Environmental Impact Assessment Report

Teindland Wind Farm

Volume 3

TA A13.3: The Aviation Lighting Assessment

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April 2025

Wind Power Aviation Consultants Ltd

Wind Farm Aviation Lighting Design Report for Teindland Wind Farm

Our Reference: WPAC 005/25 V2.0
Your Reference: WFAS 001/25

Authors: Commander John Taylor, RN (Ret)

Squadron Leader Mike Hale MBE MSc CFS RAF (Ret)

Light Modelling, GIS and Mapping – Sam Taylor BA (Hons) MSc

Wind Power Aviation Consultants Ltd, Company No.: 6811887
e-mail: enquiries@wpac.co.uk Tel.: +44 (0)2380767345 Mob.: +44 (0)7949234440
www.wpac.co.uk

Introduction

1. Eurowind is proposing a twelve-turbine wind farm, named Teindland located 9km SSW of Elgin in the county of Moray. The turbines will be situated on Findlay's Seat hill and Teindland Wood between Glen of Rothes and the River Spey.

2. From a civilian aviation perspective, the Teindland site is located in Class G airspace designated by the CAA as open-unrestricted airspace. Conversely, from a military perspective, the turbines will be located in Low Flying Area (LFA) 14; the busiest LFA in the UK.

3. In the hours of darkness (evening civil twilight to morning civil twilight) this area converts to Night Allocated Region (NAR) 1D. Although primarily a fast jet training area, the airspace is also used by MOD and NATO tactical transport aircraft and helicopters for day and night training.

4. In addition, this area will be frequented by CSAR, Police, HEMs and Air Ambulance helicopters (Some operating from Inverness Airport and or RAF Lossiemouth) by day and night. This type of activity will dictate that the site will require both visible red and infra-red obstruction lighting on its turbines.

