purpose

The purpose of the safety plan is to ensure the Mode S Ground Station safety activities are clearly defined and co-ordinated with other project activities. Furthermore, the plan shall ensure that key safety related activities, procedures and responsibilities are clearly defined and understood.

D.2 Scope

The scope of the safety plan is the total scope of supply of Mode S by the Contractor.

D.3 Definitions

Contractor to provide appropriate definitions consistent with the Safety Plan terminology.

D.4 Safety Management

Contractor's approach to Safety Management including sub-Contractor's Safety Management. Include organigram, responsibilities, accountabilities, reporting structure and interfaces with the Agency.

D.5 Mode S Safety Requirements

Contractor's approach to performing a PHA and deriving the Mode S Failure Modes as detailed in 14.7.5.4.

D.6 Hazard Log

Contractor's approach to the development and maintenance of a system hazard log as detailed in 14.7.5.3.

D.7 Hazard Identification and Analysis

Contractor's approach to System and Software Hazard Analyses as detailed in 14.7.5.4.

D.8 Progress Monitoring and Reporting

Contractor's approach to progress monitoring and reporting as detailed in 14.13.4.

D.9 Independent Safety Assessment

Contractor's approach to Independent Safety Assessment as detailed in 14.7.5.6.

D.10 Safety Assurance Traceability

Contractor's approach to Safety Assurance Traceability as detailed in 14.7.5.7.

D.11 Deliverables

Deliverables are detailed in paragraphs 14.7.3, 14.7.4 and 14.7.5 and include, but are not limited to:

(a) Design Process and Assurance, paragraph 14.7.3.2

(b) Installation, Commissioning, Integration, Test and Evaluation, paragraph 14.7.3.3

(c) PHA and Failure Mode Derivation, paragraph 14.7.5.4.

(d) Hazard Log, paragraph 14.7.5.3.

(e) Hazard Identification and Analyses:

  (i) FMECA, paragraph 14.7.5.4.4 (a).

  (ii) FTA, paragraph 14.7.5.4.4 (b).

(f) Progress Monitoring and Reporting, paragraph 14.13.4.

(g) Safety Reviews.

(h) Independent Safety Assessment, paragraph 14.7.5.6.

(i) Safety Assurance Traceability, paragraph 14.7.5.7.

D.12 Standards

Standards (e.g. IEC; Mil Std etc.) pertinent to the Safety Plan, their scope and applicability.

ANNEX E

MODE S SAFETY REQUIREMENTS

Failure Modes (<10 seconds)	Probability
Loss of all surveillance information	No Effect
Delay of all surveillance information	No Effect
Any corruption of surveillance information	No Effect
Failure Modes (>10 seconds)	**Probability**
Loss of all surveillance information	$<10^{-7}$
Detected Loss of all Height data	$<10^{-5}$
Detected Loss of all Identity data	$<10^{-7}$
Detected Loss of all target range	$<10^{-7}$
Detected Loss of all target azimuth	$<10^{-7}$
Detected Loss of all target time	$<10^{-7}$
Detected Corrupted all Height data	$<10^{-5}$
Detected Corrupted all Identity data	$<10^{-7}$
Detected Corrupted all target range	$<10^{-7}$
Detected Corrupted all target azimuth	$<10^{-7}$
Detected Corrupted all target time	$<10^{-7}$
Undetected Corrupted Height data(for individual target reports)	$<10^{-7}$
Undetected Corrupted Identity data(for individual target reports)	$<10^{-7}$
Undetected Corrupted target range(for individual target reports)	$<10^{-7}$
Undetected Corrupted target azimuth(for individual target reports)	$<10^{-7}$
Undetected Corrupted target time(for individual target reports)	$<10^{-7}$
Undetected delay of all surveillance information	$<10^{-7}$
Failure to acquire Mode S equipped aircraft	$<10^{-7}$
Failure to release Mode S equipped aircraft	$<10^{-5}$
Undetected spurious plots	$<10^{-5}$
Undetected missing plots	$<10^{-7}$

ANNEX F

LIFE CYCLE COSTING: INPUT DATA REQUIREMENTS

F.1 SYSTEM DATA

PRODUCTION SYSTEM UNIT COST	
PREDICTED MTBF	Comes from historical data, testing, predictions or the product specification
MEAN TIME TO REPAIR	Comes from the product specification.
O LEVEL	Predicted or actual MTTR for O level.
I LEVEL	Predicted or actual MTTR for I level.
D LEVEL	Predicted or actual MTTR for D level.
% BIT/BITE FAULT DETECTION	The percent of failures that BIT/BITE is capable of detecting
% MANUAL FAULT DETECTION	The percent of failures that must be detected using manual procedures or assistance of support equipment
% BIT/BITE FAULT ISOLATION	The percent of failures that BIT/BITE can isolate to a single repairable or replaceable item
% MANUAL FAULT ISOLATION	The percent of failures that must be isolated using manual procedures

F.2 INVESTMENT DATA

INVESTMENT SPARES/REPAIR PARTS	Provisioned Spares

F.3 SUPPORT EQUIPMENT DATA

O LEVEL SE UNIT COST (CM)	Actual or estimated cost for one location
O LEVEL SE UNIT COST (PM)	Actual or estimated cost for one location
I LEVEL SE UNIT COST (CM)	Actual or estimated cost for one location
I LEVEL SE UNIT COST (PM)	Actual or estimated cost for one location
D LEVEL SE UNIT COST (CM)	Actual or estimated cost for one location
D LEVEL SE UNIT COST (PM)	Actual or estimated cost for one location
OPERATIONAL SE COST	Actual or estimated cost for one set
OPERATIONAL SE RATIO TO END ITEMS	The number of end items that one set of operational support equipment will support.
SE MAINTENANCE	Percentage of SE acquisition costs required for yearly maintenance

F.4 SPARES AND CONSUMABLES DATA

REPLENISHMENT SPARES - O LEVEL (CM)	Cost of spares for a maintenance action expressed in actual/average cost
REPLENISHMENT SPARES - I LEVEL (CM)	Cost of spares for a maintenance action expressed in actual/average cost
REPLENISHMENT SPARES - D LEVEL (CM)	Cost of spares for a maintenance action expressed in actual/average cost
CONSUMABLES PER HOUR OF OPERATION	Cost of fuels, lubricants, etc. required to operate one system for one hour.
COST OF CONTRACTOR REPAIR (PER REPAIR)	Average cost of a single repair performed by Contractor or non-standard repair facility

F.5 PERSONNEL DATA

NUMBER OF SYSTEM OPERATORS	Number of persons necessary to operate one system
NUMBER OF MAINTENANCE PERSONNEL	
O LEVEL	Number of persons assigned to a single O level maintenance unit
I LEVEL	Number of persons assigned to a single I level maintenance unit
D LEVEL	Number of persons assigned to a single D level depot

F.6 TRAINING DATA

TRAINING TIME PER OPERATOR	Duration of Operator training course
TRAINING TIME PER MAINT TECH	Duration of maintenance training course
TRAINING SUPPORT COST	Incremental cost per student for training
INITIAL TRAINING PROGRAM COST	Cost of developing training program
COST OF TRAINING EQUIPMENT	
NUMBER OF TRAINING EQUIPMENT SETS	

F.7 MAINTENANCE DATA

% FAILURES R/R AT 1 LEVEL	Percent of failures that will be fixed by removal and replacement of defective items at organisational level
% FAILURES DISCARD AT 1 LEVEL	Percent of failures resulting in discard of the failed item
% FAILURES REPAIR AT 2 LEVEL	Percent of failed items that will be repaired at 2 Level
% FAILURES DISCARD AT 2 LEVEL	Percent of failed items repaired by removal and discard of a lower level assembly
% FAILURES REPAIR AT 3 LEVEL	Percent of failed items that will be repaired at Depot 3 level
% FAILURES REPAIR AT CONTRACTOR	Percent of failed items repaired by Contract
3 LEVEL/CONTRACTOR REPAIR CONDEMNATION RATE	Percent of items that will not be repaired

F.8 PREVENTIVE MAINTENANCE DATA

NUMBER OF DAILY PM TASKS	TASKS
AVG DAILY PM TASK TIME	HOURS
COST OF RESOURCES CONSUMED	
NUMBER OF WEEKLY PM TASKS	TASKS
AVG WEEKLY PM TASK TIME	HOURS
COST OF RESOURCES CONSUMED	
NUMBER OF MONTHLY PM TASKS	TASKS
AVG MONTHLY PM TASK TIME	HOURS
COST OF RESOURCES CONSUMED	
NUMBER OF SEMI-ANNUAL PM TASKS	TASKS
AVG SEMI-ANNUAL PM TASK TIME	HOURS
COST OF RESOURCES CONSUMED	
NUMBER OF ANNUAL PM TASKS	TASKS
AVG ANNUAL PM TASK TIME	HOURS
COST OF RESOURCES CONSUMED	
NUMBER OF PM TASKS PERFORMED AT 2 LEVEL	TASKS
AVERAGE 2 LEVEL PM TASK TIME	HOURS
TIMES 2 LEVEL PM PERFORMED IN 5 YEARS	TIMES
COST OF RESOURCES CONSUMED	
NUMBER OF PM/OVHL TASKS PERFORMED AT 3 LEVEL	TASKS
AVG 3 LEVEL PM/OVHL TASK TIME	HOURS
TIMES 3 LEVEL PM/OVHL PERFORMED IN 5 YEARS	TIMES
COST OF RESOURCES CONSUMED	

F.9 PHS&T DATA

INITIAL SPARES TRANSPORTATION COST	% OF SPARES COST
PACKAGING COST PER REPAIR	K PER ONE-WAY SHIPMENT
TRANSPORTATION COST PER REPAIR	K PER ONE-WAY SHIPMENT

F.10 SOFTWARE MAINTENANCE DATA

NUMBER OF SW LINES/MODULES	LINES/MODULES
ESTIMATED ANNUAL GROWTH	% PER YEAR
COST OF MAINTENANCE PER LINE/MODULE	
COST OF SW MAINTENANCE FACILITY PER YEAR	
COST OF SW MAINTENANCE EQUIPMENT	
SW MAINTENANCE EQUIPMENT MAINTENANCE PER YEAR	% OF COST

COST OF DOCUMENTATION PER MAINT ACTION	

F.11 INFLATION / ESCALATION DATA

ANNUAL ESCALATION RATE	% PER YEAR

ANNEX G

GENERAL OPERATING MODEL FOR MODE S GROUND STATION

G.1 System Parameters

G.1.1 Zenithal gap

Not below 45° above horizontal upper limit of cover >40 000ft

G.1.2 Vertical coverage

66,000 ft

G.1.3 Azimuth coverage

360°

G.1.4 Gap Free Cover

0.5 NM to 256 NM

G.1.5 Maximum Operating Range

256 NM at 4.5,7.5 and 10 rpm

150 NM, 80 NM at 15 rpm

G.1.6 Rotating Antenna Turning Rates

4.5,7.5, 10 and 15 rpm

G.1.7 IRF

2 Mode Interlace 3/A,C, nominal IRF is 150 Hz

Mode S Only All Call interrogations, nominal IRF is 50 Hz

G.1.8 IRF vs Range/Turning Rate

256 NM; 4.5 rpm; 70Hz

256 NM; 7.5 rpm; 115Hz

256 NM; 10 rpm; 150 Hz

150 NM and 80 NM; 15 rpm; 150 Hz

G.1.9 Transmitted modes

2 Mode Interlace 3/A,C

Intermode (P4 - long and short)

Mode S Only All-Call Mode S Selective

Interrogations Uplink Format 4, 5, 20, 21 and 24

G.1.10 Transponder Sensitivity

-69dBm for SSR Mode 3/A,C transponders

-71dBm for SSR Mode S transponders

G.1.11 Transponder Output Power

21dBW

18.5 dBW (for aircraft < 15,000')

G.1.12 Round Trip Reliability[1]

0.9 SSR Modes 3/A,C

G.2 Environmental Parameters

G.2.1 Mean FRUIT rate[2]

11000 FRUIT /second in the 3dB beamwidth (each of which exceeds a power level of -79 dBm referred to the sum channel RF port).

G.2.2 Number of SSR code pulses

At least 7 per FRUIT reply.

G.2.3 Target load

As in section G.4, equally distributed in azimuth and randomly distributed in range.

G.2.4 45° sectors

[1] Defined in [Ref.13] as "the probability of receiving a correct reply from an SSR interrogation".
[2] Note that it is anticipated that the level of Mode 3/A,C FRUIT is significantly higher than the level of Mode S FRUIT. The Tenderer may assume a figure of 1000 Mode S FRUIT (of which half are short and half are long replies), and assume 11,000 per second FRUIT rate is equivalent to 1/3 total; remaining 2/3 distributed over the backlobe and sidelobes.

4 off, 1 per 90°

G.2.5 3.5° sectors[3]

4 off, each centred in a diametrically opposite 45° sector.

G.2.6 Reflection False Targets

The greater of 40 targets/scan or 12% of target load.

G.3 Airborne Equipment Models

G.3.1 Model one, 100% Mode S Aircraft

(a) Mode Responses

- (i) S — 100% of all aircraft

(b) Mode S Responses

- (i) Aircraft with a 24 bit aircraft address identical to that of another aircraft: — 1% of all aircraft
- (ii) Aircraft with ACAS broadcast: — 5% of all aircraft
- (iii) Aircraft with special flight status: — 2% of all aircraft

Note: For the Mode S aircraft it can be assumed they reply initially to All-Call interrogations and are then locked out to All-Calls and reply only to selective interrogations.

G.3.2 Model Two, 50% Mode A/C and 50% Mode S Aircraft

(a) Mode Responses

- (i) 3/A and C — 40% of all aircraft
- (ii) 3/A or C (exclusive) — 10% of all aircraft
- (iii) S — 50% of all aircraft

(b) Mode A/C Responses

- (i) Non-unique identity — 25% of all aircraft
- (ii) Same identity — 5% of all aircraft
- (iii) Same identity, no mode C — 2.5% of all aircraft
- (iv) Mil Emergency — 1% of all aircraft
- (v) Codes 7500, 7600, 7700 — 1% of all aircraft
- (vi) SPI (3/A) — 4% of all aircraft
- (vii) Number of code pulses — at least 5 per reply

[3] Four 3.5° sectors total, two separated by at least 20°, within each of two large sector peaks, diagrammatically opposite in 360° (see figure 16).

(c) Mode S Responses

(i) Aircraft with a 24 bit aircraft address identical to that of another aircraft — 1% of Mode S aircraft

(ii) Aircraft with ACAS broadcast — 5% of Mode S aircraft

(iii) Aircraft with special flight status — 2% of Mode S aircraft

Note: For the Mode S aircraft it can be assumed they reply initially to All-Call interrogations and are then locked out to All-Calls and reply only to selective interrogations.

G.3.3 Model Three, 25% Mode A/C and 75% Mode S Aircraft

(a) Mode Responses

(i) 3/A and C — 22.5% of all aircraft

(ii) 3/A or C (exclusive) — 2.5% of all aircraft

(iii) S — 75% of all aircraft

(b) Mode S Responses

(i) Aircraft with a 24 bit aircraft address identical to that of another aircraft — 1% of Mode S aircraft

(ii) Aircraft with ACAS broadcast — 5% of Mode S aircraft

(iii) Aircraft with special flight status — 1% of Mode S aircraft

Note: For the Mode S aircraft it can be assumed they reply initially to All-Call interrogations and are then locked out to All-Calls and reply only to selective interrogations.

G.4 Target Load Model

Range (NM)	**5**	**10**	**20**	**40**	**60**	**80**	**90**	**130**	**150**	**200**	**256**
Aircraft Capacity	45	105	180	270	382	495	540	638	800	850	900
Large Sector Peak (45°)	12	26	45	68	96	124	135	160	200	211	222
Small Sector Peak (3.5°)	3	6	11	16	23	30	32	38	48	51	54

G.5 Volumes to be used for site performances requirements

In the table below, C means the Commissioning Volume and M the Measurement Volume.

Volume	Measurement	Requirement summary	Requirement
C	False Targets Distribution	False plots ratio < 0.1 % Multiple plot rate < 1/scan	4.2.5.1 E2 4.2.5.2 E2
C	Mode S Pd on duplicated addresses.	>=97%	7.3.2.2 E2 & 4.2.3.1 E1

Volume	Measurement	Requirement summary	Requirement
C	Range Error Distribution	Bias < 14 m	4.2.6.2 E1
C	Azimuth Error Distribution	Bias < 0.022 deg	4.2.6.3 E1
C	Overall SSR Pd	>=97%	4.2.3.1 E1
C	Overall SSR Pv&cA	>=98%	4.2.3.1 E1
C	Overall SSR Pv&cC	>=96%	4.2.3.1 E1
C	SSR Pd with Garbling	>=60% >=98% >=98%	4.2.7.1.2.1 E1 4.2.7.1.2.2 E1 4.2.7.1.2.3 E1
C	SSR Pv&cA with Garbling	>=30% >=90% >=98%	4.2.7.1.4.1 E1 4.2.7.1.4.2 E1 4.2.7.1.4.3 E1
C	SSR Pv&cC with Garbling	>=30% >=90% >=98%	4.2.7.1.4.1 E1 4.2.7.1.4.2 E1 4.2.7.1.4.3 E1
C	SSR Pv&cA for not close aircraft	>=98%	4.2.4.1.4 E1
C	SSR Pv&iA for not close aircraft	<0.1%	4.2.4.1.7 E1
C	SSR Pv&cC for not close aircraft	>=96%	4.2.4.1.4 E2
C	SSR Pv&iC for not close aircraft	<0.1%	4.2.4.1.8 E1
C	Overall Mode S Pd	97%	4.2.3.1 E1
C	Overall Mode S PcS	>=99%	4.2.4.2.1 E1
C	Overall Mode S Pv&cA	>=99%	4.2.4.2.1 E1
C	Overall Mode S Pv&cC	>=99%	4.2.4.2.1 E1
C	Jumps rate	<0.05%	4.2.6.6 E1
M	SSR Pd for not close aircraft	>=99%	4.2.3.2.2 E2
M	SSR Range Error RMS for not close aircraft	<30m	4.2.6.2 E2
M	SSR Azimuth Error RMS for not close aircraft	<0.068deg	4.2.6.3 E3
M	SSR Azimuth Bias for not close aircraft (elevation < 6°)	<0.022deg	4.2.6.3 E1
M	SSR Azimuth Bias for not close aircraft (elevation 6-10°)	<0.033deg	4.2.6.3 E2
M	Mode S Pd	>=99%	4.2.3.3.2 E4
M	Mode S Range Error RMS	<15m	4.2.6.2 E3
M	Mode S Azimuth Error RMS	<0.068deg	4.2.6.3 E3
M	Mode S Azimuth Bias (elevation < 6°)	<0.022deg	4.2.6.3 E1
M	Mode S Azimuth Bias (elevation 6-10°)	<0.033deg	4.2.6.3 E2

ANNEX H

SYSTEM ERROR ANALYSIS

H.1 General

As required in Chapter 4, Sections 4.2.6.1 the Tenderer shall include in the proposal a fully detailed error analysis with calculations and quoting assumptions. **[I1]**

This shall take into account the appropriate contributory effect of at least all of the sources of error detailed below on the overall system range, azimuth and position error for the Mode S sensors with:

(a) No radome; **[E1]**

(b) Above with rain falling at a rate of 25mm/hr and 60mm/hr. **[E2]**

The mean and standard deviation for each individual item, for range and azimuth as appropriate, shall be stated over the full range of operating and environmental conditions defined within this specification. **[E3]**

The cumulative range and azimuth error, with both mean and standard deviation values for each, shall be stated. **[E4]**

From the values for range and azimuth errors the system positional error shall be stated as a function of target range. Mean and standard deviation values shall be stated. **[E5]**

H.2 Error sources

As a minimum, the following sources of error for the radar sensor shall be stated and included in the system error analyses:

H.2.1 Antennas

(a) Wind deflection where appropriate **[E1]**

(b) Beam skewing **[E2]**

(c) Mechanical alignment **[E3]**

(d) Turning moment **[E4]**

(e) Target elevation angle **[E5]**

(f) Beam defocusing **[E6]**

H.2.2 Antenna Turning Gear

(a) Tower deflection/twist **[E1]**

(b) Drive gear backlash **[E2]**

(c) Drive shaft twist **[E3]**

(d) Azimuth encoding **[E4]**

H.2.3 Rotating Joint

(a) Insertion loss variation per channel and cross channel mis-match. **[E1]**

(b) Phase variation per channel and cross channel mis-match. **[E2]**

H.2.4 Mode S Cabling - Antenna to Tx/Rx

(a) Cable delays. **[E1]**

(b) Insertion loss per channel and cross channel mis-match. **[E2]**

(c) Phase variations per channel and cross channel mis-match. **[E3]**

(d) Insertion loss/phase variation with age. **[E4]**

(e) Insertion loss/phase variation with temperature. **[E5]**

H.2.5 Mode Transmitter-Receiver/PAF

(a) Interrogator mode to mode jitter. **[E1]**

(b) Receiver signal/noise ratio. **[E2]**

(c) Receiver gain, frequency and phase drift. **[E3]**

(d) Cross channel receiver gain, frequency and phase mis-match. **[E4]**

(e) Local oscillator drift. **[E5]**

(f) Quantisation clock drift. **[E6]**

(g) Target input signal strength. **[E7]**

(h) Target input frequency. **[E8]**

(i) Pulse sampling error. **[E9]**

(j) Analogue to digital conversion error. **[E10]**

(k) Off boresight angle table calibration error. **[E11]**

(l) Pulse quantisation error. (Mode A/C) or synch phase reversal (Mode S) **[E12]**

(m) P3 (mode A/C) or synch phase reversal (Mode S) start range error. **[E13]**

(n) Range clock accuracy. **[E14]**

(o) Pulse to reply OBA averaging error. **[E15]**

(p) Reply to plot azimuth calculation error. **[E16]**

(q) Transponder delay variation. **[E17]**

It should be noted that trials have shown some Mode S transponder replies to SSR Mode 3/A,C interrogations with a transponder delay of between 3.1 and 3.5 μs. **[A1]**

H.3 Applicability

The Tenderer shall state whether the values provided in responses to the preceding paragraphs apply to both stationary and moving targets. If they do not, two sets of values shall be provided, one set for stationary targets and one set for moving targets. **[I1]**

H.4 Verification

Verification of the overall system errors will be carried out for each of the sites on target data obtained from each system, which will be evaluated using independent software analysis tools (e.g. PTE) together with measurements made on a stationary target (e.g. Mode S Monitor). **[A1]**

Separate calculations for the on-mounted PSR/Mode and free-standing Mode S systems shall be provided in the proposal. **[I1]**

In the case of the on-mounted systems (or where the supplier is interfacing with an existing LVA/Turning Gear/Rotating Joint/cabling), where error details are required for system elements not being proposed by the Tenderer, the Tenderer shall state and clearly indicate the error limits required for their proposed system to meet the requirements of this specification. **[I2]**

ANNEX I

DESCRIPTION OF THE POEMS TEST ENVIRONMENT (PTE)

I.1 Introduction to PTE tools

The Figure 17 illustrates the different radar processing levels accessed by the PTE tools

I.2 PTE P1-P2B

I.2.1 General

The PTE-P1 and P2B tools will be built around an enhancement of the existing RASS-S system, as developed by Intersoft Electronics. As such it will comprehensively test the radars functioning by simulating radar returns, recording data present at various processing stages within the radar, verifying interfaces and conducting limited data analysis. This test tool will permit the evaluation of Mode S stations as part of FAT. Through the nature of its design it is possible for the operator to ‘follow’ a target reply through the various processing stages that the PTE P1-P2B system monitors - this capability is defined as multi-level analysis.

The verification of the Asterix syntax of the messages generated by the Mode S station will be performed by RAPS II. RAPS II is a COTS product developed by Comsoft and which has been qualified by Eurocontrol. A specific configuration of the RAPS II tool has been defined to be able to record and analyse all the Asterix messages produced by the Mode S stations. This configuration is called RAPS-PTE.

I.2.2 PTE-P1

The main enhancements of PTE-P1 regarding RASS-S are relating to the specific capabilities of a Mode S ground station compared to a classical SSR. They are listed below:

(a) Data link functionality;

(b) Enhanced RF accuracy;

(c) Specific Mode S protocol;

(d) FRUIT environment simulation using the RFT (RF Test set) as a BSG (Basic Scenario Generator);

(e) FRUIT environment simulation using one RES (Radar Environment Simulator) channel;

(f) Number of targets (1080) and maximum number of overlapping targets (4);

(g) Exporting of recorded data to PTE-P4;

(h) Figure of merit calculation (Mode S probability of detection and accuracy);

(i) Serial communication protocol viewer (separate investigation tool).

Consequently the main functions of RASS-S (scenario generation, environment simulation and data analysis) have been upgraded within PTE-P1 to allow Mode S station testing.

PTE-P1 recording capabilities:

(a) ACP (Azimuth Change Pulse) / ARP (Antenna Reference Pulse);

(b) Interrogations;

(c) Simulated scenario;

(d) Video;

(e) Primary Radar inputs;

(f) Asterix Cat 48 (Target report message) and 34 (Sector message);

(g) Asterix Cat 17 (Surveillance Co-ordination Function message);

(h) Asterix Cat 18 (Data Link Function message).

PTE-P1 generation capabilities :

(a) Target replies (according to the simulated target scenario (trajectories + datalink) and to the interrogations performed by the Mode S station);

(b) FRUIT environment (according to the FRUIT environment defined in the scenario) either using a RFT/BSG or using one RES channel;

(c) Simulated ACP/ARP;

(d) Cat 18 (according to the simulated data link scenario);

(e) Exporting of data to PTE-P4.

PTE-P1 figure of merit calculation capabilities:

(a) Mode S probability of detection;

(b) Mode S positional accuracy.

PTE-P1 Protocol viewer display capabilities:

(a) OSI layer 1 messages;

(b) LAPB (OSI layer 2) messages;

(c) X.25 (OSI layer 3) messages;

(d) Asterix (application layer) messages (Mode S categories 017, 018, 034 & 048 are supported).

PTE-P1 Protocol viewer will appear as an independent tool in the PTE top level menu.

I.2.3 PTE-P2B

The PTE-P2 (Phase B) additional capabilities are the following:

(a) PSR scenario preparation to define the characteristics of the PSR information that will be provided through the real time PSR data bsimulation;

(b) Additional scenario preparation capabilities (including simulation of either Amendment 69 or 71 transponders as specified in ICAO Annex 10 Volume III Part 1);

(c) Real time PSR data simulation;

(d) Importing of data from various sources;

(e) Merging, filtering and managing the imported data;

(f) Various data analysis computation (data link performance, sector message delay, etc...);

(g) Display and output of analysis results.

PTE-P2B generation capabilities:

(a) Primary Radar inputs (from a simulated primary radar and according to the simulated scenario).

I.3 RAPS-PTE

This tool is a standard RAPS II platform including specific Mode S and PTE Asterix categories detailed below.

The RAPS-PTE recording capabilities are the following :

(a) Asterix Cat 48 (Target report message) and 34 (Sector message)

(b) Asterix Cat 17 (Surveillance Co-ordination Function message)

(c) Asterix Cat 18 (Data Link Function message)

The RAPS-PTE will then perform Asterix verification of the recorded data.

The RAPS-PTE will also be able to check the Asterix format of PTE-P1/P4 interface file (Category 48/34, Reference scenario, Reference DGPS, Reference video extractor).

I.4 PTE-P2A - TRANSMITTER TEST TOOL

I.4.1 General

PTE-P2A is a specific transmitter test tool that can generate a range of scenarios to test the interrogation load as specified in Datalink Model A (4.2.7.4.2). It records and analyses the outputs of the transmitter of the Mode S station either when inputs are provided by the Mode S station or when inputs are provided by the transmitter test tool. The context of PTE-P2A is briefly summarised in Figure 18.

I.4.2 Functions

PTE-P2A recording capabilities:

(a) Interrogations either in passive (interrogations requested by the Mode S interrogation scheduler) or active (interrogations requested by PTE-P2A scenario replay) context. The recording is performed in compressed mode (user defined samples of each interrogation) and/or in detailed mode (recording at 16 MHz rate of interrogations during user defined period of times);

(b) Scenario of interrogation requests.

PTE-P2A generation capabilities:

(a) Interrogation requests (according to the simulated scenario of interrogation requests).

PTE-P2A analysis capabilities:

(a) In case of scenario replay, the tool will check whether the requested interrogations have been actually correctly performed by the transmitter (based on ICAO and PILOT requirements) and will calculate a global rate of success for the whole scenario.

PTE-P2A will appear as an independent tool in the PTE top level menu.

I.5 PTE-P3 - CLUSTER SIMULATION AND TESTING

I.5.1 Introduction

The role of PTE-P3 is to test (including FAT) the compliance of the SCF (Surveillance Co-ordination Function) of a Mode S station against its requirements. It will be performed through the real time simulation of adjacent Mode S stations with which the tested station form a cluster. A functional schematic of the system PTE-P3 and its interfaces is given in Figure 19.

The role of the SCF is to support surveillance co-ordination between the local Mode S station and the other Mode S stations forming a cluster and connected to a WAN (SCN, Surveillance Co-ordination Network).

This co-ordination is based on a series of protocols to be established between the different Mode S stations forming a cluster, which are :

(a) The X25 Connection Management protocol which is at the network layer;

(b) The Network Monitoring Protocol (NMP) which is at the transport/session layer;

(c) The Central Mode System Control Protocol which is at the application layer;

(d) The Track Acquisition and Support Protocol (TASP) which is at the application layer;

(e) The New Node Change Over Protocol (NNCOP) which is also at the application layer.

So, the role of PTE-P3 is to simulate the establishment of those protocols between a Mode S station under test and adjacent stations forming a cluster.

In order to provide a representative behaviour of the two application layer protocols (TASP and NNCOP) PTE-P3 will only work in conjunction with PTE P1 which simulates targets detection at the RF level of the Mode S station, in order to provide surveillance co-ordination data consistent with what the Mode S station is detecting.

An on-line assessment will be undertaken during simulation and statistics will be provided at the end of simulation run.

In parallel, the system will record, time stamp and mark all the messages exchanged between PTE-P3 and the Mode S station under test.

By processing the above information the operator will be able to quantify various performance levels for the Mode S station under test.

I.5.2 The Scenario Preparation Task

This scenario preparation encompasses the definition of the following elements:

(a) Characteristics of the simulated stations (scan rate, radar name, etc.);

(b) Characteristics of the Mode S station under test (radar name, etc.);

(c) Mode S surveillance coverage map of the simulation domain;

(d) Scenarios coming from PTE-P1;

(e) Events scenario for the simulated stations (e.g. connection, disconnection, failure, tracking request, etc.).

I.5.3 The Simulation Processing Task

The first step includes the simulation of the low level X25.3 Connection Management protocol which establishes the logical links between stations, the second step include the simulation of the NMP protocol by which a station under test joins the simulated running cluster and the third step includes the TASP and NNCOP protocols (distributed mode) or the Central Mode System Control protocol and the track acquisition and support process (central mode) which correspond to the exchanges between running applications on different stations in a cluster.

PTE-P3 recording capabilities:

(a) Asterix Cat 17;

(b) Asterix Cat 48.

PTE-P3 generation capabilities:

(a) Asterix Cat 17 (from simulated adjacent sensors and according to the simulated scenario).

The PTE-P3 tool kit consists of one SUN Workstation including standard devices and specific interface cards.

I.6 PTE-P4

I.6.1 Introduction

The function of this site analysis tool (PTE-P4) is to provide additional mono-radar analysis capabilities to those available in the PTE-P1/P2B phase for site analysis.

This analysis will be run off-line and will derive it's information from a number of sources, namely:

(a) Measured target reports recorded by the PTE-P1 system, which means that at least the PTE P1 EDR (Extended Data Recorder), including an Apple PowerMac is required.

(b) Data from an external source:

  (i) DGPS positions declared by the aircraft (if available)

  (ii) The reference trajectory derived by the Video Reference Extractor from the radar video (if available)

  (iii) The PTE-P1 scenario generator output

  (iv) Map Data

  (v) RASCAL Maps providing terrain information.

  (vi) Mode S Maps to support the analysis, detailing particular Mode S constraints applied to the radar (power levels, lockout etc.).

By processing the above information the operator will be able to quantify various performance levels for the radar under test. Of particular interest to this phase of the development will be the accuracy of the radar and the Probability of Detection it achieves.

The PTE-P4 system is designed to allow the user to analyse and validate conventional PSR and SSR radar data as well as Mode S radar data in a flexible and efficient manner. (Please note that interfaces to PSR and conventional monopulse SSR have not been developed). To do this, the system is broken down into a number of separate functional components. The relationships and high level data flows between these components are shown in the figure below. The user is able to control the system by carrying out the available functional operations in any appropriate order. The user will be prevented, however, from attempting to carry out functional operations in an inappropriate order (e.g. attempting internal reference generation prior to object correlation).

The outline of the individual functions in the PTE-P4 system (see figure below) are shown joined by solid lines to indicate data flow and dashed lines to indicate control flow.

I.6.2 Functional Architecture

The PTE-P4 functional architecture is as in Figure 20.

I.6.3 PTE-P4 functions

These PTE-P4 functions may be broadly grouped:

(a) Data acquisition (DA) - is the process that allows the user to import data, including target reports, radar service messages and external references (DGPS, reference extractor output, scenario generator data) from the PTE-P1 system via file transfer. The imported data is checked and added to the database as part of the current data set. Chained and tagged target report data may also be re-exported to the PTE-P1 tool for further analysis.

(b) Display filter (DF) - allows the user to select a subset of the current data for display on the screen. The filtering of the data is carried out by specifying one or more filters (e.g. time window, Mode S address range, SALADT screening angle volume) when the data matching the current filtering criteria are selected.

(c) Analysis filter (AF) - performs a similar role to the display filter, but is used for selecting data for input to the analysis functions.

(d) Graphical user interface (GUI) - allows the user to control the operation of the tool and displays the various results of the analyses.

(e) Object correlator (OC) - forms a key element in the PTE-P4 tool as it links target reports into target report chains, which are believed to be associated with a single aircraft, and associates them with the external reference data.

(f) Analysis reference generator (ARG) - calculates the bias model parameters (e.g. range gain) between data sets originating from different sources (e.g. target reports and DGPS data). The bias model parameters may then be used to effect target report position corrections. ARG also has the task of “completing” those external references requiring addition of velocity/acceleration data.

(g) Internal reference generator (IRG) - calculates a smoothed internal reference trajectory with full state vector information from the chained target report data.

(h) Plot accuracy analysis (PAA) - calculates statistics for the residual positional errors between the target reports and the reference trajectories, resolved onto the radar’s frame of reference.

(i) Plot resolution analysis (PRA) - identifies and calculates statistics on target reports from portions of trajectories which are within the resolution of the Mode S ground station (i.e. likely to give rise to co-channel interference within the radar’s plot extractor processing).

(j) Plot detection analysis (PDA) - calculates detection probabilities for target reports and the probabilities of successfully extracting the correct SSR codes and/or Mode S address information when applicable.

(k) False plot analysis (FPA) - calculates statistics for false plots, i.e. target reports arising from radio frequency (RF) propagation pathways other then direct path main lobe to transponder to main lobe.

(l) Airborne parameter analysis (APA) - calculates the frequency of extraction of MB fields reported by the radar and the frequency of interrogations required for extraction.

(m) Load measurement analysis (LMA) - calculates statistics to measure the work load of the radar in terms of the numbers of targets as functions of azimuth and range.

I.7 Physical Configuration

I.7.1 PTE-P1

The PTE-P1 tool kit consists of the following hardware items:

(a) 3 Apple PowerMac Laptops;

(b) 1 Apple PowerMac Desktops;

(c) 1 RVR (Radar Video Recorder) steel box, including an RVI (Radar Video Interface);

(d) 1 EDR SGR (Extended Data Recorder Scenario Generation Recorder) steel box;

(e) 1 RES (Radar Environment Simulator) consisting of:

(i) an ESG (Extended Scenario Generator) steel box;

(ii) a RIU (Radar Interface and Upconvertor) steel box.

(f) 1 RIU (Radar Interface Unit) steel box;

(g) 1 RFA (Radar Field Analyser) steel box;

(h) 1 RFT (RF Test set) steel box;

(i) 1 ACC (ACCessories) steel box, including a Gyroscope, a GPS unit and an AFU (Acp/arp Fanout Unit).

I.7.2 PTE-P2A

The PTE-P2A tool kit consists of the following hardware items :

(a) 1 RTI (Radar Transmitter Interface);

(b) 2 PDMs (Power Detector Module).

Those items will be included in a single steel box.

In order to operate the PTE-P2A tool the following PTE-P1 items are also needed:

(a) 1 RVR equipment and 1 RVI (Radar Video Interface) equipment, included in the RVR steel box;

(b) 1 Apple PowerMac (Desktop or Laptop).

I.7.3 RAPS-PTE

The RAPS-PTE platform consists of the following hardware items :

(a) 1 RAPS II standard platform (Portable x86 PC running under SCO Unix);

(b) 1 serial line extension;

(c) 1 Ethernet extension.

I.7.4 PTE-P2B

PTE-P2B will be implemented purely as a software solution, running partly on the PTE-P1 platform (PSR simulation) and partly on a platform yet to be chosen, but constrained to be identical to one of the existing ones (PowerMac as for P1, SUN as for P3 or x86/NT4 as for P4).

I.7.5 PTE-P3

The PTE-P3 tool kit consists of one SUN Workstation including standard devices and specific serial interface cards.

I.7.6 PTE-P4

The PTE-P4 tool kit consists of one x86 PC running under Microsoft Windows NT4, with standard devices.

ANNEX J

FIGURES

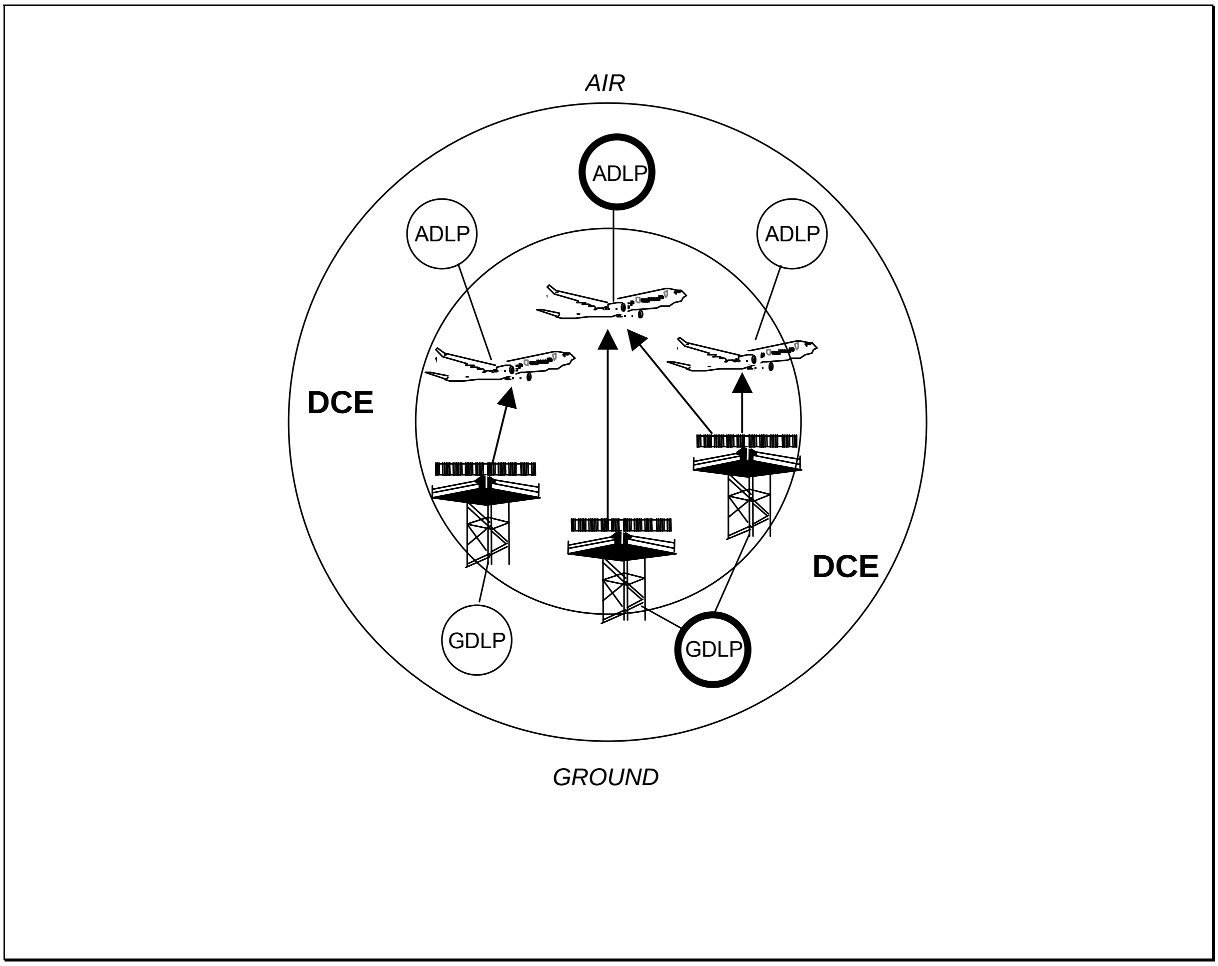


Figure 1 Mode S Subnetwork Environment

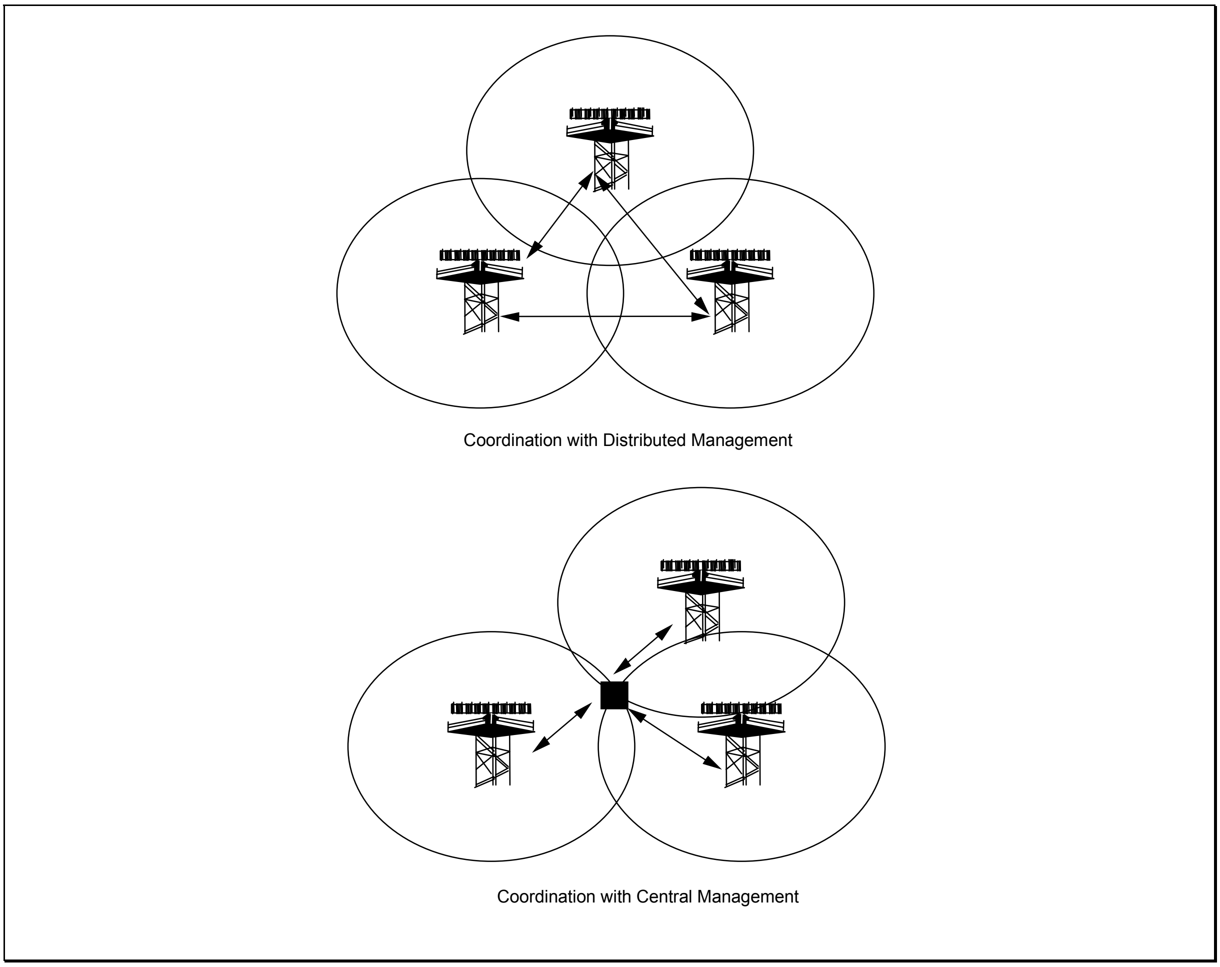


Figure 2 Cluster Co-ordination Options

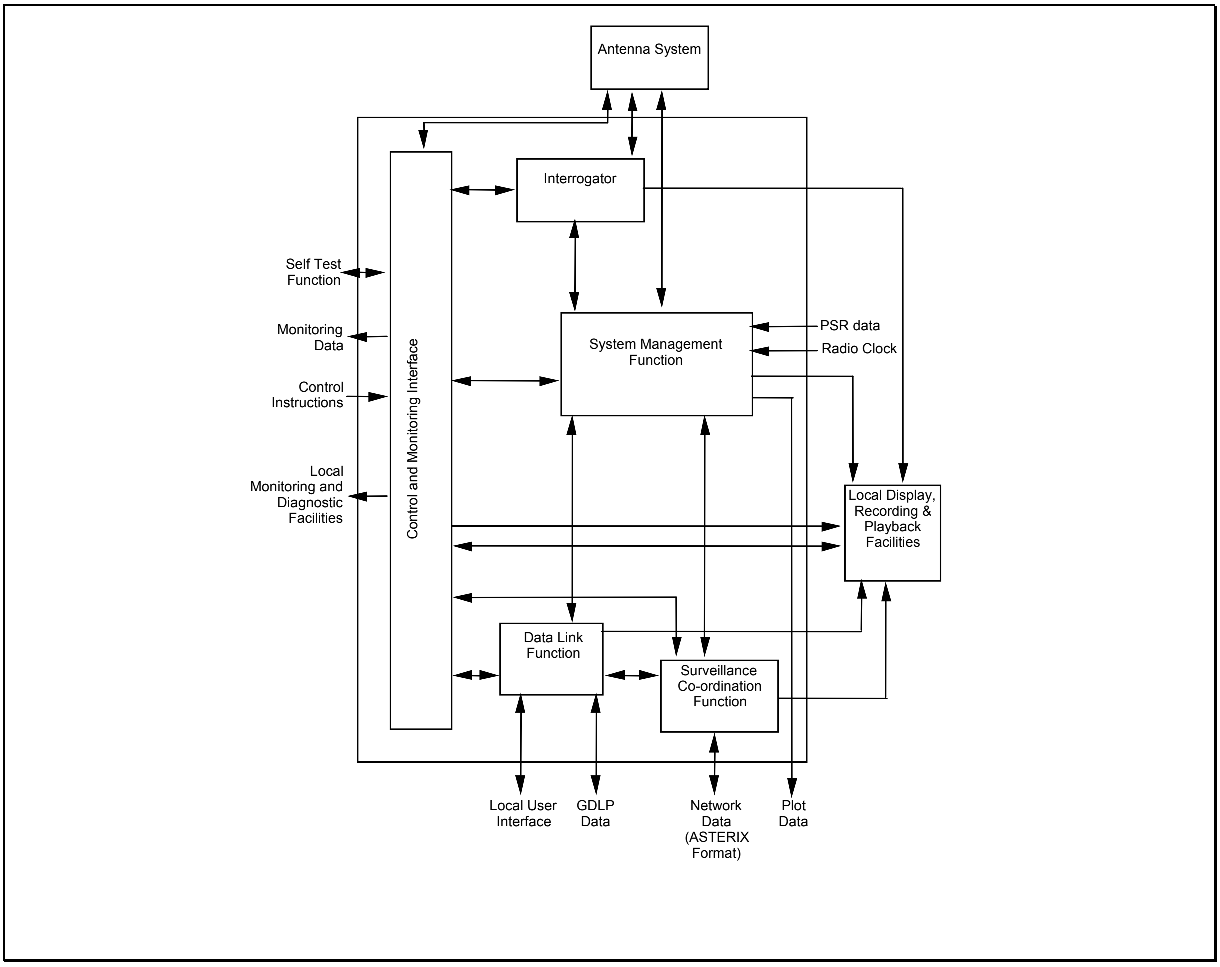


Figure 3 Mode S Ground Station Functional Overview

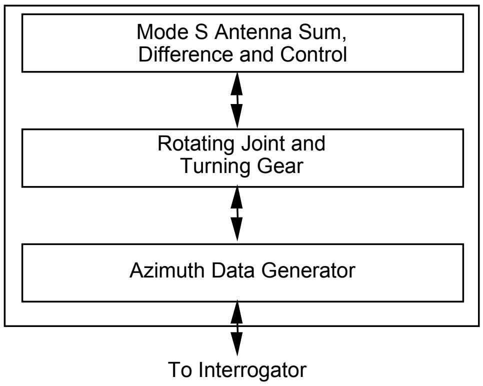


Figure 4 Antenna Functional Overview

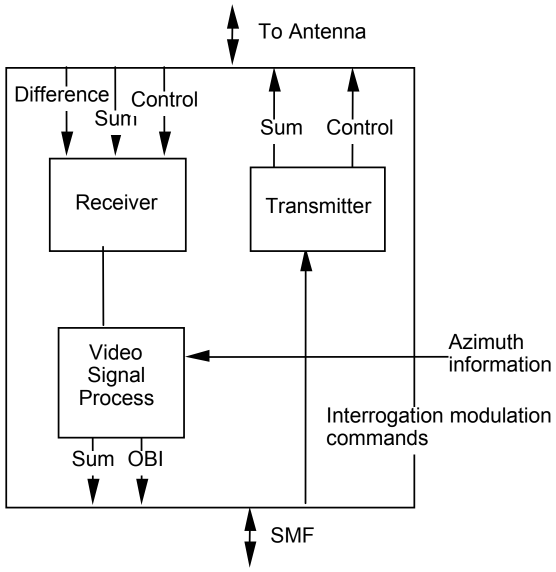


Figure 5 Interrogator Functional Overview

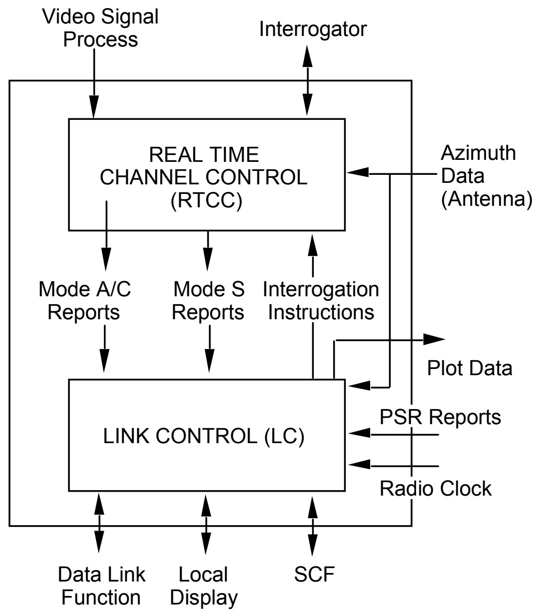


Figure 6 System Management Function (SMF) Overview

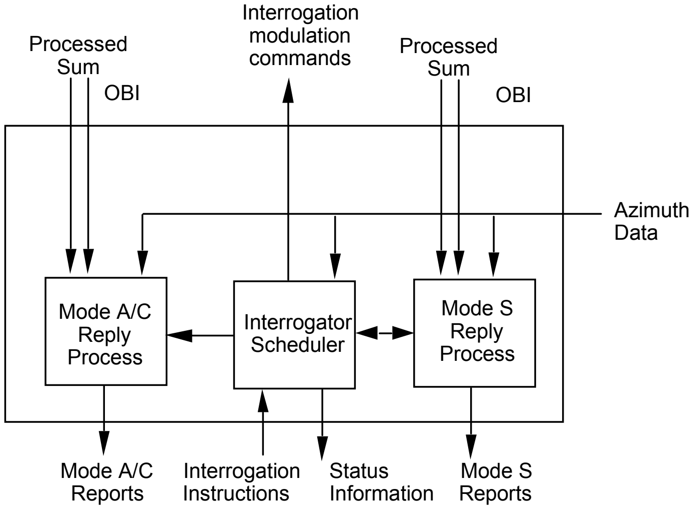


Figure 7 Real Time Channel Controller (RTCC) Functional Overview

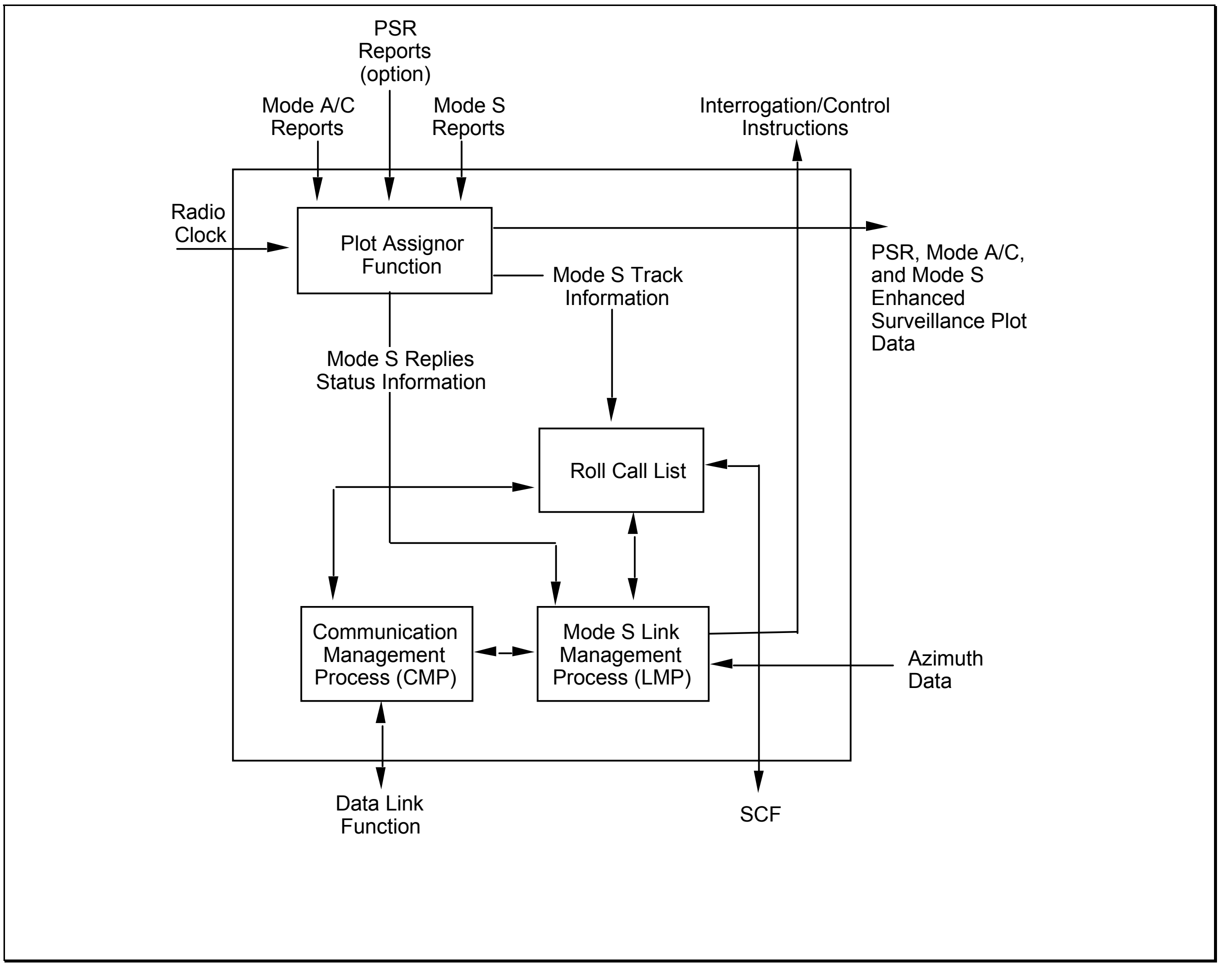


Figure 8 Link Control Functional Overview

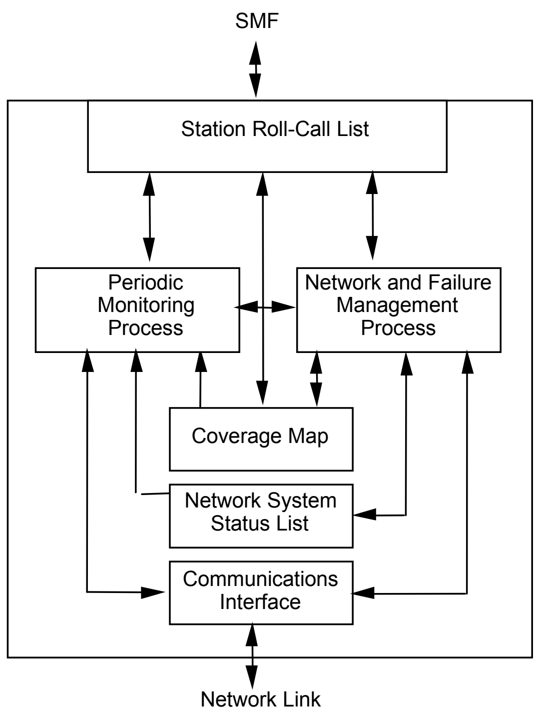


Figure 9 Surveillance Co-ordination Function (SCF) Overview

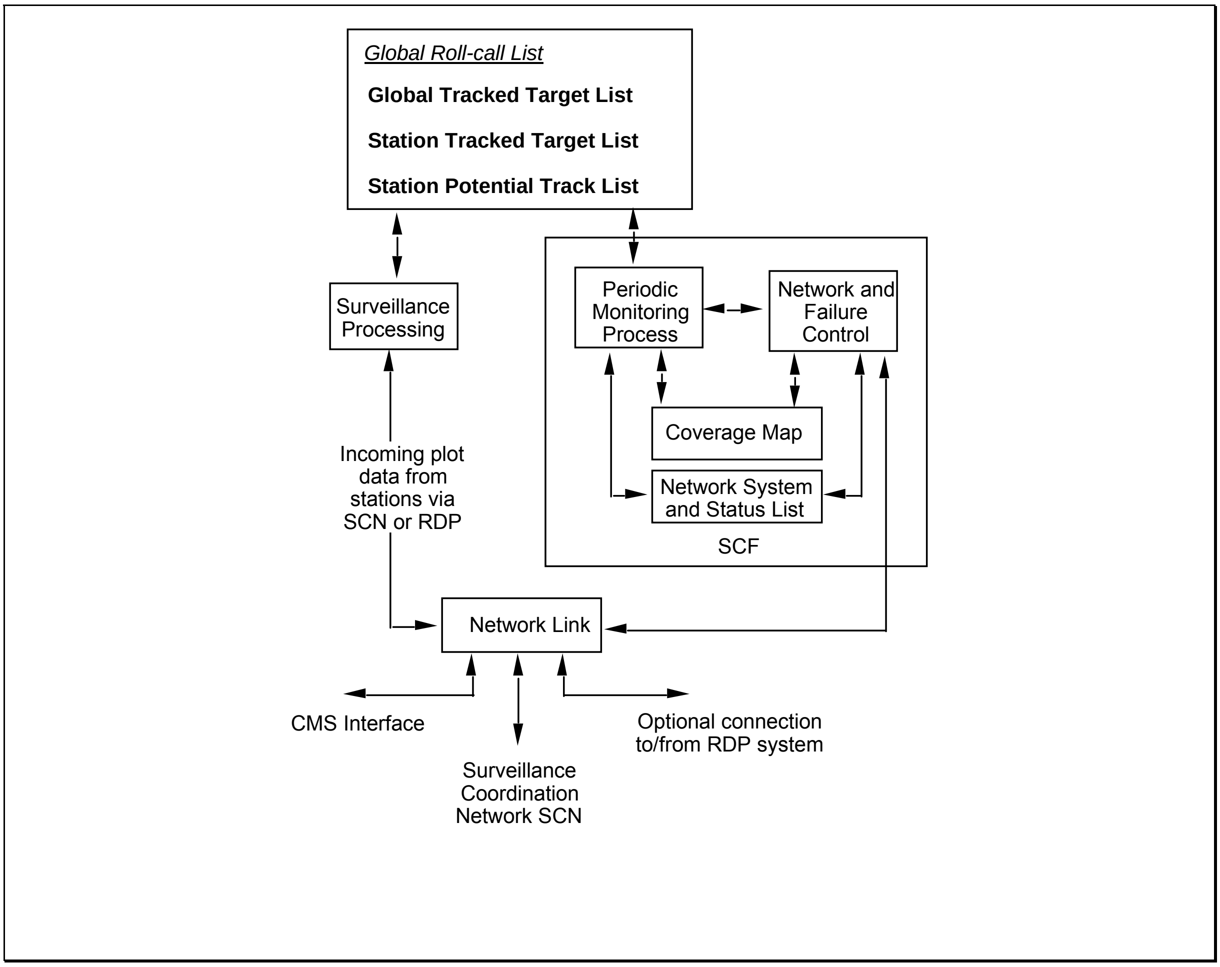


Figure 10 Cluster Controller (CC) Functional Overview

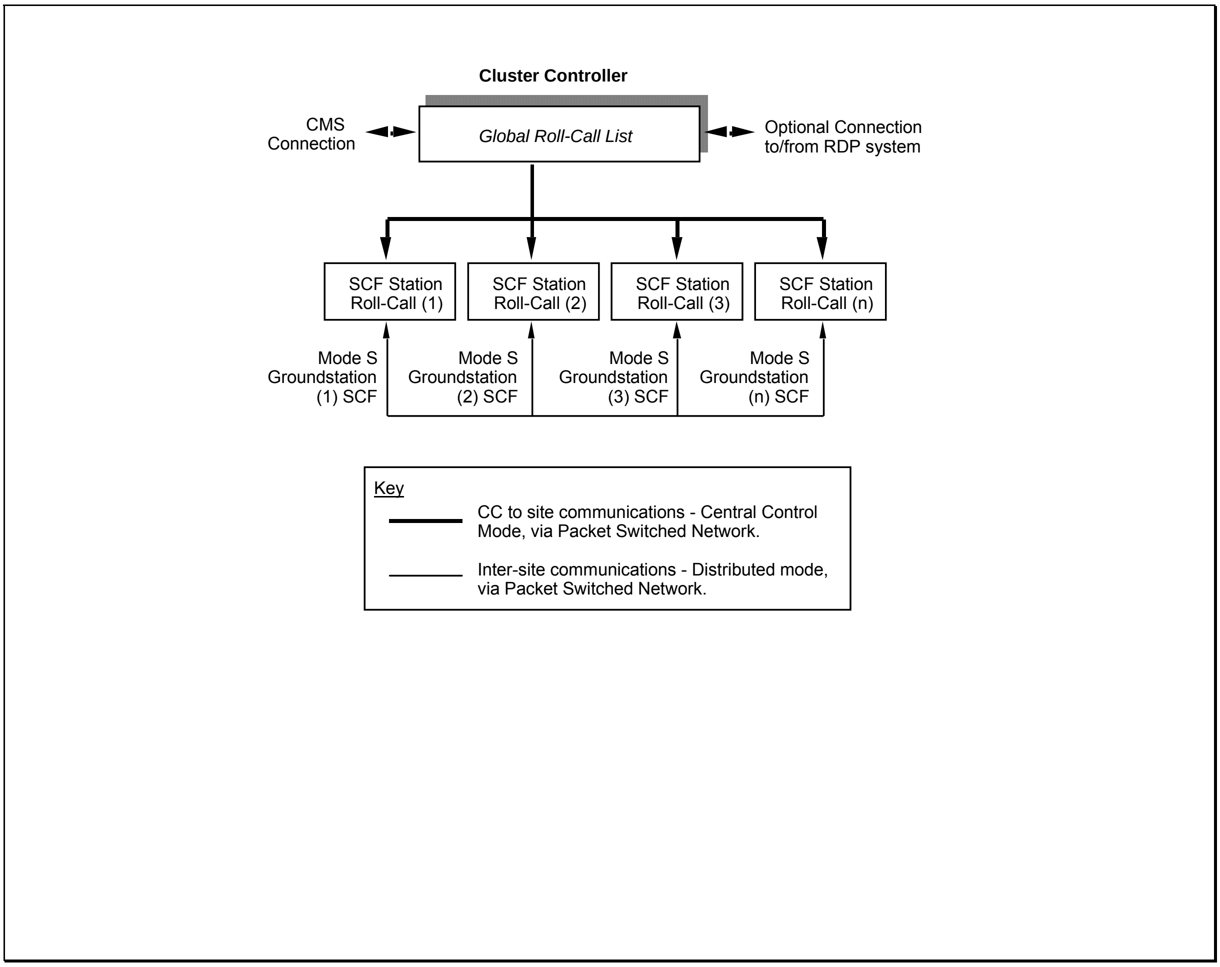


Figure 11 Surveillance Co-ordination Network (SCN)

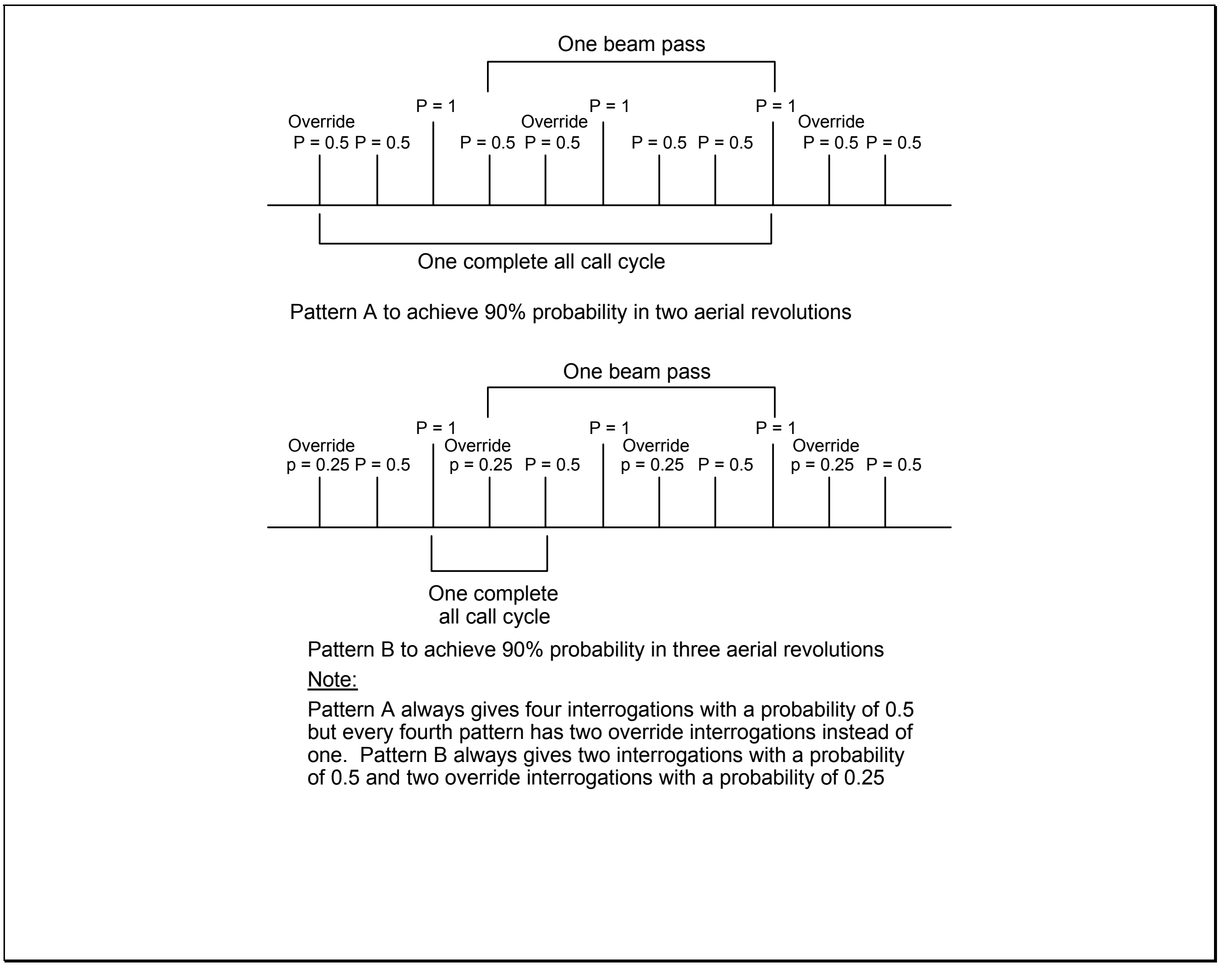


Figure 12 Stochastic All Call Example

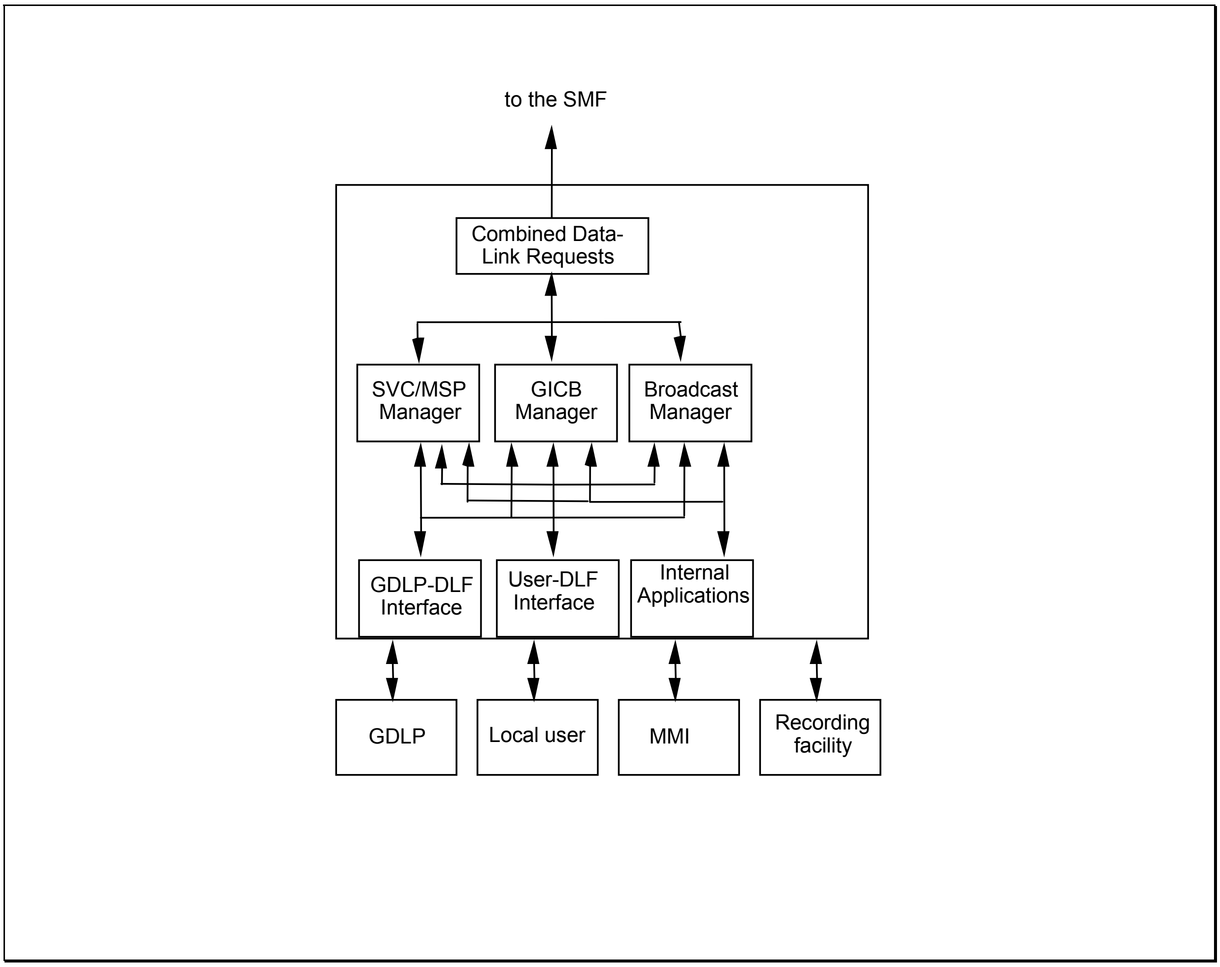


Figure 13 Datalink Function (DLF) Overview

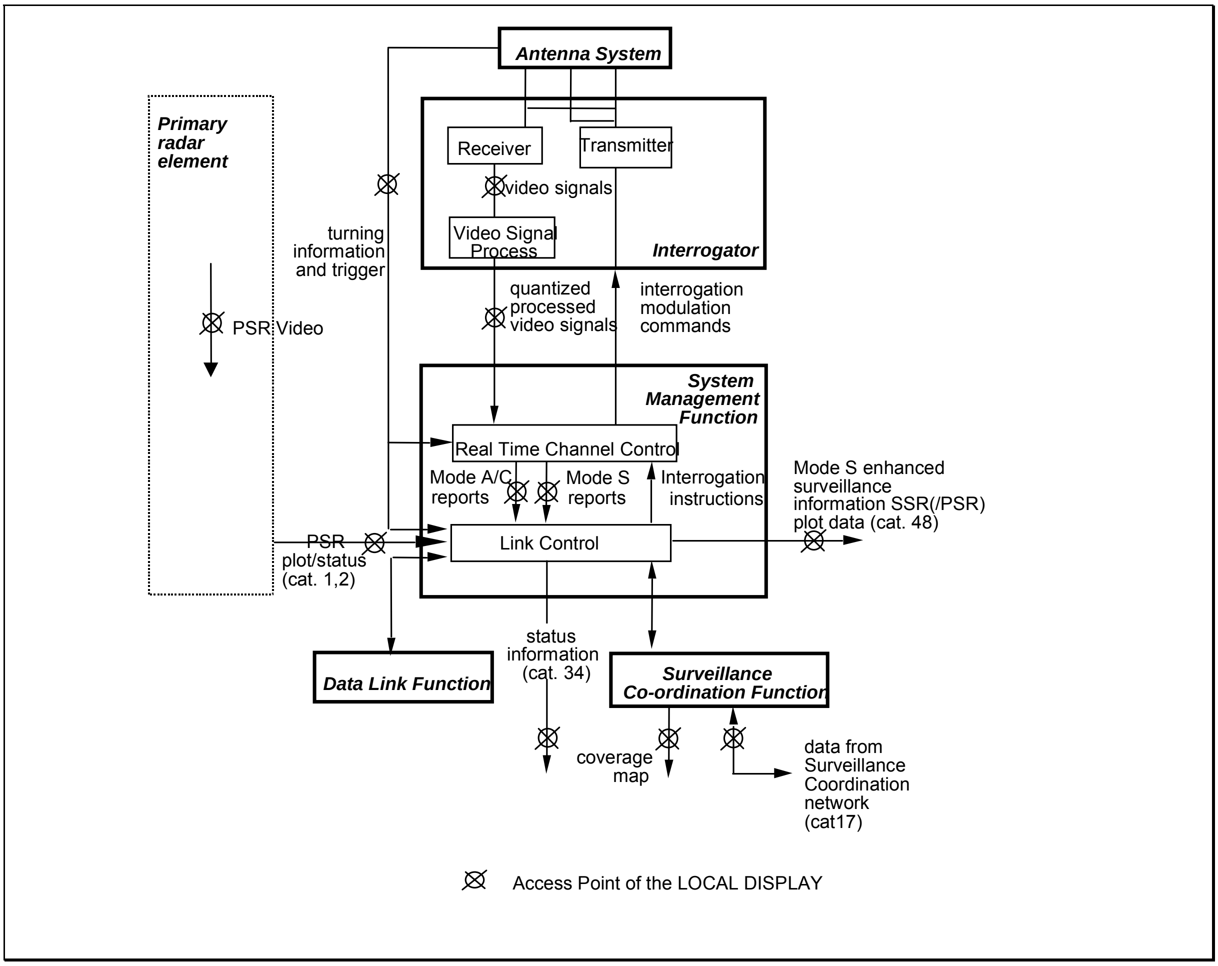


Figure 14 Local Display (LD) Acces Points

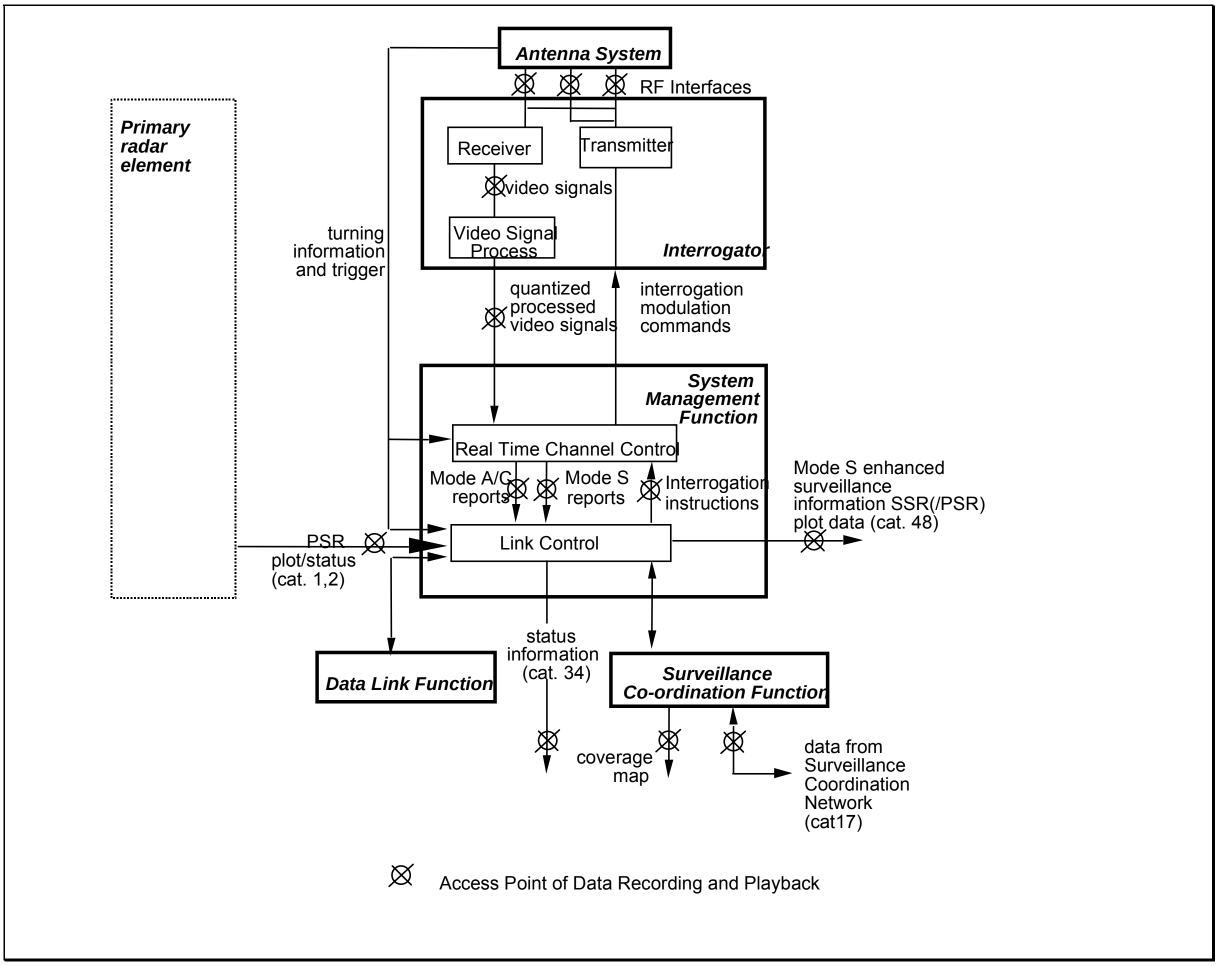


Figure 15 Data Recording and Playback Access Points

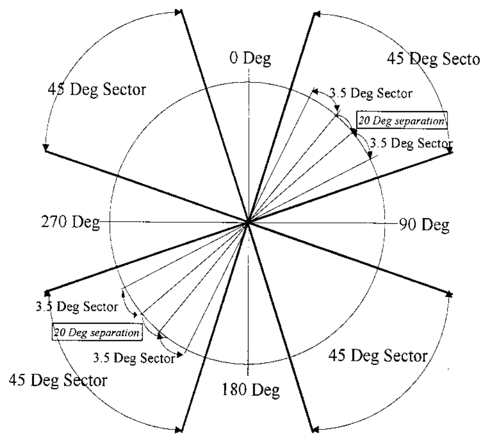


Figure 16 Illustration of Sector Distribution

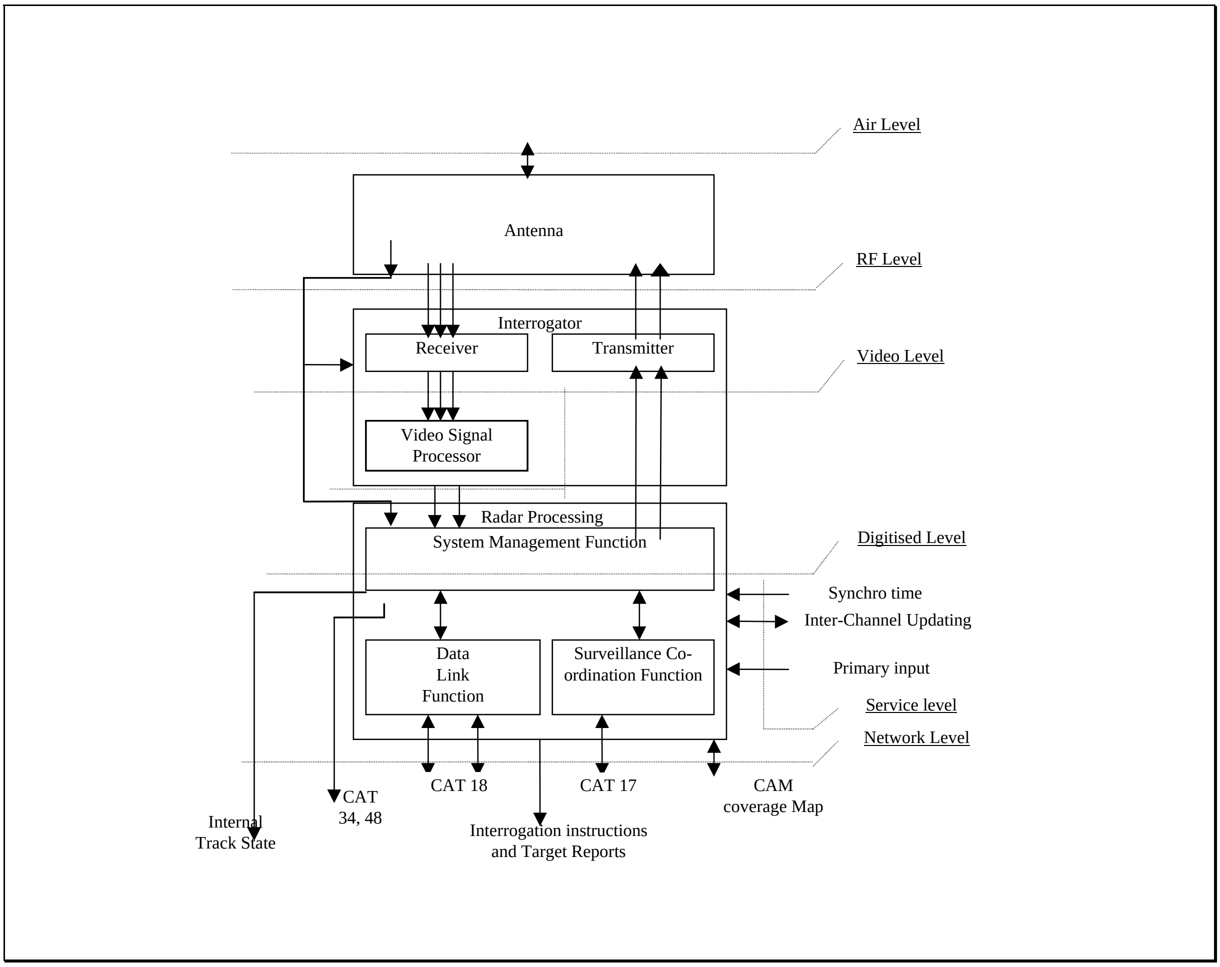


Figure 17 PTE Access Level Overview

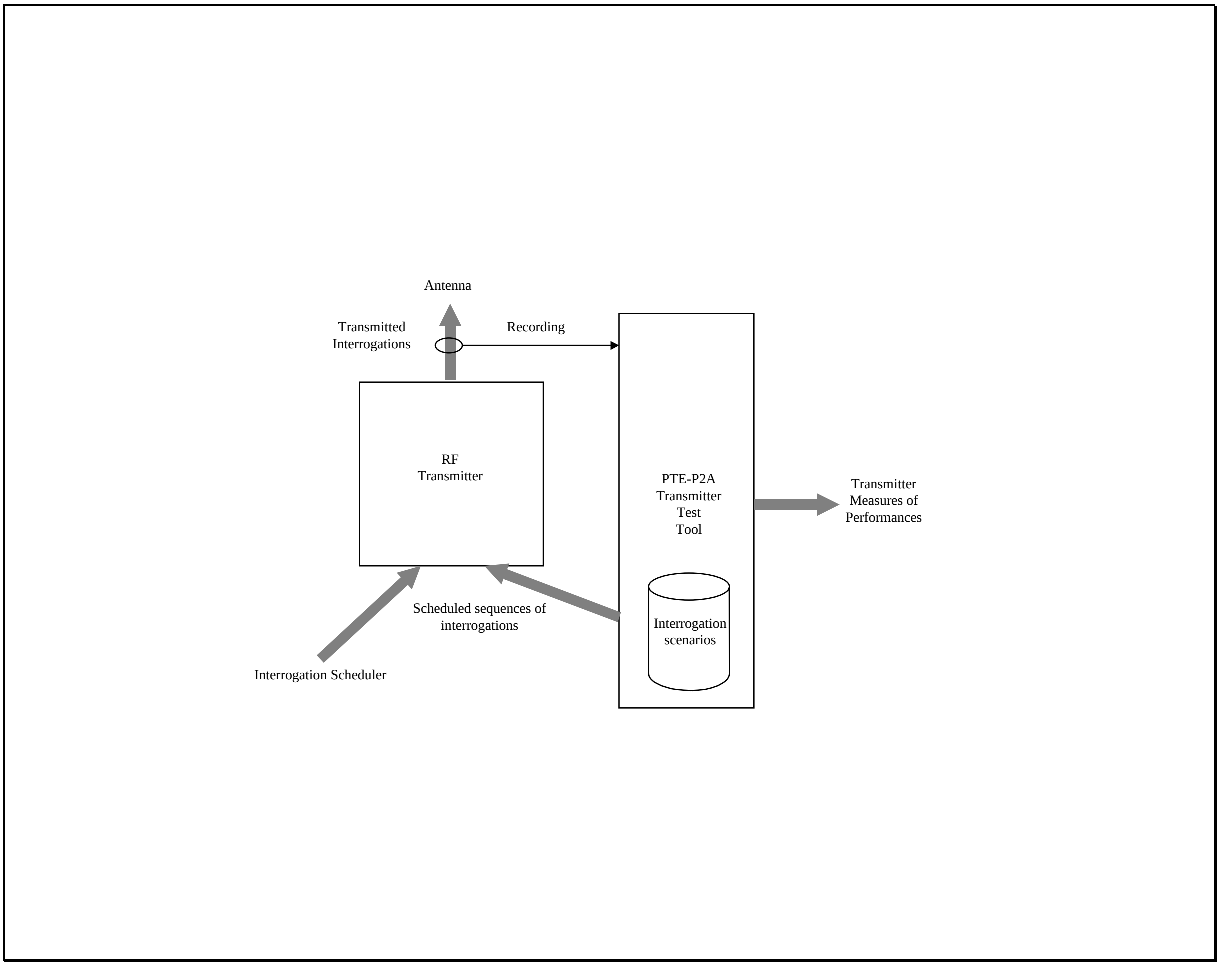


Figure 18 PTE-P2A Context

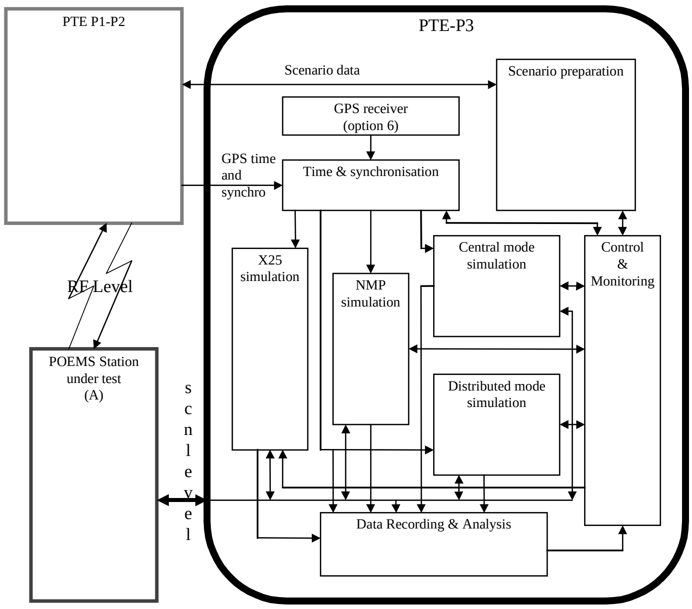


Figure 19 PTE-P3 Functional Overview

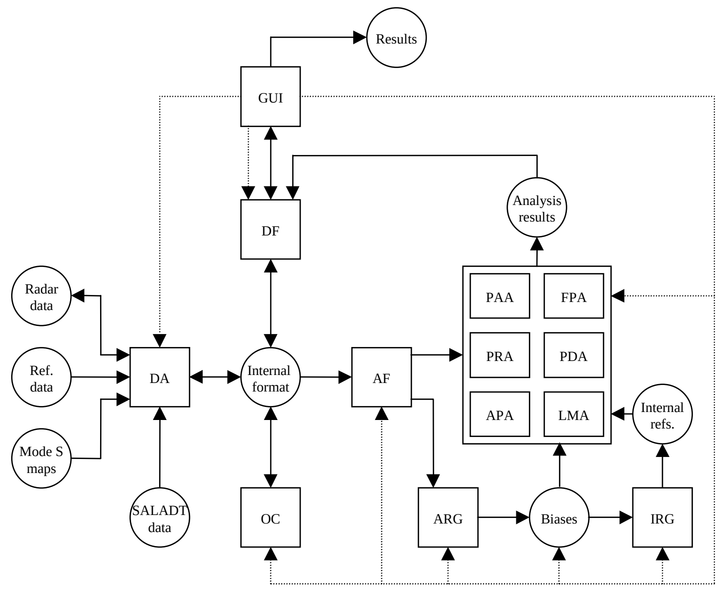
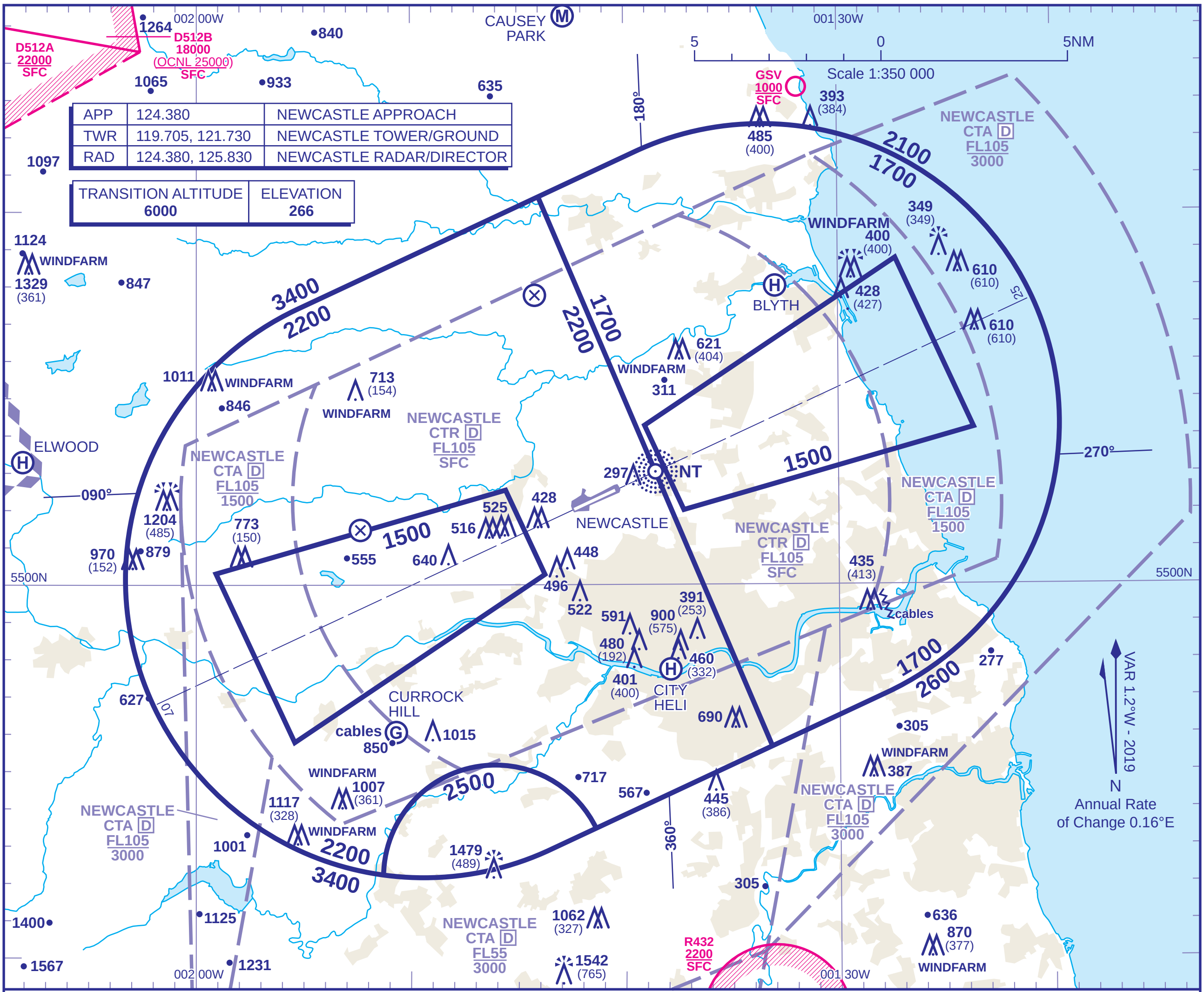


Figure 20 PTE-P4 Functional Architecture

Appendix 12

AIS AIP Newcastle Airport



MINIMUM INITIAL ALTITUDE

Within the ATC Surveillance Minimum Altitude area the minimum initial altitude to be allocated by the approach surveillance controller is:

a) **1700** in the sector defined by the lateral limits; 551023N 0014359W - 551137N 0013926W thence clockwise by an arc of a circle radius 8NM centred on 550420N 0013337W to 545705N 0012748W - 545539N 0013310W - 551023N 0014359W.

b) **2200** in the sector defined by the lateral limits; 550724N 0015517W - 551023N 0014359W - 545539N 0013310W - 545329N 0014123W thence anti-clockwise by an arc of a circle radius 3NM centred on 545210N 0014605W to 545214N 0015117W thence clockwise by an arc of a circle radius 8NM centred on 550009N 0014923W to 550724N 0015517W.

For right hand circuits to RWY 07 further descent to **2200** may be given on base leg when north of CTA boundary.

c) **2500** in the sector defined by the lateral limits; 545214N 0015117W thence clockwise by an arc of a circle radius 3NM centred on 545210N 0014605W to 545329N 0014123W - 545254N 0014331W thence clockwise by an arc of a circle radius 8NM centred on 550009N 0014923W to 545214N 0015117W.

OUTSIDE THE DESIGNATED ATC SURVEILLANCE MINIMUM ALTITUDE AREA

The minimum altitude to be allocated by the approach surveillance controller will be either the Minimum Sector Altitude, or **1000** above any fixed obstacles:

a) within 5NM of the aircraft*, and

b) within the sector 15NM ahead of and within 20° either side of the aircraft's track*.

*When the aircraft is within 15NM of the radar antennae, the 5NM in a) and the 15NM in b) may be reduced to 3NM and 10NM respectively.

LOSS OF COMMUNICATION PROCEDURES

Initial Approach

Continue visually or by means of an appropriate approved final approach aid. If not possible proceed at **2500**, or last assigned level if higher to **NDB(L) NT**†.

Intermediate and Final Approach

Continue visually or by means of an appropriate final approach aid. If not possible follow the Missed Approach Procedure to **NDB(L) NT**†.

† In all cases where the aircraft returns to the holding facility the procedure to be adopted is the Radio Failure Procedure detailed at ENR 1.1.3.

GENERAL INFORMATION

1. Levels shown are based on QNH.
2. Only significant obstacles and dominant spot heights area shown.
3. The minimum levels shown within the ATC Surveillance Minimum Altitude Area are in conformance with the Standard European Rules of the Air - SERA.5015.
4. Minimum Sector Altitudes are based on obstacles and spot heights within 25NM of NDB(L) NT.
5. Controlled airspace with a base in excess of **5000** or FL55, as appropriate, is not shown.
6. **This chart may only be used for cross-checking of altitudes assigned when in receipt of an ATC Surveillance service.**
7. **When vectoring an aircraft within the Final Approach Vectoring Area descent clearance below the SMAA to the FAVA altitude may only be issued if the aircraft is either established on the final approach track or on an intercept of 40° or less, and in the case of instrument approaches other than SRA is cleared to intercept the final approach track.**

CHANGE (5/19): D512B NAMING. OBSTACLES.

Appendix 13

Project Marshall ATC Radar Upgrade

Appendix 13

Project Marshall ATC Radar Upgrade

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 2: Natura Impact Statement

MWP

Revised Natura Impact Statement

Ballycar Wind Farm, County Clare

Ballycar Green Energy Limited

September 2024

MWP

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Explanatory Note

This revised NIS presents changes and/or updates to the NIS (Document Number 22156-6005-F) submitted with the Ballycar Wind Farm planning application (Case Number: ABP-318943-24). Amendments and additions within the main body of text to this revised NIS are provided in Tan-coloured text.

Project No.	Doc. No.	Rev.	Date	Prepared By	Checked By	Approved By	Status
22156	6005	A	February 2022	Hazel Dalton			DRAFT
22156	6005	B	January 2023	Úna Williams, HD	Gerard Hayes		DRAFT
22156	6005	C	January 2023	ÚW	Peter Barry		DRAFT
22156	6005	D	July 2023	ÚW	GH, PB		DRAFT
22156	6005	E	October 2023	ÚW	Olivia Holmes Client reviewed		DRAFT
22156	6005	F	January 2024	ÚW	OH Client reviewed	OH	FINAL
22156	6005	G	September 2024	ÚW	HD	HD	Revised FINAL

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QUALITY
I.S. EN ISO 9001:2015
NSAI Certified

HEALTH & SAFETY
I.S. ISO 45001:2018
NSAI Certified

ENVIRONMENT
I.S. EN ISO 14001:2015
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1. Summary of Findings

1.1 Natura Impact Statement

Project Title	Proposed Ballycar Wind Farm
Project Proponent	Ballycar Green Energy Limited
Project Location	The proposed development site is situated within the townlands of Glennagross, (orse Glenagross, Glennacross – hereafter referred to as Glennagross within this document) Cappateemore East, Ballycannan West, Ballycannan East, Ballycar South and Ballycar North in southeast County Clare, approximately 3 kilometres northwest of Limerick City and suburbs and 6.7 kilometres east of Sixmilebridge.
Natura Impact Statement	In cases where an Appropriate Assessment is required, a Natura Impact Statement (NIS) is prepared and includes a report of a scientific examination of evidence and data, carried out by competent persons to identify and classify any adverse impacts a project may have, either individually or in combination with other plans or projects, on the integrity of a European site(s) in view of the conservation objectives of the site(s).
Conclusion	For the reasons set out in detail in this NIS, and based on best scientific knowledge, the proposed development will not, either alone or in combination with other plans and projects, adversely affect (directly or indirectly) the integrity of two the identified European sites, namely the Lower River Shannon SAC and the River Shannon and River Fergus Estuaries SPA, considering the specific conservation objectives of each site. The NIS contains information which the competent authority may consider in making its own complete, precise and definitive findings and conclusions, and upon which the competent authority is capable of determining that all reasonable scientific doubt has been removed as to the effects of the project on the integrity of the relevant European sites. Provided that the mitigation measures are implemented in full, it is considered that the proposed development, either individually, or in combination with other plans/projects, will not affect the integrity of two European sites, namely: ▪ Lower River Shannon SAC (002165); ▪ River Shannon and River Fergus Estuaries SPA (004077).

2. Introduction

2.1 Project Overview

Ballycar Green Energy Limited ('the Applicant') is submitting a planning application for developing and operating a commercially viable 12-turbine wind farm project on lands at Ballycar in County Clare. For the purposes of this assessment, the 'proposed development' refers to all elements of the proposed wind energy project including all wind farm infrastructure and new underground 110kV collector cable – see **Section 4.5**, below, for further details on the characteristics of each element of the proposed development. It is envisaged that the project will exceed a 50-megawatt (MW) capacity scale and therefore will be a Strategic Infrastructure Development (SID) for which an application for planning permission must be made directly to An Bord Pleanála (ABP).

MWP was commissioned by Ballycar Green Energy to complete a Screening for Appropriate Assessment Report and Natura Impact Statement (NIS). An Environmental Impact Assessment Report (EIAR) has also been prepared by MWP and is submitted with the planning application.

2.2 Purpose of the Assessment and Legislative Context

Appropriate Assessment is the consideration of the impact of a project on the integrity of a European site[1], either alone or in combination with other plans or projects, with respect to the site's ecological structure and function, and in view of the site's conservation objectives. The conservation objectives of European sites are site specific and based on the ecological requirements of the species and habitats present. They define the desired conservation condition of certain species and habitat types for the site. Conservation objectives are defined using attributes and targets that are based on parameters as set out in the Habitats Directive for defining favourable status, namely area, range, structure and function. The conservation objectives may be either to maintain or restore the favourable conservation condition of a habitat/species.

Article 6(3) of Directive 92/43/EEC stipulates that certain projects and plans must be subjected to an "appropriate assessment" of their effects on the integrity of European site(s). Article 6(3) provides in full:

"*Any plan or project not directly connected with or necessary to the management of the site but likely to have a significant effect thereon, either individually or in combination with other plans or projects, shall be subject to appropriate assessment of its implications for the site in view of the site's conservation objectives. In the light of the conclusions of the assessment of the implications for the site and subject to the provisions of paragraph 4, the competent national authorities shall agree to the plan or project only after having ascertained that it will not adversely affect the integrity of the site concerned and, if appropriate, after having obtained the opinion of the general public*."

A screening for Appropriate Assessment report was completed for the proposed Ballycar Wind Farm to establish whether the project is likely to have a significant effect on any European sites. The screening for Appropriate Assessment report determined that a full Appropriate Assessment of the proposed development is required, as it could not be excluded based on objective information that the proposed development, individually or in combination with other plans or projects, will not have a significant impact on any European sites, in view of the sites' conservation objectives.

It was concluded that the proposed wind energy development at Ballycar is likely to have a significant effect, or the potential for significant effects cannot be ruled out (at the screening stage), in the absence of mitigation on the following European sites:

- Lower River Shannon SAC (002165); and

[1] 'European sites' are defined in Section 177R of Part XAB of the Planning and Development Act 2000 and include Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) at all stages of designation.

- River Shannon and River Fergus Estuaries SPA (004077).

Refer to **Appendix 1** for the Screening for Appropriate Assessment report.

An Appropriate Assessment of the project is required; hence, this Natura Impact Statement (NIS) has been prepared to detail the scientific examination of evidence and data and to identify and classify any implications for European sites likely to have a significant effect in view of the conservation objectives of those sites. The aim of the assessment is to provide a sufficient level of information to the competent authority on which to base their appropriate assessment of the project. Additionally, mitigation measures to avoid or reduce ecological effects were considered. The project is fully described in **Section 4.4**, below, and includes details on all elements of the project, particularly in relation to the aspects that could interact with the surrounding environment.

This NIS identifies the aspects of the proposed development that will interact with the ecological requirements or sensitivities of the habitats and species listed in **Section 6.2.2** and **Section 6.3.2**, below, and determines whether these will result in adverse effects for the species and/or habitats for which the European sites listed above are designated. Mitigation measures to avoid or reduce ecological effects are provided in **Section 7**, below.

2.2.1 Purpose of Natura Impact Statement Revisions

A request was made by An Bord Pleanála (ABP) to the Applicant on 26th July 2024 for the submission of a revised NIS for the proposed Ballycar Wind Farm (Case Number ABP-318943-24) to address outstanding concerns in relation to 'in-combination considerations that may arise from the proposed development and Oatfield Wind Farm' (Case Number ABP-318782-24).

On the 30th August 2024, and shortly after ABP's request was issued to the Applicant, a planning application for Knockshanvo Wind Farm was submitted to ABP (Case Number ABP-320705-24). Due to the location of Knockshanvo Wind Farm adjacent to Oatfield Wind Farm, both wind farms were considered in the revised NIS when assessing the potential for significant in-combination effects with Ballycar Wind Farm.

2.3 Statement of Competency

This Natura Impact Statement has been prepared by Hazel Dalton (BSc.) Senior Ecologist, and Úna Williams (BSc. MSc.), Ecologist and Environmental Scientist, both of Malachy Walsh and Partners (MWP) Engineering and Environmental Consultants.

Hazel has over eight years' experience with MWP in ecological surveying and impact assessment for AA and EIAR and has authored and contributed to numerous screening reports for AA, Natura Impact Statements (NIS) and Ecological Impact Assessments (EcIA). She is an appropriately qualified, trained and competent professional. She has completed numerous ecological assessments for a wide variety of projects. She is an experienced field ecologist and has a diverse ecological survey profile, including habitats and flora, mammals, birds and terrestrial/aquatic invertebrates.

Úna has worked with MWP for five years and is an experienced field ecologist. She is familiar with various ecological survey methodologies including habitat/survey mapping and zoological surveys and has worked on research teams both in Ireland and abroad. She has undertaken assessments for a wide variety of projects including renewable energy developments, and infrastructural and coastal development projects. Úna has designed and carried out several Collision Risk Models for proposed wind farms and has authored many ecological reports including Screenings for Appropriate Assessment Reports (Stage 1), Natura Impact Statements (Stage 2), and Ecological Impact Assessments.

This report was reviewed by Gerard Hayes. Gerard is a Senior Ecologist with MWP and has over 15 years' experience in environmental consultancy. He is a member of the Chartered Institute of Ecology and Environmental Management (MCIEEM) and the Freshwater Biological Association (FBA). Gerard has a diverse ecological profile, with Phase 1 habitat, mammal (including bats), bird, amphibian, macroinvertebrate and tree survey experience. He is co-author and/or carried out surveys for NPWS Irish Wildlife Manual Nos. 15, 24, 26, 37, 45.

3. Methodology

3.1 Appropriate Assessment Guidance

This NIS has been prepared in accordance with the European Commission Methodological Guidance on the provision of Article 6(3) and 6(4) of the 'Habitats' Directive 92/43/EEC (EC, 2021), the European Commission Guidance '*Managing Natura 2000 sites*' (EC, 2019), the Office of the Planning Regulator (OPR) Practice Note '*Appropriate Assessment Screening for Development Management*' (OPR, 2021) and guidance prepared by the NPWS (DoEHLG, 2010).

3.2 Consultation

Two pre-application stage meetings were held with An Bord Pleanála. The first, held on 23rd February 2022, involved the introduction of the proposed Ballycar wind development to the Board by Ballycar Green Energy Limited and MWP. The grid connection, NIS, and the EIAR were discussed. A second meeting with An Bord Pleanála took place on 1st September 2022 where the discussion focussed on project progress and the EIAR and NIS. An Bord Pleanála confirmed the project would be Strategic Infrastructure in correspondence dated the 4th November 2022 and advised on the list of prescribed bodies.

Ballycar Green Energy and MWP held a preliminary meeting with members of Clare County Council (CCC) Planning Department on 2nd March 2022 to discuss the site and its suitability for a wind farm project. Additionally, the turbine delivery route, potential visual impacts, public consultation and environmental impacts were discussed.

On 14th December 2021, the following statutory and non-statutory bodies were consulted, amongst others, in relation to the proposed project:

- Department of Housing, Local Government and Heritage;
- Department of Agriculture, Food and the Marine;
- National Parks and Wildlife Service;
- Environmental Protection Agency Ireland;
- Geological Survey Ireland;
- An Taisce – The National Trust for Ireland;
- Bat Conservation Ireland;
- Inland Fisheries Ireland;
- BirdWatch Ireland;
- Irish Whale and Dolphin Group;
- Irish Wildlife Trust;
- Irish Aviation Authority; and
- Transport Infrastructure Ireland (formerly National Roads Authority (NRA)).

A full list of the organisations/groups consulted, copies of the consultation documents and the responses received are provided in Volume III, Appendix 1B of the EIAR.

3.3 Data Requests

The study area for the proposed development lies within the Ordnance Survey National Grid hectad[2] R56. Concise and site-specific information on species records available in this hectad was retrieved from the NBDC on-line database and reviewed.

A request was made to NPWS for Sensitive Data Access for hectad R56 on 17th November 2021. A data request for records of rare or protected species from this hectad was submitted to NPWS on the 13th October 2022.

A data request was also submitted to Bat Conservation Ireland (BCI) for the provision of bat records within a 10-kilometre radius of the proposed development site. All available records were provided by BCI on the 05th May 2023.

A request was made to BirdWatch Ireland on the 18th July 2023 for the results of annual waterbird counts at specific subsites as part of the Irish Wetland Bird Survey (I-WeBS). Information was provided by BirdWatch Ireland on 29th July 2023.

Information received via the NPWS, BCI, NBDC, and BirdWatch Ireland was used to help inform the impact assessment in relation to the proposal.

The responses to these data requests can be viewed in Volume III, Appendix 1B of the EIAR.

3.4 Desktop Study

To complete the NIS, certain information on the existing environment is required. A desktop study was carried out to collate information available on the proposed development site's natural environment. This comprised a review of relevant publications, data and datasets from the following sources:

- Ordnance Survey Ireland (OSI) aerial photography, 1:50,000 mapping, GeoHive and online satellite imagery sources;
- National Parks and Wildlife Service (NPWS);
- National Biodiversity Data Centre (NBDC) (online map-viewer);
- Central Statistics Office (CSO) – Census of Agriculture (online);
- BirdWatch Ireland;
- Bat Conservation Ireland (BCI);
- Teagasc soil area maps (NBDC website);
- Geological Survey Ireland (GSI) area maps;
- Environmental Protection Agency (EPA) water quality data;
- Shannon International River Basin District (ShIRBD) datasets (Water Framework Directive);
- Inland Fisheries Ireland (IFI) online fish sampling reports and fish data;
- Review of requested records from NPWS Rare and Protected Species database;

[2] Unit of land area measuring 10 km x 10 km

- Clare County Development Plan (2023 – 2029)3, adopted by Clare County Council on 9th March 2023; and
- Other sources and research listed in **Section 11**, below, and as footnotes throughout the report.

3.5 Study Area and Zone of Influence (ZOI) of the Proposed Project

The zone of influence (ZOI) for the proposed development is the geographical area over which construction and/or operation and/or decommissioning of the proposed wind farm has the potential to affect the receiving environment in such a manner as to significantly affect the Qualifying interests (QI) of a European site. The area over which ecological features may be affected by biophysical changes because of the proposed project and associated activities is likely to extend beyond the project site where, for example, there are ecological or hydrological links beyond the site boundaries (CIEEM, 2018). Consequently, and to ensure completion of an integrated assessment, the study area for this project included the entire proposed development site, adjoining habitats and watercourses located downstream of the site (see **Figure 3-1**, below).

For details on the Zone of Influence (ZOI) of the proposed development and the use of the Source-Pathway-Receptor (SPR) model in determining which European sites are further assessed, refer to **Section 6.1**, below.

3.6 Field Surveys

Field surveys carried out on-site in support of the development application include the following:

- Habitat surveys and mapping;
- Non-volant mammal[4] surveys;
- Invasive alien plant species (IAPS) surveys;
- Freshwater aquatic ecology surveys;
- Breeding bird surveys, including Vantage Point surveys; and
- Wintering bird surveys, including Vantage Point surveys;

Full details of all surveys and survey methodologies have been presented in **Chapter 6 Biodiversity**, and **Chapter 7 Ornithology**, in **Volume II** of the **EIAR**. The results of the surveys listed above are summarised in **Section 4.4**, below.

Ecological field surveys and aquatic ecology surveys were undertaken at the proposed development site on multiple dates between 2019 and 2023 to establish the site's ecological features and resources, particularly for any rare or protected species and habitats present within the study area. Multidisciplinary walkover surveys were carried out to identify any ecological features and resources that may potentially be impacted by the proposed development.

Habitats recorded were classified according to Fossitt '*A Guide to Habitats in Ireland*' (2000). Non-volant mammals and/or evidence of their activity such as prints, faecal pellets/droppings, burrow-holes/dens and food caches, activity trails and disturbed vegetation were looked for during walkover surveys. In general, the Mammal Society publication '*How to Find and Identify Mammals'* by Muir *et al.* (2013) was followed. Evidence of otter was looked for at any watercourse/drain crossings encountered and '*Monitoring the Otter* Lutra lutra' (Chanin, 2003a) and '*Ecology of the European Otter*' by Chanin (2003b) were consulted for guidance on identification of otter signs including spraints, footprints, tracks, couches, and holts.

For this [3] Stage 3 - Adoption of Plan | Stage 3: Amendments | Clare County Council (clarecoco.ie) Accessed: 16th June 2023
[4] Non-volant mammals are land-based mammals incapable of flight i.e. all land-based mammals excluding bats.

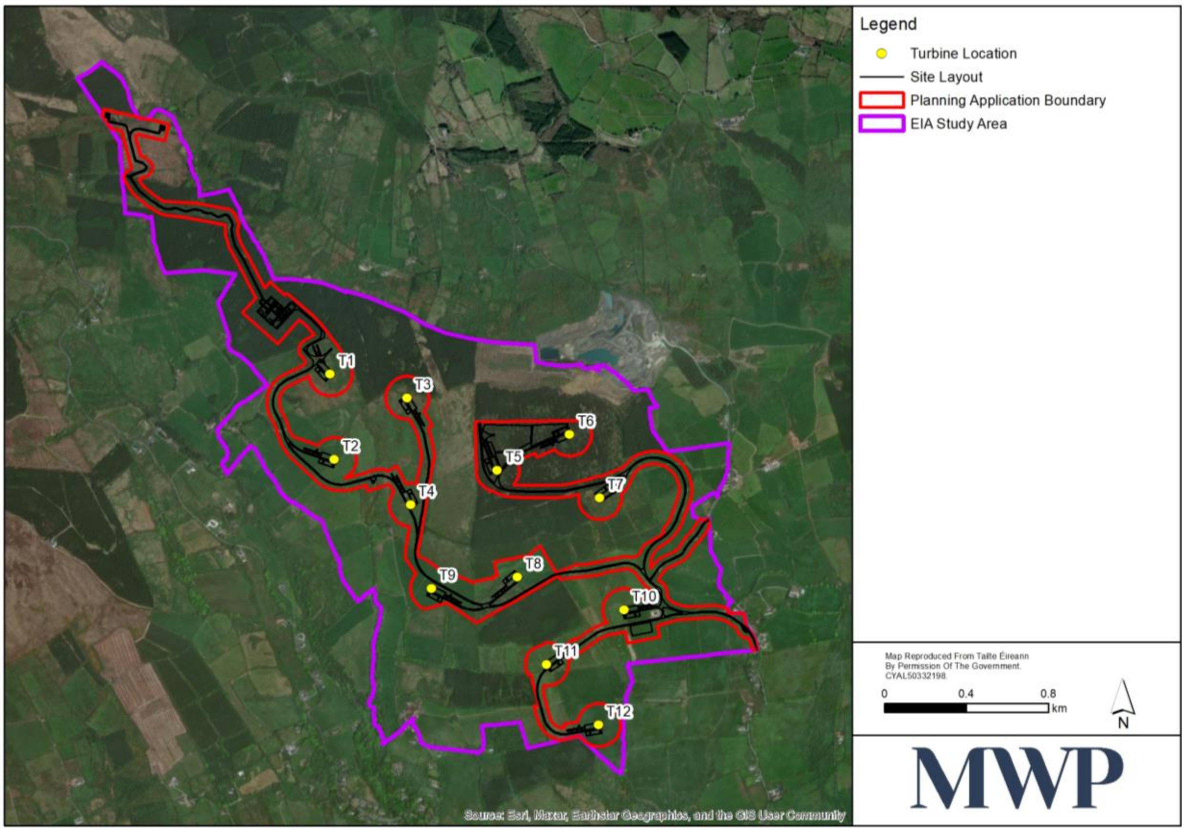

Figure 3-1: Study area and proposed development site boundary at Ballycar in County Clare.

3.6.1 Freshwater Aquatic Surveys

The freshwater aquatic ecology field surveys involved aquatic assessments of several representative sites on watercourses within and outside the study area at locations detailed in **Table 1** and **Figure 3-2**, below.

The following were all completed at Sites 1 to 11:

- Evaluation of aquatic habitats;
- Fish survey;
- Biotic assessment using aquatic macroinvertebrates; and
- Water sampling for analysis of physico-chemical water quality parameters.

Surveys listed above were completed at Sites 1 to 10 in June and August 2021. Biotic assessment and water sampling for physico-chemical analyses was repeated at Sites 1 to 10 on 21st and 22nd June 2023.

Following a revised grid connection route, the footprint of the proposed development was extended into the Blackwater (Clare) catchment and as a result, survey Sites 11 and 12 were added to the assessment. Results of aquatic surveys undertaken by MWP at the R465 Bridge in August 2018 within the Blackwater (Clare) catchment were used in this report and referenced as Site 11.

In the same catchment, survey Site 12 at Kilnacreagh Stream was visited in June 2023 and a habitat survey only was carried out due to the insufficient size of the watercourse and because of difficulty accessing the survey site.

Table 1. Details of freshwater aquatic ecology survey locations on watercourses draining the proposed development site at Ballycar.

Hydrometric Area	Sub-basin	River catchment	Site	Watercourse	River Segment Code	Stream Order	Coordinates X	Coordinates Y
Shannon Estuary North	Crompaun (East)_010	Crompaun (East)	Site 1	Crompaun	27_755	2	553790	663975
			Site 2	Glennagross	27_431	2	554084	663753
			Site 3	Cappateemore East	27_277	1	554792	663405
			Site 4	Crompaun East	27_1129	3	555000	662040
Lower Shannon	North Ballycannan _010	North Ballycannan	Site 5	North Ballycannan	25_866	1	556531	663068
			Site 6	North Ballycannan	25_185	2	556445	661639
			Site 7	West Ballycannan	25_1699	2	556084	661408
			Site 8	South Ballycar	25_1694	1	556538	664031
			Site 9	South Ballycar	25_181	3	557344	661790
			Site 10	West Roo	25_1150	2	558026	662034
	Blackwater (Clare)_010	Blackwater(Clare)	Site 11	Blackwater (Clare)	25_3209	3	559355	665585
			Site 12	Kilnacreagh	25_3206	1	553630	665468

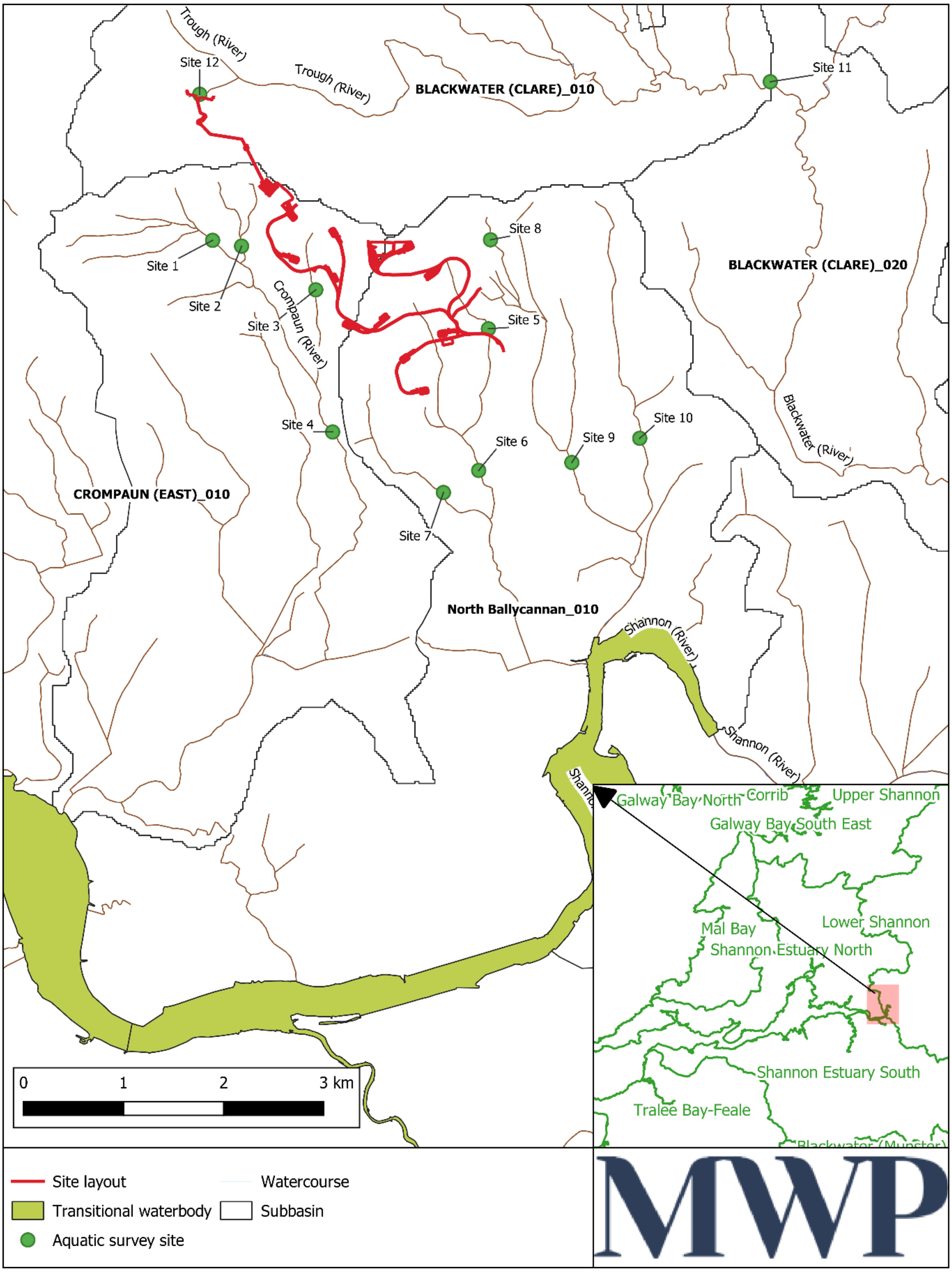

Figure 3-2: Locations of watercourses and survey sites 1 to 12 examined as part of the aquatic ecology studies for the proposed development at Ballycar.

3.6.2 Ornithological Surveys

Ornithological field surveys were undertaken at the site from October 2019 to September 2023, inclusive. The survey periods used for assessment within this report are as follows:

- Winter 2019/20 (October to March, inclusive);

- Breeding (summer) 2020 (April to September, inclusive);
- Winter 2020/21 (October to March, inclusive);
- Breeding (summer) 2021 (April to September, inclusive);
- Winter 2021/22 (October to March, inclusive);
- Breeding (summer) 2022 (April to September, inclusive);
- Winter 2022/23 (October to March, inclusive); and
- Breeding (summer) 2023 (April to September, inclusive).

There were two main elements to the bird surveys –

1) Vantage point (VP) surveys, and

2) Targeted abundance and distribution surveys that included:

- Walkover transect surveys;
- Breeding hen harrier (Circus cyaneus) surveys;
- Hen harrier winter roost surveys;
- Breeding woodcock (Scolopax rusticola) and nightjar (Caprimulgus europaeus) surveys;
- Breeding wader surveys;
- Breeding raptor surveys;
- Breeding peregrine (Falco peregrinus) / kestrel (Falco tinnunculus) surveys;
- Wintering waterfowl distribution surveys; and
- Hinterland surveys.

Prior to the commencement of survey work, a list of target species was determined, and these became the focus of the surveys. Target species are typically those species that are afforded a higher level of legislative protection, or which are more sensitive to potential impacts from wind farm developments by virtue of their behaviour (SNH, 2017). The target species list was drawn from:

- Annex I of the Birds Directive (2009/147/EC);
- Special Conservation Interests (SCI) of Special Protection Areas (SPA) within a 15-kilometre radius of the development site;
- Fourth Schedule species protected under the Wildlife Acts 1976-2012 (buzzards, eagles, falcons, harriers, hawks, kites, osprey, owls); and
- Red-listed Birds of Conservation Concern (BoCCI) 2020-2026[5].

Full details of the survey methodologies have been presented in **Chapter 7 Ornithology**, of **Volume II** of the **EIAR**. The results of the surveys are summarised in **Section 4.4**, below.

3.6.2.1 Vantage Point Surveys

Monthly vantage point (VP) surveys were carried out by suitably qualified personnel for the winter and breeding seasons (October 2019 to September 2023, inclusive). Three VP locations were chosen to ensure maximum visibility over the survey area. The viewshed coverage of each VP is illustrated in **Figure 3-3**, below, and the Irish

[5] Factor determined by most recent listing of species on the BOCCI list (Gilbert *et al*., 2021). All commonly occurring species are given a status of Red (high concern), Amber (medium concern) or Green (all other species), depending on a combination of threat categories.

Transverse Mercator (ITM) grid co-ordinates for each VP location are listed in **Table 2,** below. The VP survey design was based on the guidelines '*Recommended bird survey methods to inform impact assessment of onshore wind farms*' (SNH, 2017).

The aim of the VP surveys was to quantify flight activity levels of target species within the flight activity survey area. The flight activity survey area was taken to be the proposed development site together with the area extending 500 metres beyond the turbine locations - refer to **Figure 3-3**, below.

Table 2. Irish Transverse Mercator (ITM) grid co-ordinates of Vantage Point (VP) locations at the proposed Ballycar Wind Farm site.

Vantage Point	ITM Grid Co-ordinates
1	556727, 662659
2	554466, 662835
3	553323, 664214

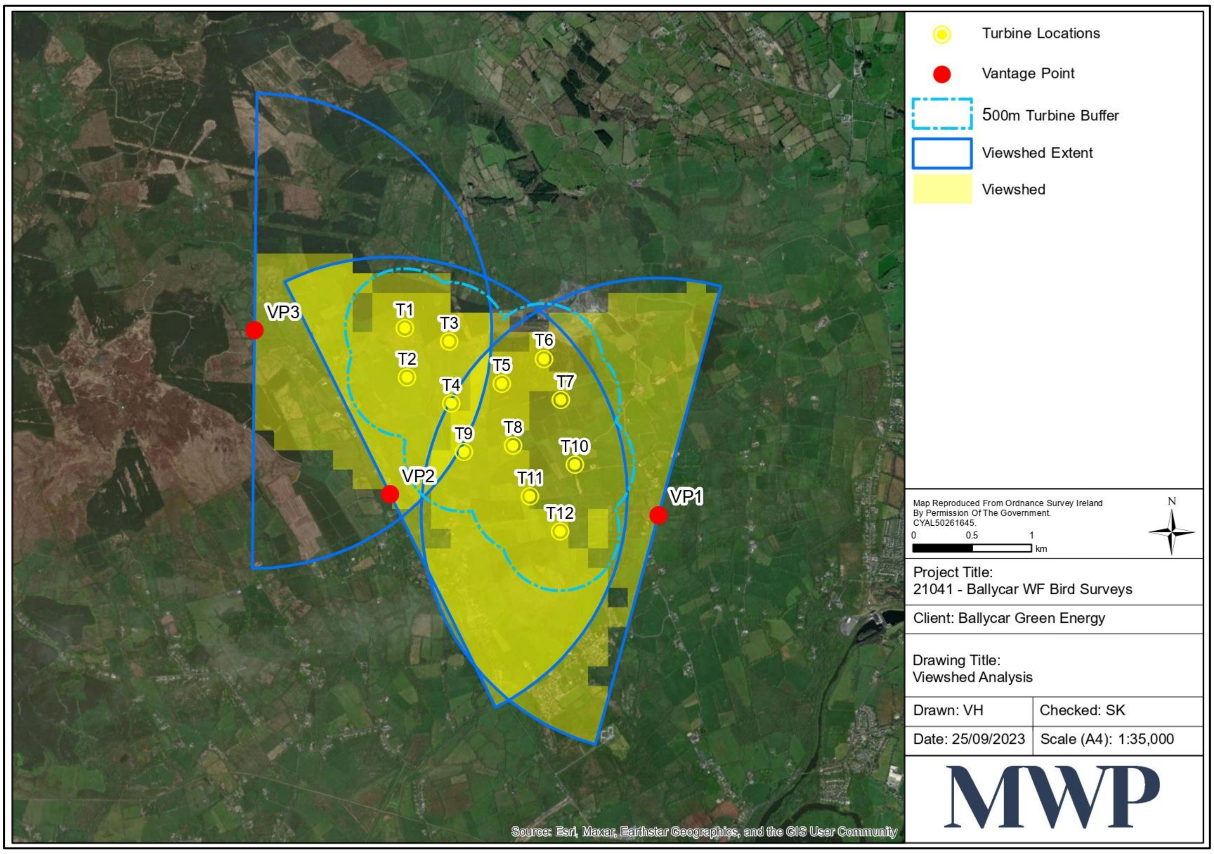

Figure 3-3: The 500-metre buffer zone around the turbines, three Vantage Pont (VP) locations, and the viewshed coverage of each VP.

During VP surveys the flight behaviour of target species was recorded. At the time of each individual observation the following information was recorded:

- The time at which the bird(s) was first detected;
- Duration (seconds) of the flight spent within various flight height categories/bands (0-20m, 20-50m, 50-100m, 100-180m and >180m) (if observed not flying e.g. perched, the location and length of time it was visible was recorded);
- Sex and age of the bird(s) (adult/juvenile), where possible to determine;

- Number of birds observed within the flight;
- Type of activity/behaviour exhibited by the bird(s) e.g. hunting, flying, displaying, perched, etc;
- Estimation of actual flight height in metres; and
- Habitat(s) in which the bird(s) was present.

Once an initial sighting was made, the individual(s) was observed until lost from view and the flight path mapped on enlarged Discovery series maps. All other non-target species were also recorded during the VP surveys, where it did not infringe on recording of target species flight data.

3.6.2.2 Distribution and Abundance Surveys

3.6.2.2.1 *Transect Surveys*

A transect survey is a survey along a defined route within the study area. The overall aim of the transect surveys was to assess general bird distribution throughout the site and gather data on bird usage of the site. Transect surveys were completed for breeding birds in summers 2020, 2021, 2022 and 2023 and for wintering birds in winters 2019/20, 2020/21, 2021/22 and 2022/23.

Transects were selected in order to survey areas of suitable breeding/foraging habitat, in areas where access was not an issue. In survey years where access was an issue, transects were confined to an existing farm access track through the west of the proposed development site where most of the site's principal habitats were present. Therefore, the transects undertaken across the study area during the period 2019 to 2023 are considered to be representative of the overall study area (see **Figure 3-4,** below).

During each transect survey, all bird species seen or heard, typically within 100 metres of the route, were recorded, although the topography of the landscape often allowed for the detection of birds at greater distances.

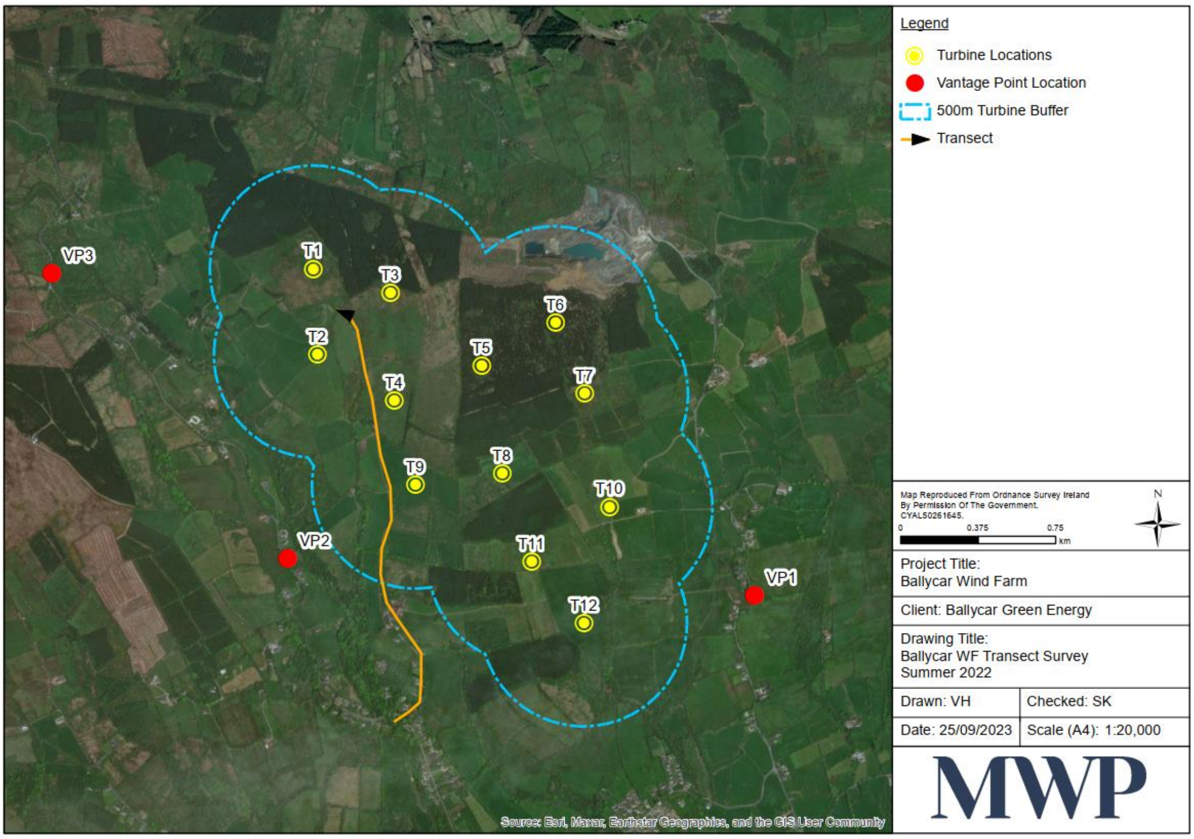

Figure 3-4: Transect survey route for the period 2019 to 2022.

3.6.2.2.2 *Wintering Waterfowl Distribution Surveys*

Counts of waterbird species were undertaken along four representative sections of the River Shannon Estuary located south and southwest of the proposed development site to provide information on the distribution and abundance of waterbird species along the section of the River Shannon closest to the proposed development site.

Based on I-WeBS survey methodology[6], the surveys were carried out at suitable estuarine waterfowl habitat including suitable foraging and roosting habitat stretching from an area upstream of Thomas Island at the Shannon Banks to Bunlicky Lake and Coonagh Point. The winter 2019/20 counts were carried out at various locations along the stretch of the Shannon Estuary shown in **Figure 4-7**, below, while for the 2022/23 winter counts, the stretch of estuary was divided into four survey areas – A, B, C, and D.

3.6.2.2.3 *Hinterland Surveys*

Hinterland surveys were undertaken within a 5km radius of the site boundary to determine the suitability of the surrounding habitats for target species with particular focus on birds of prey, and whether large assemblages of birds (e.g. wildfowl, waders) occurred regularly in the locality (see **Figure 3-5**, below), surveyors travelled roads and regularly stopped at locations with optimal views over potentially suitable habitats for birds of conservation importance, particularly waterbird species and birds of prey. However, all bird species of interest encountered around the proposed development area were recorded during the surveys. The purpose of the hinterland counts was to establish a better understanding of which bird species utilise the surrounding habitats and to gather data on whether species frequenting the region traverse the proposed development site.

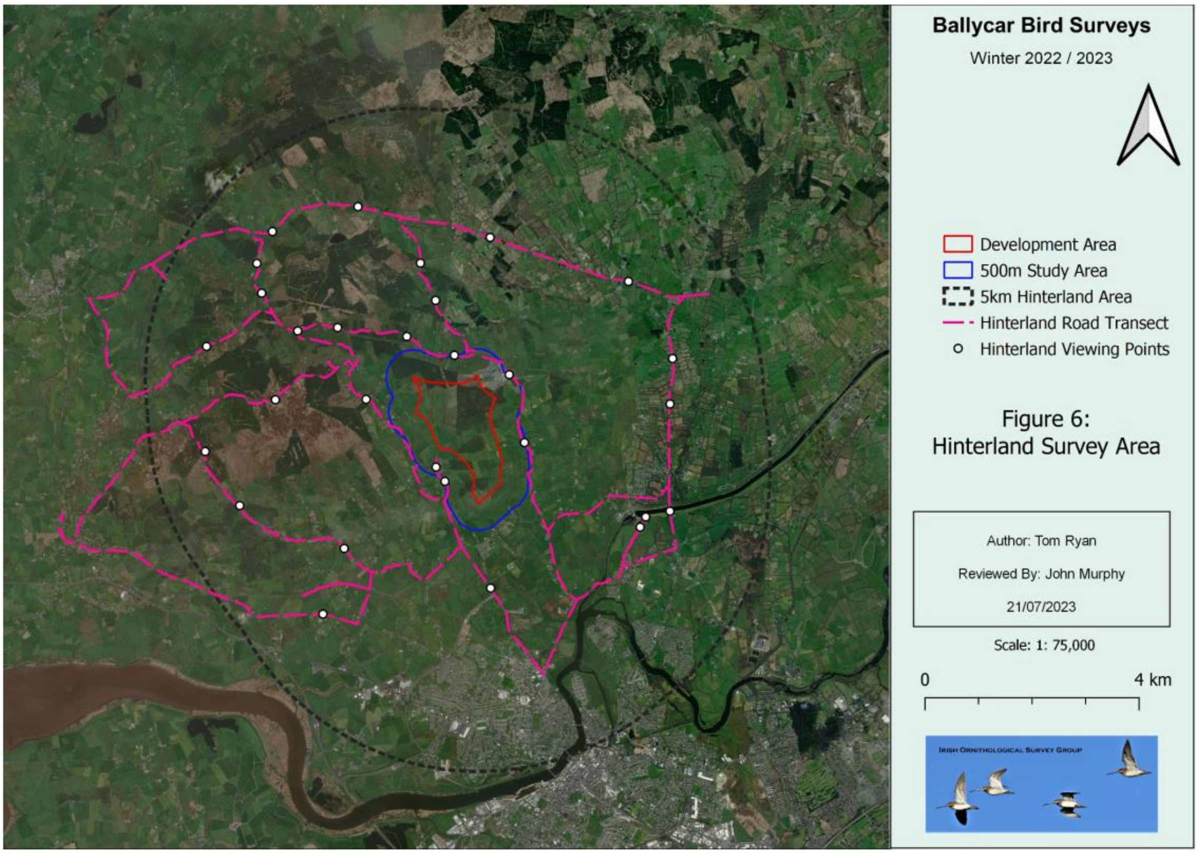

Figure 3-5: Route driven during the hinterland surveys within approximately 5 kilometres of the proposed development site.

[6] Irish Wetland Bird Survey Training Resources - BirdWatch Ireland Accessed: 30th August 2023

3.6.2.2.4 *Breeding Wader Surveys*

A breeding wader survey was carried out once in each of the months April, May and June 2023 (3 surveys in total) at suitable areas within the 500-metre buffer study area shown in **Figure 3-4**, above. The survey method was adapted from the O'Brien and Smith methodology for censusing lowland breeding wader populations as described in Gilbert *et al*., (1998).

3.7 Assessment of Potentially Significant Effects

Upon completion of the Screening for Appropriate Assessment report (see **Appendix 1**), it was concluded that the project could have significant effects, or significant effects could not be ruled out, for the following two European sites:

- Lower River Shannon SAC (002165); and
- River Shannon and River Fergus Estuaries SPA (004077).

On this basis, it was necessary to proceed to Appropriate Assessment, and an NIS was required for the proposed project. Consequently, an evaluation was undertaken to determine which of the qualifying interests (QI) of the SAC and the Special Conservation Interest (SCI) species of the SPA potentially lie within the zone of influence of the proposed project and required further assessment in the NIS (see **Section 6,** below). This was done through a scientific examination of the ecological evidence and data from the resources listed above in **Section 3.4** or referenced within the text, together with the ecological field survey results (**Section 4.4**).

The conservation objectives of a European site are site specific, are based on the ecological requirements of the species and habitats present and define the desired conservation condition of these species and habitat types for the site. For defining favourable status, conservation objectives are identified using attributes and targets that are based on parameters as set out in the Habitats Directive, namely area, range, structure and function. The conservation objectives may either be to maintain or to restore the favourable conservation condition of a habitat.

The effects of the proposed wind farm project on the QI of the SAC and the SCI species of the SPA that are potentially within the zone of influence were assessed against the measures designed to achieve the conservation objectives. This was done by way of a focussed and detailed examination, analysis, and evaluation of the implications of the project, alone and in combination with other plans and projects, on the integrity of the relevant European sites in view of the sites' conservation objectives (see **Section 6**, below).

4. Description of the Project

4.1 Site Location and Context

The proposed development site encompasses approximately 104.7 hectares and is located approximately 3 kilometres northwest of Limerick City and suburbs and 6.7 kilometres east of Sixmilebridge in southeast County Clare. Moving west to east, the site encompasses the townlands of Glennagross, Ballycar North, Cappateemore East, Ballycannan West, Ballycannan East and Ballycar South.

The elevated site is situated within a rural landscape and comprises mainly hilly and undulating terrain, with height above sea level ranging from approximately 60 metres above ordnance datum (AOD) in southwestern areas to 262 metres AOD in northern and northeastern areas of the site. The site topography generally slopes southwards giving panoramic views of Limerick City and the Shannon Estuary to the south. A series of hills form a ridgeline along the northern boundary of the site. Refer to **Figure 4-1**, below. Heading north from the R464, the site is accessed from Limerick City via two Local Roads - one to the west and one to the east - running parallel on either side of the proposed development site. Access to the west section of the site is via a local road connected to Meelick/Knockalisheen Road (Local Road) to the south, and access to the east section of the site is via a private farm track connected to Ballycar South Road (Local Road) to the east.

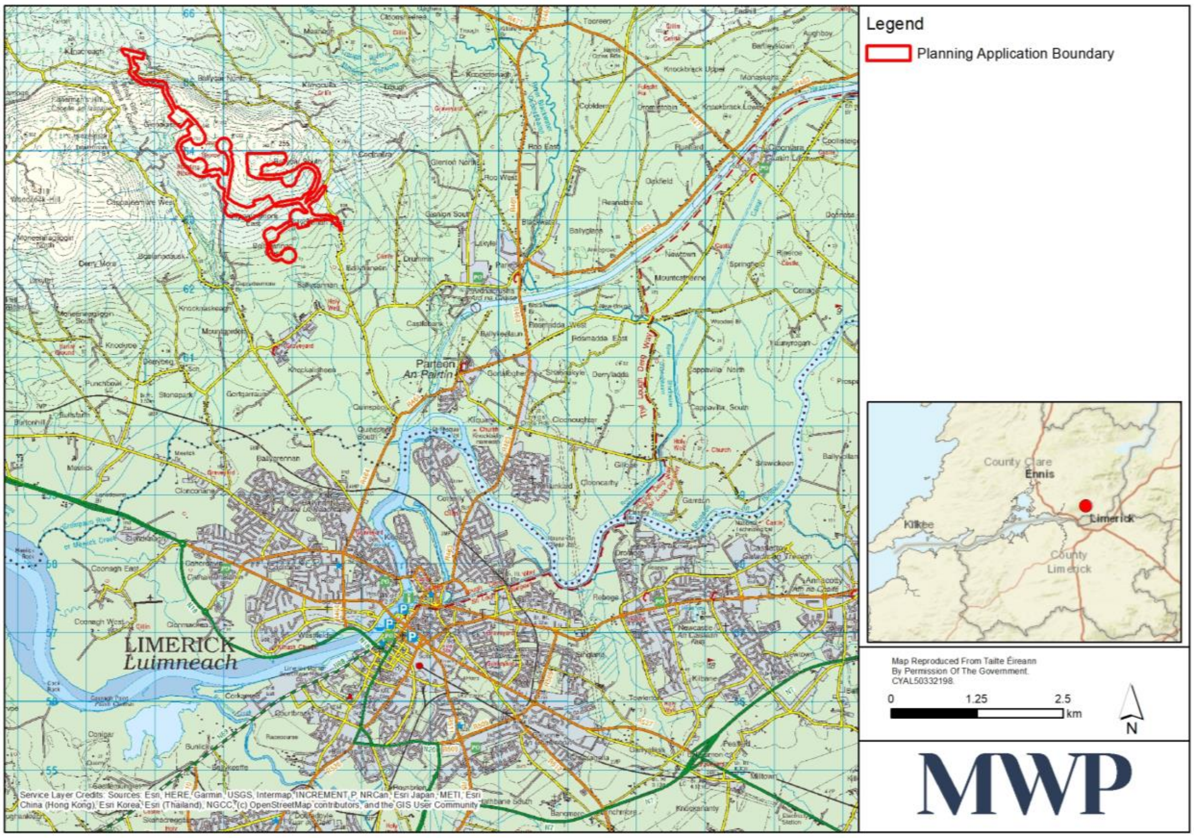

Figure 4-1: Location of proposed development site at Ballycar in County Clare.

4.2 Brief Project Description

It is proposed to erect a twelve (12) No. turbine wind farm at a location in southeast County Clare, approximately 3 kilometres northwest of Limerick City and suburbs. The total footprint of the site encompassing twelve wind turbines, access tracks, crane hardstand areas, underground high voltage collector circuit cables, substation compound, permanent meteorological mast, borrow pit, material deposition areas and temporary construction compound is approximately 104.7 hectares.

Electrical energy generated by the proposed windfarm will be exported to a new substation located approximately 340 metres northwest of T1 via the installation of an underground network of cables throughout the development. A new underground 110kV collector cable measuring approximately 1.5 kilometres will run northwestwards from the new substation and connect to National Electricity Grid (NEG) via an existing 110kV overhead line.

The characteristics of the project and the project design are described in detail in Section 4.4, below, in Chapter 3 Civil Engineering, in Volume II of the EIAR, and Planning Drawings 22156-MWP-00-00-DR-C-5005 to 5006, and 22156-MWP-00-00-DR-C-5401 to 5412.

The proposed development lands include lands under the ownership of forestry companies and privately-owned lands under agreement with Ballycar Green Energy. All proposed turbine locations are within areas that have been designated as strategic for wind energy development in the Clare County Development Plan (2023 – 2029)[7] (see **Figure 4-2**, below).

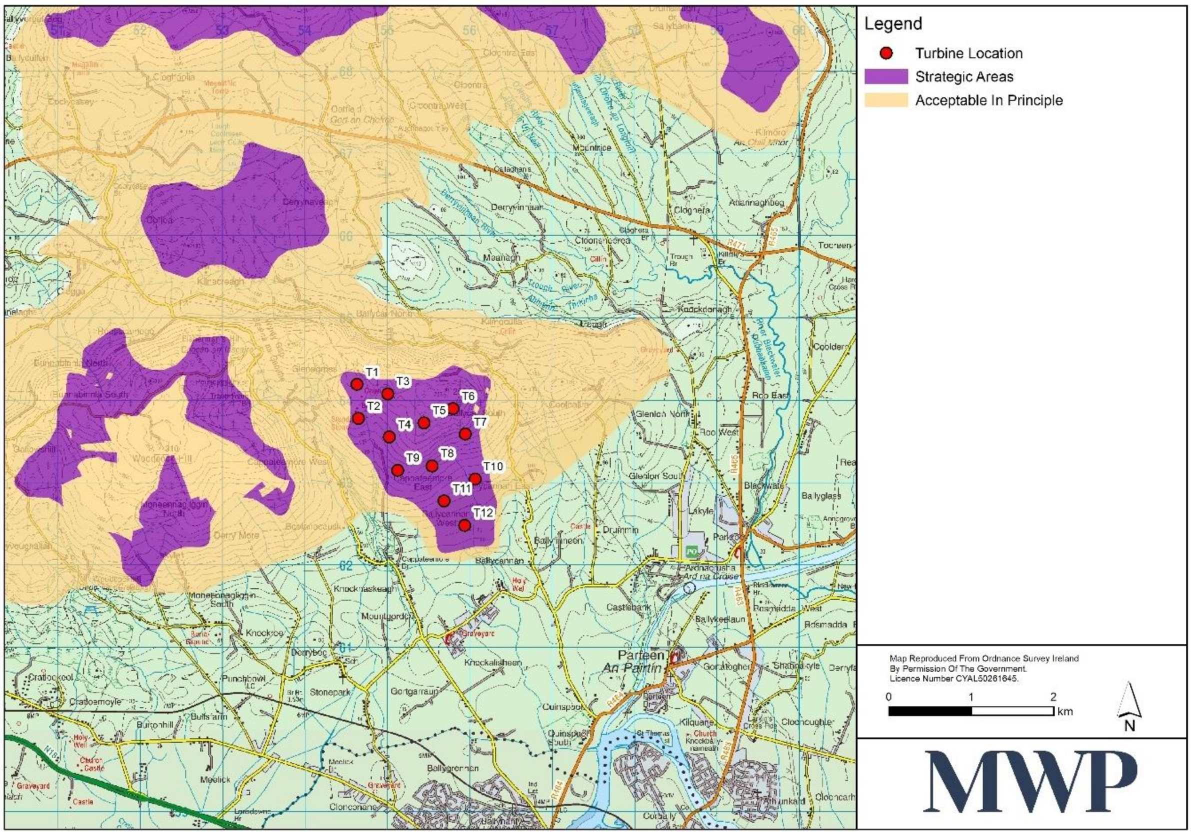

Figure 4-2: Wind energy zoning of lands within and around the proposed development site as designated in the Clare Wind Energy Strategy 2023 – 2029.

4.3 Purpose of the Proposed Project

The purpose of the project is to generate electrical energy from a renewable resource by means of a commercially viable 12-turbine wind farm which will supply electricity to the National Electricity Grid (NEG).

4.4 Description of the Existing Site

4.4.1 General Site Description

The wind farm site is located within the Electoral Divisions (EDs) of 'Ballycannan' (ED 16105) and 'Cloontra' (ED 16110). During the 2016 census, 'Ballycannan' ED was found to have a total population of 1,166 residents, occurring primarily within the small rural settlements of Meelick and Ballycannan. The 'Cloontra' ED was found to have a total of 270 persons resident and comprised mainly of one-off housing and ribbon development along the local road network[8].

The proposed development site comprises predominantly farmland (a mixture of both marginal and more improved areas), used primarily as grazing for cattle. Commercial forestry plantations also occurs within the site boundary and makes up a considerable portion of the northern part of the site.

[7] Stage 3 - Adoption of Plan | Stage 3: Amendments | Clare County Council (clarecoco.ie) Accessed: 6th July 2023
[8] Central Statistics Office - Census 2016 Small Area Population Statistics (arcgis.com) Accessed: 9th December 2022

Lands surrounding the site are predominantly used for agricultural purposes, interspersed with conifer plantations and single residential dwellings. An operational quarry is located directly north of the site, comprising an existing working area of 16.9 hectares with planning approval for a 10-hectare extension, and an existing concrete batching plant. Ardnacrusha hydroelectric power station is located approximately 2.5 kilometres southeast of the site.

The CORINE[9] (2018) land cover categories for the development site are comprised mainly of 'Pastures' and 'Coniferous forests' (refer to **Figure 4-3**, below). To the west and south-west of the site, linear riparian woodland occurs along the route of the Crompaun (East) River, set within a predominantly agricultural landscape. This band of woodland comprises 'Broadleaved forests'. Extending away from the site, 'Pastures' make up the dominant land cover category with large areas of 'Land principally occupied by agriculture with significant areas of natural vegetation', as well as pockets of 'Transitional woodland scrub'. Woodcock Hill, situated approximately 2.2 kilometres west of the site, comprises 'Peat bogs'[10].

A review of bedrock mapping determined that the geological units underlying the site are identified as 'Palaeozoic, Silurian' to the west, 'Palaeozoic, Upper Devonian – Carboniferous' within central and eastern sections and 'Palaeozoic, Carboniferous, Mississippian' to the south of the site. Soils within the site are categorised as 'Lithosols, Regosols' (shallow well-drained mineral - mainly acidic), 'Podzols (Peaty), Lithosols, Peats' (predominantly shallow soils derived from non-calcareous rock or gravels with/without peaty surface horizon), 'Surface water Gleys (Shallow), Ground water Gleys (Shallow)' (derived from mainly non-calcareous parent materials) and 'Surface water Gleys, Ground water Gleys' (derived from mainly non-calcareous parent material)[11].

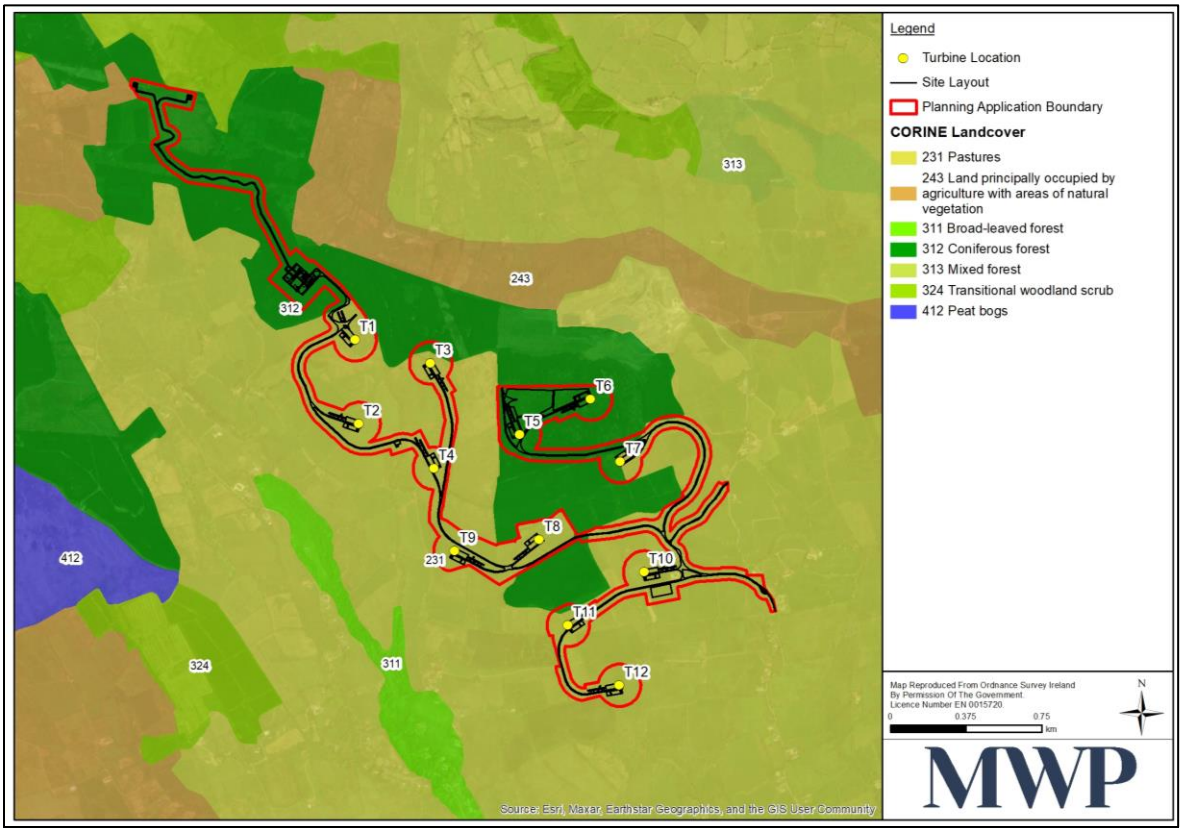

Figure 4-3: CORINE landcover of the proposed Ballycar Wind Farm site in County Clare.

[9] **C**o-**OR**dinated **IN**formation on the **E**nvironment – data series initiated in 1985 by the European Commission to gather environmental data.
[10] EPA Maps Accessed: 9th December 2022
[11] https://www.heritagemaps.ie Accessed: 9th December 2022

4.4.2 Hydrology and Hydrogeology

The five westernmost turbines – T1, T2, T3, T4, and T9 – of the proposed development are located within the Water Framework Directive (WFD) Owenogarney_SC_020 sub-catchment which are in turn situated within the Shannon Estuary North Catchment (27).

A review of the EPA map-viewer determined that the 1st Order Cappateemore East Stream is mapped within the western section of the subject site. A constituent of the Crompaun (East)_010 River Waterbody[12], the source of the Cappateemore East Stream is located to the northwest of the study area between T1 and T3. From here, the stream travels southwards for approximately 1.6 river kilometres[13] through farmland, briefly passing through the proposed development boundary near T2 and T4, before merging with the 3rd Order Crompaun (East) River (see **Figure 4-4,** below).

The upper reaches of the Crompaun (East) River and its tributaries (including the Glennagross Stream and an unnamed stream whose source lies adjacent to the proposed substation location) lie further to the west, outside the proposed development boundary. After being joined by the Cappateemore East Stream, the Crompaun (East) River continues southwestwards, eventually draining to the Upper Shannon Estuary Transitional Waterbody[14] west of Limerick City. The lower reach of the Crompaun (East) River and the estuary into which it drains are encompassed within the boundary of both the Lower River Shannon SAC (002165) and the River Shannon and River Fergus Estuaries SPA (004077). The Lower River Shannon SAC is located approximately 1.6 river kilometres downstream from watercourse crossing WC6 and WC7[15] while the River Shannon and River Fergus Estuaries SPA is located approximately 6.6 river kilometres downstream of WC1. See **Figure 4-4,** below.

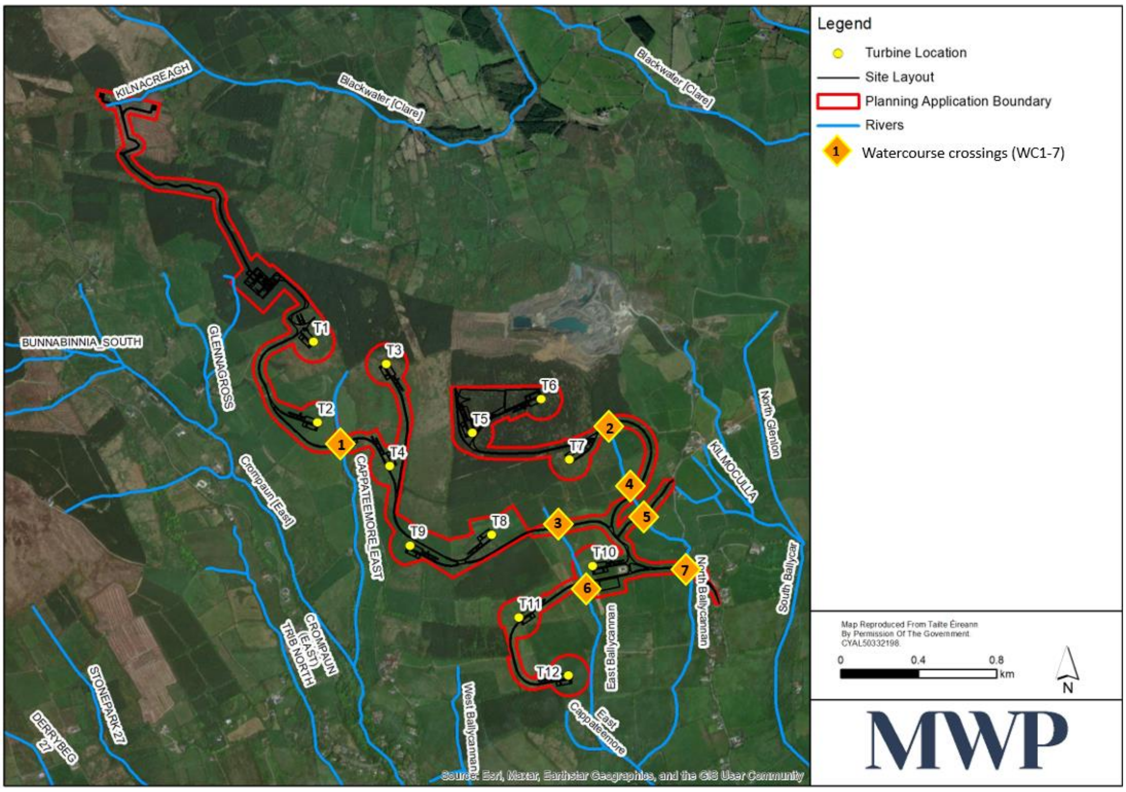

Figure 4-4: Watercourses at the proposed development site and locations of the seven watercourse crossings necessary to accommodate internal access tracks.

[12] EPA River Waterbody Code: IE_SH_27C090600
[13] River kilometres (rkm): measure of the distance in kilometres along the path of a watercourse (as opposed to a linear measure such "as the crow flies").
[14] EPA Transitional Waterbody Code: IE_SH_060_0800
[15] WC – Watercourse Crossings. See Figure 4-4, above, and Table 20, below, for locations.

The seven easternmost turbines – T5, T6, T7, T8, T10, T11, and T12 – are situated in the Shannon [Lower]_SC_100 sub-catchment which in turn is situated within the Lower Shannon Catchment (25D). There are four watercourses mapped within this catchment including the North Ballycannan River and three of its tributaries - the 1st Order East Cappateemore and East Ballycannan Streams, and the 2nd Order West Ballycannan River (see **Figure 4-4,** above). All four watercourses are part of the North Ballycannan_010 River Waterbody[16].

The East Ballycannan Stream flows southwards past T10 and T12 and merges with the North Ballycannan River south of T12. The North Ballycannan Stream then continues southwards away from the proposal site eventually veering east and draining to the estuarine waters of the Shannon Estuary north of Limerick City. This stretch of the estuary is identified as the Limerick Dock Transitional Waterbody[17]. The lower reaches of the North Ballycannan Stream and this section of the Shannon River are also encompassed within the Lower River Shannon SAC and the River Shannon and River Fergus Estuaries SPA.

Approximately 1.3 kilometres of the northern end of the proposed underground collector cable (UGC) is also located within the Shannon [Lower]_SC_100 sub-catchment (see **Figure 4-4**, above), and approximately 0.11 kilometres from where it joins the overhead lines of the National Grid, the UGC will cross the 1st Order Kilnacreagh Stream. The Kilnacreagh Stream rises at a location approximately 1.1 kilometres northwest of the proposed substation location and is part of the Blackwater (Clare)_010 River Waterbody[18]. It runs from southwest to northeast before merging with the 2nd Order Blackwater [Clare] River approximately 0.55 river kilometres downstream from the Stream's source. The Blackwater [Clare] River continues eastwards before veering southwards and eventually draining into the River Shannon near Ardnacrusha Power Station approximately 18 river kilometres downstream of where the 1st Order Kilnacreagh Stream first joined the Blackwater [Clare].

Internal site tracks will require the crossing of seven minor watercourses at locations shown in **Figure 4-4,** above, and in **Table 20**, below. These crossings are located between 1.6 and 6.6 river kilometres upstream of the Lower River Shannon SAC, and between 6.6 and 8.7 river kilometres upstream of the River Shannon and River Fergus Estuaries SPA. These watercourse crossings are discussed further in **Section 4.6.4.1**, below, and in full in Section 3.13.3 in **Chapter 3 Civil Engineering**, in **Volume II** of the **EIAR**.

Compliance with the reporting requirements of the WFD (Directive 2000/60/EC) obliges each member state to publish reports providing summary information about individual waterbodies relating to their status, risks and objectives. The WFD Status (2016 – 2021) of the Crompaun (East)_010 River Waterbody is 'Poor'. The nearest downstream EPA water quality monitoring station to the proposed development site is located at 'Cappateemore Bridge'[19], approximately 1.5 river kilometres downstream of the proposed site boundary at T9. The latest river Q value at this location is 'Q3-4, moderate', recorded by the EPA in 2022. The Crompaun (East)_010 waterbody has been assigned a WFD risk status of 'At risk'[20]. A review of the '*Owenogarney_SC_020 Sub-catchment Assessment WFD Cycle 2*' report[21] determined that the following pressures have been identified with regard to this waterbody: channelisation, forestry, embankments, wastewater discharge and agriculture. The Transitional Waterbody WFD latest status (2016 – 2021) of the Upper Shannon Estuary, into which the Crompaun (East) River drains, is 'Poor'.

The WFD Status (2016 – 2021) of the North Ballycannan_010 River Waterbody is 'Good'. There are no EPA water quality monitoring stations located along this waterbody. The North Ballycannan_010 River Waterbody has been assigned a WFD risk status of 'Not at risk'. The WFD Status (2016 – 2021) of the Blackwater (Clare)_010 River Waterbody is 'Good'. The nearest downstream EPA water quality monitoring station to the proposed development site is located at the 'Bridge southeast of Cappanagh'[22], approximately 4 river kilometres

[16] EPA River Waterbody Code: IE_SH_25N170970
[17] EPA Transitional Waterbody Code: IE_SH_060_0900
[18] EPA River Waterbody Code: IE_SH_25B060120
[19] EPA Station Code: RS27C090300
[20] *At risk* - either the waterbody is currently not achieving its WFD environmental objective of Good or High Ecological Status, or there is an upward trend in nutrients/ammonia and should this trend continue, the waterbody Status will decline by the end of Cycle 3 and will fail to meet its environmental objective (EPA, 2021a).
[21] Subcatchment Assessment (catchments.ie) Accessed: 9th December 2022
[22] EPA Station Code: RS25B060030

downstream from where the Kilnacreagh Stream rises. The latest river Q value at this location is 'Q4, good', recorded by the EPA in 2006. The Blackwater (Clare)_010 River Waterbody has been assigned a WFD risk status of 'At risk'. A review of the '*Shannon [Lower]_SC_100 Sub-catchment Assessment WFD Cycle 2*' report[23] determined that agriculture has been identified as a pressure on the waterbody. The WFD latest status (2016 – 2021) of the Limerick Dock Transitional Waterbody into which the North Ballycannan Stream drains, is 'Poor'.

The five westernmost proposed turbines overlie the 'Tulla-Newmarket-on-Fergus' ground waterbody (GWB)[24] while the rest of the proposed development overlies the Lough Graney GWB[25]. Both are described on the EPA website as 'Poorly productive bedrock' with latest Ground Waterbody WFD status (2016–2021) of 'Good'.

4.4.3 Habitats

Refer to **Appendix 2** for a habitat map of the entire proposed development site and study area, the extent of which is indicated in **Figure 3-1**, above.

The dominant habitats[26] occurring at the subject site comprise **Conifer plantation (WD4)** and **Improved agricultural grassland (GA1)** (refer to **Plate 1**, below). Dominant species of the **Conifer plantation (WD4)** are Sitka spruce (*Picea sitchensis*) and lodge pole pine (*Pinus contorta*). **Improved agricultural grassland (GA1)** is particularly common at lower elevations to the southwest and southeast and is typically species-poor and dominated by rye grasses (*Lolium* spp.) due to intensive management of pasture for cattle grazing and silage harvesting. Species recorded include creeping buttercup (*Ranunculus repens*), dock (*Rumex* spp.), white clover (*Trifolium repens*), ribwort plantain (*Plantago lanceolata*), daisy (*Bellis perennis*), and dandelion (*Taraxacum* spp.).

Plate 1. The two predominant habitats at the proposed development site – 'Conifer plantation (WD4)' (left) and 'Improved agricultural grassland (GA1)', (right).

Dry-humid acid grassland (GS3) occurs in mosaic with **Improved agricultural grassland (GA1)** in pockets within the northern half of the site. Overall, these areas, comprise marginal, rush-dominated farmland exhibiting signs of extensive cattle activity (trampling, over-grazing, exposed soil) with increased moss cover, devil's bit scabious (*Succisa pratensis*), and sheep's sorrel (*Rumex acetosella*) also apparent. **Wet grassland (GS4)** also occurs in mosaic with **Improved agricultural grassland (GA1)** in central and southern areas of the site (see **Plate 2**, below). A species-rich area of **Wet grassland (GS4)** is located within a field north of the proposed location for T9, comprising grass species such as Yorkshire fog (*Holcus lanatus*), crested dog's-tail (*Cynosurus cristatus*), rough meadow-grass (*Poa trivialis*), and sweet vernal grass (*Anthoxanthum odoratum*).

[23] Subcatchment Assessment (catchments.ie) Accessed: 9th December 2022
[24] EPA GWB Code: IE_SH_G_229
[25] EPA GWB Code: IE_SH_G_157
[26] Habitats as categorised by Fossitt (2000), available at A Guide to Habitats in Ireland - Fossitt.pdf (npws.ie) Accessed: 9th December 2022

Wet heath (HH3) was recorded in the north of the site bordered by **Conifer plantation (WD4)** to the northwest, northeast and east and **Dry-humid acid grassland (GS3)** to the west and south (see **Plate 2**, below). The heath habitat comprised three heather species - ling heather (*Calluna vulgaris),* bell heather (*Erica cinerea*), and cross-leaved heath (*Erica tetralix*) - with ling being the most abundant. Other species present included Purple moor grass (*Molinia caerulea*), deergrass (*Trichophorum caespitosum*), heath rush (*Juncus squarrosus*), bilberry (*Vaccinium myrtillus*), tormentil (*Potentilla erecta*), bugle (*Ajuga reptans*), heath milkwort (*Polygala serpyllifolia),* and green-ribbed sedge (*Carex binervis*) with pockets of *Sphagnum* mosses also recorded.


Plate 2. 'Wet grassland (GS4)' (left) within central areas of the site, and 'Wet heath (HH3)' surrounded by 'Conifer plantation (WD4)' within the mid-northern part of the site (right).

Treelines (WL2) and **Hedgerows (WL1)** within the study area delineate field boundaries and border access tracks while also adjoining drainage ditches (see **Plate 3**, below). **Treelines (WL2)** habitat mainly comprises single rows of sitka spruce, likely planted as wind breakers and field boundaries. **Hedgerows (WL1)** are typically comprised of willows (*Salix* spp.), blackthorn (*Prunus Spinosa*), hawthorn (*Crataegus monogyna),* bramble (*Rubus fructicosus*) and gorse (*Ulex europaeus*). Large mature trees were more frequent in the well-established species-rich hedgerows located in the centre, southwest and northeast sections of the study area. These tree species included ash (*Fraxinus excelsior*), sycamore (*Acer pseudoplatanus*), oak (*Quercus robur*), beech (*Fagus sylvatica*) and hazel (*Corylus avellana*), with the occasional rowan (*Sorbus aucuparia*) and holly (*Ilex aquifolium*) tree.


Plate 3. 'Mixed broadleaved woodland (WD1)' along the banks of East Ballycannan stream within the site (left), and 'Treelines (WL2)' delineating field boundaries, often occurring with 'Hedgerows (WL1)', (right).

Mixed broadleaved woodland (WD1) occurs throughout the study area either as individual stands or bounding watercourses such as the 'East Ballycannan' watercourse, located at the southeast extent of the study area (see **Plate 3**, above) where the dominant broadleaf species were hazel and ash, with some willow and sycamore. The ground flora in the area was lush with fern species such as shield ferns (*Polystichum* spp.), hart's tongue (*Asplenium* spp.), and scaly male fern (*Dryopteris affinis*). Other ground flora recorded included lords and ladies (*Arum maculatum*), common dog violet (*Viola riviniana*), wood avens (*Geum urbanum*), sanicle (*Sanicula europaea*), bluebell (*Hyacinthoides non-scriptus*), and ivy (*Hedera hibernica*).

Several patches of **Dense bracken (HD1)** also occur throughout the site. Most existing farm tracks are classified as **Spoil and bare ground (ED2)** while farm buildings and yards are classified as **Buildings and artificial surfaces (BL3).** The watercourses draining the study area are classified as **Eroding/upland rivers (FW1)** with details of their physical characteristics outlined in the **Aquatic Ecology Report** in **Appendix 6C** of **Volume III** of the **EIAR**.

The proposed substation location is within an area of **Conifer plantation (WD4)** northwest of T1. The substation access track and grid connection route are located mainly within stands of **Conifer plantation (WD4)** and along existing forestry firebreaks and tracks comprised of **Scrub (WS1).**

4.4.4 Rare and Protected Flora

No rare or protected flora species were recorded during any of the ecological surveys.

4.4.5 Invasive Alien Plant Species (IAPS)

Documented NBDC records of high-impact invasive species listed on the Third Schedule of the European Communities (Birds and Natural Habitats) Regulations 2011 to 2021 exist within the hectad R56 encompassing the study area for giant hogweed (*Heracleum mantegazzianum)*, Himalayan balsam (*Impatiens glandulifera)* and Japanese knotweed (*Fallopia japonica).* Documented records of medium-impact invasive species listed on the Third Schedule also exist for Himalayan knotweed (*Persicaria wallichii).* Invasive species recorded in the NBDC database that are not listed on the Third Schedule include sycamore (*Acer pseudoplatanus)* and winter heliotrope (*Petasites fragrans)*.

During the multidisciplinary ecological field surveys of the site carried out between 2021 and 2023, two invasive species listed under the Third Schedule of the European Communities (Birds and Natural Habitats) Regulations 2011 to 2021 were recorded; Japanese knotweed and Himalayan balsam. Cherry laurel (*Prunus laurocerasus)* was also recorded within the study area. No other invasive plant species were recorded during ecological surveys. Himalayan balsam was the most frequently encountered IAPS and was recorded at 22 locations. There were extensive infestations within the study area, mainly in central and southeastern sections (see **Plate 4**, below).

Japanese knotweed was recorded growing in the centre of a farm track along the boundary of an improved agricultural grassland field in the west section of the study area. It was noted that the infestation was not established since only three plants measuring no more than 20 centimetres high were recorded, and it is likely that it was introduced to the site in contaminated material used to build the farm track. A second infestation of Japanese knotweed was recorded within a hedgerow at a farm track near the farm holding southeast of the study area. The infestation comprised of a single but established plant measuring approximately 15 metres in height growing outwards from the hedgerow (see **Plate 4**, below).

Cherry laurel was recorded at six locations along hedgerows and field boundaries towards the centre and north of the study area. Although not listed under the Third Schedule of the European Communities Regulations, cherry laurel is also considered to be a high-impact invasive species.

No other invasive plant species were recorded during ecological surveys.

For more details, refer to the IAPS Report and Management Plan in Appendix 6F of Volume III of the EIAR, and to Chapter 6 Biodiversity, of Volume II of the EIAR.

Plate 4. Extensive Himalayan balsam infestations along drainage ditches within the study area (left), and Japanese knotweed growing outwards from the hedgerow over farm track (right).

4.4.6 Non-volant Mammals

The importance of the proposed development site is discussed hereunder with respect to otter (*Lutra lutra*). However, badger (*Meles meles*), pine marten (*Martes martes*) and several other terrestrial mammals were also recorded within the study area - for more details on all mammals documented during the MWP surveys, refer to the Non-volant Mammal Survey Report in Appendix 6B of Volume III of the EIAR, and to Chapter 6 Biodiversity, in Volume II of the EIAR.

4.4.6.1 Otter

No evidence of otter was recorded during any of the ecological field surveys and no otter breeding/resting places were identified within the study area nor were any prints or spraints found. There are records of otter in the greater area extending away from the site, none of which are hydrologically connected to the development site.

There are no documented records of otter held by the NBDC within the proposed development site. However, there are records of otter in the surrounding area[27]. The closest otter record is located on a 'stream south of Cappateemore' approximately 0.4 river kilometres downstream from where the Cappateemore East River merges with the Crompaun [East] River south of the subject site boundary. This record, identified by the EPA in 1980, pertains to two counts of droppings. Another record exists for otter from the 'stream east of Ballycannon House', identified as the South Ballycar river by the EPA, located approximately 1.2 kilometres from the closest point of the wind farm site boundary. Again, this record pertains to droppings at this location, recorded in 1980.

There are no suitable fish habitats within the proposed development site as all waterbodies are too small. Although minor watercourses within the subject site may have some potential as foraging or commuting habitat, they do not support any notable fish populations that would make it energetically feasible for foraging otter and are considered to comprise sub-optimal habitat for the species.

The lower reaches of the watercourses draining the proposed development site support fish species such as brown trout (*Salmo trutta*) and European eel (*Anguilla anguilla*), making it more likely that these larger watercourses located further downstream are more suitable for foraging, and potentially breeding otter.

[27] https://maps.biodiversityireland.ie/Map Accessed: 13th November 2022

4.4.7 Freshwater Aquatic Ecology

4.4.7.1 Aquatic Habitats

The physical characteristics of each survey site are listed in **Table 3**, below.

The watercourses within the boundary of the proposed development site and indeed the upper reaches of all watercourses draining the proposed development site are high gradient streams considered prone to drying out during prolonged dry spells, based on the water levels observed in June 2021. These upper reaches therefore were deemed to have limited lotic[28] carrying capacity. These reaches are generally fast flowing and of a spate[29] nature thereby exhibiting a fast response to rainfall. They are categorised as eroding/upland rivers (FW1) (Fossitt, 2000). The only aquatic vegetation recorded at the aquatic survey sites were (collectively) bryophytes *Leptodictyum riparium, Conocephalum* sp., *Chiloscyphus polyanthos,* and filamentous algae. Cyanobacteria *Lyngbya* were recorded at Site 10 (see **Plate 5**, below). At lower elevations, streams have lower gradients with generally finer particle sizes and smoother flows.

Excessive siltation and algal growth were observed at several survey sites (see **Plate 5**, below). This is considered a result of land management practices associated with activities such as agriculture and commercial forestry. For example, cattle access to the Cappateemore East Stream was found to be adversely affecting substrate quality and water quality because of excessive sedimentation. Water level and flow at Sites 5 to 8 were very low during the surveys - such flows can lead to loss of sensitive macroinvertebrate taxa and biomass due to the decreased buffering capacity i.e. rapid changes in temperature, oxygenation, etc.

Table 3. Physical characteristics of the twelve aquatic survey sites (see Figure 3-2, above, for locations).

Physical characteristics	Aquatic Survey Site											
	1	2	3	4	5	6	7	8	9	10	11	12
Wetted width (m)	1.5	1	1.2	3	0.5	0.8	1	0.4	1.3	1.7	4	0.3
Mean depth (cm)	5	5	3	10	2	3	4	2	5	5	20	<5
Max depth (cm)	40	30	10	60	15	5	15	4	20	35	80	5
Bedrock	5	0	5	0	0	0	0	0	20	10	0	0
Boulder (%)	15	55	25	60	5	5	30	0	20	20	5	5
Cobble (%)	20	20	30	25	15	55	30	50	25	35	50	35
Gravel (%)	40	20	30	10	70	25	20	30	20	30	30	45
Sand (%)	20	5	10	5	10	5	15	5	15	5	10	10
Silt (%)	0	0	0	0	0	10	5	15	5	0	5	5
Overlying silt (%)	30	10	50	55	20	30	60	75	30	50	40	10
Plume^	M	M	H	H	M	H	H	H	M	M	H	H
Riffle (%)	55	70	60	45	35	30	25	35	25	50	30	25
Glide (%)	10	5	15	20	0	10	5	5	25	20	40	25
Pool (%)	35	25	25	35	65	60	75	60	50	30	30	50
Algal cover (%)	2	0	0	10	0	55	0	0	0	<1	45	0
Instream vegetation (%)	5	0	5	10*	0	0	0	0	0	0	5	0
Shade (%)	95	90	80	55	85	30	95	75	85	50	70	100
Bank cover (%)	60	100	50	95	100	25	45	100	90	95	75	75

^ **H**eavy, **M**oderate, **S**light, **N**one
* In-stream vegetation of bryophytes

[28] Of organisms or habitats inhabiting or situated in rapidly moving fresh water.
[29] Fed by rainwater from overland flow.

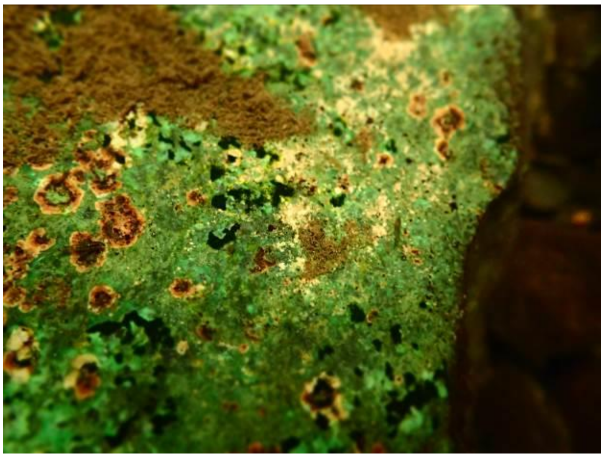 

Plate 5. Cyanobacteria *Lyngbya* (left), and siltation/algal growth at Site 4 on Crompaun East Stream (right).

4.4.7.2 Macroinvertebrates

4.4.7.2.1 *Macroinvertebrate Habitat*

Based on the physical attributes of the survey sites and assessment criteria, the sites are generally rated between marginal and suboptimal. This rating was applied to sites mainly due to the domination of substrates by one size class (rock/cobble), owing to their high gradient, suboptimal habitat complexity, coupled with mainly marginal pool quality (<1m deep), bank stability (eroding in some instances) and canopy conditions (excessive shade). Habitats of this classification can limit taxa richness as there are fewer ecological niches available. The physical habitat suitability assessment of survey sites for macroinvertebrate production is provided in Table 4, below.

Table 4. Physical habitat assessment of the survey sites regards suitability for macroinvertebrate production (adapted from Barbour & Stribling, 1991).

Site	Watercourse	Bottom substrate	Habitat complexity	Pool quality	Bank Stability	Bank Protection	Canopy	Score	Overall Assessment*
1	Crompaun	20	15	10	20	20	15	100	suboptimal
2	Glennagross	10	5	5	5	5	10	40	poor
3	Cappateemore East	20	20	10	15	15	15	95	suboptimal
4	Crompaun East	15	5	5	15	10	10	60	marginal
5	North Ballycannan	10	5	5	15	15	10	60	marginal
6	North Ballycannan	10	5	5	10	10	10	50	marginal
7	West Ballycannan	15	5	5	15	15	10	65	marginal
8	South Ballycar	20	15	10	20	15	15	95	suboptimal
9	South Ballycar	20	15	10	20	20	20	105	suboptimal/optimal
10	West Roo	20	15	10	20	20	15	100	suboptimal
11	Blackwater (Clare)	20	15	15	20	15	15	100	suboptimal
12	Kilnacreagh	10	10	0	5	4	5	35	marginal

** Scale: poor (0-25); marginal (26–50); suboptimal (51-75); optimal (75-100)*

4.4.7.2.2 *Macroinvertebrate Diversity and Abundance*

Most macroinvertebrates recorded belong to pollution sensitivity group C (pollution tolerant) (Toner *et al.*, 2005).

Mayfly (Ephemeroptern) larvae of pollution-tolerant (Group C) *Baetis rhodani* were among the most widespread and abundant macroinvertebrate and abundance ranged from 'common' to 'numerous'[30] where encountered. Larvae of Group B *Baetis muticus* were less common. Pollution-sensitive (Group A) mayfly larvae were limited to *Ecdyonurus* spp., which was sparse throughout the study area and *Rhithrogena semicolorata* (moderate distribution, 'few – common'). Larvae of less sensitive stonefly *Leuctra* sp. and pollution sensitive *Chloroperla* sp. were generally 'few' throughout the study area and occurred at less than 50% of sites. The Trichoptera were a well-represented group with three cased (Group B) taxa and four caseless (Group C) taxa recorded (see **Plate 6**, below). Cased caddisfly larvae of Limnephelidae and caseless caddisfly larvae of *Hydropsyche* sp., trumpet-net caddisflies (Polycentopodidae), finger-net caddisflies (Philopomatidae) and *Rhyacophila* sp. were well distributed across the survey sites but were generally scarce.

Dipteran larvae accounted for a significant proportion of the macroinvertebrate community at the survey sites. The most abundant true fly larvae were pollution-tolerant Simulidae (common-numerous) and *Chironomous* spp. ('few – common'). Across the entire study area, the crustacean *Gammarus deubeni* was deemed the most widespread and abundant macroinvertebrate, while *Asellus aquaticus* was recorded at Site 3 only.

Plate 6. Larvae of the caseless Hydropsychidae, Polycentropodidae and Philopotamidae caddisflies (left), and Stonefly larvae of *Chloroperla* spp. (right).

Site 11 on the Blackwater River had several macroinvertebrate taxa not recorded at Sites 1 – 10 including the pollution-sensitive large pale stonefly *Perla bipunctata, Dinocras cephalotes,* and two species of brown stoneflies (Nemouridae), the cased caddis *Athripsodes* spp., the whirligig beetle *Gyrinus substriatus*, *Brychius elevatus* and *Hydraena* spp. as well as the wandering snail *Radix balthica.* This increased diversity at Site 11 (when compared to Sites 1 to 10) can be attributed to the larger size of the watercourse combined with improved water quality.

4.4.7.3 Freshwater Pearl Mussel

The freshwater pearl mussel (FPM) (*Margaritifera margaritifera*) life cycle involves an adult stage living as a filter feeder, a juvenile stage living interstitially in sediment, and a larval (glochidial) stage living attached to the gills of trout or salmon (*Salmo salar*). All life stages therefore need consideration, as does the viability of the host species of fish. FPM are flagship, keystone and umbrella[31] species (Geist, 2005) that are a key indicator of river ecosystem

[30] Few (<5%), Common (6-20%), Numerous (21-50%), Dominant (51-74%), Excessive (>75%)

[31] Protecting the pearl mussel has a positive impact on the entire river ecosystem. The most important features of an effective umbrella species are a large range size and complex habitat requirements (Caro, 2010).

quality so protecting the pearl mussel has a positive impact on the entire river ecosystem. Adults are more tolerant of a wider range of in-river conditions than juveniles (Hastie *et al.,* 2000).

'Ecological Quality Ratio' (EQR) is an expression of the relationship between the values of the biological parameters observed for a given body of surface water and the values for those parameters in the reference conditions applicable to that body. The ratio is expressed as a numerical value between zero and one, with high ecological status represented by values close to 1 and bad ecological status by values close to 0. The Freshwater Pearl Mussel Objectives (2009)[32] requirement for an EQR ≥0.90 relates to 'high status' watercourses, that is those classified as Q4-5 or Q5, as per the EPA Q-rating system[33]. Regarding the ecological quality objectives for FPM habitat, the watercourses within and adjacent to the proposed development site generally fail on criteria for macroinvertebrates, macroalgae and siltation[34] (see **Section 4.4.7.2**, above). Additionally, the study area is not within a catchment listed in the NPWS *Margaritifera* Sensitive Areas Map (refer to **Figure 4-5**, below).

[32] S.I. No. 296/2009 - The European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations 2009 (irishstatutebook.ie) Accessed: 5th July 2023

[33] Quality Rating (Q) System devised by Toner *et al.* (2005). This method categorises invertebrates into one of five groups (A-E), depending on their sensitivity to pollution. Q values range from Q1-Q5 with Q1 being the poorest quality and Q5 being pristine/unpolluted conditions. The system is used by the EPA and, under the WFD, is the standard biological assessment technique used when surveying rivers in Ireland.

[34] The European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations 2009 to 2018.

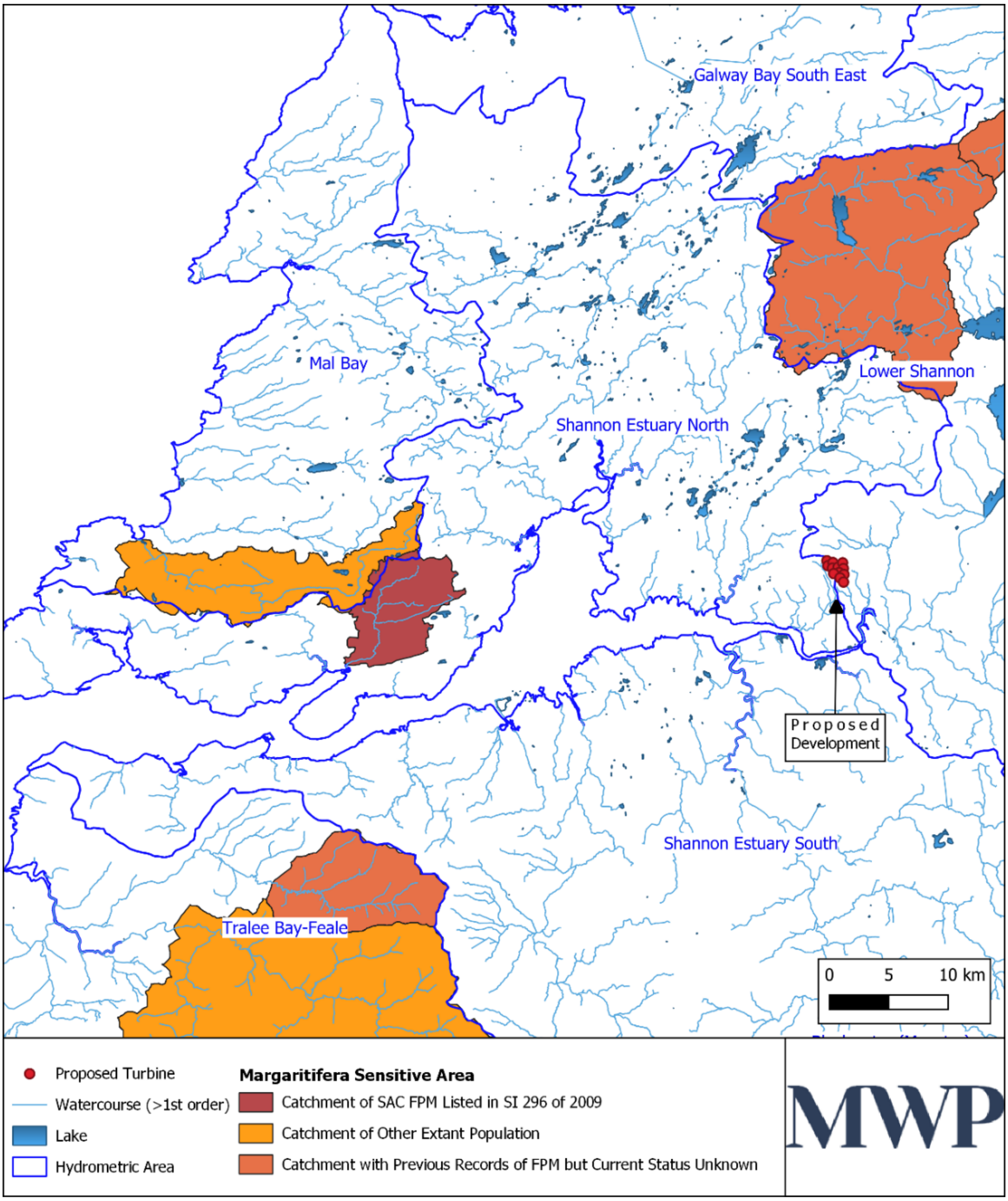

Figure 4-5: Proposed development location in the context of NPWS mapped *Margaritifera* sensitive areas.

Drainage from the proposed development site is to the Crompaun, North Ballycannan and Blackwater (Clare) Rivers, none of which have previous FPM records. Alteration in a river's flow regime, such as that caused by drainage for forestry or agriculture, may result in summer flows being insufficient to support FPM (Moorkens *et al*., 1992). The lower reaches of watercourses in the Crompaun and Ballycannan sub-basins have been drained/modified where they occur on the floodplain, a pressure on FPM noted by Moorkens (1999), while the middle to upper reaches of channels in these catchments have insufficient base flows to support FPM.

The only watercourses considered large enough to support FPM were the North Ballycannan and the Blackwater Rivers. However, no live FPM or evidence of FPM (e.g. shells) were recorded during surveys carried out on the North Ballycannan River in 2021 nor during surveys carried out at the Blackwater (Clare) River in 2018. Findings of the surveys carried out in the North Ballycannan Catchment are presented in **Table 5**, below. The sedimentation levels recorded were generally indicative of artificially induced siltation with conditions considered unfavourable in terms of the species' habitat. The lower reaches of the North Ballycannan River are modified because of drainage practises which almost certainly precludes the presence of any FPM. Water quality can negatively influence FPM habitat and the reduced macroinvertebrate diversity owing to degraded water quality at upstream locations would be a limiting factor for FPM presence.

The likelihood of FPM occurring in either the North Ballycannan River or the Blackwater (Clare) River is deemed very low considering the habitats present at each and the absence of live FPM or evidence of FPM encountered during surveys at both rivers.

Table 5. Results of FPM surveys on the North Ballycannan River draining the proposed development site

River Catchment	Segment code	Stream order	Approx. length of channel surveyed (m)	Environmental Quality Objectives (EQO)[35]			FPM population
				Filamentous algae	Macrophytes	Siltation	
North Ballycannan	25_3896	3	500	Rare	Rare	A lot of visible silt	Absent
Survey notes:	Entire channel length examined. Downstream reach deemed too sluggish and silted for FPM. Reach does not pass on the EQO's for silt. Degree of shade a likely factor in the volume of algae recorded since heavy shade reduces algal growth.						

4.4.7.4 Fish

The distribution and range of protected fish species that have previously been recorded within the hectad R56 are detailed in **Table 6**, below, based on Article 17 (2013-2018) Assessments in NPWS (2019).

Table 6. Distribution and range of aquatic Annex II habitats and species* listed within the hectad R56.

Annex II habitat/species	Code	Current distribution	Current range	Likely reason for distribution within hectad R56
Floating river vegetation	3260	Yes	Yes	The extent of this habitat has not been mapped and the area is based on the distribution of rivers. There are no particularly important watercourses draining the proposed development site with respect to 3260.
Sea lamprey (*Petromyzon marinus*)	1095	No	No	n/a
River lamprey (*Lampetra fluviatilis*)	1099	Yes	Yes	Part of the River Shannon, which supports this species occurs within R56.
Brook lamprey (*Lampetra planeri*)	1096	No	Yes	n/a
Atlantic salmon (*Salmo salar*)	1106	Yes	Yes	Part of the River Shannon, which supports this species occurs within R56.
White-clawed crayfish (*Austropotamobius pallipes*)	1092	No	Yes	Part of the River Shannon, which supports this species occurs within R56.

**Only fish known to occur in the region have been included*

Three fish species - brown trout, European eel, and brook lamprey - were recorded during the June 2021 electrical fishing surveys of watercourses draining the proposed development site within the Crompaun (East)_010 and the North Ballycannan_010 sub-basins. Salmon, brown trout, brook lamprey, three-spined stickleback (*Gasterosteus aculeatus*), stone loach (*Barbatula barbatula*) and minnow (*Phoxinus phoxinus*) were recorded in the September

[35] Ecological Quality Objectives for FPM habitat

2018 surveys in the Blackwater River within the Blackwater (Clare)_010 sub-basin. See **Table 7** and **Plate 7**, below, for summary of results. Frog (*Rana temporaria*) was recorded at Sites 7 and 10 during electrical fishing surveys.

Apart from a small section of the UGC, the proposed development site is located within two sub-basins, namely Crompaun East_010 and North Ballycannan_010, lying adjacent to the upper transitional zone of the Shannon Estuary. The carrying capacity for fish of both sub-basins is limited due to their small drainage areas in a somewhat coastal context with watercourses that are classified as being no larger than 3rd Order. The South Ballycar and West Roo Streams at the eastern part of the North Ballycannan_010 sub-basin do not appear to support any fish.

Overall, within the Crompaun East_010 and North Ballycannan_010 sub-basins, the streams draining the proposed development site are considered sub-optimal trout habitats, poor in terms of lamprey and highly unlikely to support migratory fish populations. The Blackwater Catchment to the north of the proposed development site is important for salmon and possibly lamprey downstream of its intersection with the Ardnacrusha headrace.

Table 7. Length descriptive statistics for fish captured during the 2021 electrofishing surveys at Sites 1 to 10, and during the 2018 electrofishing surveys at Site 11.

Sub-basin	Watercourse	Site	Stream Order	Fish Species	N	Length (cm)			
						Mean	Min	Max	St. Dev.
Crompaun (East)_010	Crompaun	Site 1	2	Brown trout (*S. trutta*)	30	6.9	3.9	14	3.07
	Glennagross	Site 2	2	-	-	-	-	-	-
	Cappateemore East	Site 3	1	European eel (*A. anguilla*)	1	15	15	15	-
	Crompaun East	Site 4	3	Brown trout (*S. trutta*)	130	6.68	4.5	21	2.17
				European eel (*A. anguilla*)	4	15.05	8.2	22.5	7.15
North Ballycannan_010	North Ballycannan	Site 5	1	-	-	-	-	-	-
	North Ballycannan	Site 6	2	Brown trout (*S. trutta*)	25	10.87	6.7	21	4.22
				Brook lamprey (*L. planeri*)	1	13.5	13.5	13.5	-
				European eel (*A. anguilla*)	1	35	35	35	-
	West Ballycannan	Site 7	2	European eel (*A. anguilla*)	1	20	20	20	-
	South Ballycar	Site 8	1	-	-	-	-	-	-
	South Ballycar	Site 9	3	-	-	-	-	-	-
	West Roo	Site 10	2	-	-	-	-	-	-
Blackwater (Clare)_010	Blackwater (Clare)	Site 11	3	Brown trout (*S. trutta*)	19	14.7	7	16.5	4.9
				Atlantic salmon (*S. salar*)	7	10.8	6.6	13.1	2.7
				Stone loach (*B. barbatula*)	5	7.2	6.2	8.5	1
				Three-spined stickleback (*G. aculeatus*)	5	2.6	2.1	3	0.3
				Minnow (*P. phoxinus*)	2	2.6	2	3.2	0.8
				Brook lamprey (*L. planeri*)	17	3.7	3.1	4.3	0.6

4.4.7.4.1 European Eel (*Anguilla anguilla*)

Rocks in the watercourses draining the proposed development site are considered important refuges for European eel and the species is subject to European Council Regulation 1100/2007 establishing measures for the recovery of the stock of European eel. Recruitment of glass eels is 5% of the pre-1980's levels[36]. European eel is listed as 'Critically endangered' and is now red-listed according to King *et al*. (2011) in the '*Red List No. 5: Amphibians, Reptiles & Freshwater Fish*'.

European eel (see Plate 7, below) was recorded at Sites 3, 4, 6, and 7 within the Crompaun (East)_010 and North Ballycannan_010 sub-basins, but none were recorded within the Blackwater (Clare)_010 sub-basin at Site 11.

4.4.7.4.2 Brook Lamprey (*Lampetra planerii*)

One brook lamprey was captured at Site 6 in North Ballycannan_010 sub-basin but none were recorded within the Crompaun (East)_010 sub-basin. There is only a small proportion of suitable habitat for juvenile lamprey within the streams of the North Ballycannan and Crompaun East sub-basins draining the proposed development site and it is considered that any lamprey in the subject watercourses occur in low densities and are brook lampreys. At Site 11 on the Blackwater River, 17 brook lamprey were captured with a mean length of 3.7 centimetres.

Lamprey likely occur in low densities in low gradient reaches of the surveyed rivers, in areas where flows are sufficiently slow to allow accumulation of fine substrates. Any lamprey species that do occur within the freshwater receiving environment of the proposed development site are deemed to be brook lamprey. Habitat for juvenile lampreys is unsuitable along high gradient reaches close to the proposed development site where there is a general lack of sand/silt deposits, a requirement for lamprey larvae (also known as ammocoetes) but improves in lower reaches of the watercourses where gradient is low.

Within the Blackwater River, migratory lampreys (sea and river lampreys) are highly unlikely to occur above the Ardnacrusha headrace where there is a steep artificial incline and, according to Reinhardt *et al.* (2009), lamprey are poor swimmers and cannot jump or climb. A perched bridge foundation on the lower reach of the Crompaun River at the R445 is also a likely barrier for migratory lampreys.

Plate 7. Fish captured during electrofishing survey: European eel, Site 7 (left), and brown trout (right), Site 6.

4.4.7.4.3 *Salmonids*

Salmonidae is the family of ray-finned fish species that includes salmon, trout and chars (*Salvelinus* spp.), known collectively as salmonids.

[36] European eel (Anguilla anguilla) | Inland Fisheries Ireland Accessed: 1st September 2023

Within the streams surveyed, a small proportion of the fluvial habitat is classified as suitable for salmonid spawning. This habitat occurs at the transitional areas between pool and riffle where flow accelerates, and depth decreases over gravel beds due to a marked change in hydraulic head over the gravel. The gravel substrates at the end of pools provide spawning areas where trout may spawn in small gravel patches between larger stones Crisp (2000). The higher gradient reaches of watercourses draining the proposed development site are considered suitable for the early life stages of salmonids. However, these reaches do not extend to within the proposed development site itself where the watercourses are smaller and considered unsuitable for holding salmonids.

The abundance of riffle (broken water), in-stream rocks, stream bed irregularities, overhanging banks and dappled shade, or combinations thereof, generally provide good salmonid nursery habitat in lower reaches of the subject watercourses. Furthermore, there are some deeper pools at the lower gradients of the watercourses that are also suitable for adult salmonids. However, many of these reaches are impacted by siltation and enrichment associated with in-stream works and denuded banks resulting in watercourses of uniform shape with reduced biodiversity. The degraded morphological character of lower reaches of the watercourses and the associated water quality problems reduces the quality of suitable salmonid spawning and nursery habitat rendering it sub-optimal.

4.4.7.4.3.1 Brown Trout (*Salmo trutta*)

With a total of 204 individuals captured across all three sub-basins, brown trout was the most encountered fish species during the electrofishing surveys. There were 160 individuals within the Crompaun (East)_010 sub-basin at Site 1 (n = 30) and Site 4 (n = 130); 25 individuals within the North Ballycannan_010 sub-basin at Site 6 (see Plate 7, above); and 19 individuals at Site 11 within the Blackwater (Clare)_010 sub-basin. These trout ranged in length (fork length) from 3.9 centimetres at Site 1 to 16.5 centimetres at Site 11 (mean length range 6.9 cm to 14.7 cm). Refer to Table 7, above.

Within the Crompaun (East)_010 and Ballycannan_010 sub-basins, the 1st Order streams draining the proposed development site are deemed too small to be of importance to trout. For example, trout were detected at Site 1 on a 2nd Order reach of Crompaun Stream but were not recorded at Site 2 on its 1st Order tributary the Glennagross Stream (see Table 7, above). There is a perched culvert on the Glennagross Stream more than 200 metres upstream of the Crompaun Stream which likely blocks the upstream passage of trout and limits their penetration into the middle reaches of the stream – see Plate 8, below.

Plate 8. A perched culvert that likely limits the upstream passage of trout located at Site 2 on the 1st Order Glennagross Stream, a tributary of the Crompaun Stream.

4.4.7.4.3.2 Atlantic Salmon (*Salmo salar*)

The watercourses within the Crompaun (East)_010 and Ballycannan_010 sub-basins that drain the proposed development site are deemed unsuitable for salmon due to their insufficient size and because of the presence of various types of impediments to fish movement, either in the form of barrages associated with tidal sluices in the Crompaun sub-basin or as steep inclines as is the case within the Ballycannan sub-basin. No salmon were recorded within either sub-basin during the 2021 electrofishing surveys - refer to **Table 7**, above. Based on the rivers' characteristics and electrofishing survey results, it is concluded that salmon do not occur within the watercourses of the sub-basins Crompaun (East)_010 and Ballycannan_010 draining the proposed development site.

However, the Blackwater (Clare) River within the Blackwater (Clare)_010 sub-basin is suitable for salmon because it is sufficiently large and connected to the River Shannon with no barriers to species migration. During the August 2018 electrofishing surveys at Site 11 on the Blackwater River, seven individual salmon were captured ranging in length (fork length) from 6.6 centimetres to 13.1 centimetres (mean length 10.8 cm). Refer to **Table 7**, above.

4.4.7.5 Biological Water Quality

Biological water quality surveying determined that the watercourses within the study area are of a quality adequate to support some pollution-sensitive mayfly and stonefly larvae, and trout. Biological water quality at Site 1 and Site 4 was rated 'Slightly polluted (Q3-4)', equivalent to Water Framework Directive (WFD) 'Moderate status' due to the paucity of pollution-sensitive taxa. Sites 3 and 10 were rated 'Unpolluted Q4' and equivalent to WFD 'Good status'. Sites 2, 4, 9 and 11 were rated 'Unpolluted (Q4-5)' equivalent to WFD 'High status'.

The Average Score Per Taxa (ASPT)[37] scores ranged from 4.6 (Site 5) to 8.1 (Site 2). The values at all locations except Site 5 were indicative of good water quality, where a value of > 5.5 is deemed to signify same. The EPT (Ephemeroptera, Plecoptera, Trichoptera)[38] index of water quality varied between 0 (Site 5) to 11 (Sites 9 and 11). Therefore, based on the EPT index, macroinvertebrate richness is highly variable. Summaries of the Q-ratings and EPT indices derived from the diversity and relative abundance of the macroinvertebrates at the study sites are given in **Table 8**, below.

Table 8. Biological water quality results and interpretations of surveys carried out in 2021 at study sites on watercourses potentially affected by the proposed Ballycar Wind Farm.

Site	Watercourse	Q-rating & Quality Status	Corresponding WFD Status	ASPT	EPT	St. Dev
1	Crompaun	3-4, slightly polluted	Moderate	Clean but slightly impacted	7.4	8
2	Glennagross	4-5, unpolluted	High	Unpolluted, unimpacted	8.1	10
3	Cappateemore East	4, unpolluted	Good	Clean but slightly impacted	6.6	8
4	Crompaun East	3-4, slightly polluted	Moderate	Clean but slightly impacted	6.7	7
5	North Ballycannan	3, moderately polluted	Moderate	Heavily polluted	4.6	0
6	North Ballycannan	3, moderately polluted	Moderate	Moderately impacted	5.9	3
7	West Ballycannan	3, moderately polluted	Moderate	Moderately impacted	6.3	4
8	South Ballycar	3, moderately polluted	Moderate	Clean but slightly impacted	6.5	6

[37] Based on average value of each taxa sampled - calculated by summing indicator values and then dividing by number of taxa sampled. Index values range from 0 to 10 - a high ASPT index value (greater than 5.5) indicates high ecological status and low values indicate bad/degraded ecological status.
[38] Uses three orders of easily identifiable aquatic insects: mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddisflies (Trichoptera), and is commonly used as an indicator of water quality (Lenat, 1988) - calculated by summing the number of taxa represented by the three insect orders. Index is based on premise that many aquatic insect species are pollution-intolerant and will not be found in polluted waters meaning that the greater the pollution, the lower the species richness expected.

Site	Watercourse	Q-rating & Quality Status	Corresponding WFD Status	ASPT	EPT	St. Dev
9	South Ballycar	4-5, unpolluted	High	Unpolluted, unimpacted	7.4	11
10	West Roo	4, unpolluted	Good	Unpolluted, unimpacted	6.9	10
11	Blackwater[39]	4-5, unpolluted	High	Unpolluted, unimpacted	6.8	11

Q-ratings for the 2023 sampling are presented in **Table 9,** below. There was no change to the ecological status of Sites 1, 3, 4, 5, 7 and 8. From 2021, there was a decline in biological water quality at Site 2 on the Glennagross Stream (Q3-4 to Q3), at Site 9 on the South Ballycar Stream (Q4-5 to Q3-4), and at Site 10 on the West Roo Stream (Q4 to Q3-4). This was linked to a reduction in the relative abundance of Group A pollution sensitive taxa at these locations with excessive siltation thought to be the reason for these declines. There was an improvement in biological water quality at Site 6 on the North Ballycannan Stream (Q3 to Q4).

Table 9. Biological water quality results and interpretations of surveys carried out in 2023 at study sites on watercourses potentially affected by the proposed Ballycar Wind Farm.

Survey site	Watercourse	Q-rating	Quality status	Corresponding WFD status
1	Crompaun	3-4	Slightly polluted	Moderate
2	Glennagross	3	Moderately polluted	Moderate
3	Cappateemore East	4	Unpolluted	Good
4	Crompaun East	3-4	Slightly polluted	Moderate
5	North Ballycannan	3	Moderately polluted	Moderate
6	North Ballycannan	4	Unpolluted	Unpolluted
7	West Ballycannan	3	Moderately polluted	Moderate
8	South Ballycar	3	Moderately polluted	Moderate
9	South Ballycar	3-4	Slightly polluted	Moderate
10	West Roo	3-4	Slightly polluted	Moderate

4.4.7.6 Physico-chemical Water Quality

Results of the on-site physico-chemical measurements at survey sites are presented in **Table 10,** below, while the laboratory test results for the 2021 surveys and the 2023 surveys are provided below in **Table 11** and **Table 12,** respectively. The **Aquatic Ecology Survey Report** in **Appendix 6C** of **Volume III** of the **EIAR** gives full details of the laboratory test report and provides discussion on each parameters' results.

Table 10. Physico-chemical water quality results from on-site measurements (samples taken 24th June 2021).

Parameter	Survey Site Number									
	1	2	3	4	5	6	7	8	9	10
Dissolved Oxygen (%)	82.1	78.6	77.4	100.9	43.7	64.6	56.4	37.9	76.4	82.1
Dissolved Oxygen (ppm)	8.85	8.38	8.28	11.23	4.62	6.49	6.05	4.01	8.29	8.86
Time	9.47	13.23	12.20	15.08	15.54	16.33	14.23	15.23	10.54	11.20
Conductivity (µS/cm)	269	321	291	334	302	495	399	558	444	470

[39] Survey at Site 11 carried out in 2018.

Parameter	Survey Site Number									
	1	2	3	4	5	6	7	8	9	10
Temp (°C)	10.8	12.05	11.1	11.25	12.58	16.2	12.48	12.4	12.63	13.15
pH	6.77	7.43	7.34	7.35	7.42	7.32	7.42	7.25	7.36	7.56
Turbidity (NTU - 1st)	1.35	1.8	7.32	0.81	1.02	0.99	3.17	9.16	2.05	1.31
Turbidity (NTU - 2nd)	2.22	1.53	7.09	0.94	0.82	0.86	3.82	9.07	1.36	1.06
Turbidity (NTU - 3rd)	1.04	1.5	7.28	0.95	0.85	0.71	3.56	8.62	1.48	0.71
Turbidity (NTU - average)	1.54	1.61	7.23	0.90	0.90	0.85	3.52	8.95	1.63	1.03

Table 11. Physico-chemical water quality results from laboratory analysis (samples collected 24th June 2021).

Parameter	Unit	Survey Site Number									
		1	2	3	4	5	6	7	8	9	10
B.O.D	mg/L	2.3	1	0.7	0.4	0.6	0.5	0.9	0.3	0.2	<0.1
Total Ammonia	mg/L N	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Dissolved Solids	mg/L	128	216	122	192	148	280	200	336	224	242
Total Hardness	mg/L $CaCO_3$	82	123	75	111	75	191	147	201	129	149
Total Organic Carbon	mg/L	4.2	<2	2.8	2	3	3.1	6	3.3	4.6	5.2
Total Phosphorus (as P)	mg/L P	<0.1	0.1	0.13	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Suspended Solids	mg/L	<5	<5	<10	<10	<10	<10	<10	<10	<10	<10
Nitrate (as NO_3)	mg/L NO_3	1.5	5.6	3.9	2.3	1.3	2.3	0.57	3.3	2	2.9
Nitrite (as NO_2)	mg/L NO_2	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ortho-Phosphate (as P)	mg/L P	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2

Table 12. Physico-chemical water quality results from laboratory analysis (samples taken on 26th June 2023).

Parameter	Unit	Survey Site Number									
		1	2	3	4	5	6	7	8	9	10
Conductivity	µS/cm	66	62	61	66	15	62	63	62	64	74
B.O.D	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Suspended Solids	mg/L	<4	<4	<4	<4	<4	<4	6	<4	<4	<4
Total Ammonia	mg/L N	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Nitrate (as NO_3)	mg/L NO_3	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Nitrite (as NO_2)	mg/L NO_2	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Orthophosphate (as P)	mg/L P	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Hardness	mg/L $CaCO_3$	16	16	16	17	29	16	16	16	18	22
Chemical Oxygen Demand (COD)	mg/l	<10	<10	10	<10	<10	11	<10	13	13	12
Total Phosphorus (as P)	mg/L P	0.08	0.06	0.07	0.04	0.08	0.06	0.06	0.04	0.05	0.06
Total Organic Carbon	mg/L	4.6	4.9	5.3	5.4	5	6	6	5.9	6.8	8.4
Total Dissolved Solids	mg/L	47	35	34	37	54	35	35	35	36	42

4.4.8 Ornithology

4.4.8.1 Vantage Point (VP) Surveys and Transect Surveys Results

Table 13, below, lists the primary and secondary target species recorded during VP and transect surveys at the proposed site (species listed on Annex I of the Birds Directive[40] are highlighted in **bold**). Two Special Conservation Interest (SCI) species for which the River Shannon and River Fergus Estuaries SPA is designated were recorded during VP surveys, namely black-headed gull and cormorant, and their flightpaths are shown in Figure 4-6, below.

[40] Annex I lists 194 species and sub-species of birds that are particularly threatened. EU Member States must designate Special Protection Areas (SPAs) for them and all migratory bird species.

Table 13. Primary and secondary target species recorded during VP and transect surveys carried out at the proposed Ballycar Wind Farm site between October 2019 and September 2023, inclusive.

Species	Winter 2019/20	Summer 2020	Winter 2020/21	Summer 2021	Winter 2021/22	Summer 2022	Winter 2022/23	Summer 2023
Black-headed gull (*Chroicocephalus ridibundus*)*			✓		✓		✓	
Buzzard (*Buteo buteo*)	✓	✓	✓	✓	✓	✓	✓	✓
Common gull (*Larus canus*)							✓	
Cormorant (*Phalacrocorax carbo*)*	✓							✓
Great black-backed gull (*Larus marinus*)						✓		
Grey heron (*Ardea cinerea*)					✓	✓		✓
Grey wagtail (*Motacilla cinerea*)			✓			✓		✓
Hen harrier (*Circus cyaneus*)	✓	✓			✓		✓	
Herring gull (*Larus argentatus*)		✓					✓	
Kestrel (*Falco tinnunculus*)	✓	✓	✓	✓	✓	✓	✓	✓
Lesser black-backed gull (*Larus fuscus*)		✓		✓		✓	✓	✓
Little egret (*Egretta garzetta*)		✓						
Mallard (*Anas platyrhynchos*)						✓		✓
Peregrine (*Falco peregrinus*)				✓		✓	✓	✓
Snipe (*Gallinago gallinago*)			✓		✓	✓	✓	✓
Sparrowhawk (*Accipiter nisus*)	✓	✓	✓	✓	✓	✓	✓	✓
Whimbrel (*Numenius phaeopus*)				✓				
Woodcock (*Scolopax rusticola*)	✓		✓					

*Special Conservation Interest (SCI) species for which the River Shannon and River Fergus Estuaries SPA (004077) is designated. The SPA is located 4.4 km southwest of proposal site. Refer to Section 6.3, below.

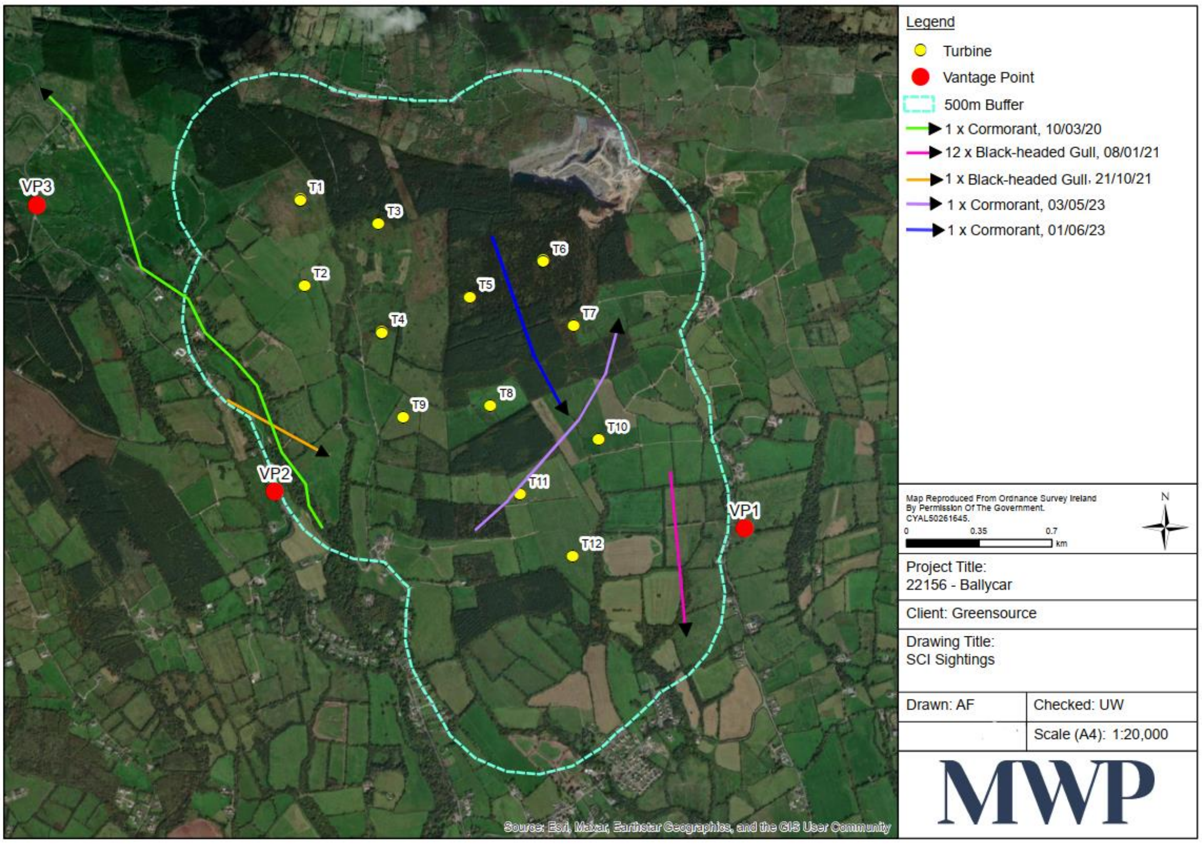

Figure 4-6: Flightpaths of the SCI species for which the River Shannon and River Fergus Estuaries SPA is designated recorded during VP surveys at the proposed development site.

4.4.8.2 Wintering Waterfowl Distribution Surveys

The species recorded were typical estuarine species which are associated with the River Shannon and River Fergus Estuaries SPA (see description of site and associated waterbirds in **Section 6.3.1**, below) and the entire Shannon and Fergus estuarine complex. The winter 2019/20 counts were carried out all along the stretch of Shannon Estuary shown in **Figure 4-7**, below, while for the 2022/23 winter counts, the stretch of estuary was divided into four survey areas – A, B, C, and D.

As the winter 2019/20 counts were carried out without the specificity of fixed locations, a peak count for the entire surveyed area per season was obtained. **Table 14**, below, details the collective peak counts for the Special Conservation Interest (SCI) wintering waterfowl species for which the River Shannon and River Fergus Estuaries is designated that were counted in the winter 2019/20 season. Black-headed gull (*Larus ridibundus*) was recorded in moderately large numbers while cormorant (*Phalacrocorax carbo*), teal (*Anas crecca*) and lapwing (*Vanellus vanellus*) were the only other SCI species counted during the 2019/20 winter counts.

Cooperhill Lake is located within Survey Section D shown in **Figure 4-7**, below, approximately 6.5 kilometres southwest of the proposed development site on the southern side of the River Shannon where each year, a population of whooper swan return to use as a regular roost. Flocks of the species were observed at Section D during every winter 2022/23 count but only once in Section A and never in Sections B or C. A peak flock count of 154 whooper swan (*Cygnus cygnus*) occurred in Section D at Cooperhill on 17th January 2023. On the same date, a flock of 14 whooper swan were recorded in Section A at King's Island, approximately 4 kilometres southeast of the proposed development site. Black-headed gull was recorded in large numbers at all four Sections A, B, C, and D with a peak count of 870 at Section D on the 7th March 2023. All wintering waterfowl Special Conservation Interest (SCI) species for which the River Shannon and River Fergus Estuaries is designated that were counted during wintering waterbird counts are summarised in **Table 14**, below.

Full results of the winter waterbird distribution surveys along the River Shannon are presented in **Appendix 7I** for winter 2022/23 and **Appendix 7F** for winter 2019/20 in **Volume III** of the **EIAR**.

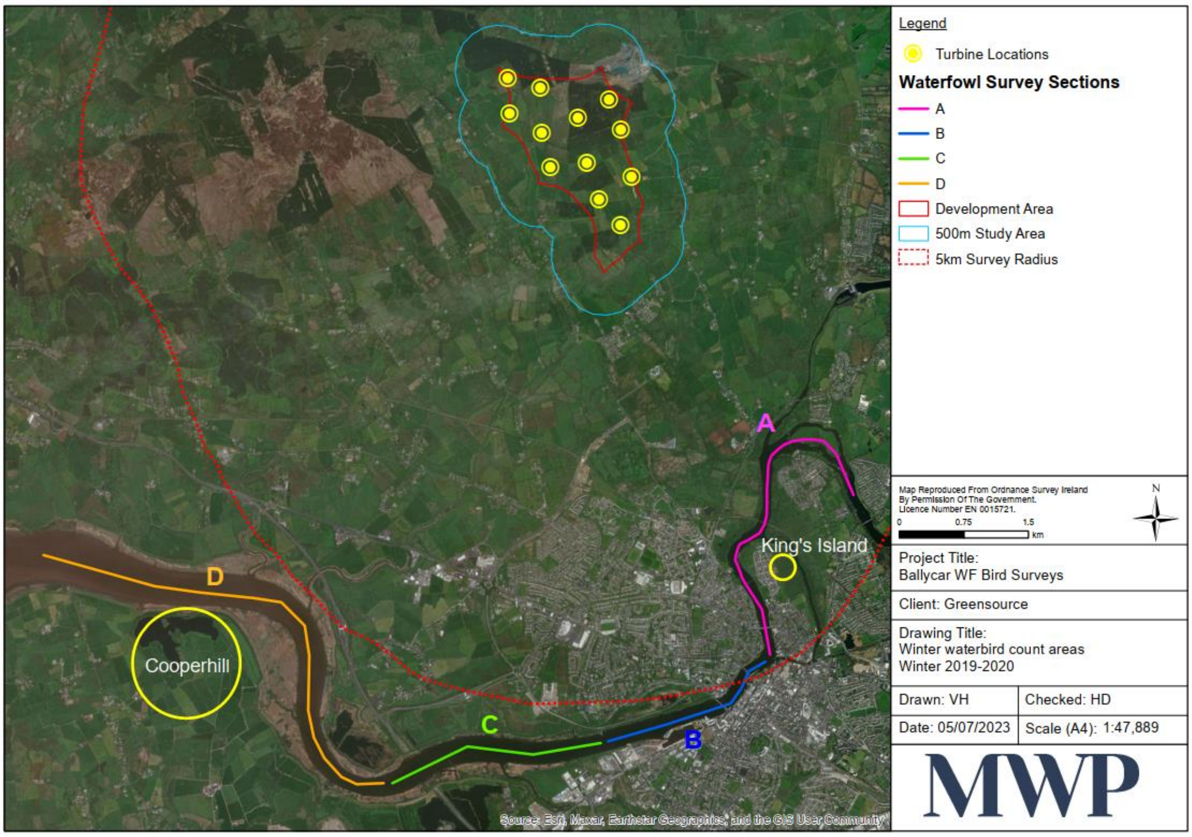

Figure 4-7: Locations of wintering waterbird counts undertaken at four sections along the Shannon Estuary.

Table 14. Peak counts along the River Shannon Estuary of any recorded Special Conservation Interest (SCI) species for which the River Shannon and River Fergus Estuaries SPA is designated.

SCI Species	Peak Count for Winter 2019/20	Peak Count for Winter 2022/23			
		Section A	Section B	Section C	Section D
Cormorant *Phalocrocorax aristotelis*	4	34	11	406	32
Whooper Swan *Cygnus cygnus*		14			154
Wigeon *Anas penelope*					48
Teal *Anas crecca*	4	10	28	235	52
Pintail *Anas acuta*			1		
Shoveler *Anas clypeata*		6	2		14
Grey Plover *Pluvialis squatarola*			3	3	
Lapwing *Vanellus vanellus*	51	6			27
Dunlin *Calidris alpina*				1	
Curlew *Numenius minimus*				11	1
Redshank *Tringa totanus*		1	1	21	
Black-headed Gull *Larus ridibundus*	242	421	495	357	870

4.4.8.3 Breeding Wader Surveys

Three breeding wader walkover surveys were carried out during the 2023 summer season at suitable locations within the 500-metre buffer survey area. The only target species recorded during these surveys was one snipe flushed from an area of wet grassland between T10 and T11 to the southeast of the site in April 2023.

4.4.8.4 Hinterland Surveys

Two flocks of black-headed gull were observed on 16th February 2023 at locations to the southeast of the proposed development site – see **Figure 4-8**, below. The first observation involved 80 individuals at Ardnacrusha Bridge approximately 3.5 kilometres from the proposed T12 location while the second, smaller group comprised four black-headed gulls at a location approximately 3.2 kilometres south of T12. No other SCI species for which the River Shannon and River Fergus Estuaries SPA is designated were observed during the hinterland surveys.

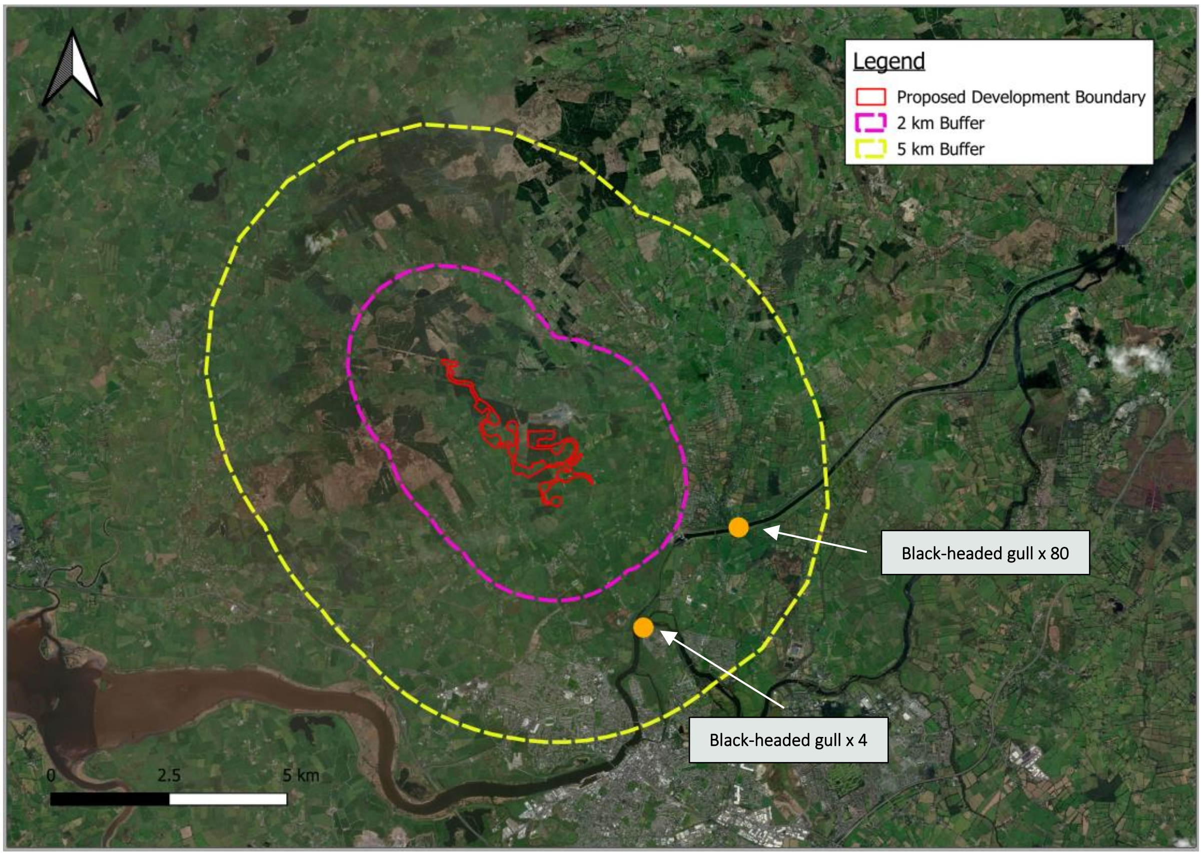

Figure 4-8: Locations of black-headed gull observed on 16th February 2023 during hinterland surveys.

4.5 Characteristics of the Project

4.5.1 Project Components and Infrastructure

The proposed wind farm will comprise twelve wind turbines and associated infrastructure including electrical cable connection to the National Energy Grid (NEG), within a total site area of 104.7 hectares, refer to map in **Figure 4-9**, below.

Table 15 sets out the elements of the project for which development consent is being sought and all other associated project components:

Table 15. Characteristics of the proposed Ballycar Wind Farm development in County Clare.

Proposed Development for which consent is sought	Core Wind Farm Components ▪ 12 No. Wind Turbines (blade tip height up to 158m. ▪ 12 No. Wind Turbine foundations and hardstand areas. ▪ 1 No. permanent Meteorological Mast (90m height) and foundation and associated hardstand areas. ▪ 1 No. Electrical Substation (110kV) including associated ancillary buildings, security fencing and all associated works. ▪ Grid connection to existing 110kV overhead line. ▪ 2 No. Developed Site Entrances, one temporary entrance to facilitate construction traffic and one permanent entrance. ▪ New and upgraded internal site access tracks. ▪ Provision of an on-site visitor cabin and parking. Associated Components of the Proposed Development ▪ All associated underground electrical and communications cabling connecting the proposed turbines to the proposed onsite substation. ▪ Turbine Delivery. ▪ Laying of approximately 1.5km of underground electricity cabling to facilitate the connection to the national grid from the proposed onsite substation to connect to an existing 110kV overhead line. ▪ Temporary works on sections of the public road network along the turbine delivery route (including hedge or tree cutting, relocation of powerlines/poles, lampposts, signage, and local road widening). ▪ 1 No. Temporary construction site compound and additional mobile welfare unit. ▪ 1 No. Borrow pit to be used as a source of stone material during construction. ▪ 3 No. spoil deposition areas (one at borrow pit location). ▪ Associated surface water management systems. ▪ Tree felling required for wind farm infrastructure.

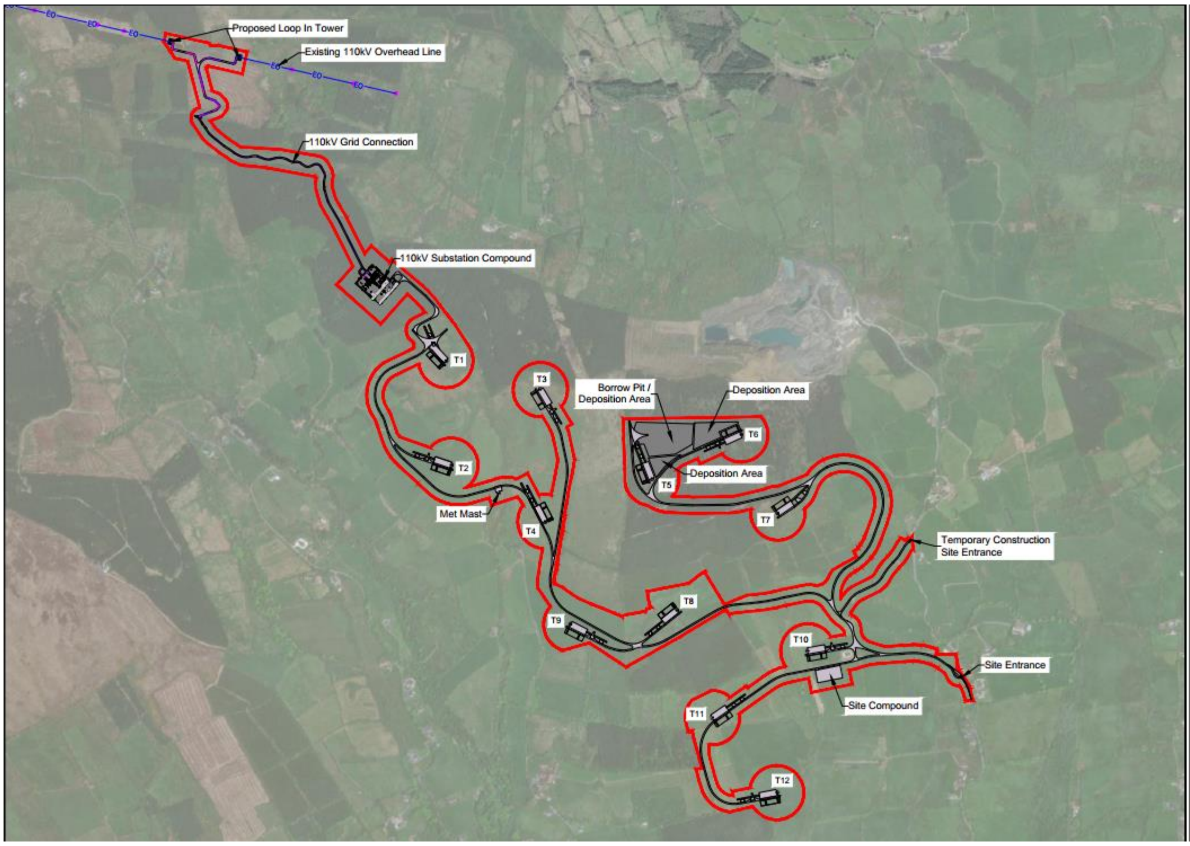

Figure 4-9: Site layout of the proposed Ballycar Wind Farm in County Clare.

4.5.2 Site Access

Primary access to the proposed development site will be provided from the local public road the L7062 (refer to **Figure 4-9**, above). There will be two site entrances – one temporary to facilitate construction traffic delivering material from a local quarry (Entrance Point A), and one permanent to facilitate turbine deliveries, materials originating from other sources and operations/maintenance vehicles (Entrance Point B).

Entrance Point A to the north-east of the site is proposed as a temporary access to be used during the construction phase only for the delivery of materials sourced from a local quarry, approximately one kilometre north of this entrance point. Entrance Point A will be reinstated to its original condition once the construction phase is completed. Entrance Point B will be from the south-east of the site from the L7062. This site access point will be for turbine deliveries, materials other than those sourced from the local quarry, and for operations and maintenance vehicles. This will be a permanent access point but will be scaled back, landscaped, and fenced and gated as the wind farm becomes operational. Refer to **Figure 4-9**, above.

4.5.3 Wind Turbines

It is proposed to install twelve (12) No. wind turbines each with a maximum tip height of up to 158 metres. Eleven (11) No. turbines will have a hub height of 90 metres and a blade length of 68 metres, and one (1) No. turbine (T10) will have a hub height of 82 metres and a blade length of 68 metres. Turbine layout has been designed to achieve the most suitable layout based on the site's specific environmental and physical characteristics. The dimensions and co-ordinates of the proposed turbines are set out in **Table 16,** below.

The turbine model selected will be certified under the International Electrotechnical Commission IEC 61400-1 safety standards and will be designed to withstand the environmental conditions encountered on site. The proposed turbines will be of a typical modern design, incorporating tubular towers and three blades attached to a nacelle. The tower supports a nacelle and rotor hub. Commercial wind turbine hubs and towers are typically made of steel, while the blades can be made of a matrix of glass-fibre reinforced polyester or wood-epoxy or a similar composite material. It is proposed to install lighting on the turbines in a pattern that is acceptable to the Irish Aviation Authority/AirNav Ireland for aviation visibility purposes.

Table 16. Dimensions and ITM co-ordinates for the 12 turbines at the proposed Ballycar Wind Farm.

Turbine Number	Hub Height (m)	Blade Length (m)	Max Tip Height (m)	Grid Co-ordinates (ITM)	
T1	90	68	158	554589	664237
T2	90	68	158	554609	663823
T3	90	68	158	554964	664122
T4	90	68	158	554981	663600
T5	90	68	158	555405	663769
T6	90	68	158	555757	663943
T7	90	68	158	555904	663633
T8	90	68	158	555503	663247
T9	90	68	158	555084	663192
T10	82	68	150	556023	663087
T11	90	68	158	555645	662822
T12	90	68	158	555899	662525

4.5.4 Wind Turbine Foundations

Each wind turbine will have a reinforced concrete base pad foundation with a central plinth above the base to support the turbine tower. Each turbine base will bear onto rock or other suitable bearing stratum and will be constructed using a wide and shallow spread foundation (see **Plate 9**, below). A typical foundation will be approximately 28 metres in diameter and will usually be installed to a depth of approximately 3 metres below ground level (BGL). Approximately 900 metres^3 of concrete and 100 tonnes of steel will be used to construct each turbine base. If poor ground conditions are encountered during excavation and a significant depth to sub-formation is necessary, piled foundation may be required. Final dimensions of the turbine bases will be confirmed as part of detailed engineering. Refer to **Planning Drawing 22156-MWP-00-00-DR-C-5402** for further details.

Plate 9. Typical construction of a wind turbine base.

4.5.5 Turbine Hardstands

Turbine hardstands are required to accommodate the delivery of the turbine components prior to their erection and to support the cranes during erection. Hardstands are also used for maintenance during the operation of the turbine. The hardstands will be rectangular in shape with additional hardstand set down areas to lay the turbine blades across once delivered (see Plate 10, below). The area of a single hardstand is approximately 68 metres long by 25 metres wide. Due to the significant loads that will be imposed by the outriggers of the main lifting crane during the turbine erection process, it is intended that the hardstands will be constructed using excavation methods over the footprint of the hardstand area/turbine base.

The hardstand areas will be excavated and bear onto rock (or other suitable bearing stratum) with a foundation of 0.5 to 1.5 metres, depending on the local bedrock profile. The hardstand areas will remain in place during the lifetime of the wind farm to facilitate turbine maintenance and final decommissioning.

Each turbine will generate electricity at a nominal voltage and will have its own transformer to step-up to an on-site distribution voltage. The transformer and associated switchgear will be located within the turbine tower. The turbines will be connected via underground cables which will then link back to the substation compound.

Plate 10. Example of typical finished hardstand on a wind farm.

4.5.6 Internal Underground Cables

A network of underground cables serving each turbine with electrical power and signal transmission will be installed along internal service tracks to electrically connect the wind turbines to the new onsite substation located northwest of T1. There will be no overhead power lines constructed within the site.

4.5.7 Substation

The proposed 110kV substation will be located approximately 340 metres northwest of T1 and will occupy an area of approximately 13,500 m^2 (1.35 ha). The substation compound will comprise an outdoor electrical yard and two single storey buildings - one for the system operator and one for the wind farm operator. The system operator building will contain a control room, a storeroom, an office/canteen and a toilet. The wind farm operator building (or Independent Power Producer (IPP) substation building) will contain a storeroom, a communications room, a control room, a staff room, an office, a switchgear room and a toilet. Both substation buildings will be approximately 6.1 metres high with pitched roofs and an external blockwork and plastered finish.

Since the requirement for water will be limited to toilet-flushing and handwashing, it is proposed that water from the roofs of the buildings be harvested. The discharge from the toilet within each building will go to a holding tank located within the substation compound where the effluent will be temporarily stored and removed at regular intervals by an approved contractor. Vehicular parking for each building will be located within the compound area. The substation buildings and associated compound will be contained within a 2.6-metre-high galvanised steel palisade fence. It is proposed to topsoil and revegetate the cut and fill slopes required for the substation site.

During the operational phase, access to the proposed 110 kV substation compound from within the site will be via the permanent site entrance.

Full details of construction methodologies to be used for the substation buildings and substation compound can be found in Section 3.8 in Chapter 3 Civil Engineering, in Volume II of the EIAR. Layout drawings of the proposed substation compound and buildings are provided in planning application **Drawings No. 05923-DR-130 to 05923-DR-142.**

4.5.8 Grid Connection Route and Grid Connection Point

Electrical energy generated by the proposed wind farm will be exported to the new loop-in substation via a 110kV underground collector cable running from the main wind farm site. From the substation, the underground cable (UGC) will run northwestwards before connecting to the National Electricity Grid (NEG) via an existing 110kV overhead line located approximately 1 kilometre northwest (straight line distance) of the proposed substation. Refer to **Figure 4-10**, below.

In total, the 110kV connection cable route will measure approximately 1.5 kilometres – 1 kilometre will be installed along existing forestry tracks and 0.5 kilometres will be routed through stands of conifer plantation. Approximately 100 metres from where the UGC terminates at the existing overhead line, it will cross the Kilnacreagh Stream – refer to **Section 7.2.6.11,** below, for further details.

The proposed grid connection cable will be carried within a single cable trench measuring approximately 1.3 metres deep and 0.8 metres wide.

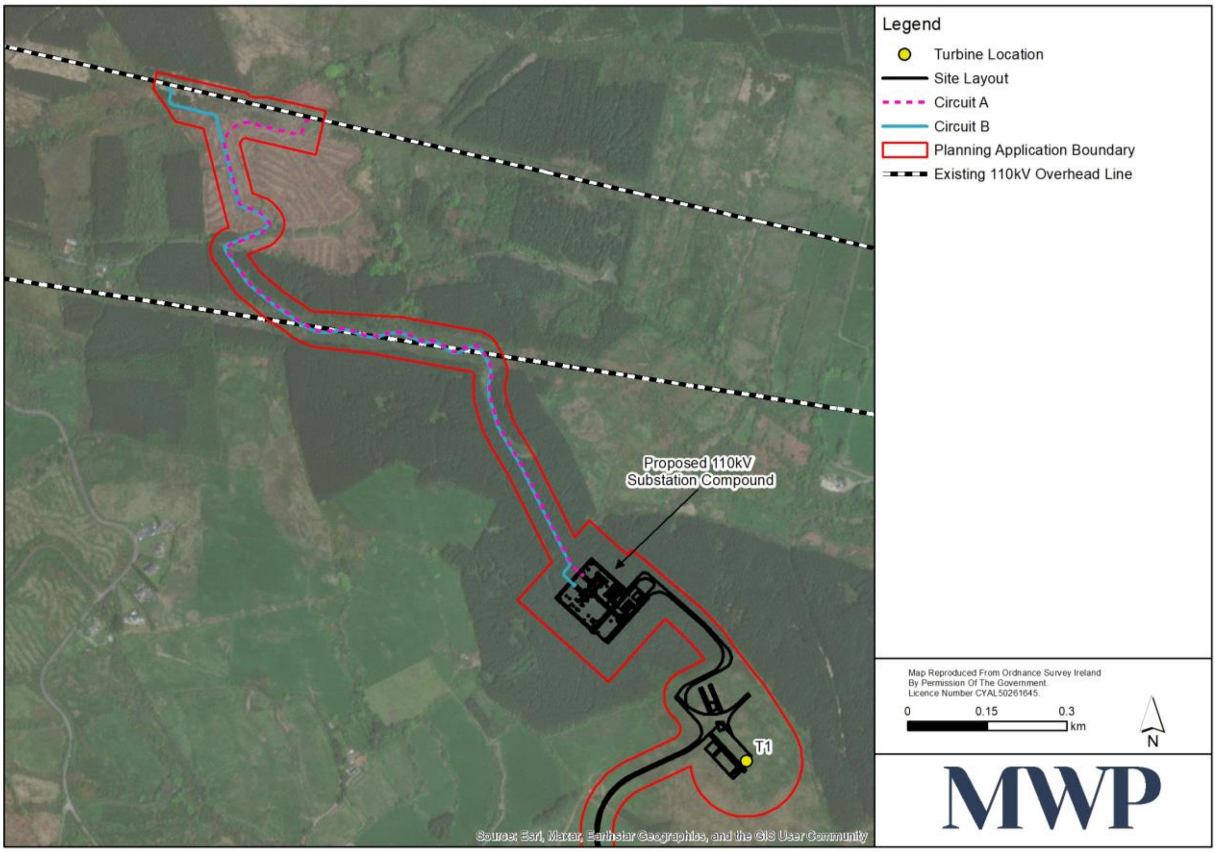

Figure 4-10: Proposed underground cable grid connection route from new substation to overhead line.

4.5.9 Communication Links

To provide communication links between the wind turbines, meteorological mast and substation, ducted fibre-optic cables will be laid in the same trench as the network of underground electrical cables around the site. Furthermore, an antenna will be positioned on the permanent met mast at a height of approximately 40 metres for radio communications for the SCADA (Supervisory Control and Data Acquisition) equipment.

This antenna is for internal wind farm site communications only. It is not for the provision of any public telecommunications services and there is no agreement with any telecommunications service providers.

4.5.10 Borrow Pit

One (1) No. onsite borrow pit is proposed at a northern location within the proposed development site - see **Figure 4-11**, below, and **Planning Drawing 22156-MWP-00-00-DR-C-5411.** Approximately 165,000 m^3 of aggregate will be won from the borrow pit to provide most of the development's required hardcore for construction of internal access tracks, crane hardstands, passing bays, foundations and temporary construction compound.

Blasting at the borrow pit may be necessary to enable excavation of the rock and increase production rates to match the construction programme. Any blasting will be carried out by a suitably qualified specialist under licence. Blasting and mitigation measures associated with the process are discussed in further detail in **Chapter 9 Land and Soils**, and in **Chapter 10 Noise and Vibration**, in **Volume II** of the **EIAR**.

Upon completion of extraction activities at the borrow pit, it will be used for the permanent storage of some excavated material from the turbine bases, crane hardstands, internal access track construction and other associated infrastructure. The borrow pit will also be suitably landscaped following reinstatement.

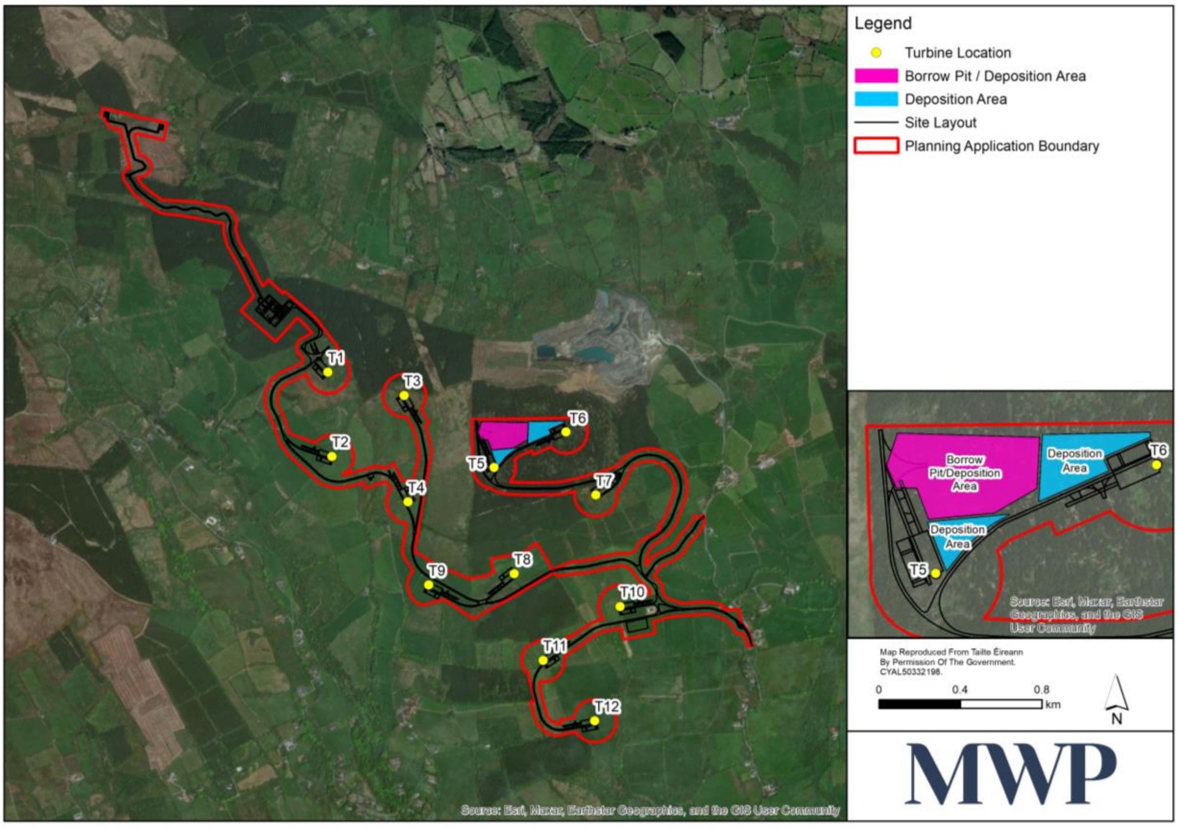

Figure 4-11: Locations of the borrow pit and deposition areas within the proposed development site.

4.5.11 Spoil Management and Material Volumes

Excavated spoil generated during construction will be reused for backfilling, landscaping, and restoration around wind farm infrastructure such as turbines and hardstands. Three dedicated spoil storage areas are proposed for the site – two adjacent to the borrow pit, and one at the borrow pit itself once rock extraction is complete. See

Figure 4-11, above, and **Planning Drawing 22156-MWP-00-00-DR-C-5411.** Refer to **Table 17**, below, for a summary of material volumes.

Although priority for storage of spoil will be given to the dedicated spoil storage areas and restoration of the borrow pit, spoil could potentially also be stored to a maximum height of one metre around the turbines and/or within some felled areas. Once extraction activities at the borrow pit have been completed, the pit will be used for the permanent storage of excavated spoil and apart from this material, there will be no permanent stockpiles left on site after construction is finished. After reinstatement works of the turbine base are complete, all remaining stockpiles are to be removed for permanent disposal.

Table 17. Summary of the construction material and spoil storage volumes for the proposed development.

Excavations	Unit	Quantity
Total volume of excavated material	m^3	418,300
Excavated Material Stored or Reused Onsite	m^3	402,000
Excavated Material Removed from Site	m^3	16,300*
Imported Stone		
Total volume of stone required	m^3	265,150
Imported Stone	m^3	100,150
Site-won Stone	m^3	165,000
Concrete and Steel		
Concrete for bases (12 @ 900 m^3 each)	m^3	10,800
Concrete for substation and met mast foundations	m^3	250
Concrete for cable route	m^3	6,700
Reinforced steel for turbine bases (12 @ 100 tonnes each)	tonnes	1,200

*This material will be reused on site as preference in trackside berms etc. however is included above as material to be removed from site as precautionary.

4.5.12 Temporary Site Construction Compound and Welfare Facilities

Upon commencement of the construction phase, one (1) No. temporary construction compound will be erected near T10 within the eastern section of the wind farm site (refer to **Figure 4-9**, above). The compound will have a total footprint of approximately 5,000 m² (0.5 ha) as shown on **Planning Drawing 22156-MWP-00-00-DR-C-5408**.

The compound will be used as a secure storage area for construction materials and contain temporary site cabins to provide welfare facilities for site personnel. Facilities will include an office space, meeting rooms, canteen area and mobile sanitary facilities. The proposed development will include an enclosed wastewater management system at the temporary compound capable of handling the demand during the construction phase. A holding tank that will be emptied by a licensed permitted contractor only is proposed at the compound for wastewater management. Upon completion of the project, the compound will be decommissioned by backfilling the area with material arising from excavation and landscaping with topsoil.

4.5.13 Permanent Meteorological Mast

A permanent meteorological mast is to be erected within the proposed wind farm to monitor the local wind regime while the wind farm is operational. The mast will be located adjacent to the turbine access track at the western side of the site between T2 and T4. The meteorological mast will be installed to a height of up to 90 metres (representative of turbine hub height) and will have a base foundation and hardstanding area.

The mast will be surrounded by a galvanised steel palisade fence measuring 2.4 metres high and will be equipped with an antenna for internal radio communications for on-site SCADA (Supervisory Control and Data Acquisition) equipment. Details of the meteorological mast are shown in **Planning Drawing 22156-MWP-00-00-DR-C-5404.**

4.5.14 Conifer Felling

Felling of commercial conifer forestry is required within and around the wind farm site to accommodate the construction of the substation compound, two turbine foundations and associated hardstands, access tracks, turbine assembly areas, and borrow pit and deposition areas. Refer to **Figure 4-12** below, for felling locations. It is proposed to fell up to 95 metres around each turbine (required clearance distance for bat species) with approximately 15.97 hectares of forestry felling required overall.

All tree felling will be undertaken in accordance with a tree felling licence, using good working practices as outlined by the Department of Agriculture, Food, and the Marine (DAFM, 2019) in their '*Standards for Felling and Reforestation*' guidelines. These standards deal with sensitive areas, buffer zone guidelines for aquatic zones, ground preparation and drainage, chemicals, fuel, and machine oils. All conditions associated with the felling licence will be complied with.

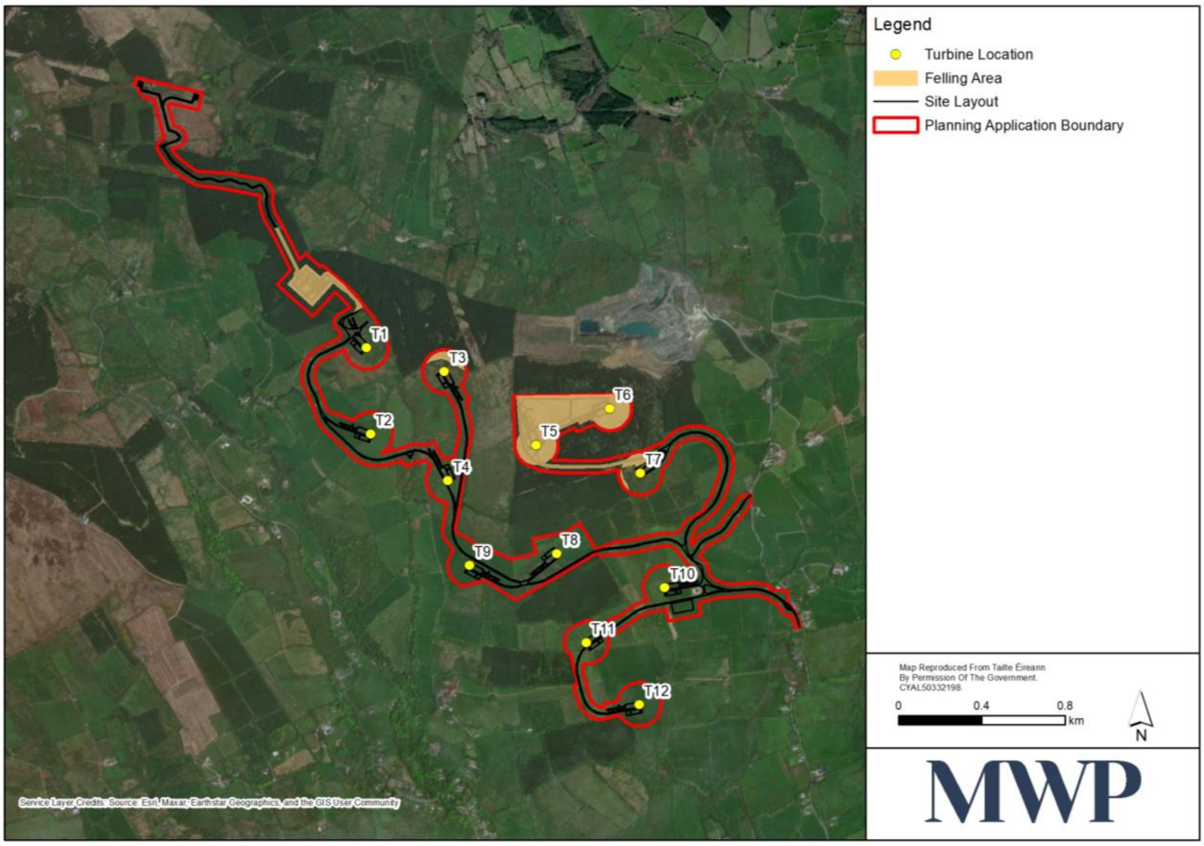

Figure 4-12: Areas within the proposed development site where tree felling is required.

4.5.15 Replant Lands

Replacement replanting of forestry in Ireland is subject to license in compliance with the Forestry Act 2014 as amended. The consent for such replanting is covered by the Forestry Regulations 2017 (S.I. No. 191 of 2017).

The total amount of felling proposed for the project is 15.97 hectares. It should be noted that the clearfelling of trees in the State requires a felling licence while the associated afforestation of alternative lands equivalent in area to those lands being permanently felled is also subject to licensing ('afforestation licensing'). The Forest Service of the Department of Agriculture, Food and the Marine is Ireland's national forest authority with responsibility for issuing all forest licensing. The Applicant commits to not commencing the project until a felling licence and an afforestation licence are both in place. This ensures the afforested lands are identified, assessed and licensed appropriately by the relevant consenting authority.

4.6 Description of Construction Phase

This section describes the methods that will be implemented when constructing the turbines, associated infrastructure, substation and grid connection. Detailed method statements will be developed and implemented by the appointed Main Contractor in advance of construction works commencing. The construction phase of the development begins with site preparation works and is complete when the turbines are built and ready for commission. Refer to **Chapter 2 Description of the Proposed Development**, and **Chapter 3 Civil Engineering**, in **Volume II** of the **EIAR** for full details of the construction phase.

4.6.1 Construction Phase Land-use Requirement

Land use requirements during the construction phase will be greater than that of the permanent land take area. The temporary land take within the planning application boundary required during the construction phase is set out below, in **Table 18**, below.

Table 18. Temporary land-use requirements of construction phase

Item	Area Required
Construction compound	5,000 metres^2 (0.5 hectares) Site Compound No. 1 only
Wind turbine construction	36,000m^2 (3,000 m^2 per hardstand) Wind turbine generator (WTG) construction requires temporary workspaces during the erection of the different turbine components. These workspaces include storage areas for turbine blades and temporary areas for assembly of the auxiliary cranes and parking.

4.6.2 Proposed Works

Construction works will be carried out in a phased manner to minimise disruption to local communities, minimise environmental impact and create the safest working conditions possible, and will principally comprise the following works:

- Felling of any areas of coniferous plantation necessary to facilitate construction works;

- Construction of site entrances and any sections of internal access tracks necessary to facilitate access to the temporary construction compound and proposed on-site borrow pit location;
- Construction of temporary construction compound including fencing (for security, water and ecology, and for archaeological exclusion zones), site offices, parking, material laydown and storage areas, etc;
- Establishment of the onsite borrow pit and temporary storage of stockpiled overburden and surplus excavated materials within material storage areas;
- Earthworks and drainage infrastructure associated with construction of new and upgraded internal access tracks, crane hardstand, turbine foundations and substation compound;
- Construction of upgraded and new watercourse crossings for construction of internal access tracks and underground cables;
- Excavation of turbine bases, permanent met mast foundations, and associated turbine hardstand areas;
- Installation of sections of underground cabling between turbines;
- Installation of sections of underground cabling to the grid connection point;
- Construction of the substation compound;
- Turbine delivery, installation and commissioning; and
- Meteorological mast delivery, installation and commissioning.

4.6.3 Construction Methods

Table 19, below, provides a summary of the types of proposed construction techniques for the various elements of the project. Construction methods are fully set out in Chapter 3 Civil Engineering, in Volume II of the EIAR and in the Construction Environmental Management Plan (CEMP) in Appendix 2A in Volume III of the EIAR.

Table 19. Summary of proposed construction techniques for Ballycar Wind Farm.

Project Element	Construction Technique
Wind turbine foundations and hardstands	Wind turbine locations will be cleared, graded, and foundations will be either excavated or piled by rotary core technique. Blasting may be required at turbine locations where bedrock is present near ground surface. An engineered concrete foundation will be installed in excavated/piled structure location. Backfill will be provided and grading will be performed to allow for immediate drainage away from each tower. Construction activities include tree/vegetation clearing, topsoil stripping, excavation and/or piling, grading, foundation construction, final grading, landscaping temporary works areas.
Permanent meteorological mast	Construction includes tree removal, topsoil stripping, excavation, grading, foundation construction, final grading, and landscaping of temporary works area.
Site access	Sightline improvements of the existing site access junction will be required. Construction activities include vegetation clearing, topsoil and/subsoil stripping, aggregate placement and grading, and landscaping of temporary works areas.
Internal trackways	Upgrading, widening and new excavated trackways: Construction activities will include vegetation clearing, topsoil stripping, excavation, placement of geogrid/geotextile layer and aggregate, compaction, grading, berm placement and landscaping. Floating Tracks: Construction activities will include removal of major protrusions, placement of geogrid/geotextile layer and aggregate, compaction, grading, berm placement and landscaping.

Project Element	Construction Technique
Internal underground site electrical cables	Underground electrical collector cables will be co-located with access tracks to minimise the area of construction disturbance. Underground cable installation construction activities include topsoil stripping, trenching, installation of cables, and revegetation of disturbed areas (unless cables are under tracks).
Substation compound	Construction includes tree/vegetation removal, topsoil stripping, excavation, filling with imported suitable material, grading, foundation construction, building construction.
Construction compound/temporary local road widening	Construction includes tree removal, topsoil stripping, excavation, grading, aggregate placement, compaction, and landscaping.
Borrow pit	Construction includes topsoil stripping, excavation and/or blasting.
Watercourse crossings	No in-stream works required. Existing crossings: Widening using pre-cast piping. New crossings: Clear span crossings.
Connection cable to grid connection point (other than at water crossings)	Construction activities include excavation, trenching, backfilling, resurfacing.

4.6.4 Internal Site Service Tracks

Internal site service tracks are required to interconnect elements of the site and allow access to all wind turbines and wind farm infrastructure. Existing tracks will be upgraded where possible and new tracks will be constructed to ensure access to each turbine, substation compound and meteorological mast. The routing of internal site service tracks is shown in **Figure 4-9**, above. Existing or new surface water collection drains will be located on either side of the service tracks - drains on the lower side of the track will be used as part of the site's dirty water drainage system, while drains on the higher side will be retained as clean water drains (refer to **Section 4.6.7**, below).

Depending on the ground conditions, the new service tracks will be constructed using either excavated or floating track techniques and will have a general running width of 5 metres. The design of any length of track within the site will depend on local geotechnical, topographical, and hydrological conditions. Both excavated and floating track construction methods will be employed to achieve a service track structure appropriate to site conditions.

New excavated tracks will be constructed by placing stone aggregate, obtained from either the proposed onsite borrow pit or imported from nearby quarries, over a layer of geogrid when all organic and soft subsoil material is excavated to formation level. Geotextile material will also be laid at formation level to separate the track building material from the subsoil. The track will be finished with imported 150 mm crushed stone of Clause 804 or similar aggregate type material.

New floating tracks will be constructed by placing a combination of geogrid and geotextile over the existing surface vegetation to be traversed with the floating track. A minimum thickness of 450 mm of site-won stone will be placed over the bottom layer of geogrid/geotextile and finished with a 150 mm surface layer of Clause 804 or similar material. Where new access tracks will be constructed through forested areas, the felled trees may be used in the construction of the floating tracks as outlined in the COFORD[41] Forest Road Manual (Ryan *et al.*, 2004). This involves layering the brash generated during the felling process onto the existing ground surface before placing the felled trees perpendicular to the direction of travel to benefit from the load spread thereby provided.

[41] Council for Forest Research and Development

Finally, a combination of geogrid and geotextile will be placed on top of the felled trees and track construction completed using the same construction method as outlined above.

Existing internal tracks will be used where possible and widened by removing organic material and soft subsoil to formation level before constructing a track on a layer of geogrid or geotextile in the same manner as described in the previous paragraph. The new width of track and existing track surface, where required, will be capped with a 150 mm layer of crushed stone of Clause 804 or similar aggregate type material.

See **Planning Drawing 22156-MWP-00-00-DR-C-5405** for more details, and a full explanation of construction methods is outlined in **Section 3.4** in **Chapter 3 Civil Engineering**, in **Volume II** of the **EIAR**.

4.6.4.1 Watercourse Crossings of Internal Site Tracks

The proposed network of internal site tracks will require seven watercourse crossings. The location of each crossing and the expected crossing methodologies for each are summarised in **Table 20**, below, and in **Figure 4-4**, above, with full details provided in **Section 3.13.3** in **Chapter 3 Civil Engineering**, in **Volume II** of the **EIAR**.

All crossings will be in accordance with this application and/or conditions attached to a grant of planning permission and agreed with the Office of Public Works (OPW) and Inland Fisheries Ireland prior to construction.

Table 20. Summary of seven watercourse crossings of the internal site tracks of the proposed development.

Crossing number	Watercourse	New/existing crossing?	Crossing methodology	In-stream works?	ITM coordinates
WC1	Cappateemore_East	New	Clear span crossing	No	554724, 663713
WC2	North Ballycannan	New	Clear span crossing	No	556099, 663803
WC3	East Ballycannan	New	Clear span crossing	No	555813, 663287
WC4	North Ballycannan	New	Clear span crossing	No	556221, 663432
WC5	North Ballycannan	New	Clear span crossing	No	556284, 663353
WC6	East Ballycannan	Existing	Clear span crossing or widening using pre-cast piping	No	555977, 663004
WC7	North Ballycannan	Existing	Clear span crossing or widening using pre-cast piping	No	556532, 663071

4.6.5 Turbine Delivery

The proposed route for the delivery of the turbine components from Foynes Port in County Limerick is outlined below and illustrated in **Figure 4-13**, below, and described in detail in the **Turbine Delivery Route Assessment** in **Appendix 2C** of **Volume III** in the **EIAR**.

4.6.5.1 Route from Foynes Port to Limerick City

The route from Foynes Port to Limerick City is via the N69 to the roundabout at the N18 interchange. From here the WTG blades and any components with loaded heights of less than 4.65 metres will travel northwards along the N18 via the Limerick Tunnel to Junction 3, through the toll to and arriving at Clonmacken Roundabout from the west. Where the component loaded height is greater than 4.65 metres, the delivery vehicles will continue along the N69, through the Dock Road Roundabouts and along the Dock Road R510 to Shannon Bridge Roundabout. From here, the components will travel northwards over Shannon Bridge and along the R527 Condell Road before arriving at Clonmacken Roundabout from the south. Refer to **Figure 4-13**, below.

4.6.5.2 Limerick City to Ballycar Wind Farm

From the Clonmacken Roundabout, there are two delivery route options through Limerick City - refer to **Figure 4-13**, below.

Option 1 involves travelling northwestwards along Condell Road to Coonagh Roundabout and then using the Coonagh to Knockalisheen Distributor Road, passing through the Coonagh Cross, Cratloe Road and Moyross Road Roundabouts to reach the Knockalisheen Distributor Road Roundabout. The route will then turn southeast onto the Knockalisheen Distributor Road before reaching the existing junction with the R464 Kileely Road. Option 2 involves travelling northeastwards along the L8570 Clonmacken Road, past the Jetland Shopping Centre towards Thomond Park via the Ennis Road junction and Moylish Roundabout. The route then turns left at the junction of Cratloe Road and the R464 Kileely Road (Hassett's Cross).

The Coonagh to Knockalisheen Distributor Road is currently under construction but when complete, it will bypass the route outlined in Option 2 providing a less intrusive delivery route to the wind farm, thereby Option 1 is the preferred delivery route through Limerick City when the Distributor Road is operational.

For both Options, the route then continues northwards along the R464 Kileely Road to Parteen before turning left onto the L3056 Local Road and directly onwards to the proposed wind farm site at Ballycar. Refer to **Figure 4-13**, below.

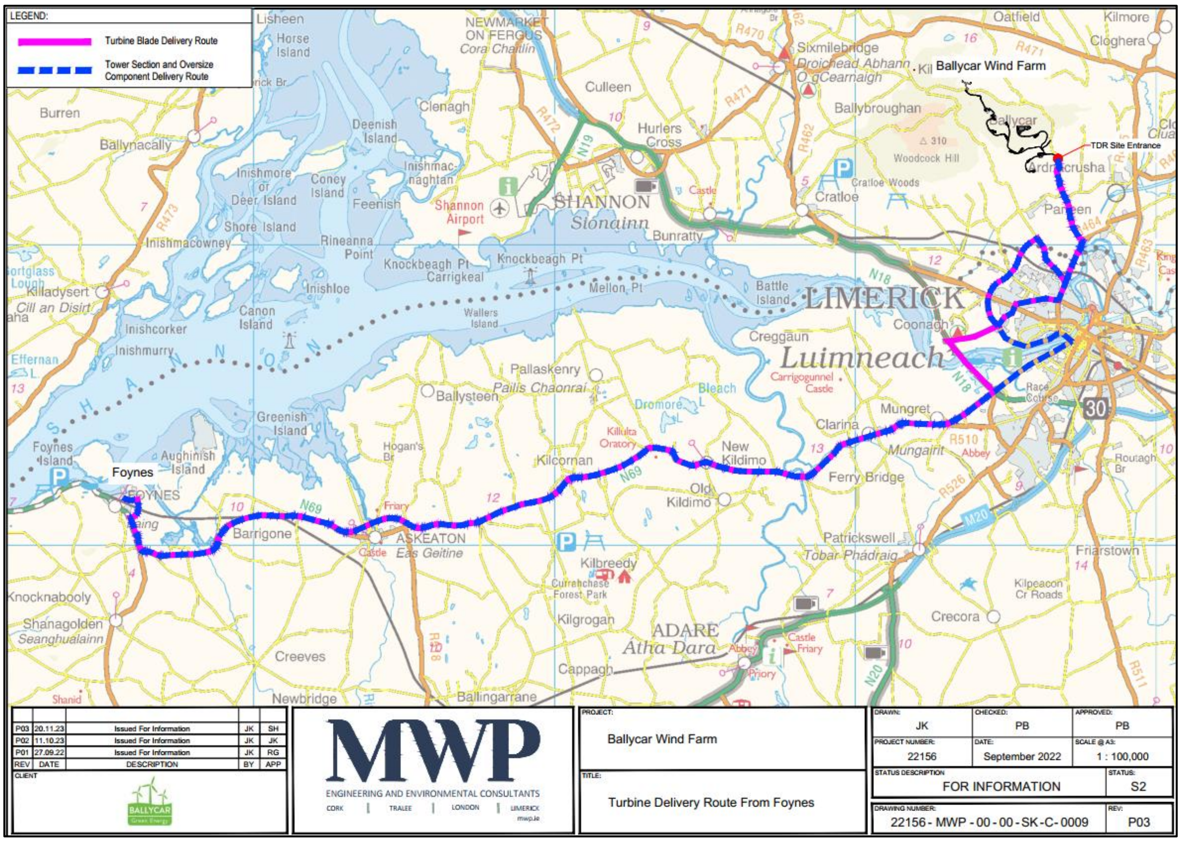

Figure 4-13: Proposed Turbine Delivery Route from Foynes Port in County Limerick to proposed development site at Ballycar.

4.6.5.3 Temporary Road Works Required for Turbine Delivery

The delivery of turbine components to the proposed development site will require temporary works on sections of the public road network along the delivery route including hedge or tree cutting, relocation of powerlines/poles, lampposts, signage and temporary local road widening. Such works will be temporary are not included in the planning application boundary.

At Parteen, temporary road widening works will be required at the junction of the R464 Kileely Road and L3056 Sweeps Road to facilitate tower and other oversize component deliveries as the route turns northwards onto Sweeps Road. The works will involve the temporary widening of a short stretch (approximately 79 metres) of the R464 that will see the road extend into the field southeast of the junction – see **Figure 4-14**, below. The works will occur approximately 46 metres northwest of the Lower River Shannon SAC boundary and approximately 3.1 kilometres north of the River Shannon and River Fergus Estuaries SPA boundary.

Refer to **Chapter 3 Civil Engineering**, in **Volume II** and the **Turbine Delivery Route Assessment** in **Appendix 2C** of **Volume III** in the **EIAR** for further details.

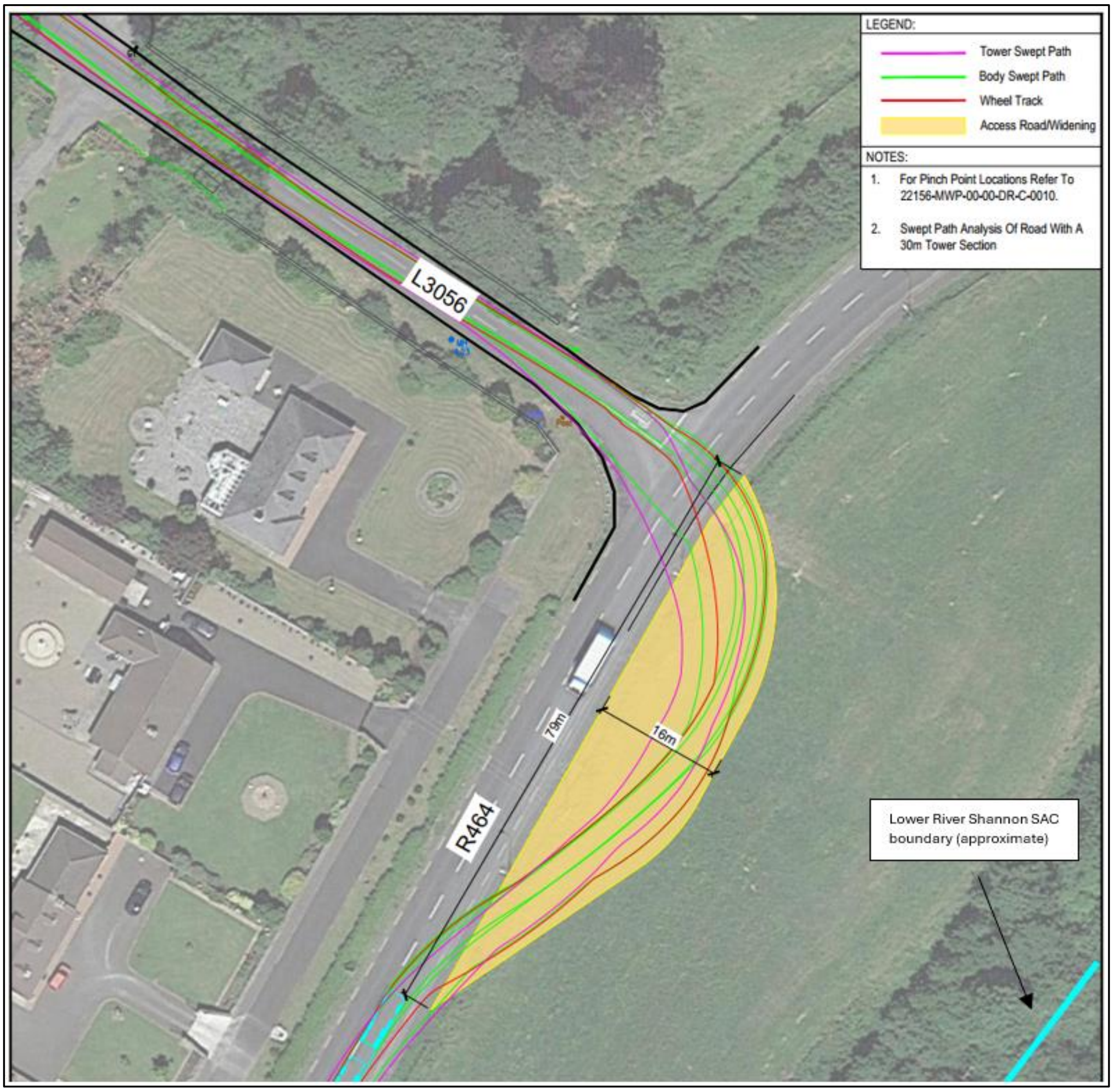

Figure 4-14: Details of temporary road widening works at the R464 / L3056 junction and their proximity to the Lower River Shannon SAC to the southeast.

4.6.6 Roads and Traffic

As discussed in Section 4.5.2 and illustrated in Figure 4-9, above, primary access to the proposed development site will be provided from the public Local Road L7062. This will be the main site entrance during both the construction and operational phases of the development. It is intended to utilise the existing public road network to the site entrance for the delivery of wind turbine components, the transportation of construction vehicles and the delivery of materials. During the construction phase, it is envisaged that aggregates required outside of those sourced from the onsite borrow pit will be sourced from the local quarries. The routes utilised by construction materials delivery vehicles are likely to include the R464 Regional Road, and L7062 and L3056 Local Roads.

Reasonable efforts will be made to minimise the impact of the works on local residents and users of the public road networks. A Traffic Management Plan (TMP) outlining the required traffic management procedures to be implemented on the public roads during the construction of the proposed development and delivery of the wind turbine components is included as Appendix 2D in Volume III of the EIAR. Should An Bord Pleanála (the Board) decide to grant approval for the proposed development, the final TMP will address the requirements of any relevant planning conditions, including any additional mitigation measures which are conditioned by the Board. The Traffic Management Plan will be updated at the construction stage (or the update commenced during planning compliance stage) to ensure controls are in place with all suppliers coming to the project site.

4.6.7 Construction Environmental Management Plan (CEMP)

A Construction and Environmental Management Plan (CEMP) has been prepared and is included in Appendix 2A of Volume III of the EIAR. The CEMP will be a key construction contract document that will ensure all mitigation measures considered necessary to protect the environment, prior to construction, during construction and during operation of the proposed development, are implemented. The CEMP will collate and manage the proposed and agreed mitigation measures, monitoring and follow-up arrangements and management of environmental impacts. The environmental commitments of the project will be managed through the CEMP and will be secured in contract documentation and arrangements for construction and later development stages.

The CEMP will mainly address the construction phase, however, where monitoring is to continue into the operational phase, these commitments will be communicated and transcribed into operational process documentation. The CEMP will be updated as required through pre-construction and construction to address, for example, any conditions stipulated in the planning permission. The primary objective of the CEMP is to provide a framework for actions, responsibilities and protocols associated with environmental management which the Appointed Contractor(s) are required to adhere to, ensuring the construction of the proposed development in accordance with regulatory requirements and to reduce and/or avoid any adverse environmental impacts.

4.6.8 Surface Water Management

A Surface Water Management System will be constructed on the site to attenuate run-off, guard against soil erosion and safeguard downstream water quality. The drainage system will be implemented along all work areas including all internal site access tracks, storage areas, crane hardstand areas, substation, met mast and temporary site construction compound/temporary road widening works. Full details of the proposed site drainage system are described in Section 3.13 in Chapter 3 Civil Engineering, in Volume II of the EIAR, and in the Construction and Environmental Management Plan (CEMP) in Appendix 2A in Volume III of the EIAR.

The site drainage system was designed integrally with the wind farm layout as a measure to ensure that the proposal will not change the existing flow regime across the site, will not deteriorate water quality and will safeguard existing water quality status of the catchments from wind farm related sediment runoff. A fundamental principle of the drainage design is that clean water flowing in the upstream catchment, including overland flow and flow in existing drains, is allowed to bypass the works areas without being contaminated by silt from the works. This will be achieved by intercepting the clean water and conveying it to the downstream side of the works areas either by piping it or diverting it by means of new drains or earth mounds.

Settlement ponds and check dams will provide the essential mechanism for the removal of silt from construction-related runoff and the controlled return of the treated runoff to the downstream watercourses. Runoff from the internal tracks, hardstands and other wind farm infrastructure will be isolated from the clean catchment runoff by means of a series of open drains that will be constructed within the works areas. These drains will be directed to settlement ponds that will be constructed throughout the site downhill from the works areas and will be discharged from settlement ponds to vegetation or forestry rill drains. Each drain will incorporate a series of check dams that will attenuate the flow and provide storage for the increased runoff from exceptional rainfall events.

4.6.9 Duration of Construction

It is envisaged that the proposed development will commence in 2026 with an 18-month construction period. The start date is dependent on whether planning is granted, whether a grid connection offer is made by EirGrid, and if funding and all permits are in place.

A typical programme of work is outlined in **Table 21,** below. A number of these phases will run concurrently, outlined as follows:

- As the internal site access tracks are constructed up to each turbine, hardstanding areas for the crane, turbine foundations and building foundations will be prepared.
- Once the tracks are completed, the trenching and laying of underground cables will begin.
- Construction of the site substation and control houses will commence to ensure they are ready to export power when the turbines are commissioned.

Table 21. Preliminary construction programme for the proposed Ballycar Wind Farm.

	Activity	Expected Duration
Phase 1	Clearfelling (to be completed before construction site mobilisation).	2 months (prior to construction)
Phase 2	Prepare site, pre-construction activities, site entrance, temporary compound.	1 month
Phase 3	Access track construction and drainage plan implementation.	3 months
Phase 4	Hardstanding construction for turbines.	2 months
Phase 5	Turbine foundation construction.	4 months
Phase 6	Trenching and ducting (underground electrical cables).	2 months
Phase 7	Substation construction.	4 months
Phase 8	Permanent meteorological mast erection.	1 month
Phase 9	Delivery of the turbine components.	3 months
Phase 10	Erection of turbines.	4 months
Phase 11	Wind Farm commissioning	4 months, approximately

4.6.10 Major Temporary Features

Temporary onsite features will include the compound facilities, plant, and equipment along with safety fencing and building materials. Large excavators and turbine erection cranes are also a temporary feature on site during the construction phase. There will be some temporary stockpiling of soils on site. Any surplus material will be placed within the material deposition areas. There will also be temporary local road widening.

4.6.11 List of Plant and Materials Required

Mechanical machinery and electrical equipment typically used for construction projects will be required to facilitate the proposed Ballycar Wind Farm development. The following is a non-exhaustive list of plant that is typically used for wind farm construction and heavy civil engineering works:

- 30-50T excavators;
- 15-30T excavator;
- Rubber-tyre 15-20T excavator;
- 3-10T mini-diggers;
- Mobile crane for construction;
- Rebar/shuttering/precast units/conc. pipes/box culverts etc. 60t to 120t;
- Cranes (1 main, 1 assist) erection 120t to 1000t;
- Telescopic handler;
- Tractors and trailers;
- Road grader;
- Double contained fuel bowsers;
- 12T rollers;
- Diesel powered generators; and
- Water bowsers.

The following is a non-exhaustive list of materials, and approximate quantities, that are expected to be used during construction of the wind farm:

- 17,750 m^3 of concrete;
- 1,200 tonnes of reinforced steel;
- Wind turbine components;
- 100,150 m^3 of imported stone for tracks, hardstands, backfill;
- Transformers/panels/cables;
- Electrical equipment;
- Stone, blocks, roofing;
- Palisade fencing;
- Wooden poles;
- Sand for duct bedding;
- Clause 804 material; and
- Coils of 400 mm^2 XLPE insulated cable.

4.6.12 Construction Working Hours

Typically, construction will occur within the hours 07.00 am to 7.00 pm, Monday to Friday, inclusive, and 07.00 am to 2.00 pm on Saturdays. Since the concrete pours need to occur continuously, the working day may extend outside normal working hours to limit traffic impact on other road users, particularly peak period school and work commuter traffic. Such activities are limited to the day of turbine foundation concrete pours, which are normally completed in a single day per turbine. Turbine and crane erections may also occasionally occur outside of these times to take advantage of periods of low wind. Working hours will be confirmed at the outset of the project and any changes in hours will be agreed with the Local Authority.

Any works along public roads will be from 9.00 am to 5.00 pm Monday to Friday, inclusive, and 9.00 am to 2.00 pm on Saturdays. A permit for moving abnormal loads will be sought from An Garda Síochána for the delivery of oversized wind turbine components such as blades, nacelles and towers. There is to be no work on Sundays or Bank Holidays without pre-approval from the Local Authority.

4.6.13 Construction Personnel

During the construction phase, the number of onsite construction personnel will vary for each phase of the development. Overall, it is envisaged that the proposed development would generate employment for up to 60 persons during the construction phase to include site contractors, on-site vehicle and plant operators, engineers, materials delivery personnel, environmental personnel, health and safety personnel.

4.7 Commissioning of the Wind Farm

Wind farm commissioning can take approximately two to four months to complete from erection of the final turbine to exporting of power. It involves commissioning engineers working through an entire schedule of SCADA (Supervisory Control and Data Acquisition) and electrical testing and control measures to ensure the wind farm will perform and export power to the National Energy Grid (NEG) as designed.

4.8 Description of Operational Phase

4.8.1 Land Use Requirement

The permanent land take will be limited to the wind turbine hardstands, access tracks, permanent crane hardstand areas, control building, permanent deposition areas and substation hardstandings which account collectively for about 31% of the total area within the wind farm planning boundary.

4.8.2 Operating Hours and Operational Conditions

The proposed development is expected to have a lifespan of approximately 35 years. The proposed development is designed to operate when wind speeds at the hub height are within the operating range of the wind turbines. Most turbine models have a cut-in wind speed of 3 metres per second (m/s) with optimum generation at approximately 12.5 m/s. The turbines are expected to have a cut-out wind speed of 25 m/s.

Each wind turbine will be computerised to control critical functions, monitor wind conditions, and report data back to a SCADA system. An anemometer mounted to the top of the wind turbine nacelle provides wind speed information which is then used to automatically set blade pitch to control the wind turbine. A windvane mounted on top of the nacelle provides information needed to yaw the wind turbine into the wind. The SCADA system monitors problems and diagnoses failures. If a problem causes a wind turbine to shut down, the wind turbine will either be restarted by the SCADA system operator or service personnel will perform the necessary repairs and manually restart the turbines. The wind turbine can also be controlled manually at the nacelle from a panel inside the base of the tower or from a remote computer via the SCADA system. Using the tower top control panel, the turbine can be stopped, started, and turned out of the wind.

Shadow flicker control modules will be installed on the appropriate turbines which can be programmed to shut down during periods when shadow flicker is predicted to occur to eliminate the occurrence of shadow flicker at a particular dwelling. The draft revised "*Wind Energy Development Guidelines*" (December 2019)[42] proposes that no existing dwelling or affected property should experience shadow flicker because of a wind energy development. Fitting turbines with shadow flicker control modules ensures that the proposed wind farm can comply with existing guideline thresholds and the draft revised guidelines on shadow flicker. This is detailed in Chapter 11 Shadow Flicker, in Volume II of the EIAR.

4.8.2.1 Turbine Maintenance

During the operational phase of the wind farm, the turbine manufacturer, the Developer, or a service company will carry out regular maintenance of the turbines, thereby creating at least two permanent jobs in the form of maintenance personnel or operators. Additionally, operation and monitoring activities may be carried out remotely with the aid of computers connected via a telephone broadband link. However, routine inspection and preventive maintenance visits will be necessary to ensure the efficient running of the wind farm and require a minimal presence.

There may also be a requirement for unscheduled maintenance that could include anything from resetting alarms to undertaking component changes that require a crane. Typically, maintenance traffic will consist of four-wheel drive vehicles/vans. The electricity substation components and site tracks will require periodic maintenance in accordance with appropriate operation maintenance plans, procedures and a health and safety plan.

4.8.2.2 Grid Maintenance

It is unlikely that the network of underground cables will require much maintenance during its operation, but should a fault occur, inspection of the fault can be carried out to determine what works may be required.

4.9 Description of Decommissioning Phase and Restoration

4.9.1 Wind Farm

At the end of the estimated 35-year lifespan of the proposed development, the Developer will make the decision to either repower or decommission the turbines. Any further proposals for development at the site during or after this time will be subject to a new planning permission application. If planning permission is not sought after the end of life of the turbines, the site will be decommissioned and reinstated with all 12 No. wind turbines and towers removed. Removal of infrastructure will be undertaken in line with landowner and regulatory requirements and best practice applicable at the time. The information below outlines the likely decommissioning tasks based on current requirements and best practice.

Prior to the decommissioning work, the following will be provided to Clare County Council for approval:

[42] gov.ie - Draft Revised Wind Energy Development Guidelines December 2019 (www.gov.ie) Accessed: 5th September 2023

- A plan outlining measures to ensure the safety of the public workforce and the use of best available techniques at the time; and
- A comprehensive reinstatement proposal, including the implementation of a programme that details the removal of all structures and landscaping.

If the site is to be decommissioned, cranes of similar size to those used for construction will disassemble each turbine, and the towers, blades and all components will be removed. Hardstand and turbine foundation areas will be left *in situ* and covered with soil to match existing landscape. Access tracks will be left for use by landowners.

At present it is anticipated that underground cables connecting the turbines to the proposed new substation will be cut back and left underground. The cables will not be removed if an environmental assessment of the decommissioning operation demonstrates that this would do more harm than leaving them *in situ*. This assessment will be carried out closer to commencement of the decommissioning operation so that any environmental changes incurred over the project's life can be considered.

Wastes generated during the decommissioning phase will be removed from site and disposed of at an authorised waste facility. Any materials suitable for recycling will be disposed of in an appropriate manner.

4.9.2 Grid Connection Cable

The grid cable will remain a permanent part of the national grid and therefore its decommissioning is not foreseen. If decommissioning should occur, it will involve removing the cable from the ducting but leaving the ducting and associated supporting structure in place. It is also likely the substation will remain in place and will previously have been taken charge of by the system operator after the wind farm is connected to the NEG.

4.10 Identification of Other Plans, Projects and Activities

4.10.1 Introduction

A cumulative impact arises from incremental changes caused by other past, present or reasonably foreseeable actions, together with the project. The surrounding environment is dominated by conifer plantation, agricultural land, and a quarry. A review was undertaken of relevant existing and proposed projects, activities and plans occurring in the environs of the proposal site that could act in combination with the proposed wind farm development to determine whether any potential significant cumulative effects may arise, and the results are presented in the following sections. In-combination impacts will be considered in Section 6.7, below.

The main pressures that could act in combination with the proposed wind farm development in its various phases (construction, operation and decommissioning) relate to land management. The lands at the proposed development site and within the surrounding area are mainly managed for forestry and agriculture, and to a lesser extent for wind energy, hydroelectric energy and mineral extraction.

4.10.2 Plans

The Clare County Development Plan 2023-2029 was adopted by the Elected Members of Clare County Council at a Special Meeting on 9th March 2023 and came into effect on 20th April 2023[43].

[43] Clare County Development Plan 2023-2029 | Planning, heritage and conservation | Services | Clare County Council (clarecoco.ie) Accessed: 12th December 2023

Within Volume 6 of the Development Plan (2023 – 2029) is the Clare Wind Energy Strategy which seeks to facilitate 'the development of onshore wind farms in Clare by maximising the wind resources of the County having regard to recent technological advances in turbine design, updated information on wind speeds, proximity and availability to grid connections and to changing energy and grid connection regulations, while minimising any environmental and visual impacts'[44].

4.10.3 Other Wind Energy Developments

There are just two operational wind turbines located within 25 kilometres of the proposed development site - a single turbine at Parteen, and a single turbine at Castletroy. There are, however, several other larger wind farm developments within the area that are either granted and not yet constructed (such as the 19-turbine Carrownagowan Wind Farm) or are in the planning system awaiting decision (such as the 11-turbine Oatfield Wind Farm) - refer to Table 22 and Figure 4-15, below, for full details.

Table 22. Status of wind energy developments located within 25 kilometres of proposed Ballycar Wind Farm.

Wind farm name	Status	No. of turbines	Approximate distance and direction from nearest proposed Ballycar turbine
Limerick Blow Moulding, Parteen	Operational	1	3.2 km southeast of proposal site
Oatfield[45]	Decision pending, due 24/06/24	11	4.2 km north of proposal site
Knockshanvo[46]	Submitted: 30/08/24 Decision due 14/03/25	9	5.2 km north of proposal site
Vistakon, Castletroy	Operational	1	8.2 km southeast of proposal site
Fahy Beg[47]	CCC Refused: 03/05/23 Appealed lodged: 31/05/23 ABP granted: 06/03/24	8	10.5 km northeast of proposal site
Carrownagowan	Permitted (not constructed)	19	13 km northeast of proposal site
Castlewaller	Granted: 18/04/12[48] Extension granted: 05/07/16[49] Permission expired: 22/05/22	16	20 km east of proposal site

[44] Volume 5 Clare Renewable Energy Strategy-Clare County Development Plan 2023-2029 (Interim) (clarecoco.ie) Accessed 26th June 2023
[45] An Bord Pleanála (ABP) Planning Application Number: 318782
[46] ABP Planning Application Number: 315797
[47] Clare County Council (CCC) Planning Application Number: 23148; ABP Planning Application Number: 317227
[48] Tipperary County Council (TCC) Planning Application Number: 11510251
[49] TCC Planning Application Number: 16600472

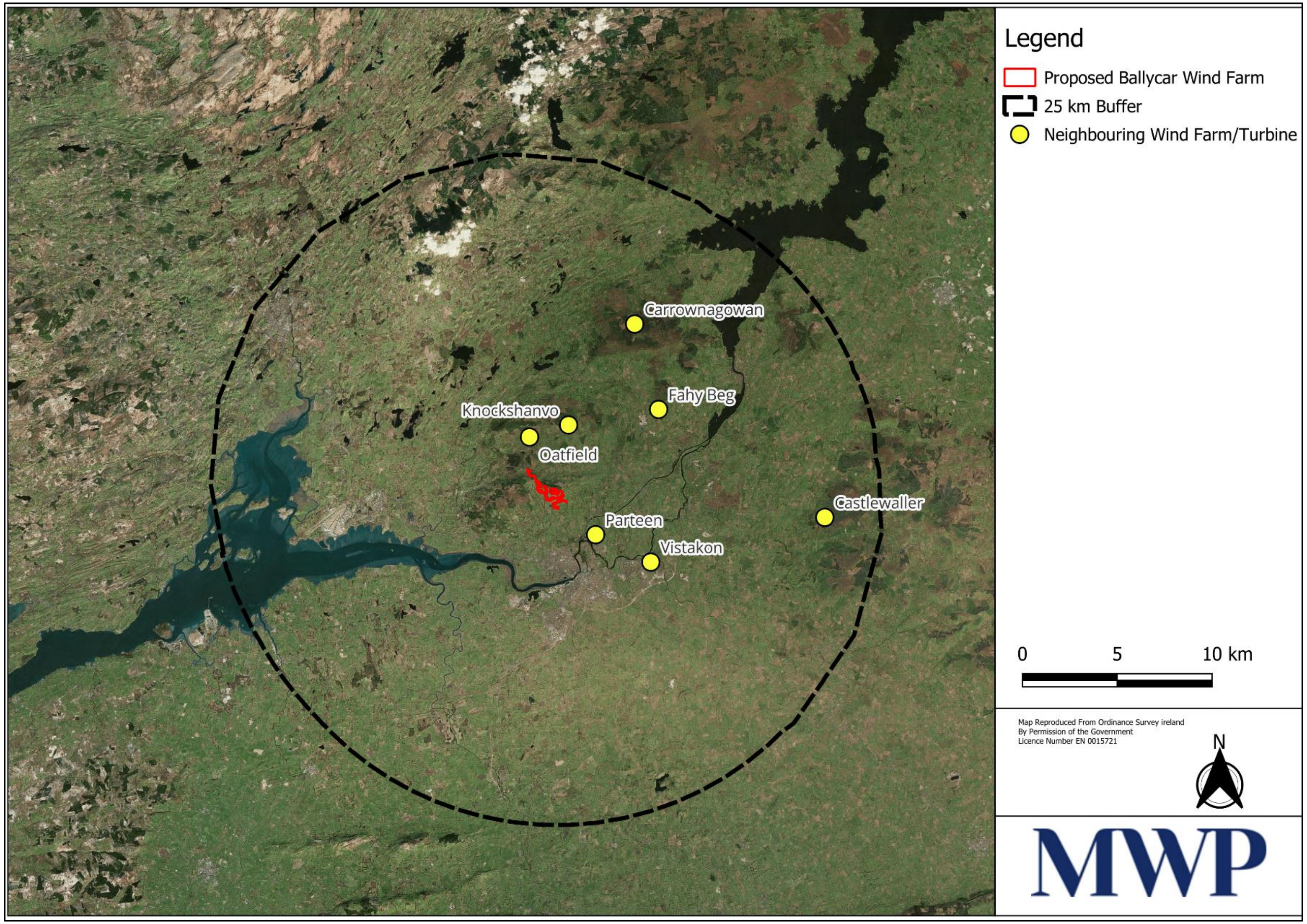

Figure 4-15: Approximate locations of other wind energy developments within 25 kilometres of the proposed Ballycar Wind Farm site.

4.10.4 Solar Energy Developments

A search of the online planning enquiry systems for Clare, Limerick and Tipperary County Councils for any granted or on-going planning applications for solar farm developments within a 25-kilometre radius of the proposed development site was undertaken on 8th December 2023. The results are summarised in **Table 23**, below.

Table 23. List of granted and/or on-going planning applications for solar energy developments within 25 kilometres of the proposed development site at Ballycar.

Planning application number	Solar Farm location	Status	Decision date	Approximate distance and direction from proposed development site
2360249	Castlebank, Drummin, Glenlon North, Glenlon South and Ballykeelaun, Co Clare.	Permitted	06/09/23	2 km east of proposal site
CCC: 2357 ABP: 316237	Castlebank, Glenlon North, Glenlon South, Drummin and Ballykeelaun, Clare.	Permitted: 03/04/23 Appealed: 14/04/23 Application withdrawn: 10/07/23	-	1.5 km east of proposal site
CCC: 22591 ABP: 316043	Ballyglass, Coolderry, Dromintobin North, Reanabrone, & Oakfield, Ardnacrusha, Co Clare.	Permitted: 17/02/23 Appealed: 14/03/23 Permitted with revised conditions	21/11/23	4.4 km northeast of proposal site
18215	Islandduane, Mungret, Co. Limerick.	Permitted	03/10/18	10.8 km southwest of proposal site
18585	Clonloghan, Caherteige, Co. Clare.	Permitted	23/08/19	14.5 km west of proposal site
22586	Ballyvonnavaum, Coolshamroge, Cloonmore, Deerpark, Manusmore, Ennis, Co Clare.	Permitted	14/04/23	18 km northwest of proposal site
20562	Manusmore, Clarecastle, Co Clare.	Permitted	12/11/20	18 km northwest of proposal site
21915	Manusmore & Carrownanelly, Clarecastle, Ennis, Co Clare.	Permitted	30/11/21	20 km northwest of proposal site
19180	Cahershaughnessy near Spancil Hill, Co Clare.	Permitted	17/08/19	22 km northwest of proposal site
19194	Knockanoura & Cranagher, Spancil Hill, Co. Clare.	Permitted	19/08/19	22 km northwest of the proposal site
171001	Lissan West, Ballaghafaddy West, Clarecastle, Co. Clare.	Permitted	06/02/19	22 km northwest of proposal site
17750	Tuogh, Cappamore, Co. Limerick.	Permitted	07/12/17	24 km southeast of proposal site

4.10.5 Other Permitted and Proposed Developments in the Locality

A search of Clare County Council's online planning enquiry system for granted or on-going planning applications for the townlands encompassed within the site boundary comprising Glennagross, Cappateemore East, Ballycannan West, Ballycannan East, Ballycar South, and Ballycar North was undertaken on 8th December 2023, the results of which are presented in **Table 24**, below.

Table 24. List of granted and/or on-going planning applications within the vicinity of the proposed development site.

Application No.	Applicant	Location	Proposed Development	Decision	Decision Date
23461	Edward Ryan	Ballycar, Ardnacrusha	To retain an agricultural structure and all associated site works.	Further information request: 19/10/23	Pending
23229	Ciaran O'Connell	Ballycar South, Ardnacrusha	Construct a cubicle house extension with slatted tank, cattle shed with slatted tank, dungstead, and ancillary works.	Further information request: 08/06/23	Due: 12/01/24
2313	Mark Manning	Glennagross, Meelick, Clare	Construct dwelling house, bored well, waste water treatment system, percolation area, entrance and all associated site works.	Conditional	25/05/23
22886	Bobby O'Connell	Ballycar South, Ardnacrusha	Renovation, alterations and extension of existing disused dwelling, upgrading of existing entrance, change of use from residential to office use, all ancillary works.	Conditional	15/03/23
21935	Bobby O'Connell	Ballycar South, Ardnacrusha	Proposed concrete batching plant, storage shed, precast concrete yard, product storage area, office/canteen, dispatch office, new site entrance, all ancillary works.	Further information request: 28/10/21	Withdrawn: 06/05/22
21454	Kieran O'Connell	Ballycar North, Sixmilebridge	Two story extension with habitable space, open shed and balcony to west, boot room to south, addition of two windows to east elevation, replacement of two windows at front with one picture window on west elevation with double doors, and replacement of two windows on south elevation with one window.	Conditional	10/08/21
CCC: 18818 ABP: 304690	Bobby O'Connell and Sons Ltd	Ballycar, Ardnacrusha	Quarrying area of 10 hectares located adjacent to existing working quarry including extraction of rock by blasting to 150m OD; Extracted rock will be processed at existing working quarry; Landscaping of quarry during operational phase and restoration of quarry on completion of extraction; All associated ancillary facilities/works.	Conditional	13/12/19
19728	Jack & Siobhán Keane	Cappateemore East, Meelick	Retain existing sunroom, all existing elevations; conversion of garage to storage room and ancillary site works.	Conditional	25/11/19
1929	Lisa Hurley	Cappateemore West, Meelick	Rebuild and extend existing burned down dwelling house and replace existing septic tank with new wastewater treatment system and percolation area along with ancillary site works.	Conditional	25/08/19

4.10.6 Environmental Protection Agency (EPA) Facilities

A review of the EPA online mapping tool[50] determined that there are no IPPC, IPC or IEL[51] facilities within the immediate vicinity of the subject site. The nearest EPA licensed facility is Longpavement Landfill (Active Waste Licence Number: W0076-01), located approximately 4.5 kilometres southwest of the proposed development site. There are two other licensed waste facilities and five active licensed Industrial Pollution Control (IPC) sites within 10 kilometres of the proposed development site, refer to **Table 25,** below.

Table 25. Licensed waste facilities and active licensed Industrial Pollution Control (IPC) sites within 10 km of the proposed development site

License type	Name	Active license number	Facility address	Approximate distance from nearest point of proposed development site
Waste	Former Racecourse	W0259-01	Greenpark, Dock Road, Limerick	6 km southwest of site
	Bunlicky	W0051-01	Limerick	6.7 km southwest of site
Integrated Pollution Control (IPC) (formerly IPPC)	Cook Ireland Ltd.	P0973-01	O' Halloran Road, National Technology Park, Limerick	5.5 km southeast of site
	Analog Devices International Unlimited Company	P0224-04	Raheen Ind. Estate, Raheen, Limerick	8.6 km southwest of site
	Adhesives Research Ireland Limited	P0452-01	Raheen Industrial Estate, Raheen, Limerick	9.5 km south of site
	James McMahon Limited	P0329-01	Corcanree, Dock Road, Limerick	5.4 km southwest of site
	IMAG Optical Storage Limited	P0265-01	MC Infonics Ireland Limited, Raheen Industrial Estate, Limerick	9.2 km south of site

Within 10 kilometres of the proposed development site, there are twelve Industrial Emissions Licence (IEL) facilities located within and around Limerick City and listed in **Table 26**, below.

Table 26. Industrial Emissions Licenced (IEL) facilities located within 10 km of proposed development site.

Facility name	Active license number	Facility address	Approximate distance from nearest point of proposed development site
Stabright Limited	P0356-01	Clondrina, Ennis Road, Limerick	4.5 km southwest of site
Limerick Gasworks	W0281-01	Dock Road, Limerick	5.3 km south of site
Galvotech Ireland Limited	P0291-01	Unit 15/16, Childers Road Industrial Estate, Childers Road, Limerick	5.7 km southeast of site
Johnson & Johnson Vision Care Ireland Unlimited Company	P0818-04	National Technology Park, Plassey, Limerick	6.4 km southeast of site

[50] EPA Maps Accessed: 19th December 2022
[51] Integrated Pollution Control (IPC) Licence (formerly IPPC Licence), and Industrial Emissions Licence (IEL)

Facility name	Active license number	Facility address	Approximate distance from nearest point of proposed development site
J.H. Roche and Sons Limited	P1048-02	Roche's Feeds, Dock Road, Limerick	5.8 km southwest of site
Starrus Eco Holdings Limited (Dock Road)	W0082-03	Ballykeefe Townland, Waste Management Section, Dock Road, Limerick	6.2 km southwest of site
Valcroft Unlimited Company	P1136-01	Dock Road, Bunlicky, Limerick	6.4 km southwest of site
Irish Cement Limited (Limerick)	P0029-06	Castlemungret, Limerick	7.5 km southwest of site
Verbatim Ltd	P0036-02	Raheen Industrial Estate, Raheen, Limerick	8.5 km southwest of site
Howmedica International S.de R.L. Trading as Stryker Orthopaedics	P0023-03	Raheen Business Park, Raheen, Limerick	8.8 km southwest of site
Regeneron Ireland Designated Activity Company	P0991-02	Regeneron Ireland, Raheen Business Park, Raheen, Limerick	9.2 km south of site
Zinc Processors Limited Trading as Shannonside Galvanizing	P0650-03	Four Elms, Drombana, Limerick	9.4 km southeast of site

There are eleven urban wastewater treatment plants (UWWTP) located within the Lower Shannon (25D) Catchment and thirteen within the Shannon Estuary North (27) Catchment - details of the ten closest to the proposal site are listed in **Table 27,** below, along with approximate distances and locations.

Table 27. Summary of the ten urban wastewater treatment plants within the Lower Shannon (25D) Catchment and the Shannon Estuary North (27) located closest to the proposed development site.

Facility name	Facility type[52]	Active license number	WFD Catchment	Approximate distance and location from proposed development site
Castletroy	> 10,000 p.e.	D0019-01	Lower Shannon	4.1 km southeast of site
Sixmilebridge	2,001 to 10,000 p.e.	D0076-01	Shannon Estuary North	6.3 km west of site
Kilkishen	500 to 1,000 p.e.	D0420-01	Shannon Estuary North	9.2 km northwest of site
Shannon Town	> 10,000 p.e.	D0045-01	Shannon Estuary North	11.4 km southwest of site
Newport	2,001 to 10,000 p.e.	D0325-01	Lower Shannon	12.8 km east of site
Newmarket on Fergus	2,001 to 10,000 p.e.	D0079-01	Shannon Estuary North	15.2 km northwest of site
Caherconlish	1,001 to 2,000 p.e.	D0308-01	Lower Shannon	15.5 km southeast of site
Tulla	1,001 to 2,000 p.e.	D0320-01	Shannon Estuary North	15.5 km northwest of site
Murroe	1,001 to 2,000 p.e.	D0306-01	Lower Shannon	16.2 km southeast of site
Ballina	2,001 to 10,000 p.e.	D0189-01	Lower Shannon	17 km northeast of site

[52] Defined using population equivalent value (p.e.)

There are also several smaller sewage treatment plants within the area that treat sewage produced by less than 500 people. The nearest two such plants are 'Ballycannon' (Reg No. A0081-01) located approximately 0.8 kilometres south of the proposed development site, and 'Brookhaven, Montpelier' (Reg No. A0499-01) located 9.7 kilometres to the northeast. Ballycannon has a plant design capacity of 279 with an agglomeration p.e. of 188 while Brookhaven, Montpelier has a plant design capacity of 50 with an agglomeration p.e. of 49.

4.10.7 Existing Land-use and On-going Activities

Agriculture and forestry are the chief land-use activities in both the Shannon Estuary North (27) and Lower Shannon (25D) Catchments that could act in combination with the proposed project to negatively affect water quality. Other land-uses include peat/mineral extraction, village settlements, one-off housing, and urban settlements such as Limerick City, Ennis, Sixmilebridge, Clarecastle and Kilrush.

The WFD (2016–2021) ecological status of the Crompaun (East)_010 Waterbody, which includes the Cappateemore East Stream and the Crompaun (East) River, is 'At risk'[53] with a water quality status of 'Poor'. The main pressures within the subcatchment are channelisation, forestry, embankments, wastewater discharge and agriculture (EPA, 2022a). To the east of the site, the North Ballycannan_010 Waterbody is also categorised as 'At risk' with a water quality status of 'Good' (2016-21) and includes the East Ballycannan Stream and the North Ballycannan River. Agriculture and forestry, and particularly the excess sedimentation they create, are the main waterbody pressures within this subcatchment (EPA, 2022b). Refer to **Figure 4-16**, below.

[53] *At risk* - either the waterbody is currently not achieving its WFD environmental objective of Good or High Ecological Status or that there is an upward trend in nutrients/ammonia and if this trend continues the waterbody Status will decline by the end of Cycle 3 and will fail to meet its environmental objective (EPA, 2021a).

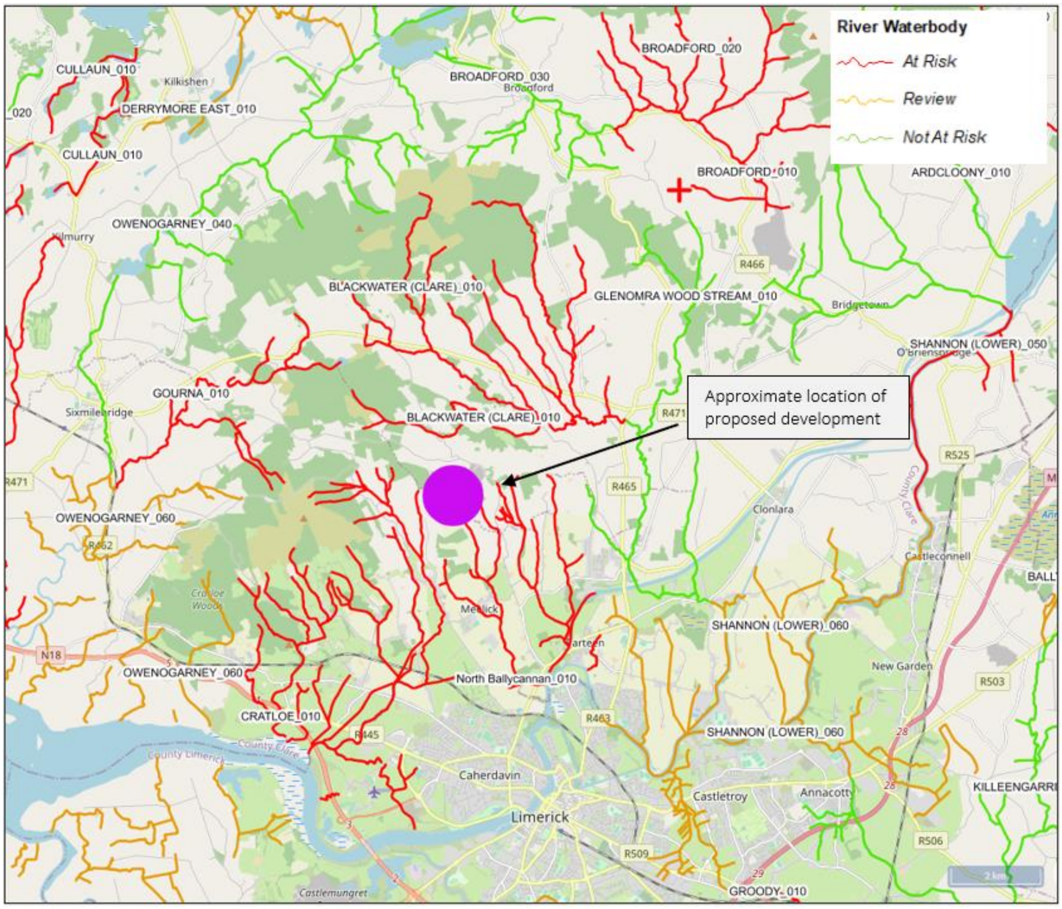

Figure 4-16: Risk status of waterbodies within the immediate vicinity of the proposed development site [adapted from EPA Maps].

Excessive nutrient loss and alteration of the hydromorphological regime is an ongoing issue for many waterbodies in surrounding sub-catchments due to the combined pressures of agricultural practices and forestry. Other significant pressures impacting waterbodies within both catchments include domestic wastewater, mines and quarries, urban wastewater/run-off and industry (EPA, 2021a; 2021b).

Within the Lower Shannon Catchment (25D), 38% of river waterbodies are classified as ‘At risk’ of not meeting their water quality objectives and 10% are in ‘Review’. Excess nutrient levels and morphological impacts are the most prevalent issues, affecting 21% and 23% of the catchment’s river waterbodies, respectively. Other significant issues impacting waterbodies within the catchment include sediment pollution, hydrological impacts, and chemical pollution (EPA, 2021a). Within the Shannon Estuary North Catchment (27), 48% of river waterbodies are classified as ‘At risk’ of not meeting their water quality objectives and 22% are in ‘Review’, while 23% of lake waterbodies within the catchment are labelled ‘At risk’. Nutrient pollution and morphological impacts are also the main issues effecting waterbodies within the Shannon Estuary North Catchment (27), affecting 32% and 30%, respectively, of the river waterbodies within the catchment. Other significant issues for the catchment’s rivers included sediment pollution, hydrological impacts and organic pollution (EPA, 2021b). Refer to maps of each catchment in Figure 4-17, below.

O’Connell Quarries (Register Number: QS0797) is located approximately 0.3 kilometres north of the proposed development site’s northeast corner. This operational commercial quarry extracts and processes rock and produces ready-mix concrete. A planning application was submitted by the operator for the construction of a concrete products manufacturing facility on adjacent lands east of the existing quarry (Planning Ref No. 21935), however, the application was withdrawn on 6th May 2022 – see Table 24, above.

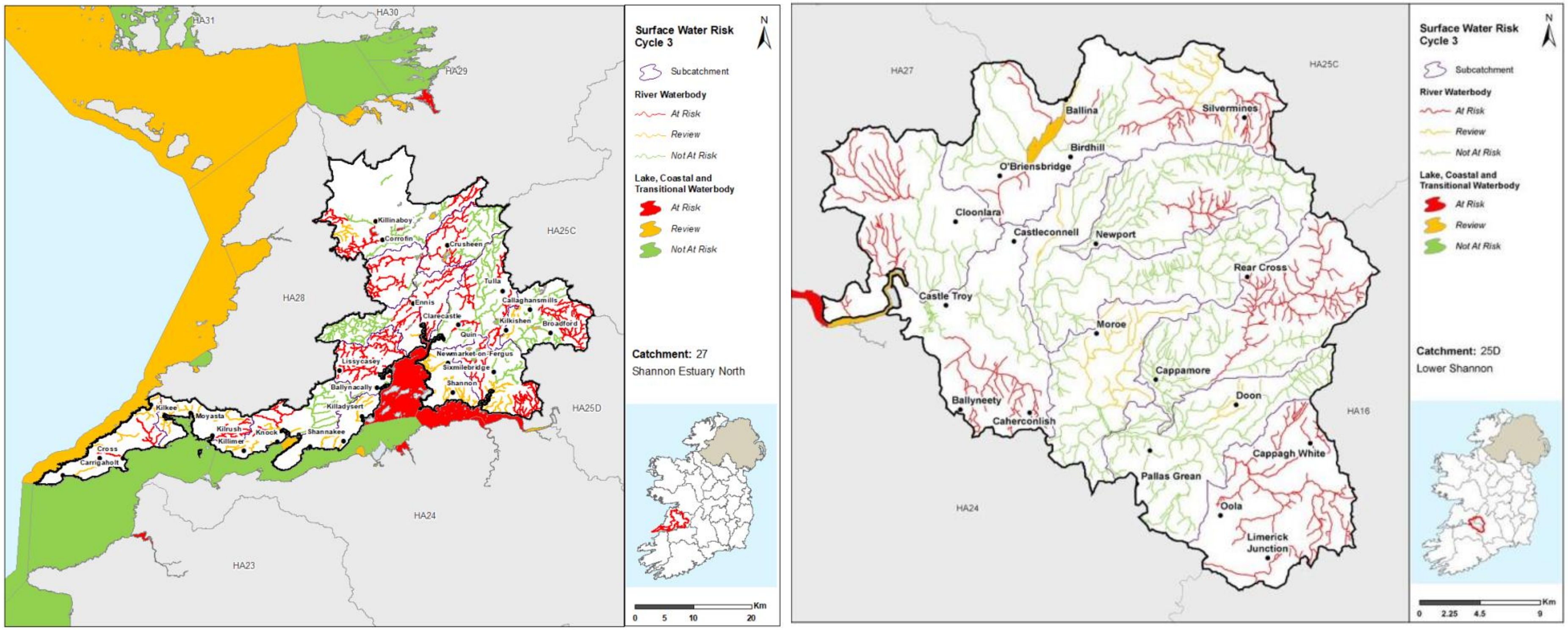

Figure 4-17: Risk status of waterbodies within the Shannon Estuary North Catchment (27) (left) and Lower Shannon Catchment (25D) (right) of not meeting water quality objectives (adapted from EPA, 2021b; EPA, 2021a, respectively).

4.10.8 Hydromorphology and Drainage

After agriculture, the most significant pressure to watercourses within the Shannon Estuary North (27) and Lower Shannon (25D) Catchments is hydromorphological modification due to the presence of drainage schemes that have created high levels of siltation (EPA, 2021b). Practices intended to improve the land for agricultural purposes and prevent flooding, such as the deepening of drains and channelisation, can change the morphological character of watercourses and result in an alteration of flows and substrate composition. Impacts to water quality resulting from dams, barriers, locks, weirs, bank erosion and embankments have also been noted within both catchments (EPA, 2021a). These hydromorphological changes to drainage channels in the area may act in combination with the proposed project to negatively affect water quality of watercourses and/or physically alter their integrity.

4.10.9 Climate Change

Climate change is an important environmental influence on ecosystems. Changing climate affects ecosystems in a variety of ways and could act in-combination with the project.

4.10.10 Potential for Significant In-combination Effects

It is considered that agriculture, forestry, on-going and future potential quarrying operations and to a lesser extent one-off rural residential developments comprise the land-uses and activities which could potentially interact synergistically with the proposed development to result in significant cumulative or in-combination effects.

The potential in-combination effects are discussed further in **Section 6.7,** below.

5. Identification of Potential Effects

Potential likely direct, indirect or secondary ecological impacts arising from the proposed development (either alone or in combination with other plans or projects) are identified in **Table 28** and **Table 29**, below.

Table 28. Description of elements of the project likely to give rise to potential ecological impacts.

Construction Phase
▪ Excavations, clear felling, ground moving, and heavy engineering required to construct windfarm tracks & hardstands, sub-station, underground cabling, grid connection, surface water drainage system, permanent met mast, buildings & fencing. ▪ Machinery: The presence and sustained use of heavy and light plant machinery on site, albeit at variable rates and numbers, during daylight hours for the duration of the works. ▪ Use of fuels/oils/lubricants, concrete and other such substances considered harmful to the aquatic environment. ▪ Human presence: Sustained increase in human activity, albeit at variable rates and numbers, during daylight hours for the duration of the works. ▪ Increased noise and air emissions associated with construction activity. ▪ Erection of turbines. Introduction of large physical structures in a previously unoccupied/uninterrupted air space. ▪ Temporary storage of excavated spoil. ▪ Permanent deposition of excavated spoil at specific areas on site. ▪ Temporary site compound, local road widening. ▪ Temporary surface water flow management systems for specific engineering elements at various locations.
Operational Phase

▪ Operation of wind turbines at 12 locations (rotation of turbine blades). ▪ Operation of substation. ▪ Operational maintenance works. ▪ Human presence (wind farm staff).	
Decommissioning Phase	
▪ Decommissioning of wind farm infrastructure including excavation and heavy engineering works, ground moving, use of machinery, temporary storage of spoil, temporary site drainage. ▪ Increased human activity, increased noise and air emissions. ▪ Permanent disassembly and removal of wind farm components including turbines. ▪ Permanent disposal and storage of excavated materials. ▪ Temporary site compound.	

Table 29. Description of potential direct, indirect or secondary ecological impacts of the construction, operational and decommissioning phases (either alone or in combination with other plans or projects).

Describe any likely direct, indirect or secondary ecological impacts of the project (either alone or in combination with other plans or projects) by virtue of: o *Size and scale* o *Land-take* o *Distance from Natura 2000 Site or key features of the Site* o *Resource requirements* o *Emissions* o *Excavation requirements* o *Transportation requirements* o *Duration of construction, operation etc.* o *Other.*	**Construction Phase** ▪ There is no spatial overlap between the subject site and any Natura 2000 site; therefore, there will be no direct habitat loss/alteration/land-take from within any Natura 2000 site. ▪ There will be loss and direct alteration of habitats (comprising mainly mature conifer forestry and agricultural grassland) within the construction footprint and because of spoil deposition. ▪ Potential for direct species disturbance/displacement impacts due to construction activity including fugitive noise emissions from machinery, human activity. ▪ The subject site is hydrologically connected to two European sites - Lower River Shannon SAC [002165] and the River Shannon and River Fergus Estuaries SPA [004077] - via watercourses draining the site. ▪ Potential for water quality impacts through erosion and run-off of silt, and/or ingress of fuels/oils, cementitious material, or other such substances via overland flow and/or the existing/proposed drainage network to local watercourses and estuarine waters of River Shannon into which they drain. ▪ Potential for groundwater contamination via spillage of oils/fuels/chemicals. ▪ Potential for indirect alteration of habitats outside of but hydrologically linked to the development site. ▪ Potential for indirect species disturbance/displacement due to *in-situ* or *ex-situ* habitat loss/alteration impacts, impairment of water quality and/or impacts on prey availability. ▪ Potential for spread of invasive alien species. **Operational Phase** ▪ Risk of bird mortality through collision or interaction with turbine blades or other wind farm infrastructure. ▪ Potential for species disturbance and displacement (indirect habitat loss) due to operation and on-going maintenance of wind turbines and substation. ▪ Potential for species displacement because of 'barrier effects' whereby birds are deterred from using normal routes to access breeding, foraging or roosting habitats elsewhere. For example, behavioural responses to the presence of turbines could cause some species to stop using or reduce their use of foraging grounds in proximity to the turbine envelope. ▪ Potential for water quality impacts through erosion and silt run-off, and/or ingress of fuels/oils via overland flow and/or the drainage network to local watercourses and estuarine waters of River Shannon into which they drain. ▪ Potential for groundwater contamination via spillage of oils/fuels/chemicals.

	▪ Potential for indirect alteration of habitats outside of but hydrologically linked to the development site. ▪ Potential for indirect species disturbance/displacement due to impairment of water quality and/or impacts on prey availability.
	Decommissioning Phase
	▪ Potential for water quality impacts, as above. ▪ Potential for groundwater contamination, as above. ▪ Potential for direct species disturbance/displacement due to fugitive noise emissions associated with disassembly and/or removal of wind farm components and human activity. ▪ Potential for indirect alteration of habitats outside of but hydrologically linked to the development site. ▪ Potential for indirect species disturbance/displacement due to impairment of water quality and/or impacts on prey availability. ▪ Potential for spread of invasive alien species.

6. European Sites Selected for Further Assessment

6.1 Stage 1 of the Appropriate Assessment Process

To establish which European sites are located within the ZOI, the Source-Pathway-Receptor (SPR) model was applied during the screening stage of AA, since according to the Office of the Planning Regulator guidelines (OPR, 2021), 'a European site will only be at risk from likely significant effects where the Source-Pathway-Receptor link exists between the proposed development and the European site'.

The SPR model firstly considered the nature, size and location of the proposed development and identified characteristics that may provide a source of direct (e.g. water, habitat loss) or indirect (e.g. collision risk, impact to prey species of a QI) ecological impacts. Secondly, any pathways (e.g. watercourses) linking the proposed development site to the European sites were identified before, finally, 'the location, nature and sensitivities of the qualifying species/habitats, the ecological conditions underpinning their survival, and the conservation objectives specified to maintain or restore favourable conservation status' were established (OPR, 2021).

Following this, in view of best scientific knowledge, an assessment was made to ascertain whether the proposed development, individually or in combination with other plans/projects, was likely to have a significant effect on the European sites in view of the sites' conservation objectives. It could not be objectively concluded during the screening stage of AA for the proposed construction, operation and decommissioning of a 12-turbine wind farm at Ballycar in County Clare that significant effects on two European sites listed in **Table 30**, below, could be ruled out. It was, therefore, advised that the project proceed to Stage 2 of the AA process and an NIS be produced.

The Screening for Appropriate Assessment Report is included in **Appendix 1** of this report.

Table 30. European sites included for Stage 2 Appropriate Assessment.

Designated site & Code	Approximate distance of designated site to nearest point of subject site	Hydrological/Ecological connection?
Lower River Shannon SAC (002165)	Located 1 km to southeast (46 m southeast of temporary road works at R464 / L3056 junction)	Yes (1.6 rkm downstream from WC6 and WC7)
River Shannon and River Fergus Estuaries SPA (004077)	Located 4.4 km to southwest (3.1 km south of temporary road works at R464 / L3056 junction)	Yes (6.6 rkm downstream from WC1)

Identifying a risk that could, in theory, cause an impact does not automatically mean that the risk event will occur or that it will cause or create an adverse impact. However, identification of the risk does mean that there is a latent possibility of ecological or environmental damage occurring, with the level and significance of the impact depending upon the nature of the risk, the extent of the exposure to the risk and the characteristics of the receptor. Therefore, bearing in mind the scope, scale, nature and size of the project, its location relative to the distribution of the species and habitats listed, and the degree of connectedness that exists between the project and potential receptors, it is considered that not all are within the zone of potential impact of the proposal.

An evaluation based on these factors to determine which species and habitats are the plausible ecological receptors for potential impacts of the unmitigated proposal has been conducted in **Section 6.2.2** and **Section 6.3.2,** below, for the proposed development in County Clare. This evaluation determined the specific qualifying features of the SAC and SPA (listed below in **Table 31** and **Table 32,** respectively), that should be selected for further assessment as plausible ecological receptors.

6.2 Lower River Shannon SAC [002165]

6.2.1 Description of the European Site

The following text summarises the Natura 2000 Standard Data Form for the site[54]. Refer to **Figure 6-1**, below.

The Lower River Shannon SAC is a large, narrow site that measures approximately 14 kilometres wide and 120 kilometres long. It encompasses the Shannon River Estuary, the broader River Fergus Estuary and several smaller estuaries such as Poulnasherry Bay along with the freshwater lower reaches of the Shannon River between Killaloe and Limerick and some freshwater stretches within the Feale and Mulkear catchments. The SAC also includes a marine area at the mouth of the Shannon estuary with high rocky cliffs to the north and south; ericaceous heath on Kerry Head and Loop Head; and several lagoons. Refer to **Figure 6-1**, below.

The underlying geology ranges from Carboniferous limestone (east of Foynes) to Namurian shales and flagstones (west of Foynes) to Old Red Sandstone (at Kerry Head). The ebb and flood of the tide and annual seasonal rainfall fluctuations ensure that the salinity of the system varies daily.

The Lower River Shannon SAC contains many Annex I habitats including the most extensive area of estuarine habitat in the country. A wide range of Annex II species are also present within the SAC including all three Irish species of lamprey, a good population of Atlantic salmon, and the only known resident population of Common bottlenose dolphin in Ireland. Many bird species listed on the EU Birds Directive either winter or breed at the site. The site is internationally important for waterfowl with more than 50,000 individuals occurring in winter. Several plant species listed in the Irish Red Data Book are also found within the SAC including two species of stonewort (*Chara canescens* and *Chara cf. connivens*) at Shannon Airport Lagoon, and the only known Irish populations of triangular club-rush (*Scirpus triqueter*).

The Lower River Shannon SAC is designated for the protection of the following qualifying features of conservation interest:

<u>Habitats</u>

- Sandbanks which are slightly covered by sea water all the time [1110];
- Estuaries [1130];
- Mudflats and sandflats not covered by seawater at low tide [1140];
- Coastal lagoons [1150];
- Large shallow inlets and bays [1160];

[54] N2K IE0002165 dataforms (europa.eu) Accessed: 6th June 2023

- Reefs [1170];
- Perennial vegetation of stony banks [1220];
- Vegetated sea cliffs of the Atlantic and Baltic coasts [1230];
- *Salicornia* and other annuals colonising mud and sand [1310];
- Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) [1330];
- Mediterranean salt meadows (*Juncetalia maritimi*) [1410];
- Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation [3260];
- *Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*) [6410]; and
- Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*) [91E0].

<u>Species</u>

- Margaritifera margaritifera (Freshwater Pearl Mussel) [1029];
- Petromyzon marinus (Sea Lamprey) [1095];
- Lampetra planeri (Brook Lamprey) [1096];
- Lampetra fluviatilis (River Lamprey) [1099];
- Salmo salar (Salmon) [1106] (QI status pertains only to freshwater phases of life cycle);
- Tursiops truncatus (Common Bottlenose Dolphin) [1349]; and
- Lutra lutra (Otter) [1355].

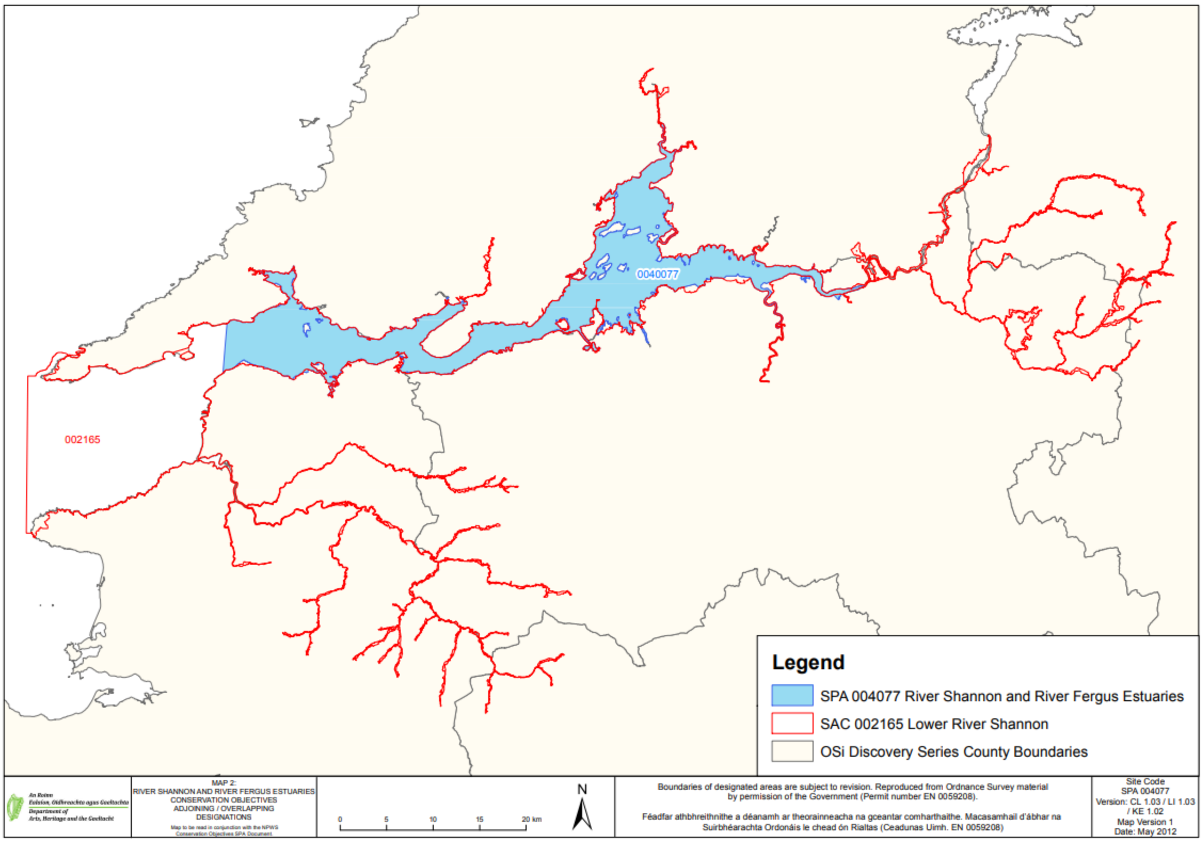

Figure 6-1: Extent of Lower River Shannon SAC (002165) and River Shannon and River Fergus Estuaries SPA (004077) (adapted from NPWS, 2012c).

6.2.2 Identification of Potentially Significant Impacts to Qualifying Features

Table 31, below, lists the qualifying features of the Lower River Shannon SAC and evaluates through a scientific examination of evidence and data whether these features should or should not be selected for further assessment in the NIS.

Table 31. Selection of qualifying features of the Lower River Shannon SAC (002165) for impact assessment

Qualifying features	Potential for significant impacts	Rationale
Sandbanks which are slightly covered by seawater all the time [1110]	No	The likely extent of sandbanks within the SAC has been mapped as south of Rinevella Point, Co. Clare and west of Ballybunion, Co. Kerry within the mouth of the Shannon Estuary (NPWS, 2012b), over 70 km from the proposed development site. Given the intervening distance between the proposal site and this marine/coastal habitat, it is considered that the project does not have potential for significant effects on sandbanks. The Shannon Estuary is approximately 45 km long and is well-connected to the Atlantic Ocean, meaning that exchange rates of water within the estuary can be expected to be very high with an almost constant movement of water into and out of the estuary. Any change to the water quality of the watercourses draining into the estuary from the proposed development site would be considered imperceptible/undetectable given the volumes of freshwater entering the estuary (from Rivers Shannon, Maigue, Fergus, and Deel) at each low tide, and the volume of saline/brackish water filling the estuary on each flooding tide. Thus, the project will not affect the conservation objectives for 'sandbanks which are slightly covered by seawater all the time' and the habitat is not considered further in the NIS.
Estuaries [1130]	**Yes**	The extent of the estuary has been mapped as occurring eastwards from Carrig Island on the southern shores of the Shannon Estuary to Aylevarroo Point on the northern shore (NPWS, 2012b). Distribution mapping for the SAC shows the closest estuarine habitat to the proposed development site is located approximately 4.2 river km downstream from WC6 and WC7 (refer to **Figure 4-4** and **Table 20**, above, for watercourse crossing locations). Additionally, via the existing drainage network at the site, there is an indirect hydrological connection to mapped estuarine habitat located approximately 3.6 river km downstream from the proposed development boundary adjacent to the North Ballycannan River at T12. Surface water drainage from all parts of the proposed wind farm site eventually drains into the Shannon Estuary. The boundary of the SAC is approximately 46 m from the temporary works at the junction of the R464 and L3056. Although the very high exchange rates of water within the estuary are noted, and it is considered that any potential water quality impacts during the construction phase will be localised in view of the nature, extent and scale of the proposed works, a precautionary approach will be taken due to the hydrological link and relatively short distance between the proposal site and the QI downstream. Therefore, the potential for significant impacts to occur cannot be ruled out and 'Estuaries' will be considered further in the NIS.

Qualifying features	Potential for significant impacts	Rationale
Mudflats and sandflats not covered by seawater at low tide [1140]	**Yes**	Both the Fergus and inner Shannon Estuaries feature vast expanses of intertidal mudflats. Within the SAC, mudflats are mapped as occurring south of Ballybunion at Bunaclugga Bay, Querrin Point and Poulnasherry Bay. Other areas of mudflats occur further east within the estuary channel at Limerick City (NPWS, 2012b). The closest area of this habitat to the proposed development site is located approximately 7.7 river km downstream from WC6 and WC7 (refer to **Figure 4-4** and **Table 20**, above). Additionally, via the existing drainage network at the site, there is an indirect hydrological connection to mapped mudflat/sandflat habitat located approximately 6.9 river km downstream from the proposed development boundary adjacent to the North Ballycannan River at T12. Surface water drainage from all parts of the proposed wind farm site eventually drains into the Shannon Estuary. The boundary of the SAC is approximately 46 m from the temporary works at the junction of the R464 and L3056. While it is considered that any potential water quality impacts during the construction phase will be localised in view of the nature, extent and scale of proposed works, a precautionary approach will be taken due to the hydrological link and relatively short distance between the proposal site and the QIs downstream. Therefore, the potential for significant impacts to occur cannot be ruled out and 'Mudflats and sandflats not covered by seawater at low tide' will be considered further in the NIS.
Coastal lagoons [1150]	No	There are four coastal lagoons within the SAC, namely Quayfield and Poulaweala Loughs, Shannon Airport Lagoon, Scattery Lagoon, and Cloonconneen Pool (NPWS, 2012b). Coastal lagoons are areas of shallow, coastal salt water, wholly or partially separated from the sea by sandbanks, shingle or rocks. Given the intervening distance of almost 30 river km between the proposed development site and the nearest area of this habitat at Shannon Airport, and as this habitat type is confined to coastline above the high tide mark and is therefore outside the zone of influence of any potential impact arising from the proposed wind farm construction/operation, there will not be a significant impact to 'coastal lagoons' and this habitat type is not considered further in the NIS.
Large shallow inlets and bays [1160]	No	The habitat 'large shallow inlets and bays' is a large physiographic feature that may wholly or partly incorporate other Annex I habitats including reefs, sandbanks and mudflats and sandflats within its area. In contrast to estuaries, large shallow inlets and bays have limited freshwater influence. The site supports an excellent example of a large shallow inlet and bay. Littoral sediment communities in the mouth of the Shannon Estuary occur in areas that are exposed to wave action and in areas extremely sheltered from wave action (NPWS, 2012b). The entire mouth of the Shannon Estuary extending eastwards as far as Carrig Island is mapped as large shallow inlets and bays. This habitat, with an estimated area of approximately 25,000 ha, is mapped as occurring west of Shannon towards the mouth of the estuary and more than 45 km west of the proposed development site. Given the intervening distance between the proposal and this habitat, in conjunction with very high exchange rates of water within Shannon Estuary, it is considered that

Qualifying features	Potential for significant impacts	Rationale
		the project does not have potential for significant effects on this habitat. Thus, the project will not affect the conservation objectives for 'large shallow inlets and bays' and the habitat is not considered further in the NIS.
Reefs [1170]	**Yes**	The intertidal reefs in the Shannon Estuary are exposed or moderately exposed to wave action and subject to moderate tidal streams. The infralittoral reefs range from sloping platforms with some vertical steps, to ridged bedrock with gullies of sand between the ridges, to ridged bedrock with boulders or a mixture of cobbles, gravel and sand. The communities found are tolerant to sand scour and tidal streams. 'Reefs' occur throughout the estuary, mainly as scattered and isolated pockets within the inner estuary and covering extensive areas at the mouth of the Shannon Estuary (NPWS, 2012b). A review of available mapping determined that there are numerous small patches of reefs located to the eastern extent of the estuary towards Limerick City. Furthermore, the Annex I habitat 'Estuaries [1130]' 'may wholly or partly incorporate other Annex I habitats including reefs…. within its area' (NPWS, 2012e). Consequently, and since there is a hydrological link between the proposal site and the downstream reefs habitat, the potential for significant impacts to occur cannot be ruled out at this stage so 'Reefs' are to be considered further in the NIS.
Perennial vegetation of stony banks [1220]	No	This habitat type occurs along the coast where shingle (cobbles/pebbles) and gravel have accumulated to form elevated ridges or banks above the high tide mark. This habitat is mapped as occurring in nine locations along the Shannon River and Estuary scattered throughout the hard coastline of the River Shannon (NPWS, 2012b). The nearest area of this habitat to the proposal site occurs at Ballymacrinan Bay, more than 53 km to the west. Given the characteristics of the project and distance intervening, it is not considered that the proposal has any potential to significantly impact on this habitat-type. Thus, the project will not affect the conservation objectives for 'perennial vegetation of stony banks' and the habitat is not considered further in the NIS.
Vegetated sea cliffs of the Atlantic and Baltic coasts [1230]	No	Vegetated sea cliffs are steep slopes fringing hard or soft coasts, created by past or present marine erosion, and supporting a wide diversity of vegetation types with variable maritime influence. Most of the designated site west of Kilcredaun Point/Kilconly Point is bounded by high rocky sea cliffs, including Kilclogher, Loop Head, Ballybunion and Kerry Head. Cliff-top vegetation usually consists of either grassland or maritime heath. The boulder clay cliffs further up the estuary tend to be more densely vegetated (NPWS, 2012b). The nearest area of this habitat to the proposed development site occurs at Burrane, more than 48 km to the west. Given the characteristics of the project and the distance intervening, it is not considered that the proposal has any potential to significantly impact on this habitat-type. Thus, the project will not affect the conservation objectives for 'Vegetated sea cliffs of the Atlantic and Baltic coasts' and the habitat is not considered further in the NIS.

Qualifying features	Potential for significant impacts	Rationale
Salicornia and other annuals colonising mud and sand [1310]	No	This is a coastal habitat where pioneer salt-marsh vegetation colonises intertidal mud and sandflats in areas protected from strong wave action. It is an important precursor to the development of more stable saltmarsh vegetation and develops at the lower reaches of saltmarshes where the vegetation is frequently flooded by the tide. Within Lower River Shannon SAC the areas of *Salicornia* habitat are limited (NPWS, 2012b). A review of habitat mapping and supporting document available for the SAC determined that of the ten sub-sites surveyed as part of the Saltmarsh Monitoring Project (McCorry & Ryle, 2009) the closest occurring area of *Salicornia* habitat is the 'Inishdea, Owenshere' sub-site, located 25 km west of the proposed development site. Within the sub-site, *Salicornia* habitat is not well-developed occupying a single patch of ground of 0.003 ha (NPWS, 2012b). Given the characteristics of the project including the nature, extent and scale of the proposed works, and the distance intervening, it is not considered that the proposal has any potential to significantly impact on this habitat-type. Thus, the project will not affect the conservation objectives for '*Salicornia* and other annuals colonising mud and sand' and the habitat is not considered further in the NIS.
Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) [1330]	No	'Atlantic salt meadows' (ASM) generally occupy the widest part of the saltmarsh gradient and develop when halophytic vegetation colonises soft intertidal sediments of mud and sand in areas protected from strong wave action. This vegetation forms the middle and upper reaches of saltmarshes where tidal inundation still occurs but with decreasing frequency and duration. A review of habitat mapping and the SAC's coastal habitats supporting document determined that of the ten sub-sites surveyed for the Saltmarsh Monitoring Project (SMP) (McCorry & Ryle, 2009), the closest mapped area of ASM habitat is the 'Bunratty' sub-site (SMP code: 0081) (NPWS, 2012b). 'Bunratty' saltmarsh is located within the upper part of the Shannon Estuary in Co. Clare, approximately 9.5 km southwest of the proposal area. ASM is the dominant saltmarsh habitat at the site and measures approximately 27 ha. Typically, it occurs within this sub-site as a narrow band at the landward side of the brackish vegetation. Given the characteristics of the project including the nature, extent and scale of the proposed works, and the distance intervening, it is not considered that the proposal has any potential to significantly impact upon this habitat-type. Thus, the project will not affect the conservation objectives for 'Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)' and the habitat is not considered further in the NIS.

Qualifying features	Potential for significant impacts	Rationale
Mediterranean salt meadows (*Juncetalia maritimi*) [1410]	No	'Mediterranean salt meadows' (MSM) occupy the upper zone of salt marshes and usually occur adjacent to the boundary with terrestrial habitats. They are widespread on the Irish coastline; however, they are not as extensive as Atlantic salt meadows. This habitat includes salt marshes in the Mediterranean basin dominated by *Juncus* (rushes), especially *Juncus maritimus* (sea rush) tolerant of saline soils. Although Mediterranean salt meadows are more restricted in their distribution and size, a review of habitat mapping and the coastal habitats supporting document available for the SAC determined that of the ten sub-sites surveyed, mapped and assessed as part of the Saltmarsh Monitoring Project (SMP) (McCorry & Ryle, 2009), the closest occurring area of MSM habitat is mapped as the 'Bunratty' sub-site (SMP code: 0081) (NPWS, 2012b). 'Bunratty' saltmarsh is located within the upper part of the Shannon Estuary, approximately 9.5 km southwest of the proposal area. MSM is not particularly well developed at this site and is confined to narrow, fragmented patches. With an area measuring approximately 0.87 ha, MSM represents less than 0.2% of the total marsh area surveyed (McCorry & Ryle, 2009). Given the characteristics of the project including the nature, extent and scale of the proposed works, and the distance intervening, it is not considered that the proposal has any potential to significantly impact on this habitat-type. Thus, the project will not affect the conservation objectives for 'Mediterranean salt meadows (*Juncetalia maritimi*)' and it is not considered further in the NIS.
Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation [3260]	**Yes**	This annexed habitat has a broad definition, covering from upland, flashy, oligotrophic, bryophyte- and algal-dominated rivers, to tidal reaches dominated by higher plants. Floating river vegetation characterised by species of water-crowfoot (*Ranunculus* spp.), pondweeds (*Potamogeton* spp.) and the moss *Fontinalius antipyretica* are present throughout the major river systems within the site. In Ireland, this particular sub-type is associated with tidal reaches of rivers and other periodically disturbed watercourses (e.g. canals and drains) (NPWS, 2012b). Since the full distribution of this habitat and its sub-types within the SAC is currently unknown, a precautionary approach will be taken. The watercourse crossings, the closest of which is 1.6 river km upstream of the SAC (see **Figure 4-4** and **Table 20**, above), create several hydrological links between the proposed development site and the SAC. Additionally, the existing drainage network at the site empties into watercourses that ultimately merge with the SAC, thereby creating an indirect hydrological connection between the proposal site and the SAC. The boundary of the SAC is approximately 46m from the temporary works at the junction of the R464 and L3056. Through these hydrological links there is potential for water quality impacts to occur, particularly during the construction phase of the proposed development. This QI habitat may occur in the freshwater reach of the River Shannon at Limerick, within the potential ZOI of the proposed development. Therefore, the project has potential to affect the conservation objectives for 'Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation' and the habitat will be considered further in the NIS.
Molinia meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*) [6410]	No	*Molinia* meadows are found mainly on moist, moderately base-rich, peats and peaty gley soils, often with fluctuating water tables. They usually occur as components of wet pastures or fens, and often form mosaics with dry grassland, heath, mire and scrub communities. The current full extent of this habitat within the SAC is not mapped within the conservation objectives

Qualifying features	Potential for significant impacts	Rationale
		mapping; however, the site synopsis states that *Molinia* meadows occur in several parts of the site with an especially noteworthy example at Worldsend on the River Shannon (NPWS, 2012b). As this habitat type is confined to terrestrial locations above the high tide mark and outside of the ZOI of any potential impact arising from the construction/operation of the wind farm, there will not be a significant impact to *Molinia* meadows on calcareous, peaty or clavey-silt-laden soils.
Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*) [91E0]	No	Alluvial woodland occurs on the banks of the Shannon, in the valley bottoms of the tributaries and on seepage zones on valley sides within the site (NPWS, 2012a). The most prominent woodland type is gallery woodland where white willow (*Salix alba*) dominates the tree layer with occasional alder (*Alnus glutinosa*). This habitat can occur on islands in river channels or low-lying wetlands alongside the channels and is characterised by periodic inundation of water. As there is no hydrological connection between areas of this habitat within the SAC and the proposed development site, and since the habitat type is confined to restricted terrestrial locations above the high tide mark, it is outside of the ZOI of any potential impact arising from the proposed wind farm. Therefore, no significant impact to the conservation objectives for 'Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior*', is anticipated and this habitat is not considered further in the NIS.
Freshwater Pearl Mussel (*Margaritifera margaritifera*) [1029]	No	The freshwater pearl mussel is a large, long-lived bivalve mollusc found in clean, fast-flowing, well-oxygenated rivers with unconsolidated substrates. Stable, clean gravel and sand with adequate availability of dissolved oxygen provides ideal habitat for juveniles. Water pH and hardness is also important with distribution mainly restricted to acidic, soft waters over-lying non-calcareous rock-types. Low nutrient status is also critical such that excess macrophyte and algal growth is prevented, therefore oligotrophic waterbodies are required. Conservation objectives for this species within the SAC apply to the freshwater pearl mussel population in the Cloon River, Co. Clare. This population is confined to the main channel and distributed from Croany Bridge to upstream of Clonderalaw Bridge (NPWS, 2012a). The Cloon River enters the main Shannon Estuary at a point more than 41 km west of the proposal site. Given the characteristics and location of the project, and species' ecology, it is not considered that the proposal has any potential to significantly impact on freshwater pearl mussel. Thus, the project will not affect the conservation objectives for 'Freshwater Pearl Mussel' and the species is not considered further in the NIS.

MWP

Qualifying features	Potential for significant impacts	Rationale
River Lamprey (*Lampetra fluviatilis*) [1099] Sea Lamprey (*Petromyzon marinus*) [1095]	Yes	The life cycles of sea lamprey and river lamprey contain both a marine phase and a freshwater phase. Both species spend their adult life in marine and estuarine waters, living as external parasites on other fish species before migrating up rivers in spring to spawn in areas of clean gravel, after which they die. Sea lamprey and river lamprey often spawn in the lower reaches of rivers but can also migrate up to 50 miles upstream (Kurz & Costello, 1999). Sea and river lampreys are poor swimmers (Reinhardt *et al*., 2009) and are generally considered unable to navigate past weirs and other barriers meaning that both lamprey species are restricted to the lower reaches of the SAC. Neither lamprey species occurred at any of the sites surveyed (see **Figure 3-2,** above, for sampling locations) and it is unlikely that either are to be found within the study area. However, the watercourse crossings, the closest of which is 1.6 river km upstream of the SAC (see **Figure 4-4** and **Table 20**, above), create several hydrological links between the proposed development site and the SAC. Additionally, the existing drainage network at the site empties into watercourses that ultimately merge with the SAC, thereby creating an indirect hydrological connection between the proposal site and the SAC. The boundary of the SAC is approximately 46m from the temporary works at the junction of the R464 and L3056. Through these hydrological links there is potential for water quality impacts to occur, particularly during the construction phase of the proposed development. Therefore, based on this and the precautionary principle, it is deemed that there is potential for significant impacts to the conservation objectives for sea and/or river lamprey so both species will be considered further in the NIS.
Brook Lamprey (*Lampetra planeri*) [1096]	Yes	Brook lamprey is the smallest of the three lamprey species native to Ireland. Unlike sea and river lamprey, it is not parasitic and is non-migratory, spending its entire life in freshwater. Species distribution within river catchments is dependent on the availability of suitable habitat; adults require fine sand/gravel areas in which to spawn while the juvenile form needs clean, fine sediment into which to burrow (King *et al*., 2011). The watercourse crossings, the closest of which is 1.6 river km upstream of the SAC (**Figure 4-4** and **Table 20**, above), create several hydrological links between the proposed development site and SAC. Additionally, the existing drainage network at the site empties into watercourses that ultimately merge with the SAC, thereby creating an indirect hydrological connection between the proposal site and the SAC. The SAC boundary is approx. 46 m from the temporary works at the R464 and L3056 junction. Through these hydrological links there is potential for water quality impacts to occur, particularly during construction phase. Since brook lamprey was recorded at the North Ballycannan Stream and Blackwater (Clare) River, whose lower reaches are located within the SAC, there is potential for significant impacts to the conservation objectives of brook lamprey should any water quality impacts arise due to the proposed development. Therefore, the species will be considered further.
Atlantic Salmon (*Salmo salar*) [1106]	Yes	Salmon is an anadromous species, living in freshwater for at least the first two or three years of life before migrating to sea. Salmon has been observed spawning in the lower Shannon and its tributaries. Adult salmon occur in the Shannon Estuary prior to returning to natal streams to spawn, and smolts occur in the estuary on their journey from influent rivers to the sea (NPWS, 2012b). Salmon was recorded at Survey Site 11 on the Blackwater (Clare) River during the aquatic ecology surveys carried out

Qualifying features	Potential for significant impacts	Rationale
		by MWP in 2018. The watercourses at each of the other sites surveyed were deemed sub-optimal due to siltation and enrichment of the water at higher reaches and the morphologically degraded nature of watercourses in lower reaches. The watercourse crossings, the closest of which is 1.6 river km upstream of the SAC (see **Figure 4-4** and **Table 20**, above), create several hydrological links between the proposed development site and the SAC. Additionally, the existing drainage network at the site empties into watercourses that ultimately merge with the SAC, thereby creating an indirect hydrological connection between the proposal site and the SAC. The SAC boundary is approximately 46 m from the temporary works at the junction of the R464 and L3056. Through these hydrological links there is potential for water quality impacts to occur, particularly during the construction phase of the proposed development. Therefore, based on this, it is deemed that there is potential for significant impacts to the conservation objectives for salmon so the species will be considered further in the NIS.
Common Bottlenose Dolphin (*Tursiops truncatus*) [1349]	No	The only known resident population of bottlenose dolphin in Ireland are found in the Shannon Estuary. Most of the estuary comprises suitable habitat for this Annex II species, apart from the inter-tidal areas of the Fergus Estuary and the inner estuary channel near Shannon town stretching east towards Limerick - a review of on-line species records shows that sightings are concentrated in the outer channel. Within the SAC two 'critical areas' of habitat used preferentially by the species have been identified – one near Tarbert/Killimer and the second further west near Ballybunion and Kilcredaun Point (NPWS, 2012a). Given the characteristics and location of the project including the nature, extent and scale of the proposed works, the dilution potential of the River Shannon and Estuary, the distribution of bottlenose dolphin habitat and records within the estuary, it is not considered that the proposal has the potential to significantly impact on this species. Thus, the project will not affect the conservation objectives for bottlenose dolphin and the species is not considered further.
Otter (*Lutra lutra*) [1355]	**Yes**	Otter has a widespread distribution throughout Ireland and can be found in a variety of aquatic habitats such as lakes, rivers, streams, estuaries, and along the coast. They are mainly solitary animals and highly territorial preying on a wide variety of vertebrate and invertebrate species, although their diet primarily comprises fish. The amount of time spent within different parts of an individual's home range is related to prey abundance. No evidence of otter was recorded during the ecological field surveys and there are no documented records of otter held by the NBDC for the proposed development site. However, the watercourse crossings, the closest of which is 1.6 river km upstream of the SAC (see **Figure 4-4** and **Table 20**, above), create several hydrological links between the proposed development site and the SAC. Additionally, the existing drainage network at the site empties into watercourses that ultimately merge with the SAC, thereby creating an indirect hydrological connection between the proposal site and the SAC. The boundary of the SAC is approximately 46 m from the temporary works at the junction of the R464 and L3056. Through these hydrological links there is potential for water quality impacts to occur, particularly during the construction phase, creating potential for otter to be indirectly affected through a reduction in prey source and habitat availability. Thus, there is potential for significant impacts to the conservation objectives for otter so the species will be considered further.

It has been determined (see **Table 31**, above) that the proposed development has the potential to result in significant effects to the conservation objectives of the following Qualifying Interests (QIs) of the Lower River Shannon SAC:

- Estuaries [1130];
- Mudflats and sandflats not covered by seawater at low tide [1140];
- Reefs [1170];
- Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation [3260];
- River Lamprey (*Lampetra fluviatilis*) [1099];
- Sea Lamprey (*Petromyzon marinus*) [1095];
- Brook Lamprey (*Lampetra planeri*) [1096];
- Atlantic Salmon (*Salmo salar*) [1106]; and
- Otter (*Lutra lutra*) [1355].

6.3 River Shannon and River Fergus Estuaries SPA (004077)

6.3.1 Description of the European Site

The following text summarises the Natura 2000 Standard Data Form for the site[55]. Refer to **Figure 6-1**, above.

The estuaries of the River Shannon and River Fergus form the largest estuarine complex in Ireland. The SPA comprises the entire estuarine habitat from Limerick City and Ennis town westwards as far as Doonaha in County Clare and Dooneen Point in County Kerry. Also included are several areas in the outer Shannon Estuary, such as Clonderalaw Bay and Poulnasherry Bay. The site has vast expanses of intertidal flats containing a diverse macro-invertebrate community, e.g. *Macoma-Scrobicularia-Nereis*, which provides a rich food resource for wintering birds. Eelgrass (*Zostera* spp.) is also present in places. Salt marsh vegetation frequently fringes the mudflats, and this provides important high tide roost areas for the wintering birds. Elsewhere in the site the shoreline comprises stony or shingle beaches. The tidal channels and creeks within the most inner parts of the estuaries are fringed with species such as common reed (*Phragmites australis*) and sedges (*Scirpus* spp.). Common cordgrass (*Spartina anglica*) is frequent in parts.

This is the most important coastal wetland site in Ireland and regularly supports more than 50,000 wintering waterfowl including internationally important numbers of redshank, black-tailed godwit and dunlin, and nationally important numbers of 16 other species. The site is of particular importance for dunlin (11% of national total), grey plover (7.5% of national total), lapwing (6.5% of national total), redshank (6.1% of national total), and shelduck (6.0% of national total), with significant numbers of whooper swan, golden plover and bar-tailed godwit also occurring at the site. A population of Greenland white-fronted goose (*Anser albifrons flavirostris*) once frequented the site but have since abandoned the area. The site provides both feeding and roosting areas for the wintering birds while the quality of estuarine habitats at the site is generally good.

The River Shannon and River Fergus Estuaries SPA is designated for the protection of the following qualifying features of conservation interest:

- Cormorant (*Phalacrocorax carbo*) [A017] Breeding & Wintering
- Whooper Swan (*Cygnus cygnus*) [A038] Wintering

[55] N2K IE0004077 dataforms (europa.eu) Accessed: 6th July 2023

- Light-bellied Brent Goose (*Branta bernicla hrota*) [A046] Wintering
- Shelduck (*Tadorna tadorna*) [A048] Wintering
- Wigeon (*Anas Penelope*) [A050] Wintering
- Teal (*Anas crecca*) [A052] Wintering
- Pintail (*Anas acuta*) [A054] Wintering
- Shoveler (*Anas clypeata*) [A056] Wintering
- Scaup (*Aythya marila*) [A062] Wintering
- Ringed Plover (*Charadrius hiaticula*) [A137] Wintering
- Golden Plover (*Pluvialis apricaria*) [A140] Wintering
- Grey Plover (*Pluvialis squatarola*) [A141] Wintering
- Lapwing (*Vanellus vanellus*) [A142] Wintering
- Knot (*Calidris canutus*) [A143] Wintering
- Dunlin (*Calidris alpine*) [A149] Wintering
- Black-tailed Godwit (*Limosa limosa*) [A156] Wintering
- Bar-tailed Godwit (*Limosa lapponica*) [A157] Wintering
- Curlew (*Numenius arquata*) [A160] Wintering
- Redshank (*Tringa tetanus*) [A162] Wintering
- Greenshank (*Tringa nebularia*) [A164] Wintering
- Black-headed Gull (*Chroicocephalus ridibundus*) [A179] Wintering
- Wetlands [A999]

6.3.2 Identification of Potentially Significant Impacts to Qualifying Features

Table 32, below, lists the qualifying features of the River Shannon and River Fergus Estuaries SPA and evaluates through a scientific examination of evidence and data whether these features should or should not be selected for further assessment in the NIS. When explaining the rationale behind each selection, results of the 2010/11 Waterbird Survey Programme (NPWS, 2012d)are used and subsites are referenced – a map indicating the subsite locations is included in **Figure 6-2,** below, at the end of this section. Additionally, the waterbird counts undertaken in winter 2019/20 and winter 2022/23 along the Shannon Estuary and as discussed in **Sections 3.6.2.2.2** and **4.4.8.2**, above, are also used in this section to determine if further assessment of the SPA's qualifying features is necessary.

Table 32. Selection of qualifying features of the River Shannon and River Fergus Estuaries SPA (004077) for impact assessment.

Qualifying features	Potential for significant impacts?	Rationale
Cormorant (*Phalacrocorax carbo*) [A017]	**Yes**	A review of waterbird distribution for cormorant within the SPA carried out as part of the sub-site assessments for the 2010/11 Waterbird Survey Programme determined that cormorant was recorded within sub-sites 0I444 and 0I445, approximately 10 km southwest of the proposed development site (see **Figure 6-2,** below, for subsite locations). Furthermore, cormorant was seen regularly during waterbird counts of the estuary (see **Section 4.4.8.2**, above). Additionally, cormorant was recorded flying within the study area on three occasions during VP surveys (see **Figure 4-6**, above). The SPA also supports a nationally important breeding population of cormorant (93 pairs in 2010) (NPWS, 2012d). The proposed development is hydrologically linked to the SPA. Therefore, there is potential for significant impacts to the SPA's water quality, and thus, potentially to the habitat, distribution and feeding opportunities of the cormorant population there. Additionally, since an individual was observed during the VP surveys, there is also potential that once the turbines are built, they could become a collision risk or possibly create a barrier to movement resulting in species displacement. Based on this, the species is deemed to be within the zone of potential influence of the proposal and will be considered further in the NIS.
Whooper Swan (*Cygnus cygnus*) [A038]	**Yes**	The SPA is designated for wintering whooper swan that usually forage on low-lying grasslands, estuaries (NPWS, 2012d) and improved pasture (Burke *et al*., 2021). The improved agricultural grassland at the proposed development site may have some potential as foraging grounds for the species but there were no observations reported during the VP surveys undertaken at the site from October 2019 to September 2023, inclusive, with a survey effort of 864 hours. During the 2022/23 waterbird surveys, the species was counted regularly within Survey Section D at Cooperhill, approximately 6.5 kilometres southwest of the proposed development site and outside the core foraging range of 5 km for the species (SNH, 2016). However, 14 whooper swan were recorded at Survey Section A at King's Island during the waterbird counts, more than 4 km southeast of the proposed T12 location. According to the sub-site assessments carried out for the 2010/11 Waterbird Survey Programme, (NPWS, 2012d), whooper swan was recorded foraging within sub-sites 0I457, 0I427, 0I446 and 0I445 between the Maigue Estuary and Limerick City, approximately 6.8 km southwest of the proposed development site (see **Figure 6-2,** below, for subsite locations). Although no whooper swan were observed within the proposed development site or within 500 metres of it, the site is located within the core foraging range of the 14 whooper swan counted at King's Island (refer to **Section 6.4.2.2**, below). Furthermore, the proposed development site is hydrologically linked to the SPA and to King's Island, and there is potential for significant impacts to the water quality of the SPA, and thus, potentially to the habitat, distribution and feeding opportunities of the whooper swan population there. Additionally, if the agricultural grassland at the proposed development site is used as foraging grounds, there is potential that once the turbines are built, they could become a collision risk or possibly create a barrier to

Qualifying features	Potential for significant impacts?	Rationale
		movement resulting in displacement of the species. Based on this, the species is deemed to be within the zone of potential influence of the proposal and will be considered further in the NIS.
Light-bellied Brent Goose (*Branta bernicla hrota*) [A046]	No	The site is designated for wintering light-bellied Brent goose. This species is amber-listed as the majority of the population winter at less than ten sites and the Irish population is also internationally significant. It winters on coastal estuaries during the autumn and early winter as well as on grasslands from mid-winter before departing to breeding grounds in Canada in late April. Brent geese are grazers and are known for their preference for foraging in intertidal areas with the Eelgrass *Zostera* sp. (Robinson *et al*. 2004). Where this food source is absent the birds feed upon algae and saltmarsh plants and the species also grazes terrestrially. A review of waterbird distribution for light-bellied brent goose within the SPA carried out as part of the sub-site assessments for the 2010/11 Waterbird Survey Programme, determined that brent geese at the SPA had a relatively restricted distribution occurring in only seven sub-sites that were mostly located at the outer western section of the site (NPWS, 2012d). There were no records of foraging or roosting brent geese anywhere within the zone of potential influence of the proposal during the ornithological surveys. Based on this, this species is not considered to be within the zone of potential influence of the proposal and will not be considered further in the NIS.
Shelduck (*Tadorna tadorna*) [A048]	**Yes**	A review of waterbird distribution for shelduck within the SPA carried out as part of the sub-site assessments for the 2010/11 Waterbird Survey Programme determined that shelduck were recorded foraging and roosting intertidally at sub-sites 0H419, 0I431 and 0H514 (see **Figure 6-2,** below, for subsite locations), located approximately 10 km southwest of the proposed development site (NPWS, 2012d). The proposed development is hydrologically linked to the SPA. Therefore, there is potential for significant impacts to the water quality of the SPA, and thus, potentially to the habitat, distribution and feeding opportunities of the shelduck population there. Based on this and the precautionary principle, the species is deemed to be within the zone of potential influence of the proposal and will be considered further in the NIS.
Wigeon (*Anas penelope*) [A050] Teal (*Anas crecca*) [A052]	**Yes**	A review of waterbird distribution for wigeon and teal within the SPA carried out as part of the subsite assessment for the 2010/11 Waterbird Survey Programme determined that they were both relatively widespread over the SPA. They were both recorded foraging and roosting intertidally at sub-sites 0I445 and 0I446 (see **Figure 6-2,** below, for subsite locations), approximately 8.5 km southwest of the proposed development site (NPWS, 2012d). During wintering waterbird counts, teal was recorded in all surveys while wigeon was counted in 2022/23 in Section D only (see **Section 4.4.8.2**, above). The proposed development is hydrologically linked to the SPA. Therefore, there is potential for significant impacts to the water quality of the SPA, and thus, potentially to the habitat, distribution and feeding opportunities of the wigeon and teal populations

Qualifying features	Potential for significant impacts?	Rationale
		there. Based on this, both species are deemed to be within the zone of potential influence of the proposal and will be considered further in the NIS.
Pintail (*Anas acuta*) [A054]	**Yes**	A review of waterbird distribution for pintail within the SPA carried out as part of the sub-site assessments for the 2010/11 Waterbird Survey Programme (NPWS, 2012d) determined that the species was recorded at two subsites only – 0H519 and 0K509 (see **Figure 6-2,** below, for subsite locations) located at the western extreme of the SPA at some distance from the proposed development site. However, during the waterbird counts, one pintail was counted at Section B and since the proposed development is hydrologically linked to the SPA and to Section B, there is potential for significant impacts to the water quality of the SPA, and thus, potentially to the habitat, distribution and feeding opportunities of the pintail population there. Based on this and the precautionary principle, the species is deemed to be within the zone of potential influence of the proposal and will be considered further in the NIS.
Shoveler (*Anas clypeata*) [A056]	**Yes**	No shoveler was recorded at the proposed development site during the surveys, but the species was recorded at Sections A, B, and D during the waterbird counts (see **Figure 4-7**, above, for Survey Sections locations). A review of waterbird distribution for shoveler within the SPA carried out as part of the sub-site assessments for the 2010/11 Waterbird Survey Programme (NPWS, 2012d) determined that there were four shoveler records from subsite 0I431 located approximately 10.5 km to the southwest of the proposed development site (see **Figure 6-2,** below, for subsite locations). However, an I-WeBS report by Fitzgerald *et al.,* (2021) lists shoveler as a species occurring in numbers of national importance at the site based on counts from 2013/14 to 2017/18 (mean 2,311). The proposed development is hydrologically linked to the SPA. Therefore, there is potential for significant impacts to the water quality of the SPA, and thus, potentially to the habitat, distribution and feeding opportunities of the shoveler population there. Therefore, based on this and bearing in mind the precautionary principle, the species is deemed to be within the zone of potential influence of the proposed development and will be considered further in the NIS.
Scaup (*Aythya marila*) [A062]	No	Scaup are a winter visitor to Ireland, arriving from northern breeding sites between November and April to coastal areas, estuaries, brackish lagoons and freshwater lakes close to the coast. They forage in sub-tidal areas, diving to hunt for molluscs and crustaceans as well as feeding on marine plants in areas typically with a depth of less than 10 m. Scaup is red-listed for its small breeding population and its localised wintering range. During waterbird counts, no scaup were recorded at any of the four Survey Sections nor were they recorded at the proposed development site during the other bird surveys. Furthermore, a review of waterbird distribution for scaup within the SPA carried out as part of the subsite assessments for the 2010/11 Waterbird Survey Programme (NPWS, 2012d) determined that the species was recorded foraging at three subsites only - 0H519, 0H521 and 0H522 (see **Figure 6-2,** below, for subsite locations). Since all three sites are located at the western extreme of the SPA at some distance from the proposed development site and

Qualifying features	Potential for significant impacts?	Rationale
		because no scaup were observed at the proposal site during the ornithological surveys, this species is deemed to be outside the zone of potential influence of the proposal and will not be considered further in the NIS.
Ringed Plover (*Charadrius hiaticula*) [A137]	No	Ringed plovers are 'visual foragers' searching the sediment surface for signs of prey such as worms, crustaceans and insects. A substantial proportion of ringed plovers occur on non-estuarine coasts, exhibiting a degree of plasticity in habitat choice such as shingle shores, saltmarsh and short grassland as well as artificial habitats. Ringed plover is amber-listed as internationally important numbers winter in Ireland. They breed on shingle and sandy beaches (Dempsey & O'Clery, 2002) and rough ground near the coast. During waterbird counts, no ringed plover were recorded at any of the four Survey Sections nor were they recorded at the proposed development site during the other bird surveys. A review of waterbird distribution for ringed plover within the SPA carried out as part of the subsite assessments for the 2010/11 Waterbird Survey Programme (NPWS, 2012d) determined that the species was found predominantly in the outer section of the estuary, towards the mouth, on intertidal mudflats. There was a single individual recorded roosting in subsite 0I427 in February 2011 (see **Figure 6-2,** below, for subsite locations). Since all but one record of ringed plover occurred within the western extent of the SPA away from the proposed development site, and because no ringed plover was observed at the proposal site during the ornithological surveys, this species is deemed to be outside the zone of potential influence of the proposal and will not be considered further in the NIS.
Golden Plover (*Pluvialis apricaria*) [A140]	**Yes**	A review of waterbird distribution for golden plover within the SPA carried out as part of the sub-site assessments for the 2010/11 Waterbird Survey Programme determined that the species are relatively widespread over the SPA foraging and roosting. They were recorded foraging and roosting intertidally at sub-sites 0I445 and 0I444 (see **Figure 6-2,** below, for subsite locations), located approximately 8.5 km southwest of the proposed development site (NPWS, 2012d). The proposed development is hydrologically linked to the SPA. Therefore, there is potential for significant impacts to the water quality of the SPA, and thus, potentially to the habitat, distribution and feeding opportunities of the golden plover population there. Based on this and bearing in mind the precautionary principle, the species are deemed to be within the zone of potential influence of the proposal and will be considered further in the NIS.
Grey Plover (*Pluvialis squatarola*) [A141]	**Yes**	Grey plover is a red-listed species in Ireland as the majority spend winter at less than ten sites. The SPA is designated for wintering grey plover. They feed on various marine molluscs, crustaceans and worms, foraging on intertidal mudflats within the estuary and on beaches. There were no grey plover observed at the proposal site during the surveys but there were 3 individuals seen at both Sections B and C. The proposed development is hydrologically linked to the SPA. Therefore, there is potential for significant impacts to the water quality of the SPA, and thus, potentially to the habitat, distribution and feeding opportunities of the grey plover population

Qualifying features	Potential for significant impacts?	Rationale
		there. Based on this, the species are deemed to be within the zone of potential influence of the proposal and will be considered further in the NIS.
Lapwing (*Vanellus vanellus*) [A142]	**Yes**	A review of waterbird distribution for lapwing within the SPA carried out as part of the sub-site assessments for the 2010/11 Waterbird Survey Programme determined that the species are widespread over the SPA. They were recorded foraging and roosting intertidally at sub-sites 0I427 and 0I445 (see **Figure 6-2,** below, for subsite locations), approximately 5 km southwest of the proposed development site (NPWS, 2012d). Additionally, during the 2019/20 winter waterbird counts, a peak count of 51 lapwing were recorded, while during the 2022/23 counts, lapwing were recorded at Sections A and D. The proposed development is hydrologically linked to the SPA. Therefore, there is potential for significant impacts to the water quality of the SPA, and thus, potentially to the habitat, distribution and feeding opportunities of the lapwing population there. Based on this, the species are deemed to be within the zone of potential influence of the proposal and will be considered further in the NIS.
Knot (*Calidris canutus*) [A143]	No	Knot are a winter visitor to Ireland, arriving from northern Greenland and Arctic Canada between October and February to coastal areas and estuarine sites with extensive muddy sand. They are specialist intertidal foragers and use sensors on their bill to detect buried prey. Preferred prey includes different species of bivalve molluscs and crustaceans. Knot is red-listed in Ireland due to falling numbers and its relatively localised wintering range. A review of waterbird distribution for SCI species within the SPA carried out as part of the sub-site assessments for the 2010/11 Waterbird Survey Programme, as outlined in NPWS (2012b) found knot to have a relatively restricted foraging/roosting distribution within the site and were not recorded further east than subsite 0I430 (Black Rock to Mellon Pt.) (see **Figure 6-2,** below, for subsite locations). They were not recorded in any of the subsites in the vicinity of the proposal site. Furthermore, knot were not observed during the ornithological surveys and the proposed development site is considered to be sub-optimal roosting/foraging habitat for the species. Based on these reasons, this species is not considered to be within the zone of potential influence of the proposal and will not be considered further in the NIS.
Dunlin (*Calidris alpina*) [A149]	**Yes**	A review of waterbird distribution for dunlin within the SPA carried out as part of the sub-site assessments for the 2010/11 Waterbird Survey Programme determined that the species are widespread within the SPA. They were recorded foraging and roosting intertidally at sub-sites 0I427 and 0I445 (see **Figure 6-2,** below, for subsite locations), approximately 5 km southwest of the proposed development site (NPWS, 2012d). The proposed development is hydrologically linked to the SPA so there is potential for significant impacts to the water quality of the SAC and thereby to the habitat, distribution and feeding opportunities of the dunlin population there. Therefore, the species are deemed to be within the zone of potential influence of the proposal and will be considered further in the NIS.

Qualifying features	Potential for significant impacts?	Rationale
Black-tailed Godwit (*Limosa limosa*) [A156]	No	Black-tailed godwit is a red-listed species in Ireland as the majority winter at less than ten sites within the country. The SPA is designated for wintering black-tailed godwit. They are large, long-billed wading birds that forage within intertidal flats for their preferred prey of bivalves such as *Macoma balthica*, *Scrobicularia plana* and *Mya arenaria*. At some sites, polychaete worms form a larger proportion of the diet, and the species is relatively adaptable, utilising other habitats for foraging where available, such as terrestrial grassland, coastal marshes or freshwater callows. A review of waterbird distribution for black-tailed godwit within the SPA carried out as part of the sub-site assessments for the 2010/11 Waterbird Survey Programme determined that black-tailed godwit activity was predominantly concentrated within the middle of the site in an area between the Maigue Estuary and Aughinish. Apart from a small number of foraging birds recorded at subsites 0I445 and 0I446, there were no records of black-tailed godwit west of the Maigue Estuary within the vicinity of the proposed development site (see **Figure 6-2,** below, for subsite locations). This provides an intervening distance between the proposed development site and the Maigue Estuary of approximately 11 km over land or 14.5 river km, where potential adverse water quality impacts can be avoided, reduced or offset. Based on this, this species is not considered to be within the zone of potential influence of the proposal and will not be considered further in the NIS.
Bar-tailed Godwit (*Limosa lapponica*) [A157]	No	Bar-tailed godwits forage by probing intertidal sediment for invertebrate species, predominantly large polychaete worms such as *Arenicola marina* and *Nepthys* sp. They often feed at the tide's edge with their heads in water. The species is characteristic of sites with sandy substrates (Hill *et al*., 1993) or sections of a site that have sandy (as opposed to muddy) sediment. The dominant intertidal benthic community type across the site is 'intertidal sand to mixed sediment with polychaetes, molluscs and crustaceans' (NPWS, 2012d). This broad community type has a wide variability in sediment type from gravel to fine sand to muds. Of note are high abundances of *Nephtys hombergii* occurring from the lower Fergus Estuary westwards and is a known prey species of bar-tailed godwit. The bar-tailed godwit is amber-listed in Ireland as the majority winter at less than ten sites. A review of waterbird distribution for SCI species within the SPA carried out as part of the sub-site assessments for the 2010/11 Waterbird Survey Programme, as outlined in NPWS (2012b) found bar-tailed godwits to have a relatively restricted foraging distribution within the site. They were not recorded in any of the sub-sites in the vicinity of the proposal site (see **Figure 6-2,** below, for subsite locations). Based on this, this species is not considered to be within the zone of potential influence of the proposal and will not be considered further in the NIS.
Curlew (*Numenius arquata*) [A160]	Yes	A review of waterbird distribution for curlew within the SPA carried out as part of the sub-site assessments for the 2010/11 Waterbird Survey Programme determined that the species are widespread throughout the SPA. They were recorded foraging and roosting intertidally at sub-sites 0I446 and 0I457 (see **Figure 6-2,** below, for subsite locations), approximately 5 km southwest of the proposed development site (NPWS, 2012d). The proposed development is hydrologically linked to the SPA so there is potential for significant impacts to water quality of the SAC, and potentially to the habitat, distribution and feeding

Qualifying features	Potential for significant impacts?	Rationale
		opportunities of the curlew population there. Based on this, the species are deemed to be within the zone of potential influence of the proposal and will be considered further in the NIS.
Redshank (*Tringa totanus*) [A162] Greenshank (*Tringa nebularia*) [A164]	Yes	During the waterfowl counts, redshank was recorded at Survey Sections A, B, and C but there were no records of greenshank. A review of waterbird distribution for redshank and greenshank within the SPA carried out as part of the sub-site assessments for the 2010/11 Waterbird Survey Programme determined that both species are widespread throughout the SPA, particularly redshank. They were both recorded foraging and roosting intertidally at sub-sites 0I427, 0I457 and 0I448 (see **Figure 6-2,** below, for subsite locations), approximately 5 km southwest of the proposed development site (NPWS, 2012d). The proposed development is hydrologically linked to the SPA. Therefore, there is potential for significant impacts to the water quality of the SAC, and thus, potentially to the habitat, distribution and feeding opportunities of the redshank and greenshank populations there. Based on this, both redshank and greenshank are deemed to be within the zone of potential influence of the proposal and will be considered further in the NIS.
Black-headed Gull (*Chroicocephalus ridibundus*) [A179]	Yes	A review of waterbird distribution for SCI species within the SPA carried out as part of the sub-site assessments for the 2010/11 Waterbird Survey Programme determined that black-headed gull was recorded within subsites 0I446 and 0I447 (see **Figure 6-2,** below, for subsite locations), approximately 5 km southwest of the proposed development site. Furthermore, the innermost subsite 0I448 recorded peak numbers during the October and November 2010 low tide surveys (NPWS, 2012d). Additionally, there were three separate black-headed gull flights recorded during bird surveys carried out – one sighting of a flock of twelve in January 2021, one sighting of an individual gull in October 2021, and one sighting of a flock of nine in March 2023. Furthermore, during the wintering waterbird counts, black-headed gull was observed in large numbers during all surveys. The proposed development is hydrologically linked to the SPA. Therefore, there is potential for significant impacts to the water quality of the SPA, and thus, potentially to the habitat, distribution and feeding opportunities of the black-headed gull population there. Additionally, since there were three separate records of the species during the VP surveys, there is also potential that once the turbines are built, they could become a collision risk or possibly create a barrier to movement resulting in disturbance/displacement of the species. Based on this, the species is deemed to be within the zone of potential influence of the proposal and will be considered further in the NIS.
Wetlands [A999]	Yes	There is a hydrological connection between the SPA and the proposal site via the various watercourses that drain the site and ultimately merge with the River Shannon and the SPA, located approximately 6.6 rkm downstream from WC1 via the Crompaun [East] River, merging with the Shannon at Meelick Rock (see **Figure 4-4**, above). The SPA is approximately 3.1 km from the temporary works at the junction of the R464 and L3056. Based on this, the habitat 'Wetlands' is deemed to be within the zone of potential influence of the proposal and will be considered further in the NIS.

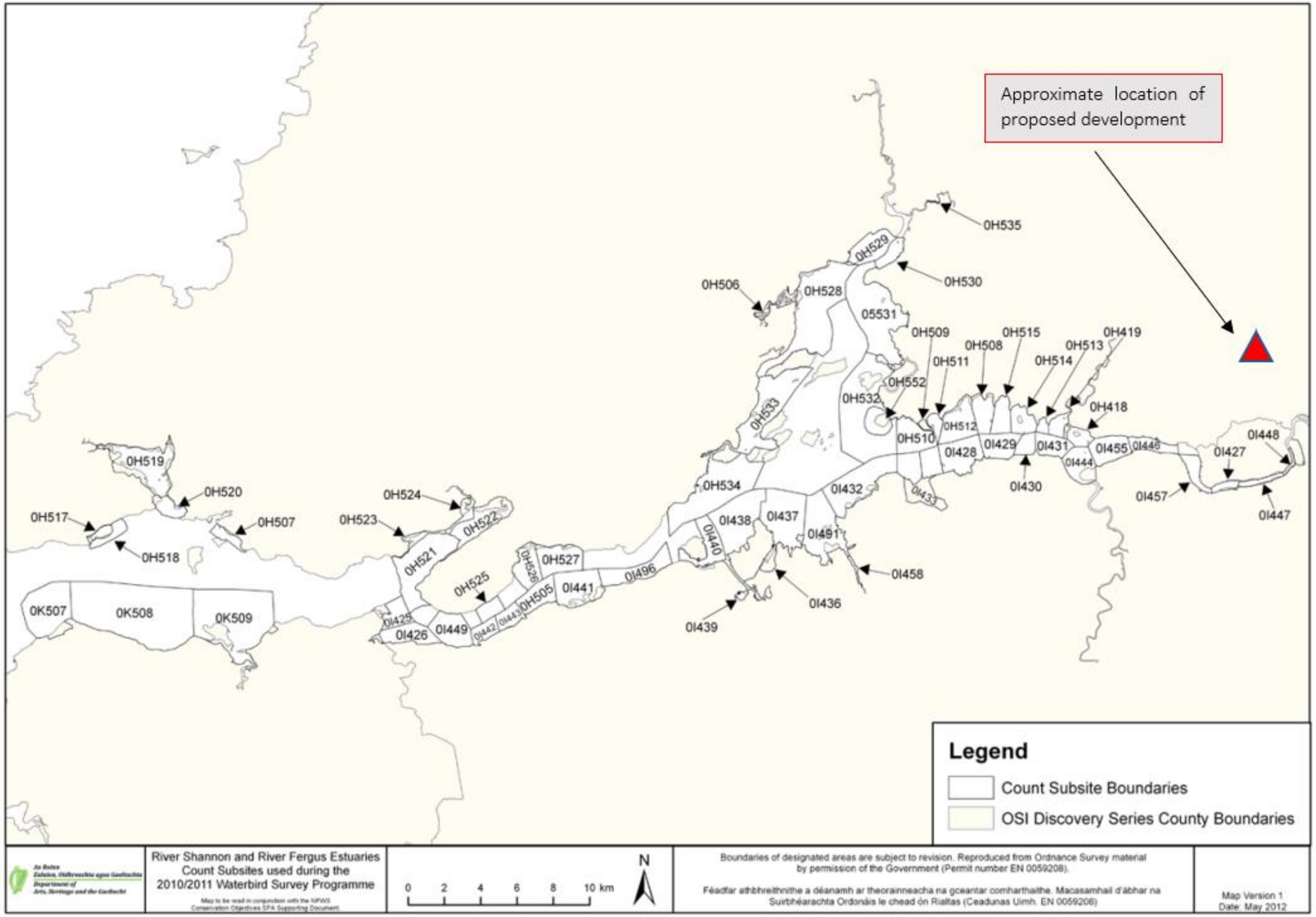

Figure 6-2: Locations of the subsites used for the 2010/11 Waterbird Survey Programme surveys within the River Shannon and River Fergus Estuaries SPA [adapted from NPWS, 2012c].

It has been determined (see **Table 32**, above) that the proposed development has the potential to result in significant effects to the conservation objectives of the following Special Conservation Interest (SCI) species of the River Shannon and River Fergus Estuaries SPA:

- Cormorant (*Phalacrocorax carbo*) [A017] Breeding & wintering
- Whooper Swan (*Cygnus cygnus*) [A038] Wintering
- Shelduck (*Tadorna tadorna*) [A048] Wintering
- Wigeon (*Anas penelope*) [A050] Wintering
- Teal (*Anas crecca*) [A052] Wintering
- Pintail (*Anas acuta*) [A054] Wintering
- Shoveler (*Anas clypeata*) [A056] Wintering
- Golden Plover (*Pluvialis apricaria*) [A140] Wintering
- Grey Plover (*Pluvialis squatarola*) [A141] Wintering
- Lapwing (*Vanellus vanellus*) [A142] Wintering
- Dunlin (*Calidris alpina*) [A149] Wintering
- Curlew (*Numenius arquata*) [A160] Wintering
- Redshank (*Tringa totanus*) [A162] Wintering
- Greenshank (*Tringa nebularia*) [A164] Wintering
- Black-headed Gull (*Chroicocephalus ridibundus*) [A179] Wintering
- Wetlands [A999]

6.4 Assessment of Potentially Significant Effects

There follows an evaluation of potentially significant effects which may arise because of the proposed development on the qualifying features that have been selected for impact assessment in **Sections 6.2.2** and **6.3.2,** above, together with the potential effects identified in **Section 5,** above. Following this, a determination is made as to whether the proposal is likely to have adverse effects on the integrity of the European sites selected for assessment.

The likelihood of adverse effects to a European site from the proposed development has been determined based on the following indicators:

- Water quality;
- Habitat loss or alteration;
- Disturbance and/or displacement of species; and
- Habitat or species fragmentation.

The likelihood of significant cumulative/in-combination effects is assessed in **Section 6.7,** below.

6.4.1 Water Quality

As discussed in **Section 4.4.2** and illustrated in **Figure 4-4**, above, there are several watercourses draining the proposed development site and surrounding area that ultimately drain into two European sites downstream – firstly, the Lower River Shannon SAC, located approximately 1.6 river kilometres downstream from WC6 and WC7, and secondly, the River Shannon and River Fergus Estuaries SPA located approximately 6.6 river kilometres downstream of WC1. The existing drainage network within the development site, together with the network of drains within the surrounding area, create the potential for a hydrological link between the proposed wind farm site and the SAC and SPA downstream. Additionally, although there will be no direct hydrological connection between the proposed temporary road widening works at the R464 / L3056 junction (see Figure 4-14, above) and either the SAC or the SPA, the proximity of the SAC (46 metres to the southeast of the junction) creates the potential for a tenuous indirect hydrological connection via run-off and overland flow. This in turn has the potential to create an equally as tenuous hydrological link between the proposed temporary works at the R464 / L3056 junction and the SPA located approximately 3.1 kilometres further downstream.

During a wind farm's construction phase, and in the absence of any pollution prevention controls, earthworks have the potential to adversely impact water quality due to soil erosion. The subsequent suspension of soil sediment particles in site run-off and overland flow can eventually reach the natural watercourses draining the site. Nutrients such as phosphorous can be bound to soil from past fertilisation of forestry crop and can become transported in overland flow. The presence of felled trees and brash at a site can increase the risk of such phosphorous release to local drains and watercourses. Potential also exists for accidental ingress of fuel and oils, concrete and cementitious material and other such substances considered harmful to the aquatic environment that could enter the streams draining the proposed development site - including the Cappateemore East River, the East Ballycannan Stream, the North Ballycannan River, and the South Ballycar River - via run-off, overland flow or the existing forestry drainage network and tributary streams.

Water quality is a key environmental factor underpinning the conservation condition of the complex of wetland habitats and aquatic species and birds that the Lower River Shannon SAC and the River Shannon and River Fergus Estuaries SPA are selected for. Several watercourses drain the study area and their proximity to the proposed development site boundary provides a hydrological pathway between the proposed development site and the two European sites located downstream. Given the pollution risk associated with the construction phase of the works and the identified hydrological pathways, it is considered that there is potential for some localised reduction in water quality of the Lower River Shannon SAC and the River Shannon and River Fergus Estuaries SPA.

Potential sedimentation, nutrient-enrichment, or other aquatic pollution, which could arise in the absence of effective water quality protection measures, could impact on freshwater ecology of watercourses within the vicinity of the works. There is also potential for significant water quality impacts within the Lower River Shannon SAC and the River Shannon and River Fergus Estuaries SPA in the absence of appropriate mitigation measures as these sites include waterbodies that are downstream receptors with respect to the streams draining the site.

Based on the characteristics and scale of the proposed development, no significant impacts to water quality are foreseen during the operational phase; however, based on the precautionary principle, mitigation measures are recommended.

In conclusion, there is a risk that without a programme of mitigation measures the proposed development may potentially result in adverse water quality impacts within the Lower River Shannon SAC and the River Shannon and River Fergus Estuaries SPA during construction, with the potential for operational impacts also possible, though highly unlikely. Adverse water quality impacts, should they arise, could then exert indirect impacts on aquatic/water-dependant habitats and species protected within the SAC and SPA, which could adversely affect the integrity of these sites.

Section 7, below, outlines a programme of mitigation measures designed to control and eliminate the point and diffuse pollution sources identified and to avoid, reduce or offset the potential adverse water quality impacts that might ensue because of the proposed development. Mitigation measures for the decommissioning phase will be similar to those of the construction phase but will be of a considerably lesser scale since excavations will not be required. Residual impacts are assessed in Section 9, below.

6.4.2 Habitat Loss/Alteration

There is no spatial overlap between the proposed development and either of the European sites located downstream, namely the Lower River Shannon SAC, and the River Shannon and River Fergus Estuaries SPA, so there will be no direct habitat loss within either. However, as has already been stated in Section 6.4.1, above, there is potential for significant water quality effects to both the SAC and SPA during the construction phase of the project via the hydrological links provided by watercourses draining the area and the proximity of the temporary road widening works. This creates potential for significant indirect alteration/loss of the aquatic habitats within the designated sites in the absence of mitigation.

6.4.2.1 Lower River Shannon SAC

Contaminated water entering the SAC creates potential for habitat alteration (or indirect habitat loss) of riverbeds downstream from sediments suspended in overland flows that may clog up gravels suitable for spawning salmon or lamprey because of the unmitigated proposal. Otter habitat may be indirectly affected by a reduction in water quality which can significantly alter the suitability of a site for otters and their requirements. Furthermore, the construction works may temporarily displace commuting or foraging otters. However, this impact is deemed to be limited given the localised and temporary nature of the works and the wide availability of similar suitable habitat in the vicinity of the works and the fact that the site is of relatively little ecological value to otter.

Four habitats within the SAC - 'Estuaries', 'Mudflats and sandflats not covered by seawater at low tide', 'Reefs' and 'Watercourses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation' - also have the potential to be indirectly affected by a decrease in water quality. The habitats of the subtidal and intertidal animal communities living within the different regions of sediment, silt, mud and rock of estuaries, mudflats and reefs have the potential to be altered or lost should there be a reduction in water quality.

In conclusion, there is a risk that without a programme of mitigation measures, the proposed development may potentially result in indirect alteration of 'Estuaries [1130]', 'Mudflats and sandflats not covered by seawater at low tide [1140]', 'Reefs [1170]' and 'Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation [3260]' habitat within the Lower River Shannon SAC during construction, with the potential for operational impacts also possible, though highly unlikely. This could adversely affect the integrity of the Lower River Shannon SAC, and thus mitigation measures in relation to protection of water quality are recommended and are discussed in Section 7, below.

6.4.2.2 River Shannon and River Fergus Estuaries SPA

As discussed in Section 6.4.1, above, during the proposed development's construction phase, there is the potential for water quality within the River Shannon and River Fergus Estuaries SPA to be indirectly affected via contamination of watercourses draining the proposed development site which ultimately drain into the SPA downstream. This creates potential, via a reduction in water quality, for significant indirect alteration/loss of the 'Wetlands [A999]' habitat for which the SPA is designated. This wetland habitat is a critical resource for the regularly occurring migratory waterbirds that use it and is of particular importance to many of the SPA's SCI bird species listed in Table 32, above.

However, the risk of this occurring can be adequately prevented through the implementation of standard best management practices and controls and, therefore, certain mitigation measures are recommended with regards to protection of water quality. Section 7, below, outlines a programme of mitigation measures designed to avoid, reduce or offset the potential adverse water quality impacts and thus indirect habitat impacts that might ensue from the proposed development.

There is no spatial overlap between the proposed development site and the SPA so there will be no direct loss/alteration of habitat within the SPA. The proposal site contains large areas of agricultural grassland as well as smaller areas of wet grassland and upland peat (refer to **Section 4.4.3**, above) which may have the potential to be utilised by foraging/grazing SCI bird species such as curlew, whooper swan, lapwing or black-headed gull. However, none of the SPA's designated SCI bird species listed in **Table 32**, above, were recorded foraging or grazing at the study area. During the 48 months of VP surveys at the site, only black-headed gull and cormorant were recorded at the site twice and three times, respectively, but each flight was completed without the birds grounding – refer to **Figure 4-6**, above, for flightpaths.

6.4.2.2.1 *Whooper Swan*

The guidance document '*Assessing Connectivity with Special Protection Areas (SPAs)*' (SNH, 2016) provides species-specific foraging distances for wintering geese and swan species which may be considered to connect bird populations to SPA sites. For whooper swan, the 'core range' with regards to foraging distances of the species from SPAs during winter is within 5 kilometres. This 'core range' is the buffer area around relevant SPAs within which whooper swan could reasonably be expected to regularly commute to outlying foraging areas from roost sites within the SPA boundary. This places the proposed development site within the core foraging range of the 14 individuals recorded at King's Island (as detailed in **Section 4.4.8.2**, above) and although not located within the River Shannon and River Fergus Estuaries SPA, King's Island is located less than two kilometres from the SPA's boundary. Consequently, it could reasonably be assumed that the 14 whooper swan observed at King's Island may be part of the SPA's whooper swan population. The SNH (2016) guidance does not provide information on the core foraging distances during winter for other species relevant to this site.

The majority of whooper swan counted (73.6%) as part of the 2020 International Swan Census[56] were observed on grassland habitats. This is consistent with previous years' findings (72.6% in 2015 and 79.2% in 2010) (Burke *et al*., 2021) and the increasing preference shown by foraging whooper swan in Ireland for dry, improved pastures (Brides *et al*., 2021) first noted in the mid 1990's (Crowe, 2005). The reason for this may be partly due to the general overall increasing numbers of whooper swan within Ireland every winter and their current conservation status in Ireland as 'Favourable' (NPWS, 2012c). In County Clare, for example, there was a 38.4% increase in the county's whooper swan population when the 2020 Swan Census results were compared with those of the 2015 Census, while in January 2020, whooper swan were recorded for the first time in all 32 counties during the census count (Burke *et al*., 2021).

Whooper swan belong within two trophic (foraging) guilds, namely 'surface swimmer' (meaning it can dabble/up-end on the water) and 'terrestrial walker' (meaning it can graze and/or probe in areas such as grassland and marsh) (NPWS, 2012c). These characteristics ensure the species has a wide prey/food range and, although displaying a relatively high level of site fidelity during winter, they can be highly mobile in relation to food supply utilising alternative habitats outside the SPA boundaries if necessary (Bowler, 2021). Considering this and the fact that the proposed development site lies within the core foraging range of 5 kilometres for the SPA's whooper swan population (SNH, 2016), there is potential for them to utilise the agricultural grassland areas within and around the proposed development site as foraging grounds.

However, over the 48-month survey period from October 2019 to September 2023, inclusive, whooper swan was never observed at the proposed development site nor within 4 kilometres of the proposed development site's boundary. During the wintering waterfowl counts at areas of suitable estuarine habitat along the River Shannon Estuary, flocks of whooper swan were regularly counted at the Cooperhill area within Section D, approximately 6.5 kilometres southwest of the proposed development site. The closest whooper swan record to the proposed development site was a flock of 14 individuals observed at King's Island within Section A, approximately 4 kilometres southeast of the proposed development site. Refer to **Section 4.4.8.2** and **Figure 4-7**, above, for survey details and locations.

[56] Internationally coordinated censuses carried out every five years over a single weekend - 2020 marked the 8th such census. They are coordinated in the Republic of Ireland by BirdWatch Ireland under contract to the National Parks and Wildlife Service.

Furthermore, whooper swan roost within wetland habitats such as lagoons, intertidal mudflats or shallow subtidal areas (NPWS, 2012c), and there are no significant bodies of standing water within the proposed development site or its immediate surroundings and therefore, no suitable whooper swan roost sites within the area. This is likely to be a significant factor in explaining the absence of whooper swan records from the proposed development site during the 48 months of bird surveys carried out there since 'the importance of permanent waterbodies as roost sites, near to suitable feeding habitat, should not be underestimated' (Burke *et al*., 2021). Similarly, Brides *et al.* (2021) noted that the existence of permanent standing water habitat 'in close proximity to feeding areas…..is vital as roosting habitat'.

This fact has already been confirmed in Section 4.4.8.2, above, with the details of the winter 2022/23 waterbird survey results where flocks of whooper swan were frequently observed at Cooperhill in survey Section D approximately 6.5 kilometres southwest of the proposed development site (refer to Figure 4-6, above). The permanent standing waterbody at the Cooperhill site is surrounded to the south, west and east by large swathes of agricultural fields, and to the north by the estuarine waters of the River Shannon which ensures the site is used by returning whooper swan every winter. Additionally, information obtained from BirdWatch Ireland on the waterbird species recorded at the closest I-WeBS subsites confirmed the presence of whooper swan at lakes surrounded by agricultural grassland approximately 10 kilometres northwest of the proposed development site and at southern estuarine areas near Cooperhill such as Coonagh Ponds and Bunlicky Lake. There are no I-WeBS sites within 5.5 kilometres of the proposed development site.

It has been established in the preceding paragraphs that whooper swan can and do frequently utilise habitat outside the boundaries of an SPA. However, upon completion of the entire suite of ornithological surveys carried out over 48 months (see Section 3.6.2, above) no evidence was found to indicate that any whooper swan population, whether from the River Shannon and River Fergus Estuaries SPA or elsewhere, utilised the grassland habitats within the proposed development site as feeding habitat. It has also been established that whooper swan roost within wetland habitats that preferably are near suitable foraging areas. The absence of any significant permanent standing waterbodies within the proposed development site or its environs decreases the optimality of grasslands in the area for foraging. Furthermore, the proposed development site is an already highly disturbed region due to relatively intense agricultural practices and activities associated with conifer plantations.

Therefore, in the context of the greater landscape containing more suitable foraging habitat and considering the absence of any whooper swan recorded within or around the proposed development site over 48 months of surveys, the loss of any potential foraging habitat to facilitate construction of the wind farm is not considered to have the potential to adversely impact the River Shannon and River Fergus Estuaries SPA in light of the whooper swan conservation objectives of the SPA – see also Section 6.4.3.2.2, below.

6.4.3 Disturbance and/or Displacement of Species

6.4.3.1 Lower River Shannon SAC

The Lower River Shannon SAC is designated for the protection of several aquatic species, and the semi-aquatic species, otter. Table 33, below, outlines the qualifying interest species for the SAC which have been selected for impact assessment.

Table 33. Qualifying Interest (QI) species of the Lower River Shannon SAC selected for impact assessment.

Qualifying Interest (QI) Species	Distribution within the SAC
Sea lamprey (*Petromyzon marinus*) [1095]	Freshwater aquatic
Brook lamprey (*Lampetra planeri*) [1096]	Freshwater aquatic
River lamprey (*Lampetra fluviatilis*) [1099]	Freshwater aquatic
Salmon (*Salmo salar*) [1106]	Freshwater aquatic
Otter (*Lutra lutra*) [1355]	Freshwater/coastal/terrestrial [semi aquatic]

There is potential for indirect disturbance or displacement of salmon and lamprey arising from potential pollutants entering watercourses during the construction phase of the proposed development. Spawning salmon and lamprey, in this case confined to brook lamprey, need a clean, well-aerated riverbed substrate to survive. Siltation of the substrate and eutrophication leading to increased biomass of filamentous algae could reduce the availability of suitable habitat. A reduction in water quality in the water column can reduce the suitability of the river for adult salmon and lamprey, resulting in disturbance/displacement of the species. There is potential for significant indirect effects to salmon and lamprey due to a reduction in water quality.

Regarding otter and the potential for disturbance or displacement impacts because of noise and/or human activity associated with construction of the development, it is noted that the drains in the vicinity of the proposed development site are considered to comprise marginal/sub-optimal foraging habitat for otter. No evidence of otter was recorded during the ecological site surveys. Although there is some potential for otter to occur, any disturbance or displacement impacts that arise due to fugitive noise from machinery and/or human activity during site preparation and construction will be temporary and will be restricted to the immediate vicinity of the proposed development site. In relation to possible otter disturbance or displacement impacts arising from the temporary road widening works that are to occur at the R464 / L3056 junction approximately 46 metres northwest of the SAC boundary, it is noted that works will be confined to the busy R464 Regional Road and adjacent areas that are already heavily modified and anthropogenically impacted with near constant levels of traffic. Therefore, any temporary road widening works at the junction are highly unlikely to significantly disturb or displace otter from the area when existing disturbance levels are considered.

Furthermore, otter is unlikely to use the 1st Order streams within the surrounding area given the small size and relatively low biomass of suitable prey species within the streams. However, larger watercourses downstream from the proposed development site can provide otter with a potential food source due to the wide variety of aquatic species present as described in **Section 4.4.7**, above. Therefore, while the proposed development is unlikely to result in any direct displacement of otter, there is potential for indirect displacement of the species through a reduction in water quality and suitability of the main channel for aquatic fauna and, consequently, reducing the available prey biomass for otter.

It has been determined in **Section 6.4.1**, above, that there is a risk, without a programme of mitigation measures to control any potential emissions from site preparation works and construction activity, that point or diffuse sources of pollution that could ensue from the proposed development could exert an impact on water quality. **Section 7,** below, outlines a programme of mitigation measures designed to avoid, reduce or offset potential adverse water quality impacts and thus indirect disturbance or displacement of aquatic species that might ensue because of the proposed development. Residual impacts are assessed in **Section 9,** below.

6.4.3.2 River Shannon and River Fergus Estuaries SPA

As described in SNH Guidance (2017), wind farms present three main potential risks to birds (Drewitt & Langston 2006, 2008; Band *et al*., 2007). These include:

- Direct habitat loss through construction of wind farm infrastructure.
- Indirect effects such as displacement (sometimes called indirect habitat loss) if birds avoid the wind farm and its surrounding area due to turbine construction and operation. Displacement due to disturbance during the construction and operational phase may occur. Displacement may also include barrier effects in which birds are deterred from using normal routes to feeding or roosting grounds.
- Direct effect of mortality caused by collisions with turbine blades and other infrastructure.

6.4.3.2.1 *Direct Habitat Loss*

There will be no direct loss of habitat within the SPA because of the proposed project. Furthermore, it is considered that the habitats contained within the footprint of the proposed turbine area do not comprise optimal foraging/roosting habitat for the SCI bird species in the context of other more suitable habitats within the surrounding areas – see more details in Section 6.4.2.2, above.

6.4.3.2.2 *Displacement Effects (Indirect Habitat Loss)*

While the SPA is more than 4 kilometres southwest of the wind farm site (3.1 km from the temporary works at the junction of the R464 and L3056), there is potential for indirect displacement effects on the SCI species that may use habitats outside of the SPA boundary. It is noted, however, that monthly VP surveys carried out over 48 months at the proposed development site did not record any SCI species foraging, roosting or nesting within the footprint of the proposed development or its environs. The proposed development site and its environs are an already relatively disturbed region due to ongoing agricultural practices and conifer plantations and they do not include any standing water or habitats that are preferentially selected by the populations of waterfowl and seabirds listed in Table 32, above, for which the SPA is designated.

These SCI species' preference is for large bodies of water such as the estuarine regions of the Shannon, Fergus and Maigue Rivers located further west towards the Atlantic. The terrestrial habitats available at the development site are not similar or ecologically analogous to the habitats preferred by these species and therefore, the site does not have the ecological resources required to attract nor support these qualifying interest (QI) species. While most of the species are generalists that can exploit alternative habitats, all are expected to, and based on the survey data appear to, preferentially select the range of coastal and estuarine habitats of higher ecological value abundantly available within the SPA site. As a result, it is considered that the wind farm construction will not disturb or displace foraging or roosting SCI species for which the River Shannon and River Fergus Estuaries SPA is designated.

There is potential for disturbance and displacement effects due to fugitive noise emissions generated during the construction phase of the proposal. It is considered that groundworks to prepare the wind farm site prior to installation of turbines and associated infrastructure will comprise the main activities with the potential to generate noise emissions greatly over and above ambient noise levels. However, such activities will be restricted to within the main footprint of the wind farm and at some distance from the SPA. Similarly, in terms of visual intrusion, the project's human resource requirement of work crews and other personnel will be located within the main wind farm site for the duration of the works.

It has already been noted in Section 6.4.1, above, that adverse water quality effects have the potential to arise during the construction phase of the project due to run-off from materials or through the accidental release of pollutants such as fuels, oils, silt, chemicals or hydrocarbons associated with construction activities. Siltation of the substrate and eutrophication leading to increased biomass of filamentous algae would reduce the available suitable habitat. Therefore, without mitigation, poor water quality brought about by the proposed works has the potential to significantly impact River Shannon and River Fergus Estuaries SPA and the SCI bird species for which it is designated.

6.4.3.2.3 *Collision Risk*

Wind farms create the potential for avian disturbance/displacement effects through collision of the birds with wind turbine structures and the rotating blades. The risk of collision is dependent on a wide range of factors including bird species, number of birds, weather conditions, topography and the character of the wind farm itself (Drewitt & Langston, 2006) and collision rates can vary greatly between different wind farms. Raptors have been reported as being more susceptible to turbine collision than many other species due to their morphology and flight behaviour (Gove *et al.*, 2013) while conversely, the risk of collision for waders is generally considered to be low 'due to a relatively low cursory flight path, coupled with high flight manoeuvrability' (McGuinness *et al*., 2015). None of the SCI species for which the River Shannon and River Fergus Estuaries SPA is designated were observed within the proposed development site boundary during the 48 months of ornithological surveys carried out onsite by experienced ecologists and ornithologists. Indeed, only two SCI species were recorded within the flight activity survey area (see Section 4.4.8, above), namely cormorant and black-headed gull (see Figure 4-6, above).

Although larger bird species such as cormorant and swans have reduced manoeuvrability when compared with smaller birds (McGuinness *et al*., 2015; Drewitt & Langston, 2006), the observed collision rate for cormorant has appeared to remain low. A review of the number of bird collision victims at fourteen wind farms in Germany since 1989 by Hötker *et al*., (2006) found only two cormorants among the fatalities, while a review of data from wind farms in seven other European countries did not find any additional cormorant collision victims. At offshore wind turbines near Blyth in northeast England, 'no collision mortality was witnessed during 352 hours of daytime watches post-construction' (Rothery *et al*., 2009) and 'cormorants did not appear to be at risk and were observed to avoid flying critically close to the turbines' (Lowther, 2000).

In general, gull species are reportedly killed by turbine strikes more frequently than would initially be expected based on their abundance (Rydell *et al.*, 2017; Hötker *et al*., 2006; Everaert *et al*., 2002) and they appear not to display any avoidance measures, thereby making them more prone to collision (Gove *et al*., 2013). The only gull species designated an SCI species for the River Shannon and River Fergus Estuaries SPA is the black-headed gull and, as already discussed in Section 4.4.8, above, it was one of two SCI species observed during the Vantage Point surveys carried out at the proposed development site. Although gull fatalities because of wind farms can be relatively high, black-headed gulls display less susceptibility to turbine strikes than most other gull species. As noted in the previous paragraph, Rothery *et al* (2009) did not observe any turbine collisions at Blyth in the UK and reported that only 4% of black-headed gull flights at the site were within the height band of the rotor blades (above 26.4 metres). Furthermore, also at Blyth, black-headed gull flight heights occurred predominantly at heights of less than 15 metres making the species less vulnerable to turbine collisions than other larger gull species (Langston & Pullan, 2003).

As illustrated in Figure 4-6, above, only two of the River Shannon and River Fergus Estuaries SPA's qualifying interest bird species - cormorant and black-headed gull - were observed within the proposed development site boundary's 500 metre buffer (or flight activity survey area) throughout the suite of ornithological surveys carried out at the site over 48 months. Black-headed gull flights occurred close to the western and southeastern boundaries of the flight activity survey area and did not traverse the footprint of the proposed development. Similarly, a single cormorant was observed in-flight on only three occasions during the 48 months of bird surveys. Although two cormorant flights did pass through the airspace of the proposed development, the paucity of cormorant and black-headed gull activity at the site indicates that it is highly unlikely that either species regularly uses the proposed development site to fly between habitats. This conclusion has also been reached in relation to the SPA's other SCI bird species since none were recorded within the proposed development site or the surrounding areas during the ornithological surveys.

As mentioned above, swans cannot manoeuvre themselves as efficiently as smaller birds due to their comparatively much bigger size. However, despite this, the collision rate reported for whooper swan has remained low. Hötker *et al*., (2006) reviewed collision data from wind farms in six European countries and found that birds such as geese and swans 'were only rarely found among the victims' and when compared to other birds, they 'were killed relatively infrequently'. Data on bird carcasses found under turbines was systematically collected in Germany since 1989 and revealed that duck, geese and swans made up only 5% of fatalities (or 65 birds) from 1989 to 2010 (Rydell *et al*., 2012). Furthermore, species such as geese and swans react to wind turbines at greater distances than most birds due to their heavier bodies and slower flight speed. This quicker reaction time coupled with the 'good eyesight' of geese and swans (Rees, 2012) means that the species have extremely high levels of avoidance rates for wind turbines – 99.5% for swans and 99.8% for geese (SNH, 2018).

Finally, the proposed turbines will have a relatively large blade length measuring 68 metres (see Table 16, above) and a greater rotor sweep resulting in increased power output at a wider range of wind speeds. Turbines with larger blades generally have a lower rotor speed than smaller turbines and, despite the larger rotor surface and higher altitude-range, it has been reported that the risk of collision with the larger blades is less than that of smaller blades. Krijgsveld *et al.* (2009) studied the collision rates of birds with large, modern turbines in the Netherlands and found that the 'risk was threefold lower than for smaller turbines'. Similarly, in Japan, Shimada (2021) used simple collision risk models to analyse collision rates and turbines of differing sizes and concluded that 'the number of collisions per MW decreases as the blade lengths or blade swept area increases'.

Consequently, for the reasons outlined in the preceding paragraphs, the potential for turbine collision to result in displacement or disturbance of the SCI bird species for which the River Shannon and River Fergus Estuaries SPA is designated is considered low.

6.4.3.2.4 *Barrier Effects*

Wind energy developments also have the potential to create 'barrier effects' where a barrier to movement is created that can disturb or displace a species from an area. This effect is of particular concern due to the possibility of increasing a bird's energy expenditure should they be required to fly further distances than they would otherwise need do to avoid turbines and/or access feeding, roosting and/or breeding areas. As is the case with collision risk, barrier effects are dependent on many different factors such as, amongst others, species of bird, flight height, wind force/direction, and time of day (Drewitt & Langston, 2006). Indeed, the actual barrier effect itself can vary hugely ranging from a slight change in flight direction, height or speed to a considerable diversion that may significantly affect an individual's energy budget (Gove *et al*., 2013).

A review of publications and reports on the issue of barrier effects carried out by Hötker *et al*. (2006) determined a barrier effect for 104 out of 168 cases (81 species), indicating that it is a relatively common occurrence but does not seem to affect all species equally. The review also established that geese, kites, cranes and some smaller passerines exhibited a particularly high level of sensitivity to barrier effects while birds such as cormorants, ducks, gulls, terns and some raptors 'were all less sensitive or less willing to change their original migration direction when approaching wind farms….and their local populations were less influenced by wind farms'.

Daytime observations at the East dam in the port of Zeebrugge, in Belgium, and at Maasvlakte in the port of Rotterdam, in The Netherlands, found that wind turbines did not act as a barrier for the daily migration routes of local breeding gull and tern colonies, with the birds flying between the turbines as they moved to and from their marine feeding areas (Everaert *et al*., 2002; Langston & Pullan, 2003). Similarly, at Blyth in Northumberland in northwest England with globally significant numbers of overwintering purple sandpipers (*Calidris maritima*), the wind turbines did not appear to act as a barrier to movement and the species displayed an apparently high level of tolerance to the turbines (Lowther, 2000).

As discussed in Section 6.4.3.2.3, above, and illustrated in Figure 4-6, above, only two of the SCI bird species for which the River Shannon and River Fergus Estuaries SPA is designated were recorded within the flight activity survey area – cormorant on three occasions and black-headed gull on two occasions. This dearth of activity recorded over 48 months of surveys suggests that the potential for either species, or indeed any other of the SPA's SCI bird species, to regularly use the proposed development site as an ecological link to fly between habitats is low.

Considering the information outlined in the preceding paragraphs, the potential for disturbance and/or displacement of the SCI bird species of the River Shannon and River Fergus Estuaries SPA due to barrier effects is considered low.

6.4.4 Habitat or Species Fragmentation

Habitat fragmentation has been defined as 'reduction and isolation of patches of natural environment' (Franklin *et al*., 2002; Morrison *et al*., 2012) usually due to an external disturbance that alters the habitat and 'create[s] isolated or tenuously connected patches of the original habitat' (Wiens, 1989). This results in spatial separation of habitat units which had previously been in a state of greater continuity. Negative effects of habitat fragmentation on species or populations can include increased isolation of populations or species which can detrimentally impact on the resilience or robustness of the populations reducing overall species diversity and altering species abundance.

The proposed development will not result in any habitat loss within either of the relevant European sites - Lower River Shannon SAC and River Shannon and River Fergus Estuaries SPA – and significant habitat or species fragmentation impacts are not envisaged. However, a programme of mitigation measures pertaining to protection of water quality is recommended (see Section 7, below). Residual impacts are assessed in Section 9, below.

6.5 Assessment of Effects on the Conservation Objectives of the Lower River Shannon SAC [002165]

An evaluation was undertaken to determine which of the Qualifying Interests (QIs) of the Lower River Shannon SAC (see Section 6.2.2, above) potentially lie within the zone of influence of the proposed development and required further assessment in the NIS. This was done through a scientific examination of ecological evidence and data listed above in Section 3, above, or referenced, as well as the results of the ecological field survey (Section 4.4, above).

In this case, certain qualifying aquatic habitats and certain qualifying aquatic/water-dependant species were selected for further assessment. The remaining QI habitats and species were deemed to be outside of the zone of influence of the proposed development and were not selected for further assessment in the NIS. The effects of the project on the qualifying interests potentially within the zone of influence of the proposed development have been assessed against the measures designed to achieve the conservation objectives of the site. The outcome of the assessment has been presented in the following sections.

6.5.1 Estuaries [1130]

The conservation objective for 'Estuaries' is to maintain the favourable conservation condition of this habitat in the Lower River Shannon SAC. The specific habitat Attributes and Targets for this QI defined in relation to the achievement of the Conservation Objectives for the SAC are presented in **Table 34,** below. An assessment of the effects of the proposed development against these measures is also included.

Table 34. Attributes and targets for 'Estuaries [1130]' within the Lower Shannon SAC (NPWS, 2012b)

Attribute/ Measure	Target	Assessment of Potentially Significant Effects	Mitigation Required
Habitat area/ Hectares	The permanent habitat area is stable or increasing, subject to natural processes. Habitat area estimated as 24,273 ha.	There will be no reduction in habitat area within the SAC. Thus, this attribute will not be adversely affected by the project.	No
Community distribution/ Hectares	Conserve the following community types in a natural condition: Intertidal sand to mixed sediment with polychaetes, molluscs and crustaceans community complex; Estuarine subtidal muddy sand to mixed sediment with gammarids community complex; Subtidal sand to mixed sediment with *Nucula nucleus* community complex; Subtidal sand to mixed sediment with *Nephtys* spp. community complex; Fucoid-dominated intertidal reef community complex; Faunal turf-dominated subtidal reef community; and Anemone-dominated subtidal reef community.	Sediment-laden run-off may arise from exposed areas during groundworks or from construction vehicles/plant. These are potential sources of nutrients which could discharge into watercourses. Accidental fuel/oil spills or uncontrolled emissions of cementitious material/wastewater or other harmful substances also pose a risk to water quality, conservation of communities and habitat distribution.	Yes Refer to Section 7

6.5.2 Mudflats and sandflats not covered by seawater at low tide [1140]

The conservation objective for 'Mudflats and sandflats not covered by seawater at low tide' is to maintain the favourable conservation condition of this habitat in the Lower River Shannon SAC. The specific habitat Attributes and Targets for this QI defined in relation to the achievement of the Conservation Objectives for the SAC are presented in Table 35, below. An assessment of the effects of the proposed development against these measures is also included.

Table 35. Attributes and targets for 'Mudflats and sand flats not covered by sea water at low tide' within the Lower River Shannon SAC (NPWS, 2012b)

Attribute/Measure	Target	Assessment of Potentially Significant Effects	Mitigation Required
Habitat area/Hectares	The permanent habitat area is stable or increasing, subject to natural processes. Habitat area estimated using OSI data as 8,808 ha.	There will be no reduction in habitat area within the SAC. Thus, this attribute will not be adversely affected by the project.	No
Community distribution/ Hectares	Conserve the following community types in a natural condition: Intertidal sand with *Scolelepis squamata* and *Pontocrates* spp. community; and Intertidal sand to mixed sediment with polychaetes, molluscs and crustacean community complex.	Sediment-laden run-off may arise from exposed areas during groundworks or from construction vehicles/plant. These are potential sources of nutrients which could discharge into watercourses. Accidental fuel/oil spills or uncontrolled emissions of cementitious material/wastewater or other harmful substances also pose a risk to water quality, conservation of communities and habitat distribution.	Yes Refer to Section 7

6.5.3 Watercourses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation [3260]

The conservation objective for 'Watercourses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation' is to maintain the favourable conservation condition of this habitat in the Lower River Shannon SAC. The specific habitat Attributes and Targets for this QI defined in relation to the achievement of the Conservation Objectives for the SAC are presented in **Table 36,** below. An assessment of the effects of the proposed development against these measures is also included.

Table 36. Assessment of effects on conservation objectives of 'Watercourses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation [3260]' (NPWS, 2012b).

Attribute/Measure	Target	Assessment of Potentially Significant Effects	Mitigation Required
Habitat area/Kilometres	Area stable or increasing, subject to natural processes. Three sub-types of high conservation value are known to occur in the SAC.	There will be no reduction in habitat area within the SAC. Thus, this attribute will not be adversely affected by the project.	No
Habitat distribution/ Occurrence	No decline, subject to natural processes.	There will be no decline in habitat distribution within the SAC. Thus, this attribute will not be adversely affected by the project.	No
Hydrological regime: river flow/ metres per second	Maintain appropriate hydrological regimes	A natural flow regime is required for both plant communities and channel geomorphology to be in favourable condition. There will be no alteration of hydrological regime within the habitat within the SAC. Thus, this attribute will not be adversely affected by the project.	No
Hydrological regime: tidal influence/ Daily water level fluctuations - metres	Maintain natural tidal regime	There will be no alteration of hydrological regime or natural tidal influence within the habitat within the SAC. Thus, this attribute will not be adversely affected by the project.	No
Hydrological regime: freshwater seepages/ metres per second	Maintain appropriate freshwater seepage regimes	There will be no alteration of hydrological regime or the freshwater seepages regime of the habitat within the SAC. Thus, this attribute will not be adversely affected by the project.	No
Substratum composition: particle size range/ Millimetres	The substratum should be dominated by the particle size ranges, appropriate to the habitat sub-type (frequently sands, gravels and cobbles)	Sediment laden run-off may arise from disturbed areas during groundworks or from construction vehicles/plant. When combined with heavy rainfall these activities pose a risk of silt runoff into waterways, including the North Ballycannan Stream and River Shannon downslope of the site and within the SAC. Such impacts may occur via the existing drainage network around the site in the absence of appropriate controls.	Yes Refer to Section 7

Attribute/Measure	Target	Assessment of Potentially Significant Effects	Mitigation Required
Water quality: nutrients/ Milligrams per litre	The concentration of nutrients in the water column should be sufficiently low to prevent changes in species composition or habitat condition. The specific targets may vary among sub- types	Nutrient enrichment typically leads to increased filamentous algal biomass and consequent changes in algae, bryophyte and macrophyte species composition and abundance. Excess algal growth can lead to oxygen depletion in aquatic environments. Sediment-laden run-off may arise from exposed areas during groundworks or from construction vehicles/plant. These are potential sources of nutrients which could discharge into watercourses. Accidental fuel/oil spills or uncontrolled emissions of cementitious material/wastewater or other harmful substances also pose a risk to water quality and habitat condition.	Yes Refer to Section 7
Vegetation composition: typical species/ Occurrence	Typical species of the relevant habitat sub-type should be present and in good condition	The sub-types of this habitat include higher plants, bryophytes and microalgae. Site preparation and construction activity could adversely affect water quality and in turn habitat condition and typical vegetation composition.	Yes Refer to Section 7
Floodplain connectivity/ Area	The area of active floodplain at and upstream of the habitat should be maintained	River connectivity with the floodplain is essential for the functioning of this habitat and is particularly important in terms of sediment sorting and nutrient deposition. The proposed development will not affect floodplain connectivity within the catchment. Thus, this attribute will not be adversely affected by the project.	No
Riparian habitat/ Area	The area of riparian woodland at and upstream of the bryophyte-rich sub-type should be maintained	The proposed development will not result in any loss in area of riparian woodland. Thus, this attribute will not be adversely affected by the project.	No

6.5.4 Sea Lamprey [1095]

The conservation objective for sea lamprey is to restore the favourable conservation condition of this QI species in the Lower River Shannon SAC. The specific species Attributes and Targets for sea lamprey defined in relation to the achievement of the Conservation Objectives for the SAC are presented in **Table 37,** below. An assessment of the effects of the project against these measures is also included.

Table 37. Assessment of effects on conservation objectives of 'Sea lamprey [1095]' (NPWS, 2012b)

Attribute/Measure	Target	Assessment of Potentially Significant Effects	Mitigation Required
Distribution: extent of anadromy/ % of river accessible	Greater than 75% of main stem length of rivers accessible from estuary	The proposed development will not result in any change in distribution or accessibility of rivers from the estuary for sea lamprey. Thus, this attribute will not be adversely affected by the project.	No
Population structure of juveniles/ Number of age/size groups	At least three age/size groups present	Potential adverse water quality effects which may arise because of the proposed development could impact on the population structure of juveniles within the SAC.	Yes Refer to **Section 7**
Juvenile density in fine sediment/ Juveniles/m^2	Juvenile density at least $1/m^2$	Potential adverse water quality effects which may arise because of the proposed development could impact on juvenile sea lamprey habitat condition and juvenile population structure within the SAC.	Yes Refer to **Section 7**
Extent and distribution of spawning habitat/ m^2 and occurrence	No decline in extent and distribution of spawning beds	Lampreys require areas of clean gravels to spawn. Potential adverse water quality effects which may arise because of the proposed development could impact on spawning habitat potentially located downstream of the site and could result in a decline in spawning habitat extent within the SAC.	Yes Refer to **Section 7**
Availability of juvenile habitat/ Number of positive sites in 3rd order channels (and greater), downstream of spawning areas	More than 50% of sample sites positive	Juvenile lampreys require areas of clean sand and silt in which to develop and mature. Potential adverse water quality effects which may arise because of the proposed development could impact on juvenile lamprey habitat condition and availability in watercourses downstream of the site within the SAC.	Yes Refer to **Section 7**

6.5.5 River Lamprey [1099] and Brook Lamprey [1096]

The conservation objective for river and brook lamprey is to maintain the favourable conservation condition of these species in the Lower River Shannon SAC. The specific species Attributes and Targets for river and brook lamprey defined in relation to the achievement of the Conservation Objectives for the SAC are presented in **Table 38,** below. An assessment of the effects of the project against these measures is also included.

Table 38. Assessment of effects on conservation objectives of 'River lamprey [1099]' and 'Brook lamprey [1096]' (NPWS, 2012b)

Attribute/Measure	Target	Assessment of Potentially Significant Effects	Mitigation Required
Distribution/ % of river accessible	Access to all watercourses down to 1st order streams	The proposed development will not result in any change in distribution or accessibility of watercourses for river/brook lamprey. Thus, this attribute will not be adversely affected by the project.	No
Population structure of juveniles/ Number of age/size groups	At least three age/size groups of brook/river lamprey present	Potential adverse water quality effects which may arise because of the proposed development could impact on the population structure of juvenile river or brook lamprey within the SAC.	Yes Refer to Section 7
Juvenile density in fine sediment/ Juveniles/m^2	Mean catchment juvenile density of river/brook lamprey at least $2m^2$	Potential adverse water quality effects which may arise because of the proposed development could impact on juvenile lamprey habitat condition and mean catchment juvenile density within the SAC.	Yes Refer to Section 7
Extent and distribution of spawning habitat/ m^2 and occurrence	No decline in extent and distribution of spawning beds	Lampreys require areas of clean gravels to spawn. Potential adverse water quality effects which may arise because of the proposed development could impact on spawning habitat potentially located downstream of the site and could result in a decline in spawning habitat extent within the SAC.	Yes Refer to Section 7
Availability of juvenile habitat/ Number of positive sites in 2nd order channels (and greater) downstream of spawning areas	More than 50% of sample sites positive	Juvenile lampreys require areas of clean sand and silt in which to develop and mature. Potential adverse water quality effects which may arise because of the proposed development could impact on juvenile lamprey habitat condition and availability in watercourses downstream of the site within the SAC.	Yes Refer to Section 7

6.5.6 Atlantic Salmon [1106]

The conservation objective for Atlantic salmon is to restore the favourable conservation condition of this species in the Lower River Shannon SAC. The specific species Attributes and Targets for Atlantic salmon defined in relation to the achievement of the Conservation Objectives for the SAC are presented in **Table 39,** below. An assessment of the effects of the project against these measures is also included.

Table 39. Assessment of effects on conservation objectives of 'Atlantic salmon [1106]' (NPWS, 2012b)

Attribute/Measure	Target	Assessment of Potentially Significant Effects	Mitigation Required
Distribution: extent of anadromy/ % of river accessible	100% of river channels down to 2nd order streams accessible from estuary	The proposed development will not result in any change in distribution or accessibility of rivers for salmon. Thus, this attribute will not be adversely affected by the project.	No
Adult spawning fish/ Number	Conservation Limits (CL) for each system consistently exceeded	Potential adverse water quality effects which may arise because of the proposed development could impact adult salmon, fry, or smolts.	Yes Refer to **Section 7**
Salmon fry abundance/ Number of fry/ 5 minutes electrofishing	Maintain or exceed 0+ fry mean catchment-wide abundance threshold value. Currently set at 17 salmon fry/5 min sampling		
Out-migrating smolt abundance/ Number	No significant decline		
Number and distribution of redds/ Number and occurrence	No decline in number and distribution of spawning redds due to anthropogenic causes	Salmon require areas of clean gravel and cobble to spawn. Potential adverse water quality effects which may arise because of the proposed development could impact on spawning habitat potentially located downstream of the site and could result in a decline in spawning habitat within the SAC.	Yes Refer to **Section 7**
Water quality/ EPA Q value	At least Q4 at all sites sampled by EPA	Potential adverse water quality effects which may arise because of the proposed development could impact on river water quality as measured by the Q-value.	Yes Refer to **Section 7**

6.5.7 Otter [1355]

The conservation objective for otter is to restore the favourable conservation condition of this species in the Lower River Shannon SAC. The specific species Attributes and Targets for otter defined in relation to the achievement of the Conservation Objectives for the SAC are presented in **Table 40,** below. An assessment of the effects of the project against these measures is also included.

Table 40. Assessment of effects on conservation objectives of 'Otter [1355]' (NPWS, 2012b)

<table>
<tr><th>Attribute/Measure</th><th>Target</th><th>Assessment of Potentially Significant Effects</th><th>Mitigation Required</th></tr>
<tr><td>Distribution/ percentage positive survey sites</td><td>No significant decline</td><td>The proposed development site features some small streams which are evaluated as marginal/sub-optimal potential foraging habitats for otter. Due to the nature, location and scale of the proposed development, a significant decline in distribution of otter is not likely. Thus, this attribute will not be adversely affected by the project.</td><td>No</td></tr>
<tr><td>Extent of terrestrial habitat/ hectares</td><td>No significant decline. Area mapped as 596.8 ha above high-water mark, 958.9 ha along riverbanks/around ponds</td><td rowspan="4">The proposed development will not result in any significant decline in the extent of terrestrial/ marine/freshwater (river) or freshwater (lake/lagoon) habitat for otter. Thus, this attribute will not be adversely affected.</td><td rowspan="4">No</td></tr>
<tr><td>Extent of marine habitat/ hectares</td><td>No significant decline. Area mapped as 4,461.6 ha</td></tr>
<tr><td>Extent of freshwater (river) habitat/ kilometres</td><td>No significant decline. Length mapped as 500.1 km</td></tr>
<tr><td>Extent of freshwater (lake/lagoon) habitat/ hectares</td><td>No significant decline. Area mapped as 125.6 ha</td></tr>
<tr><td>Couching sites and holts/ number</td><td>No significant decline</td><td>Field surveys did not identify any suitable couching sites or breeding habitat. The proposed development will not result in any decline in the number of couching sites and holts for otter. Any otter using the proposed development site are considered transient i.e. only passing through from one catchment to another. Thus, this attribute will not be adversely affected.</td><td>No</td></tr>
<tr><td>Fish biomass available/ kilograms</td><td>No significant decline</td><td>Potential adverse water quality effects may arise because of the proposed development could impact on water quality within downstream watercourses and therefore the fish biomass available to otter.</td><td>Yes Refer to Section 7</td></tr>
<tr><td>Barriers to connectivity/ number</td><td>No significant increase.</td><td>The proposed development will not result in any increase in the number of barriers to connectivity for otter. Thus, this attribute will not be adversely affected.</td><td>No</td></tr>
</table>

6.6 Assessment of Effects on the Conservation Objectives of the River Shannon and River Fergus Estuaries SPA [004077]

An evaluation was undertaken to identify which of the Special Conservation Interest (SCI) bird species of the River Shannon and River Fergus Estuaries SPA (see **Section 6.3.2,** above) potentially lie within the zone of influence of the proposed development and require further assessment in the NIS. This was done through a scientific examination of ecological evidence and data listed above in **Section 3**, above, or referenced, as well as the results of the ecological field surveys (**Section 4.4**, above). In this case, certain qualifying SCI species were selected for further assessment. The remaining species were deemed to be outside of the zone of influence of the proposed development and were not selected for further assessment in the NIS.

Following this, an assessment of the potentially significant effects that may arise due to the proposed development was carried out in **Section 6.4**, above, and a determination was made as to whether the integrity of the SPA is likely to be adversely effected by the proposal. Potential indirect effects to the water quality of the SPA were identified along with the possible indirect ramifications this may have on the wetland habitat and species within the SPA. Displacement of SCI species that may be created by the proposed turbines due to risk of collision and/or the potential barriers to movement was also addressed in **Sections 6.4.3.2.3** and **6.4.3.2.4**, respectively, above, and the potential risk was concluded as being low.

The effects of the project on the qualifying interests potentially within the zone of influence of the proposed development have been assessed against the measures designed to achieve the conservation objectives of the site and the outcome of the assessment has been presented in the following sections. In addition to the wintering waterbird counts described in **Sections 3.6.2.2.2** and **4.4.8.2**, above, surveys carried out for the 2010/11 Waterbird Survey Programme (NPWS, 2012d) at the subsites illustrated in **Figure 6-2**, above, are referred to throughout the following assessments. Given that habitats within the SPA have not undergone any significant change in recent years, the current distribution of SCI species within the SPA can be expected to correlate to the distributions recorded during the 2010/11 Waterbird Survey Programme (NPWS, 2012d) and the most recent I-WeBS data.

6.6.1 Cormorant [A017]

Cormorant is a resident species in Ireland occurring along the coast and breeding in colonies mainly on offshore islands and rocky coastlines although there are some inland breeding populations. This diving species feeds on fish, foraging mainly in shallow waters (<30m depth) and may roost in intertidal or supratidal areas. The species is amber-listed in Ireland due to a localised breeding population. Cormorant is the only qualifying species with a breeding population within the River Shannon and River Fergus Estuaries SPA (NPWS, 2012c).

The conservation objective for cormorant is to maintain the favourable conservation condition of this species in the River Shannon and River Fergus Estuaries SPA. The specific species Attributes and Targets for cormorant defined in relation to the achievement of the Conservation Objectives for the SPA are presented in **Table 41,** below. An assessment of the effects of the project against these measures is also included.

Table 41. Assessment of effects on conservation objectives of 'Cormorant [A017]' (NPWS, 2012c).

Attribute/Measure	Target	Assessment of Potentially Significant Effects	Mitigation Required
Breeding population abundance: apparently occupied nests (AONs)/ Number	No significant decline	Cormorant usually breed in colonies on rocky coastlines along the SPA's outer extent or inland in suitable trees. Habitats at the proposed development site are modified/disturbed and considered unsuitable for breeding cormorant. There is ample suitable breeding habitat along the Shannon Estuary and further west to the Atlantic or east towards the Foyle Estuary. The project is not expected to cause significant decline in cormorant breeding population but water quality impacts and/or disturbance is possible which may potentially affect the breeding population and range. While no significant effects are expected, mitigation will be applied as a precaution.	Yes Refer to **Section 7**
Productivity rate/ Mean number	No significant decline	The project is not expected to cause a significant decline on the productivity of this species. Therefore, no significant effects to this measure are expected.	No
Distribution: breeding colonies/ Number; location; area (hectares)	No significant decline	The project does not affect habitat types for which cormorant most commonly nest upon, namely rocky islets, sea stack tops and cliffs (Walsh *et al*., 1995). Cormorant can also nest in trees as is the case with the population at Bunlicky Lake, almost 7 km south of the proposal site. However, since only three cormorant observations were reported during 48 months of ornithological surveys at Ballycar and all involved a single bird travelling over the proposed development site, the species is not considered to use the area within or around the proposed development site for the purposes of a breeding colony. Therefore, no significant effects to this measure are expected.	No
Prey biomass available/ Kilogrammes	No significant decline	Cormorant are piscivorous and use subsites 0I448, 0I447 and 0I427 and surrounding areas for foraging (see **Figure 6-2,** above, for subsite locations). Impacts on water quality could therefore impact prey items of this specialist species.	Yes Refer to **Section 7**

Attribute/Measure	Target	Assessment of Potentially Significant Effects	Mitigation Required
Barriers to connectivity/ Number; location; shape; area (hectares)	No significant increase	Applies to breeding colonies of cormorant – the species often utilise extensive areas of marine waters for foraging. Since only three cormorant flights were recorded during the 48 months of bird surveys and all involved a single bird, and because the nearest proposed turbine location (T12) is at least 4.5 km north of the SPA and almost 7 km from the nearest known breeding colony at Bunlicky Lake (Gerard Hayes, pers. Comm.), the species is not considered to use the proposed development area as a connecting corridor to foraging grounds. Therefore, no significant barrier effects to connectivity are expected and the proposed project is unlikely to impact this measure.	No
Disturbance at breeding site/ Level of impact	Human activities should occur at levels that do not adversely affect the breeding cormorant population	Key habitats include sandy areas, rocky and vegetated substrate. There is ample suitable breeding habitat along the Shannon Estuary and further west towards the Atlantic or east towards the Foyle Estuary. The project is not expected to cause a significant decline in the breeding population of cormorant but water quality impacts and/or disturbance of this species is possible which could potentially affect the breeding population and range. While no significant effects to this measure are expected, mitigation will be applied as a precaution.	Yes Refer to **Section 7**
Population trend/ Percentage change	Long term population trend stable or increasing	The most recent cormorant population status assessment for the SPA reports a species decline within the 'Intermediate' range (1.0% - 24.9% decline). This range allows for natural fluctuations and represents a range within which population declines are relatively small and potentially reversible and are less likely to influence the species' long-term conservation status. An all-Ireland trend for the period 1994/95 to 2008/09 is an increase of 31.5% (NPWS, 2012d). This attribute applies to non-breeding cormorant only and while the proposed project is not expected to cause a significant decline in the cormorant population, water quality impacts and/or disturbance of this species is possible which could potentially affect population trend. While no significant effects to this measure are expected, mitigation will be applied as a precaution.	Yes Refer to **Section 7**
Distribution/ Range, timing and intensity of use of areas	There should be no significant decrease in the range, timing or intensity of use of areas by cormorant other than that occurring from natural patterns of variation	Cormorant was recorded only three times during the 48 months of VP surveys and each observation involved a single bird flying over the proposed development site. Cormorant were recorded relatively frequently at subsites nearest the proposed development site (see **Figure 6-2,** above, for subsite locations). The waterbird counts recorded cormorant during both 2019/20 and 2022/23 winters with a peak count of 406 in Section C (see **Section 4.4.8.2**, above). This attribute applies to non-breeding cormorant only, and while the proposed project is not expected to cause a significant decline in the distribution of the cormorant population, water quality impacts and/or disturbance is possible which could potentially affect population distribution. While no significant effects to this measure are expected, mitigation will be applied as a precaution.	Yes Refer to **Section 7**

6.6.2 Whooper Swan [A038]

Whooper swan is an Annex I species and is amber-listed in Ireland as the country hosts more than 20% of the European wintering population with birds usually arriving in late autumn and departing by mid-April. Flood plains and grassland areas adjacent to rivers provide optimal foraging/roosting habitat for whooper swan during the winter months when they can be seen in estuaries and other wetland habitats as well as lowland agricultural areas. Flooded areas of cutaway bog are also regularly utilised by whooper swans as foraging grounds. They forage diurnally, primarily on agricultural grasses and grains although aquatic plants in inter-tidal areas are also taken. This is a highly mobile species whose movement is dependent upon the degree of flooding in suitable foraging habitats; they also exhibit a high level of site fidelity to wintering areas (Wilson *et al*., 1991; Warren *et al*., 1992; Stroud *et al.*, 2012).

The conservation objective for whooper swan is to maintain the favourable conservation condition of this species in the River Shannon and River Fergus Estuaries SPA. The specific species Attributes and Targets for whooper swan defined in relation to the achievement of the Conservation Objectives for the SPA are presented in **Table 42,** below. An assessment of the effects of the project against these measures is also included.

Table 42. Assessment of effects on conservation objectives of 'Whooper Swan [A038]' (NPWS, 2012c)

Attribute/ Measure	Target	Assessment of Potentially Significant Effects	Mitigation Required
Population trend/ Percentage change	Long term population trend stable or increasing	Results of the 2020 International Swan Census (Burke *et al*., 2021) showed a 'substantial increase' in numbers of whooper swan on the island of Ireland up 26.5% since the 2015 census with the entire Shannon & Fergus Estuary area supporting internationally important numbers of the species. The project is not expected to cause a significant decline in the whooper swan population but water quality impacts and/or disturbance of this species is possible which could potentially affect population trend. While no significant effects to this measure are expected, mitigation will be applied as a precaution.	Yes Refer to **Section 7**
Distribution/ Range, timing and intensity of use of areas	There should be no significant decrease in the range, timing or intensity of use of areas by whooper swan other than that occurring from natural patterns of variation	During the 2010/11 waterbird survey programme, there were no whooper swan recorded at the five closest subsites to the proposed development site – 0I446, 0I457, 0I427, 0I447, and 0I448 (see **Figure 6-2,** above) and none were recorded during the VP surveys at the proposed development site (NPWS, 2012c). The wintering waterbird counts did not record any whooper swan in 2019/20 but did record flocks in Section D on four occasions and in Section A on one occasion during the 2022/23 counts (see **Section 4.4.8.2**, above). Although the project will not directly affect the water quality of the SPA, there is potential for construction phase activities to indirectly affect water quality via the watercourses draining the development site. This in turn has the potential to cause significant adverse effects to the range of whooper swan foraging and roosting habitats within the SPA. Mitigation will, therefore, be applied as a precaution.	Yes Refer to **Section 7**

6.6.3 Shelduck [A048]

Shelduck is amber-listed in Ireland as the majority of the Irish wintering population occurs at less than ten sites. Shelduck nest in sand dune systems, and on islands and grassy parts of estuaries. Shelduck forage in a variety of ways from scything their bill through wet mud on exposed tidal flats, to dabbling and scything in shallow water and up-ending in deeper waters. They can therefore forage throughout the tidal cycle. Shelduck mainly confines itself to the intertidal area and coastlands of the SPA and feeds on mudflats.

The conservation objective for shelduck is to maintain the favourable conservation condition of this species in the River Shannon and River Fergus Estuaries SPA. The specific species Attributes and Targets for shelduck defined in relation to the achievement of the Conservation Objectives for the SPA are presented in **Table 43,** below. An assessment of the effects of the project against these measures is also included.

Table 43. Assessment of effects on conservation objectives of 'Shelduck [A048]' (NPWS, 2012c).

Attribute/ Measure	Target	Assessment of Potentially Significant Effects	Mitigation Required
Population trend/ Percentage change	Long term population trend stable or increasing	Population status of shelduck at the SPA was assessed as declining by more than 50% when the baseline data for the period 1995/96 to 1999/00 was compared with data from the period 2006/07 to 2010/11 (NPWS, 2012d), with Burke *et al*. (2018) estimating a 14% decrease in all-Ireland shelduck numbers when 2015/16 core counts were compared with the 2006/07 to 2010/11 population estimates. The project is not expected to cause a significant decline in the shelduck population, however there is potential for adverse water quality impacts and/or disturbance of this species which could potentially affect the population trends. While no significant effects to this measure are expected, mitigation will be applied as a precaution.	Yes Refer to **Section 7**
Distribution/ Range, timing and intensity of use of areas	There should be no significant decrease in the range, timing or intensity of use of areas by shelduck other than that occurring from natural patterns of variation	During the 2010/11 Waterbird Survey Programme, there was very little shelduck activity recorded in the subsites located nearest the proposed development site with highest densities occurring further west near Breckinish (NPWS, 2012d). There were no shelduck recorded at all during the wintering waterbird counts (see **Section 4.4.8.2**, above). While the project will not directly affect the water quality of the SPA, there is potential for construction phase activities to indirectly affect water quality via the watercourses draining the development site. This in turn has the potential to cause significant adverse effects to the range of shelduck foraging and roosting habitats within the SPA. Mitigation will be applied as a precaution.	Yes Refer to **Section 7**

6.6.4 Wigeon [A050]

Wigeon is amber-listed due to a decline in its non-breeding (wintering) population. Wigeon are highly migratory, arriving to Ireland in August/September and wintering in ponds and flooded fields around the SPA. Their diet is almost entirely vegetarian, and a major part of the diet comprises seagrass and algae species which are taken by grazing or dabbling in shallow water. Wigeon also forage within grasslands and agricultural crops for seeds, stems and rhizomes. A gregarious bird, they are rarely seen far from water.

The conservation objective for wigeon is to maintain the favourable conservation condition of this species in the River Shannon and River Fergus Estuaries SPA. The specific species Attributes and Targets for wigeon defined in relation to the achievement of the Conservation Objectives for the SPA are presented in **Table 44,** below. An assessment of the effects of the project against these measures is also included.

Table 44. Assessment of effects on conservation objectives of 'Wigeon [A050]' (NPWS, 2012c)

Attribute/Measure	Target	Assessment of Potentially Significant Effects	Mitigation Required
Population trend/ Percentage change	Long term population trend stable or increasing	Population status of wigeon at the SPA was assessed as declining by more than 50% when the baseline data for the period 1995/96 to 1999/00 was compared with data from the period 2006/07 to 2010/11 (NPWS, 2012d). Burke *et al*. (2018) estimated a 12% decrease in all-Ireland wigeon numbers when 2015/16 core counts were compared with the 2006/07 to 2010/11 population estimates. Although the project is not expected to cause a significant decline in the wigeon population, there is potential for adverse water quality impacts and/or disturbance of this species which could potentially affect the population trends. Mitigation will be applied as a precaution.	Yes Refer to **Section 7**
Distribution/ Range, timing and intensity of use of areas	There should be no significant decrease in the range, timing or intensity of use of areas by wigeon other than that occurring from natural patterns of variation	During the 2010/11 Waterbird Survey Programme, wigeon was recorded foraging and roosting in relatively high numbers in the subsites 0I445 and 0I446 near Newtown and Scarlet Reach (NPWS, 2012d), more than 8.5 river km downstream of the proposed development site via the Crompaun [East] River (see **Figure 6-2,** above, for subsite locations). The wintering waterbird counts recorded wigeon in Section D only (see **Section 4.4.8.2**, above). While the project will not directly affect the water quality of the SPA, there is potential for construction phase activities to indirectly affect water quality via watercourses draining the development site. This in turn has the potential to cause significant adverse effects to the range of foraging/roosting habitats within the SPA. Mitigation will, therefore, be applied as a precaution.	Yes Refer to **Section 7**

6.6.5 Teal [A052]

Teal is largely migratory, moving south of their breeding range during winter. Being highly responsive to cold spells they can show rapid and extensive movement during these periods. Teal is amber-listed due to a decline in the breeding population. Teal is a very common winter visitor to the Shannon and Fergus estuaries area. They are omnivorous and have a variety of foraging methods (e.g. dabbling and up-ending) within differing habitats. Areas of shallow water are favoured including shallow estuaries, tidal creeks and the edges of salt and freshwater marsh (NPWS, 2012d).

The conservation objective for teal is to maintain the favourable conservation condition of this species in the River Shannon and River Fergus Estuaries SPA. The specific species Attributes and Targets for teal defined in relation to the achievement of the Conservation Objectives for the SPA are presented in **Table 45,** below. An assessment of the effects of the project against these measures is also included.

Table 45. Assessment of effects on conservation objectives of 'Teal [A052]' (NPWS, 2012c)

Attribute/Measure	Target	Assessment of Potentially Significant Effects	Mitigation Required
Population trend/ Percentage change	Long term population trend stable or increasing	Population status of the species at the SPA was assessed as declining by more than 50% when the baseline data for the period 1995/96 to 1999/00 was compared with data from the period 2006/07 to 2010/11 (NPWS, 2012d), while Burke *et al*. (2018) estimated a 6% increase in All-Ireland teal numbers when the 2015/16 core counts were compared with the 2006/07 to 2010/11 population estimates. Although the project is not expected to cause a significant decline in the teal population, there is potential for adverse water quality impacts and/or disturbance of this species which could potentially affect the population trends. Mitigation will be applied as a precaution.	Yes Refer to **Section 7**
Distribution/ Range, timing and intensity of use of areas	There should be no significant decrease in the range, timing or intensity of use of areas by teal other than that occurring from natural patterns of variation	During the 2010/11 Waterbird Survey Programme, teal was widespread and recorded within 53 subsites with relatively high numbers recorded at subsites closest the proposed development site – 0I448, 0I447 and 0I427 (NPWS, 2012d) (see **Figure 6-2,** above). It was also noted that across the whole estuary, intertidal foraging was widespread. The wintering waterbird counts recorded teal during both 2019/20 and 2022/23 seasons with a peak count of 235 in Section C (see **Section 4.4.8.2**, above). The wintering waterbird counts undertaken recorded teal relatively frequently in all survey Sections with a peak count of 235 in Section C. While the project will not directly affect the water quality of the SPA, there is potential for construction phase activities to indirectly affect water quality via the watercourses draining the development site. This in turn has the potential to cause significant adverse effects to the range of foraging and roosting habitats for teal within the SPA. Mitigation will, therefore, be applied as a precaution.	Yes Refer to **Section 7**

6.6.6 Pintail [A054]

Pintail is amber-listed due to a decline in its non-breeding (wintering) population. It is an extremely rare breeding species with records from the Midlands and north (Dempsey & O' Clery, 2002). Wintering takes places primarily within estuaries or coastal brackish lagoons. Pintail feed on a variety of plant and animal material obtained from shallow water although they can be observed foraging on land.

The conservation objective for pintail is to maintain the favourable conservation condition of this species in the River Shannon and River Fergus Estuaries SPA. The specific species Attributes and Targets for pintail defined in relation to the achievement of the Conservation Objectives for the SPA are presented in **Table 46,** below. An assessment of the effects of the project against these measures is also included.

Table 46. Assessment of effects on conservation objectives of 'Pintail [A054]' (NPWS, 2012c)

Attribute/Measure	Target	Assessment of Potentially Significant Effects	Mitigation Required
Population trend/ Percentage change	Long term population trend stable or increasing	Population status of the species at the SPA was assessed as 'undetermined' but with an all-Ireland trend of a 26.8% increase for the period 1994/95 to 2008/09 (NPWS, 2012d). However, Burke *et al*. (2018) estimated a 12.8% decrease in all-Ireland pintail numbers when 2015/16 core counts were compared with the 2006/07 to 2010/11 population estimates. Although the proposed project is not expected to cause a significant decline in the SPA's pintail population, there is potential for indirect adverse water quality impacts and/or disturbance during construction phase which could potentially affect the population trends. Mitigation will be applied as a precaution.	Yes Refer to **Section 7**
Distribution/ Range, timing and intensity of use of areas	There should be no significant decrease in the range, timing or intensity of use of areas by pintail other than that occurring from natural patterns of variation	During the 2010/11 Waterbird Survey Programme, pintail was recorded at only two subsites – 0H519 and 0K509 – both of which are at least 55 km west of the proposed development site. During the wintering waterbird counts, one pintail was counted at Section B in January 2023 (see **Section 4.4.8.2**, above). While the project will not directly affect the water quality of the SPA, there is potential for construction phase activities to indirectly effect water quality via the watercourses draining the development site which turn has the potential to cause significant adverse effects to the range of foraging and roosting habitats for pintail within the SPA. Mitigation will be applied as a precaution.	Yes Refer to **Section 7**

6.6.7 Shoveler [A056]

The small numbers of shoveler breeding in Ireland are largely sedentary or dispersive and are supplemented during winter by migratory birds from other locations within northwest and central Europe. Shovelers are omnivorous, and feed on a range of items from planktonic crustaceans and small molluscs to insects, larvae, plant material and seeds. A true dabbling duck, shovelers feed by surface-feeding, swimming with head and neck immersed, up-ending, and less often, by shallow dives. Shoveler is red-listed due to a decline in its non-breeding (wintering) population.

The conservation objective for shoveler is to maintain the favourable conservation condition of this species in the River Shannon and River Fergus Estuaries SPA. The specific species Attributes and Targets for shoveler defined in relation to the achievement of the Conservation Objectives for the SPA are presented in **Table 47,** below. An assessment of the effects of the project against these measures is also included.

Table 47. Assessment of effects on conservation objectives of 'Shoveler [A056]' (NPWS, 2012c)

Attribute/Measure	Target	Assessment of Potentially Significant Effects	Mitigation Required
Population trend/ Percentage change	Long term population trend stable or increasing	Population status of the species at the SPA was assessed as 'undetermined' but with an all-Ireland trend of a 21.3% increase for the period 1994/95 to 2008/09 (NPWS, 2012d). However, Burke *et al*. (2018) estimated a 30.6% decrease in all-Ireland shoveler numbers when the 2015/16 core counts were compared with the 2006/07 to 2010/11 population estimates. Although the proposed project is not expected to cause a significant decline in the SPA's shoveler population, there is potential for indirect adverse water quality impacts and/or disturbance during construction phase which could potentially affect the population trends. Mitigation will be applied as a precaution.	Yes Refer to **Section 7**
Distribution/ Range, timing and intensity of use of areas	There should be no significant decrease in the range, timing or intensity of use of areas by shoveler other than that occurring from natural patterns of variation.	During the 2022/23 wintering waterbird counts, shoveler was recorded in Sections A, B and D in relatively small numbers (see **Section 4.4.8.2**, above). There was also little shoveler activity recorded in the subsites located nearest the proposed development site during the 2010/11 Waterbird Survey Programme (NPWS, 2012d). While the project will not directly affect the water quality of the SPA, there is potential for construction phase activities to indirectly affect water quality via the watercourses draining the development site. This in turn has the potential to cause significant adverse effects to the range of foraging and roosting habitats for shoveler within the SPA. Mitigation will, therefore, be applied as a precaution.	Yes Refer to **Section 7**

6.6.8 Golden Plover [A140]

During winter, golden plovers feed primarily within agricultural grassland and arable land. Tidal flats are used more as a roosting/resting habitat and the birds tend to favour large, open tidal flats. Consequently, golden plover tends to occur in large aggregations when observed upon tidal flats. Intertidal feeding is observed to a greater degree during cold weather periods when grassland feeding areas are frozen over. Golden plover is red-listed as a breeding species due to a decline in the breeding and non-breeding (wintering) population.

The conservation objective for golden plover is to maintain the favourable conservation condition of this species in the River Shannon and River Fergus Estuaries SPA. The specific species Attributes and Targets for golden plover defined in relation to the achievement of the Conservation Objectives for the SPA are presented in **Table 48,** below. An assessment of the effects of the project against these measures is also included.

Table 48. Assessment of effects on conservation objectives of 'Golden Plover [A140]' (NPWS, 2012c)

Attribute/ Measure	Target	Assessment of Potentially Significant Effects	Mitigation Required
Population trend/ Percentage change	Long term population trend stable or increasing	Population status of the species at the SPA was assessed as declining by more than 50% when the baseline data for the period 1995/96 to 1999/00 was compared with data from the period 2006/07 to 2010/11 (NPWS, 2012d), while Burke *et al*. (2018) estimated a 23.5% decrease in all-Ireland golden plover numbers when the 2015/16 core counts were compared with 2006/07 to 2010/11 population estimates. Although the project is not expected to cause a significant decline in the golden plover population, there is potential for adverse water quality impacts and/or disturbance which could potentially affect the population trends. Mitigation will be applied as a precaution.	Yes Refer to **Section 7**
Distribution/ Range, timing and intensity of use of areas	There should be no significant decrease in the range, timing or intensity of use of areas by golden plover other than that occurring from natural patterns of variation	The subsite 0I445 at Scarlet Reach was one of four areas that held peak numbers of roosting golden plover at low tide surveys during the 2010/11 Waterbird Survey Programme (see **Figure 6-2,** above, for subsite locations). The wintering waterbird counts did not record any golden plover at any survey locations (see **Section 4.4.8.2**, above). While the project will not directly affect the water quality of the SPA, there is potential for construction phase activities to indirectly affect water quality via the watercourses draining the development site. This in turn has the potential to cause significant adverse effects to the range of foraging and roosting habitats for golden plover within the SPA and mitigation is required.	Yes Refer to **Section 7**

6.6.9 Grey Plover [A141]

Grey plover is a red-listed species in Ireland as the majority spend winter at less than ten sites within in the country. The SPA is designated for wintering grey plover. They feed on various marine molluscs, crustaceans and worms, foraging on intertidal mudflats within estuaries and on beaches.

The conservation objective for grey plover is to maintain the favourable conservation condition of this species in the River Shannon and River Fergus Estuaries SPA. The specific species Attributes and Targets for grey plover defined in relation to the achievement of the Conservation Objectives for the SPA are presented in **Table 49,** below. An assessment of the effects of the project against these measures is also included.

Table 49. Assessment of effects on conservation objectives of 'Grey Plover [A141]' (NPWS, 2012c).

Attribute/ Measure	Target	Assessment of Potentially Significant Effects	Mitigation Required
Population trend/ Percentage change	Long term population trend stable or increasing	Population status of the species at the SPA was assessed as declining by more than 50% when the baseline data for the period 1995/96 to 1999/00 was compared with data from the period 2006/07 to 2010/11 (NPWS, 2012d), while Burke *et al*. (2018) estimated a 5.8% decrease in all-Ireland grey plover numbers when the 2015/16 core counts were compared with 2006/07 to 2010/11 population estimates. Although the project is not expected to cause a significant decline in the grey plover population, there is potential for adverse water quality impacts and/or disturbance which could potentially affect the population trends. Mitigation will be applied as a precaution.	Yes Refer to **Section 7**
Distribution/ Range, timing and intensity of use of areas	There should be no significant decrease in the range, timing or intensity of use of areas by grey plover other than that occurring from natural patterns of variation	During the 2022/23 wintering waterbird counts, grey plover was recorded in Sections B and C in relatively small numbers (see **Section 4.4.8.2**, above). There were low levels of grey plover activity recorded in subsites located nearest the proposed development site during the 2010/11 Waterbird Survey Programme (NPWS, 2012d). While the project will not directly affect the water quality of the SPA, there is potential for construction phase activities to indirectly affect water quality via the watercourses draining the development site. This in turn has the potential to cause significant adverse effects to the range of foraging and roosting habitats for grey plover within the SPA. Mitigation will, therefore, be applied as a precaution.	Yes Refer to **Section 7**

6.6.10 Lapwing [A142]

Lapwing are traditionally 'inland' waders. During winter they can be observed across a wide variety of habitats, principally using lowland farmland and freshwater wetlands (e.g. turloughs and callows) but also coastal wetlands where they feed on a variety of soil- and surface-living invertebrates. They are opportunistic and mobile birds and will readily exploit temporary food sources such as recently ploughed fields. Estuaries are typically used as roosting areas where large flocks may be observed upon the tidal flats. Coastal habitats tend to be used more during cold weather events when farmland and freshwater habitats freeze over. Lapwing is a red-listed species in Ireland due to a decline in both the breeding and non-breeding populations.

The conservation objective for lapwing is to maintain the favourable conservation condition of this species in the River Shannon and River Fergus Estuaries SPA. The specific species Attributes and Targets for lapwing defined in relation to the achievement of the Conservation Objectives for the SPA are presented in **Table 50,** below. An assessment of the effects of the project against these measures is also included.

Table 50. Assessment of effects on conservation objectives of 'Lapwing [A142]' (NPWS, 2012c)

Attribute/Measure	Target	Assessment of Potentially Significant Effects	Mitigation Required
Population trend/ Percentage change	Long term population trend stable or increasing	Population status of the species at the SPA was assessed as declining by more than 50% when the baseline data for the period 1995/96 to 1999/00 was compared with data from the period 2006/07 to 2010/11 (NPWS, 2012d), while Burke *et al*. (2018) estimated a 16.4% decrease in all-Ireland lapwing numbers when the 2015/16 core counts were compared with 2006/07 to 2010/11 population estimates. Although the project is not expected to cause a significant decline in the lapwing population, there is potential for adverse water quality impacts and/or disturbance which could potentially affect the population trends. Mitigation will be applied as a precaution.	Yes Refer to **Section 7**
Distribution/ Range, timing and intensity of use of areas	There should be no significant decrease in the range, timing or intensity of use of areas by lapwing other than that occurring from natural patterns of variation	During the 2019/20 winter waterbird counts, a peak count of 51 lapwing was recorded, while lapwing was recorded in Sections A and D during the 2022/23 counts (see **Section 4.4.8.2**, above). The subsite 0I445 at Scarlet Reach was one of three areas that held peak numbers of lapwing at low tide during the 2010/11 Waterbird Survey Programme (see **Figure 6-2,** above, for subsite locations). While the project will not directly affect the water quality of the SPA, there is potential for construction phase activities to indirectly affect water quality via the watercourses draining the development site. This in turn has the potential to cause significant adverse effects to the range of foraging and roosting habitats for lapwing within the SPA and mitigation is therefore required.	Yes Refer to **Section 7**

6.6.11 Dunlin [A149]

Dunlin is a common wader along the Irish coast. Wintering populations favour coastal areas such as estuaries and mudflats with the population peaking in mid-winter. They tend to feed in groups on mudflats, often at the water's edge, taking a variety of prey including molluscs, crustaceans and worms. Dunlin is widespread within the site favouring inter-tidal foraging areas. Dunlin is a red-listed species in Ireland as the majority of the Irish population winters at less than ten sites.

The conservation objective for dunlin is to maintain the favourable conservation condition of this species in the River Shannon and River Fergus Estuaries SPA. The specific species Attributes and Targets for dunlin defined in relation to the achievement of the Conservation Objectives for the SPA are presented in **Table 51,** below. An assessment of the effects of the project against these measures is also included.

Table 51. Assessment of effects on conservation objectives of 'Dunlin [A149]' (NPWS, 2012c)

Attribute/ Measure	Target	Assessment of Potentially Significant Effects	Mitigation Required
Population trend/ Percentage change	Long term population trend stable or increasing	Population status of the species at the SPA was assessed as declining by more than 50% when the baseline data for the period 1995/96 to 1999/00 was compared with data from the period 2006/07 to 2010/11 (NPWS, 2012d), while Burke *et al*. (2018) estimated a 23.2% decrease in all-Ireland dunlin numbers when the 2015/16 core counts were compared with 2006/07 to 2010/11 population estimates. Although the project is not expected to cause a significant decline in the dunlin population, there is potential for adverse water quality impacts and/or disturbance which could potentially affect the population trends. Mitigation will be applied as a precaution.	Yes Refer to **Section 7**
Distribution/ Range, timing and intensity of use of areas	There should be no significant decrease in the range, timing or intensity of use of areas by dunlin other than that occurring from natural patterns of variation	During the 2010/11 Waterbird Survey Programme, dunlin were recorded foraging at subsites 0I445, 0I446 and 0I427, approximately 8.5 river km downstream of the proposed development site via the Crompaun [East] River (see **Figure 6-2,** above), while in November 2010, a site total of 14,537 dunlin were recorded, representing numbers of international threshold (NPWS, 2012d). During the waterbird counts, one dunlin was recorded in Section C (see **Section 4.4.8.2**, above). While the project will not directly affect the water quality of the SPA, there is potential for construction phase activities to indirectly affect water quality via the watercourses draining the development site. This in turn has the potential to cause significant adverse effects to the range of foraging and roosting habitats for dunlin within the SPA and mitigation is therefore required.	Yes Refer to **Section 7**

6.6.12 Curlew [A160]

Curlews are the largest wader to spend the non-breeding season in Ireland. Within intertidal areas they seek out larger prey items such as crabs, large worms and bivalves with their decurved bill ideally suited to extracting deep-living worms such as lugworms (*Arenicola marina*). They also take terrestrial worms in damp grasslands. Ireland supports a small and declining population of breeding curlew that are thought to make only short migrations. Many are resident during winter with their numbers enhanced by birds moving in from breeding grounds. Curlew is a red-listed species in Ireland due to a long-term decline in the breeding and wintering population and a contraction of its breeding range. Curlew spend winters in the Shannon and Fergus Estuaries and surrounding coastal grasslands feeding on intertidal mudflats.

The conservation objective for curlew is to maintain the favourable conservation condition of this species in the River Shannon and River Fergus Estuaries SPA. The specific species Attributes and Targets for curlew defined in relation to the achievement of the Conservation Objectives for the SPA are presented in **Table 52,** below. An assessment of the effects of the project against these measures is also included.

Table 52. Assessment of effects on conservation objectives of 'Curlew [A160]' (NPWS, 2012c)

Attribute/ Measure	Target	Assessment of Potentially Significant Effects	Mitigation Required
Population trend/ Percentage change	Long term population trend stable or increasing	Population status of the species at the SPA was assessed as declining by more than 50% when the baseline data for the period 1995/96 to 1999/00 was compared with data from the period 2006/07 to 2010/11 (NPWS, 2012d), while Burke *et al*. (2018) estimated a 13.4% decrease in all-Ireland curlew numbers when the 2015/16 core counts were compared with 2006/07 to 2010/11 population estimates. Although the project is not expected to cause a significant decline in the curlew population, there is potential for adverse water quality impacts and/or disturbance which could potentially affect the population trends. Mitigation will be applied as a precaution.	Yes Refer to **Section 7**
Distribution/ Range, timing and intensity of use of areas	There should be no significant decrease in the range, timing or intensity of use of areas by curlew other than that occurring from natural patterns of variation	During the 2010/11 Waterbird Survey Programme, curlew was recorded roosting and foraging at the subsites 0I445 and 0I446, and foraging only at 0I447 and 0I457 (see **Figure 6-2,** above, for subsite locations), approximately 8.8 river km downstream of the proposed development site via the Crompaun [East] River (NPWS, 2012d). During the 2022/23 wintering waterbird counts, curlew was recorded in Sections C and D only (see **Section 4.4.8.2**, above). While the project will not directly affect the water quality of the SPA, there is potential for construction phase activities to indirectly affect water quality via the watercourses draining the development site. This in turn has the potential to cause significant adverse effects to the range of foraging and roosting habitats for curlew within the SPA and mitigation is therefore required.	Yes Refer to **Section 7**

6.6.13 Redshank [A162]

Redshank feed along the upper shore of estuaries and along muddy river channels. They forage mainly by pecking at the surface or probing within intertidal mudflats, often favouring the muddier sections of sites where they prey upon species such as ragworm (*Hediste diversicolor)* and mud snail (*Hydrobia ulvae)*. A particularly favoured prey is the burrowing amphipod *Corophium volutator*, and the redshank will alter its distribution in response to depletion/changes in distribution of these mobile amphipods. Redshank is a red-listed species in Ireland due to a long-term decline in its breeding population.

The conservation objective for redshank is to maintain the favourable conservation condition of this species in the River Shannon and River Fergus Estuaries SPA. The specific species Attributes and Targets for redshank defined in relation to the achievement of the Conservation Objectives for the SPA are presented in **Table 53,** below. An assessment of the effects of the project against these measures is also included.

Table 53. Assessment of effects on conservation objectives of 'Redshank [A162]' (NPWS, 2012c)

Attribute/Measure	Target	Assessment of Potentially Significant Effects	Mitigation Required
Population trend/ Percentage change	Long term population trend stable or increasing	Population status of the species at the SPA was assessed as declining by more than 50% when the baseline data for the period 1995/96 to 1999/00 was compared with data from the period 2006/07 to 2010/11 (NPWS, 2012d), while Burke *et al*. (2018) estimated a 23.6% decrease in all-Ireland redshank numbers when the 2015/16 core counts were compared with 2006/07 to 2010/11 population estimates. Although the project is not expected to cause a significant decline in the redshank population, there is potential for adverse water quality impacts and/or disturbance which could potentially affect the population trends. Mitigation will be applied as a precaution.	Yes Refer to **Section 7**
Distribution/ Range, timing and intensity of use of areas	There should be no significant decrease in the range, timing or intensity of use of areas by redshank other than that occurring from natural patterns of variation	During the 2010/11 Waterbird Survey Programme, redshank was recorded foraging and roosting within the estuary's innermost subsites 0I448, 0I447, 0I427 and 0I457 (see **Figure 6-2,** above, for subsite locations), approximately 8.8 river km downstream of the proposed development site via the Crompaun [East] River (NPWS, 2012d). During the 2022/23 wintering waterbird counts, redshank was recorded in Sections A, B and C (see **Section 4.4.8.2**, above). While the project will not directly affect the water quality of the SPA, there is potential for construction phase activities to indirectly affect water quality via the watercourses draining the proposal site. This in turn has the potential to cause significant adverse effects to the range of foraging and roosting habitats for redshank within the SPA and mitigation is therefore required.	Yes Refer to **Section 7**

6.6.14 Greenshank [A164]

Most of the Irish greenshank population winters at less than ten sites, mainly on estuaries with some remaining along non-estuarine coasts. It feeds in shallow water and soft mud and is an intermediate (100-200 sites) intertidal walker (in water) that requires a wide range of food prey. It is considered totally reliant on wetland habitats due to unsuitable surrounding habitats and is limited by habitat requirements.

The conservation objective for greenshank is to maintain the favourable conservation condition of this species in the River Shannon and River Fergus Estuaries SPA. The specific species Attributes and Targets for greenshank defined in relation to the achievement of the Conservation Objectives for the SPA are presented in **Table 54,** below. An assessment of the effects of the project against these measures is also included.

Table 54. Assessment of effects on conservation objectives of 'Greenshank [A164]' (NPWS, 2012c).

Attribute/Measure	Target	Assessment of Potentially Significant Effects	Mitigation Required
Population trend/ Percentage change	Long term population trend stable or increasing	Population status of the species at the SPA was assessed as declining by 25% to 49% when the baseline data for the period 1995/96 to 1999/00 was compared with data from the period 2006/07 to 2010/11 (NPWS, 2012d), while Burke *et al*. (2018) estimated a 16.8% increase in all-Ireland greenshank numbers when the 2015/16 core counts were compared with 2006/07 to 2010/11 population estimates. Although the project is not expected to cause a significant decline in the greenshank population, there is potential for adverse water quality impacts and/or disturbance which could potentially affect the population trends. Mitigation will be applied as a precaution.	No
Distribution/ Range, timing and intensity of use of areas	There should be no significant decrease in the range, timing or intensity of use of areas by greenshank other than that occurring from natural patterns of variation.	During the 2010/11 Waterbird Survey Programme, greenshank was recorded foraging and roosting mainly within central and western subsites and was infrequently recorded in very small numbers at the subsites nearest the proposed development, namely subsites 0I445, 0I447 and 0I427 (NPWS, 2012d) (see **Figure 6-2,** above, for subsite locations). No greenshank were recorded during the wintering waterbird counts (see **Section 4.4.8.2**, above). While the project will not directly affect the water quality of the SPA, there is potential for construction phase activities to indirectly affect water quality via the watercourses draining the proposal site. This in turn has the potential to cause significant adverse effects to the range of foraging and roosting habitats for greenshank within the SPA. Mitigation will, therefore, be applied as a precaution.	Yes Refer to **Section 7**

6.6.15 Black-headed Gull [A179]

Black-headed gull is resident in Ireland throughout the year with numbers boosted by wintering individuals arriving from mainland Europe. The species over-winters and breeds in both coastal and inland locations, nesting in colonies, in sand dunes, coastal islands, moorland polls, bogs and on freshwater lake islands. They are opportunistic feeders and take a wide variety of food items including fish, worms, molluscs, insects and plant material, taking advantage of any available food-source including domestic/fishing waste. They have a wide distribution within the SPA, favouring inter-tidal foraging areas. Black-headed gull is an amber-listed species in Ireland due to a long-term decline in its breeding population and distribution.

The conservation objective for black-headed gull is to maintain the favourable conservation condition of this species in the River Shannon and River Fergus Estuaries SPA. The specific species Attributes and Targets for black-headed gull defined in relation to the achievement of the Conservation Objectives for the SPA are presented in **Table 55,** below. An assessment of the effects of the project against these measures is also included.

Table 55. Assessment of effects on conservation objectives of 'Black-headed Gull [A179]' (NPWS, 2012c)

Attribute/Measure	Target	Assessment of Potentially Significant Effects	Mitigation Required
Population trend/ Percentage change	Long term population trend stable or increasing	Population status of the species at the SPA was assessed as declining by 25% to 49% when the baseline data for the period 1995/96 to 1999/00 was compared with data from the period 2006/07 to 2010/11 (NPWS, 2012d). Although the project is not expected to cause a significant decline in the black-headed gull population, there is potential for adverse water quality impacts and/or disturbance which could potentially affect the population trends. Mitigation will be required.	Yes Refer to **Section 7**
Distribution/ Range, timing and intensity of use of areas	There should be no significant decrease in the range, timing or intensity of use of areas by black-headed gull other than that occurring from natural patterns of variation	During the 2010/11 Waterbird Survey Programme, black-headed gull was recorded foraging and roosting in large numbers throughout the site, particularly innermost subsites of 0I448, 0I447 and 0I427 (see **Figure 6-2,** above, for subsite locations) (NPWS, 2012d). In subsite 0I448, 502 gulls were recorded roosting terrestrially outside the SPA border on structures such as bridges and quays, approximately 8 river km downstream of the proposed development site via the Crompaun [East] River. During VP surveys, black-headed gulls were observed on two occasions flying within the 500 m buffer but not within the airspace of the proposed development (refer to **Figure 4-6**, above). During the wintering waterbird counts, large numbers of black-headed gull were counted during both the 2019/20 and 2022/23 seasons, with a peak count of 870 at Section D (see **Section 4.4.8.2**, above) while during hinterland surveys, two flocks were observed at locations approximately 3.5 km south-southeast of the proposed T12 location – see **Figure 4-8**, above. While the project will not directly affect the water quality of the SPA, there is potential for construction phase activities to indirectly affect water quality via watercourses draining the development site. This in turn has the potential to cause significant adverse effects to the range of foraging/roosting habitats for black-headed gull within the SPA, and mitigation is therefore required.	Yes Refer to **Section 7**

6.6.16 Wetlands [A999]

The conservation objective for 'Wetlands' is to maintain the favourable conservation condition of this habitat within the River Shannon and River Fergus Estuaries SPA as a resource for the regularly occurring migratory waterbirds that utilise it. The specific Attributes and Targets for the habitat defined in relation to the achievement of the Conservation Objectives for the SPA are presented in **Table 56,** below. An assessment of the effects of the project against these measures is also included.

Table 56. Assessment of effects on conservation objectives of 'Wetlands [A999]' (NPWS, 2012c).

Attribute/ Measure	Target	Assessment of Potentially Significant Effects	Mitigation Required
Wetland habitat area/ Hectares	The permanent area occupied by the wetland habitat should be stable and not significantly less than the area of 32,261 ha, other than that occurring from natural patterns of variation.	The wetland habitats contained within the River Shannon and River Fergus Estuaries SPA are identified as being of conservation importance for non-breeding (wintering) migratory waterbirds. Therefore, the wetland habitats are deemed to be an additional Special Conservation Interest. The wetland habitats of the SPA are categorised into five types – subtidal; intertidal; supratidal; lagoon and associated; and freshwater and associated (NPWS, 2012d). There is no overlap of the proposal site with the SPA so there will be no direct loss of this habitat because of the proposed development. However, there is a hydrological connection between the SPA and the proposed development site via various watercourses that drain into the River Shannon and ultimately the SPA. While the project is not expected to cause a significant decline in the permanent area of wetland habitat, there is potential for water quality of the habitat to be adversely affected which may results in habitat loss, therefore, mitigation will be applied.	Yes Refer to **Section 7**

6.7 Assessment of Potentially Significant Cumulative Effects

When in-combination impacts are assessed, it is necessary to identify the types of impacts that may ensue from the project under consideration and from other sources in the existing environment that cumulatively are likely to affect aspects of the structure and function of the relevant European sites (EC, 2021).

The EC (2021) guidelines on the provision of Article 6 of the Habitats' Directive state that the phrase 'in combination with other plans or projects' in Article 3(3) of the Habitats Directive refers to the cumulative effects due to plans or projects 'that are currently under consideration together with the effects of any existing or proposed projects or plans.' Relevant plans and projects have been identified in **Section 4.10,** above.

6.7.1 Ongoing Activities

6.7.1.1 Introduction

Irish waterbodies are frequently subjected to various anthropogenic activities and pressures that can adversely impact upon water quality. Indeed, more than half of affected waterbodies are impacted upon by more than one pressure type. Agriculture is the dominant pressure source in the country, effecting 53% of Irish waterbodies from 2013 to 2018 (O'Boyle *et al*., 2019), mainly through nutrient pollution (nitrogen and phosphorus) which can cause excessive plant growth and increase the likelihood of harmful algal blooms.

Significant issues in waterbodies classified as 'At Risk' of not meeting surface waterbody environmental objectives within the Lower Shannon and Mulkear Catchment (25D) and the Shannon Estuary North Catchment (27) by 2027 are identified in EPA (2021a) and EPA (2021b), respectively. The most significant pressure on waterbodies within both catchments is agricultural pressure due mainly to the release of excess nutrients (elevated phosphate and ammonia). Other pressures include hydromorphology, urban wastewater, urban run-off, peat extraction, domestic wastewater, industry, forestry, mines, quarries, and other impacts[57]. Additionally, the EPA Water Quality in Ireland 2016-2021 Report lists the Shannon Estuary North (27) Catchment as one of thirteen catchments 'with the lowest percentage of monitored satisfactory river water bodies' (Trodd *et al*, 2021).

Many watercourses in both catchments are also subject to significantly increased levels of sediment loading due to forestry activities, mineral/peat harvesting and bank erosion. Forestry and peat extraction can cause ecological problems through increased erosion rates, siltation and nutrient loss. Phosphorus losses come primarily from wastewater discharges, and from runoff losses from agriculture on poorly draining soils (O'Boyle *et al*., 2019). Habitat condition in both catchments is compromised due to hydrological and morphological modifications to the waterbodies, particularly within the Lower Shannon Catchment (25D) where dams, barriers, locks and weirs are in use.

The primary pressures in the sub-catchments containing the proposed development, namely the Owenogarney_SC_020 and the Shannon [Lower]_SC_100, are considered to result from forestry and agriculture. Anthropogenic activities and agricultural intensification have been identified as medium impact pressures on Lower River Shannon SAC, while forestry and peat-harvesting have been classed as low-level pressures as defined in the Natura 2000 Data Form[58] and listed in **Table 57**, below. Within the River Shannon and River Fergus Estuaries SPA, high impact pressures include fertilisation and urbanisation, while medium impact pressures include recreation, shipping lanes and discharges as defined in the Natura 2000 Data Form[59] and listed in **Table 58**, below.

[57] 'Abstractions, aquaculture, atmospheric, anthropogenic pressures, historically polluted sites, wastewater treatment and invasive species' (EPA, 2021b).
[58] N2K IE0002165 dataforms (europa.eu) Accessed: 20th January 2023
[59] N2K IE0004077 dataforms (europa.eu) Accessed: 20th January 2023

Table 57. Most important impacts and activities with high effect on the Lower River Shannon SAC as defined in the associated Natura 2000 Data Form.

Threat Level	Threats and Pressures Code	Reference
Medium	E01	Urbanised areas, human habitation
Medium	K02.03	Eutrophication (natural)
Medium	J02.01.02	Reclamation of land from sea, estuary or marsh
Low	C01.01.02	Removal of beach materials
Low	F01	Marine and freshwater Aquaculture
Medium	E03	Discharges
Low	J02.10	Management of aquatic and bank vegetation for drainage purposes
Medium	A08	Fertilisation
Medium	H04	Air pollution, air-borne pollutants
Medium	A08	Fertilisation
Low	F03.01	Hunting
Medium	A04	Grazing
Low	B	Sylviculture, forestry
Low	J02.12.01	Sea defence or coast protection works, tidal barrages
Low	G01.01	Nautical sports
Medium	J02.01.01	Polderisation
Low	D01.01	Paths, tracks, cycling tracks
Low	C01.03.01	Hand cutting of peat
Low	I01	Invasive non-native species

Table 58. Most important impacts and activities with high effect on the River Shannon and River Fergus Estuaries SPA as defined in the associated Natura 2000 Data Form.

Threat Level	Threats and Pressures Code	Reference
Medium	G01.01	Nautical sports
Medium	D03.02	Shipping lanes
High	E03	Discharges
High	E01	Urbanised areas, human habitation
High	A08	Fertilisation
High	E02	Industrial or commercial areas
Medium	E03	Discharges

6.7.1.2 Agriculture

The main impacts of farming are the loss of excess nutrients and sediment to water. Excess ammonium may also be a problem in some waterbodies. These losses arise from point sources such as farmyards or from diffuse sources such as spreading of fertilisers and manures. Excess phosphorus and sediment are typical issues for rivers and lakes, and too much nitrogen is the main issue for estuaries and coastal waters (O'Boyle *et al*., 2019).

In the 3rd Cycle Lower Shannon and Mulkear Catchment (25D) Report (EPA, 2021a), agriculture was identified as a significant pressure in 13 waterbodies within the catchment (including one transitional waterbody – Upper Shannon Estuary). Farming-related impacts within this catchment mainly involve the loss of phosphorus to surface waters from, for example, direct discharges, or runoff from yards, roadways or other compacted surfaces, or runoff from poorly draining soils. It takes only very small amounts of phosphorus to be lost, relative to the amounts used in agriculture, to cause a water quality problem. Sediment from land drainage works and bank erosion because of animal access also impact upon water quality. The Lower Shannon and Mulkear Catchment (25D) was also found to be one of two catchments in the country with the highest number of river sites with strongly increasing phosphate concentration (Trodd *et al*, 2021).

In the 3rd Cycle Draft Shannon Estuary North Catchment (27) Report (EPA, 2021b), agriculture was identified as a significant pressure in 33 waterbodies (including two transitional waterbodies – Fergus Estuary and Upper Shannon Estuary). The farming-related impacts in this catchment are similar to those of the Lower Shannon and Mulkear Catchment (25D) described in the previous paragraph with regards elevated levels of phosphate and ammonia in surface waters due to poorly draining soil and direct discharges. The report does also mention that 'land drainage for agricultural purposes has been noted by both IFI and Clare County Council as a significant pressure in several rivers' (EPA, 2021b).

Within the Owenogarney_SC_020 and Shannon [Lower]_SC_100 sub-catchments that drain the proposed development site, agriculture is one of the principal land uses. The water quality effects of the proposed development during the construction phase, together with the previously discussed effects of agricultural practices, could exacerbate potential impacts associated with the project within the catchment and undermine the conservation objectives for the qualifying features of the Lower River Shannon SAC and the River Shannon and River Fergus Estuaries SPA as discussed in Sections 6.2 and 6.3, above.

6.7.1.3 Hydromorphology and Drainage

Hydromorphology is the study of the physical character and processes that occur within a waterbody. Hydromorphological modification is a physical alteration to the conditions of a habitat or to the natural functioning of a waterbody that can change flow patterns and have an ecological impact. Changes may be caused by various activities such as dredging or straightening of rivers (channelisation), land drainage, or hard infrastructure such as dams, weirs, culverts, or other obstructions (O'Boyle *et al*., 2019).

According to EPA (2021b), hydromorphological modification is a significant pressure in twelve river waterbodies within the Shannon Estuary North (27) Catchment due to the presence of drainage schemes and the resulting increased levels of siltation. Modification of riverbanks due to implementation of embankment schemes effects four river waterbodies in the catchment. Furthermore, five river waterbodies within the catchment contain barriers to fish migration such as sloped concrete sills and weirs. Within the Lower Shannon (25D) Catchment, four waterbodies are deemed to be under significant pressure because of hydromorphological issues. This includes two river waterbodies – the Doonane_010 and the Grange (Tipperary)_010 – both been subjected to channelisation that impacts habitat condition due to hydrological and morphological changes. Impediments to fish passage including locks and dams are also present and it has been noted by Inland Fisheries Ireland (IFI) that 'an impoundment has resulted in the loss of spawning grounds in Shannon (Lower)_050' (EPA, 2021a).

The water quality effects of the proposed development during the construction phase together with the effects of hydromorphological modification could exacerbate potential impacts associated with the proposed development within the Lower Shannon and Mulkear Catchment (25D) and the Shannon Estuary North Catchment (27), and undermine the conservation objectives for the qualifying features of the Lower River Shannon SAC, and the River Shannon and River Fergus Estuaries SPA as discussed in **Sections 6.2** and **6.3**, above.

6.7.1.4 Forestry

Poorly managed and inappropriately sited forestry operations can adversely affect water quality and aquatic habitats and species. The release of sediment and nutrients and the impacts of acidification are the most common water quality issues arising from forestry. Forestry may also bring about changes in stream flow regimes caused by associated land drainage (O'Boyle *et al*., 2019). Forestry has been identified as a significant pressure in ten waterbodies within the Shannon Estuary North (27) Catchment (EPA, 2021b) and four waterbodies within the Lower Shannon (25D) Catchment (EPA, 2021a). The significant issues are a combination of the general forestry pressures of clear-felling and an increased sediment loading that affects habitats. The proposed development will involve the construction of new tracks, turbines and other infrastructure, which give rise to earthworks that can mobilise silt and nutrients. A proportion of the proposed development occurs in and adjacent to conifer plantation.

During the construction phase of the proposed wind farm development, there is potential for negative water quality impacts on downstream waterbodies due mainly to earthworks and the release of sediment. During the later stages of construction, exposed areas will be revegetated and will then continue to revegetate within the early stage of operation, thereby eliminating the source of sediment. There is potential for the project to contribute to a cumulative impact on water quality in local watercourses, within and downstream of the site, by way of sediments and other pollutants potentially entering the watercourses. The felling of forestry to accommodate the proposed development may impact downstream water quality. These water quality effects, coupled with the abovementioned forestry effects, could exacerbate potential impacts associated with the proposed project within the Lower Shannon and Mulkear Catchment (25D) and the Shannon Estuary North Catchment (27) and thereby undermine the conservation objectives for the qualifying features of the Lower River Shannon SAC, and the River Shannon and River Fergus Estuaries SPA as discussed in **Sections 6.2** and **6.3**, above.

6.7.1.5 Domestic Wastewater and Diffuse Urban Run-off

Domestic wastewater discharged by households predominantly originates from human metabolism or from day-to-day human activities within single houses that are not connected to sewers and usually in rural settings and is treated on-site in septic tank systems or in individual wastewater treatment systems. If not correctly located, designed, installed and well-maintained, untreated effluent can leak into surrounding waters resulting in elevated nutrient concentrations and posing a significant ecological threat (EPA, 2013).

Within the Shannon Estuary North Catchment (27) domestic wastewater has been identified as a significant pressure in five river waterbodies due to the proximity of domestic wastewater treatment systems to those waterbodies on poorly draining soil, and the excessive volumes of nutrients entering local surface waters as a result. Three of these waterbodies are located within the Owenogarney_SC_020 subcatchment - namely Cratloe_010, Crompaun (East)_010, and Cloverhill Stream_010 (EPA, 2021b). Within the Lower Shannon and Mulkear Catchment (25D), domestic wastewater has been identified as a significant pressure in two river waterbodies, but neither are located within Shannon [Lower]_SC_100 subcatchment (EPA, 2021a).

Pollution from diffuse urban run-off can also exert significant pressure on the integrity of waterbodies. Sources include run-off from paved/unpaved areas, domestic plumbing misconnections and leaking sewers which can result in the release of untreated effluent into receiving waterbodies causing elevated nutrient levels and ecological deterioration (O'Boyle *et al*., 2019). Within the Lower Shannon and Mulkear Catchment (25D) diffuse urban run-off has been identified as a significant pressure in two river waterbodies – Groody_010 and Whitehall_010 – where nutrient and organic pollution are the significant water issues (EPA, 2021a). There are four river waterbodies within the Shannon Estuary North Catchment (27) that have been identified as being under significant pressure due to diffuse urban run-off, with nutrient and organic pollution being the significant water issues (EPA, 2021b). None of the identified river waterbodies from either catchment are located within the Owenogarney_SC_020 subcatchment or the Shannon [Lower]_SC_100 subcatchment.

The water quality effects of the wind farm during the construction and early operational phases, together with the previously discussed effects of domestic wastewater and diffuse urban run-off, could exacerbate potential impacts associated with the proposed development within the Lower Shannon and Mulkear Catchment (HA25D) and the Shannon Estuary North Catchment (HA27) and thereby undermine the conservation objectives for the qualifying features of the Lower River Shannon SAC, and the River Shannon and River Fergus Estuaries SPA as discussed in **Sections 6.2** and **6.3**, above.

6.7.1.6 Wastewater Treatment

Since 2013, the national population has increased by almost a quarter of a million with a resultant increase in the amount of wastewater requiring treatment. Works are ongoing by Irish Water to improve the level of wastewater treatment nationally; however, the level of treatment is still inadequate at 120 locations around the country and raw sewage from 36 towns and villages is being released into rivers at five locations and into coastal waters at 31 locations (O'Boyle *et al*., 2019). As detailed in **Section 4.10.6** and **Table 27**, above, there are eleven urban wastewater treatment plants (UWWTP) located within the Lower Shannon (25D) Catchment and thirteen located within the Shannon Estuary North (27) Catchment. Of these 24 treatment plants, six have been identified as exerting a significant pressure on one 'At Risk' waterbody in the catchment as listed in EPA (2021a; 2021b) and presented in **Table 59**, below.

Table 59. Details of urban wastewater treatment (UWWT) plants identified as being a significant pressure in 'At Risk' waterbodies and the expected completion time of any upgrades (EPA, 2021a; 2021b).

WFD Catchment	Facility name	Facility type[60]	Active license no.	Waterbody impacted	2013-18 ecological status	Expected completion[61]
Lower Shannon (25D)	Cappawhite	500 to 1,000 p.e.	D0440	Cappawhite Stream_010	Poor	N/A
Lower Shannon (25D)	Ballina	2,001 to 10,000 p.e.	D0016	Grange (Tipperary)_010	Unassigned	2024
Shannon Estuary North (27)	Ennis North	Combined sewer overflows	D0048	Fergus_060	Poor	N/A
Shannon Estuary North (27)	Ennis North	Combined sewer overflows	D0048	Fergus_070	Poor	N/A
Shannon Estuary North (27)	Tulla	1,001 to 2,000 p.e.	D0320	Liskenny_010	Poor	N/A
Shannon Estuary North (27)	Quin	1,001 to 2,000 p.e.	D0318	Rine_030	Moderate	2021

[60] Defined using population equivalent value (p.e.)
[61] Expected completion date for upgrades scheduled under Uisce Éireann's Capital Investment Programme (CIP) (2020-2024).

The water quality effects of the proposed wind farm during the construction and early operational phases, together with the previously discussed effects of urban wastewater, could exacerbate potential impacts associated with the proposed development within the Lower Shannon and Mulkear Catchment (HA25D) and the Shannon Estuary North Catchment (HA27) and thereby undermine the conservation objectives for the qualifying features of the Lower River Shannon SAC, and the River Shannon and River Fergus Estuaries SPA as discussed in Sections 6.2 and 6.3, above.

6.7.1.7 Industry, Mines and Quarries

Industry has been identified as a significant pressure for watercourses within both the Shannon Estuary North (27) and Lower Shannon (25D) Catchments. Significant pressures exerted on watercourses because of industrial practices include impacts brought about by discharges and emissions from industrial and commercial facilities leading to nutrient and organic problems and a diminution of water quality (O'Boyle *et al.*, 2019). The Moyana_010 Waterbody[62] within the Shannon Estuary North (27) Catchment is affected by nutrient and organic issues due to Section 4-licensed[63] emissions from an unidentified industrial facility. Within the same catchment (27), the 'Industrial Facility (P0012-04)' ground waterbody[64] is significantly impacted by an EPA licenced facility, Roche Ireland Limited, through excess nutrient and chemicals (EPA, 2021b). Industry is also a significant pressure for the Dead_10 Waterbody[65] within the Lower Shannon (25D) Catchment where the waterbody is affected by nutrient-related issues due to emissions from an unidentified Section 4-licensed industrial facility. Also, in this catchment (25D), the 'Industrial facility (P0331-01)' ground waterbody[66] is impacted by elevated concentrations of polycyclic aromatic hydrocarbons (PAH) in discharges from an EPA licensed facility, Spaight Timber Preservatives Limited (EPA, 2021a).

Within the wider area of the River Shannon and River Fergus estuaries, larger industrial operations that exert pressure on local watercourses and indeed, on the estuarine waterbodies themselves, include the Rusal Aughinish Alumina Plant - the largest bauxite refinery in Europe, producing two million tons of alumina per year for shipment to smelting plants throughout Europe. The plant has a bauxite residue disposal area (BRDA) that stores millions of tons of the toxic 'red mud' bauxite residue left over after production of alumina[67]. Planning permission was granted and then quashed by order of the high court (Case Reference: PA91.312146) from An Bord Pleanála to Aughinish Alumina to expand the BRDA. A new case number (318302) has generated and decision is expected in March 2024. Point source industrial discharges from the plant causing nutrient and organic issues have been identified as a significant pressure to watercourses within the Shannon Estuary South (HA24) Catchment (EPA, 2021c).

The water quality of various river habitats and waterbodies can be adversely affected by quarrying via the generation of elevated levels of silt and dust which can eventually accumulate within watercourses resulting in excessive sedimentation of river channels followed by ecological deterioration. Mining operations mainly impact on the quality of water through the dewatering process used for mineral extraction. This drainage and extraction of minerals can lead to a release of ammonia and fine-grained suspended sediments and can bring about changes to the hydromorphological condition of rivers[68]. Ecological problems caused by quarrying and mining include increased erosion rates, siltation and nutrient loss (O'Boyle *et al.*, 2019).

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[62] Waterbody Code: IE_SH_27M010150
[63] Discharge licences issued under Section 4 of the Local Government (Water Pollution) Act 1977-1990, for the discharge of trade effluent to surface water or groundwater. Licences set conditions so discharge is treated and controlled in a way that protects the receiving environment.
[64] Waterbody Code: IE_SH_G_082
[65] Waterbody Code: IE_SH_25D010100
[66] Waterbody Code: IE_SH_G_219
[67] Aughinish plant gets €2m IDA grant to treat 'red mud' dump | Business Post Accessed: 25th January 2023
[68] *Draft River Basin Management Plan for Ireland 2022 – 2027* 199144_7f9320da-ff2e-4a7d-b238-2e179e3bd98a (2).pdf Accessed: 20th January 2023

Mines have been identified as exerting a significant pressure in three river waterbodies within the Lower Shannon and Mulkear Catchment (HA25D), namely Kilmastulla_010, Kilmastulla_030 and Kilmastulla_040 (EPA, 2021a). The issues arising from this pressure relate to elevated heavy metal concentrations from the historic Silvermines zinc and lead mining site.

The water quality effects of the proposed wind farm during the construction and early operational phases, together with the previously discussed effects of industry, mining and quarrying, could exacerbate potential impacts associated with the proposed development within the Lower Shannon and Mulkear Catchment (HA25D) and the Shannon Estuary North Catchment (HA27), and thereby undermine the conservation objectives for the qualifying features of the Lower River Shannon SAC and the River Shannon and River Fergus Estuaries SPA as discussed in Sections 6.2 and 6.3, above.

6.7.2 Other Wind Energy Developments

There is potential for interaction to occur between the proposed Ballycar Wind Farm and other wind farms in the area which increases the risk of potentially significant cumulative effects occurring and, thereby, increases the risk of a detrimental impact to the integrity of European sites located within the ZOI.

There are two single wind turbines currently in operation within a 25-kilometre radius of the proposed development site at Ballycar – one turbine at Limerick Blow Moulding, Parteen, approximately 3.2 kilometres southeast of the proposal site, and one at Vistakon in Castletroy, approximately 8.2 kilometres southeast of the proposal site. Permission has been granted but construction has not yet begun for two other wind energy developments - a 19-turbine wind farm at Carrownagowan, approximately 12 kilometres northeast of the proposed development site, and an 8-turbine wind farm at Fahy Beg, approximately 10.5 kilometres northeast of the proposed development site (refer to Figure 4-15 and Table 22, above). Due to their size and/or their significant separation distances from the proposed development, these four wind farms/turbines - Parteen, Castletroy, Carrownagowan, and Fahy Beg – are not deemed likely to interact with the construction, operation or decommissioning phases of the proposed development and, therefore, the occurrence of significant cumulative effects are not envisaged.

There are two other wind energy developments currently within the planning system – Oatfield Wind Farm[69] and Knockshanvo Wind Farm[70] – that, due to their magnitudes and locations, have the potential to interact with the proposed Ballycar Wind Farm in such a way that potentially increases the risk of significant impacts to the conservation objectives of the designated European sites within the ZOI. These potential interactions and the significance of their cumulative effects, if any, are discussed in the following sub-sections.

6.7.2.1 Potential In-combination Effects – Lower River Shannon SAC

The main wind farm areas (all infrastructure excluding grid connection) of Oatfield Wind Farm and Knockshanvo Wind Farm are situated approximately 4.2 kilometres and 5.2 kilometres, respectively, north of the proposed development site. These intervening distances are considered to be of a sufficient length to ensure that there is no viable pathway to link the proposed development to the main wind farm areas of Oatfield Wind Farm and Knockshanvo Wind Farm through which any cumulative noise/disturbance impacts could occur. Therefore, no exacerbation of any potential noise/disturbance impacts associated with the construction, operation or decommissioning of the proposed development is envisaged.

Furthermore, the main wind farm areas of Oatfield Wind Farm and Knockshanvo Wind Farm are located upgradient of the proposed development with no discernible hydrological or ecological link between the

[69] ABP Planning Application Number: 318782
[70] ABP Planning Application Number: 320705

proposed development and either wind farm (there is a tenuous hydrological connection between the grid routes of the proposed development and Oatfield Wind Farm – this is discussed in detail in Section 6.7.2.1.1, below).

Considering the intervening distances between the main wind farm areas (all infrastructure excluding grid routes) of the proposed development and Oatfield Wind Farm and Knockshanvo Wind Farm, and the lack of any viable pathway connecting them, significant cumulative effects are not expected to occur.

6.7.2.1.1 *Hydrological Connection of Grid Connection Routes to Lower River Shannon SAC*

The grid connection cable for the proposed development crosses the 1st Order Kilnacreagh Stream close to where the cable terminates and approximately 0.4 river kilometres upstream from where the stream empties to the Blackwater [Clare] River (see Section 4.4.2, above, and Figure 6-3, below). Similarly, the grid connection route for Oatfield Wind Farm is proposed to cross the Blackwater [Clare] River at a location approximately 1.7 river kilometres downstream from the proposed development's Kilnacreagh Stream crossing. This creates a tenuous hydrological link between the proposed developments and, therefore, a potential pathway by which cumulative water quality impacts could potentially occur.

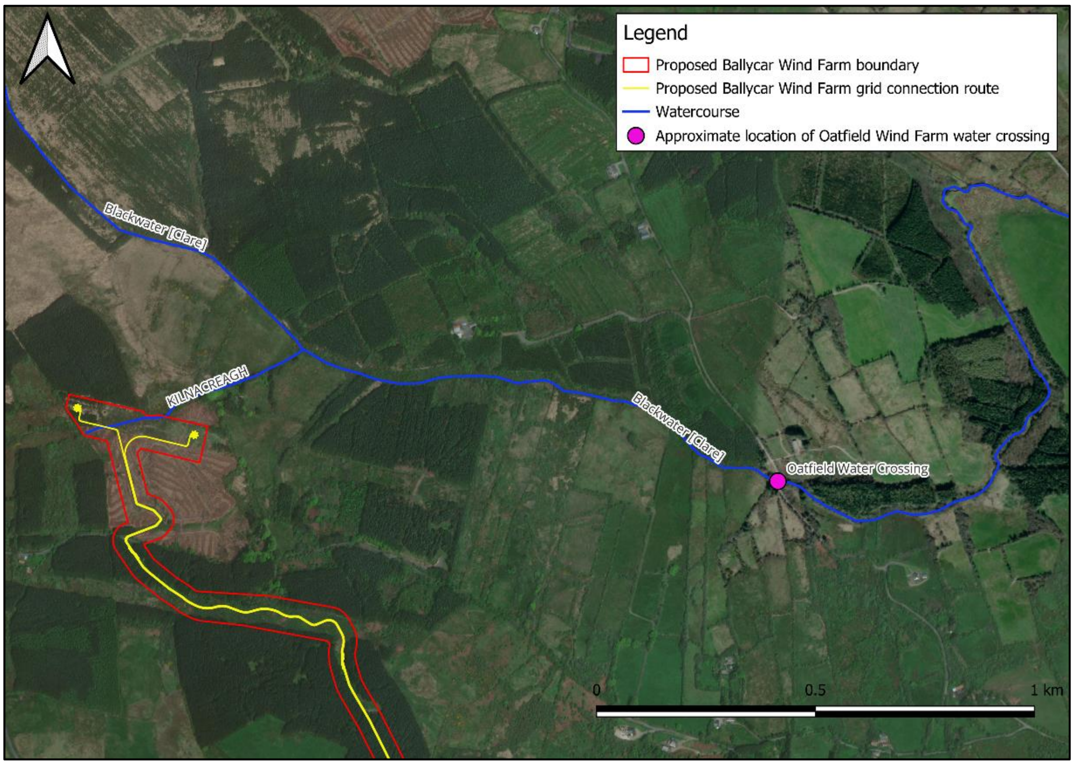

Figure 6-3: Section of the Blackwater (Clare) River providing a tenuous hydrological connection between the proposed Ballycar Wind Farm and the proposed Oatfield Wind Farm.

However, as discussed in Section 4.5.8, above, no in-stream works will be required for the Ballycar Wind Farm grid connection crossing of the Kilnacreagh Stream and any potential water quality impacts during the cable's installation will be localised in view of the nature, extent and scale of the proposed stream crossing. Considering this and the intervening distances of more than 18 river kilometres to the Lower River Shannon SAC, the potential for significant in-combination water quality impacts effecting the QIs of the SAC is low. However, due to the hydrological link between Ballycar Wind Farm and Oatfield Wind Farm via the Blackwater (Clare) River (see Figure

6-3, above), a precautionary approach will be taken and a programme of mitigation measures pertaining to protection of water quality is recommended (see Sections 7.1.2 and 7.2.6, below).

With regards any potential cumulative disturbance/displacement effects to otter that may arise due to increased noise levels and human presence at the Kilnacreagh Stream and Blackwater (Clare) River during installation of the Ballycar Wind Farm and Oatfield Wind Farm grid routes, it is noted that the Kilnacreagh Stream is located within a conifer plantation while the Blackwater [Clare] River crossing point is at a road bridge used by vehicular traffic. Both these watercourses are located within already highly modified/disturbed areas and are considered too small to be able to support sufficient levels of suitable prey species for otter. Furthermore, any fugitive noise from machinery and/or human activity at the Kilnacreagh Stream during installation of the Ballycar grid connection cable will be temporary and restricted to the immediate vicinity of the stream without any significant risk of interaction with fugitive noise of Oatfield Wind Farm construction works downstream.

It is, therefore, concluded that there is no potential for synergistic interaction between the proposed wind farm development and either Oatfield Wind Farm or Knockshanvo Wind Farm, that could result in significant cumulative effects that would undermine the conservation objectives for the qualifying features of the Lower River Shannon SAC as discussed in Sections 6.2, above.

6.7.2.2 Potential In-combination Effects – River Shannon and River Fergus Estuaries SPA

The potential for operational phase in-combination effects of the proposed Ballycar Wind Farm with other wind farms is predominantly concerned with those that could disturb/displace the SCI bird species of the River Shannon and River Fergus Estuaries SPA. These effects usually occur in two main ways – increased collision mortality and barrier effects - and both can be caused when several wind farms are situated in such proximity that they create a possible increase in collision mortality and/or disrupt the movements of birds through an area. It has already been concluded in Section 6.4.3.2, above, that disturbance/displacement of the SCI species of the River Shannon and Fergus Estuaries SPA during the operational phase of the proposed development is not likely to occur.

Upon considering the possibility of in-combination effects of the proposed development with Oatfield Wind Farm and Knockshanvo Wind Farm, it is noted that the nearest turbines are located approximately 4.2 kilometres and 5.2 kilometres away, respectively, from the proposed development site – see Figure 4-15, above. These significant intervening distances ensure a relatively wide dispersal without clustering of individual wind farms with the proposed development. Consequently, there is no plausible potential pathway for operational in-combination effects to occur between the proposed Ballycar Wind Farm and other wind farms that could result in significant cumulative effects.

It is, therefore, concluded that there is no potential for synergistic operational interaction of the proposed wind farm development with either Oatfield Wind Farm or Knockshanvo Wind Farm that could cause in-combination barrier, disturbance or mortality effects to the SCI species for which the River Shannon and River Fergus Estuaries SPA is classified.

6.7.3 Climate Change

The Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2023) published in 2023 states that anthropogenic activities have ‘unequivocally caused global warming’ and altered global climactic patterns due to the continued increase in global greenhouse gas (particularly carbon) emissions arising from ‘unsustainable energy use, land-use and land-use changes, lifestyles and patterns of consumption and production’. Changing climate is an important environmental influence on ecosystems and can affect them in a variety of ways. For instance, warming may force species to migrate to higher latitudes or higher elevations where temperatures are more conducive to their survival.

As the frequency of events such as wildfires, flooding, and drought become more common, the ability of an ecosystem to temper the impacts of these extreme conditions may become restricted. Moreover, climate change not only affects ecosystems and species directly, but it also interacts with other human stressors such as development which may, cumulatively, lead to dramatic ecological changes (Settele *et al.*, 2015). Since species differ in their ability to adjust, asynchronies can develop that reduce the survival rates of species and the health of ecosystems due to mismatches in the timing of migration, breeding, pest avoidance, and food availability (Horton *et al.* 2014).

In Ireland, shifting climactic systems have resulted in higher temperatures and rainstorms of increased intensity and frequency which can have a range of ecological effects. For example, the riverbanks of watercourses draining the proposed development site (see **Figure 3-2**, above) can be left more vulnerable to erosion in times of heavy rainfall which can then be exacerbated by land 'improvement' measures and hydromorphological changes associated with agricultural activities. The resulting uncontrolled erosion of riverbanks and riparian areas, in combination with soil loss and run-off from fields, has the potential to result in unnatural sediment loads and siltation of rivers. The construction phase of the proposed project has the potential to impact downstream water quality which, when combined with the aforementioned effects of climate change, may increase the impacts' intensity and undermine the conservation objectives for the QI species and habitats of the Lower River Shannon SAC (as discussed in **Section 6.5**, above) and the SCI bird species of the River Shannon and River Fergus Estuaries SPA (as discussed in **Section 6.6**, above) located downstream.

To limit the consequences of human-caused global climate change, the achievement of net zero CO^2 emissions via a transition from fossil fuels to low- or zero-carbon energy sources, such as wind-generated, is required (IPCC, 2023). A Renewable Energy Statistics 2023 Report produced by the International Renewable Energy Agency[71] (IRENA, 2023) puts the global total amount of electricity generated from renewable sources in 2021 at 7,858 TWh (terawatt-hour), and of this, 1,838 TWh (23%) was generated by wind energy, representing a 16% increase in global wind power generation when compared to 2020.

Wind-generated electricity in Ireland has increased hugely in recent years, going from an output of 1,923 MW (megawatts) in 2013 to an output of 4,619 MW in 2022 (IPCC, 2023). As detailed in the Renewable Energy in Ireland 2020 Report (SEAI, 2020), 28% of Ireland's electricity in 2018 was wind-generated and the country is now 'a world leader at incorporating large amounts of wind-generated electricity onto the network'. Once operational, Ballycar Wind Farm will be part of Ireland's expanding renewable energy network that is set to have a huge role in ensuring the country meets its future carbon emissions reduction targets and, ultimately, in reducing the effects of climate change on the Qualifying Interests of the country's European sites.

7. Mitigation

7.1 Mitigation by Design

7.1.1 Introduction

Hydrology was an important constraint during the design stage of the project. The siting of the development's infrastructure, such as turbines and access tracks, was constraint-driven to avoid or reduce adverse effects. As discussed in **Section 6.4.1**, above, the existing drainage network within and around the proposed development

[71] IRENA is a 'lead global intergovernmental agency for energy transformation that serves as the principal platform for international cooperation, supports countries in their energy transitions, and provides state of the art data and analyses on technology, innovation, policy, finance and investment'. [About (irena.org)] Accessed: 18th October 2023.

site creates the potential for a tangible impact pathway between proposal site and the two European sites downstream – firstly, the Lower River Shannon SAC, located approximately 1.6 river kilometres downstream from WC6 and WC7 (46m approximately from the temporary works at the junction of the R464 and L3056), and secondly, the River Shannon and River Fergus Estuaries SPA located approximately 6.6 river kilometres downstream of WC1 (3.1km approximately from the temporary works at the junction of the R464 and L3056). There is, therefore, a risk of potentially significant impacts to the Qualifying Interest species and habitats of both these European sites should contaminated surface water run-off enter the watercourses draining the proposed development site.

While the NIS has been conducted in the absence of water quality control measures, all measures outlined below are included in the design of the project to avoid or minimise water quality impacts arising during the construction phase of the project. Refer to **Chapter 2 Description of the Proposed Development**, **Chapter 3 Civil Engineering**, and **Chapter 8 Water**, in **Volume II** of the **EIAR** for full details.

7.1.2 Surface Water Drainage and Treatment System

A site-specific Surface Water Management Plan has been designed for the proposed Ballycar Wind Farm to avoid and minimise impacts to water quality within the site. Refer to Section 3.13 in **Chapter 3 Civil Engineering** in **Volume II** of the **EIAR** for full details. The main elements of the plan are described below.

A surface water run-off drainage system will be constructed to ensure that clean water flowing in the upstream catchment, including overland flow and flow in existing drains, is allowed to bypass the works areas without being contaminated by silt generated during on-site works such as excavations for the turbine infrastructure or from movement of delivery vehicles and on-site traffic. Separating the clean and dirty water will minimise the volume of water requiring treatment and dirty water drains will be provided on one or both sides of the access tracks and along the periphery of the turbines, crane hardstands, substation compound, met mast, borrow pit and the temporary site construction compound.

Clean water will be intercepted and conveyed to the downstream side of the works areas either by piping it or diverting it by means of new drains or earth mounds that are all positioned upslope to prevent any mixing of the clean and dirty water. The outflow from these drains is then piped under the tracks at suitable intervals and at low points depending on the site topography.

Drains carrying construction site runoff (dirty water) will be directed to settlement ponds that reduce flow velocities, allow for silt settlement and removal of sediment before eventual discharge of treated water via overland dispersal across a wide area of vegetation at a location down-gradient of the proposed construction site. Each settlement pond unit has been micro-sited using contour maps and aerial photos to avail of any level areas and to ensure the outflow is spread over as much vegetation as possible before entering an aquatic buffer zone. A modular approach has been adopted for the design of the settlement ponds which have been sized to cater for a specific-sized works area. The settlement ponds have been designed as a three-stage tiered system which has been proven to work effectively on wind farm construction sites. The three-stage system also facilitates effective cleaning with minimal contamination of water exiting the pond.

The entire drainage system will be managed and monitored at all times during the construction phase, particularly after heavy rainfall events. A programme of regular inspections and maintenance will be designed and carried out by dedicated construction personnel to ensure any failures are quickly identified and repaired to prevent water pollution. A checklist of the inspection and maintenance control measures will be developed, and records kept of inspections carried out. These drainage controls will be kept in place during the operational phase of the wind farm until vegetation is re-established.

Settlement ponds will also require regular inspection and cleaning when necessary and this will be carried out under low or zero flow conditions so as not to contaminate clean effluent. The water level will first be lowered to a minimum level by pumping without disturbing the settled sediment before the sediment is removed by mechanical excavator and disposed of in areas designated for spoil deposition. Settlement ponds will require perimeter fencing and signage to ensure that there are no health and safety risks.

Each drain will incorporate a series of check dams that will attenuate the flow and provide storage for the increased runoff generated during exceptional rainfall events and where necessary, sandbags and/or silt fences will be installed in adjacent roadside drainage ditches to ensure optimum standard of water running into adjacent streams from the roadside drainage. During periods of heavy precipitation and increased run-off, works will be halted or working surfaces/pads will be provided to minimise soil disturbance.

Silt fencing will be erected around the perimeter of temporary works to minimise run-off.

Additional water quality control infrastructure and measures will include:

- Settling out as far as reasonably practicable any silty water generated on site through drainage mitigation measures (silt traps, etc.) and channelled into suitable vegetation (as defined by Ecological Clerk of Works (ECoW)) at least 50 metres from watercourses;
- Establishing vegetation on exposed areas by using top sod or reseeding with a suitable seed mix;
- Regular road cleaning;
- Provision of wheel washes;
- Provision of check dams on drains to slow water velocity;
- Provision of silt fences on drains to reduce sediment loading;
- Daily and weekly weather forecast monitoring;
- Programme of daily, weekly and monthly water quality monitoring.

All design and works in proximity to watercourses shall follow the best practice guidance outlined in the following documents:

- *Draft Revised Wind Energy Development Guidelines* (DHLGH, 2019).
- *Guidelines on Protection of Fisheries during Construction Works in and adjacent to Waters* (IFI, 2016).
- *Control of water pollution from linear construction projects* (Murnane *et al.,* 2006).
- *Guidelines for the crossing of Watercourses during Construction of National Road Schemes* (NRA[72], 2008).

7.2 Mitigation by Management

7.2.1 Project Ecologist/Ecological Clerk of Works (ECoW)

A suitably qualified and experienced project ecologist/Ecological Clerk of Works (ECoW) will be employed during the construction phase of the project to ensure all environmental impact prevention controls relevant to construction activities occurring at the time are in place. Duties will include, but are not limited to, a review of all method statements to ensure works are undertaken in compliance with the CEMP and the Conditions of Planning; delivery of toolbox talks; and monitoring of construction phase activities to ensure all environmental controls and EIAR mitigation is implemented in full. The ECoW will be awarded a level of authority and will be allowed to stop construction activities if he/she deems it necessary. Refer to the CEMP in Appendix 2A of Volume III of the EIAR for further detail.

[72] National Roads Authority, now known as Transport Infrastructure Ireland (TII)

7.2.2 Invasive Alien Plant Species (IAPS) Management

Best Practice and mitigation measures to avoid the spread of invasive alien species are incorporated into the CEMP. All management and control measures implemented on-site during the construction phase will be carried out strictly in accordance with best practice guidance as set out in '*The Management of Noxious Weeds and Non-native Invasive Species on National Roads*' (NRA, 2010) and best practice management guidelines for various species published by Invasive Species Ireland[73].

Prior to being brought onto the site, all plant and equipment will be cleaned and free of soil/mud/debris or any attached plant or animal material. Prior to entering the site, all plant/equipment will be visually inspected by the Environmental Officer to ensure all adherent material and debris has been removed. A pre-construction survey for IAPS will be carried out by a suitably qualified ecologist prior to any works commencing. Where IAPS occur within the works footprint, the appointed Contractor will develop and implement an appropriate method statement regarding the on-site management of IAPS.

All footwear/waders and equipment that are to be placed (or could possibly be placed) within the water will be treated before using to prevent foreign flora and/or fauna entering the water, and they will be treated after use to prevent IAPS spreading to other catchments. Non-native species control will be practised according to '*IFI Biosecurity Protocol for Field Survey Work*' (IFI, 2010) noting that some works components are located at/near watercourses.

7.2.3 Tree Felling and Vegetation Removal – Protection of Birds

Felling of commercial conifer stands is required within the proposed construction site to accommodate the construction of the substation and two turbine foundations, and associated hardstands, access tracks, turbine assembly areas, borrow pit and deposition areas. Overall, felling of approximately 15.97 hectares of forestry will be required.

All tree felling will be undertaken in accordance with a tree felling licence, using good working practices as outlined by the Department of Agriculture, Food and the Marine (DAFM) Standards for Felling and Reforestation (DAFM, 2019). These standards deal with sensitive areas, buffer zone guidelines for aquatic zones, ground preparation and drainage, chemicals, fuel and machine oils. Tree felling will also comply with all measures prescribed in the CEMP and in accordance with the proposed surface water management for the project. All conditions associated with a proposed felling licence will be complied with.

Where possible, forestry felling and vegetation clearance will only take place before or after the bird breeding season (1st April to August 31st, inclusive). Construction work will commence before the breeding season begins (1st April) to ensure that incubating birds or birds with young are not displaced by the disturbance work commencing during the breeding season.

Should it be necessary to remove vegetation during the breeding season, for instance where bramble and ephemeral plant species have become established on ground cleared earlier, this will be surveyed by an ornithologist up to ten days before any clearance. Should an active nest be located, the area will be restricted from works by a distance where it is considered that the works would not cause disturbance or abandonment of the nest. Such distances, which will vary according to species and local topography, will be determined by the ornithologist. The restriction will be maintained until it is established that any young birds present have fledged.

[73] Resources - Invasives.ie Accessed: 25th January 2023

7.2.4 Otter – Protection of Species

Pre-construction surveys will be undertaken to ensure that newly established holts do not occur within the works area before the commencement of construction. Should a holt be identified, additional surveys/enabling works will only be undertaken under the appropriate NPWS licence.

7.2.5 Construction Environmental Management Plan (CEMP)

A **Construction and Environmental Management Plan (CEMP)** has been prepared (see **Appendix 2A** of **Volume III** of the **EIAR**) and will be updated throughout pre-construction and construction and will be implemented on site to reduce the risk of pollution and improve the sustainable management of resources (see **Section 2.4.9** in **Chapter 2 Description of the Proposed Development**, of the **EIAR**). The detailed CEMP will outline construction practices and environmental management measures which will be implemented during the construction phase to ensure that the entire development is constructed in accordance with best practice with minimum impact on the surrounding environment.

The CEMP will provide for systematic waste management identifying types and quantities of wastes arising, their management, documentation, treatment/disposal, and the parties responsible, at all stages of the project. The implementation of the proposed and agreed mitigation measures, monitoring and follow-up arrangements, and management of impacts will be managed through the CEMP. The CEMP will ensure that the proposed development will be carried out in accordance with any planning conditions applicable and within the agreed schedule.

The construction works will be strictly managed in line with the Contractors CEMP, which will include measures for the management of fuel, concrete, stockpiles, run-off, spills and the provision of emergency procedures. The CEMP and associated pollution control measures have been devised with reference to the following:

- *Control of water pollution from linear construction projects. Technical guidance (C648)* (Murnane *et al.,* 2006).
- *Control of water pollution from construction sites. Guidance for consultants and contractors* (Masters-Williams, 2001).
- *The management of noxious weeds and non-native invasive plant species on National Roads* (NRA, 2010).

Construction method statements will be prepared prior to commencement of construction and incorporated into the CEMP which will be submitted to Clare County Council for agreement and approval prior to commencement of any construction activity. The finalised CEMP will include, but not be limited to, the following environmental controls:

- Management of excavations;
- Surface water management plan (sediment and erosion control);
- Fuels and oils management;
- Management of concrete;
- Construction waste management plan;
- Wheel wash management procedure;
- Construction dust management;
- Construction noise management;

- Ecological management plan for the protection of habitats and fauna;
- Management of invasive species;
- Monitoring and auditing procedures; and
- Environmental accidents, incidents and corrective actions.

7.2.6 Surface Water Management and Protection of Water Quality

The main risk to water quality arises from the potential for ingress of sediment or accidental fuel/oil spillages discharging to the watercourses at the proposed development site via the site drainage system or surface flow. Any pollutants entering these watercourses could then be transferred to the downstream freshwater and/or marine waters of the Lower River Shannon SAC, located approximately 1.6 river kilometres downstream from WC6 and WC7 (46m approximately from the temporary works at the junction of the R464 and L3056), and/or the River Shannon and River Fergus Estuaries SPA located approximately 6.6 river kilometres downstream of WC1 (3.1km approximately from the temporary works at the junction of the R464 and L3056).

These risks are particularly acute during excavation and construction activities. Consequently, mitigation measures will be implemented to ensure that pollutants and sediment are not transferred to receiving watercourses via surface water and run-off on the site. Furthermore, the drainage system proposed for the construction phase of the project has been designed to cause minimal disturbance to the current hydrological regime by maintaining diffuse flows. Cross-drains are designed to facilitate existing drains and overland flow, and maintenance of the construction drainage design will be required during the operational phase.

As discussed in Section 6.4.1, above, water quality is a crucial environmental factor underpinning the conservation condition of the complex of wetland habitats and aquatic species and birds that the Lower River Shannon SAC and the River Shannon and River Fergus Estuaries SPA are selected for. Increased sediment levels, nutrient-enrichment, and other aquatic pollution, which could arise in the absence of effective water quality protection measures, would impact on the freshwater ecology of watercourses within the vicinity of the works.

A site-specific Surface Water Management Plan has been designed and is summarised in Section 7.1.2, above, and described in full in the CEMP of Appendix 2A in Volume III of the EIAR. The following subsections provide further detail on the various mitigation measures that will be incorporated into the proposed development to avoid or minimise any water quality impacts that could significantly affect the Conservation Objectives of the Lower River Shannon SAC and the River Shannon and River Fergus Estuaries SPA.

7.2.6.1 Drainage System Inspections and Surface Water Monitoring

The drainage and treatment system for the proposed wind farm will be managed and always monitored, particularly after heavy rainfall events during the construction phase. A programme of inspection and maintenance will be designed for dedicated construction personnel ensuring that any failures are quickly identified and repaired to prevent water pollution. A checklist of the inspection and maintenance control measures will be developed, and records kept of inspections and maintenance works. These drainage controls will be kept in place during the operational phase of the wind farm until the vegetation is re-established.

A surface water monitoring schedule will be finalised prior to construction and then followed throughout the construction phase of the project - refer to the Surface Water Management Plan in Appendix 2B in Volume III of the EIAR. Monitoring of suspended solids will be undertaken on a weekly basis and whenever else required such as after a rainfall event. Monthly monitoring of pH, metals, nitrates, and phosphates will also take place. This will be compared with the baseline data obtained prior to construction, as described in Section 4.4.7.6, above. If the measured value exceeds the baseline values, the cause will be identified, and remedial measures put in place.

Further details on the surface water quality monitoring programme for all phases of the proposed development are available in **Section 8.4** in **Chapter 8, Water**, in **Volume II** of the **EIAR**.

7.2.6.2 Management of Concrete

There shall be the requirement for some concrete works at the site. It is extremely important to prevent any concrete from entering surface water drains within or around the site as wet concrete is silty and very alkaline (high pH) and can have a serious effect on watercourses and aquatic life if ingress occurs. Refer to the **CEMP** in **Appendix 2A** of **Volume III** of the **EIAR** for further details.

The following measures will be implemented during concrete works at the site:

- A designated trained operator, experienced in working with concrete, will be employed during the concrete-pouring phase and pouring will be supervised by the Construction Manager, a suitably qualified Engineer, and the Environmental Manager/ECoW.
- There shall be no pouring of concrete during extreme/prolonged rainfall or forecasted heavy rainfall.
- The use of concrete close to drainage features will be carefully controlled to avoid spillage.
- Any small volumes of incidental wash generated from cleaning hand tools, cement mixers or other plant, as required, will be trapped on-site to allow sediment to settle out and reach neutral pH before clarified water is released to the surface water drains or allowed to percolate to ground. Settled solids will need to be appropriately disposed of off-site.
- There will be a dedicated concrete chute washout area on site. To reduce the volume of cementitious water, washout of concrete trucks will not take place on site. Concrete trucks will be washed out off site at the source quarry.

7.2.6.3 Construction Wheel Wash

Wheel washes will be provided for heavy vehicles exiting the site to ensure that roads outside of the site boundary are clean. These can take the form of dry or wet wheel wash facilities. In the case of a wet wheel wash a designated bunded and impermeable wheel wash area will be provided, and the resultant wastewater will be diverted to a settlement pond for settling out of suspended solids. The wheel wash area will be cleaned regularly to avoid the buildup of residue.

7.2.6.4 Management of Fuel/Oil

Site management should include the checking of equipment, materials storage and transfer areas, drainage structures and their attenuation ability on a regular basis during the construction phase of the project. The purpose of this management control is to ensure that the measures in place are operating effectively, prevent accidental leakages, and identify potential breaches in the protective retention and attenuation network during earthworks operations. Refer to the **CEMP** in **Appendix 2A** of **Volume III** of the **EIAR** for further details.

Appropriate fuel management will include the following elements:

- Mobile bowsers, tanks and drums will be stored in secure, impermeable storage areas on flat ground a minimum distance of 50 metres from any watercourse or other water-conducting features e.g. drains.
- Fuel containers will be stored within a secondary containment system e.g., bund for static tanks or a drip tray for mobile stores. Chemicals will be bunded and where applicable, stored within double skinned tanks/containers with the capacity to hold 110% of the volume of chemical contents.
- Ancillary equipment such as hoses and pipes will be contained within the bund.

- Taps, nozzles or valves will be fitted with a lock system and be regularly inspected for leaks and/or signs of damage. Fuel/oil stores including tanks and drums will also be inspected regularly for the same reasons.
- Where required, refuelling on-site will only be carried out at a designated area at least 50 metres from any watercourse with the use of a delivery fuel truck, operated by appropriately trained personnel. Only designated trained operators will be authorised to refuel plant on site.
- Only mechanically sound plant will be permitted to gain access to the site.
- Controls will be regularly inspected and maintained. Regular cleaning and servicing of bunds, gullies, pipe work, oil interceptors will be carried out to ensure this system is operating at its optimum.
- Procedures and contingency plans will be set up to deal with emergency accidents or spills. An emergency spill kit with oil boom and absorbers will be kept on site in the event of an accidental spill. The contents of the spill kit will be replenished if used and they will be checked on a scheduled basis during environmental inspections and audits. All crews will be trained in the use of spill kit equipment.
- All emergency procedures and equipment will be in place prior to the commencement of any works.

7.2.6.5 Refuelling of Construction Plant On-Site

All plant, such as excavators and dumpers, will be refuelled on-site, while rigid and articulated vehicles and all site vehicles (jeeps, cars and vans) will be refuelled off-site. Refer to the **CEMP** in **Appendix 2A** of **Volume III** of the **EIAR** for further detail. The plan outlined will have regard to the following elements:

- Refuelling will be carried out using 110% capacity double-bunded mobile bowsers. The refuelling bowser will be operated by trained personnel. The bowser will have spill containment equipment which the operators will be fully trained to use.
- Plant nappies or absorbent mats to be placed under refuelling point during all refuelling to absorb drips.
- Mobile bowsers, tanks and drums will be stored in secure and impermeable storage area, 50 metres away from drains and open water.
- To reduce the potential for oil leaks, only vehicles and machinery will be allowed onto the site that are mechanically sound. An up-to-date service record will be required from the main contractor.
- Should there be an oil leak/spill, it will be contained immediately using oil spill kits. All oil and contaminated material will be removed from site and properly disposed of in a licensed facility.
- Immediate action will be facilitated by easy access to oil spill kits. An oil spill kit that includes absorbing pads and socks will be kept at the site compound and within site vehicles and machinery.
- Correct action in the event of a leak or spill will be facilitated by training all vehicle/machinery operators in the use of the spill kits and the correct containment and cleaning up of oil spills or leaks. This training will be provided by the Environmental Manager at site induction.
- In the event of a major oil spill, a company who provide a rapid response emergency service for major fuel spills will be immediately called for assistance, their contact details will be kept in the site office and in the spill-kits kept inside site vehicles and machinery.

7.2.6.6 Storage

The storage of materials, containers, stockpiles and waste, however temporary, will follow best practice at all times and be stored at designated areas. All containers will be stored upright and clearly labelled. Sufficient storage will be supplied near all working areas.

Storage will be located as follows:

- Away from drains and streams;
- On an impermeable base;
- Under cover to prevent damage from the elements;
- In secure areas;
- Well away from moving plant, machinery and vehicles.

Temporary storage of Cement Bound Granular Mixtures (CBGM) during construction of the cable trench will be on hardstand areas, or areas that are not prone to run off and where there is no direct drainage to surface waters. The area will be appropriately bunded in the form of sandbags, geotextile sheeting, or silt fencing. This method will prevent any solids run-off.

7.2.6.7 Excavations

All site excavations and construction will be supervised by a suitably qualified and experienced engineer. The Contractor's method statements for each element of work will be reviewed and approved by the engineer prior to site operations. Specific method statements will be developed for each turbine and hardstanding location within the site.

Prior to excavation, drains will be established to effectively intercept overland flow prior to earthworks. The existing network of drainage within the site will be used whenever possible.

Bulk excavations will be done during periods of dry weather to avoid run off from exposed excavation areas. Weather will be monitored during the project and no excavation works will be allowed during severe or heavy rainfall events. All temporary cuts/excavations will be carried out such that they are stable or adequately supported. Where appropriate and necessary, cuts and excavations will be protected against ingress of water or erosion using cut-off drains around the excavation works. Temporary works will be such that they do not adversely interfere with existing drainage channels/regimes.

Plant and materials will be stored in approved locations only (such as the proposed site compound) and will not be positioned or trafficked in a manner that would surcharge existing or newly formed slopes. Vehicular movements will be restricted to the footprint of the permitted development, particularly with respect to the newly constructed access tracks. This implies that machinery will be restricted to use on existing tracks/hardstands and, aside from advancing excavations, will not move onto areas that are not permitted for the development.

7.2.6.8 Excavated Materials and Soil Management

All soils generated from excavation works within the proposed wind farm site such as from turbine, track, substation and internal cable construction will be retained on site and reused in bunding, landscaping and restoration of borrow pit and deposition areas. No soils will be removed from the site. Stockpiling of soils will be avoided on site. After completion of the construction phase works, no permanent stockpiles will be left on site apart from material placed in the designated permanent storage area.

During grid connection excavations, excavated material will be temporarily stockpiled adjacent to the section of trench as it is removed for re-use as backfill. Excess/unsuitable material will be immediately removed to a deposition area. Appropriate siltation measures will be put in place prior to excavations. Stockpiles will be temporarily stored a minimum of 50 metres back from watercourses on level ground. Silt-retaining measures (silt fence/silt curtain or other suitable materials) employed to reduce the risk of silt run-off will be installed along the downgradient edges of stockpiled earth materials.

7.2.6.9 Dewatering

All groundwater/surface water that may enter turbine foundations or cable trenches/joint bays will be removed and treated and disposed of appropriately, in accordance with the measures outlined hereunder. Any dewatering (if/where required) will adhere to the following measures:

- Groundwater/surface water will not be pumped directly into trackside drains/watercourses;
- Groundwater/surface water within the turbine base excavations will be conveyed through drainage channels to the drainage and settlement system. High-capacity pumps will be avoided to prevent significant flow rates to the drainage and settlement system that may overload the system; and
- Where necessary, temporary storage of groundwater/surface water will be provided within the excavations and dewatering carried out at a flow rate that is within the capacity of the settlement ponds.

7.2.6.10 Borrow Pit

Prior to tree felling at the location of the proposed borrow pit, an interceptor drain will first be excavated upslope. This drain will intercept the existing overland flows, diverting them around the borrow pit prior to discharge via a buffer zone on the downslope side. Any subsoil material overlying the rock will be excavated and stockpiled. The stockpile will be sealed, and a perimeter drain installed to intercept any run-off before discharging it through an appropriately designed silt trap.

Any surface water run-off, water pumped from within the borrow pit or standing water is likely to contain an increased concentration of suspended solids. Consequently, this water will be isolated from the clean catchment run-off by means of a series of open drains (check dams) to be constructed within the area. These drains will attenuate the flow and provide storage for the increased run-off generated during exceptional rainfall events.

Borrow pit inspections will be carried out by a geotechnical engineer through regular monitoring of the opening works. The appointed Contractor will review work practices at the borrow pit and should periods of heavy rainfall be expected, work will be halted to prevent excessive run-off generation.

The backfilling of the borrow pit with excavated material from the construction works will be undertaken under the same conditions as described above.

7.2.6.11 Grid Connection Cable Works Watercourse Crossings and Land Drainage Ditches

Approximately 110 metres from where it joins the overhead lines of the National Grid, the 110kV grid connection route will cross the Kilnacreagh Stream within coniferous plantation (refer to **Figure 4-4**, above). An access track will be provided over the cable and the crossing point of the cable will coincide with the crossing point of the proposed access track. A new bottomless culvert will be installed to carry both the track and the cable over the crossing with no instream works required.

Where land drains are encountered on the proposed grid connection route there are two scenarios proposed:

I. If there is adequate cover, the new ducts and trench will pass over the drain without interruption and no works will be required within the drain with the trench being installed in existing public/private access track.

II. Where there is insufficient cover over a drain crossing point, the new grid connection route will be installed underneath the existing crossing using the following approach:

    - Using sandbags and stable clay soil material, a sump will be formed upslope of the crossing where water will accumulate. A 50mm or 100mm submersible pump will then move the drain water across the track and back into the drain on the down flow section below the track.
    - To prevent siltation/sedimentation, two silt fences and filters will be placed downslope of the crossing point. Once the sump and over-pumping mechanism is in place, the trench excavation will progress.
    - A section of drain crossing (pipe or stone culvert) will be temporarily removed allowing the duct to pass under the drain. Once in place, the drain will be surrounded with lean mix concrete and the trench backfilled with suitable stone.
    - Finally, the drain will be put back in place, surrounded with stone/lean mix concrete and the track restored to its finished level before the over-pumping measures are removed and normal drain flow can resume.

7.2.6.12 Temporary Local Road Widening Works

As described in Section 4.6.5.3, above, it will be necessary to undertake some temporary road widening works along the local road network at the junction of the R464 and L3056 to facilitate delivery of turbine components to the proposed development site. While there are no watercourses traversing the proposed temporary works area, the Lower River Shannon SAC is located approximately 46 metres southeast of the junction (see Figure 4-14, above). This creates the potential for ingress of sediment or accidental fuel/oil spillages discharging to the SAC via surface flow which could then be transferred downstream to the River Shannon and Fergus Estuaries SPA and the estuarine/ marine waters of the SAC. To ensure pollutants/sediment are not transferred from the temporary road widening works site to the SAC via surface water and run-off, various mitigation measures will be implemented.

Prior to works commencing, silt fencing will be erected around the perimeter of the works area to limit the potential for sediment run-off. Further management measures will include:

- No excavation of materials will take place;
- Works will not take place during periods of high rainfall;
- There will be no temporary stockpiling of material;
- There will be no refuelling of vehicles/storage of fuels;
- An oil spill kit that includes absorbing pads and socks will be kept site vehicles and machinery.

7.2.7 Risk of Accidents

Given the temporary nature of the construction stage and the scale of the proposed project, as well as the environmental controls that will be implemented from the outset, the risk of disasters (typically considered to be natural catastrophes e.g. a very severe weather event) or accidents (e.g. fuel spill, traffic accident) is considered low. To minimise environmental risk, no concrete pours will take place during severe weather events such as during flooding or heavy rainfall (10 mm/hr).

Best construction practice, including that for Health and Safety, will be employed to minimise the risk of any accidents occurring. All work on site will be carried out in compliance with the Safety, Health and Welfare at Work Act 2005, the Safety, Health and Welfare at Work (Construction) Regulations 2013, and all relevant Legislation and Work Practice to ensure that the construction areas, site environs and public roads remain safe for all users.

7.3 Operational Phase

7.3.1 Water Quality Measures

Following completion of construction, on-site levels of traffic and excavation works will be extremely low, and the risk of sediment run-off will be negligible. Sediment ponds and silt fences erected for the protection of water quality during the construction phase will remain in place, although it is proposed to partly fill in the sediment ponds with stone so that they will not present a long-term safety risk. Run-off from the tracks, hard-standings, and other works areas will continue to be directed to these ponds and from there to the outfall weirs. Check dams within the drainage channels will also remain in place. Temporary works areas and the compound will be reinstated and revegetated.

There will be increased rates of surface water run-off at the site due to the increased amount of hard surface areas of the development which could lead to an increased flood risk downgradient of the site. The retention of the drainage infrastructure will ensure that run-off continues to be attenuated and dispersed across existing vegetation before reaching downstream receiving waters. The run-off control measures for the wind farm site have been designed in the context of storm events of varying duration and intensity. The settlement ponds have been designed to cater for a maximum continuous flow rate associated with a medium intensity rainfall event. Higher intensity run-off will be attenuated by the open drain collection system which provides temporary storage and limits the rate at which the run-off enters the settlement ponds.

The surface water drainage system will be managed and appropriately maintained as per standard best practice to ensure an adequate discharge quality and to control the quantity of run-off. Regular inspections by the operational maintenance personnel will ensure culverts are free from blockages and that there is no damage or erosion of the stream crossing wing walls, particularly after storm events. Silt ponds will also be inspected and maintained before drains and verges have vegetated.

Water monitoring will continue during Years 1 and 2 of the operational phase, commencing after completion of the construction phase.

Biological water quality monitoring will be undertaken to monitor surface water quality during the operational phase. Macroinvertebrates will be sampled annually for the first three years at the aquatic survey sites summarised in Table 1 and Figure 3-2, above, and detailed in the Aquatic Ecology Report in Appendix 6C of Volume III of the EIAR. Should it be found that there is instability within the macroinvertebrate communities, the surveys should continue beyond Year 3 until stabilisation of the communities has been achieved.

7.3.2 Lights on Turbines

Lights on turbines can reduce the potential risk of collision to birds. The use of “white lights” on the turbines will be avoided as these can attract insects, which may then attract insectivorous bird species or night-flying birds such as migrating individuals.

Any form of lighting on turbines or other structures will be agreed in advance with the Irish Aviation Authority/AirNav Ireland.

Any lighting introduced to the Proposed Development site will follow guidance in the documents:

- *Guidance Note GN 08/23. Bats and Artificial Lighting at Night* (BCT, 2023);
- *Bats and Lighting: Guidance Notes for planners, engineers, architects and developers* (BCI, 2010);
- *Bat Mitigation Guidelines for Ireland* Version 2. (Marnell *et al.,* 2022); and,
- *Bats and onshore wind turbines – survey, assessment and mitigation* (NatureScot, 2021).

7.4 Decommissioning Phase

Mitigation measures for the decommissioning phase will be like those of the construction phase; however, decommissioning will be of a significantly lesser scale, as large-scale excavations will not be required.

8. Monitoring (Avian Fauna)

A programme of post-construction bird monitoring will take place to establish whether the construction and operation of the proposed development has had effects on the bird species associated with the site prior to construction (as shown by the baseline surveys completed within the 48-month survey period as summarised in **Section 4.4.8**, above, and in more detail in Section 7.2.3 in **Chapter 7 Ornithology**, in **Volume III** of the **EIAR**).

The monitoring programme will comprise the following:

<u>Flight Activity Surveys</u>

Flight activity surveys will be undertaken using the Vantage Point method (SNH, 2017). The purpose of the surveys is to determine if the presence of the turbines is causing species to avoid the site. The surveys will utilise the same Vantage Point locations as used for the baseline EIAR surveys (see **Figure 3-3**, above) so that a valid comparison can be made between the two periods. The surveys will be undertaken monthly in Years 1, 2, 3, 5, 10 and 15 of the proposed development's lifetime (in accordance with SNH, 2009).

<u>Transect Survey within the Site</u>

A transect survey will be undertaken to monitor short-term and long-term effects on bird populations within the site. The transect location and the survey methodology will be the same as employed for the baseline EIAR surveys which will allow a comparison of data to be made for each monitoring year. Two surveys will be undertaken in each of the summer and winter seasons in the same monitoring years as the vantage point surveys described in the preceding paragraph.

<u>Collision searches</u>

The objective of collision monitoring and corpse searches is to establish whether bird fatalities are occurring as a result of collision with turbine blades. This will also provide data to determine the accuracy of the predictions from the Collision Risk Modelling carried out for the proposed development (for Collision Risk Modelling report see **Appendix 7K** in **Volume III** of the **EIAR**).

Carcass searches were traditionally completed by human observers whose efficiency is influenced by several factors including carcass type, environmental conditions and observer competence. Numerous studies have been conducted demonstrating that dogs have a superior ability to detect bird and bat carcasses than humans, particularly with small carcasses or in well vegetated areas (see for example Mathews, 2013). A trained dog under the control of a handler will be used.

A standard plot size will be selected at each turbine location where the search will occur. At the start of each survey, data recorded will include meteorological and ground cover information. The locations of any carcasses found will be recorded by GPS and will be photographed *in-situ*. The state of each carcass will be recorded on a corpse record card, using the following categories (after Johnson, 2003):

- Intact - a carcass that is completely intact, is not badly decomposed, and shows no sign of being fed upon by a predator or scavenger;
- Scavenged - an entire carcass which shows signs of being fed upon by a predator or scavenger, or a portion(s) of a carcass in one location such as wings, legs, skeletal remains or pieces of skin; and
- Feather Spot - ten or more feathers at one location indicating predation or scavenging. If only feathers are found, 10 or more total feathers or two or more primaries must be discovered to consider the observation a casualty.

Searcher efficiency and predation tests will be carried out at the commencement of the programme in order to calibrate the results to account for the search dog's ability to find bird corpses and to also account for scavenging of corpses by animals.

As the site is primarily of ornithological importance for breeding birds, it is proposed that the programme will be confined to the 6-month period March to August, inclusive.

9. Residual Impacts

Based on the best scientific information available, it has been determined that in the absence of mitigation, the proposed development has potential for significant adverse water quality and/or direct/indirect species disturbance/displacement impacts within the Lower River Shannon SAC and the River Shannon and River Fergus Estuaries SPA.

Detailed mitigation measures have been prescribed with regards to the protection of water quality, aquatic habitats and water-dependant species during the construction phase.

With the implementation of the recommended mitigation measures, as outlined in Section 7, above, it is objectively concluded that significant adverse residual impacts on the Conservation Objectives of any of the identified European sites evaluated herein, namely the Lower River Shannon SAC and the River Shannon and River Fergus Estuaries SPA, will not occur as a result of the proposed development, either independently or in combination with other plans or projects.

10. Conclusion

The Habitats Directive 92/43/EEC provides legal protection for species and habitats of European importance via the selection of geographical areas considered to be of particular importance to a region's most valuable and threatened species. This pan-European Natura 2000 network of protected areas, otherwise known in Ireland as 'European sites', includes Special Areas of Conservation (SACs) designated for habitats, plants and non-avian species, and Special Protection Areas (SPAs) designated for avifauna and their habitats (under the Birds Directive (79/409/ECC as codified by Directive 2009/147/EC)). To ensure the longevity of these European sites and to maintain or restore the favourable conservation statuses of the habitats and species within them, Articles 6(3) and 6(4) of the Habitats Directive set out a series of steps/stages that must be applied to plans and projects that may have a significant effect on a European site.

A Screening for Appropriate Assessment (Stage 1) was undertaken to identify whether the proposed Ballycar Wind Farm development is likely to have significant direct or indirect impacts (or significant impacts could not be ruled out) on European sites identified as being within the zone of impact influence of the proposed development. The zone of impact was ascertained through the application of the Source-Pathway-Receptor (SPR) model and as a precautionary measure, all European sites located within 15 kilometres of the proposed development site were considered. The screening process concluded that the proposed construction, operation and eventual decommissioning of Ballycar Wind Farm was not likely to have significant direct or indirect effects, either individually or in combination with other plans or projects, on six European sites within the zone of influence. However, the same conclusion could not be reached with regards two European sites, namely Lower River Shannon SAC and River Shannon and River Fergus SPA, and significant effects because of the proposed development could not be ruled out. Consequently, the project proceeded to Stage 2 of the Appropriate Assessment process and a Natura Impact Statement was produced.

This Natura Impact Statement (Stage 2) has considered the impact of the proposed development on the integrity of two European sites, namely the Lower River Shannon SAC and the River Shannon and River Fergus SPA, either alone or in combination with other plans or projects, in relation to the structure, function and conservation objectives of each site. Following an examination, analysis and evaluation of the relevant information and best scientific knowledge, including in particular the nature of the predicted impacts from the proposed development, and with the implementation of the mitigation measures proposed, it has been determined the proposed construction, operation and eventual decommissioning of a 12-turbine wind farm at Ballycar in County Clare will not adversely affect (either directly or indirectly) the integrity of either the Lower River Shannon SAC or the River Shannon and River Fergus SPA, either alone or in combination with other plans or projects, in light of the specific conservation objectives of each site.

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Appendix 1

Screening for Appropriate Assessment Report

MWP

Screening for Appropriate Assessment Report

Ballycar Wind Farm, County Clare

Ballycar Green Energy Limited

September 2024

Contents

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Project Number	Document Number	Revision	Date	Prepared By	Checked By	Status
22156	6003	A	February 2022	Hazel Dalton		DRAFT
22156	6003	B	January 2023	Úna Williams, HD	Gerard Hayes	DRAFT
22156	6003	C	July 2023	ÚW	John O'Connor (Greensource)	DRAFT
22156	6003	D	October 2023	ÚW	GH, Client reviewed	Draft
22156	6003	E	January 2024	ÚW	GH, HD	FINAL
22156	6003	F	September 2024	ÚW	HD	Revised FINAL

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1. Summary of Findings

1.1 Screening for Appropriate Assessment

Project Title	Proposed Ballycar Wind Farm
Project Proponent	Ballycar Green Energy Limited
Project Location	The proposed development site is situated within the townlands of Glennagross (orse Glenagross, Glennacross – hereafter referred to as Glennagross within this document), Cappateemore East, Ballycannan West, Ballycannan East, Ballycar South, and Ballycar North in southeast County Clare, approximately 3 kilometres northwest of Limerick City and 6.7 kilometres east of Sixmilebridge.
Screening for Appropriate Assessment	The screening for Appropriate Assessment report is undertaken to determine the potential for likely significant effects of a proposed wind energy development, individually, or in combination with other plans or projects, in view of the conservation objectives of certain European sites identified within this report.
Conclusion	It has been objectively concluded during the screening process that significant effects on the following European sites are not likely to occur because of the proposed development: • Glenomra Wood SAC (001013) • Danes Hole, Poulnalecka SAC (000030) • Ratty River Cave SAC (002316) • Kilkishen House SAC (002319) • Slieve Bernagh Bog SAC (002312) • Slievefelim to Silvermines Mountains SPA (004165) However, it cannot be objectively concluded, at this stage, that the proposed Ballycar Wind Farm will not result in likely significant effects on the following designated European sites: • Lower River Shannon SAC (002165) • River Shannon and River Fergus Estuaries SPA (004077) Therefore, an Appropriate Assessment is required, and a Natura Impact Statement is necessary to assess the implications of the project alone and in-combination with other plans and projects on the integrity of the European sites in view of their conservation objectives.

2. Introduction

2.1 Purpose of the Assessment

This screening for Appropriate Assessment (AA) report has been undertaken to determine whether a proposed 12-turbine wind energy development, 'Ballycar Wind Farm', in the townlands of Glennagross, Cappateemore East, Ballycannan West, Ballycannan East, Ballycar South, Ballycar North in southeast County Clare is likely to result in significant effects on nearby European sites with conservation designations (i.e. Natura 2000 Sites)[1].

This report has been prepared in order to provide a sufficient level of information to the competent authority, in this case An Bord Pleanála (ABP), on which to base an Appropriate Assessment of the proposed wind energy development described in **Section 4.2,** below.

The report comprises a description of the proposed development, particularly the aspects that could interact with the receiving environment, the identification in **Section 4.7** of the impacts that are reasonably foreseeable as potentially ensuing from it, and a determination as to whether these predicted impacts, either alone or in combination with the other plans or projects identified in **Section 4.5**, are likely to have significant direct and/or indirect effects on the European sites identified in **Section 4.6**, in view of those sites' conservation objectives.

2.2 Statement of Competency

This screening for Appropriate Assessment report has been prepared by Hazel Dalton (BSc.) Senior Ecologist, and Úna Williams (BSc. MSc.), Ecologist and Environmental Scientist, both of Malachy Walsh and Partners (MWP) Engineering and Environmental Consultants in County Kerry.

Hazel has over eight years' experience with MWP in ecological surveying and impact assessment for AA and Environmental Impacts Assessment Reports (EIAR) and has authored and contributed to numerous screening reports for AA, Natura Impact Statements (NIS) and Ecological Impact Assessments (EcIA). She is an appropriately qualified, trained and competent professional. She has completed numerous ecological assessments for a wide variety of projects. She is an experienced field ecologist and has a diverse ecological survey profile, including habitats and flora, mammals, birds and terrestrial/aquatic invertebrates.

Úna has worked with MWP for over four years and is an experienced field ecologist. She is familiar with various ecological survey methodologies including habitat/survey mapping and zoological surveys and has worked on research teams both in Ireland and abroad. She has undertaken assessments for a wide variety of projects including for renewable energy developments, and infrastructural and coastal developments. Úna has designed and carried out several Collision Risk Models for proposed wind farms and has authored many ecological reports including Screenings for Appropriate Assessment Reports (Stage 1), Natura Impact Statements (Stage 2), and Ecological Impact Assessments.

This report was reviewed by Gerard Hayes. Gerard is a Senior Ecologist with MWP and has over 15 years' experience in environmental consultancy. He is a member of the Chartered Institute of Ecology and Environmental Management (MCIEEM) and the Freshwater Biological Association (FBA). Gerard has a diverse ecological profile, with Phase 1 habitat, mammal (including bats), bird, amphibian, macroinvertebrate and tree survey experience. He is co-author and/or carried out surveys for NPWS Irish Wildlife Manual Nos. 15, 24, 26, 37, 45.

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[1] 'European sites' are defined in Section 177R of Part XAB of the Planning and Development Act 2000 and include Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) at all stages of designation.

2.3 Project Overview

Ballycar Green Energy is submitting a planning application for developing and operating a commercially viable 12-turbine wind farm project on lands at Ballycar in southeast County Clare. For the purposes of this assessment, the 'proposed development' refers to all elements of the proposed wind energy project including all wind farm infrastructure and new underground 110kV collector cable – see **Section 4.2**, below, for further details.

It is envisaged that the project will exceed a 50-megawatt (MW) capacity scale and therefore will be a Strategic Infrastructure Development (SID) for which an application for planning permission must be made directly to An Bord Pleanála. MWP was commissioned by Ballycar Green Energy to complete a Screening for Appropriate Assessment Report. An Environmental Impact Assessment (EIA) and an Environmental Impact Assessment Report (EIAR) have been prepared by MWP. This will be submitted as part of the planning application.

2.4 Legislative Context

The Habitats Directive (92/43/EEC) seeks to conserve natural habitats and wild fauna and flora through the designation of Special Areas of Conservation (SACs), while the Birds Directive (2009/147/EC) seeks to protect bird species of special importance by the designation of Special Protected Areas (SPAs). It is the responsibility of each European Union member state to designate SPAs and SACs that form part of Natura 2000, a network of protected sites throughout the European Community. The European Communities (Birds and Natural Habitats) Regulations 2011-2021 transpose the Habitats Directive and the Birds Directive into Irish law. The requirement for Appropriate Assessment of the implications of plans and projects on the Natura 2000 network of sites comes from the Habitats Directive (Article 6(3)). Further information is available at:

http://ec.europa.eu/environment/nature/legislation/habitatsdirective/

http://www.npws.ie/planning/appropriateassessment/

The current assessment was conducted within this legislative framework and in accordance with the European Commission Methodological Guidance on the provision of Article 6(3) and 6(4) of the Habitats Directive 92/43/EEC (EC, 2021), the European Commission Notice '*Managing Natura 2000 sites: The provisions of Article 6 of the 'Habitats' Directive 92/43/EEC*' (EC, 2019), '*Appropriate Assessment of Plans & Projects - Guidance for Planning Authorities'* prepared by the National Parks and Wildlife Service (NPWS) (DoEHLG, 2010), and the Office of the Planning Regulator (OPR) Practice Note '*Appropriate Assessment Screening for Development Management*' (OPR, 2021). As outlined in these, it is the responsibility of the proponent of the project, in this case Ballycar Green Energy ('the Applicant'), to provide a comprehensive and objective screening for Appropriate Assessment report which can then be used by An Bord Pleanála to assist them in completing their screening exercise.

If it is determined that an Appropriate Assessment should be required in respect of the construction, operation and decommissioning of the proposed wind farm, a Natura Impact Statement (NIS) must be prepared. The NIS will assist the competent authority to conduct the Appropriate Assessment for the project.

2.5 Stages of Appropriate Assessment

The Appropriate Assessment process is a four-stage process with issues and tests at each stage. The purpose of the screening assessment is to record in a transparent and reasoned manner the likely effects on European sites of a proposed development. An important aspect of the process is that the outcome at each successive stage determines whether a further stage in the process is required. The stages are set out in **Appendix A** of this report. This proposal has proceeded as far as Stage 2.

3. Methodology

3.1 Appropriate Assessment Guidance

A plan or project can only be authorised by a competent authority if it has made certain that it will not adversely affect the integrity of the European sites relevant to the project in view of their conservation objectives, either alone or in combination with other plans and projects. This can only be the case where “no reasonable scientific doubt remains as to the absence of such effects”[2].

As set out in the NPWS guidance, the task of establishing whether a plan or project is likely to influence a European site(s) is based on a preliminary impact assessment using available information and data, including that outlined above, and other available environmental information, supplemented as necessary by local site information and ecological surveys (DoEHLG, 2010). This is followed by a determination of whether it is likely that the effects identified could be significant. The precautionary principle approach is required.

Once the potential impacts that may arise from the proposal are identified, the significance of these is assessed using the following key indicators:

- Water quality and resource;
- Habitat loss or alteration;
- Disturbance and/or displacement of species; and
- Habitat or species fragmentation.

3.2 Consultation

Two pre-application stage meetings were held with An Bord Pleanála. The first, held on 23rd February 2022, involved Ballycar Green Energy and MWP introducing the proposed Ballycar wind development to the Board. The grid connection, Natura Impact Statement (NIS), and the Environmental Impact Assessment Report (EIAR) were discussed. A second meeting with An Bord Pleanála took place on 1st September 2022 where the discussion focussed on project progress and the EIAR and NIS. An Bord Pleanála confirmed the project would be Strategic Infrastructure in correspondence dated the 4th November 2022 and advised on the list of prescribed bodies.

Ballycar Green Energy and MWP held a preliminary meeting with members of Clare County Council (CCC) Planning Department on 2nd March 2022 to present the site and discuss its suitability for a wind farm project - the turbine delivery route, any potential visual impacts, public consultation and environmental impacts were all considered.

On 14th December 2021, the following statutory and non-statutory bodies were consulted, amongst others, in relation to the proposed project:

- Department of Housing, Local Government and Heritage;
- Department of Agriculture, Food and the Marine;
- National Parks and Wildlife Service;
- Environmental Protection Agency Ireland;
- Geological Survey Ireland;
- An Taisce - The National Trust for Ireland;

[2] European Court of Justice Case C-127/02 Landelijke Vereniging tot Behoud van de Waddenzee

- Bat Conservation Ireland;
- Inland Fisheries Ireland;
- BirdWatch Ireland;
- Irish Whale and Dolphin Group;
- Irish Wildlife Trust;
- Irish Aviation Authority; and
- Transport Infrastructure Ireland (TII)3.

A full list of the organisations/groups consulted, copies of the consultation documents and the responses received are provided in **Appendix 1B** in **Volume III** of the **EIAR**.

3.3 Desktop Study

To complete the screening for Appropriate Assessment report, certain information on the existing environment is required. A desktop study was carried out to collate information available on the proposed development site's natural environment. This comprised a review of the following publications, data and datasets:

- Ordnance Survey Ireland (OSI) aerial photography, 1:50000 mapping, GeoHive and online satellite imagery sources;
- National Parks and Wildlife Service (NPWS);
- National Biodiversity Data Centre (NBDC) (online map-viewer);
- Central Statistics Office (CSO) – Census of Agriculture (online);
- BirdWatch Ireland (online datasets);
- Bat Conservation Ireland (BCI);
- Teagasc soil area maps (NBDC website);
- Geological Survey Ireland (GSI) area maps;
- Environmental Protection Agency (EPA) water quality data;
- Shannon International River Basin District (ShIRBD) datasets (Water Framework Directive);
- Inland Fisheries Ireland (IFI) online fish sampling reports and data;
- Review of requested records from NPWS Rare and Protected Species database;
- 'Managing Natura 2000 Sites: The provisions of Article 6 of the 'Habitats' Directive 92/43/EEC' (EC, 2019);
- Interim Version of the Clare County Development Plan (2023 – 2029)4; and
- Other sources and research listed in Section 5, below, and as footnotes throughout the report.

[3] Transport Infrastructure Ireland (TII) – established in August 2015 through a merger of the National Roads Authority (NRA) and the Railway Procurement Agency under the Roads Act 2015.
[4] Stage 3 - Adoption of Plan | Stage 3: Amendments | Clare County Council (clarecoco.ie) Accessed: 6th July 2023.

3.3.1 Data Requests and Database Searches

The study area lies within the Ordnance Survey National Grid hectad[5] R56. Concise and site-specific information on species records available in this hectad was retrieved from the NBDC on-line database and reviewed.

A request was made to NPWS for Sensitive Data Access for hectad R56 on 17th November 2021. A data request for records of rare or protected species from this hectad was submitted to NPWS on the 13th October 2022.

A data request was also submitted to Bat Conservation Ireland (BCI) for the provision of bat records within a 10-kilometre radius of the proposed development site. All available records were provided by BCI on the 05th May 2023.

A request was made to BirdWatch Ireland on the 18th July 2023 for the results of annual waterbird counts at specific subsites as part of the Irish Wetland Bird Survey (I-WeBS). Information was provided by BirdWatch Ireland on 29th July 2023.

Information received via the NPWS, BCI, NBDC, and BirdWatch Ireland was used to help inform the impact assessment in relation to the proposal.

The responses to these data requests can be viewed in Appendix 1B in Volume III of the EIAR.

3.4 Study Area and Zone of Influence (ZOI) of the Proposed Project

The zone of influence (ZOI) for the proposed development is the geographical area over which construction and/or operation of the proposed wind farm has the potential to affect the receiving environment in such a manner as to significantly affect the Qualifying interests (QI) of a European site. The area over which ecological features may be affected by biophysical changes because of the proposed project and associated activities is likely to extend beyond the project site where, for example, there are ecological or hydrological links beyond the site boundaries (CIEEM, 2018). Consequently, and to ensure completion of an integrated assessment, the study area for this project included the entire proposed development site, adjoining habitats and watercourses located downstream of the site (see Figure 1).

For information on the use of the Source-Pathway-Receptor (SPR) model in determining which European sites should be further assessed, refer to Section 4.6.1.

[5] Hectad - unit of land area measuring 10 km x 10 km

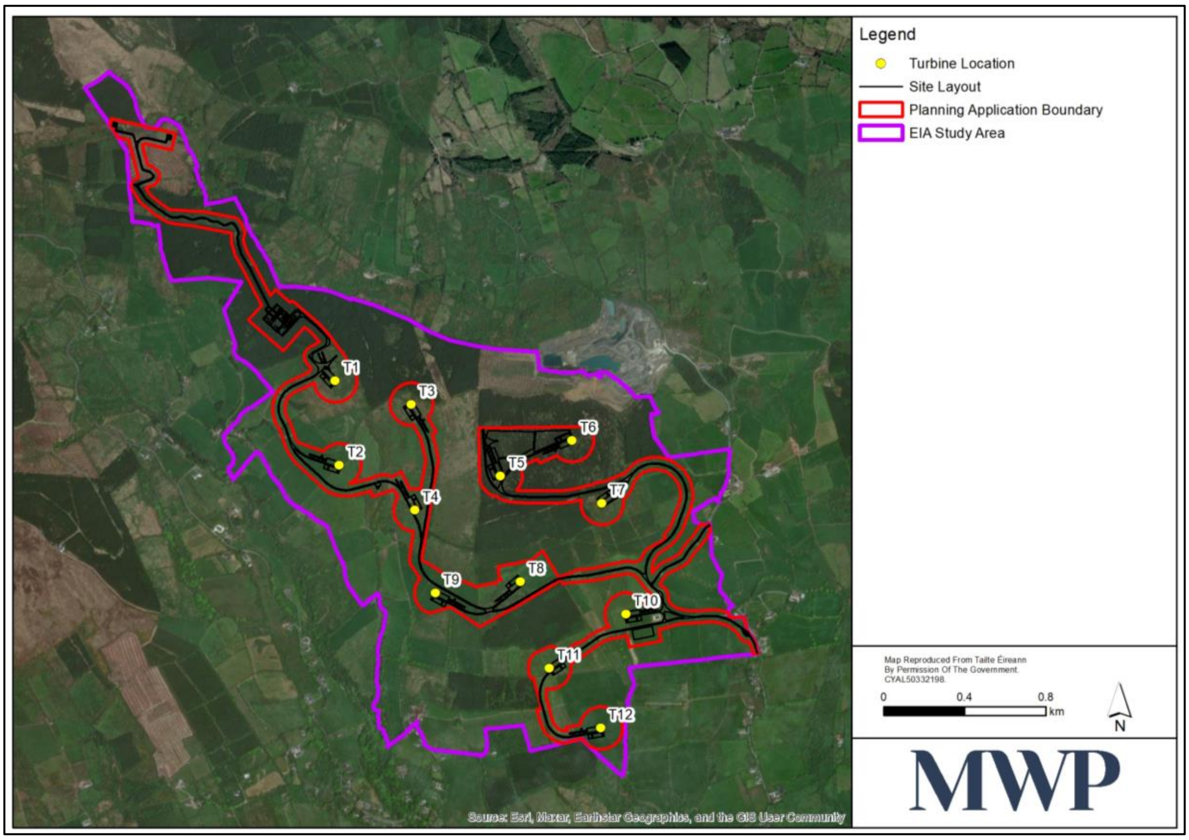

Figure 1: Study area and proposed development site boundary at Ballycar in County Clare.

3.5 Field Surveys

Ecological field surveys and aquatic ecology surveys were undertaken at the proposed development site on multiple dates between 2019 and 2023 to establish the site's ecological features and resources, particularly for any rare or protected species and habitats present within the study area. Multidisciplinary walkover surveys were carried out to identify any ecological features and resources that may potentially be impacted by the proposed development.

Field surveys carried out on-site in support of the development application and relevant to this assessment are outlined as follows:

- Habitat surveys and mapping;
- Non-volant mammal[6] surveys;
- Invasive alien plant species (IAPS) surveys;
- Aquatic surveys;
- Breeding bird surveys including Vantage Point surveys; and
- Wintering bird surveys including Vantage Point surveys.

Full details of survey methodologies have been presented in **Chapter 6 Biodiversity**, and **Chapter 7 Ornithology**, in **Volume II** of the **EIAR**.

[6] Non-volant mammals – Land-based mammals incapable of flight i.e. all land-based mammals excluding bats.

4. Screening for Appropriate Assessment

The purpose of the screening assessment is to record in a transparent and reasoned manner the direct and indirect likely effects, on relevant European sites, of the project, either alone or in combination with other plans and projects, and whether these likely effects are significant. Screening for Appropriate Assessment (Stage 1) determines the need for a full Appropriate Assessment (Stage 2) and consists of several steps, each of which is addressed in the following sections of this report:

- **4.1** Establish whether the project is necessary for the management of a European site(s).
- **4.2** & **4.3** Description of the project (construction of a 12-turbine wind energy development at Ballycar in County Clare).
- **4.4** Description of the existing site's ecological characteristics and a summary of the results of the field surveys.
- **4.5** Identification of other plans, projects and activities with which the proposed development could interact to create in-combination effects.
- **4.6** Identification of European site(s) potentially affected.
- **4.7** Identification and description of potential individual and cumulative impacts (in-combination effects) of the project.
- **4.8** Assessment of the significance of potential impacts on European site(s).
- **4.9** Conclusion of screening stage.

4.1 Management of European Sites

The proposal is not connected with or necessary to the conservation management of a European site.

4.2 Description of Project

4.2.1 Site Location and Context

The proposed development site boundary encompassing approximately 104.7 hectares is situated approximately 3 kilometres northwest of Limerick City and suburbs and 6.7 kilometres east of Sixmilebridge in southeast County Clare. Moving west to east, the site encompasses the townlands of Glennagross, Ballycar North, Cappateemore East, Ballycannan West, Ballycannan East and Ballycar South.

The elevated site is situated within a rural landscape and comprises mainly hilly and undulating terrain, with height ranging from approximately 60 metres above ordnance datum (AOD) to 262 metres AOD. The site topography generally slopes southwards giving panoramic views of Limerick City and the Shannon Estuary to the south. A series of hills form a ridgeline along the northern boundary of the site. Refer to **Figure 2**. Heading north from the R464, the site is accessed from Limerick City via two Local Roads - one to the west and one to the east - running parallel on either side of the proposed development site. Access to the west section of the site is via a local road connected to Meelick/Knockalisheen Road (Local Road) to the south, and access to the east section of the site is via a private farm track connected to Ballycar South Road (Local Road) to the east.

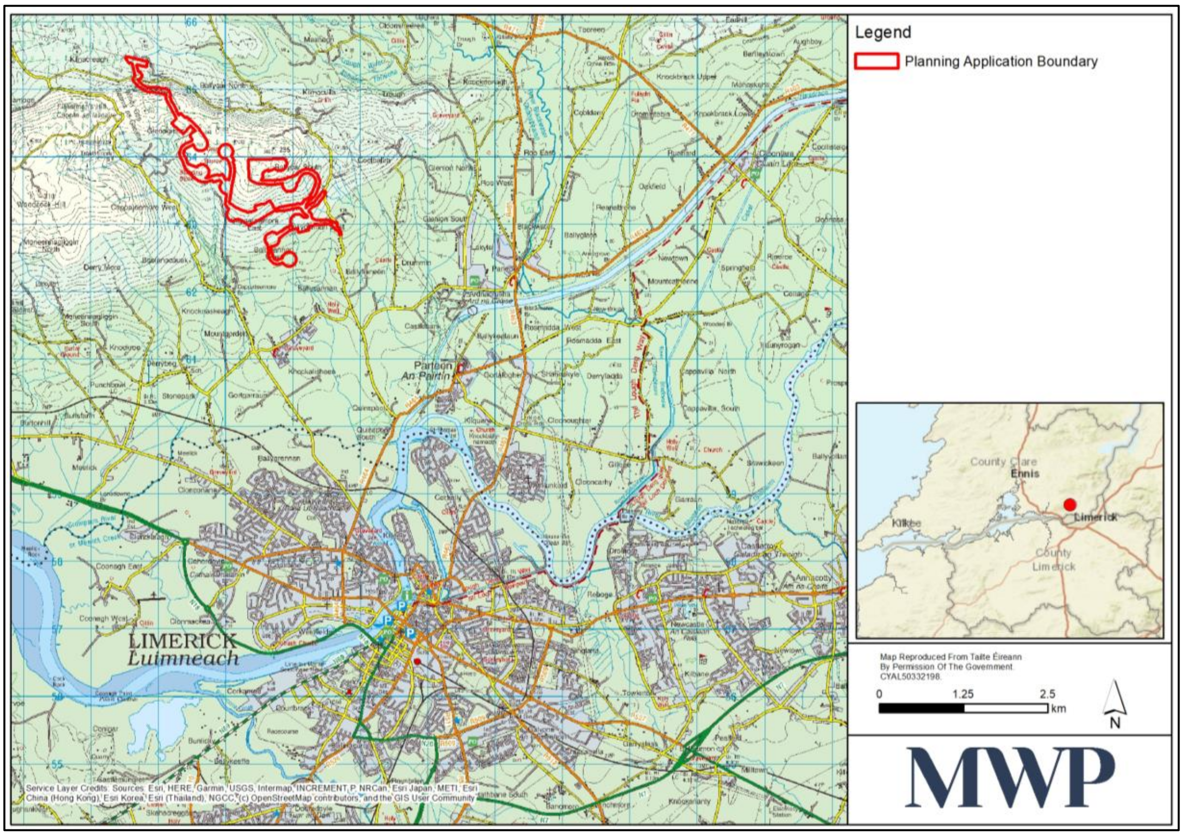

Figure 2: Location of proposed development site at Ballycar in County Clare.

4.2.2 Brief Project Description

It is proposed to erect a twelve (12) No. turbine wind farm at a location in southeast County Clare, approximately 3 kilometres northwest of Limerick City. The total planning boundary of the site encompassing twelve wind turbines, access tracks, crane hardstand areas, underground medium voltage collector circuit cables, permanent meteorological mast, borrow pit, material deposition areas and temporary construction compound is approximately 104.7 hectares (see **Figure 3**, below).

The approximate area of commercial forestry to be clear-felled is 15.97 hectares. Electrical energy generated by the proposed windfarm will be exported to a proposed new substation located approximately 0.37 kilometres northwest of T1 via a proposed new underground 110kV collector cable running from T1 to the new substation. From the substation, the collected electrical energy will be fed into a 110kV overhead electricity line and connected to the National Electricity Grid (NEG). The underground cable will measure approximately 1.5 kilometres – 1 kilometre will be installed along existing forestry tracks and 0.5 kilometres will be routed through stands of conifer plantation (refer to **Figure 3** and **Figure 4**).

The characteristics of the project and the project design have been confirmed with the project engineer and are briefly described in **Section 4.3**, and in detail in **Chapter 3 Civil Engineering,** in **Volume II** of the **EIAR**, and **Planning Drawings 22156-MWP-00-00-DR-C-5005** to **5006** and **22156-MWP-00-00-DR-C-5401** to **5412.**

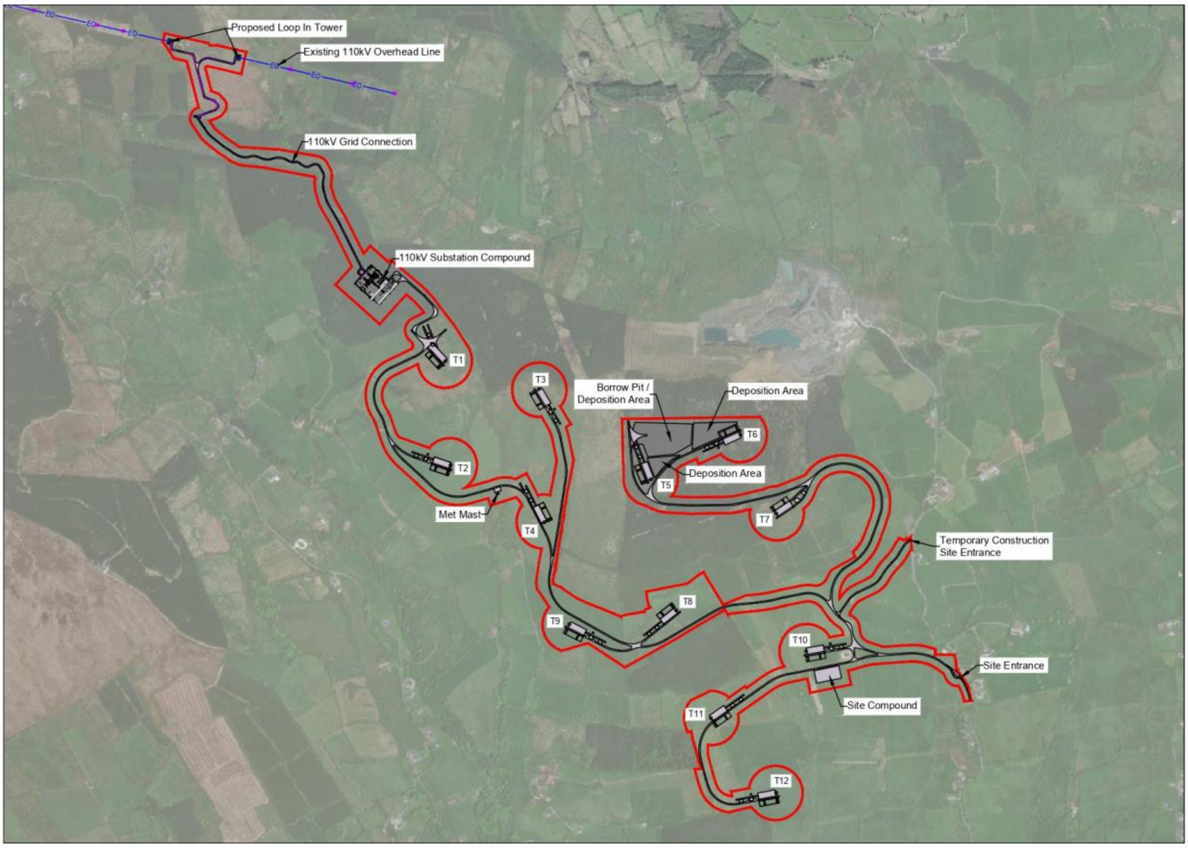

Figure 3: Site layout of proposed Ballycar Wind Farm in County Clare.

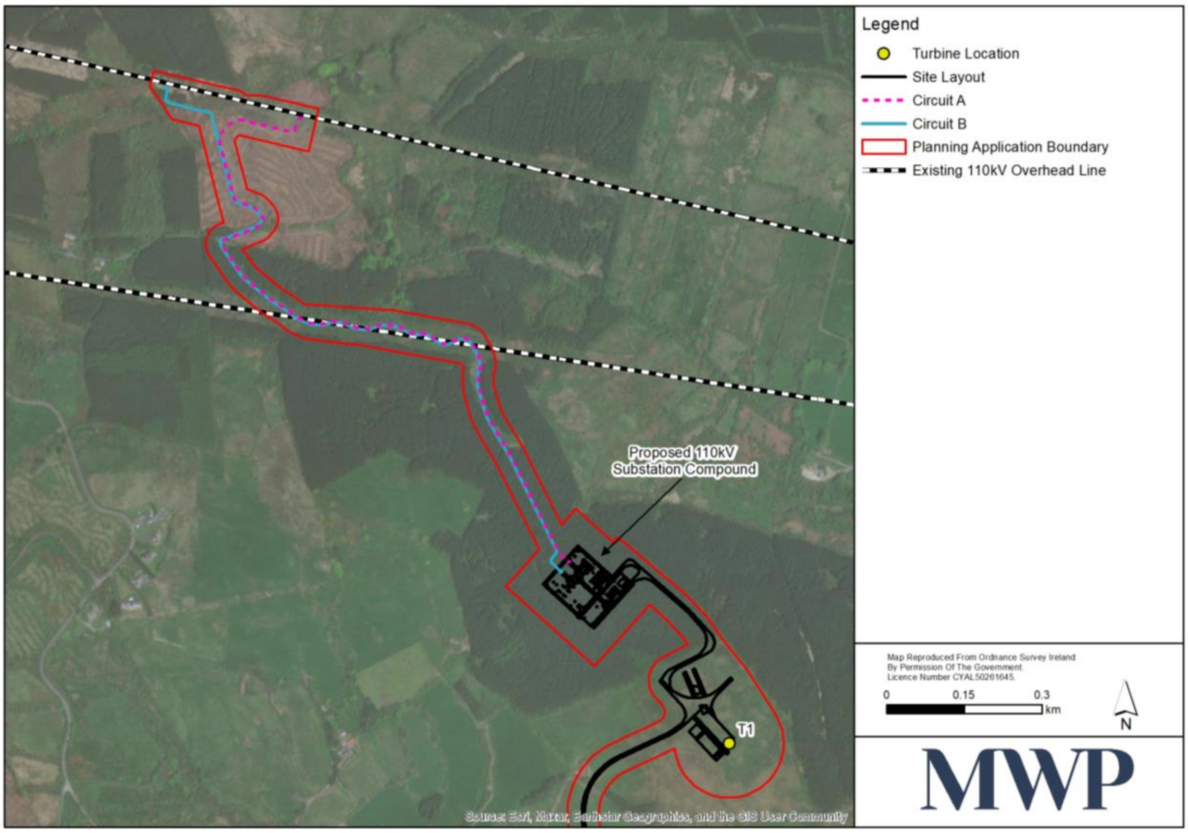

Figure 4: Proposed underground cable grid connection route from T1 to the proposed new substation.

The proposed development lands include lands under the ownership of forestry companies and privately-owned lands under agreement with Ballycar Green Energy. All proposed turbine locations are within areas that have been designated as strategic for wind energy development in the Clare County Development Plan (2023 – 2029)[7].

The proposed delivery route of wind farm components from Foynes Port in County Limerick to the proposed development site at Ballycar is shown on drawing 22156-MWP-00-00-DR-C-5009 and in Figure 5.

Wind farm components will be delivered from Foynes Port in County Limerick to the proposed development site via the N69 (see Figure 5). To avoid Limerick City centre, deliveries of turbine blades will be via the Limerick Tunnel. Components with a loaded height greater than 4.65 metres, such as the tower components, will be delivered along the R510 Dock Road and Shannon Bridge before continuing along Condell Road to Clonmacken Roundabout and rejoining the blade delivery route.

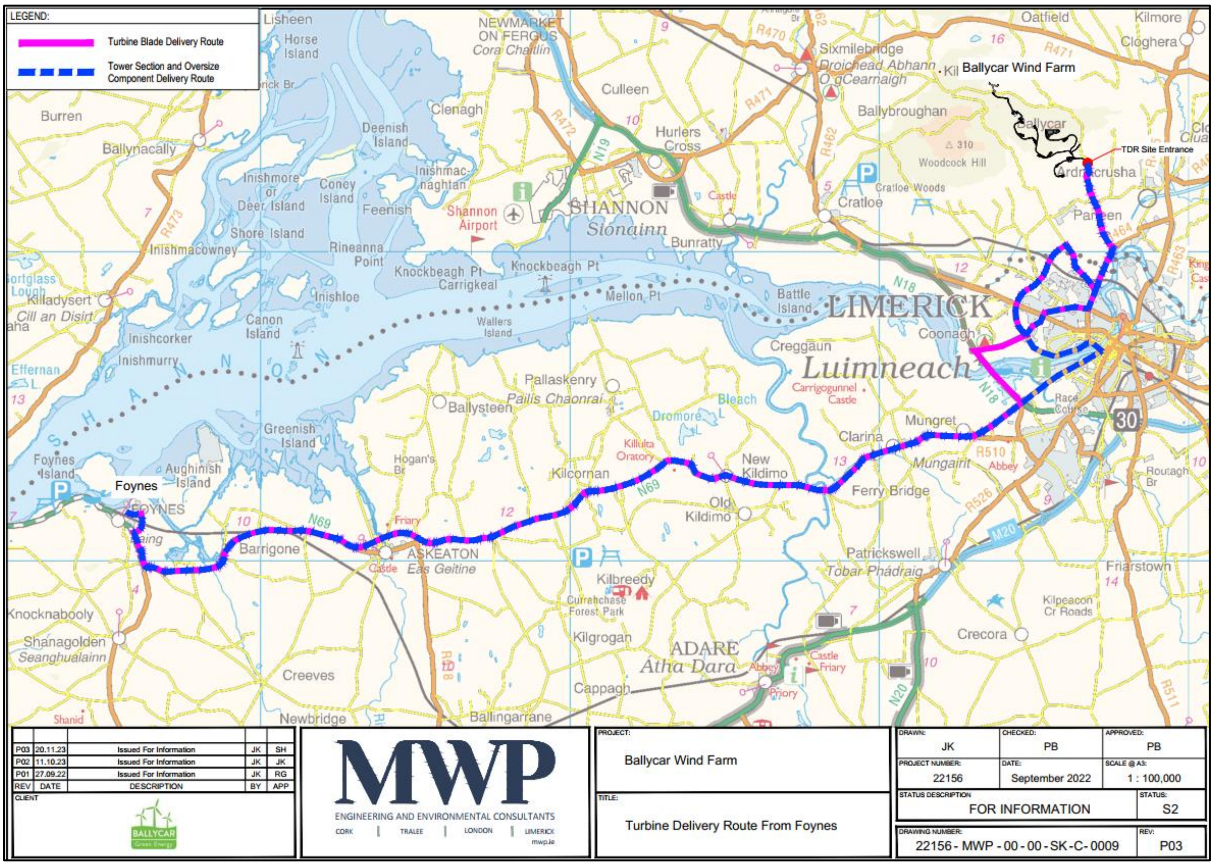

Figure 5: Proposed Turbine Delivery Route to the development site from Foynes Port in County Limerick.

Turbine delivery and access route is described further in Appendix 2C, Turbine Delivery Route Assessment, in Volume III of the EIAR for this project. The delivery of turbine components to the proposed development will require temporary works on sections of the public road network along the delivery route including hedge or tree cutting, relocation of powerlines/poles, lampposts, signage and temporary local road widening. Such works are temporary for the delivery of turbine components and are not included in the planning application boundary.

[7] Stage 3 - Adoption of Plan | Stage 3: Amendments | Clare County Council (clarecoco.ie) Accessed: 6th July 2023

4.2.3 Purpose of the Project

The purpose of the project is for the generation of electricity from a renewable resource by means of a commercially viable 12-turbine wind farm which will supply electricity to the National Electricity Grid (NEG).

4.3 Characteristics of the Project

The following table sets out the elements of the project for which development consent is being sought and all other associated project components:

Table 1: Characteristics of the proposed project at Ballycar in County Clare.

Proposed Development for which consent is sought	Core Wind Farm Components ▪ 12 No. Wind Turbines (blade tip height up to 158m). ▪ 12 No. Wind Turbine foundations and hardstand areas. ▪ 1 No. permanent Meteorological Mast (90m height) and foundation and associated hardstand areas. ▪ 1 No. Electrical Substation (110kV) including associated ancillary buildings, security fencing and all associated works. ▪ Grid connection to existing 110kV overhead line. ▪ 2 No. Developed Site Entrances, one temporary entrance to facilitate construction traffic and one permanent entrance. ▪ New and upgraded internal site access tracks. ▪ Provision of an on-site visitor cabin and parking. Associated Components of the Proposed Development ▪ All associated underground electrical and communications cabling connecting the proposed turbines to the proposed onsite substation. ▪ Turbine Delivery. ▪ Laying of approximately 1.5km of underground electricity cabling to facilitate the connection to the national grid from the proposed onsite substation to connect to an existing 110kV overhead line. ▪ Temporary works on sections of the public road network along the turbine delivery route (including hedge or tree cutting, relocation of powerlines/poles, lampposts, signage, and local road widening). ▪ 1 No. Temporary construction site compound and additional mobile welfare unit. ▪ 1 No. Borrow pit to be used as a source of stone material during construction. ▪ 3 No. spoil deposition areas (one at borrow pit location). ▪ Associated surface water management systems. ▪ Tree felling required for wind farm infrastructure.

4.4 Description of Existing Site

4.4.1 General Site Description

The wind farm site is located within the Electoral Divisions (ED) of Ballycannan (ED: 16105) and Cloontra (ED: 16110). During the 2016 census, Ballycannan ED was found to have a total population of 1,041 residents, occurring primarily within the small rural settlements of Meelick and Ballycannan. The Cloontra ED was found to have a total of 307 persons resident, comprising one-off housing and ribbon development along the local road network[8].

The proposed development site comprises predominantly farmland (a mixture of both marginal and more improved areas), used primarily as grazing for cattle. Commercial forestry plantations also occurs within the site boundary and makes up a considerable portion of the north part of the site.

Lands surrounding the site are predominantly used for agricultural purposes, interspersed with conifer plantations and single residential dwellings. An operational quarry, O'Connell Quarries, is located directly north of the site, comprising an existing working area of 16.9 hectares (with planning approval for an extension of 10 hectares) and an existing concrete batching plant. Ardnacrusha hydroelectric power station is located approximately 2.6 kilometres southeast of the proposed T12 location.

The Corine[9] (2018) land cover categories for the proposed development site comprise 'Pastures' and 'Coniferous forests'. To the west and southwest of the site, linear riparian woodland occurs along the route of the Crompaun (East) River, set within a predominantly agricultural landscape. This band of woodland comprises 'Broadleaved forests'. Extending away from the site, 'Pastures' make up the dominant land cover category with large areas of 'Land principally occupied by agriculture with significant areas of natural vegetation', as well as pockets of 'Transitional woodland scrub'. Woodcock Hill is situated approximately 2.2 kilometres west of the site and comprises 'Peat bogs'[10].

A review of bedrock mapping determined that the geological units underlying the site are 'Palaeozoic, Silurian' in the west of the site, 'Palaeozoic, Upper Devonian – Carboniferous' in the central and eastern sections of the site and 'Palaeozoic, Carboniferous, Mississippian' in the south of the site. Soils within the site are categorised as 'Lithosols, Regosols' (shallow well-drained mineral - mainly acidic), 'Podzols (Peaty), Lithosols, Peats' (predominantly shallow soils derived from non-calcareous rock or gravels with/without peaty surface horizon), 'Surface water Gleys (Shallow), Ground water Gleys (Shallow)' (derived from mainly non-calcareous parent materials) and 'Surface water Gleys, Ground water Gleys' (derived from mainly non-calcareous parent material)[11].

4.4.2 Hydrology and Hydrogeology

The proposed substation and the five westernmost turbines – T1, T2, T3, T4, and T9 – of the proposed development are located within the Water Framework Directive (WFD) Owenogarney_SC_020 sub-catchment which are in turn situated within the Shannon Estuary North Catchment (27).

A review of the EPA map-viewer determined that the 1st Order Cappateemore_East Stream is mapped within the western section of the subject site. A constituent of the Crompaun (East)_010 River Waterbody[12], the source of the Cappateemore_East Stream is located to the northwest of the study area between T1 and T3. From here, the

[8] https://cso.maps.arcgis.com/ Accessed: 9th December 2022
[9] Co-ORdinated INformation on the Environment – data series initiated in 1985 by the European Commission to gather environmental data.
[10] EPA Maps Accessed: 9th December 2022
[11] https://www.heritagemaps.ie Accessed: 9th December 2022
[12] EPA River Waterbody Code: IE_SH_27C090600

Stream travels southwards for approximately 1.6 river kilometres[13] through farmland, briefly passing through the proposed development boundary near T2 and T4, before merging with the 3rd Order Crompaun (East) River (see **Figure 6,** below).

The upper reaches of the Crompaun (East) River and its tributaries (including the Glennagross Stream and an unnamed stream whose source lies adjacent to the proposed substation location) lie further to the west, outside the proposed development boundary. After being joined by the Cappateemore_East Stream, the Crompaun (East) River continues southwestwards, eventually draining to the Upper Shannon Estuary Transitional Waterbody[14] west of Limerick City. The lower reach of the Crompaun (East) River and the estuary into which it drains are encompassed within the boundary of both the Lower River Shannon SAC (002165) and the River Shannon and River Fergus Estuaries SPA (004077). The Lower River Shannon SAC is located approximately 1.6 river kilometres downstream from watercourse crossings WC6 and WC7[15] while the River Shannon and River Fergus Estuaries SPA is located approximately 6.6 river kilometres downstream of WC1 – refer to **Figure 6**.

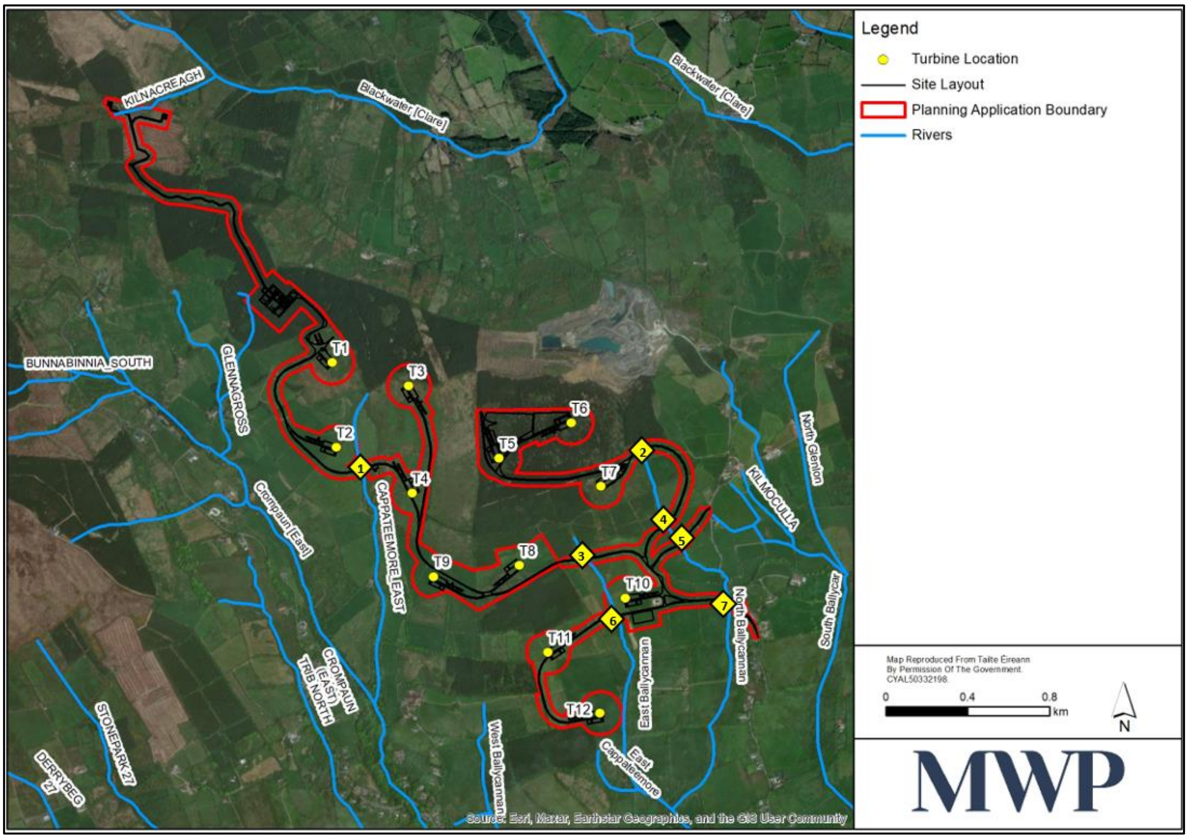

Figure 6: Watercourses at the proposed development site and the locations of the seven watercourse crossings (WC) necessary to accommodate internal access tracks.

The seven easternmost turbines – T5, T6, T7, T8, T10, T11, and T12 – are all situated within the Shannon [Lower]_SC_100 sub-catchment which in turn is situated within the Lower Shannon Catchment (25D). There are four watercourses mapped within this catchment at the eastern extent of the site including the North Ballycannan River and three of its tributaries - the 1st Order East Cappateemore and East Ballycannan Streams, and the 2nd

[13] River kilometres (rkm): measure of the distance in kilometres along the path of a river/watercourse (as opposed to a linear measure such "as the crow flies").
[14] EPA Transitional Waterbody Code: IE_SH_060_0800
[15] WC – Watercourse Crossings. See **Figure 6,** below, for locations.

Order West Ballycannan River (see **Figure 6,**). All four watercourses are part of the North Ballycannan_010 River Waterbody[16].

The East Ballycannan Stream flows southwards past T10 and T12 and merges with the North Ballycannan River south of T12. The North Ballycannan Stream then continues southwards away from the proposal site eventually veering east and draining to the estuarine waters of the Shannon Estuary north of Limerick City. This stretch of the estuary is identified as the Limerick Dock Transitional Waterbody[17]. The lower reaches of the North Ballycannan Stream and this section of the Shannon River are also encompassed within the Lower River Shannon SAC and the River Shannon and River Fergus Estuaries SPA.

Approximately 1.3 kilometres of the northern end of the proposed underground collector cable (UGC) is also located within the Shannon [Lower]_SC_100 sub-catchment (see **Figure 6**), and approximately 0.11 kilometres from where it joins the overhead lines of the National Grid, the UGC will cross the 1st Order Kilnacreagh Stream. The Kilnacreagh Stream rises at a location approximately 1.1 kilometres northwest of the proposed substation location and is part of the Blackwater (Clare)_010 River Waterbody[18]. It runs from southwest to northeast before merging with the 2nd Order Blackwater [Clare] River approximately 0.55 river kilometres downstream from the Stream's source. The Blackwater [Clare] River continues eastwards before veering southwards and eventually draining into the River Shannon near Ardnacrusha Power Station approximately 18 river kilometres downstream of where the 1st Order Kilnacreagh Stream first joined the Blackwater [Clare].

Internal site tracks will require the crossing of seven minor watercourses at locations shown in **Figure 6**. These crossings are located between 1.6 and 6.6 river kilometres upstream of the Lower River Shannon SAC, and between 6.6 and 8.7 river kilometres upstream of the River Shannon and River Fergus Estuaries SPA. These watercourse crossings and drain diversion are discussed in full in Section 3.13.3 in **Chapter 3 Civil Engineering**, in **Volume II** of the **EIAR**.

Compliance with the reporting requirements of the WFD (Directive 2000/60/EC) obliges each member state to publish reports providing summary information about individual waterbodies relating to their status, risks and objectives. The WFD Status (2016 – 2021) of the Crompaun (East)_010 River Waterbody is 'Poor'. The nearest downstream EPA water quality monitoring station to the proposed development site is located at 'Cappateemore Bridge'19, approximately 1.5 river kilometres downstream of the proposed site boundary at T9. The latest river Q value at this location is 'Q3-4, moderate', recorded by the EPA in 2022. The Crompaun (East)_010 waterbody has been assigned a WFD risk status of 'At risk'. A review of the '*Owenogarney_SC_020 Sub-catchment Assessment WFD Cycle 2*' report[20] determined that the following pressures have been identified with regard to this waterbody: channelisation, forestry, embankments, wastewater discharge and agriculture. The Transitional Waterbody WFD latest status (2016 – 2021) of the Upper Shannon Estuary, into which the Crompaun (East) River drains, is 'Poor'.

The WFD Status (2016 – 2021) of the North Ballycannan_010 River Waterbody is 'Good'. There are no EPA water quality monitoring stations located along this waterbody. The North Ballycannan_010 River Waterbody has been assigned a WFD risk status of 'Not at risk'. The WFD Status (2016 – 2021) of the Blackwater (Clare)_010 River Waterbody is 'Good'. The nearest downstream EPA water quality monitoring station to the proposed development site is located at the 'Bridge southeast of Cappanagh'[21], approximately 4 river kilometres downstream from where the Kilnacreagh Stream rises. The latest river Q value at this location is 'Q4, good', recorded by the EPA in 2006. The Blackwater (Clare)_010 River Waterbody has been assigned a WFD risk status of 'At risk'. A review of the '*Shannon [Lower]_SC_100 Sub-catchment Assessment WFD Cycle 2*' report[22]

[16] EPA River Waterbody Code: IE_SH_25N170970
[17] EPA Transitional Waterbody Code: IE_SH_060_0900
[18] EPA River Waterbody Code: IE_SH_25B060120
[19] EPA Station Code: RS27C090300
[20] Subcatchment Assessment (catchments.ie) Accessed: 9th December 2022
[21] EPA Station Code: RS25B060030
[22] Subcatchment Assessment (catchments.ie) Accessed: 9th December 2022

determined that agriculture has been identified as a pressure on the waterbody. The WFD latest status (2016 – 2021) of the Limerick Dock Transitional Waterbody into which the North Ballycannan Stream drains, is 'Poor'.

