AERONAUTICAL TECHNICAL BRIEFING NOTES

PROPOSED WINDFARM

CASTLEBANNY COUNTY KILKENNY

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Requested by Kieran O'Malley

Coillte

Macroom

Cork

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Executive Summary

It is my professional opinion that the proposed Castlebanny wind farm will have no measurable negative effect on the Air Corps' operations in the area including its ability to access regional areas. It may even have a net positive effect in providing excellent landmarks for visual navigation. All manoeuvres that might be carried out while using the relatively straight stretch of the M9 as an aid for visual navigation can be comfortably carried out within a distance of less than a half a nautical mile from the motorway centreline. In addition, the locations of the turbines, the closest to the motorway being 1.5 nautical miles, are on high hills to the east of the motorway where the visibility and cloud base will almost inevitably be less than on the motorway or to the west of it.

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1. THE AUTHOR

This report has been prepared by Captain Fintan Richard Ryan. Capt. Ryan is a Chartered Engineer and holds a Master's Degree in Engineering from University College Dublin. He is a member of The Institution of Engineers of Ireland and a Fellow of the Royal Aeronautical Society. For 22 years he was an airline pilot with Aer Lingus, the last five as a senior captain and has total flight hours circa 9000. Capt. Ryan has completed courses on accident investigation and safety assessment of aircraft systems at Cranfield University, UK. While employed as a pilot by Aer Lingus Capt. Ryan investigated a number of major air accidents and was an "Accredited Accident Investigator" for The International Federation of Airline Pilots' Association. In 1985 he was employed by Inmarsat (International Mobile Satellite Organization) London. Capt. Ryan was also a lead member in the team that designed and implemented their aeronautical satellite communication and navigation systems.

2. INTRODUCTION

I have been engaged by Coillte to provide some briefing/technical notes in connection with a proposed windfarm at Castlebanny near Mullinavat in County Kilkenny and respond to issues raised by the Department of Defence in a letter to Tobin Consulting Engineers dated 20 March 2020.

It is my personal opinion that currently, in relation to aviation, tall structures such as wind turbines should be allowed anywhere provided they do not limit the operational performance of aircraft when they are taking off and landing. That is they do not restrict a flight in any way as regards distance to destination and/or in relation to the maximum payload. In addition, due consideration should be given to areas designated for low flying by the Air Corps and cases where navigation systems/radar civil and/or military might be adversely affected.

As regards navigation, the turbines are marked on maps, lit at night and entered into aircraft navigation databases and therefore can be avoided during flight.

3. AIR CORPS REQUIREMENTS

The Air Corps in its draft[1] document: Air Corps Wind Farm/Tall Structures Position Paper lists critical low level routes in support of their operational requirements and is opposed to the erection of wind farms or tall structures within 3NM of the route centreline which could affect Air Corps' ability to access regional areas. Among these critical routes is listed the M9. The proposed development comprises 21 turbines in two 3.5 NM rows almost parallel to a relatively straight stretch of the motorway. They differ in distance from the M9 with the furthest being 3.7 NM and the closest 1.5 NM from the motorway centreline.

Every structure, in the limit, will affect the Air Corps' ability to access regional areas. However, the question is how much will a given structure affect a flight and how much extra time and/or fuel is involved if so affected? It is my opinion that the proposed Castlebanny wind farm will have no measurable negative effect on Air Corps

[1] *The Irish Air Corps position paper… is a draft document that outlines the organisation's concerns about the impact wind farm development may have on safety and capabilities.* Air Corps quote from Irish Times, Jan 26, 2019, 01:00

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operations in the area. It may even have a net positive effect in providing excellent visual landmarks for VFR navigation.