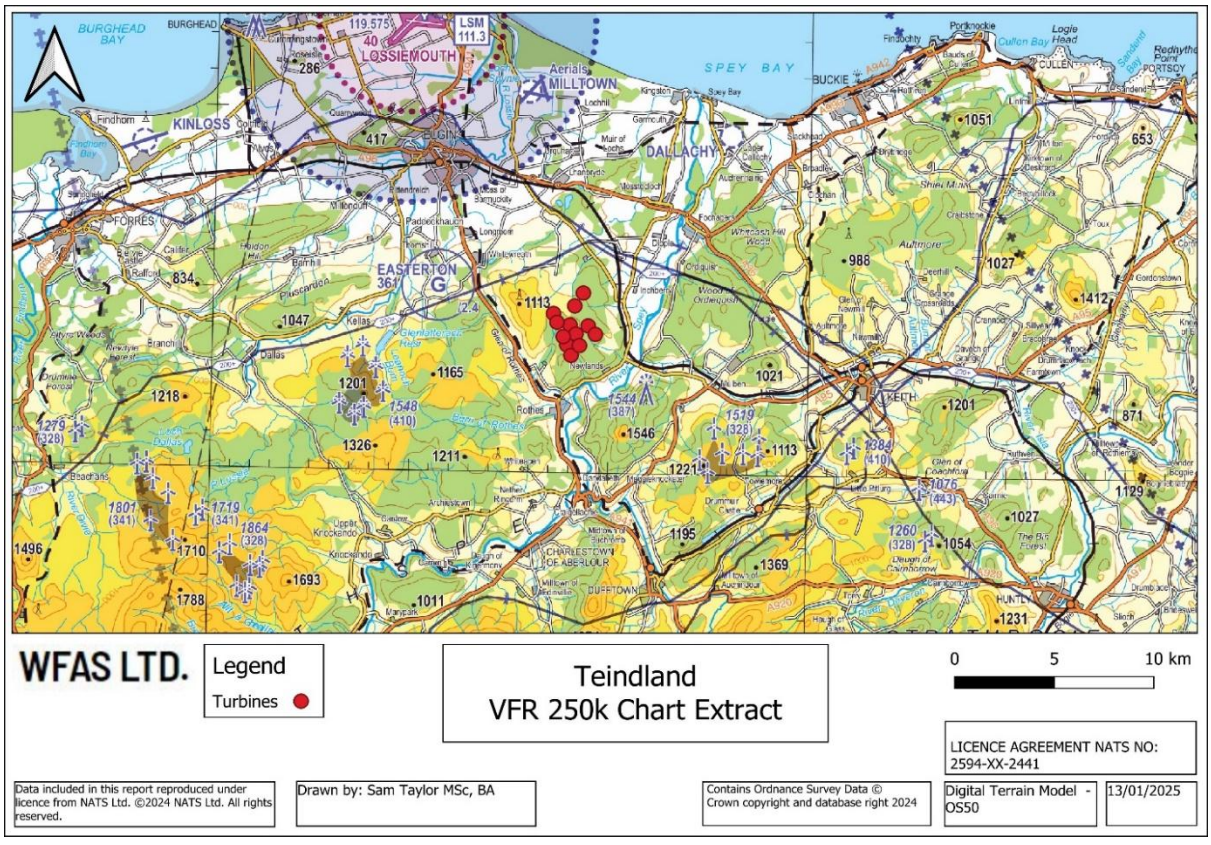

Figure 1: Teindland Turbine Site

Teindland Wind Turbine Site

Teindland Turbine Table				
Turbine	Easting	Northing	Tip Ht	AMSL
1	328302	853741	230	259
2	329214	853691	200	238
3	327475	854327	230	251
4	328139	852711	230	240
5	328975	855377	200	179
7	328350	852177	230	223
8	328543	854715	200	208
9	328598	853271	230	245
10	327650	853877	230	251
11	329575	853252	230	229
12	328775	852677	230	233
13	327962	853140	200	241

Table 1: Teindland Turbine Details

Starting Assumptions and Lighting Criteria

- Teindland will be assessed as below/in Class G 'en route' airspace insofar as visible obstruction lighting is concerned.
- Local airspace constraints will be considered for their potential impact on the site.
- Expected CAA and MOD dispensations will be assessed for the site.
- The visible lighting component of the lighting proposal will be developed in accordance with the latest (still draft) CAA CAP 764.
- To accommodate MOD requirements, and other lower airspace night operators, the site will be assessed for Night Vision Equipment compatible lighting in accordance with MOD published obstruction lighting specifications.
- Where possible, the recommended lighting configuration will be optimised to reduce light impact on the local area.
- The Teindland wind farm proposal is for twelve turbines at 200 and 230m to tip.

CAA-ANO Red 2000/200cd Lighting

5. The CAA requires:

- That all perimeter turbines be lit unless removing a light will leave a gap of less than 900m total between the remaining lit turbines (This distance is negotiable/extendable by application to the CAA).
- That any turbine within 200m of the perimeter be lit unless the distance between adjacent turbines is less than 900m total (Again, this distance/requirement is negotiable by application to the CAA).
- That any unlit turbine does not exceed a 10° up-slope from adjacent lit turbines. All perimeter turbines are lit and conform to this requirement.

Applying these criteria, without expected CAA dispensations, dictates that ten turbines will require ANO visible red lighting.

Turbines with 2000/200cd Lights: T2, T3, T4, T5, T7, T8, T10, T11, T12 and T13

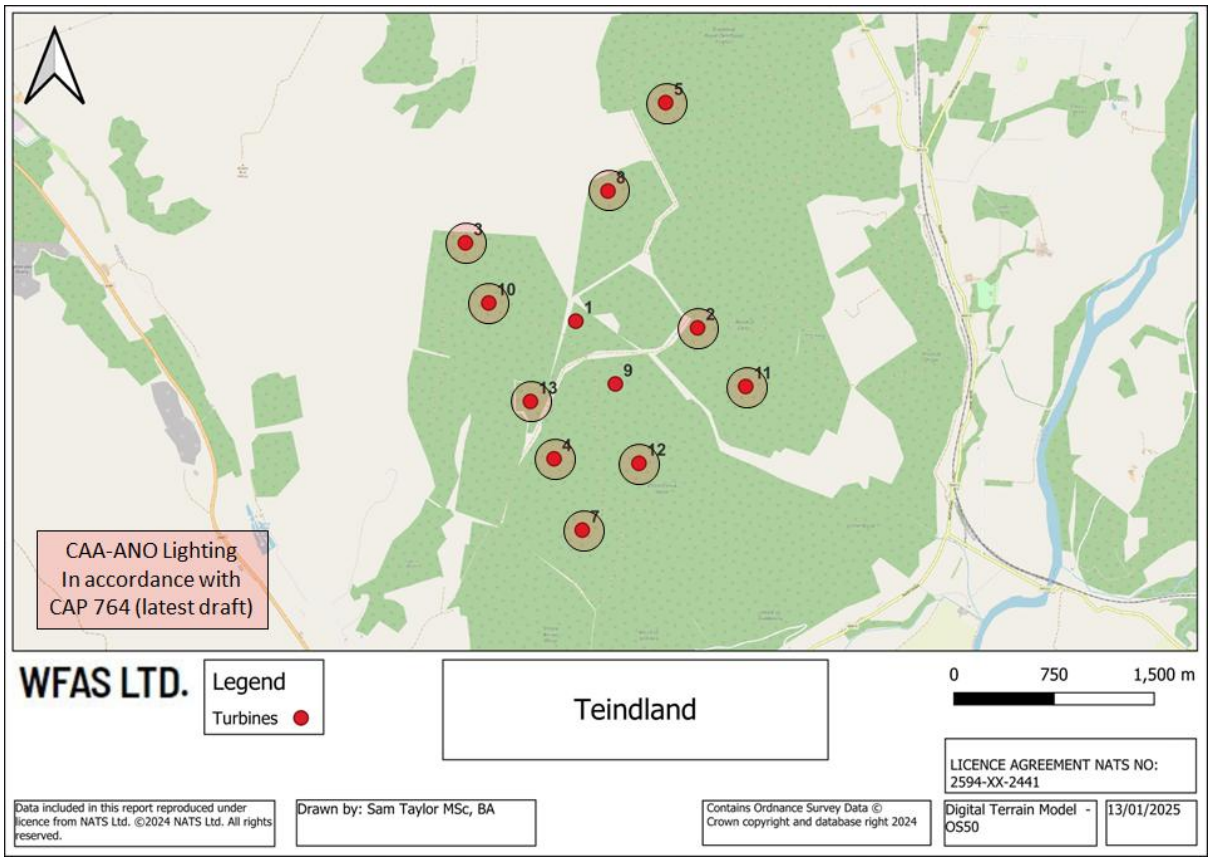

Figure 2: Reduced CAA-ANO Visible Red Lighting.

CAA-ANO Red 2000/200cd Lighting – Reduced and Balanced Option

6. The military have operated at low level at night for many decades now using night vision equipment. In more recent times, the last decade or so, more civilian operators have moved to night low level using suitable night vision equipment: night vision goggles (NVGs) etc. Such civilian operators include Coast Guard (CSAR), Police, Helicopter Emergency Medical Services (HEMS) and Air Ambulance.

7. Although, in the past, some night operators would fly at night at low level without night equipment (on carefully pre-planned exercises pre-flown by day) such events have been overtaken by the ever-widening use of night vision equipment. As a result, operators who now night fly without night vision equipment will fly at or above 'safety altitude' when not under the guidance of Air Traffic Control.

8. Aircraft operating at safety-altitude or above, and depending upon the protocol adopted or phase of flight, the safety-altitude used will be 1000ft (300m), 1500ft (450m) or 2000ft (600m) above the local terrain/highest obstacle, this includes the turbine tip heights. Aircraft/helicopters flying as such, will only need enough visible lights to define the wind farm and its size/shape/perimeter.

9. Accordingly, the regular outline of the Teindland turbine site could be identified with four visible red lights on turbines T3, T5, T7 and T11 forming an irregular rectangular perimeter.

