UK Civil Aviation Authority

CAA Policy and Guidelines on Wind Turbines

CAP 764



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Revision History

Edition 1 July 2006

CAP 764 is published to assist aviation stakeholders to help understand and address wind energy related issues, thereby ensuring greater consistency in the consideration of the potential impact of proposed wind turbine developments. Enabling the co-existence of wind turbines and aviation is complex and new or improved mitigation solutions are being developed all the time. Therefore, it is expected that this CAP will be a living document, which will be updated periodically to reflect the outcome of any further research into the interaction between wind turbine developments and aviation. It will also be revised to take account of changes in regulations, feedback from industry, and recognised best practice.

Edition 2 February 2009

The way in which Aviation Stakeholders and Wind Turbine Developers interact has matured since the initial release of CAP 764 in 2006. This revision includes updates on Government renewable energy policy and details of how all interested parties interact. Additionally, the scope of the document has been widened to include all aspects of aviation that may be affected by Wind Turbines. The appendix detailing the method for determining if a wind turbine is in line of sight of an aeronautical radar station has been simplified.

Edition 3 May 2010

This revision is published to update references to the Air Navigation Order which has been completely re-numbered and to incorporate editorial corrections.

Edition 4 July 2011

This revision follows extensive consultation amongst the aviation and renewable energy communities.

A re-issue to issue 4 was made in August 2011 incorporating corrections to the Glossary, Chapter 2, