Ørsted

Oatfield Wind Farm

Appendix 8.1
Collision Risk Modelling

November 2023

This report considers the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

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Quality Assurance

The findings outlined within this report and the data we have provided are to our knowledge true and express our bona fide professional opinions. This report has been prepared and provided in accordance with the Chartered Institute of Ecology and Environmental Management (CIEEM) Code of Professional Conduct. Where pertinent CIEEM Guidelines used in the preparation of this report include the *Guidelines for Ecological Report Writing* (CIEEM, 2017a), *Guidelines for Preliminary Ecological Appraisals* (CIEEM, 2017b) and *Guidelines for Ecological Impact Assessment in the UK and Ireland. Terrestrial, Freshwater, Coastal and Marine* (CIEEM, 2019). CIEEM Guidelines include model formats for Preliminary Ecological Appraisal and Ecological Impact Assessment. Also, where pertinent, evaluations presented herein take cognisance of recommended Guidance from the EPA such as *Draft Guidelines on the information to be contained in Environmental Impact Assessment Reports* (EPA, 2017), and in respect of European sites, *Managing Natura 2000 sites. The provisions of Article 6 of the 'Habitats' Directive 92/43/EEC* (European Commission, 2018).

Due cognisance has been given at all times to the provisions of the *Wildlife Acts 1976 - 2021,* the *European Union (Natural Habitats) Regulations. SI 378/2005*, the *European Communities (Birds and Natural Habitats) Regulations 2011,* EU Regulation on Invasive Alien Species under *EU Regulation 1143/2014*, the EU Birds *Directive 2009/147/EC* and the EU *Habitats Directive 92/43/EEC*.

No method of assessment can completely remove the possibility of obtaining partially imprecise or incomplete information. Any limitation to the methods applied or constraints however are clearly identified within the main body of this document.

Version	**Date**		**Name**	**Signature**
1	09/11/2023	**Document prepared by:**	Dr. Alex Copland BSc PhD MIEnvSc	
1	10/11/2023	**Document reviewed by:**	Peig Healy BSc MSc GradIEMA	
1	10/11/2023	**Document signed off by:**	Howard Williams BSc CEnv, MCIEEM CBIOL MRSB MIFM	
Project Reference	**1385**	**Title**	Oatfield Wind Farm Collision Risk Modelling	

Notice

This report was produced by INIS Environmental Consultants Ltd. (INIS) on behalf of Ørsted, the client, for the specific purpose of undertaking an assessment of collision risk for target bird species at the proposed Oatfield Wind Farm, Co. Clare, with all reasonable skill, care and due diligence within the terms of the contract with the client, incorporating our terms and conditions and taking account of the resources devoted to it by agreement with the client.

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Appendices

1. INTRODUCTION

Inis Environmental Consultants Ltd. (INIS) was commissioned to undertake an assessment of collision risk for potentially sensitive avian receptors at the proposed Oatfield Wind Farm in Co. Clare using standardised Collision Risk Modelling (CRM) methods.

1.1. Constraints and Limitations

There are a number of constraints and limitation associated with pre-planning ecological assessments of potential development sites, as well as constraints and limitations inherent to the collection and analysis of field-based ecological data (Band *et al.*, 2012; SNH, 2017).

The data evaluated here comprises:

- Bird flight data from timed Vantage Point (VP) watches, clipped to the proposed development footprint with a 1km buffer and consisting of flights within the rotor-swept heights (20-200m). Flight duration (in seconds) for all bird observations, along with data relevant to each flight record (date, timing, weather conditions, VP location (number), etc.), are included;
- Vantage Point survey effort data (recorded as hours of observations) on a monthly basis during the breeding season (April to September for 2022 and 2023) and wintering season (October 2021 to March 2022 and October 2022 to Match 2023) for all VP survey work undertaken;
- Area viewed from each VP collectively (in hectares);
- Area of the wind farm footprint (plus 1km buffer) as indicated above; and
- Description and metrics for the wind farm as a whole, as well as for individual turbines.

This collision risk model relates specifically to the VP survey data. In particular, any variation in the flight data, coverage of the VPs surveyed during fieldwork, layout of the wind farm or individual turbine specifications, including upper and lower rotor swept heights, would require the outputs from this model to be amended.

Arising from initial monitoring work, areas that showed sensitivity to a range of ecological and non-ecological receptors at the early stages of monitoring were dropped from consideration for turbine placement by the developer. This iterative approach is recommended as Best Practice in the design of wind farms (IWEA, 2012), but means in the project area changing over time to reflect changes to the proposed turbine layout. The proposed number of turbines reduced and, as a result, the number of VPs were reduced where viewshed sufficiency could be retained to comply with Best Practice guidance (SNH, 2017) in the selection of VP locations. As a result, although 12 VPs were used at various parts of this assessment for surveys, the data for four VPs (VP3, VP4, VP6 and VP7) provide adequate viewshed coverage (98%) of the proposed windfarm layout (+500m buffer) area.

Note that the methodology presented here involves using a 1km buffer to clip flight lines. This is beyond the minimum indicated by Best Practice guidelines (800m buffer). Therefore, the CRM results presented here indicate a substantially more conservative (i.e. higher) estimate of collision risk than is likely to be the case by incorporating additional flight lines within this extended buffer. This precautionary approach therefore allows a more robust evaluation of potential impacts (if any) arising from the data presented here.

For field-based surveys, the availability of suitable weather conditions for completing surveys, with good visibility and little wind or rain of paramount importance, must be considered. The avian flight data presented here were all collected in optimal weather conditions, as determined by Best Practice guidance. In some circumstances, this required re-arrangement of monthly schedules, with some VPs being surveyed twice in one month to compensate for months when no survey work took place. These are clearly indicated within the data and are presented in **Appendix A**. It should be noted that such scheduling falls well within the tolerances of Best Practice guidelines for such survey work. In all cases, Best Practice guidance on selection and surveying at VPs has been adhered to throughout the work being reported.

When recording birds in flight, exact determination of ground location and flight height, both of which are essential to calculating collision risk, can be subject to variation between observers. It is therefore required to allow some margin of error for determining the exact location of flying birds, and this has been included within the CRM presented here by the inclusion of all recorded flight lines in an expanded 1km buffer zone, and also including data from all flight lines that intersect with this extended buffer, i.e. if a flight line originated within the buffer zone, but flew beyond the 1km boundary, the flight was continuously recorded, and the time flying outside the buffer also included within the CRM calculations. Similarly for flight height, with a lowest swept area of 30m and a maximum swept height of 180m within the Turbine Range proposed for Oatfield Wind Farm, all bird records consisting of flight heights between 20m and 200m are included in the model.