Turbines with 2000/200cd ANO Visible Red Lights: T3, T5, T7 and T11

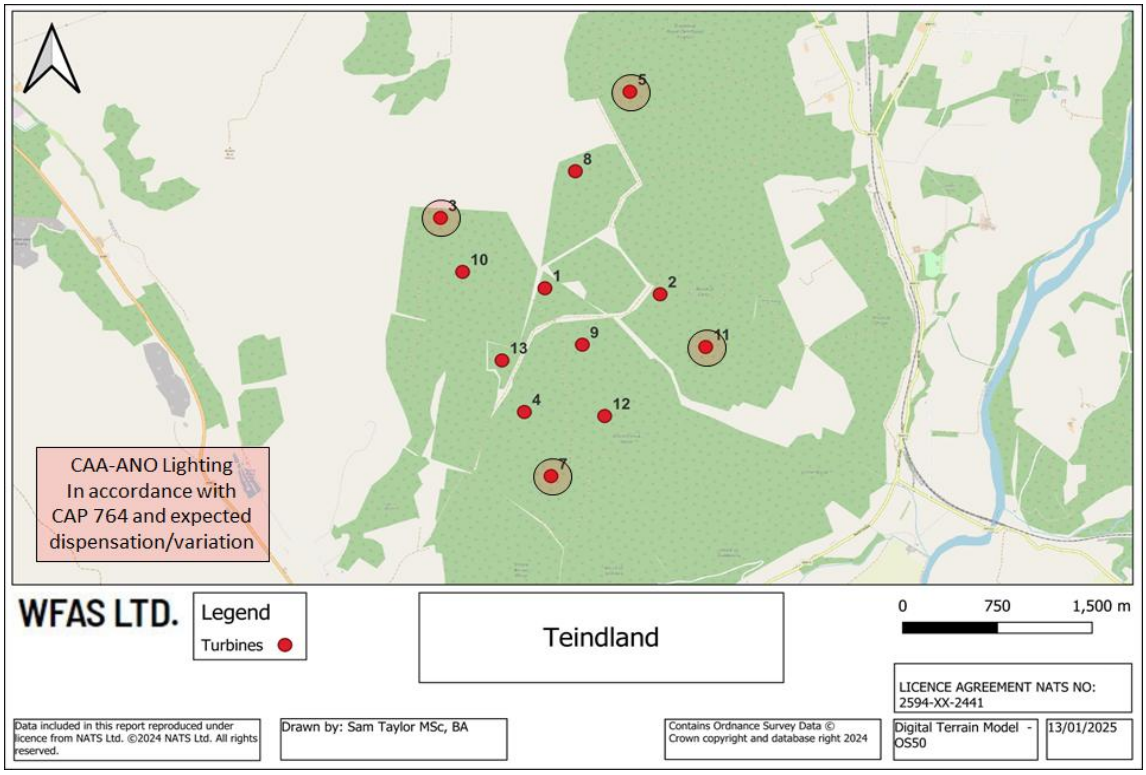

Figure 3 Reduced ANO Lighting Layout

MOD IR Lighting

10. The MOD requires:

- That all perimeter turbines be lit unless removing a light will leave a gap of less than 500m between the remaining perimeter lit turbines.
- That any dominant turbine, by location or height, be lit. Note: here, all turbines are lit.

11. Teindland does not meet the MOD small site criteria (blue dotted circle). This allows for non-perimeter central turbines to not carry an IR light. However, the Teindland site is too large for the criteria and all turbines must carry an IR light.

Applying the MOD criteria dictates that all turbines of the Teindland site will require IR lighting. Twelve hub mounted IR lights in total.

Turbines with Infra-Red Lighting: T1, T2, T3, T4, T5, T7, T8, T9, T10, T11, T12 and T13

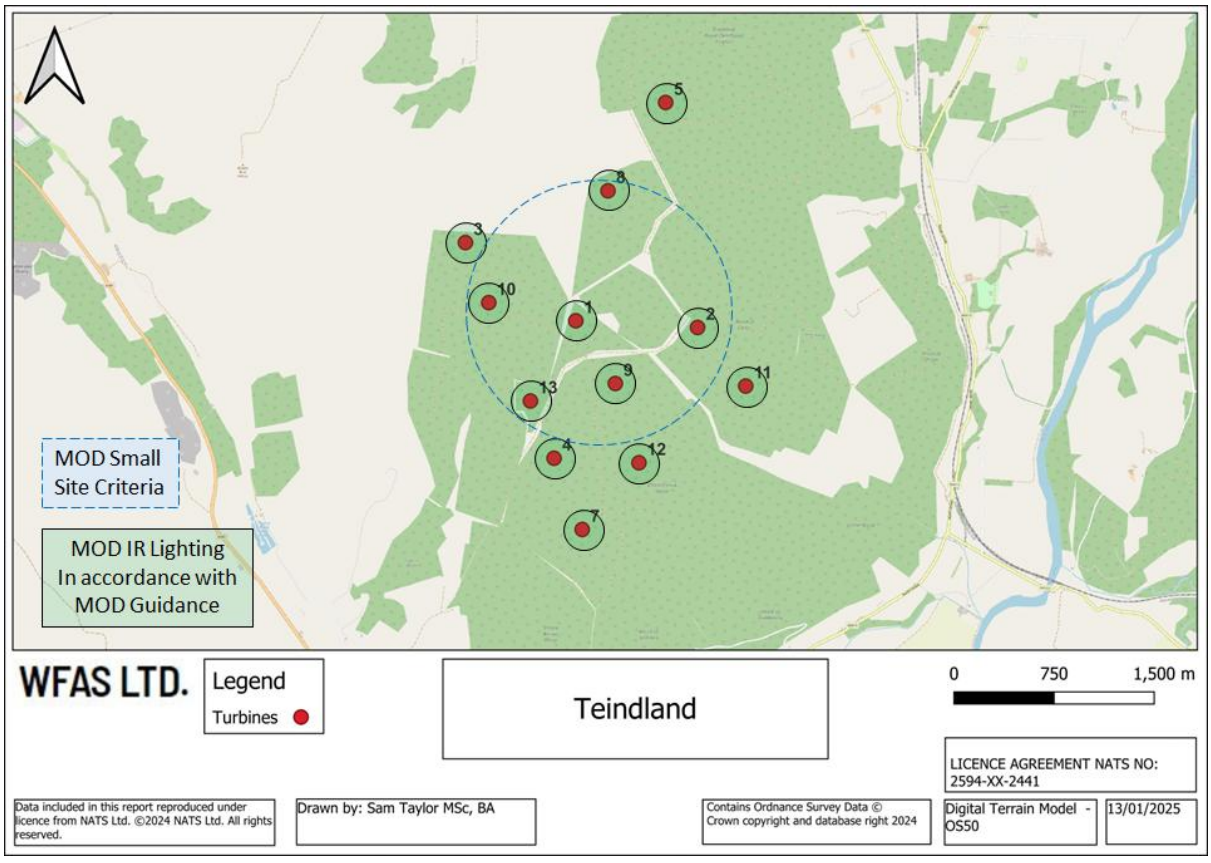

Figure 4: MOD Compliant IR Lighting.

Combined CAA ANO and MOD IR Lighting Proposal for Teindland

Teindland Turbine Table						
Turbine	Easting	Northing	Tip Ht	AMSL	CAA ANO	MOD IR
1	328302	853741	230	259		600mW/sr
2	329214	853691	200	238		600mW/sr
3	327475	854327	230	251	2000/200cd	600mW/sr
4	328139	852711	230	240		600mW/sr
5	328975	855377	200	179	2000/200cd	600mW/sr
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10	327650	853877	230	251		600mW/sr
11	329575	853252	230	229	2000/200cd	600mW/sr
12	328775	852677	230	233		600mW/sr
13	327962	853140	200	241		600mW/sr

Table 2: CAA ANO & MOD IR Lighting Table.

