PAGERPOWER
Urban & Renewables

ILS Calibration Flight Impact Assessment

TOBIN Consulting Engineers

Castlebanny Wind Farm

December, 2020

PAGERPOWER
Urban & Renewables

ADMINISTRATION PAGE

Job Reference:	10027C
Date:	October, 2020
Prepared for:	TOBIN Consulting Engineers
Author:	Danny Scrivener
Telephone:	+44 (0)1787 319001
Email:	dannyscrivener@hotmail.com

First Reviewer:	Michael Sutton and Kai Frolic
Second Reviewer:	Mike Watson
Date:	October, 2020
Telephone:	+44 (0)1787 319001
Email:	michael@pagerpower.com; mike@pagerpower.com; kai@pagerpower.com

Issue	Date	Detail of Changes
1	October, 2020	Initial issue
2	December, 2020	Minor amendments – review by Kai Frolic

Pager Power Limited, Stour Valley Business Centre, Brundon Lane, Sudbury, CO10 7GB

T: +44 (0)1787 319001 E: info@pagerpower.com W: www.pagerpower.com

KEY FINDINGS

Background

Pager Power has conducted an Instrument Landing System (ILS) Calibration Flight Impact Assessment for the proposed Castlebanny Wind Farm development, which is located southeast of Ballyhale, Ireland. The assessment has considered the impact upon ILS calibration associated with Waterford Airport. The proposed wind farm lies approximately 25km north northwest (13.5 nautical miles) of Waterford Airport.

The proposed development consists of 21 wind turbines with a tip height of 185m above ground level (agl). This report considers potential impacts on flight checking of the airport's Instrument Landing System (ILS).

Waterford Airport

The diagram below shows the relative locations of the turbines, the runway and its extended centre line. The marks on the extended centre line have a spacing of 1 nautical mile.

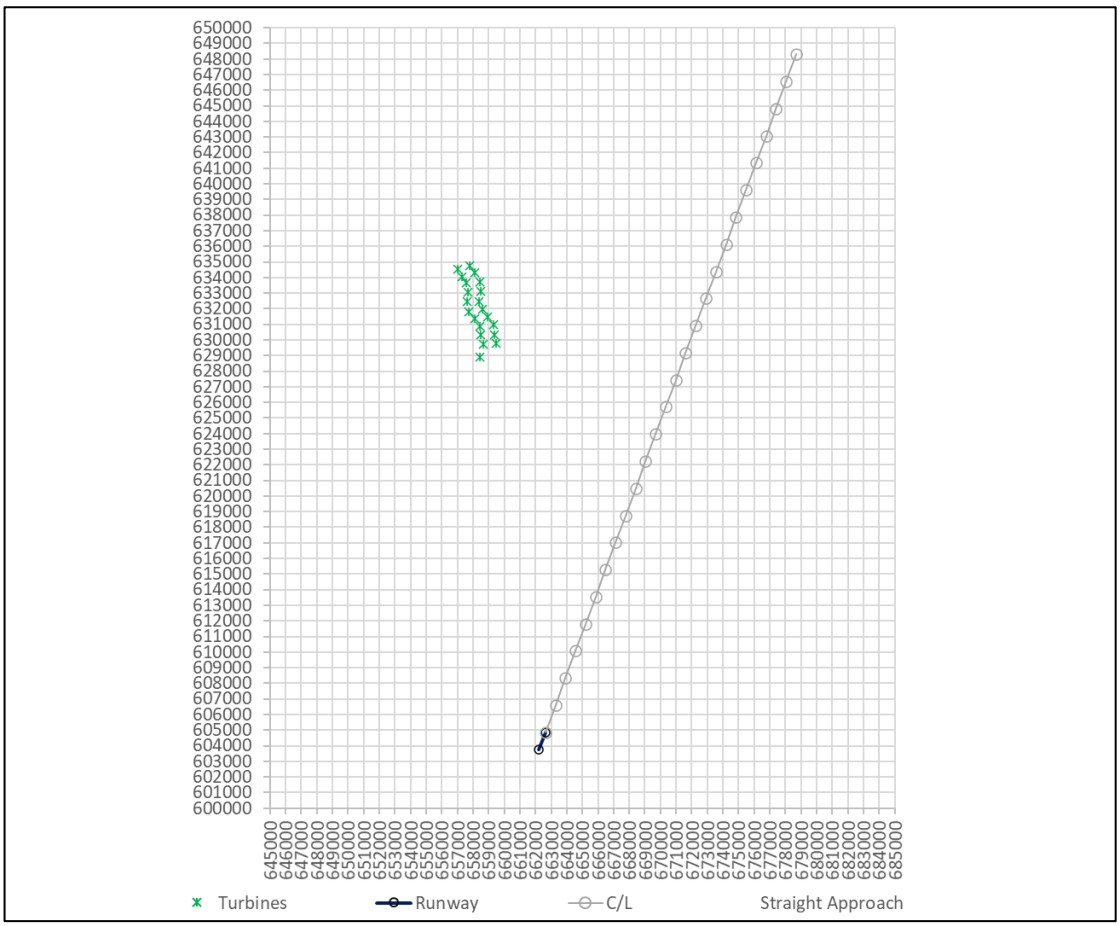

Chart showing Runway 03/21 extended centre line (C/L) and proposed wind farm

The chart shows proposed turbines, Runway 03/21 and extended runway Centre Line (marked C/L)

Test Flights

Waterford Airport has a range of radio transmitters which pilots use to navigate - one of these systems being an Instrument Landing System (ILS). The proposed wind farm will not affect aircraft using the ILS normally – however the Irish Aviation Authority (IAA) could raise concerns that the wind farm could affect periodic test flights that are used to calibrate and check the ILS.

These test flights fly a range of trajectories which either fly towards the airport or in an arc, or orbit, centred on the runway threshold[1]. The IAA has provided a schedule of ILS checks and their associated flight trajectories.

Assessment

The aircraft altitude (or height) has no impact on the horizontal separation between wind turbine and aircraft. Similarly, the wind turbine altitude (or height) has no impact on horizontal separation.

In this analysis only the horizontal clearance between aircraft and the turbines has been considered. This means that the results of this analysis apply for aircraft flying at any altitude profile on the specified horizontal trajectory. Similarly the results apply for any turbine height.

A software tool has been used to calculate the minimum horizontal separation between each specific (horizontally defined) trajectory and the nearest wind turbine or permanent meteorological masts.

Test Flight Procedures beyond 2 Nautical Miles from the Wind Farm

Most test flight procedures[2] will not be affected by the proposed wind farm and are more than 2 nautical miles away.

Aircraft flying approaches 8-degrees left of the runway extended centre line, commencing at 10 nautical miles or less, will be at least 8.04 nautical miles from the proposed wind farm with turbine 2 being closest.

Aircraft flying orbits of 6 nautical miles will be at least 7.17 nautical miles from the proposed wind farm with turbine 1 being closest.

Aircraft flying orbits of 25 nautical miles will be at least 8.64 nautical miles from the proposed wind farm with turbine 20 being closest.

[1] In practice the arcs are centred on the Runway 21 threshold which is the zero reference point for the DME (Distance Measuring Equipment) associated with the Instrument Landing System

[2] Plots showing these trajectories and the proposed wind turbines are available on request

Test Flight Procedures Nearest the Wind Farm

The three test flight procedures that are closest the proposed wind farm have been assessed:

- Aircraft flying the extended runway centre-line from 10nm pass 6.59 nautical miles south east of the proposed wind farm with turbine 2 being closest;
- Aircraft flying an eight-degree left slice approach from 16nm pass 4.44 nautical miles east of the proposed wind farm with turbine 2 being closest.
- Aircraft flying a 17 nautical mile orbit pass 0.64 nautical miles north of the proposed wind farm with turbine 20 (highlighted) being closest. This is shown on the diagram[3] below.