Collectively, the inclusion of these data offer additional precaution in determining collision risk, supporting more robust outputs and therefore interpretation of results than would otherwise be the case.

1.2. Statement of Authority

Dr Alex Copland BSc PhD MIEnvSc is Technical Director with INIS and undertook the Collision Risk Modelling. He has over 25 years of professional experience working in both statutory and private companies, in third-level research institutions and with environmental NGOs. He is proficient in experimental design and data analysis and has managed several large-scale, multi-disciplinary ecological projects. These have included research and targeted management work for species of conservation concern, the design and delivery of practical conservation actions with a range of stakeholders and end-users, education and interpretation on the interface between people and the environment and the development of co-ordinated, strategic plans for birds and biodiversity.

He has written numerous scientific papers, developed and contributed to evidence-based position papers, visions and strategies on birds and habitats in Ireland. He has supervised the successful completion of research theses for several post-graduate students, including doctoral candidates. He lectures to both undergraduate and post-graduate students at UCD, as well as being a collaborative researcher with both UCD and UCC. He also sits on the Editorial Panel of the scientific journal, *Irish Birds*, which publishes original ornithological research relevant to Ireland's avifauna.

Ms Peig Healy BSc MSc GradIEMA is an Environmental Specialist with Inis Environmental Consultants Ltd. who checked this report. Peig was awarded a distinction MSc in Environmental Leadership and an Honours BSc in International Development and Food Policy. As part of her BSc and MSc, Peig has compiled two dissertation projects relating to sustainability and environmental research. In association with these projects, Peig has carried out policy analysis, case study review, and reporting in relation to Fisheries Policy and EIA respectively. Peig is also a Graduate Member of the Institute of Environmental Management and Assessment (IEMA). During her employment with Inis, Peig has been involved in conducting a range of reports, including Appropriate Assessment (AA) Screenings, Natura Impact Statements (NIS), and Environmental Impact Assessment (EIA) Screenings.

Howard Williams BSc CEnv MCIEEM CBiol MRSB MIFM (Principal Ecologist and CEO Inis Environmental Consultants Ltd.) signed off on this report. Howard is a Chartered Environmentalist and a Chartered Biologist and has written and managed many Article 6 Appropriate Assessments and Ecological Impact Assessments for more than €2billion of major infrastructure in Ireland. Howard is an expert in the field of avian ecology in addition to having considerable knowledge and experience producing management strategies/prescriptions for a range of protected species, both terrestrial and aquatic.

1.3. Site and Development Description

The Proposed Oatfield Wind Farm is located in Co. Clare, c.4km north-east of Broadford village and c.7km north-west of Killaloe. The receiving environment for proposed development is representative of upland habitats and includes lands under active management for agriculture and forestry.

The layout of the proposed development consists of 11 turbines, located in two discrete groups at the site. Three possible turbine models have been identified for the proposed development (see **Table 1.1**) Note that, as all flight data between 20m and 200m is used for the modelling presented here, the varying tip height (of between 176.5m and 180m) and hub height range (of between 105m and 110m; so a lowest swept height of between 30m and 43.5m) are all included within the model parameters. The specifications of the three turbine specifications used to cover the Turbine Range are shown in **Table 1.1**.

1.4. Background to bird species assessed

The species selected for the Collision Risk Model are shown in **Tables 1.2** (breeding season) and **Table 1.3** (wintering season). Whilst some birds can occur at a site all year round, there tends to be differing activity levels between breeding and non-breeding seasons. This can be seen by the differences in activity between **Table 1.2** and **Table 1.3** where, for example, raptors (e.g., Buzzard, Hen Harrier and Kestrel) are more regularly observed in summer months compared to winter. Conversely, wintering waders (including Goden Plover and Snipe) are only observed in winter months. To accurately reflect the changing avifauna between season, separate CRMs are presented for wintering and breeding seasons.

Table 1.1 *Turbine specifications the proposed Oatfield Wind Farm*

Technical information	Data used		
Indicated wind turbine model	Nordex N149	Vestas V150-6MW	Nordex N133
Number of turbines	11	11	11
Number of blades per turbine	3	3	3
Rotor diameter	149m	150m	133
Rotor radius	74.5m	75m	66.5
Rotor blade maximum chord	4.15m	4.2m	3.94
Pitch angle of the blade during normal operation[1]	30°	30°	30°
Rotation speed	10.7rpm	11rpm	11.2
Rotation period	5.6s	5.5s	5.4s
Lowest swept area of blade	30.5m	30m	43.5
Turbine operation time[2]	85%	85%	85%

[1]*The pitch angle of the blade is determined by wind speed, which is variable depending upon geographical location, landscape, local topographic factors, etc. To maintain a constant operating speed for a turbine, altering the pitch angle of the blade is used. This is usually determined by wind speed, with higher wind speeds requiring greater pitch angle to "feather" the wind and thereby control the rotation speed. The figure of 30° used here is derived from Band (2012) which gives an average pitch along the blade length of between 25 – 30 degrees (30° results in greater likelihood of effects and is used within this model which has adopted a precautionary approach to the determination of risk).*

[2] *European Wind Energy Association (2016) gives the average operation time of a turbine of between 70% and 85% of the time; 85% is used in this model as this adopts the precautionary approach.*

Target species for the proposed development are based upon likely collision risk as well as their status as Birds of Conservation Concern in Ireland (BoCCI) Red or Amber Lists (Gilbert *et al*., 2021). Target species were:

- All species of waterfowl;
- All species of raptor;
- All species of owl;
- All species of grouse;
- All species of wader; and
- All species of gull.

From this target species list, ten species were recorded during VP Watches (see **Table 1.2** and **Table 1.3**). From these species, Raven was not included in the CRM as it was not identified as a target species. Of the remaining species, only those with sufficient flight activity (defined as a minimum total of five flights or minimum of ten individuals of each target species recorded in during each season of analysis; numbers below these thresholds are likely to exhibit negligible collision risk). This resulted in three species being assessed for collision risk during the breeding season (Buzzard, Hen Harrier and Kestrel; see **Table 1.2**) and three species being assessed during the wintering season (Buzzard, Golden Plover and Kestrel; **see Table 1.3**).