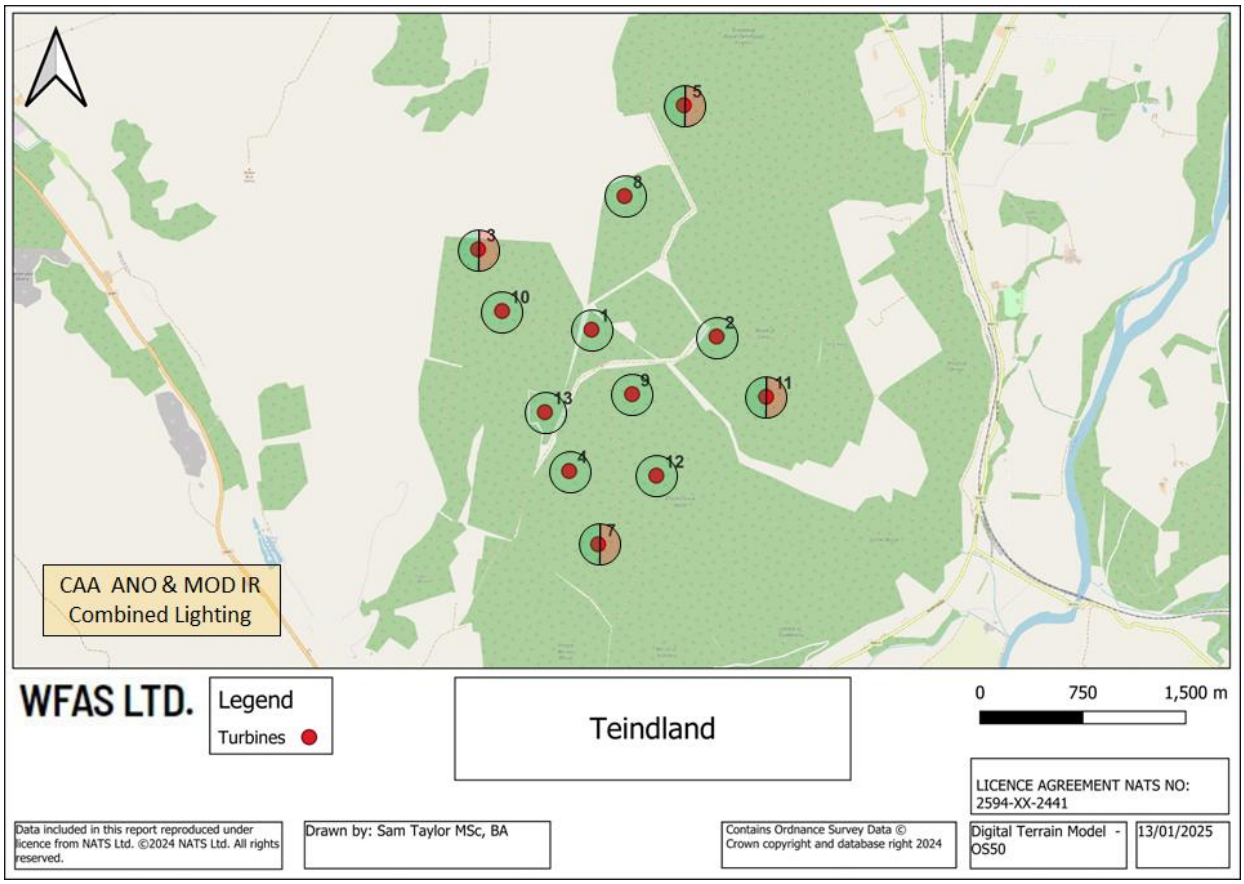

Figure 4: CAA ANO & MOD IR Lighting Proposal.

Light Specifications

Medium Intensity Hub Mounted Lights

12. The ANO 2000/200cd Lights will conform to the ICAO specification as set-out in Annex 14 Table 6-3. The lights will also be controlled such that when the met visibility is greater than 5km in all directions from all turbine hubs, the lights will be reduced to 200cd (10% of normal power).

This reduction in power will not apply to MOD IR Lights.

ICAO Annex 14 Table 6-3 (excerpt)

Benchmark intensity	Minimum requirements					Recommendations				
	Vertical elevation angle (b)			Vertical beam spread (c)		Vertical elevation angle (b)			Vertical beam spread (c)	
	0°		-1°			0°	-1°	-10°		
	Minimum average intensity (a)	Minimum intensity (a)	Minimum intensity (a)	Minimum beam spread	Intensity (a)	Maximum intensity (a)	Maximum intensity (a)	Maximum intensity (a)	Maximum beam spread	Intensity (a)
2000	2000	1500	750	3°	750	2500	1125	75	N/A	N/A

a) 360° horizontal. All intensities are expressed in Candela. For flashing lights, the intensity is read into effective intensity, as determined in accordance with the Aerodrome Design Manual (Doc 9157), Part 4.
b) Elevation vertical angles are referenced to the horizontal when the light unit is levelled.
c) Beam spread is defined as the angle between the horizontal plane and the directions for which the intensity exceeds that mentioned in the "intensity" column.

.Figure 5 ICAO Annex 14 Table 6-3 Medium Intensity Obstacle Lighting Specifications

Table 6-2. Light distribution for low-intensity obstacle lights

	Minimum intensity (a)	Maximum intensity (a)	Vertical beam spread (f)	
			Minimum beam spread	Intensity
Type A	10 cd (b)	N/A	10°	5 cd
Type B	32 cd (b)	N/A	10°	16 cd
Type C	40 cd (b)	400 cd	12° (d)	20 cd
Type D	200 cd (c)	400 cd	N/A (e)	N/A

Note.— This table does not include recommended horizontal beam spreads. 6.2.1.3 requires 360° coverage around an obstacle. Therefore, the number of lights needed to meet this requirement will depend on the horizontal beam spreads of each light as well as the shape of the obstacle. Thus, with narrower beam spreads, more lights will be required.

Figure 6 ICAO Annex 14 Table 6-2 Low Intensity Obstacle Lights.

IR Light Specifications

13. The IR lights will conform to the MOD specification as set-out in MOD Lighting Guidance below.

MOD Specification IR.

IR wavelength – 750 to 900nm.
But ideally concentrated within 800 to 850nm for optimum detection by all military NVG types.