The five westernmost proposed turbines overlie 'Tulla-Newmarket-on-Fergus' ground waterbody (GWB)[23] while the rest of the proposed development overlies the Lough Graney ground waterbody[24]. Both are described on the EPA website as 'Poorly productive bedrock' with a Ground Waterbody WFD latest status (201 – 2021) of 'Good'.

4.4.3 Field Surveys Results

4.4.3.1 Habitats

Refer to **Figure 7** and **Figure 8** for a habitat map for the entire proposed development site.

The dominant habitats[25] occurring at the subject site comprise **Conifer plantation (WD4)** and **Improved agricultural grassland (GA1)** (refer to **Plate 1**, below).

Wet grassland (GS4) and **Dry-humid acid grassland (GS3)** habitats occur in the northern section of the site, particularly in upland areas. **Wet grassland (GS4)** also occurs in mosaic with **Improved agricultural grassland (GA1)**, again mainly in the northern half of the site along the upper fringes of farmland, and to a lesser extent with **Scrub (WS1)**. Remnant pockets of **Upland blanket bog (PB2)** in mosaic with **Wet heath (HH3)** occur to the north where deergrass (*Trichophorum caespitosum*), *Cladonia* lichens, and *Sphagnum* mosses were frequently recorded.

Plate 1: The two predominant habitat types at the proposed development site - Conifer plantation (WD4) (left) and Improved agricultural grassland (GA1) (right).

Treelines (WL2) and **Hedgerows (WL1)** forming field boundaries and along existing farm access tracks are distributed throughout the site and consist typically of species such as willow (*Salix* spp.), hawthorn (*Crataegus monogyna)* and bramble (*Rubus fructicosus*). The well-established, species-rich hedgerows in the central, southwest and northeast regions of the study area contain tree species such as ash (*Fraxinus excelsior*), sycamore (*Acer pseudoplatanus*), oak (*Quercus robur*), beech (*Fagus sylvatica*) and hazel (*Corylus avellana*).

Riparian woodland (WN5) occurs along the Cappateemore (East) Stream from the stream's source northwest of the site to the south beyond the confluence with the Crompaun (East) Stream. **Mixed broadleaved woodland (WD1)** occurs throughout the study area either as individual stands or bounding watercourses with scattered patches of **Dense bracken (HD1)** occurring in centrally. Most existing farm tracks are classified as **Spoil and bare**

[23] EPA GWB Code: IE_SH_G_229
[24] EPA GWB Code: IE_SH_G_157
[25] Habitats as categorised by Fossitt (2000), available at [A Guide to Habitats in Ireland - Fossitt.pdf (npws.ie)] Accessed: 9th December 2022

ground (ED2) while farm buildings and yards are classified as **Buildings and artificial surfaces (BL3).** The watercourses draining the study area are classified as **Eroding/upland rivers (FW1)** with details of their physical characteristics outlined in the Aquatic Ecology and Fish Survey Report in **Appendix 6C** in **Volume III** of the **EIAR**.

The substation, access track and grid connection route are located mainly within stands of **Conifer plantation (WD4)** and along existing forestry firebreaks and tracks comprised of **Scrub (WS1)**.

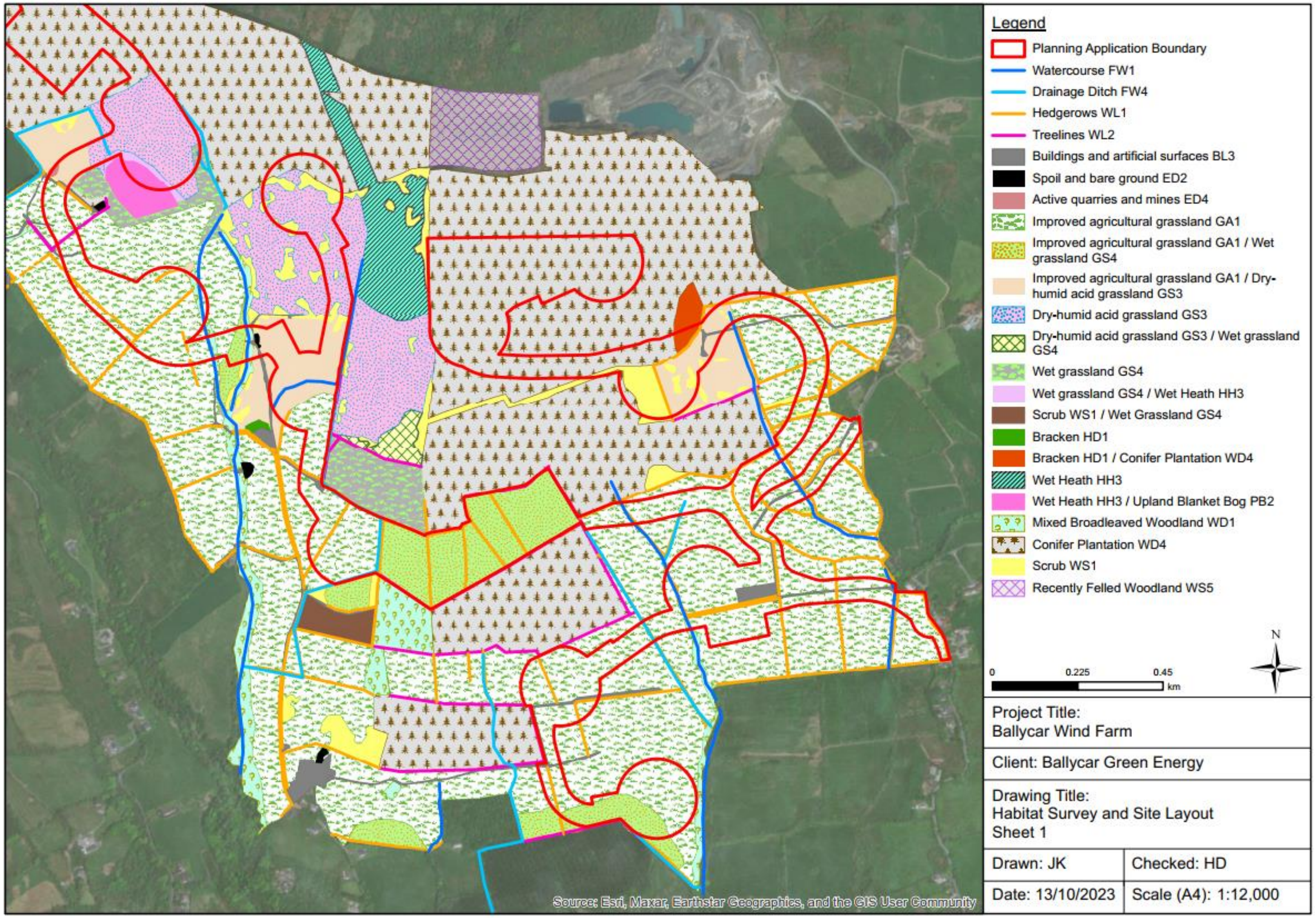

Figure 7: Habitat map of the proposed wind farm site and adjacent areas

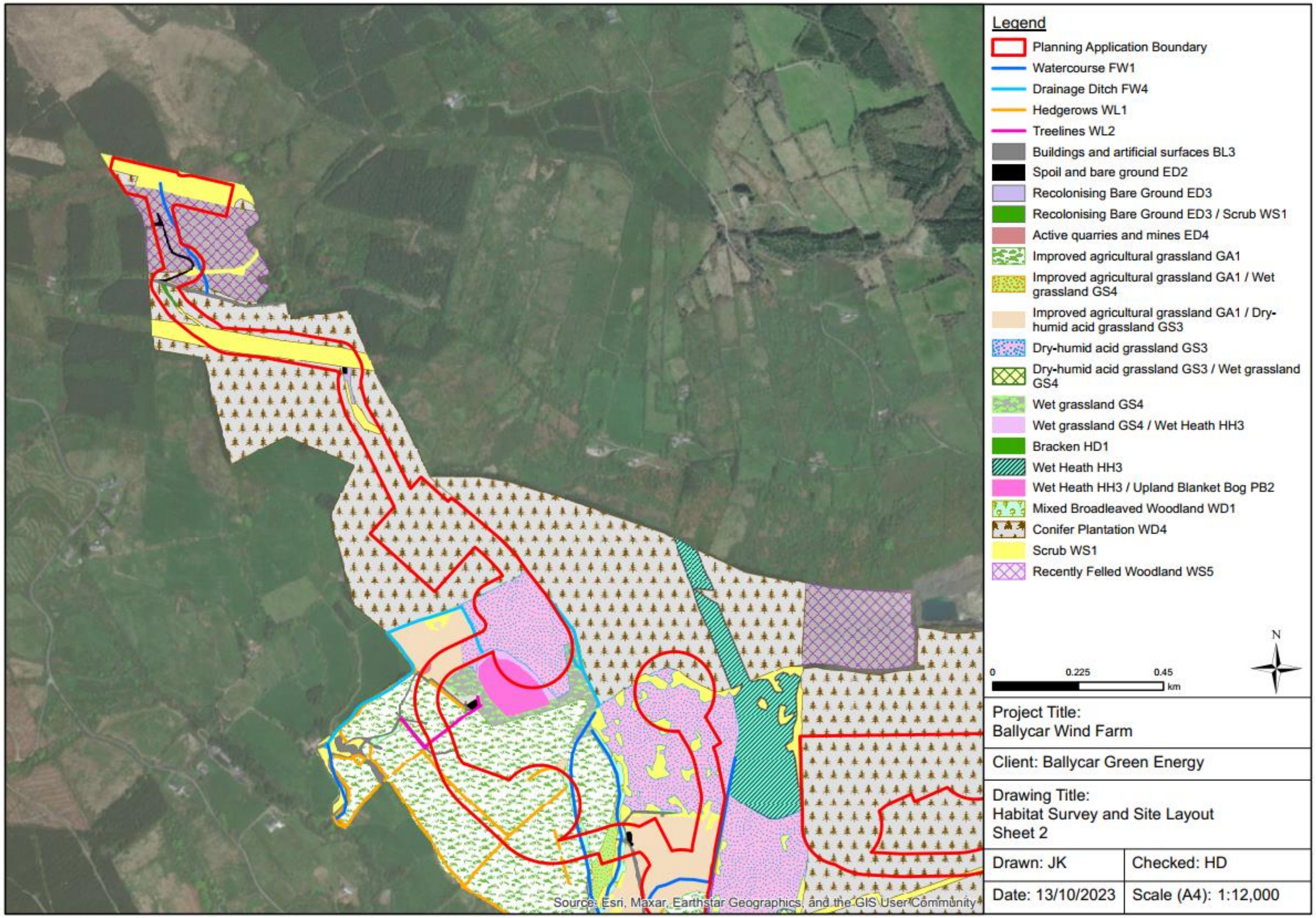

Figure 8: Habitat map for the proposed substation and grid connection cable route locations in northwesternmost corner of the proposed development site.

4.4.3.2 Rare and Protected Flora

No rare or protected flora species were recorded during any of the ecological surveys.

4.4.3.3 Invasive Alien Plant Species (IAPS)

Documented NBDC records of high-impact invasive species listed on the Third Schedule of the European Communities (Birds and Natural Habitats) Regulations 2011 (SI 477 of 2011, as amended) exist within the hectad R56 encompassing the study area for giant hogweed (*Heracleum mantegazzianum)*, Himalayan balsam (*Impatiens glandulifera)* and Japanese knotweed (*Fallopia japonica).* Documented records of medium-impact invasive species listed on the Third Schedule also exist for Himalayan knotweed (*Persicaria wallichii).*

During ecological field surveys carried out between June 2021 and June 2022, two invasive species listed under the Third Schedule of the European Communities Regulations 2011 (S.I. 477 of 2015) were recorded, namely Japanese knotweed and Himalayan balsam. Cherry laurel (*Prunus laurocerasus)* was also recorded within the study area. No other invasive plant species were recorded during ecological surveys.

Extensive infestations of Himalayan balsam were recorded mainly in central and southeastern sections of the site, and at one location along the turbine delivery route. Japanese knotweed was recorded at two locations within the study area; a minor infestation comprising three immature plants growing at the edge of a field to the west, and a single, mature plant recorded in a hedgerow in the southeast. Cherry laurel was recorded at six locations along hedgerows and field boundaries towards the centre and north of the study area.

For more details, refer to the IAPS Report in Appendix 6F of Volume III of the EIAR, and to Chapter 6 Biodiversity, of Volume II of the EIAR.

4.4.3.4 Otter

No evidence of otter was recorded during any of the ecological field surveys nor during the dedicated mammal surveys carried out in June and July 2021 and February 2022. There were no otter breeding/resting places were identified within the study area. Additionally, there are no NBDC documented records of otter within the proposed development site, and although there are NBDC records of otter in the greater area extending away from the site, none of the locations are hydrologically connected to the development site.

There are no suitable fish habitat within the proposed development site and all waterbodies are deemed too small to support any notable fish populations. Although minor watercourses within the subject site may have some potential as foraging or commuting habitat, they are considered to comprise sub-optimal habitat for otter. The watercourses draining the proposed development support fish species such as brown trout and European eel (*Anguilla anguilla*). It is likely that the larger watercourses further downstream are more suitable for foraging, and potentially breeding, otter.

For more details, refer to the Non-Volant Mammal Survey Report in Appendix 6B of Volume III of the EIAR, and to Chapter 6 Biodiversity, of Volume II of the EIAR.

4.4.3.5 Freshwater Aquatic Ecology

Apart from a small section of the UGC that lies within the Blackwater (Clare)_010 sub-basin, the entire proposed development site is located within two sub-basins - Crompaun East_010 and North Ballycannan_010 - that lie adjacent to the upper transitional zone of the Shannon Estuary. The carrying capacity for fish of both sub-basins is limited due to the small drainage areas of the sub-basins in a somewhat coastal context with watercourses classified no larger than 3rd Order. The watercourses within the boundary of the proposed development site, and indeed the upper reaches of all watercourses draining the proposed development site, are high gradient streams that are liable to drying out during prolonged dry spells.

In June 2021, brown trout, European eel and brook lamprey (*Lampetra planeri*) were recorded during the aquatic surveys of relevant watercourses within the Crompaun East_010 and North Ballycannan_010 sub-basins. The higher gradient reaches of these watercourses are considered suitable for the early life stages of salmonids[26], but such reaches do not occur within the proposed development site itself due to the small size of the watercourses. Lower reaches are more suitable for adult fish, with some deeper pools, but these reaches were found to be impacted by siltation and were considered suboptimal for spawning due to their low gradient and/or degraded morphological character (drained). Within the streams surveyed, a small proportion of the fluvial habitat was classified as suitable for salmonid spawning, but many featured some type of impediment to fish movement.

Salmon, brown trout, brook lamprey, three-spined stickleback (*Gasterosteus aculeatus*), stone loach (*Barbatula barbatula*) and minnow (*Phoxinus phoxinus*) were recorded in September 2018 electrical fishing surveys carried out by MWP within the Blackwater (Clare)_010 sub-basin. The Blackwater (Clare) River is deemed suitable for salmon because it is sufficiently large and is connected to the River Shannon with no barriers to species migration.

Overall, within the Crompaun East_010 and North Ballycannan_010 sub-basins, the streams draining the proposed development site are considered sub-optimal trout habitats, poor in terms of lamprey and highly unlikely to support migratory fish populations. The Blackwater Catchment to the north of the proposed development site is judged to be important for salmon and, downstream of its intersection with the Ardnacrusha headrace, the river is possibly also important for lamprey.

The proposed development site is not located within a freshwater pearl mussel (FPM) catchment (*Margaritifera* Sensitive Area) according to NPWS data maps available online[27] and there was no live FPM nor evidence of FPM (e.g. shells) recorded during the surveys carried out on the North Ballycannan River. The sedimentation levels recorded were generally indicative of artificially induced siltation and conditions considered unfavourable in terms of the species' habitat.

For more details, refer to the Aquatic Ecology and Fish Survey Report in **Appendix 6C** of **Volume III** of the **EIAR**, and to **Chapter 6 Biodiversity**, of **Volume II** of the **EIAR**.

4.4.3.6 Ornithology

A comprehensive suite of ornithological field surveys was undertaken at the proposed development site from October 2019 to September 2023, inclusive. These surveys included vantage point surveys, walkover transect surveys, breeding and winter roost surveys for hen harrier, breeding raptor, woodcock and nightjar surveys, hinterland surveys, breeding wader surveys, and wintering waterfowl counts at the Shannon Estuary. Surveys relevant to the SCI species of European sites within the ZOI of the proposed development are discussed in the following sections.

For full details of survey methodologies and results, refer to **Appendices 7B**, **7I** and **7J** in **Volume III** of the **EIAR**, and to **Chapter 7 Ornithology**, in **Volume II** of the **EIAR**.

4.4.3.6.1 Vantage Point Surveys and Transect Surveys Results

Table 2, lists the primary and secondary target species recorded during the vantage point and transect surveys at the proposed wind farm site (species listed on Annex I of the Birds Directive[28] are highlighted in **bold**). Two Special

[26] Salmonids – family (*Salvelinus*) of fishes that include salmon, trout, and chars.
[27] EPA Maps Accessed: 9th November 2022
[28] Annex I lists 194 species and sub-species of birds that are particularly threatened. EU Member States must designate Special Protection Areas (SPAs) for them and all migratory bird species.

Conservation Interest (SCI) species for which the River Shannon and River Fergus Estuaries SPA is designated were recorded during VP surveys at the site, namely black-headed gull and cormorant, and their flightpaths are shown in Figure 9.

Table 2: Primary and secondary target species recorded during VP and transect surveys carried out at the proposed Ballycar Wind Farm site between October 2019 and September 2023, inclusive.

Species	Winter 2019/20	Summer 2020	Winter 2020/21	Summer 2021	Winter 2021/22	Summer 2022	Winter 2022/23	Summer 2023
Black-headed gull (*Chroicocephalus ridibundus*)*			✓		✓		✓	
Buzzard (*Buteo buteo*)	✓	✓	✓	✓	✓	✓	✓	✓
Common gull (*Larus canus*)							✓	
Cormorant (*Phalacrocorax carbo*)*	✓							✓
Great black-backed gull (*Larus marinus*)						✓		
Grey heron (*Ardea cinerea*)					✓	✓		✓
Grey wagtail (*Motacilla cinerea*)			✓			✓		✓
Hen harrier (*Circus cyaneus*)	✓	✓			✓		✓	
Herring gull (*Larus argentatus*)		✓					✓	
Kestrel (*Falco tinnunculus*)	✓	✓	✓	✓	✓	✓	✓	✓
Lesser black-backed gull (*Larus fuscus*)		✓		✓		✓	✓	✓
Little egret (*Egretta garzetta*)		✓						
Mallard (*Anas platyrhynchos*)						✓		✓
Peregrine (*Falco peregrinus*)				✓		✓	✓	✓
Snipe (*Gallinago gallinago*)			✓		✓	✓	✓	✓
Sparrowhawk (*Accipiter nisus*)	✓	✓	✓	✓	✓	✓	✓	✓
Whimbrel (*Numenius phaeopus*)				✓				
Woodcock (*Scolopax rusticola*)	✓		✓					

*Special Conservation Interest (SCI) species for which the River Shannon and River Fergus Estuaries SPA (004077) is designated. The SPA is located 4.4 km southwest of proposal site. Refer to **Section 4.6**, below.

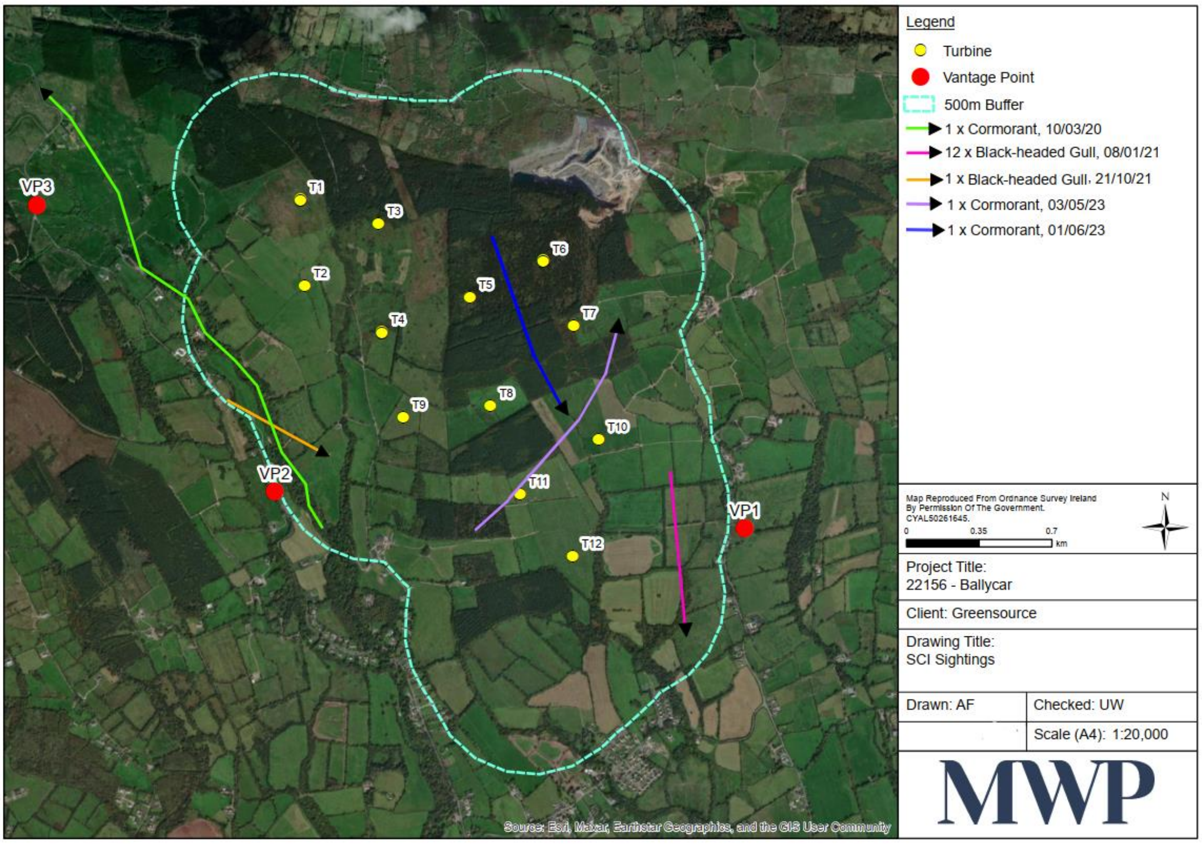

Figure 9: Flightpaths of the SCI species for which the River Shannon and River Fergus Estuaries SPA is designated recorded during VP surveys of the proposed development site.

4.4.3.6.2 Wintering Waterbird Distribution Surveys

The species recorded were typical estuarine species associated with the River Shannon and River Fergus Estuaries SPA and the entire Shannon and Fergus estuarine complex. The winter 2019/20 counts were carried out all along the stretch of Shannon Estuary shown in **Figure 10**, while for the 2022/23 winter counts, the stretch of estuary was divided into four survey areas – A, B, C, and D.

As the winter 2019/20 counts were carried out without the specificity of fixed locations, a peak count for the entire surveyed area per season was obtained. **Table 3**, below, details the collective peak counts for the Special Conservation Interest (SCI) wintering waterfowl species for which the River Shannon and River Fergus Estuaries is designated that were counted in the winter 2019/20 season. Black-headed gull (*Larus ridibundus*) was recorded in moderately large numbers while cormorant (*Phalacrocorax carbo*), teal (*Anas crecca*) and lapwing (*Vanellus vanellus*) were the only other SCI species counted during the 2019/20 winter counts.

Cooperhill Lake is located within Survey Section D shown in **Figure 10**, approximately 6.5 kilometres southwest of the proposed development site on the southern side of the River Shannon where each year, a population of whooper swan return to use as a regular roost. During the 2022/23 counts, a peak flock count of 154 whooper swan (*Cygnus cygnus*) occurred in Section D on 17th January 2023. On the same date, a flock of 14 whooper swan were recorded in Section A at King's Island, approximately 4 kilometres southeast of the proposed development site. Black-headed gull was recorded in large numbers at all four of Sections A, B, C, and D with a peak count of 870 at Section D on the 7th March 2023. All wintering waterfowl Special Conservation Interest (SCI) species for which the River Shannon and River Fergus Estuaries is designated that were counted during wintering waterbird counts are summarised in **Table 3**.

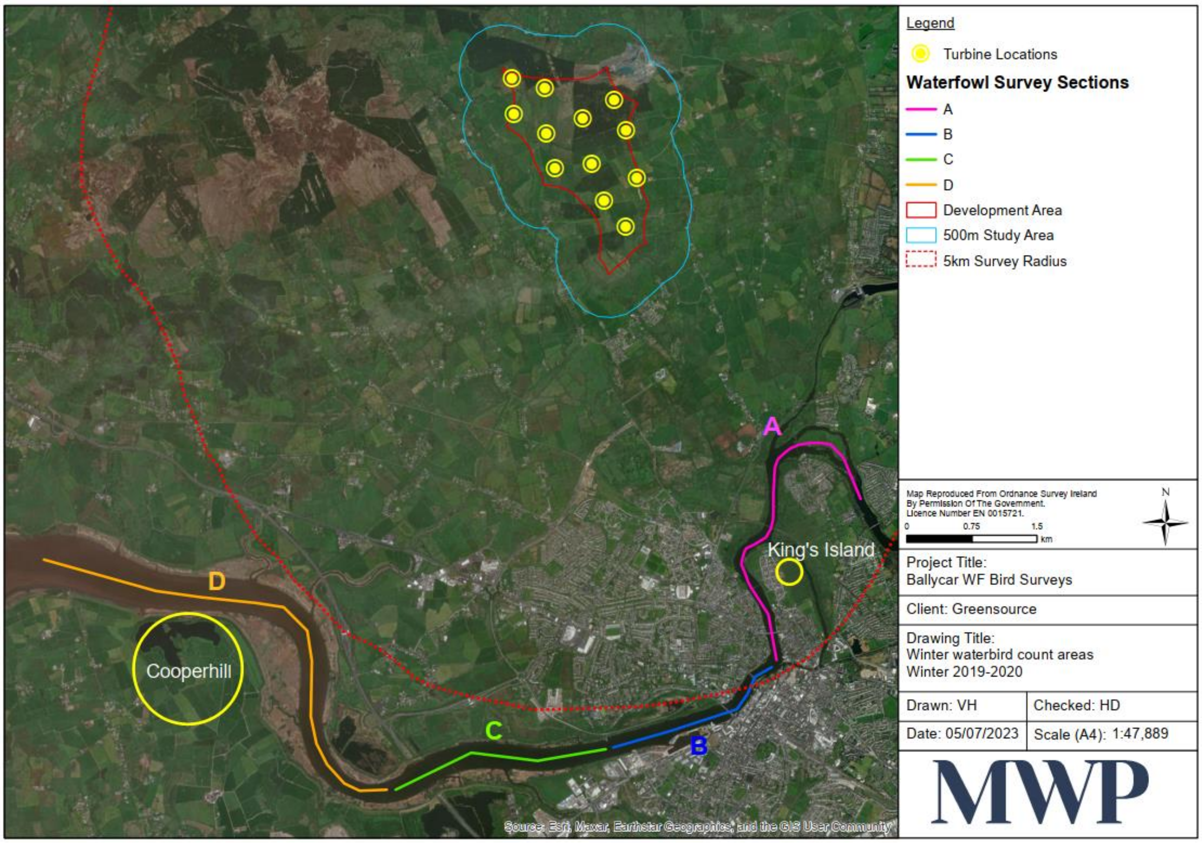

Figure 10: Locations of wintering waterbird counts undertaken at four sections along Shannon Estuary.

Table 3: Peak counts recorded during winter waterbird distribution surveys of Special Conservation Interest (SCI) species for which the River Shannon and River Fergus Estuaries SPA is designated.

SCI Species	Peak Count for Winter 2019/20	Peak Count for Winter 2022/23			
		Section A	Section B	Section C	Section D
Cormorant *Phalocrocorax aristotelis*	4	34	11	406	32
Whooper Swan *Cygnus cygnus*		14			154
Wigeon *Anas penelope*					48
Teal *Anas crecca*	4	10	28	235	52
Pintail *Anas acuta*			1		
Shoveler *Anas clypeata*		6	2		14
Grey Plover *Pluvialis squatarola*			3	3	
Lapwing *Vanellus vanellus*	51	6			27
Dunlin *Calidris alpina*				1	
Curlew *Numenius minimus*				11	1
Redshank *Tringa totanus*		1	1	21	
Black-headed Gull *Larus ridibundus*	242	421	495	357	870

4.4.3.6.3 Breeding Wader Survey Results

Breeding wader surveys were carried out in April, May and June 2023 at suitable areas within the 500-metre buffer study area shown in Figure 9. The only target species recorded during these surveys was one snipe seen in April between T10 and T11 to the southeast of the site as it was flushed from an area of wet grassland.

4.5 Identification of Other Projects or Plans or Activities

4.5.1 Introduction

A review of relevant existing and proposed projects, plans and activities occurring within the wider geographical area around the proposed development site was conducted and the results are presented in the following sections. In-combination impacts will be considered in Section 4.8.7.

4.5.2 Plans

Plans that are relevant to the region encompassing the proposed Ballycar Wind Farm site include the Clare County Development Plan (2023 – 2029). The Clare County Development Plan 2023-2029 was adopted by the Elected Members of Clare County Council at a Special Meeting on 9th March 2023 and came into effect on 20th April 2023.

Within Volume 6 of the County Development Plan (2023 – 2029) is the Clare Wind Energy Strategy which seeks to facilitate 'the development of onshore wind farms in Clare by maximising the wind resources of the county having regard to recent technological advances in turbine design, updated information on wind speeds, proximity and availability to grid connections and to changing energy and grid connection regulations, while minimising any environmental and visual impacts'[29].

4.5.3 Other Wind Energy Developments

There are just two operational wind turbines located within 25 kilometres of the proposed development site - a single turbine at Parteen, and a single turbine at Castletroy. There are, however, several other larger wind farm developments within the area that are either granted and not yet constructed (such as the 19-turbine Carrownagowan Wind Farm) or are in the planning system awaiting decision (such as the 11-turbine Oatfield Wind Farm) – refer to Table 4.

Table 4: Statuses of wind energy developments within 25 kilometres of proposed Ballycar Wind Farm

Wind Farm Name	Status	No. of turbines	Approximate distance and direction from proposed Ballycar development site
Limerick Blow Moulding, Parteen	Operational	1	3.2 km southeast of proposal site
Oatfield[30]	Decision pending, due 24/06/24	11	4.2 km north of proposal site
Knockshanvo[31]	Submitted: 30/08/24 Decision due 14/03/25	9	5.2 km north of proposal site
Vistakon	Operational	1	8.2 km southeast of proposal site

[29] Volume 5 Clare Renewable Energy Strategy-Clare County Development Plan 2023-2029 (Interim) (clarecoco.ie) Accessed 26th June 2023
[30] An Bord Pleanála (ABP) Planning Application Number: 318782
[31] ABP Planning Application Number: 315797

Wind Farm Name	Status	No. of turbines	Approximate distance and direction from proposed Ballycar development site
Fahy Beg[32]	Refused: 03/05/23 Appealed lodged: 31/05/23 ABP granted: 06/03/24	8	8.5 km northeast of proposal site
Carrownagowan	Permitted (not constructed)	19	13 km northeast of proposal site
Castlewaller	Granted: 18/04/12[33] Extension granted: 05/07/16[34] Permission expired: 22/05/22	16	20 km east of proposal site

[32] Clare County Council (CCC) Planning Application Number: 23148; ABP Planning Application Number: 317227
[33] Tipperary County Council (TCC) Planning Application Number: 11510251
[34] TCC Planning Application Number: 16600472

MWP

4.5.4 Solar Energy Developments

Within a 25-kilometre radius of the proposed development site there are several granted and on-going planning applications for solar farm developments as detailed in **Table 5**. A search of Clare County Council's online planning enquiry system for granted or on-going planning solar energy developments within a 25-kilometre radius of the proposed development site was undertaken on 8th December 2023.

Table 5: List of granted and/or on-going planning applications for solar energy developments within 25 kilometres of the proposed development site.

Planning application number	Solar Farm location	Status	Decision date	Approximate distance and direction from proposed development site
2360249	Castlebank, Drummin, Glenlon North, Glenlon South and Ballykeelaun, Co Clare	Permitted	06/09/23	2 km east of proposal site
CCC: 2357 ABP: 316237	Castlebank, Glenlon North, Glenlon South, Drummin and Ballykeelaun, Clare.	Permitted: 03/04/23 Appealed: 14/04/23 Application withdrawn: 10/07/23	-	1.5 km east of proposal site
CCC: 22591 ABP: 316043	Ballyglass, Coolderry, Dromintobin North, Reanabrone and Oakfield, Ardnacrusha, Co Clare.	Permitted: 17/02/23 Appealed: 14/03/23 Permitted with revised conditions	21/11/23	4.4 km northeast of proposal site
18215	Islandduane, Mungret, Co. Limerick.	Permitted	03/10/18	10.8 km southwest of proposal site
18585	Clonloghan, Caherteige, Co. Clare.	Permitted	23/08/19	14.5 km west of proposal site
22586	Ballyvonnavaum, Coolshamroge, Cloonmore, Deerpark, Manusmore, Ennis, Co Clare.	Permitted	14/04/23	18 km northwest of proposal site
20562	Manusmore, Clarecastle, Co Clare.	Permitted	12/11/20	18 km northwest of proposal site
21915	Manusmore & Carrownanelly, Clarecastle, Ennis.	Permitted	30/11/21	20 km northwest of proposal site
19180	Cahershaughnessy near Spancil Hill, Co Clare.	Permitted	17/08/19	22 km northwest of proposal site
19194	Knockanoura and Cranagher, Spancil Hill, Co. Clare.	Permitted	19/08/19	22 km northwest of the proposal site
171001	Lissan West, Ballaghafaddy West, Clarecastle, Clare.	Permitted	06/02/19	22 km northwest of proposal site
17750	Tuogh, Cappamore, Co. Limerick.	Permitted	07/12/17	24 km southeast of proposal site

4.5.5 Other Permitted and Proposed Developments in the Locality

A search of Clare County Council's online planning enquiry system for granted or ongoing planning applications for the townlands Glennagross, Cappateemore East, Ballycannan West, Ballycannan East, Ballycar South, and Ballycar North was undertaken on 8th December 2023, the results of which are presented in **Table 6**.

Table 6: Granted and/or ongoing planning applications within the vicinity of the proposed development.

Application No.	Applicant	Location	Proposed Development	Decision	Decision Date
23461	Edward Ryan	Ballycar, Ardnacrusha	To retain an agricultural structure and all associated site works.	Further information request: 19/10/23	Pending
23229	Ciaran O'Connell	Ballycar South, Ardnacrusha	Construct a cubicle house extension with slatted tank, cattle shed with slatted tank, dungstead, and ancillary works.	Further information request: 08/06/23	Due: 12/01/24
2313	Mark Manning	Glennagross, Meelick, Clare	Construct dwelling house, bored well, waste water treatment system, percolation area, entrance and all associated site works.	Conditional	25/05/23
22886	Bobby O'Connell	Ballycar South, Ardnacrusha	Renovation, alterations and extension of existing disused dwelling, upgrading of existing entrance, change of use from residential to office use, all ancillary works.	Conditional	15/03/23
21935	O'Connell Quarry	Ballycar South, Ardnacrusha	Proposed concrete batching plant, storage shed, precast concrete yard, product storage area, office/canteen, dispatch office, new site entrance, all ancillary works.	Further information request: 28/10/21	Withdrawn: 06/05/22
21454	Kieran O'Connell	Ballycar North, Sixmilebridge	Two story extension with habitable space, open shed and balcony to west, boot room to south, addition of two windows to east elevation, replacement of two windows at front with one picture window on west elevation with double doors, and replacement of two windows on south elevation with one window.	Conditional	10/08/21
CCC: 18818 ABP: 304690	Bobby O'Connell and Sons Ltd	Ballycar, Ardnacrusha	Quarrying area of 10 hectares located adjacent to existing working quarry including extraction of rock by blasting to 150m OD; Extracted rock will be processed at existing working quarry; Landscaping of quarry during operational phase and restoration of quarry on completion of extraction; All associated ancillary facilities/works.	Conditional	13/12/19
19728	Jack & Siobhán Keane	Cappateemore East, Meelick	Retain existing sunroom, all existing elevations; conversion of garage to storage room and ancillary site works.	Conditional	25/11/19
1929	Lisa Hurley	Cappateemore West, Meelick	Rebuild and extend existing burned down dwelling house and replace existing septic tank with new wastewater treatment system and percolation area along with ancillary site works.	Conditional	25/08/19

4.5.6 EPA Licenced/Registered Facilities

A review of the EPA mapping tool determined that there are no IPPC, IPC or IEL[35] facilities within the immediate vicinity of the subject site. Stabright Limited[36] (IEL Registered Licence No. P0356-01) is located at Clondrina, Ennis Road, Limerick, approximately 4.5 kilometres southwest of the proposed wind farm.

Other EPA licenced facilities comprise Ballycannon[37] sewerage treatment works (<500 p.e.[38]) is located at Meelick, approximately 0.9 kilometres south of the proposed wind farm site. This treatment works has a plant design capacity of 279 with an agglomeration p.e. of 188. This facility discharges treated effluent to the North Ballycannon_010 WFD River Waterbody which drains to the River Shannon.

Extending southwards towards the Shannon, a licenced landfill site (identified as Longpavement Landfill[39] is situated at Monabraher, Longpavement approximately 2.9 kilometres southeast of the proposed wind farm.

4.5.7 Existing Land-use and On-going Activities

Lands within the proposed development site and within the surrounding areas are managed for agricultural purposes under varying levels of farming practice intensity with areas of conifer plantation interspersed throughout.

Commercial quarrying takes place in the immediate environs of the subject site. O'Connell Quarries (Register No. QS0797) is located approximately 0.32 kilometres north of the proposed development site's northeast corner. This operational quarry extracts and processes rock and produces ready-mix concrete and has an existing working area of 16.9 hectares with planning approval for an extension of 10 hectares (Planning Ref No. 18818) (refer to Table 6), and an existing concrete batching plant.

The Ardnacrusha hydroelectric power plant is operational and is located approximately 2.3 kilometres southeast of the proposed permanent wind farm entrance. A regulating weir at Parteen controls the flow of water to the power plant using a sluice barrage and diverts the normal flow of the River Shannon into the 12-kilometre long headrace canal and on to the 30 metre high dam at Ardnacrusha Power Station[40].

Residential properties and farms are scattered throughout the surrounding area.

4.5.8 Potential for Significant In-combination Effects

It is considered that agriculture, forestry, on-going (and future) quarrying operations, and to a lesser extent, one-off rural residential developments comprise the land-use and activities which could potentially interact synergistically with the proposed development and result in significant cumulative/in-combination effects.

The potential in-combination effects are discussed further in Section 4.8.7.

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[35] Integrated Pollution Control (IPC) Licence (formerly IPPC Licence), and Industrial Emissions Licence (IEL)
[36] According to EPA mapping database, this facility is currently 'in voluntary liquidation'
[37] Ballycannon Reg Number: A0081-01
[38] Defined using population equivalent value (p.e.)
[39] EPA Waste License Number: W0076-01
[40] Preliminary Synopsis of the WFD Surveillance Monitoring Fish Stock Survey on Lough Lene in the Western River Basin District, August 2010 (wfdfish.ie) Accessed: 11th January 2023

4.6 Identification of European Sites

4.6.1 Zone of Impact Influence and Selection of European Sites

As discussed in Section 3.4, above, the ZOI for the proposed development is the geographical area over which there is potential for the Qualifying interests (QI) of a European site may be affected by biophysical changes arising from the construction and/or operation and/or decommissioning of the proposed wind farm. To establish which European sites are located within the ZOI, the Source-Pathway-Receptor (SPR) model is applied during the screening stage of AA, since according to the Office of the Planning Regulator guidelines (OPR, 2021), 'a European site will only be at risk from likely significant effects where the Source-Pathway-Receptor link exists between the proposed development and the European site'.

The SPR model firstly considers the nature, size and location of the proposed development and then identifies characteristics that may provide a source of direct (e.g. water, noise, habitat loss) or indirect (e.g. collision risk, impact to the prey species of a QI) ecological impacts. Secondly, any pathways (e.g. watercourses) that exist linking the proposed development site to the European site(s) are identified, before, finally, establishing 'the location, nature and sensitivities of the qualifying species and habitats, the ecological conditions underpinning their survival and the conservation objectives specified to maintain or restore favourable conservation status' (OPR, 2021).

Following this, and in view of best scientific knowledge, an assessment is made to ascertain whether the proposed development, individually or in combination with other plans/projects, is likely to have a significant effect on a European site(s) in view of its conservation objectives. If there are any significant, potentially significant, or uncertain effects, it will be necessary to proceed to Appropriate Assessment and submit an NIS.

With regards the proposed Ballycar development and identification of potentially affected European sites, adoption of the SPR risk assessment principle and use of the precautionary approach, has led to the inclusion of all European sites within a 15-kilometre radius of the proposal site, details of which are included in Table 7 and Figure 11.

Table 7: European sites within a 15-kilometre radius of the proposed development site at Ballycar.

Designated site	Site code	Approximate distance of designated site from nearest point of subject site	Hydrological/ Ecological connection?
Lower River Shannon SAC	002165	1km southeast of proposed development (46m approx. from temporary works at junction of R464 and L3056)	Yes (1.6 rkm downstream from WC6 and WC7[41])
River Shannon and River Fergus Estuaries SPA	004077	4.4km southwest of proposed development (3.1km from temporary works at junction of R464 and L3056)	Yes (6.6 rkm downstream from WC1)
Glenomra Wood SAC	001013	5.8km northeast of proposed development	No
Danes Hole, Poulnalecka SAC	000030	6.1km north of proposed development	No
Ratty River Cave SAC	002316	6.4km northwest of proposed development	No
Kilkishen House SAC	002319	8.7km northwest of proposed development	No
Slieve Bernagh Bog SAC	002312	10.7km north of proposed development	No
Lough Gash Turlough SAC	000051	14.4km northwest of proposed development	No

[41] WCX – Watercourse Crossing No. X - Refer to Figure 6.

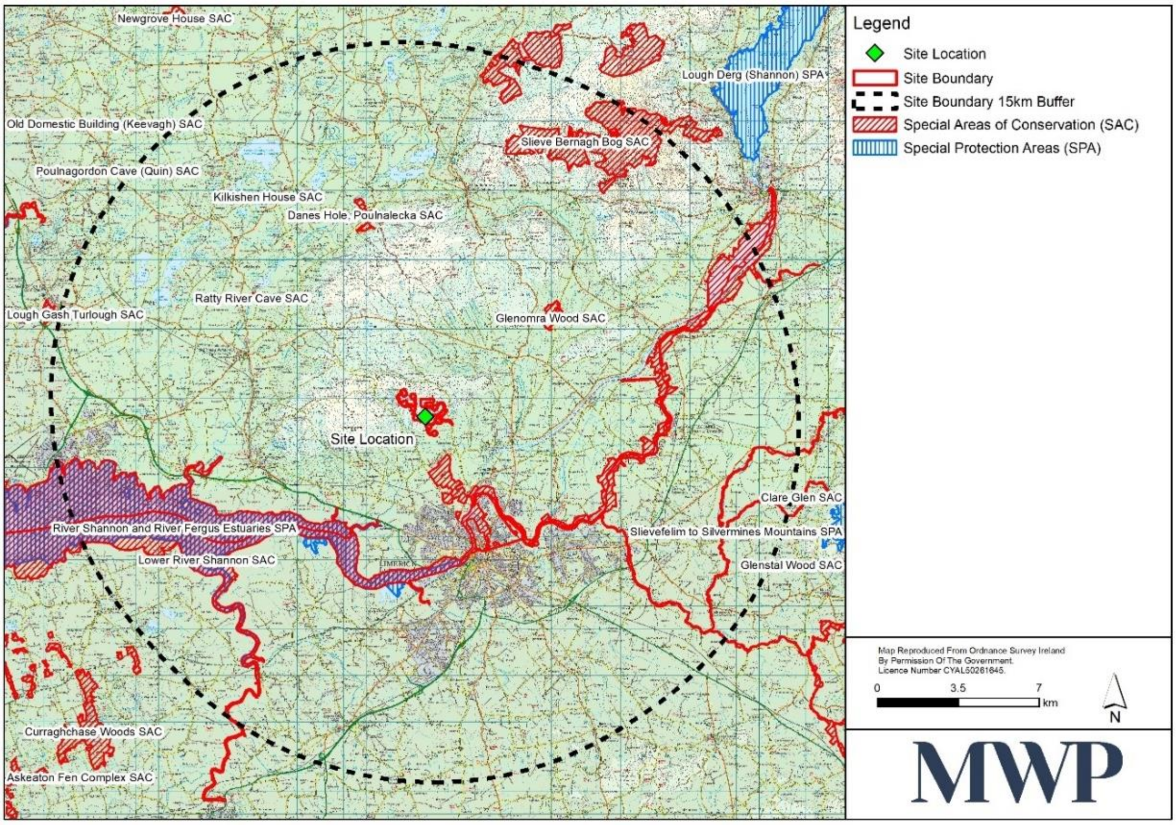

Figure 11: European sites located within 15 kilometres of the proposed development site at Ballycar.

4.6.2 Characteristics of European Sites

The following table lists the qualifying features of conservation interest for the European sites identified in the previous table. Information pertaining to the European sites is from the site synopses, conservation objectives and other information available on [Protected Sites in Ireland | National Parks & Wildlife Service (npws.ie)](npws.ie).

Table 8: European sites located within 15 km of the proposed development and their associated qualifying interests (QI) or special conservation interest (SCI) species.

Designated Site and code	Qualifying features of conservation interest[42]
Lower River Shannon SAC (002165)	▪ Sandbanks which are slightly covered by sea water all the time [1110] ▪ Estuaries [1130] ▪ Mudflats and sandflats not covered by seawater at low tide [1140] ▪ Coastal lagoons [1150] ▪ Large shallow inlets and bays [1160] ▪ Reefs [1170] ▪ Perennial vegetation of stony banks [1220] ▪ Vegetated sea cliffs of the Atlantic and Baltic coasts [1230] ▪ *Salicornia* and other annuals colonising mud and sand [1310] ▪ Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) [1330] ▪ Mediterranean salt meadows (*Juncetalia maritimi*) [1410] ▪ Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation [3260]

[42] Asterisk (*) denotes a priority habitat considered to be in danger of disappearance.

Designated Site and code	Qualifying features of conservation interest[42]
	▪ *Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*) [6410] ▪ Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*) [91E0] ▪ Freshwater Pearl Mussel (*Margaritifera margaritifera*) [1029] ▪ Sea Lamprey (*Petromyzon marinus*) [1095] ▪ Brook Lamprey (*Lampetra planeri*) [1096] ▪ River Lamprey (*Lampetra fluviatilis*) [1099] ▪ Atlantic Salmon (*Salmo salar*) [1106] QI status applies only to freshwater phases of lifecycle. ▪ Common Bottlenose Dolphin (*Tursiops truncatus*) [1349] ▪ Otter (*Lutra lutra*) [1355]
River Shannon and River Fergus Estuaries SPA (004077)	▪ Cormorant (*Phalacrocorax carbo*) [A017] Wintering and breeding ▪ Whooper Swan (*Cygnus cygnus*) [A038] Wintering ▪ Light-bellied Brent Goose (*Branta bernicla hrota*) [A046] Wintering ▪ Shelduck (*Tadorna tadorna*) [A048] Wintering ▪ Wigeon (*Anas penelope*) [A050] Wintering ▪ Teal (*Anas crecca*) [A052] Wintering ▪ Pintail (*Anas acuta*) [A054] Wintering ▪ Shoveler (*Anas clypeata*) [A056] Wintering ▪ Scaup (*Aythya marila*) [A062] Wintering ▪ Ringed Plover (*Charadrius hiaticula*) [A137] Wintering ▪ Golden Plover (*Pluvialis apricaria*) [A140] Wintering ▪ Grey Plover (*Pluvialis squatarola*) [A141] Wintering ▪ Lapwing (*Vanellus vanellus*) [A142] Wintering ▪ Knot (*Calidris canutus*) [A143] Wintering ▪ Dunlin (*Calidris alpina*) [A149] Wintering ▪ Black-tailed Godwit (*Limosa limosa*) [A156] Wintering ▪ Bar-tailed Godwit (*Limosa lapponica*) [A157] Wintering ▪ Curlew (*Numenius arquata*) [A160] Wintering ▪ Redshank (*Tringa totanus*) [A162] Wintering ▪ Greenshank (*Tringa nebularia*) [A164] Wintering ▪ Black-headed Gull (*Chroicocephalus ridibundus*) [A179] Wintering ▪ Wetland and Waterbirds [A999]
Glenomra Wood SAC (001013)	▪ Old sessile oak woods with *Ilex* and *Blechnum* in the British Isles [91A0]
Danes Hole, Poulnalecka SAC (000030)	▪ Caves not open to the public [8310] ▪ Old sessile oak woods with *Ilex* and *Blechnum* in the British Isles [91A0] ▪ Lesser Horseshoe Bat (*Rhinolophus hipposideros*) [1303]
Ratty River Cave SAC (002316)	▪ Caves not open to the public [8310] ▪ Lesser Horseshoe Bat (*Rhinolophus hipposideros*) [1303]
Kilkishen House SAC (002319)	▪ Lesser Horseshoe Bat (*Rhinolophus hipposideros*) [1303]
Slieve Bernagh Bog SAC (002312)	▪ Northern Atlantic wet heaths with *Erica tetralix* [4010] ▪ European dry heaths [4030] ▪ Blanket bogs (* if active bog) [7130]
Lough Gash Turlough SAC (000051)	▪ Turloughs* [3180] ▪ Rivers with muddy banks with *Chenopodion rubri* p.p. and *Bidention* p.p. vegetation [3270]

4.6.3 Conservation Objectives

According to the Habitats Directive, the *conservation status of a natural habitat* will be taken as 'favourable' within its biogeographic range when:

- its natural range and the areas covered within that range are stable or increasing, and
- the specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future, and
- the conservation status of its typical species is favourable as defined below.

According to the Habitats Directive, the *conservation status of a species* means the sum of the influences acting on the species concerned that may affect the long-term distribution and abundance of its populations. The conservation status will be taken as 'favourable' within its biogeographical range when:

- population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, and
- the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future, and
- there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis.

The conservation objectives for each European site listed in **Table 8**, above, were accessed online on the 19th July 2023. Management plans are not currently available for any of the designated sites.

Site-specific conservation objectives were available for the following sites:

- Lower River Shannon SAC (002165). Version 1.0. Produced August 2012.
- River Shannon and River Fergus Estuaries SPA (004077). Version 1.0. Produced September 2012.
- Glenomra Wood SAC (001013). Version 1.0. Produced June 2018.
- Danes Hole, Poulnalecka SAC (000030). Version 1.0. Produced July 2018.
- Ratty River SAC (002316). Version 1.0. Produced July 2018.
- Kilkishen House SAC (002319). Version 1.0. Produced July 2018.
- Slieve Bernagh Bog SAC (002312). Version 1.0. Produced August 2016.
- Lough Gash Turlough SAC (000051). Version 1.0. Produced November 2017.

4.7 Identification of Potential Impacts of the Project

Potential likely direct, indirect or secondary ecological impacts arising from the proposed development (either alone or in combination with other plans or projects) are identified in this section.

Table 9: Identification of the impacts of the proposed wind energy development at Ballycar.

Description of elements of the project likely to give rise to potential ecological impacts sites.	Wind Farm Construction Phase ▪ Excavations, clear felling, ground moving, and heavy engineering required to construct windfarm tracks & hardstands, sub-station, underground cabling, grid connection, temporary works areas, surface water drainage system, permanent met mast, buildings & fencing.

	▪ Machinery: The presence and sustained use of heavy and light plant machinery on site, albeit at variable rates and numbers, during daylight hours for the duration of the works. ▪ Use of fuels/oils/lubricants, concrete and other such substances considered harmful to the aquatic environment. ▪ Human presence: Sustained increase in human activity, albeit at variable rates and numbers, during daylight hours for the duration of the works. ▪ Increased noise and air emissions associated with construction activity. ▪ Erection of turbines. Introduction of large physical structures into a previously unoccupied and uninterrupted air space. ▪ Temporary storage of excavated spoil. ▪ Temporary site compound. ▪ Temporary surface water flow management systems for specific engineering elements as required at various locations. ▪ Localised works along turbine delivery route. Wind Farm Operational Phase ▪ Operation of wind turbines at 12 locations (rotation of turbine blades). ▪ Operation of substation. ▪ Operational maintenance works. ▪ Human presence (wind farm staff and increased vehicular activity). Wind Farm Decommissioning Phase ▪ Decommissioning of wind farm infrastructure including excavation and heavy engineering works, ground moving, use of machinery, temporary storage of spoil, temporary site drainage. ▪ Increased human activity, increased noise and air emissions. ▪ Permanent disassembly and removal of wind farm components including turbines. ▪ Permanent disposal and storage of excavated materials. ▪ Temporary site compound.
Describe any likely direct, indirect or secondary ecological impacts of the project (either alone or in combination with other plans or projects) by virtue of: ▪ *Size and scale* ▪ *Land-take* ▪ *Distance from European Site or key features of the site* ▪ *Resource requirements* ▪ *Emissions* ▪ *Excavation requirements* ▪ *Transportation requirements* ▪ *Duration of construction, operation etc.* ▪ *Other.*	Wind Farm Construction Phase ▪ There is no spatial overlap between the subject site and any European site; therefore, there will be no direct habitat loss/alteration/land-take within any European site. ▪ There will be loss and direct alteration of habitats (comprising mainly mature conifer forestry and agricultural grassland) within the construction footprint. ▪ Potential for direct species disturbance/displacement impacts due to construction activity including fugitive noise emissions from machinery, human activity. ▪ Subject site is hydrologically connected to two European sites - the Lower River Shannon SAC and the River Shannon and River Fergus Estuaries SPA - via watercourses draining the site. ▪ Potential for water quality impacts through the erosion and run-off of silt, and/or ingress of fuels/oils, cementitious material, or other such substances via overland flow and/or the existing/proposed drainage network to local watercourses and the estuarine waters of the River Shannon into which they drain. ▪ Potential for groundwater contamination via spillage of oils/fuels, chemicals.

	- Potential for indirect alteration of habitats located outside the development site but hydrologically linked to it. - Potential for indirect species disturbance/displacement due to *in-situ* or *ex-situ* habitat loss/alteration impacts, impairment of water quality and/or impacts on prey availability. - Potential for spread of invasive species. Wind Farm Operational Phase - Risk of bird mortality through collision or interaction with turbine blades or other infrastructure. - Potential for species disturbance/displacement (indirect habitat loss) due to operation and maintenance of wind turbines and substation. - Potential for species displacement because of 'barrier effects' whereby species are deterred from using normal routes to access breeding, foraging or roosting habitats. For example, behavioural responses to the presence of turbines could cause some species to stop using or reduce their use of foraging grounds in proximity to the turbine envelope. - Potential for water quality impacts through the erosion and run-off of silt, and/or ingress of fuels/oils via overland flow and/or the drainage network to local watercourses and the estuarine waters of the River Shannon into which they drain. - Potential for groundwater contamination through spillage of oils, fuels and chemicals. - Potential for indirect alteration of habitats outside of but hydrologically linked to the development site. - Potential for indirect species disturbance/displacement due to impairment of water quality and/or impacts on prey availability. Wind Farm Decommissioning Phase - Potential for water quality impacts, as above. - Potential for groundwater contamination, as above. - Potential for direct species disturbance/displacement due to fugitive noise emissions associated with disassembly and/or removal of wind farm components and human activity. - Potential for indirect alteration of habitats outside of but hydrologically linked to the development site. - Potential for indirect species disturbance/displacement due to impairment of water quality and/or impacts on prey availability. - Potential for spread of invasive species.

4.8 Assessment of Significance of Potential Impacts

This section considers the list of sites identified in **Table 8**, together with the potential ecological impacts identified in **Table 9**, and determines whether the project is likely to have significant effects on a European site. As discussed in **Section 4.6.1**, when assessing impact, European sites are only considered relevant where a credible or tangible source-pathway-receptor link exists between the proposed development and a protected species or habitat type. For an impact to occur there must be a risk initiated by having a 'source' (e.g. excavation) and an impact pathway between the source and the receptor (e.g. a waterbody which connects the proposal site to the protected species or habitats). An evaluation based on these factors to determine which European sites are the plausible ecological receptors for potential impacts of the proposed development will be conducted in **Sections 4.8.1** and **4.8.2**. The evaluation takes cognisance of the scope, scale, nature and size of the project, its location relative to the European sites listed in **Table 7**, and the degree of connectedness that exists between the project and each European site's potential ecological receptors.

4.8.1 European Sites Outside the Zone of Potential Impact after Application of SPR Model

With regards to the proposal, it is considered that the works do not include any element that has the potential to significantly affect the conservation objectives for which certain European sites are designated. Although located within 15 kilometres of the proposed development site, these European sites are deemed to be outside the zone of potential impact influence of the proposed development due to the absence of plausible impact pathways when the SPR model was applied (see **Section 4.6.1** for details of the model). Therefore, it is objectively concluded that significant effects on the conservation objectives of these sites are not reasonably foreseeable because of the proposed development described at **Section 4.3**. These sites are listed in **Table 10**, along with their approximate distances from the subject site and the rationale for their exclusion, and therefore will not be considered further in this report.

Table 10: European sites excluded from further assessment including rationale for exclusion.

Designated site and code	Approximate distance from proposal site	Rationale for exclusion from further assessment
Glenomra Wood SAC (001013)	5.8 km to the northeast	- Designated for woodland habitat. - No spatial overlap with the proposal site. - No plausible impact pathway linking the proposed development site to SAC
Danes Hole, Poulnalecka SAC (000030)	6.1 km to the north	- Designated for cave, woodland habitat, and lesser horseshoe bat. - No spatial overlap with the proposal site. - Proposal site located outside the maximum foraging range of lesser horseshoe bat (c.6 km) (BCI, 2012). - No plausible impact pathway linking the proposed development site to SAC.
Ratty River Cave SAC (002316)	6.4 km to the northwest	- Designated for caves and lesser horseshoe bat. - No spatial overlap with the proposal site. - Proposal site located outside the maximum foraging range of lesser horseshoe bat (c.6 km) (BCI, 2012). - No plausible impact pathway linking the proposed development site to SAC.
Kilkishen House SAC (002319)	8.7 km to the northwest	- Designated for lesser horseshoe bat. - No spatial overlap with the proposal site. - Proposal site located outside the maximum foraging range of lesser horseshoe bat (c.6 km) (BCI, 2012). - No plausible impact pathway linking the proposed development site to SAC.
Slieve Bernagh Bog SAC (002312)	10.7 km to the north	- Designated for three peatland habitats. - No spatial overlap with the proposal site. - Proposal site is in separate WFD sub-catchment to the SAC[43] with no hydrological connection between the two. - No plausible impact pathway linking the proposed development site to SAC.

[43] Slieve Bernagh Bog SAC (002312) overlaps with the Owenogarney_SC_010, Shannon [Lower]_SC_080, Graney [Shannon]_SC_010 and the Shannon [Lower]_SC_070 WFD Sub-catchments. Available at https://gis.epa.ie/EPAMaps/ Accessed: 28th November 2022

Designated site and code	Approximate distance from proposal site	Rationale for exclusion from further assessment
Lough Gash Turlough SAC (000051)	14.4 km to the west	- Designated for turlough habitat and associated flora. - No spatial overlap with the proposal site. - Proposal site is in separate WFD sub-catchment to the SAC with no hydrological connection between the two. - No plausible impact pathway linking the proposed development site to SAC.

4.8.2 European Sites Within the Zone of Potential Impact after Application of SPR Model

The assessment of significance of potential impacts that follows focuses on the two remaining European sites identified in **Table 11**. When the SPR framework discussed in **Section 4.6.1**, is applied, these sites are deemed to have the potential to be impacted by the proposal described in **Section 4.3**, due to the existence of plausible impact pathways linking the proposed development site (source) to the Qualifying Interest species and habitats (receptors) of the European sites. Therefore, it is objectively concluded that significant effects on the conservation objectives of these two European sites because of the proposed development described at **Section 4.3**, have the potential to occur and cannot be ruled out at this stage. These sites are listed in **Table 11**, along with their approximate distances from the subject site and will be subjected to further assessment in this report.

Table 11: European sites within the likely zone of impact and rationale for inclusion

Designated site and code	Approximate distance from subject site	Rationale for inclusion for assessment
Lower River Shannon SAC (002165)	1 km southeast of T12 1.6 rkm downstream from WC6 and WC7 46m approx. from temporary works at junction of R464 and L3056	- Designated for wide variety of aquatic and terrestrial habitats and species. - No spatial overlap: however, several watercourses draining the proposal site drain to the SAC. - Direct hydrological connection between the proposal site and the SAC, located approximately 1.6 rkm downstream. - Habitats within the proposal site suitable for some QI's. - Potential for significant effects to the SAC. - Further assessment is required.
River Shannon and River Fergus Estuaries SPA (004077)	4.4 km southwest of subject site 6.6 rkm downstream from WC1 3.1km from temporary works at junction of R464 and L3056	- Designated for wide variety of predominantly wintering waterfowl species, and wetlands. - No spatial overlap: however, several watercourses draining the proposal site drain to the SPA. - Direct hydrological connection between the proposal site and the SPA, located approximately 6.6 km downstream. - Foraging and roosting habitats such as agricultural grassland, wet grassland and bog within proposal site suitable for some SCI's. - Potential for significant effects to the SPA. - Further assessment is required.

The likelihood of significant effects from the project to the European sites outlined above was determined based on several indicators including:

- Water quality;

- Habitat loss/alteration;
- Habitat or species fragmentation; and
- Disturbance and/or displacement of species.

The likelihood of significant in-combination effects is assessed in Section 4.8.7.

4.8.3 Water Quality

The topography of the proposed wind farm site undulates, and elevations range from 60 to 262 metres AOD with the terrain gently sloping south-eastwards to Ardnacrusha. As described in Section 4.4.2, watercourses leaving the proposed development site all eventually drain into the River Shannon and the Lower River Shannon SAC and subsequently into the River Shannon and River Fergus SPA located slightly further downstream. Therefore, via overland and existing drain pathways, there is potential for a hydrological link between the proposed wind farm site and two European sites located downstream. Temporary local road widening works are proposed at the junction of R464 and L3056 approximately 46m from the SAC.

As detailed in Table 8, the Lower River Shannon SAC is designated for a variety of marine and freshwater aquatic habitats and species, and the River Shannon and River Fergus Estuaries SPA is designated for a variety of water-dependant bird species and wetland habitat.

During a wind farm's construction phase, and in the absence of any pollution prevention controls, earthworks have the potential to adversely impact water quality due to soil erosion. The subsequent suspension of soil sediment particles in site run-off and overland flow can eventually reach the natural watercourses draining the site in the absence of implementation of appropriate controls and protective measures. Nutrients such as phosphorous can be bound to soil from past fertilisation of forestry crop and can become transported in overland flow. The presence of felled trees and brash at a site can increase the risk of this phosphorous release to local drains and watercourses. Potential also exists for accidental ingress of fuel and oils, concrete and cementitious material and other such substances considered harmful to the aquatic environment via overland flow, direct discharges to drainage features and/or leaching to groundwater in the event of a spillage/leakage.

Water quality is a key environmental factor underpinning the conservation condition of the complex of aquatic and wetland habitats and species that support the qualifying features for which the Lower River Shannon SAC and the River Shannon and River Fergus Estuaries SPA are classified. There is a hydrological connection between the proposed development site and both European sites via the various watercourses that drain the proposed development area (see Figure 6). Given the pollution risk associated with the construction phase of the works and this hydrological pathway and the proximity of the temporary works proposed, it is considered that potential significant effects on water quality to the Lower River Shannon SAC and the River Shannon and River Fergus Estuaries SPA cannot be ruled out.

The decommissioning phase of the project and, to a lesser extent, the operational phase are also considered to have the potential to result in water quality impacts.

Consequently, in the absence of mitigation, it is objectively concluded that significant water quality effects within the Lower River Shannon SAC and the River Shannon and River Fergus Estuaries SPA arising from the impacts identified in Section 4.7, above, have the potential to occur and further assessment is required.

4.8.4 Habitat Loss and Alteration

There is no spatial overlap between the subject site and any European site; therefore, there will be no direct loss/alteration of any of the qualifying habitats of conservation interest for which the European sites outlined in

Table 8, are designated. Any permanent direct habitat loss arising because of the proposal will be restricted to the proposed development site boundary. However, as detailed in **Section 4.4.2**, the proposed development site is hydrologically connected to both the Lower River Shannon SAC and the River Shannon and River Fergus Estuaries SPA.

The Lower River Shannon SAC site is designated for fourteen Annex I habitat types as listed in **Table 8**. The River Shannon and River Fergus Estuaries SPA is designated for the protection of the habitat and species complex 'Wetlands and waterbirds [A999]' which requires the conservation of wetland habitat within the SPA as a resource for regularly occurring migratory waterbirds. As discussed in **Section 4.8.3**, significant indirect impacts to the water quality of the SAC and SPA have the potential to occur which subsequently creates the potential for an indirect loss and/or alteration of habitats within the SAC and/or the SPA located downstream.

Consequently, in the absence of mitigation, it is objectively concluded that significant loss and/or alteration of habitats within the Lower River Shannon SAC and the River Shannon and River Fergus Estuaries SPA arising from the impacts identified in **Section 4.7**, have the potential to occur and further assessment is required.

4.8.5 Disturbance and/or Displacement of Species

4.8.5.1 Lower River Shannon SAC

The Lower River Shannon SAC is designated for the following QI species:

- Freshwater pearl mussel (*Margaritifera margaritifera*) [1029];
- Sea lamprey (*Petromyzon marinus*) [1095];
- Brook lamprey (*Lampetra planeri*) [1096];
- River lamprey (*Lampetra fluviatilis*) [1099];
- Atlantic salmon (*Salmo salar*) [1106] (QI status pertains only to freshwater phases of life cycle);
- Bottlenose dolphin (*Tursiops truncates*) [1349]; and
- Otter (*Lutra lutra*) [1355].

All these QIs are exclusively aquatic in nature and/or dependant on aquatic habitats (i.e. otter) and require an adequate level of water quality to be maintained within their environments.

The Conservation Objective for the freshwater pearl mussel within the SAC applies only to the population occurring within the Cloon River (NPWS, 2012) which is situated in a different sub-catchment to those of the proposed development site at Ballycar. There is no hydrological connection between the proposal site and the Cloon River and therefore no plausible pathway for impacts to the Cloon River's designated freshwater pearl mussel population can occur.

It has already been concluded in **Section 4.8.3**, above, that because of the proposal and in the absence of water quality protection mitigation measures, there is potential for significant impacts to the water quality of the watercourses draining the proposed development site and the SAC located approximately 1.6 river kilometres downstream (46m approx. from temporary local road widening works).

The Ballycar Aquatic Ecology and Fish Survey Report (see **Appendix 6C** in **Volume III** of the **EIAR**) concluded that the watercourses draining the proposed development site 'are suboptimal trout habitats, poor in terms of lampreys and highly unlikely to support migratory fish populations. The lower reaches of some watercourses draining the proposal site contain some deeper pools that are more suitable for adult fish, however, these are also considered suboptimal for spawning (e.g. salmon) due to siltation, drainage (hydromorphological changes), and their low gradients.

Nevertheless, as a precautionary measure, it is assumed for this assessment that the watercourses draining the proposed development site have the potential, albeit slight, to support areas of habitat considered suitable for lamprey, salmon and otter and which may be constituents of the SAC's QI populations. Therefore, there is potential for indirect disturbance and/or displacement of these species to occur via impairment of water quality and the resulting impacts on prey availability, and/or the indirect alteration of habitats located downstream. Such impacts could affect QIs within watercourses which are outside the SAC, but which have been identified as potential pathways for impacts in **Section 4.8.3**, above, as well as within the SAC boundary located downstream.

Additionally, there is potential for indirect disturbance and/or displacement of otter because of the proposed works due to an increase in noise levels, lighting and human activity, primarily during the construction phase and to a lesser extent during the operational and decommissioning phases.

Consequently, in the absence of mitigation, it is objectively concluded that significant disturbance and/or displacement of QI species within the Lower River Shannon SAC arising from the impacts identified in **Section 4.7**, above, have the potential to occur and further assessment is required.

4.8.5.2 River Shannon and River Fergus Estuaries SPA (004077)

The River Shannon and River Fergus Estuaries SPA is designated for the following SCI species:

- Cormorant (*Phalacrocorax carbo*) [A017];
- Whooper Swan (*Cygnus cygnus*) [A038];
- Light-bellied Brent Goose (*Branta bernicla hrota*) [A046];
- Shelduck (*Tadorna tadorna*) [A048];
- Wigeon (*Anas penelope*) [A050];
- Teal (*Anas crecca*) [A052];
- Pintail (*Anas acuta*) [A054];
- Shoveler (*Anas clypeata*) [A056];
- Scaup (*Aythya marila*) [A062];
- Ringed Plover (*Charadrius hiaticula*) [A137];
- Golden Plover (*Pluvialis apricaria*) [A140];
- Grey Plover (*Pluvialis squatarola*) [A141];
- Lapwing (*Vanellus vanellus*) [A142];
- Knot (*Calidris canutus*) [A143];
- Dunlin (*Calidris alpina*) [A149];
- Black-tailed Godwit (*Limosa limosa*) [A156];
- Bar-tailed Godwit (*Limosa lapponica*) [A157];
- Curlew (*Numenius arquata*) [A160];
- Redshank (*Tringa totanus*) [A162];
- Greenshank (*Tringa nebularia*) [A164]; and
- Black-headed Gull (*Chroicocephalus ridibundus*) [A179].

This SPA site is selected for the resident population of one species, namely cormorant, and the migratory overwintering populations of twenty other SCI species, as listed above (and listed in **Table 8**, above). The SCI species for which the SPA is selected comprise seabirds and wildfowl, both groups that are deemed to be at risk from wind farms (Percival, 2003). As detailed in **Figure 9** and **Table 2**, above, there were two SCI species recorded during the vantage point surveys carried out at the site, namely black-headed gull and cormorant, and each record occurred outside the proposed development boundary.

There are no waterbodies encompassed within the proposed development site in which any of the SCI species for which the SPA is designated could reasonably be expected to occur. Species may fly over the site when moving between suitable habitats within the greater area, however none were recorded within the proposed development's site boundary during bird surveys of the area. A review of the BirdLife report on the potential impacts of wind farms on birds determined that most, if not all, of the SPA's SCI species have the potential to be disturbed and/or displaced from wind farms through collision, habitat loss/damage, or the barrier effect of turbines once operational (BirdLife, 2003).

Indirect ecological impacts potentially arising because of the proposed works include an increase in noise levels/human activity during the construction phase and/or the operational phase and/or decommissioning phase of the proposed development whereby species are disturbed and avoid the area, although it is noted that these aspects of the proposal will be temporary in nature and will be carried out on a phased basis. Further assessment is required to determine whether any potential disturbance/displacement impacts to the SCI species for which the SPA is designated will be significant. Additionally, it has already been concluded in Section 4.8.3, that in the absence of water quality protection mitigation measures, there is potential for significant impacts to the water quality of the watercourses draining the proposed development site and, therefore, to the SPA located approximately 6.6 river kilometres downstream (3.1m approx. from temporary local road widening works). This creates the potential for indirect disturbance and/or displacement of SCI species via impacts to aquatic habitats and/or prey resource.

Consequently, in the absence of mitigation, it is objectively concluded that significant disturbance and/or displacement of SCI species within the River Shannon and River Fergus Estuaries SPA arising from the impacts identified in Section 4.7, have the potential to occur and therefore further assessment will be required.

4.8.6 Habitat or Species Fragmentation

Habitat fragmentation has been defined as 'reduction and isolation of patches of natural environment' (Franklin *et al*., 2002; Morrison *et al*., 2012) which results in spatial separation of habitat areas which had previously been in a state of greater continuity. Adverse effects of habitat fragmentation on species include the increased isolation of populations which can detrimentally impact upon the resilience or robustness of the populations.

The preceding Sections 4.8.3, 4.8.4 and 4.8.5 have concluded that habitat loss and alteration impacts, water quality impacts and disturbance/displacement impacts cannot be ruled out for the Lower River Shannon SAC and the River Shannon and River Fergus Estuaries SPA because of the proposed development. Therefore, significant habitat or species fragmentation on these European sites also cannot be ruled out and further assessment is required.

4.8.7 Cumulative/In-combination Impacts

As set out in the preceding sections, there is potential for the proposed development to cause indirect habitat loss/alteration, water quality impacts, disturbance/displacement of species, and/or habitat/species fragmentation impacts to the QI species and habitats for which two European sites are designated, namely the Lower River Shannon SAC and the River Shannon and River Fergus Estuaries SPA. However, as established in Section 4.6, above, no plausible pathway exists to connect either the Lower River Shannon SAC or the River Shannon and River Fergus Estuaries SPA with the European sites located outside the zone of impact (listed in Table 10, above) and, therefore, the potential for cumulative impacts with other European sites is negligible.

There is, however, the potential that any or all the possible effects to the Lower River Shannon SAC or the River Shannon and River Fergus Estuaries SPA could cause significant cumulative/in-combination impacts with other developments, plans and activities within the area identified in **Section 4.5,** above. Further assessment is required to determine whether significant cumulative/in-combination impacts will ensue from the proposed development.

4.9 Conclusion of Screening Stage

In conclusion, to determine any potential impacts of the proposed project on nearby European sites, a screening process for Appropriate Assessment was undertaken. The permitted development site is located within 15 kilometres of eight European sites.

It has been objectively concluded during this screening process that the proposed construction, operation and eventual decommissioning of a 12-turbine wind farm at Ballycar in County Clare, either individually or in combination with other plans or projects, is not likely to have significant effects on the following six European sites located within 15 kilometres of the proposed development in view of those sites' Conservation Objectives, and further assessment is deemed unnecessary:

- Glenomra Wood SAC (001013);
- Danes Hole, Poulnalecka SAC (000030);
- Ratty River Cave SAC (002316);
- Kilkishen House SAC (002319);
- Slieve Bernagh Bog SAC (002312); and
- Lough Gash Turlough SAC (000051).

It cannot be objectively concluded at this stage that the proposed development at Ballycar in County Clare will not result in significant effects on the following designated European sites due to the impacts identified in **Sections 4.8.3** to **4.8.7**, above:

- Lower River Shannon SAC (002165); and
- River Shannon and River Fergus Estuaries SPA (004077).

Therefore, it has been concluded that, in respect of these European sites, the project should proceed to Stage 2 of the Appropriate Assessment process and as such, a Natura Impact Statement is required. It is concluded that all other European sites have been correctly screened out or excluded from further consideration based on objective information that the project, individually or in-combination with other plans or projects, will have no, or no appreciable, effects on those sites.

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Appendix A

Stages of Appropriate Assessment

Stage 1 - Screening

This is the first stage of the Appropriate Assessment process and is undertaken to determine the likelihood of significant direct and indirect effects on European Sites, in light of their conservation objectives, because of a proposed project or plan, individually or in-combination with other plans or projects. It determines the need for a full Appropriate Assessment.

If it can be concluded that no significant direct and indirect effects to European Sites are likely, in light of their conservation objectives, either individually or in-combination with other plans or projects, then the assessment can stop here. If not, it must proceed to Stage 2 for a more detailed assessment.

Stage 2 - Natura Impact Statement (NIS)

The second stage of the Appropriate Assessment process assesses the impact of the proposal (either alone or in combination with other projects or plans) on the integrity of the European site(s) with respect to the conservation objectives of the site(s) and its ecological structure and function. This is a much more detailed assessment that Stage 1. A Natura Impact Statement is required to contain a professional scientific examination of the proposal and include any mitigation measures deemed necessary to avoid, reduce or offset negative impacts.

If the outcome of Stage 2 is negative i.e. adverse impacts to the site(s) cannot be scientifically ruled out despite mitigation, the plan or project should proceed to Stage 3 or be abandoned.

Stage 3 - Assessment of alternative solutions

A detailed assessment must be undertaken to determine whether alternative ways of achieving the objective of the project/plan exists.

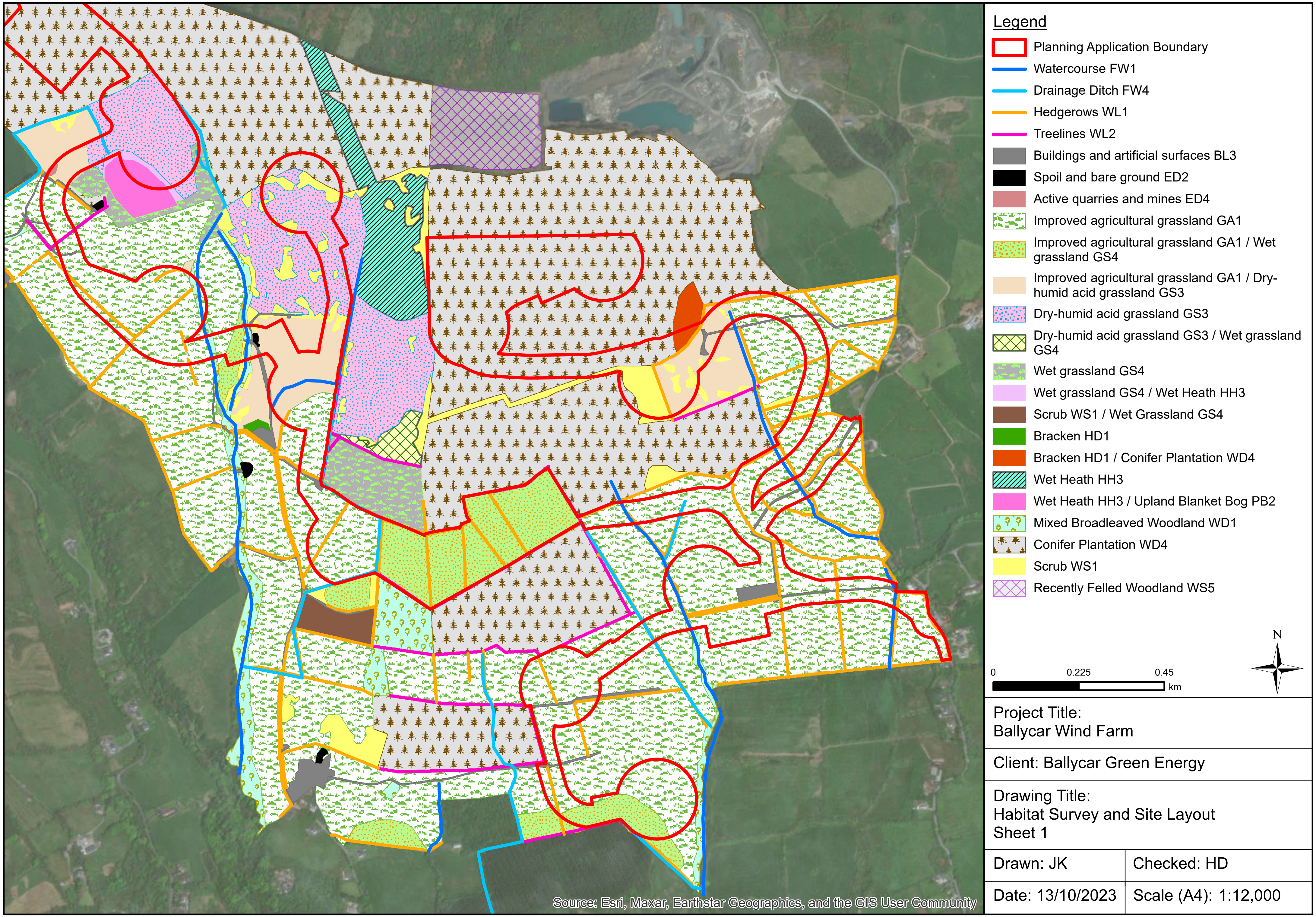
Where no alternatives exist, the project/plan must proceed to Stage 4.

Stage 4 - Assessment where no alternative solutions exist and where adverse impacts remain

The final stage is the main derogation process examining whether there are imperative reasons of overriding public interest (IROPI) for allowing a plan or project to adversely affect a European Site where no less damaging solution exists.

Appendix 2

Habitat Map

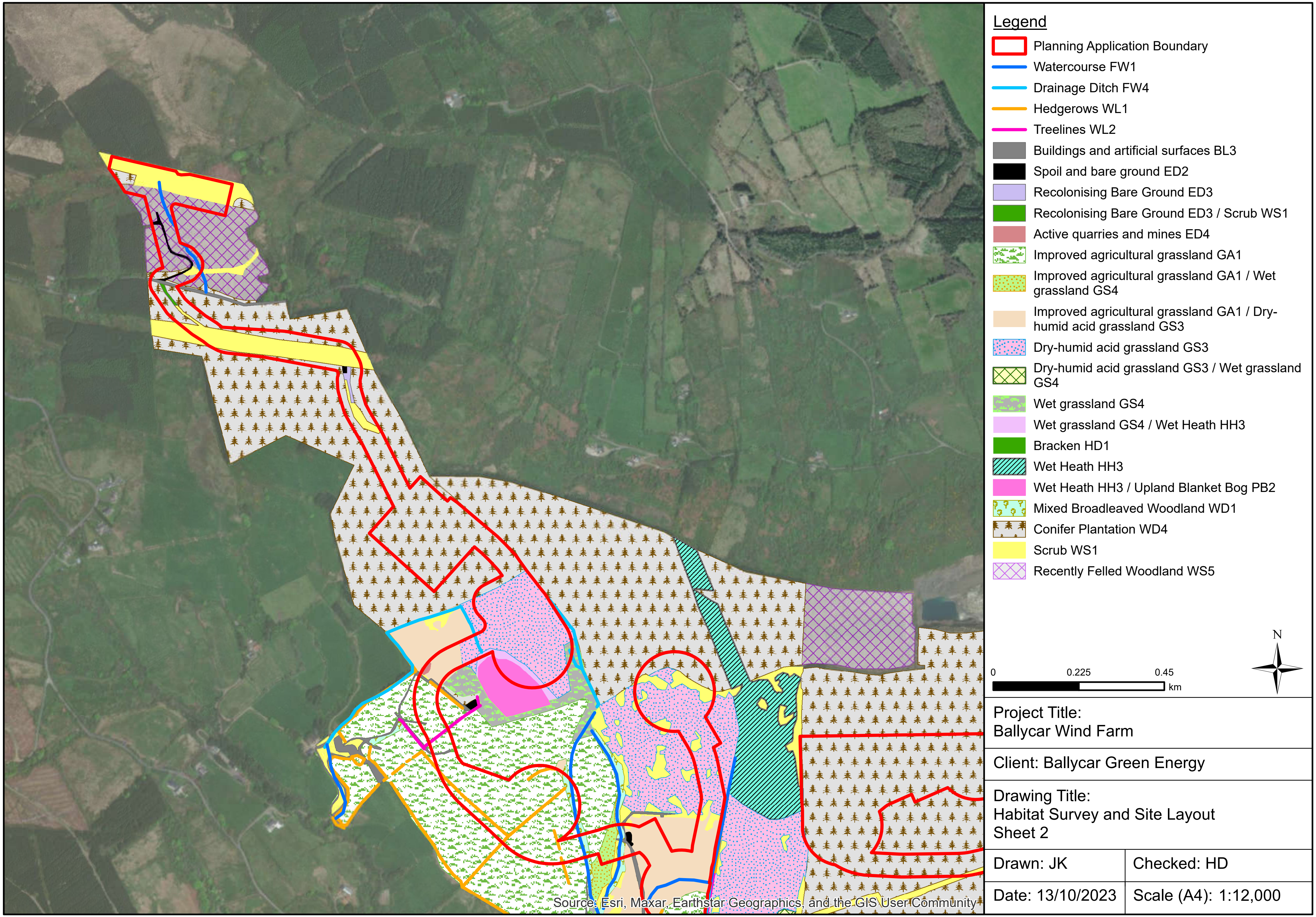


Project Title:
Ballycar Wind Farm

Client: Ballycar Green Energy

Drawing Title:
Habitat Survey and Site Layout
Sheet 1

Drawn: JK	Checked: HD
Date: 13/10/2023	Scale (A4): 1:12,000



Project Title:
Ballycar Wind Farm

Client: Ballycar Green Energy

Drawing Title:
Habitat Survey and Site Layout
Sheet 2

Drawn: JK	Checked: HD
Date: 13/10/2023	Scale (A4): 1:12,000