For the four species being assessed, biometric data is required for inputting to the CRM. These are shown in **Table 1.4**, along with the recommended avoidance rates for use with the CRM (SNH, 2017).

Table 1.2 *Breeding season flight data for target species from Vantage Point Surveys*

Species	Total Number of Bouts	Total Number of Individuals	Total Duration of Bouts (s)	Inclusion in CRM
Buzzard *Buteo buteo*	**24**	**30**	**4,970**	**Yes**
Grey Heron *Ardea cinerea*	3	3	180	No
Hen Harrier *Circus cyaneus*	**7**	**7**	**1,905**	**Yes**
Kestrel *Falco tinnunculus*	**39**	**42**	**8,340**	**Yes**
Lesser Black-backed Gull *Larus fuscus*	2	2	50	No
Mallard *Anas platyrhynchos*	3	5	145	No
Raven *Corvus corax*	5	10	500	No
Sparrowhawk *Accipiter nisus*	3	3	455	No

Table 1.3 *Wintering season flight data for target species from Vantage Point Surveys*

Species	Total Number of bouts	Total Number of individuals	Total Duration of bouts	Inclusion in CRM
Buzzard *Buteo buteo*	**13**	**19**	**2,685**	**Yes**
Golden Plover *Pluvialis apricaria*	**5**	**86**	**3,855**	**Yes**
Grey Heron *Ardea cinerea*	1	1	80	No
Hen Harrier *Circus cyaneus*	1	1	90	No
Kestrel *Falco tinnunculus*	**20**	**20**	**2,515**	**Yes**
Raven *Corvus corax*	16	22	1,125	No
Snipe *Gallinago gallinago*	1	4	120	No
Sparrowhawk *Accipiter nisus*	2	2	340	No

Table 1.4 *Bird species biometrics and avoidance rates for use in CRM*

Biometric parameter[1]	Buzzard	Golden Plover	Hen Harrier	Kestrel
Assessment season	**Breeding + Winter**	**Winter**	**Breeding**	**Breeding + Winter**
Length (bill to tail)	0.57m	0.29m	0.52m	0.35m
Wingspan	1.28m	0.76m	1.20m	0.80m
Flight speed[2]	$11.6ms^{-1}$	$17.9\ ms^{-1}$	$9.1ms^{-1}$	$10.1ms^{-1}$
Collision Avoidance rate (%)[3]	98%	98%	99%	95%

[1] Data sourced from https://www.rspb.org.uk/birds-and-wildlife/wildlife-guides/bird-a-z/ [Accessed November 2023]
[2] Data sourced from Alerstam *et al*. (2007); for Golden Plover, data for Grey Plover *Pluvialis squatarola* are used.
[3] Avoidance rates sourced from SNH (2019*)*

2. METHODOLOGICAL APPROACH

Collision Risk Modelling adopts a mathematical approach to determining the likelihood of a bird species colliding with wind turbine rotors at a pre-defined site and is fully described by Band *et al*. (2007) and Scottish Natural Heritage (SNH, 2000), with supporting information provided by Scottish Natural Heritage (SNH, 2019). This determination is based upon field data collected at the proposed wind farm site. The output from the model indicates the number of birds likely to collide with rotors of all turbines within the wind farm per year of operation of the wind farm as a whole. The inverse of this (i.e., the number of years over which a single fatality would be likely) is also often indicated.

Data on the site (such as the number, size, dimensions and likely functioning of the turbines proposed for the site; see **Table 1.1**) forms part of the model, along with biometric data on the bird species themselves (see **Table 1.4**). These are reconciled against standardised field data collected using systematic and prescribed Best Practice methods on birds flying through the proposed site (SNH, 2017). Collectively, these data are then used to determine the number of bird flights through the rotors of all turbines within the area on an annual basis (CRM Stage 1) as well as the probability that a bird flying through the turbine will collide with the rotors (CRM Stage 2). The product of the numerical output from these two stages of assessment then indicate the number of birds likely to collide with the rotors if no avoiding action is being taken by the bird species in question. This value is then corrected using published avoidance rates (CRM Stage 3; see **Table 1.4**), to give a final indication of collision risk (number of bird colliding with the rotors per annum).

2.1. Collection of field data

The CRM is based upon data collected from VPs at the proposed Oatfield Wind Farm, during the breeding season (March to September inclusive), for two years (2022 and 2023) and two wintering seasons (October 2021 to March 2022 and October 2022 to March 2023). These data are collected following strict adherence to Best Practice methods (SNH, 2017).

2.2. CRM Stage 1: Determination of Bird Species Activity

Stage 1 of the CRM determines the number of transits through the rotors for a given period. For the calculation below, this is expressed as the number of birds flying through the rotors per breeding season (April to September inclusive) or winter season (October to March inclusive). Calculations of bird flights through the rotor swept area are provided for each of the three turbine models. The data used and calculations performed are shown in **Table 2.1a** to **Table 2.1c** (for the breeding season) and **Table 2.2a** to **Table 2.2c** (for the wintering season).

A full description of all the parameters used, and the derivation for calculations for the models, is presented in **Appendix B**.

Table 2.1a *Parameters used in the CRM for Buzzard (breeding season activity)*

Model parameter		Nordex N149	Vestas V150	Nordex N133
Survey Area Visible from Vantage Points (ha)	Acc	1,470	1,470	1,470
Flight Risk Area (ha)	A_{FR}	627	627	627
Total Survey Time (s)	T	1,040,400	1,040,400	1,040,400
Length of Season (days)	T_{SS}	183	183	183
Daily Duration of Bird Activity (hours)	T_{DD}	15	15	15
Duration of Bird Activity at Rotor Height (s)	T_{TH}	4,970	4,970	4,970
Proportion of Bird Activity at Rotor Height: (T_{TH}/T)	t	**0.004777**	**0.004777**	**0.004777**
Flight Activity in Visible Area (per hectare): (t/Acc)	F	**3.25×10^{-6}**	**3.25×10^{-6}**	**3.25×10^{-6}**
Flight Time within Flight Risk Area: (A_{FR}*F)	t_{FR}	**2.04×10^{-3}**	**2.04×10^{-3}**	**2.04×10^{-3}**
Occupancy of the Flight Risk Area (hrs/season): (T_{SS}*T_{DD}*t_{FR})	n	**5.623612**	**5.623612**	**5.623612**
Flight Risk Volume (m^3)	Vw	934,230,000	940,500,000	833,910,000
Combined Rotor Volume (m^3)	Vr	905,310	927,221	689,227
Occupancy of Rotor Volume (bird-secs): ((Vr/Vw)*n)	b	**19.618289**	**19.959171**	**16.732508**
Transit Time through Rotors	v	0.41	0.41	0.39
Number of Transits through Rotors (per season): (b/v)	b_{FR}	**48.214439**	**48.538026**	**43.037050**
Viewshed sufficiency (%)	Vs	**98%**	**98%**	**98%**
Corrected Number of Transits through Rotors (per season): (b_{FR} /Vs)	b_C	**49.198407**	**49.528598**	**43.915357**

Table 2.1b *Parameters used in the CRM for Hen Harrier (breeding season activity)*

Model parameter		Nordex N149	Vestas V150	Nordex N133
Survey Area Visible from Vantage Points (ha)	Acc	1,470	1,470	1,470
Flight Risk Area (ha)	A_{FR}	627	627	627
Total Survey Time (s)	T	1,040,400	1,040,400	1,040,400
Length of Season (days)	T_{SS}	183	183	183
Daily Duration of Bird Activity (hours)	T_{DD}	15	15	15
Duration of Bird Activity at Rotor Height (s)	T_{TH}	1,905	1,905	1,905
Proportion of Bird Activity at Rotor Height: (T_{TH}/T)	t	**0.001831**	**0.001831**	**0.001831**
Flight Activity in Visible Area (per hectare): (t/Acc)	F	**1.25×10^{-6}**	**1.25×10^{-6}**	**1.25×10^{-6}**
Flight Time within Flight Risk Area: (A_{FR}*F)	t_{FR}	**7.81×10^{-4}**	**7.81×10^{-4}**	**7.81×10^{-4}**
Occupancy of the Flight Risk Area (hrs/season): (T_{SS}*T_{DD}*t_{FR})	n	**2.155529**	**2.155529**	**2.155529**
Flight Risk Volume (m^3)	Vw	934,230,000	940,500,000	833,910,000
Combined Rotor Volume (m^3)	Vr	895,719	917,502	681,586
Occupancy of Rotor Volume (bird-secs): ((Vr/Vw)*n)	b	**7.440029**	**7.570154**	**6.342463**
Transit Time through Rotors	v	0.51	0.52	0.49
Number of Transits through Rotors (per season): (b/v)	b_{FR}	**14.497700**	**14.595000**	**12.940900**
Viewshed sufficiency (%)	Vs	**99%**	**99%**	**99%**
Corrected Number of Transits through Rotors (per season): (b_{FR} /Vs)	b_C	**14.644142**	**14.742424**	**13.071616**

Table 2.1c *Parameters used in the CRM for Kestrel (breeding season activity)*

Model parameter		Nordex N149	Vestas V150	Nordex N133
Survey Area Visible from Vantage Points (ha)	Acc	1,470	1,470	1,470
Flight Risk Area (ha)	A_{FR}	627	627	627
Total Survey Time (s)	T	1,040,400	1,040,400	1,040,400
Length of Season (days)	T_{SS}	183	183	183
Daily Duration of Bird Activity (hours)	T_{DD}	15	15	15
Duration of Bird Activity at Rotor Height (s)	T_{TH}	8,340	8,340	8,340
Proportion of Bird Activity at Rotor Height: (T_{TH}/T)	t	**0.008016**	**0.008016**	**0.008016**
Flight Activity in Visible Area (per hectare): (t/Acc)	F	**5.45 x 10^{-6}**	**5.45 x 10^{-6}**	**5.45 x 10^{-6}**
Flight Time within Flight Risk Area: (A_{FR}*F)	t_{FR}	**3.42 x 10^{-3}**	**3.42 x 10^{-3}**	**3.42 x 10^{-3}**
Occupancy of the Flight Risk Area (hrs/season): (T_{SS}*T_{DD}*t_{FR})	n	**9.436805**	**9.436805**	**9.436805**
Flight Risk Volume (m^3)	Vw	934,230,000	940,500,000	833,910,000
Combined Rotor Volume (m^3)	Vr	863,113	884,457	655,606
Occupancy of Rotor Volume (bird-secs): ((Vr/Vw)*n)	b	**31.386385**	**31.948110**	**26.708620**
Transit Time through Rotors	v	0.45	0.45	0.42
Number of Transits through Rotors (per season): (b/v)	b_{FR}	**70.444998**	**70.917784**	**62.880435**
Viewshed sufficiency (%)	Vs	**98%**	**98%**	**98%**
Corrected Number of Transits through Rotors (per season): (b_{FR} /Vs)	b_C	**74.152630**	**74.650299**	**66.189931**

Table 2.2a *Parameters used in the CRM for Buzzard (winter season activity)*

Model parameter		Nordex N149	Vestas V150	Nordex N133
Survey Area Visible from Vantage Points (ha)	Acc	1,470	1,470	1,470
Flight Risk Area (ha)	A_{FR}	627	627	627
Total Survey Time (s)	T	1,036,800	1,036,800	1,036,800
Length of Season (days)	T_{SS}	182	182	182
Daily Duration of Bird Activity (hours)	T_{DD}	12	12	12
Duration of Bird Activity at Rotor Height (s)	T_{TH}	2,685	2,685	2,685
Proportion of Bird Activity at Rotor Height: (T_{TH}/T)	t	**0.002590**	**0.002590**	**0.002590**
Flight Activity in Visible Area (per hectare): (t/Acc)	F	**1.76 x 10^{-6}**	**1.76 x 10^{-6}**	**1.76 x 10^{-6}**
Flight Time within Flight Risk Area: (A_{FR}*F)	t_{FR}	**1.10 x 10^{-3}**	**1.10 x 10^{-3}**	**1.10 x 10^{-3}**
Occupancy of the Flight Risk Area (hrs/season): (T_{SS}*T_{DD}*t_{FR})	N	**2.438926**	**2.438926**	**2.438926**
Flight Risk Volume (m^3)	Vw	934,230,000	940,500,000	833,910,000
Combined Rotor Volume (m^3)	Vr	905,310	927,221	689,227
Occupancy of Rotor Volume (bird-secs): ((Vr/Vw)*n)	b	**8.508331**	**8.65169**	**7.256785**
Transit Time through Rotors	v	0.41	0.41	0.39
Number of Transits through Rotors (per season): (b/v)	b_{FR}	**20.910305**	**21.050642**	**18.664903**
Viewshed sufficiency (%)	Vs	**98%**	**98%**	**98%**
Corrected Number of Transits through Rotors (per season): (b_{FR} /Vs)	b_C	**21.337046**	**21.480247**	**19.045819**

Table 2.2b *Parameters used in the CRM for Golden Plover (winter season activity)*

Model parameter		Nordex N149	Vestas V150	Nordex N133
Survey Area Visible from Vantage Points (ha)	Acc	1,470	1,470	1,470
Flight Risk Area (ha)	A_{FR}	627	627	627
Total Survey Time (s)	T	1,036,800	1,036,800	1,036,800
Length of Season (days)	T_{SS}	182	182	182
Daily Duration of Bird Activity (hours)	T_{DD}	12	12	12
Duration of Bird Activity at Rotor Height (s)	T_{TH}	3,855	3,855	3,855
Proportion of Bird Activity at Rotor Height: (T_{TH}/T)	t	**0.003718**	**0.003718**	**0.003718**
Flight Activity in Visible Area (per hectare): (t/Acc)	F	**2.53 x 10^{-6}**	**2.53 x 10^{-6}**	**2.53 x 10^{-6}**
Flight Time within Flight Risk Area: (A_{FR}*F)	t_{FR}	**1.59 x 10^{-3}**	**1.59 x 10^{-3}**	**1.59 x 10^{-3}**
Occupancy of the Flight Risk Area (hrs/season): (T_{SS}*T_{DD}*t_{FR})	n	**3.501698**	**3.501698**	**3.501698**
Flight Risk Volume (m^3)	Vw	934,230,000	940,500,000	833,910,000
Combined Rotor Volume (m^3)	Vr	851,605	872,793	646,437
Occupancy of Rotor Volume (bird-secs): ((Vr/Vw)*n)	b	**11.491201**	**11.698597**	**9.772107**
Transit Time through Rotors	v	0.25	0.25	0.24
Number of Transits through Rotors (per season): (b/v)	b_{FR}	**46.327141**	**46.638061**	**41.352414**
Viewshed sufficiency (%)	Vs	**98%**	**98%**	**98%**
Corrected Number of Transits through Rotors (per season): (b_{FR} /Vs)	b_C	**47.272592**	**47.589858**	**42.196341**

Table 2.2c *Parameters used in the CRM for Kestrel (winter season activity)*

Model parameter		Nordex N149	Vestas V150	Nordex N133
Survey Area Visible from Vantage Points (ha)	Acc	1,470	1,470	1,470
Flight Risk Area (ha)	A_{FR}	627	627	627
Total Survey Time (s)	T	1,036,800	1,036,800	1,036,800
Length of Season (days)	T_{SS}	182	182	182
Daily Duration of Bird Activity (hours)	T_{DD}	12	12	12
Duration of Bird Activity at Rotor Height (s)	T_{TH}	2,515	2,515	2,515
Proportion of Bird Activity at Rotor Height: (T_{TH}/T)	t	**0.002426**	**0.002426**	**0.002426**
Flight Activity in Visible Area (per hectare): (t/Acc)	F	**1.65×10^{-6}**	**1.65×10^{-6}**	**1.65×10^{-6}**
Flight Time within Flight Risk Area: (A_{FR}*F)	t_{FR}	**1.03×10^{-3}**	**1.03×10^{-3}**	**1.03×10^{-3}**
Occupancy of the Flight Risk Area (hrs/season): (T_{SS}*T_{DD}*t_{FR})	n	**2.284506**	**2.284506**	**2.284506**
Flight Risk Volume (m^3)	Vw	934,230,000	940,500,000	833,910,000
Combined Rotor Volume (m^3)	Vr	863,113	884,457	655,606
Occupancy of Rotor Volume (bird-secs): ((Vr/Vw)*n)	b	**7.598163**	**7.734148**	**6.465747**
Transit Time through Rotors	v	0.45	0.45	0.42
Number of Transits through Rotors (per season): (b/v)	b_{FR}	**17.053654**	**17.168108**	**15.222389**
Viewshed sufficiency (%)	Vs	**98%**	**98%**	**98%**
Corrected Number of Transits through Rotors (per season): (b_{FR} /Vs)	b_C	**17.951215**	**18.071693**	**16.023567**

2.3. CRM Stage 2: Determination of Collision Risk

The probability of a bird flying through the rotors and colliding with the blades is determined in Stage 2 of the CRM. The probability of a collision depends upon the bird's size (both length and wingspan) and flight speed. In order to simplify the calculations, birds are assumed to be of simple cruciform shape, with the wings half-way down the length of the bird. Characteristics of the turbine and rotor blades are also required, including the width and pitch of the rotor blades and the rotation speed of the turbine. The turbine blade is assumed to have no thickness for Stage 2 of the CRM, although rotor blade depth is considered in Stage 1 of the model.

The risk of a bird colliding with the rotor blades changes depending upon whether it passes through the rotor swept area next to the hub (where the blades have a wider chord width, occupy a large volume of the airspace and are travelling quite slowly) or towards the blade tips (where the blades are only present for a small proportion of the time, have a short chord width and are travelling faster). Closer to the hub, the wingspan of the bird compared to the physical distance between the blades is the controlling factor. Towards the blade tips, it is the length of the bird that offers and greater contribution to the determination of collision risk.

The bird is assumed to enter the rotor swept area at random anywhere on the disc. The calculations determine the collision risk at 20 locations along the length of the rotor blade (in intervals of 0.05R, where R is the radius of the rotor swept area) using numerical integration of various elements in relation to the rotors (notably chord width and angular velocity of the blade) and the Hen Harrier (such as the point at which the bird enters the rotor along the radius and the flight speed of the bird). These are calculated for both up-wind and down-wind flights and averaged to give a probability of collision per season, assuming no avoiding action is taken.

These calculations are performed in the SNH collision risk model[1], where the relevant data on the turbines and bird species are entered, and the model estimates the probability of a collision when a bird flies through the rotor area. This calculation is based solely upon the behaviour and structure of the bird and the specifications of the turbines. Only a single calculation is therefore required for all the VP data collected.

For the proposed development, the average probability of a bird passing through the rotor swept area and colliding with the rotors (if it takes no avoiding action) for the three proposed turbine options is shown in **Table 2.3**.