4. THE AIRSPACE IN THE AREA

The airspace in the area of the Castlebanny wind farm is Class G below about 7500 feet above sea level, depending on atmospheric pressure. That means that no flight plan is required, and pilots are responsible for their own separation from other aircraft and obstacles. Air Traffic Control are not normally involved. There is no special arrangement for military aircraft in this airspace and it is not in a prohibited, restricted, military operating area or danger area. In my opinion the airspace would be considered an area of low volume traffic regarding Note b) 2 of Rule 34 of IAA Rules of the Air. Above about 7500 feet is controlled air space and it is necessary to file a flight plan to fly there. Aircraft operating under instrument flight rules will not be affected by the proposed turbines. The tracks from Casement Aerodrome to the licensed and certified aerodromes in Ireland do not pass over the wind farm. The closest is Waterford where the direct track is about 6 NM east.

5. SURROUNDING TERRAIN

The terrain to the east of the M9 is very unfriendly, especially for single engine aircraft, as it mostly forestry, rising steeply to a height of 826 feet near Mullinavat. Best options by far for manoeuvring such as loitering, reverse course, avoiding low cloud or low visibility and forced or precautionary landings would be to the west of the M9, where the land is more or less the same elevation as the road with lots of big fields, on the opposite side of the motorway from the proposed turbines

6. THE PROPOSED TURBINES

The 21 turbines are configured in two lines to the east of the M9 over a distance of about 3.5 NM. Each turbine tip is 607 feet above ground level with the hubs at 353 feet above ground level. The location of the turbines relative to the motorway is to the east, between Junction 11, Mullinavat and Junction 10, Knocktopher. At a typical cruising ground speed of 120 KT (Cessna 172, Eurocopter 135) the location would be traversed in less than 2 minutes. Pilots using the motorway for navigation guidance would easily identify the beginning and end of the wind farm area from the sight of the junctions. The highest turbine tip elevation is turbine 4, 1440 feet above MSL, which is 2.3 NM from motorway. The nearest turbine to the road is turbine 1 at 1.5 NM, 1273 feet above MSL. The average elevation of the motorway in the area is about 350 feet.

7. VISUAL METEOROLOGICAL CONDITIONS

Visual Flight Rules (VFR) are rules which apply when navigating visually in Visual Meteorological Conditions (VMC). VMC means meteorological conditions expressed in terms of visibility, distance from cloud, and cloud base equal to or better than the minima specified in Rule 34 of Rules of the Air.

The visibility etc required to fly legally in VMC are varied, and for example, can change from 8 Kms to less than 1.5 Kms for some helicopters, and depend on speed and manoeuvrability and even traffic density. An extremely difficult area to argue about so an area to stay out of if possible.

The minimum legal height in the area is 500 feet above the ground or water.

8. WEATHER CONSIDERATIONS

If the cloud base is below 500 feet over the M9 then it will be on the surface in the area of the turbines. In the case of reducing cloud base (ceiling) and or visibility, the likely alteration in course is to the west away from the higher ground and the wind farm.

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9. USING RADIO NAVIGATION AIDS IN VFR FLIGHT

In general it shows good airmanship to use all the information available, even for VFR flights. This includes the tools available for instrument flight rules (IFR).

In the area of the windfarm, particularly at higher altitudes, the State certified terrestrial navigation aids at Waterford Airport (20 NM) and the DME at Wolftrap (40 NM) are well within reliable range. The Cork VOR/DME may also be useful (50 NM). Using modern satellite based navigation receivers such as GNSS/GPS, which no doubt are or will be installed in Air Corps aircraft, can provide very good guidance for pilots flying VFR if the installed database is correct. The GNSS equipment can be used as a secondary or reference aid to provide situational awareness. In particular this enables pilots to be aware of where obstacles such as wind turbines are located related to aircraft position. As I write there are 27 GNSS satellites in view above 20° in elevation, any 4 of which would give accuracies better than about 10 metres. See Appendix 2.

To quote the IAA: "*Fly and navigate your route visually, only use the GNSS as a secondary aid and cross-check regularly.*"

10. USING THE M9 AS A NAVIGATION AID IN VISUAL FLIGHT RULES

There are many reasons why the Air Corps would wish to have a clear distance on either side of the M9, but it may be useful to ask for the rationale for picking this 3 NM figure. The reasons and necessary distances are discussed below:

a) Reverse Course

Due to deteriorating visibility and/or reducing cloud base it may be necessary to reverse course by performing a 180° turn while following a linear feature.

Let us assume that the aircraft is flying south above the M9 at a low speed, considering the conditions, and flying say 300 ft (0.05 NMs), to the right of the road as per Rules of the Air. Assuming a Cessna 172 or helicopter as an example and a true airspeed of 80 KT, initially turning towards the road so as to leave the road to the left on completion of the reversal. As regards wind, assume a worst case of 25 KT crosswind. This puts the aircraft 0.33 NMs east of the road on completion of the turn. This is less than a quarter of the of the distance to the nearest turbine, number 1.

b) Deviation from course

When following a linear feature, the primary consideration is not maintaining visual contact with the feature but ensuring that legal requirement to see the ground at a legal altitude is maintained. This may require deviation off the track being followed. Due to the right hand rule, this deviation should be to the right.

Since around the location of the proposed turbines the road is in a valley with the highest ground to the east, the likely best visibility, especially with lowering cloud base, is not to either side where the ground is generally higher but straight ahead. Good airmanship would dictate that deviations from track to remain in VMC would take place taking into account the location of known obstacles. In this case any deviation should be to the west and away from the higher hills and proposed turbines to the east.

c) Forced Landing

Assuming the aircraft was forced to land due engine failure near the turbines, in the case of the Cessna with a glide ratio of 9 approximately and at 1,000 ft height it would glide only 9000 ft in air and presumably shorter

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over the ground since such a landing would be made into wind. The wind turbines should not be a problem since they are located mostly in wooded, hilly areas unsuitable for forced landings. A helicopter of course would be less of a problem in choosing a landing site near the road.

d) Loiter

Loitering is a term used to describe a period when an aircraft is "killing time" waiting for something to happen such as a weather event to clear. Such loitering is normally carried out at the maximum endurance airspeed and in a suitable area away from obstacles. The maximum endurance speed is the speed which allows the aircraft to stay airborne for the longest time with the fuel available.

For the Cessna 172 this speed is approximately 70 KTs. At a bank angle of 25° the radius of turn would be 933 ft or 0.15 NMs, well clear of turbines. As regards a helicopter, it of course can turn in its own radius while hovering but for maximum endurance a higher speed would be preferred. Either way it can loiter within a fraction of a nautical mile radius

e) Landing

In the area west of the M9 near the turbines there are many large fields that would be suitable for a helicopter (particularly a twin engine) or even a Cessna 172 to make a precautionary landing. However, landing a fixed wing aircraft could be problematic to the east even if the wind farm did not go ahead. Nevertheless, the location of the nearest wind turbine is in a forested area which of course would never be suitable for a landing.

f) Conclusion on M9 Navigation

The wind turbines around 1.5 NMs from the motorway at closest point, should not have any effect on aircraft using the road as an aid to navigation and the safety margins for the operation of such flights will remain the same as before. I do not believe any flight would have to be cancelled or abandoned on the route along the M9 because of the existence of the proposed turbines.

11. EXISTING WIND FARMS NEAR ROADS

According to Irish Aviation Authority figures there are 165 wind farms in Ireland with heights above the ground of 100 metres or greater. Probably the closest to a major road is a 12-turbine farm near Roscrea with the nearest turbine to the M7 only 0.23 NMs and the furthest only 1.2 NMs.

The Irish Times in an article quotes the Department of Defence "*The Irish Air Corps position paper… is a draft document that outlines the organisation's concerns about the impact wind farm development may have on safety and capabilities.. [it] was compiled in line with international practice and takes into account the necessities to defend the state and carry out other roles."*

A Google search for wind turbines on the edges of motorways gives multiple images from all over the world.