IR intensity – 600mW/sr minimum at peak flash but not above 1200mW/sr.
(Note: Typically a 300mW/sr steady burn LED IR light will generate 600mW/sr at peak flash)
This will generate a 7-8 nm NVG pick-up range - remaining above 5nm as the light ages.

Horizontal Pattern – unrestricted 360 deg.

Vertical Pattern – Minimum flash intensity of 600 mW/sr between +30 deg and -15 deg elevation.
– up to 50% reduction between +25 to +30 deg and -10 to -15 deg is acceptable.
– Maximum intensity of 1200 mW/sr for all angles of elevation.
– Vertical overspill is acceptable.

Flash Pattern – 60 flashes per min at 100-500 ms duration (ideally 250ms)

Synchronisation – all lights to be visually synchronised across a wind farm site

Figure 7: MOD Specification for IR Obstacle Lights.

Timings

14. The lights (IR and ANO) will be switched-on between Evening Civil Twilight and Morning Civil Twilight in accordance with the UK Almanac; approximately 11 hours per day averaged over the year. Conversely, the lights can be switched on by a suitable Lux Meter when the sun light falling on a vertical surface reduces to below 500 Lux.

Intensity Reduction (ANO Lighting: 2000cd down to 200cd)

15. It is possible to take advantage of the CAA SARG Policy Statement dated 01/06/2017 and incorporate the option to reduce the hub height lighting to not less than 10% of the of the minimum peak intensity specified for the installation in good weather. In essence, reducing the 2000cd obstruction lights to 200cd in meteorological visibilities greater than 5km.

Visibility Meter Locations

16. The CAA currently state: *met visibility should be measured at suitable points around the wind farm*. In the case of Teindland turbines Visibility Meters on T3, T5, T7 and T11 will meet this requirement.

Mid-Mast Lighting

17. Mid mast lighting was originally intended to give an attitude/range reference (horizon indication) to pilots flying at night in the days before Night Vison Devices. When fitted to a single vertical structure, a tip/hub light with a mid/mast light will give a vertical reference (from which a horizontal reference can be gauged). In contrast, a single light on a single structure will not be able

to give a vertical or horizontal reference or indication of range, range-rate and sight-line spin values or changes to an approaching pilot. However, a series of single tip/hub lights, on a group of structures, will provide a good horizon reference together with range, range-rate and sight line spin clues to a pilot. Accordingly, the requirement for mid-mast lights is much diminished if not made redundant in the case of lit multiple vertical structures such as wind farms.

18. All of the current commercially available 32cd (supposedly focused) lights are over-engineered (up to 70cd between -30deg and +40deg) to fit a multitude of aviation and marine applications. As a result, they induce a disproportionately large environmental impact, often significantly more than the focused hub 2000/200cd lights. WPAC requested that the CAA guidance requirement for 32cd (Type B) mid mast lights be removed for Teindland. This was approved in their reduced lighting dispensation letter dated 28 February 2025 attached at Appendix A.

Conclusion

19. The purpose of this Lighting Brief is to identify an obstruction lighting arrangement that is environmentally friendly but at the same time is a safe design for night low level operators. This has been accomplished by using a combination of CAA ANO and MOD IR lights.

20. Applying the CAP 764 Draft criteria, for visible red obstruction lighting, results in a solution that requires all except two turbines to carry an ANO 2000cd visible red light. By initially applying current CAA dispensations, and then matching the lighting to the night operators' requirements, an environmentally friendly, but aviation safe, layout has been achieved. When combined with MOD IR Lighting requirements, the result is below:

4 x ANO Visible Red 2000/200cd lights and 10 x MOD IR 600mW/sr lights.

Authors

Cdr John Taylor RN (Ret) – after a career in the Royal Navy specialising in Air Traffic Control (ATC), Airspace Management and Air Defence which culminated in leading both the ATC and Fighter Control Specialisations, John worked for Lockheed Martin UK for three years as a Principal Consultant and Business Area Manager responsible for Air Traffic Management Consultancy, including the provision of advice to wind farm developers. In 2008 he founded WPAC Ltd and since then he and his team have provided aviation advice in relation to over 2000 wind farm and wind turbine sites, given evidence at a number of planning inquiries and enabled many sites to overcome aviation objections where it was feasible to do so. He and his team have also provided advice to a number of Local Planning Authorities, Renewable UK and the Aviation Fund Management Board, including organising workshops and the provision of guidance documents. John also advises planners and developers in relation to physical and technical safeguarding of non-wind farm developments in the vicinity of aviation facilities.