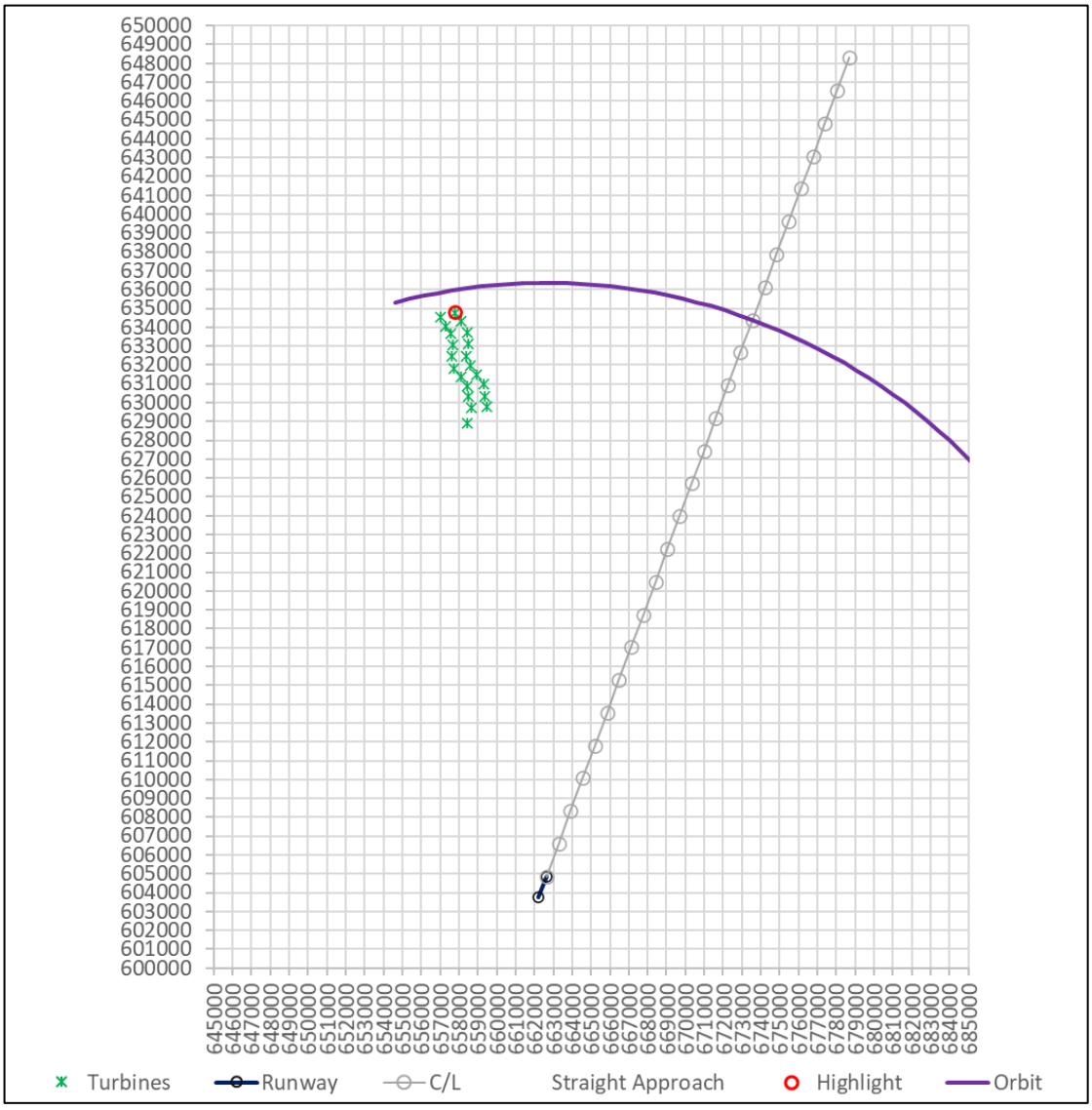

Chart showing proximity of turbines to 17 nautical mile orbit

[3] Chart shows proposed turbines, the procedure (purple line), Runway 03/21 and extended Centre Line (marked C/L).

Visual Flight Rules

Test flights are conducted under Visual Flight Rules (VFR) whereby pilots rely on their eyesight, rather than instruments[4], to avoid collisions. When flying VFR, pilots must ensure that they do not fly within 150 metres of any structure[5].

Wind turbines are complex structures with large moving rotors. The clearance distances in the analysis above relate to the wind turbine bases rather than the entire wind turbine structure. It is necessary to consider the assumed rotor radius of 77.5 metres when evaluating the calculated clearances.

All test flight procedures are 0.64 nautical miles or more from the proposed wind turbine towers. One nautical mile is 1852 metres which means that all trajectories are 1,185[6] metres from the proposed towers. Taking the rotor into account reduces the clearance distance between the test flight procedures and turbine to 1,107.5[7] metres.

Proposed New Runway

The proposed runway would extend the runway 21 threshold circa 480m further north northeast. The closest test flight procedure is the 17 nautical mile orbit. Considering the relative location to the proposed wind farm, the clearance would increase beyond those calculated for the existing runway. All other clearance from the test flight procedure would remain sufficiently clear. No change to the overall conclusions of this report considering the runway extension are anticipated.

Overall Impact

The horizontal clearance between aircraft flying the test trajectories and the turbines is circa 7.4 times the minimum horizontal clearance distance of 150 metres applicable for VFR (Visual Flight Rules) flights in Ireland. The proposed turbines will therefore not directly affect aircraft flying ILS test trajectories and should be therefore tolerable.

Mitigation

Whilst the proposed wind farm will not directly impede aircraft flying the test flight procedures it is recommended that pilots of test aircraft are made fully aware of the presence of wind turbines before undertaking any test flights. The following mitigation measures are therefore recommended:

- All turbines and meteorological masts having a height of 100m or more are promulgated in the Irish Air Navigation Obstacle database;
- The extremities of the wind farm are lit in accordance with IAA guidance;

[4] When relying on instruments pilots fly in accordance with Instrument Flight Rules (IFR)
[5] Irish Aviation Authority (Rules of the Air) Order, 2004 – Rule 3
[6] 0.141 x 1852 = 1,185
[7] 1,185 – 77.5 = 1,107.5

- Any meteorological masts are lit
- Location of any meteorological masts having a height of less than 100m are promulgated to the pilots of test aircraft[8]
- Test aircraft are fitted with Terrain Awareness and Warning System (TAWS);
- Test aircraft TAWS obstacle databases are regularly updated to ensure they contain the wind turbine locations prior to construction;
- Pilots of test aircraft are briefed regarding the proximity of wind turbines to aircraft flying a 17 nautical mile orbit.

Conclusions and Recommendations

It is recommended that this report is shared with Waterford Airport.

[8] This could be via the Aeronautical Information Publication or directly to pilots

LIST OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABOUT PAGER POWER

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company specializes in assessing the impact of wind turbines on aviation and radar - having undertaken projects in 48 countries within Europe, Africa, America, Asia and Australia.

The company comprises a team of experts to provide technical expertise and guidance on a range of planning issues for large and small developments.

Pager Power was established in 1997. Initially the company focus was on modelling the impact of wind turbines on radar systems. Over the years, the company has expanded into numerous fields including:

- Renewable energy projects.
- Building developments.
- Aviation and telecommunication systems.

Pager Power prides itself on providing comprehensive, understandable and accurate assessments of complex issues in line with national and international standards. This is underpinned by its custom software, longstanding relationships with stakeholders and active role in conferences and research efforts around the world.

Pager Power's assessments withstand legal scrutiny and the company can provide support for a project at any stage.

1 INTRODUCTION

1.1 Overview

Pager Power has conducted an ILS Calibration Flight Impact Assessment for the proposed Castlebanny Wind Farm development, which is located southeast of Ballyhale, Ireland. The assessment has considered the impact upon ILS calibration associated with Waterford Airport. The proposed wind farm lies approximately 25km north northwest (13.5 nautical miles) of Waterford Airport.

The proposed development consists of 21 wind turbines with a tip height of 185m above ground level (agl) with the maximum tip altitude rising to approximately 441.3m/1,447.8ft above mean sea level (amsl).

This report considers potential impacts on flight checking of the airport's Instrument Landing System (ILS).