12. LIGHTING REQUIREMENTS

The obstruction lightning standards for Wind Turbines are contained in (ICAO Annex 14 , 2018) and as an ICAO[2] signatory country these standards and recommendations would be required by the IAA.

[2] International Civil Aviation Organisation

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13. CONCLUSION

It is my opinion that the proposed Castlebanny wind farm will have no measurable negative effect on Air Corps operations in the area including its ability to access regional areas. It may even have a net positive effect in providing excellent visual landmarks for VFR navigation. All manoeuvres that might be carried out while using the M9 as an aid for visual navigation can be comfortably carried out within a distance of less than a half a nautical mile from the motorway centreline. In addition, the locations of the turbines, the closest to the motorway being 1.5 nautical miles, are on high hills to the east of the motorway where the visibility and cloud base will almost inevitably be less than on the motorway or to the west of it.

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APPENDIX 1 - TURN RADIUS CALCULATIONS

The calculations below refer to the turn radius and g loading of an aircraft in a 25° banked turn. In visual flying one uses bank angle, normally the ICAO recommended 25° which gives a g loading of 1.1 g, the normal load felt say in a commercial aircraft, certainly not in any way stressful even for an invalid. I have done calculations for 25° as per ICAO but as a pilot in an aircraft like a Cessna 172, which I have flown a lot myself, I would be happy to do a bank angle of up to 45°to turn back giving a radius of about 570 feet or less than 0.1 NMs with a g loading of about 1.4.

Rate of turn: $ROT = 1091 \times Tan\ \theta / TAS$

For 25° banked turn at 80 KTs: 1091x0.47/80 = 6.36°per minute

Radius of turn feet: R = V^2/11.26 Tan θ

For 25° bank angle at 80 KTs: 6400/11.26 x 0.47 = 1209 feet = 0.2 NM

Load factor (g): 1/Cos θ

For 25° = 1/0.91 = 1.1 g

Where **θ** = Aircraft bank angle and **V** = Aircraft true airspeed

Formula from Mechanics of Flight Keremode and Pilot's Handbook Aeronautical Knowledge (FAA)

	For 25° Bank Angle	
knots	radius feet	Radius NMs
70	933	0.15
80	1219	0.20
90	1543	0.25
100	1905	0.31
110	2305	0.38
120	2743	0.45

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APPENDIX 2 CURRENT SATELLITE NAVIGATION - GNSS

Introduction

We are most of us familiar with Satnav as used in our cars and by hikers etc. In much the same way, aircraft pilots are guided by the same satellite systems but with a much higher level of integrity and with various augmentations. In many cases the signals from these satellite systems are trusted by pilots to take them right down to the runway threshold. These satellite systems together with their augmentations are called Global Navigation Satellite System (GNSS).

ICAO defines GNSS as *a worldwide position and time determination system that includes one or more satellite constellations, aircraft receivers and system integrity monitoring, augmented as necessary to support the required navigation performance for the intended operation."* [from ICAO Annex 10, Volume I].

Currently GNSS use two systems, GPS and Glonass with the European System Galileo joining the mix with initial service already available from 22 satellites. Three Airports in Ireland already have GNSS approaches with Obstacle Clearance Heights below 300 feet: Dublin, Knock and Kerry.

GPS

Many years ago the United States announced it would stop the intentional degradation of the Global Positioning System (GPS) signals available to the public. This degradation feature is called Selective Availability (SA). This means that civilian users of GPS are able to pinpoint locations up to ten times more accurately than previously. The GPS system is currently operating with approximately 30 satellites giving a very high degree of accuracy and redundancy. Redundancy is having multiple critical components or functions of a system with the intention of increasing reliability of the system and ensuring component failures do not affect the overall performance.