Sqn Ldr Mike Hale RAF (Rtd) has over 45 years, piloting, instructing and examining experience on numerous military fast jet aircraft through to a range of civilian and military general aviation training aircraft and gliders. He has held many posts including Flying Instructor, Training Officer, Flight Commander, Squadron Commander and Principal Tornado AD Force Examiner. He has amassed over 10,000 flying hours of experience when operating at many locations around the world. In parallel to his flying duties, Mike held the post of Officer Commanding the MOD Low Flying Operations Squadron (OC LFOS). In this post he was both Low Level Airspace Manager for the MOD & Wind-Farm Subject Matter Expert for the Defence Infrastructure Organization (DIO). During that period, he assessed over 14,000 wind-farm pre-applications and 2000 full applications against low flying, weapons range, specialist airspace, local community and aerodrome safeguarding criteria. Mike also instigated two Qinetiq ground based Infra Red obstruction lighting trials. These were followed by instigating and managing the MOD Infra Red/Low Intensity (Henlow) flight trials and the CAA/MOD/Trinity-House/RUK off-shore IR/Morse (North Hoyle) flight trials. In conjunction, Mike organised numerous and various supporting trials including night vision equipment compatibility and detailed lighting beam overspill analysis (where light is emitted outside the required specification envelope). In 2012, he was awarded an MBE for generating a proactive and mutually successful working relationship between the Wind Power Industry and the MOD Air Staff.

Cdr John Taylor RN (Ret)
Managing Director
Wind Power Aviation Consultants Ltd
www.wpac.co.uk

Sqn Ldr Mike Hale MBE MSc CFS RAF (Retd)
Aviation Consultant for WPAC Ltd

Appendix A CAA Lighting Dispensation Letter

OFFICIAL - Named Parties Only. This information is intended for Wind Power Aviaton Consultants Ltd. only

Strategy and Policy Group
Windfarm Policy

Civil Aviation Authority

Mike Hale
Aviation Consultant
Wind Power Aviation Consultants Ltd.
38 Hadrian Way
Chilworth
Southampton
SO16 7HX

28 February 2025
Ref Windfarms / Teindland

Dear Mike,

Proposed Obstacle Lighting Scheme for Teindland Wind Farm

Reference: Teindland Wind Farm Lighting report dated 14 January 2025

1. Thank you for the lighting brief at reference. The report discusses the proposed obstacle lighting plan for the Teindland Wind Farm, located approximately 9km SSW of Elgin in Moray.

2. The proposed Teindland Wind Farm consists of 12 turbines, with heights between 200m and 230m ground to tip. This brings the turbines within scope of the Air Navigation Order (ANO) Article 222 obstacle lighting requirements.

3. We have considered the report carefully and take note of the intent to address concerns relating to adverse visual impacts of aviation lighting on non-aviation receptors while ensuring that the lighting installed on the turbines meets air safety requirements.

4. We note the proposed lighting scheme identifies the perimeter outline and that some mitigation is proposed to be provided by the provision of infra-red lighting for those operators who carry Night Vision Device capability.

5. Under provisions given in the Air Navigation Order (ANO) Article 222 section 6, the CAA provides for the following variation:

- medium intensity steady red (2000 candela) lights on the nacelles of turbines T03, T05, T07 and T11;
- a second 2000 candela light on the nacelles of the above turbines to act as alternates in the event of a failure of the main light (note that both lights should not be lit at the same time);

Civil Aviation Authority
2E Aviation House Beehive Ring Road Crawley West Sussex RH6 0YR www.caa.co.uk
Telephone 0330 138 3166 andy.wells@caa.co.uk

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- the lights on these turbines to be capable of being dimmed to 10% of peak intensity when the lowest visibility as measured at suitable points around the wind farm by visibility measuring devices exceeds 5km;
- infra-red lights to MoD specification installed on the nacelles of turbines T01, T02, T03, T04, T05, T07, T08, T09, T10, T11, T12 and T13 (note that dimming permission is applicable only to visible lights, not infra-red lighting).

6. Intermediate level 32 candela lights are not required to be fitted on the turbine towers.

7. If the proposed design of the wind farm changes (other than variations due to micrositing etc.) this is likely to require a revision to this aviation obstacle lighting variation.

Yours sincerely,

AWells

Andy Wells
Manager Aviation and Wind Turbine Policy

Continued (2 of 2 pages)