1.2 Units of Measurement and Coordinate Systems

Units of measurement and coordinate systems normally used by the aviation and wind farm development industries differ. These differences are set out in the Table 1 below.

Parameter	Aviation	Onshore wind – Ireland	Conversion
Distance	Nautical Mile (nm)	Kilometre (km)	1nm = 1.852km
Height	Feet (ft)	Metres (m)	1ft = 0.3048m
Location	WGS84 Lat/Long	ITM Eastings and Northings	Specialist tool required

Table 1 *Units of measurement and coordinate systems*

2 PROPOSED DEVELOPMENT INFORMATION

2.1 Wind Turbine Details

The turbine details used in the assessment are as follows:

- Tip height: 185m;
- Rotor diameter: 155m.

The maximum altitude of the highest turbine (T6) is 441.3m/1,447.8ft above mean sea level (amsl).

2.2 Wind Turbine Layout

The preliminary wind turbine layout has been assessed within this report as provided by the developer. The co-ordinates of the turbine locations are shown in Table 2 below. The co-ordinates are presented in WGS84 longitude and latitude and also Irish Transverse Mercator Easting and Northing format.

ID	Longitude	Latitude	Easting	Northing	Maximum altitude (land height plus turbine height)	
					m	ft
T1	-7.14072	52.40853	658464.1	628904.1	394.8	1,295.3
T2	-7.12596	52.4162	659457.9	629770.2	433.8	1,423.2
T3	-7.13744	52.41566	658677.5	629700.7	403.2	1,322.8
T4	-7.12745	52.42138	659349.4	630344.9	438.2	1,437.7
T5	-7.14031	52.42132	658474.9	630327.9	383.2	1,257.2
T6	-7.12819	52.42701	659291.8	630970.6	441.3	1,447.8
T7	-7.14043	52.42625	658460.3	630875.9	390.0	1,279.5
T8	-7.13315	52.43146	658948	631462.1	422.4	1,385.8
T9	-7.14534	52.43062	658120.2	631358.7	369.2	1211.3
T10	-7.13789	52.43596	658620.1	631958.2	402.9	1321.9
T11	-7.15064	52.43488	657754.4	631827.8	365.9	1200.5

ID	Longitude	Latitude	Easting	Northing	Maximum altitude (land height plus turbine height)	
					m	ft
T12	-7.14133	52.44047	658380	632457.3	407.6	1337.3
T13	-7.15244	52.4404	657624.7	632440.5	379.0	1243.4
T14	-7.13927	52.44652	658511.9	633132.2	420.9	1380.9
T15	-7.15141	52.44615	657687.2	633081.1	398.9	1308.7
T16	-7.14055	52.45157	658418.4	633692.8	429.0	1407.5
T17	-7.15302	52.45132	657571.1	633654.6	413.4	1356.3
T18	-7.14506	52.45721	658104.6	634316.5	418.3	1372.4
T19	-7.1569	52.45506	657302.6	634068.7	410.4	1346.5
T20	-7.14946	52.46142	657799.8	634781.4	409.3	1342.8
T21	-7.1609	52.45933	657025.2	634540.6	367.7	1206.4

Table 2 *Turbine co-ordinates*

The locations of the assessed wind turbines are shown in Figure 1[9] on the following page.

[9] Source: Aerial imagery copyright © 2020 Google.

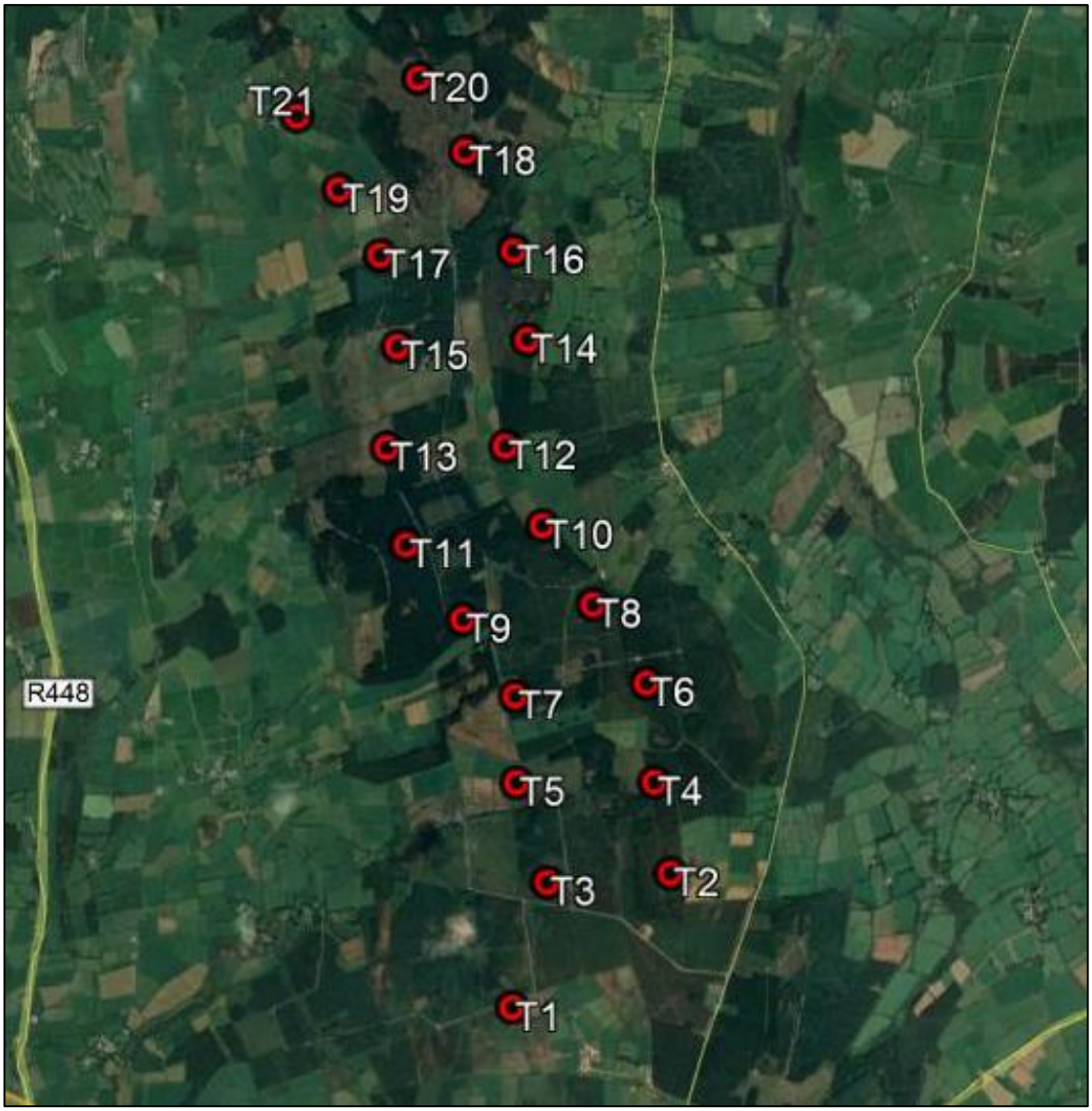

Figure 1 *Proposed wind farm layout*

3 WATERFORD AIRPORT

3.1 Airport Information

Waterford Airport is an Irish Aviation Authority (IAA) licensed aerodrome used predominately by private and commercial jet and fixed wing propeller aircraft. An ATC Tower is present on the airport.

3.2 Waterford Airport's Existing and Proposed Runway

The airport has indicated that the existing runway may be extended to allow for a larger aircraft to utilise the airport. The extension of the runway may have implications on proposed wind farm because the runway will be extended in the direction of the turbines which means the measurement point for ILS calibration (typically the runway threshold) would likely be relocated closer to the wind farm. The details for the existing and proposed runway are presented below.

Waterford Airport has one existing physical runway, 03/21, which measures 1,433m by 30m. This is shown on the aerodrome chart in Figure 2[10] on the following page. The runway threshold co-ordinates are presented in Table 3[11] below. Co-ordinates are presented in both decimal degree and degrees, minutes and seconds format (as per the Aeronautical Information Publication - IFP).