GLONASS

GLONASS is a Russian global satellite navigation system, providing real time position and velocity determination for military and civilian users. GLONASS orbit makes it especially suited for usage in high latitudes where getting a GPS signal with good geometry can be problematic at times. A fully operational constellation with global coverage consists of 24 satellites. As I write 24 satellites are operational.

Galileo

The Galileo program is Europe's initiative for a state-of-the-art global satellite navigation system, providing a highly accurate, guaranteed global positioning service under civilian control. While providing autonomous navigation and positioning services, Galileo is interoperable with other GNSS systems such as GPS and GLONASS.[3] The system will consist of 30 satellites, to be deployed in a

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staggered approach, and the associated ground infrastructure. Currently there are 22 operational satellites.

Beidou

The BeiDou Navigation Satellite System is a Chinese satellite navigation system. It consists of two separate satellite constellations – a limited test system that has been operating since 2000, and a full-scale global navigation system that is currently under construction. There are currently 14 operational satellites.

Augmentations

To insure the accuracy, integrity and reliability of GNSS it includes augmentations, space based and local. Augmentation of GPS Signal in Space is provided by SBAS (Space Based Augmentation System). In Europe this is provided by the European Geostationary Navigation Overlay Wide Area Augmentation System and Service (EGNOS).[3] The IAA have contracted a company called NSL to monitor the performance of GNSS and they have monitoring stations in Sligo and Mullingar.

ABAS and RAIM

The most common Airborne Based Augmentation System (ABAS) technique is called receiver autonomous integrity monitoring (RAIM). RAIM requires redundant satellite range measurements to detect faulty signals and alert the pilot. The requirement for redundant signals means that navigation guidance with integrity provided by RAIM may not be available 100 per cent of the time. In short, to get a 3D position and altitude you need four satellites with suitable geometry. If you have five satellites, you can tell if there is a problem given two different positions, but you can't identify which position is correct. However, if you have six satellites or more in view you can get three or more independent positions and isolate the faulty one by majority vote. As I write from my location there are 41 GNSS satellites in view with a minimum elevation of 25°.[4] This would give many independent positions for comparison and integrity checking. Adding the Galileo satellites as they become operational will of courses give extra redundant positions for comparison.

Operational Implications

As outlined above, in Ireland we have close to precision approaches using GNSS at three airports and departure and arrival procedures based on GNSS at some others. Already most navigation systems include information from GPS and GLONASS with Galileo being included recently, and BEIDOU to follow. This capability is a tremendous aid to pilots while VFR navigating and enables them to determine their exact position at any time. No doubt the Air Corps has many aircraft equipped with these systems and will be implementing similar procedures at Casement and other landing areas in the near future. Needless to say, this capability will be invaluable during VFR flights for cross checking position and avoiding obstacles.

[3] One of the 34 ranging integrity monitoring stations for EGNOS is based in Cork Airport.

[4] This gives horizontal accuracy of about 5 metres.

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Conclusion

The existence of modern satellite navigation systems combined with aircraft onboard enhancements provide extremely accurate navigation information, easily interpreted by pilots and providing them with added information to avoid obstacles during VFR operations.

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APPENDIX 3 - DEFINITIONS FROM RULES OF THE AIR

"altitude" means the vertical distance of a level, a point or an object considered as a point, measured from mean sea level (MSL);

"ceiling" means the height above the ground or water as the case may be of the base of the lowest layer of cloud which is below 6,000 metres (20,000 feet) covering more than half the sky;

"congested area" means in relation to a city, town or settlement, an area substantially used for residential, commercial or recreational purposes without adequate safe forced landing areas;

"flight level" means a surface of constant atmospheric pressure which is related to a

specific pressure datum of 1013.2 hectopascals (hPa) and is separated from other such surfaces by specific pressure intervals;

"flight plan" means specified information provided to air traffic services units, relative to an intended flight or portion of a flight of an aircraft;

"flight visibility" means the visibility forward from the cockpit of an aircraft in flight;

"ground visibility" means the visibility at an aerodrome, as reported by an observer accredited by the appropriate authority;