Table 2.3 *Risk of collision for birds passing through turbine swept areas*

Turbine model	Buzzard	Golden Plover	Hen Harrier	Kestrel
Nordex N149	8.3%	5.0%	10.1%	8.3%
Vestas V150	8.5%	5.1%	10.4%	8.5%
Nordex N133	8.4%	5.0%	10.2%	8.3%

[1] https://www.nature.scot/wind-farm-impacts-birds-calculating-probability-collision [accessed November 2023]

3. Results

The overall collision risk model output from the first two stages is the number of bird collisions per annum. This is the product of the number of transits through the rotors per season and the probability of a bird passing through the rotor swept area colliding with the blade.

It has been well documented that birds demonstrate avoidance of wind turbines. This includes macro-avoidance, where birds avoid the whole wind farm area, as well as micro-avoidance, where birds fly within the wind farm but avoid the turbines and blades. The documented level of avoidance for different species varies (SNH, 2019), and published avoidance rates for the bird species being assessed at the proposed development are shown in **Table 4.1**.

Incorporation of these avoidance rates forms part of the stage of the CRM to determine collision risk for the species assessed.

3.1. Collision Risk Assessment for Breeding Season

Collision Risk Modelling outputs are provided below for the three species considered during the breeding season (Buzzard (see **Table 3.1a**), Hen Harrier (see **Table 3.1b**) and Kestrel (see **Table 3.1c**)) for each of the three turbine models being assessed.

Table 3.1a *Risk of collision for Buzzard passing through turbine swept area (breeding)*

	Nordex N149	Vestas V150	Nordex N133
Collisions/annum (no avoiding action)	3.48	3.59	3.14
Collisions/annum (with 98% avoidance)	0.0697	0.0718	0.0627
Collision likelihood (years)	14.36	13.93	15.94

Table 3.1b *Risk of collision for Hen Harrier passing through turbine swept area (breeding)*

	Nordex N149	Vestas V150	Nordex N133
Collisions/annum (no avoiding action)	1.26	1.30	1.13
Collisions/annum (with 99% avoidance)	0.0126	0.0130	0.0113
Collision likelihood (years)	79.36	76.92	88.31

Table 3.1c *Risk of collision for Kestrel passing through turbine swept area (breeding)*

	Nordex N149	Vestas V150	Nordex N133
Collisions/annum (no avoiding action)	5.21	5.39	4.67
Collisions/annum (with 99% avoidance)	0.2603	0.2694	0.2333
Collision likelihood (years)	3.84	3.71	4.29

Buzzard has an estimated collision risk, with as estimation of between 0.06 and 0.07 collisions per annum (see **Table 3.1a**), equating to one collision every 13.93 to 15.94 years depending upon the turbine model chosen.

Hen Harrier has the lowest risk of collision for the three species assessed during the breeding season, with an estimated collision likelihood of approximately 0.01 bird collisions per annum (see **Table 3.1b**), equating to one collision every 76.92 to 88.31 years depending upon the turbine model selected.

Of the three species assessed, Kestrel has the greatest collision risk, with between 0.23 and 0.27 collisions per annum (see **Table 3.1c**), depending upon the turbine model chosen. This equates to one collision event for Kestrel occurring every 3.71 to 4.29 years.

3.2. Collision Risk Assessment for Wintering Season

Collision Risk data are provided for the three species considered during the wintering season (Buzzard (see **Table 3.2a**), Golden Plover (see **Table 3.2b**) and Kestrel (see **Table 3.2c**)) for each of the three turbine models being assessed.

Table 3.2a *Risk of collision for Buzzard passing through turbine swept area (winter)*

	Nordex N149	Vestas V150	Nordex N133
Collisions/annum (no avoiding action)	1.51	1.56	1.36
Collisions/annum (with 99% avoidance)	0.0302	0.0311	0.0272
Collision likelihood (years)	33.10	32.11	36.75

Table 3.2b *Risk of collision for Golden Plover passing through turbine swept area (winter)*

	Nordex N149	Vestas V150	Nordex N133
Collisions/annum (no avoiding action)	1.99	2.04	1.81
Collisions/annum (with 99% avoidance)	0.0398	0.0409	0.0362
Collision likelihood (years)	25.12	24.46	27.63

Table 3.2a *Risk of collision for Kestrel passing through turbine swept area (winter)*

	Nordex N149	Vestas V150	Nordex N133
Collisions/annum (no avoiding action)	1.26	1.30	1.13
Collisions/annum (with 99% avoidance)	0.0630	0.0652	0.0565
Collision likelihood (years)	15.87	15.33	17.71

Collision risk in winter is substantially lower than in summer, possibly as a result of reduced occupancy of the area around the proposed development (which includes upland habitats). This highlights the value of assessing the bird flight activity data in separate season to better understand the likelihood of collision risk for the target species.

Buzzard has an estimated collision risk, with as estimation of c.0.03 collisions per annum (see **Table 3.2a**), equating to one collision every 32.11 to 36.75 years depending upon the turbine model chosen.

Golden Plover has an estimated collision likelihood of approximately 0.04 bird collisions per annum (see **Table 3.2b**), equating to one collision every 24.46 to 27.63 years depending upon the turbine model selected.

Kestrel has the lowest winter collision risk of the three species assessed, with c.0.06 collisions per annum (see **Table 3.2c**), depending upon the turbine model chosen. This equates to one collision event for Kestrel occurring every 15.33 to 17.71 years.

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Appendix A OATFIELD WINDFARM VANTAGE POINT SURVEY EFFORT

Table A-1a *Vantage Point Survey hours for the two breeding seasons used for the CRM calculations*

VP	Breeding season 2022							Breeding season 2023							TOTAL (Two Seasons)
	Apr	May	Jun	Jul	Aug	Sep	Total	Apr	May	Jun	Jul	Aug	Sep	Total	
3	6	3	9	6	6	6	36	0	10	8	6	8	4	36	**72**
4	6	6	3	9	6	6	36	0	10	6	9	3	9	37	**73**
6	6	6	6	6	6	6	36	0	6	4	8	15	3	36	**72**
7	6	6	6	12	3	9	42	0	6	12	6	8	4	36	**72**
Total	**24**	**21**	**24**	**33**	**21**	**24**	**144**	**0**	**32**	**30**	**29**	**34**	**20**	**145**	**289**

Table A-1b *Vantage Point Survey hours for the two wintering seasons used for the CRM calculations*