Runway Threshold	Longitude	Latitude	Altitude	Comments
THR 03	-7.0902472 0070524.89W	52.1819389 521054.98N	86ft 26.2m	Displaced 90m
THR 21	-7.0839556 70502.24W	52.1920111 521131.24N	113ft 34.4m	Displaced 143m

Table 3 *Runway threshold data used for the OLS assessment*

Waterford Airport have indicated that the runway maybe extended. This would involve relocating the runway 21 threshold further north[12] by approximately 480m. The details for the new runway 21 threshold are presented in Table 4 below.

Runway Threshold	Longitude	Latitude	Altitude	Comments
New THR 21	-7.0814194 7 ° 4'53.11" W	52.1960694 52° 11'45.85" N	131.7ft 40.14m	None

Table 4 *Runway threshold data used for the OLS assessment*

[10] Source: Irish Aviation Authority IAP.
[11] As above.
[12] Not including the threshold displacement.

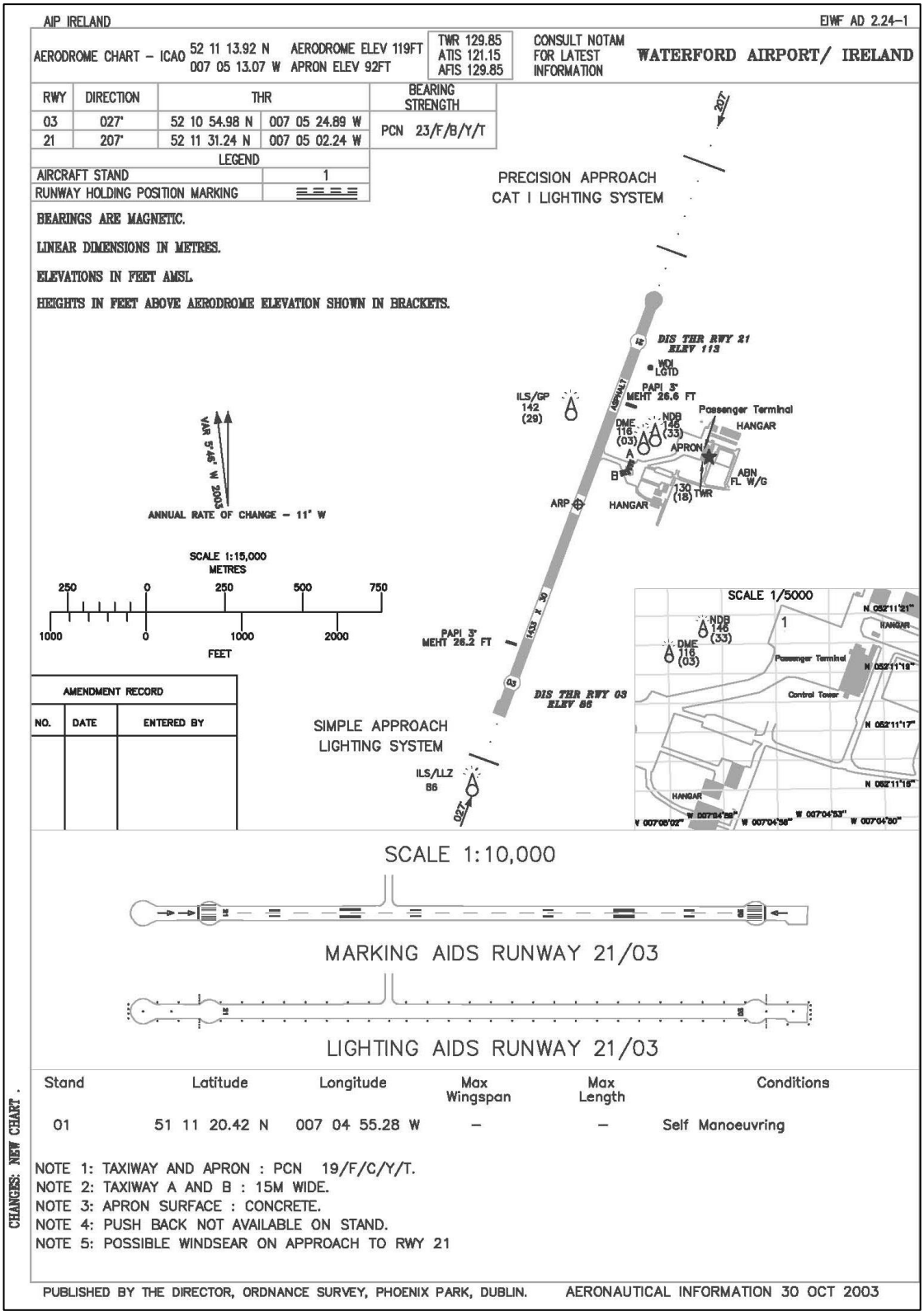

Figure 2 *Waterford Airport aerodrome chart*

The runway 21 threshold co-ordinates for the existing and proposed runway are shown in Figure 3[13] below.

Figure 3 *Runway 21 existing and proposed threshold co-ordinates*

3.3 Instrument Landing System

Specific parameters pertaining to the existing Runway 21 Instrument Landing System are shown in the Irish Aviation Authority Aeronautical Information Publication (AIP). These are presented in Table 5 below.

Parameter	Units	Value
ILS Category	n/a	Cat I
Slope	Degrees	3.2
Threshold Elevation	Feet	Existing runway 21 = 113 Proposed runway 21 = 131.7

Table 5 *Instrument Landing System Parameters*

As stated previously, the extension of the runway will likely relocate the ILS calibration test point to the new runway threshold. Throughout this analysis reference is made to this change where required.

[13] Source: Aerial imagery copyright © 2020 Google.

4 IAA ILS FLIGHT CHECK SCHEDULE AND KEY DATA

4.1 Overview

Waterford Airport has a range of radio transmitters which pilots use to navigate - one of these systems being an Instrument Landing System (ILS). The proposed wind farm will not affect aircraft using the ILS normally – however the Irish Aviation Authority (IAA) could raise concerns that the wind farm could affect periodic test flights that are used to calibrate and check the ILS.

The following section presents the flight schedule used for calibrating the ILS. A breakdown of what is involved within the procedure is also given.

4.2 Relevant Technical Data

4.2.1 Wind Farm Relevant Distances

The relevant ranges (to nearest and furthest wind turbines – T1 and T21 respectively) from the existing threshold, the proposed threshold and the DME are presented in Table 6 below.

Range from existing runway 21 threshold	Range from proposed runway 21 threshold	Range from the DME
24.40 – 30.31 km 13.18 - 16.37 nm	23.98 – 29.89 km 12.95 - 16.14 nm	24.76 – 30.66 km 13.37 - 16.56 nm

Table 6 *Proposed wind farm relevant distances*

4.2.2 Distance Measuring Equipment (DME)

The location and details regarding the DME are presented in Table 7 below.

Navigation Aid	Position of transmitting antenna coordinates	Elevation of DME transmitting antenna	Remarks
DME	521119.6N 0070502.0 W	110 ft	Designated Operational Coverage 25 DME reads Zero at RWY 21 THR. DME reads 0.3D at RWY 03 THR. Monitored only during hours as per ATS

Table 7 *DME details*

4.2.3 Summary

Based on the details presented above, relevant ILS check located at distances of 12-17nm may require further consideration depending on their specific procedure e.g. altitude. Any flight checks outside of this distance would be well clear of the turbines. It is assumed that the ILS calibration distances are referenced to the runway threshold. Consideration of both the existing and proposed runway 21 threshold has been made (see Section 5.3).

4.3 Relative Location to Waterford Airport

Figure 4 below shows the relative locations of the turbines, the runway and its extended centre line. The marks on the extended centre line have a spacing of 1 nautical mile.