"heading" means the direction in which the longitudinal axis of an aircraft is pointed, usually expressed in degrees from North (true, magnetic, compass or grid);

""height" means:

(a) the vertical distance of a level, a point, or an object considered as a point, measured from a specified datum,

(b) the vertical dimension of an object;

"IFR" means the symbol used to designate the Instrument Flight Rules;

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“IFR flight” means a flight conducted or obliged to be conducted in accordance with the Instrument Flight Rules;

“IMC” means the symbol used to designate Instrument Meteorological Conditions;

“Instrument Approach Procedure” means a series of predetermined manoeuvres by

reference to flight instruments with specified protection from obstacles from the initial approach fix, or where applicable, from the beginning of an arrival route as defined by the appropriate ATS authority to a point from which a landing can be completed and thereafter, if a landing is not completed, to a position at which holding or en-route obstacle clearance criteria apply;

“Instrument Meteorological Conditions” means meteorological conditions expressed in terms of visibility, distance from cloud, and ceiling, less than the minima specified in Rule 34 of Rules of the Air for Visual Meteorological Conditions;

““level” means the vertical position of an aircraft in flight and includes height, altitude or flight level;

““night” means the hours between the end of evening civil twilight and the beginning of morning civil twilight, or such other period between sunset and sunrise as may be specified by the appropriate authority. In or over the State, “night” shall be deemed to be, during the period beginning on the 1st day of April, and ending on the 30th day of September, the time between half an hour after sunset and half an hour before sunrise, and during the remainder of the year, the time between sunset and sunrise, and for the purpose of this definition sunset shall be determined at surface level;

“Performance Class 1” means, in relation to a helicopter, performance such that, in the case of critical power unit failure, it is able to land on the rejected take-off area or safely continue the flight to an appropriate landing area, depending on when the failure occurs;

“Performance Class 2” means, in relation to a helicopter, performance such that in the case of critical power unit failure, it is able to safely continue the flight, except when the failure occurs prior to a defined point after take-off or after a defined point before landing, in which case a forced landing may be required;

“Performance Class 3” means, in relation to a helicopter, performance such that, in the case of power unit failure at any point in the flight profile, a forced landing must be performed;

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“pilot-in-command” means the pilot designated by the operator of an aircraft, or in the case of general aviation, the registered owner of the aircraft, as being in command and charged with the safe conduct of a flight by that aircraft;

“pressure altitude” means an atmospheric pressure expressed in terms of altitude which corresponds to that pressure in the Standard Atmosphere as defined in Annex 8 to the Chicago Convention;

“prohibited area” means airspace of defined dimensions designated by the appropriate authority above the land areas of the country or territorial waters thereof, within which the flight of aircraft is prohibited by such authority;

“restricted area” means an airspace of defined dimensions designated by the appropriate authority above the land areas of a country or the territorial waters thereof, within which the flight of aircraft is restricted by the appropriate authority in accordance with certain specified conditions;

;

“track” means the projection on the earth's surface of the path of an aircraft, the direction of which path at any point is usually expressed in degrees from North (whether true, magnetic or grid);

“traffic avoidance advice” means advice provided by an air traffic services unit specifying manoeuvres to assist a pilot to avoid a collision;

“VFR” means the symbol used to designate the Visual Flight Rules;

“VFR flight” means a flight conducted in accordance with the Visual Flight Rules;

“visibility” for aeronautical purposes is the greater of:

a) the greatest distance at which a black object of suitable dimensions, situated near the ground can be seen and recognised when observed against a bright background;

b) the greatest distance at which lights in the vicinity of 1000 candelas can be seen and identified against an unlit background;

“Visual Meteorological Conditions” means meteorological conditions expressed in terms of visibility, distance from cloud, and ceiling equal to or better than the minima specified in Rule 34 of Rules of the Air

“VMC” means the symbol used to designate Visual Meteorological Conditions;

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