VP	Winter season 2021/22							Winter season 2022/23							TOTAL (Two Seasons)
	Oct	Nov	Dec	Jan	Feb	Mar	Total	Oct	Nov	Dec	Jan	Feb	Mar	Total	
3	0	12	**72**	6	6	6	36	6	6	6	6	8	4	36	**72**
4	0	12	**73**	0	12	6	36	6	3	9	6	6	6[2]	36	**72**
6	0	12	**72**	0	6	12	36	6	12	0	5	7	6[3]	36	**72**
7	0	6	**72**	0	6	12	36	6	6	6	6	3.5	8.5	36	**72**
Total	**0**	**42**	**289**	**6**	**30**	**36**	**144**	**24**	**27**	**21**	**17**	**24.5**	**24.5**	**144**	**288**

[2] VP4 March Effort completed in April (3hrs) and May (3hrs)
[3] VP6 March effort completed in April

Appendix B PARAMETERS AND CALCULATION STEPS FOR CRM STAGE 1

Survey Area visible from Vantage Points (Acc)

In order to determine the level of flight activity in an area, the total area over which observations are being made needs to be assessed. The area viewed from each VP is not necessarily mutually exclusive form the area viewed from another VP; indeed there needs to be some overlap to maximise coverage of the survey area. As a result, the total survey area visible from each VP is calculated, and these are summed for each VP to give the accumulated total area surveyed. The accumulated survey area from VPs will therefore be greater than the total survey area. This total is calculated in hectares.

Flight Risk Area (A_{FR})

The area where there may be a flight risk must be established and surveyed. Determination of this will largely have taken place in advance of undertaking survey work, but an iterative design approach may result in changes to the area that is required for survey. For CRM, the area should cover the whole wind farm, defined as a polygon encompassing the outer turbines plus the rotor radius. With the layout at Oatfield (which incorporates two discrete areas of turbines) the wind turbine area, plus a 500m buffer around all wind turbines, can be used. However, as the exact locations of flight-lines may be subject to error, an increased buffer is recommended from which to use for the inclusion of flight lines, with 800m often applied. For Oatfield, a more conservative buffer of 1km was applied to all turbines to adequately cover the whole of the flight risk area and ensure the robustness of the CRM.

Total Survey time (T)

To assess flight activity in an area, the total survey time undertaken from the VP watches is needed. This is expressed as seconds.

Length of Activity Season (T_{SS})

The period when birds are likely to be active in the area during the season being assessed. This is indicated as 1st April to 30th September for breeding, and 1st October to 31st March for wintering in each year. Expressed as days.

Daily Duration of Activity (T_{DD})

The number of hours that birds are potentially active during the day, within each season, forms part of the model. This is quantified as 15 hours per day for the period 1st April to 30th September, and 12 hours per day for the period 1st October to 31st March. This is likely to be an over-estimate of activity, which would be difficult to quantify in simple term otherwise. Nevertheless, the provision of an over-estimation of activity time increases the likelihood of a collision as birds are considered to be more active (i.e., taking more flights) than if activity hours are reduced. This approach therefore offers a more robust estimation of collision risk within the CRM.

Duration of Activity at Turbine Height (T_{TH})

This metric is based on the observation of flight-lines from the VP surveys. Turbine height is determined by the hub height +/- the length of the blade. This swept area may be subject to change depending upon final design iterations. For a turbine with a hub-height of 100m and a blade length of 70m, the swept area (Turbine Height) will be 30-170m.

However, it may be difficult to be certain about individual observations of flight heights, and a precautionary approach needs to be taken about which data to include. A tolerance of +/- 5m at lower flight heights should be considered and these tolerances may need to be greater at higher flight elevations (e.g., +/- 20m at 200m height). In the example above, all birds flying in the 20m-30m band would be included, in addition to all birds flying between 30m and up to 200m. For Oatfield, with a lowest swept area of between 30m and 43.5m, and turbine diameters ranging from 133m to 150m, all records between 20m and 200m were retained for analysis within the model.

Flight-lines recorded within the determined flight height bands are therefore selected, and the total numbers of seconds for birds observed within the Survey Area are summed. To ensure a precautionary approach is applied, any flight-lines at the relevant height bands recorded wholly or partially within the survey area are retained for analysis within the CRM.

Proportion of Time at Turbine Height (t)

This metric is obtained by dividing the Duration of Activity at Turbine Height (T_{TH}) by Total Survey Time (T).

Flight Activity in the Visible Area (F)

The level of flight activity within the survey area is determined by dividing the Proportion of Time (birds were recorded) at Turbine Height (t) by the Visible Survey Area (Acc).

Flight Time within the Flight Risk Area (t_{FR})

The amount of time a bird is likely to be within the flight risk area is the product of the Flight Risk Area (A_{FR}) and the Flight Activity in the Visible Area (F).

Occupancy of the Flight Risk Area (n)

The time that a bird is likely to be within the Flight Risk Area is a product of the Length of Activity Season (T_{SS}), the Daily Duration of Activity (T_{DD}) and the Flight Time within the Flight Risk Area (t_{FR}). The output of this provides the number of hours that a bird is within the Flight Risk Area per breeding season.

Flight Risk Volume (Vw)

This is the volume of airspace within the rotor height over the whole wind farm survey area. It is calculated by multiplying the Flight Risk Area (A_{FR}) with the diameter of the rotor (149m, 150m or 133m depending upon the turbine specifications provided for Oatfield).

Combined Rotor Volume (Vr)

This is the actual volume of airspace occupied by the rotors within the wind farm. Although the volume of airspace occupied by a single rotor is its depth (*d*) multiplied by its circumference (πr^2, where *r* is the radius of the rotor), the CRM also takes into account the length of the bird (which varies depending upon species) into the rotor depth calculation, as the rotor could collide with the bird anywhere along its length if flying through the swept area. Note the depth of the rotor is taken as the maximum chord of the blade (i.e., the width of the rotor blade at its maximum). Clearly rotors do not operate within this volume (the blade is never at a 90° pitch) nor is the width constant along the length of the blade. Nevertheless, the use of this metric in the calculation ensures that the output of the model follows the precautionary approach to maximise the robustness of the model output. The volume for a single rotor is therefore expressed as $(d+l)*\pi r^2$. The combined rotor volume is this individual rotor volume multiplied by the number of turbines (n=11 for Oatfield). See **Table B-1a** to **Table B-1d** for the relevant metrics for this calculation for each of the three proposed turbine models for Oatfield.