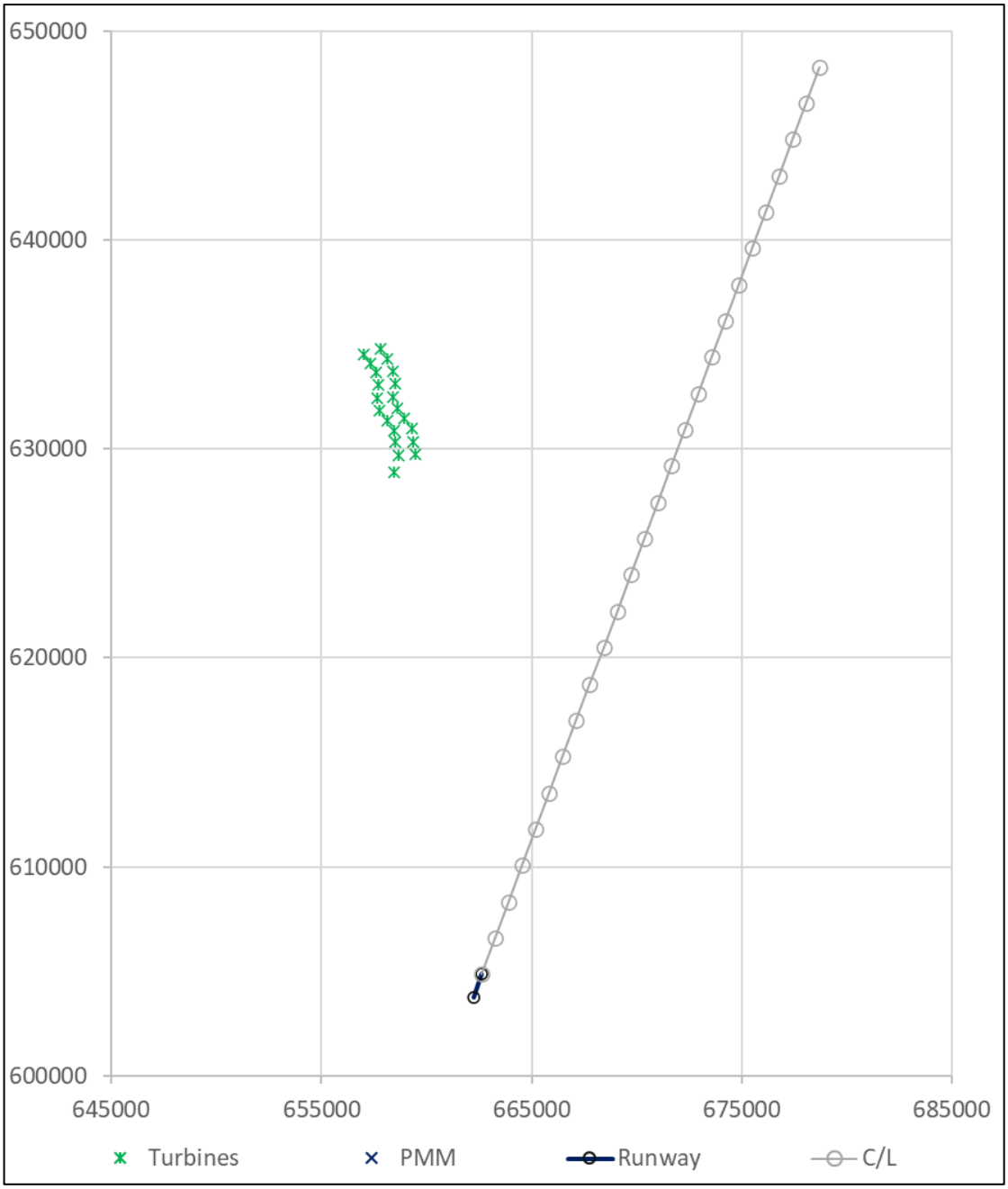

Figure 4 *Chart showing extended centre line and turbines*

4.4 ILS Flight Check Schedule – Test Flights

The test flights fly a range of trajectories which either fly towards the airport or in an arc, or orbit, centred on the runway threshold[14]. The IAA has previously provided a schedule of ILS checks and their associated flight trajectories. The flight check schedule[15] is presented on the following pages.

[14] In practice the arcs are centred on the Runway 21 threshold which is the zero reference point for the DME (Distance Measuring Equipment) associated with the Instrument Landing System

[15] Source: Provided by the IAA.

ILS flight check profiles

4.2 Routine ILS Inspection Profile Requirements

Note: Where only 1 transmitter is checked on a routine, subsequently the other transmitter will be checked on the next routine.

Section	Profile	Description	Procedure	Notes	TX
9.1.1	01	Centreline Approach	10NM-Threshold 3000'	Course Structure, Alignment, GP Angle & RF measurement	1or2
9.1.3	04	Loc Orbit	6NM 1500' +35-35°	Clearance	1or2
9.1.1	05	Centreline Approach Cat III only	2NM to Point E level 50ft down runway Centreline	Loc Course Structure, Alignment	1or2
9.1.1	12	Top Edge	1 NM required between 4NM-Point B 1800'	(75µA) 90Hz width	1or2
9.1.1	13	Bottom Edge	1 NM Required between 4NM-Point B 1500'	(75µA) 150Hz width	1or2
9.1.2	14	Slice for 3° GP	0.3θ ≈12NM-Threshold 1000'	Clearance	1or2
9.1.2	15	Left Slice for 3° GP	10NM-0.45θ 1000'	Coverage 8° of Centreline Both transmitters if M Array	Alt 1or2
9.1.2	16	Right Slice for 3° GP	10NM-0.45θ 1000'	Coverage 8° of Centreline Both transmitters if M Array	Alt 1or2
	All	Ident Loc/DME	Co-Pilot listens/FI	Check ident and synchronization	1or2
9.1.1	01	DME	4NM-1NM 1500'	DME Range Error	1or2

4.3 Annual ILS Inspection Profile Requirements

Section	Profile	Description	Procedure	Notes	TX
9.1.1	01	Centreline Approach	10NM-Threshold 3000'	RF, Course Structure, Alignment Angle GP & Loc	1&2
9.1.1	01	Centreline Approach	DOC or 10NM-Threshold on GP	Course Structure, Alignment Angle GP & Loc	1or2
9.1.1	01	Centreline Approach	10-4NM on GP & Loc	Power Ratio check (Two Freq Only) Course Line TX OFF	1or2

			C/L		
9.1.3	04	Loc Orbit	6NM 1500' +35-35°	Clearance	1&2
9.1.3	04	Loc Orbit	17NM 1500' +35-35°	Clearance & Coverage	1or2
9.1.3	04	Loc Orbit	25NM 2000' +10-10°	Clearance & Coverage	1or2
9.1.2	14	Loc Range Run	DOC or 25NM 2000'	Clearance	Alt 1or2
9.1.2	14	Slice for 3° GP	0.3θ DOC or 12NM-Threshold 1000'	Course Only (Two Freq Only)	1or2
9.1.1	05	Centreline Approach Cat III only	10NM to Point E level 50ft down runway Centreline	Course Structure, Alignment, GP Angle & RF measurement	1&2
9.1.1	12	Top Edge	4NM-Point B 1800'	(75μA) 90Hz width	1or2
9.1.1	13	Bottom Edge	4NM-Point B 1500'	(75μA) 150Hz width. See Note	1or2
9.1.2	14	Slice for 3° GP	0.3θ DOC or 12NM-Threshold 1000'	Course, Clearance & Coverage	1&2
9.1.2	14	Slice for 3° GP	0.3θ DOC or 12NM-Threshold 1000'	Course Only (Two Freq Only)	1or2
9.1.2	15	Left Slice for 3° GP	10NM-0.45θ 1000'	Coverage 8° of Centreline	Alt 1or2
9.1.2	16	Right Slice for 3° GP	10NM-0.45θ 1000'	Coverage 8° of Centreline	Alt 1or2
9.1.1	11	Centreline Approach	4NM-Threshold 1500'	Low & Wide, then Low & High Angle Alarm	1or2
9.1.1	12	Top Edge	4NM-Point B 1800'	Low & Wide then Wide & Narrow Alarm	1or2
9.1.1	13	Bottom Edge	4NM-Point B 1500'	Low & Wide, then Wide & Narrow Alarm	1or2
9.1.2	14	Slice	DOC or 10-2NM @ 1000'	Low & Wide Alarm for Clearance	1or2
9.1.2	14	Slice	DOC or 10NM-THD @ 1000'	Normal	1or2

9.1.1	01 *	Centreline Approach	4NM-Threshold 1500'	Fly Left & Right Alarms	1or2
9.1.3	04 *	Loc Orbit	6NM 1500' +35-35°	Wide Alarm	1or2
9.1.3	04 *	Loc Orbit	6NM 1500' +35-35°	Narrow Alarm	1or2
9.1.3	04 *	Loc Orbit	6NM 1500' +35-35°	Normal Check	1or2
	All	Ident LOC/DME	Co-Pilot/FI listens	Check ident and synchronisation	1&2
9.1.1	01	DME	4NM-1NM 1500'	DME Range Error	1or2
9.1.4		Promulgated procedure	Procedure-Threshold	Pilot comments	1 or2
9.1.5		Promulgated procedure & DME IFPs	Procedure-Threshold	Pilot comments	1or2

4.4 Commissioning ILS Inspection Profile Requirements

Section	Profile	Description	Procedure	Notes	TX
9.1.1	01	Centreline Approach	DOC or 10NM-Threshold on GP	RF, Course Structure, Alignment Angle GP & Loc	1&2
9.1.1	01	Centreline Approach	2000' 25NM-Threshold	Course Structure, Alignment Angle GP & Loc	1or2
9.1.1	01	Centreline Approach	10-4NM on GP & Loc C/L	Power Ratio check (Two Freq Only) Course Line TX OFF	1or2
9.1.1	01*	Centreline Approach	4NM-Theshold on GP & Loc C/L	Polarisation Check Roll 20° Left & Right	1or2
9.1.1	02	Left Edge	4NM-Point B 1500'	(150µA) 90Hz course width	1&2
9.1.1	03	Right Edge	4NM-Point B 1500'	(150µA) 150Hz course width	1&2
9.1.3	04	Loc Orbit	6NM 1500' +35-35°	Clearance & Coverage	1&2
9.1.3	04	Loc Orbit	17NM 1500'	Clearance & Coverage	1or2

			+35-35°		
9.1.3	04	Loc Orbit	25NM 2000' +10-10°	Clearance & Coverage	1or2
9.1.2	14	Loc Range Run	DOC or 25NM 2000'	Clearance	Alt 1or2
9.1.1	05	Centreline Approach Cat III only	2NM to Point E level 50ft down runway Centreline	Loc Course Structure, Alignment	1&2
9.1.1	12	Top Edge	4NM-Point B 1800'	(75µA) 90Hz width	1&2
9.1.1	13	Bottom Edge	4NM-Point B 1500'	(75µA) 150Hz width	1&2
9.1.2	14	Slice for 3° GP	0.3θ DOC or 12NM-Threshold 1000'	Course, Clearance & Coverage	1&2
9.1.2	14	Slice for 3° GP	0.3θ DOC or 12NM-Threshold 1000'	Course Only (Two Freq Only)	1or2
9.1.2	15	Left Slice for 3° GP	16NM-0.45θ 1000'	Coverage 8° of Centreline	1&2
9.1.2	16	Right Slice for 3° GP	16NM-0.45θ 1000'	Coverage 8° of Centreline	1&2
9.1.1	11	Centreline Approach	4NM-Threshold 1500'	Low & Wide, then Low & High Angle Alarm	1or2
9.1.1	12	Top Edge	4NM-Point B 1800'	Low & Wide then Wide & Narrow Alarm	1or2
9.1.1	13	Bottom Edge	4NM-Point B 1500'	Low & Wide, then Wide & Narrow Alarm	1or2
9.1.2	14	Slice	DOC or 10-2NM @ 1000'	Low & Wide Alarm for Clearance	1or2
9.1.2	14	Slice	DOC or 10NM-THD @ 1000'	Normal	1or2
9.1.1	01 *	Centreline Approach	4NM-Threshold 1500'	Fly Left & Right Alarms	1or2
9.1.3	04 *	Loc Orbit	6NM 1500' +35-35°	Wide Alarm	1or2
9.1.3	04 *	Loc Orbit	6NM 1500' +35-35°	Narrow Alarm	1or2
9.1.3	04 *	Loc Orbit	6NM 1500' +35-35°	Normal Check	1or2
9.1.3	20	Orbit	5NM @1500' 360°	DME Coverage check 20° only on 2nd TX	1&2
9.1.4		Promulgated procedure	Procedure-Threshold	Pilot comments	1or2
9.1.5		Promulgated procedure	Procedure distance spot checks for:-	IFP's, Missed Approach, Direct arrivals, Hold, En-Route	1or2

4.5 Additional Commissioning ILS Inspection Profile Requirements

For Side Band Reference & M Array Glide Paths

	Profile	Description	Procedure	Notes	TX
9.1.2	14	Slice	DOC or 10-2NM @ 1000'	Dephase Upper Antenna with monitor in Alarm	1or2
9.1.2	14	Slice	DOC or 10-2NM @ 1000'	Dephase Lower Antenna with Monitor in Alarm	1or2
9.1.2	14	Slice	DOC or 10-2NM @ 1000'	Advance Middle Antenna	1or2
9.1.2	14	Slice	DOC or 10-2NM @ 1000'	Retard Middle Antenna	1or2

Figure 5 *ILS flight check schedule*

4.5 ILS Flight Check Schedule Discussion

The list below presents each of the flight check procedures which warrant further investigation:

1. Extended Runway Centre-Line – 10nm;
2. Eight Degree Right Slice Approach – 16nm at 1,000ft[16];
3. Loc Orbit – 17nm at 1,500ft centred on the threshold 35 degrees either side.

[16] This is a commissioning procedure. A similar procedure out to 10nm rather than 16nm is also completed under a routine ILS inspection. This commissioning procedure has been considered for completeness because it passes closer to the wind farm.

5 ILS ASSESSMENT AND DISCUSSION

5.1 Overview

The aircraft altitude (or height) has no impact on the horizontal separation between wind turbine and aircraft. Similarly, the wind turbine altitude (or height) has no impact on horizontal separation.

In this analysis the horizontal clearance between aircraft and the turbines has been considered initially. These initial horizontal results of this analysis apply for aircraft flying at any altitude and for any turbine height.

A software tool has been used to calculate the minimum horizontal separation between each specific (horizontally defined) trajectory and the nearest wind turbine.

Three flight check procedures have been analysed in greater detail (see Section 4.5). All remaining procedures are well at distances where no effects would be anticipated (discussed in Section 5.2.1). Chart for these can be provided upon request.

Where a potential horizontal conflict between trajectories and turbines is identified an analysis of vertical separation has been undertaken.

5.2 Flight Check Analysis

The analysis for the relevant flight checking procedures is presented in the following subsections.

5.2.1 Key Test Flight Procedures beyond 2 nautical miles from the Wind Farm

Most test flight procedures[17] will not be affected by the proposed wind farm and are more than 2 nautical miles away.

Aircraft flying approaches 8-degrees left of the runway extended centre line, commencing at 10 nautical miles or less, will be at least 8.04 nautical miles from the proposed wind farm with turbine 2 being closest.

Aircraft flying orbits of 6 nautical miles will be at least 7.17 nautical miles from the proposed wind farm with turbine 1 being closest.

Aircraft flying orbits of 25 nautical miles will be at least 8.64 nautical miles from the proposed wind farm with turbine 20 being closest.

[17] Plots showing these trajectories and the proposed wind turbines are available on request

5.2.2 Test Flight Procedures nearest the Wind Farm

The three test flight procedures that are closest the proposed wind farm have been assessed.

5.2.2.1 Extended Runway Centre-Line

Aircraft flying the extended runway centre-line from 10nm pass 6.59 nautical miles south east of the proposed wind farm with turbine 2 being closest. Turbine 2 is highlighted in Figure 6 below. This chart shows Runway 03/21, the procedure (red line), the extended centre-line as well as the proposed turbines.