Table B-1a *Risk of collision for Buzzard passing through turbine swept areas*

Turbine model	Nordex N149	Vestas V150	Nordex N133
Rotor diameter	149m	150m	133m
Rotor radius (*r*)	74.5m	75m	66.5m
Rotor area (πr^2)	17,437m^2	17,671m^2	13,893m^2
Rotor depth (*d*)	4.15m	4.2m	3.94m
Buzzard Length (bill to tail) (*l*)	0.57m	0.57m	0.57m
Rotor volume ($(d+l)*\pi r^2$)	82,301m^3	84,293m^3	62,627m^3
Number of turbines	11	11	11
Combined Rotor Volume (Vr)	905,310m^3	927,221m^3	689,227m^3

Table B-1b *Risk of collision for Golden Plover passing through turbine swept areas*

Turbine model	Nordex N149	Vestas V150	Nordex N133
Rotor diameter	149m	150m	133m
Rotor radius (*r*)	74.5m	75m	66.5m
Rotor area (πr^2)	17,437m^2	17,671m^2	13,893m^2
Rotor depth (*d*)	4.15m	4.2m	3.94m
Golden Plover Length (bill to tail) (*l*)	0.29m	0.29m48	0.29m
Rotor volume ($(d+l)*\pi r^2$)	77,419m^3	79,345m^3	58,767m^3
Number of turbines	11	11	11
Combined Rotor Volume (Vr)	851,605m^3	872,793m^3	646,437m^3

Table B-1c *Risk of collision for Hen Harrier passing through turbine swept areas*

Turbine model	Nordex N149	Vestas V150	Nordex N133
Rotor diameter	149m	150m	133m
Rotor radius (*r*)	74.5m	75m	66.5m
Rotor area (πr^2)	17,437m^2	17,671m^2	13,893m^2
Rotor depth (*d*)	4.15m	4.2m	3.94m
Hen Harrier Length (bill to tail) (*l*)	0.52m	0.52m	0.52m
Rotor volume ($(d+l)*\pi r^2$)	81,429m^3	83,409m^3	61,962m^3
Number of turbines	11	11	11
Combined Rotor Volume (Vr)	895,719m^3	917,502m^3	681,586m^3

Table B-1d *Risk of collision for Kestrel passing through turbine swept areas*

Turbine model	Nordex N149	Vestas V150	Nordex N133
Rotor diameter	149m	150m	133m
Rotor radius (*r*)	74.5m	75m	66.5m
Rotor area (πr^2)	17,437m^2	17,671m^2	13,893m^2
Rotor depth (*d*)	4.15m	4.2m	3.94m
Kestrel Length (bill to tail) (*l*)	0.35m	0.35m	0.35m
Rotor volume ($(d+l)*\pi r^2$)	78,465m^3	80,405m^3	59,601m^3
Number of turbines	11	11	11
Combined Rotor Volume (Vr)	863,113m^3	884,457m^3	655,606m^3

Occupancy of the Rotor Volume (b)

This is an estimation of the time that birds will occur within the rotors. It is calculated by dividing the Combined Rotor Volume (Vr) by the Flight Risk Volume (Vw), which gives the proportion of the Flight Risk Volume that is occupied by the rotors. This is then multiplied by the Occupancy of the Flight Risk Area (n).

Transit Time through Rotors (v)

This is calculated by adding length of the bird to the depth of the rotor swept area and then dividing by the flight speed. See **Table B-2a** to **Table B-2d** for the relevant metrics for this calculation for each of the three proposed turbine models for Oatfield.

Table B-2a *Buzzard Transit time through the rotors*

Turbine model	Nordex N149	Vestas V150	Nordex N133
Buzzard Length (bill to tail) (*l*)	0.57m	0.57m	0.57m
Buzzard Flight Speed (ms^{-1})	11.6ms^{-1}	11.6ms^{-1}	11.6ms^{-1}
Rotor depth (*d*)	4.15m	4.2m	3.94m
Transit Time (s)	0.41s	0.51s	0.45s

Table B-2b *Golden Plover Transit time through the rotors*

Turbine model	Nordex N149	Vestas V150	Nordex N133
Golden Plover Length (bill to tail) (*l*)	0.29m	0.29m	0.29m
Golden Plover Flight Speed (ms^{-1})	17.9ms^{-1}	17.9ms^{-1}	17.9ms^{-1}
Rotor depth (*d*)	4.15m	4.2m	3.94m
Transit Time (s)	0.25s	0.25	0.24

Table B-2c *Hen Harrier Transit time through the rotors*

Turbine model	Nordex N149	Vestas V150	Nordex N133
Hen Harrier Length (bill to tail) (*l*)	0.52m	0.52m	0.52m
Hen Harrier Flight Speed (ms^{-1})	9.1ms^{-1}	9.1ms^{-1}	9.1ms^{-1}
Rotor depth (*d*)	4.15m	4.2m	3.94m
Transit Time (s)	0.51s	0.52s	0.49s

Table B-2d *Kestrel Transit time through the rotors*

Turbine model	Nordex N149	Vestas V150	Nordex N133
Kestrel Length (bill to tail) (*l*)	0.35	0.35	0.35
Kestrel Flight Speed (ms^{-1})	10.1ms^{-1}	10.1ms^{-1}	10.1ms^{-1}
Rotor depth (*d*)	4.15m	4.2m	3.94m
Transit Time (s)	0.45s	0.45s	0.42s

Number of Transits through Rotors (b_{FR})

The number of times a bird will pass through the rotors in a season is calculated by dividing the Occupancy of the Rotor Volume (b) by the Transit Time through Rotors (v).

Viewshed Sufficiency (Vs)

Due to local topography, it may not be possible to achieve complete coverage of a whole Flight Risk Area from VPs due to dips or hollows in the landscape. Viewshed Analysis is a topographical model designed to determine the area that can be seen from a VP. It sets the observer height at 1.5m and the "floor" of the viewshed as required for the lowest swept area of the turbine blade (for Oatfield, this was set to 25m). The area visible down to 25m is then calculated. For Oatfield, Viewshed Sufficiency (Vs)was 98% of the Flight Risk Area.

Corrected Number of Transits through Rotors (b_C)

This is the Number of Transits through Rotors (b_{FR}) divided by the Vs. This correction assumes that none of the airspace within the area missed by the viewshed analysis is covered. Clearly this is not the case, as the higher the viewshed analysis floor rises, the greater the viewshed coverage will be. However, this correction factor therefore increases the number of transits used in the CRM, offering a more robust estimation of collision risk within the CRM.

This final metric concludes the calculations for Stage 1 of the CRM.