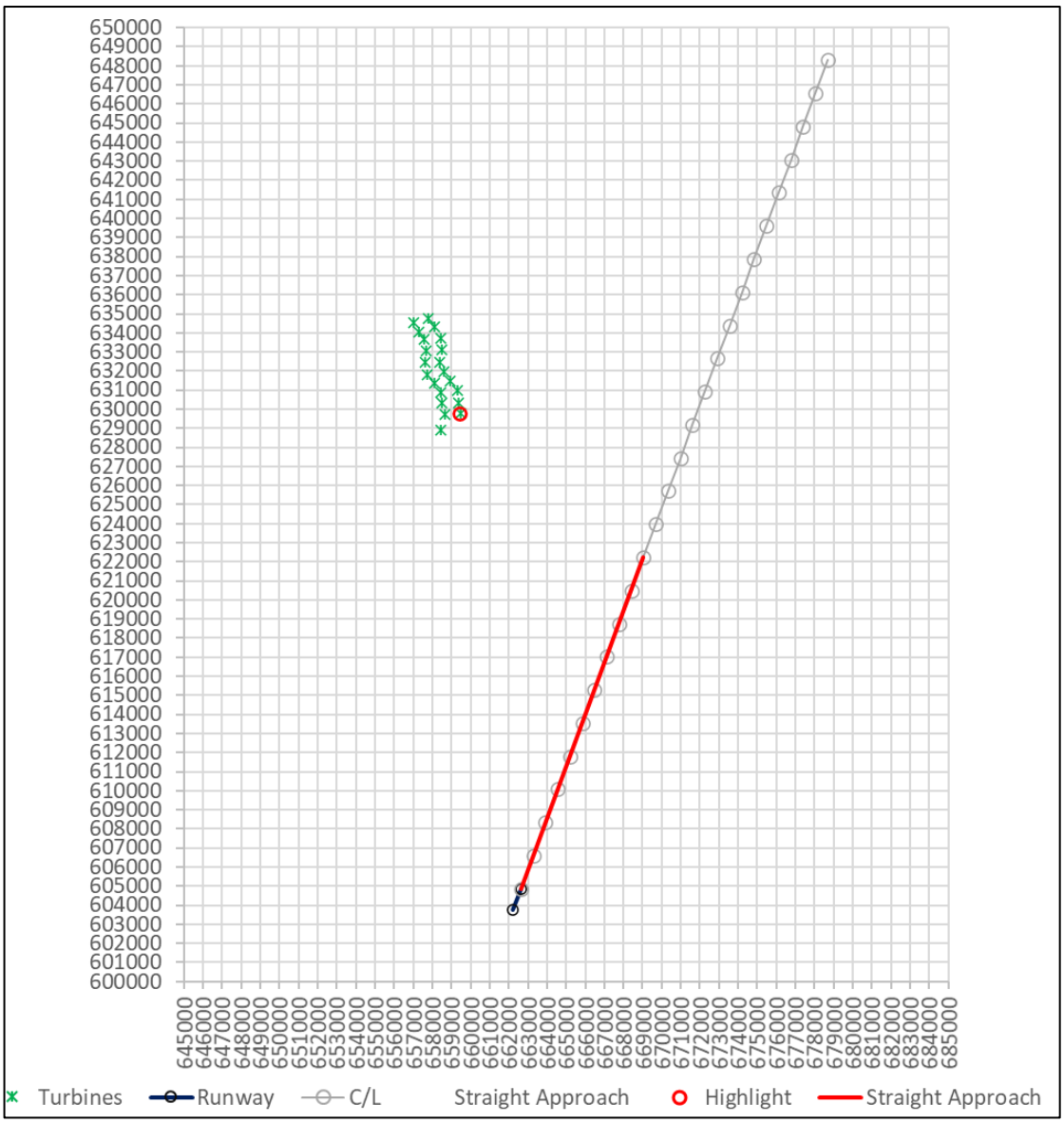

Figure 6 *Chart showing proximity of turbines to Extended Runway Centre-Line*

5.2.2.2 Eight Degree Right Slice Approach

Aircraft flying an eight-degree left slice approach from 16nm pass 4.44 nautical miles east of the proposed wind farm with turbine 2 being closest. Turbine 2 is highlighted in Figure 7 below. This chart shows Runway 03/21, the procedure (red line), the extended centre-line as well as the proposed turbines.

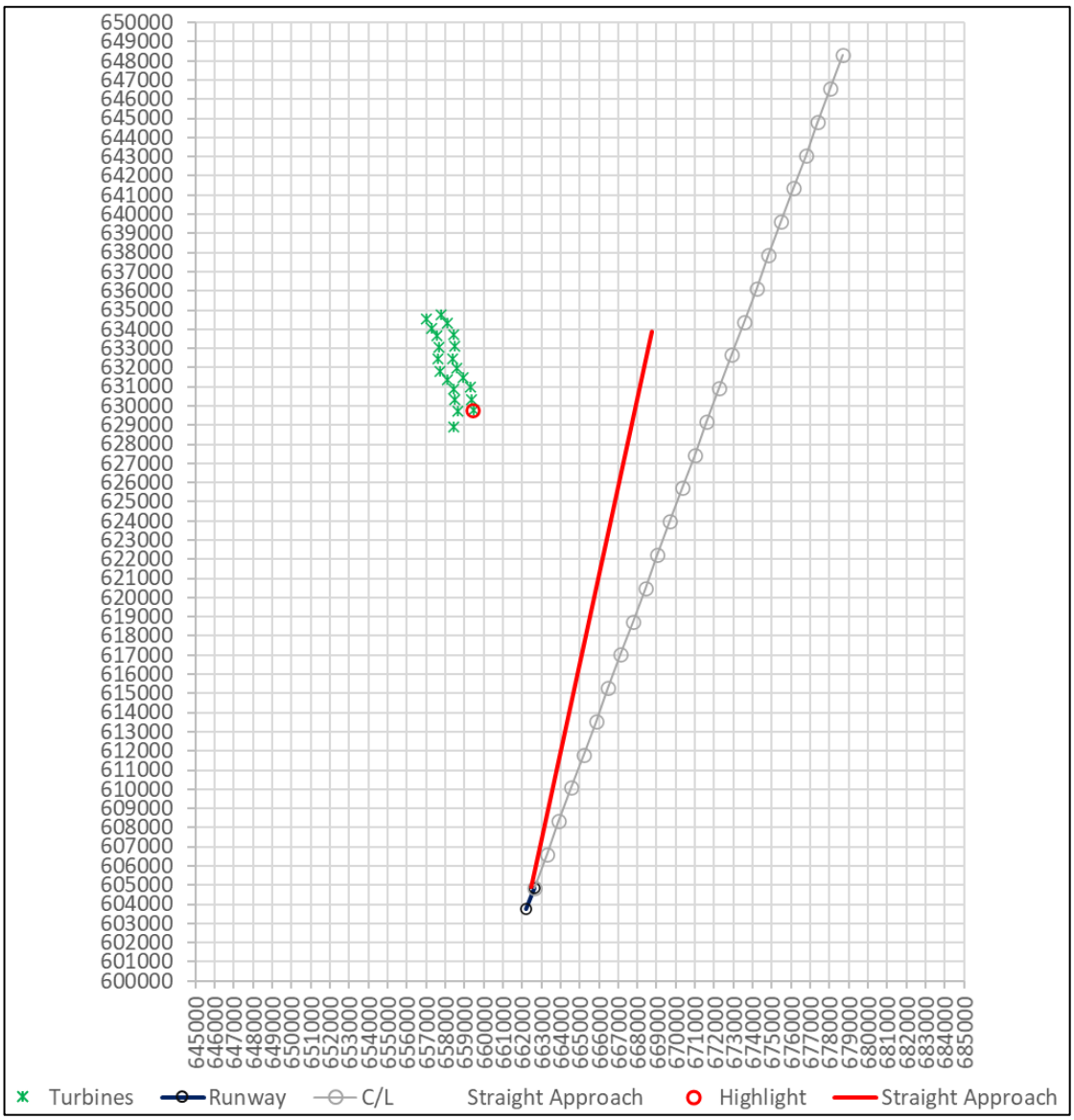

Figure 7 *Chart showing proximity of turbines to 8-degree right slice approach*

5.2.2.3 17 Nautical Mile Orbit

Aircraft flying a 17 nautical mile orbit pass 0.64 nautical miles north of the proposed wind farm with turbine 20 being closest. Turbine 20 is highlighted in Figure 8 below. This chart shows Runway 03/21, the procedure (purple line), the extended centre-line as well as the proposed turbines.

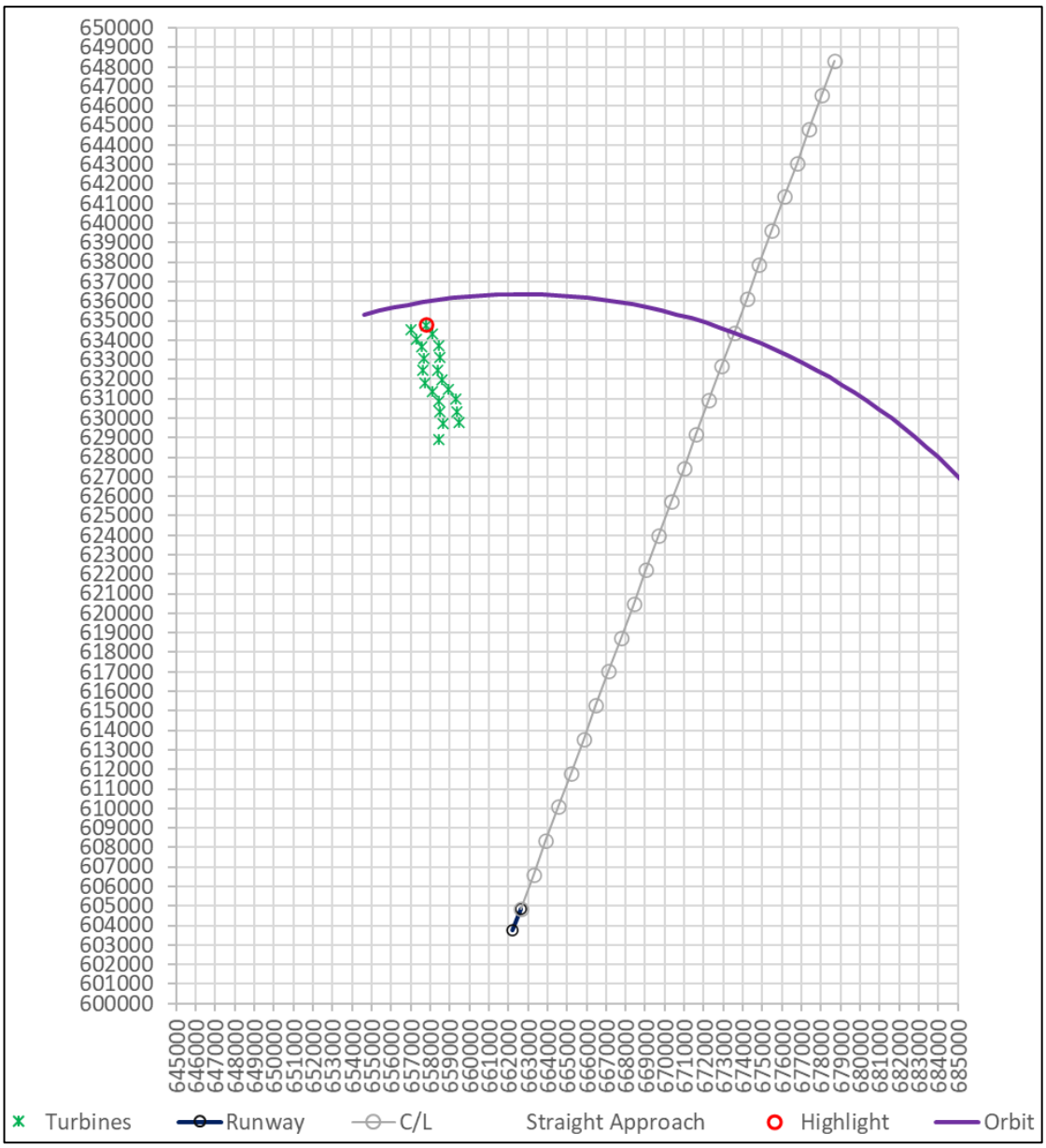

Figure 8 *Chart showing proximity of turbines to 17 nautical mile orbit*

5.2.3 Visual Flight Rules

Test flights are conducted under Visual Flight Rules (VFR) whereby pilots rely on their eyesight, rather than instruments[18], to avoid collisions. When flying VFR, pilots must ensure that they do not fly within 150 metres of any structure[19].

Wind turbines are complex structures with large moving rotors. The clearance distances in the analysis above relate to the wind turbine bases rather than the entire wind turbine structure. It is necessary to consider the assumed rotor radius of 77.5 metres when evaluating the calculated clearances.

All test flight procedures are 0.64 nautical miles or more from the proposed wind turbine towers. One nautical mile is 1,852 metres which means that all trajectories are 1,185[20] metres from the proposed towers. Taking the rotor into account reduces the clearance distance between the test flight procedures and turbine to 1,107.5[21] metres.

5.2.4 Vertical Clearance Calculation

The test flights, on the current trajectory, will have to fly within 1,107.5 metres horizontally of the turbines. Vertical analysis has therefore been undertaken to determine whether there will be sufficient clearance between aircraft flying a 17 Nautical Mile Orbit and the wind turbines.

Aircraft flying this orbit will be flying at an altitude of 1,500 feet which is above the maximum turbine tip altitude of 1,447.8 feet. There is therefore a minimum vertical clearance between wind the turbines and aircraft flying this test flight procedure of 52.2 feet.

5.3 Proposed New Runway

The proposed runway would extend the runway 21 threshold circa 480m further north northeast. The closest test flight procedure is the 17 nautical mile orbit. Considering the relative location to the proposed wind farm, the clearance would increase beyond those calculated for the existing runway. All other clearance from the test flight procedure would remain sufficiently clear. No change to the overall conclusions of this report considering the runway extension are anticipated.

5.4 Overall Impact

The horizontal clearance between aircraft flying the test trajectories and the turbines is circa 7.4 times the minimum horizontal clearance distance of 150 metres applicable for VFR flights in Ireland. The proposed turbines will therefore not directly affect aircraft flying ILS test trajectories and should be therefore tolerable.

---

[18] When relying on instruments pilots fly in accordance with Instrument Flight Rules (IFR)
[19] Irish Aviation Authority (Rules of the Air) Order, 2004 – Rule 3
[20] 0.141 x 1852 = 1,185
[21] 1,185 – 77.5 = 1,107.5

6 CONCLUSIONS AND MITIGATION

6.1 Conclusions and Mitigation

The proposed development will not directly impede aircraft flying the test trajectories. This is because the horizontal clearance between aircraft and the turbines is circa 7.4 times the minimum horizontal clearance distance of 150 metres applicable for VFR flights in Ireland. It is, however, recommended that pilots of test aircraft are made fully aware of the presence of wind turbines, and any associated anemometry masts, before undertaking any test flights. The following mitigation measures are therefore recommended:

- All turbines and meteorological masts having a height of 100m, or more, are promulgated in the Irish Air Navigation Obstacle database;
- The extremities of the wind farm are lit;
- Meteorological masts are lit;
- Locations of meteorological masts having a height of less than 100m are promulgated to the pilots of test aircraft[22];
- Test aircraft are fitted with Terrain Awareness and Warning System (TAWS);
- Test aircraft TAWS obstacle databases are regularly updated to ensure they contain the wind turbine locations prior to construction;
- Pilots of test aircraft are briefed regarding the proximity of wind turbines to aircraft flying a 17 nautical mile orbit.

6.2 Conclusions and Recommendations

It is recommended that this report is shared with Waterford Airport.

[22] This could be via the Aeronautical Information Publication or directly to pilots

PAGERPOWER

Urban & Renewables

Pager Power Limited
Stour Valley Business Centre
Sudbury
Suffolk
CO10 7GB

Tel: +44 1787 319001 **Email:** info@pagerpower.com **Web:** www.pagerpower.com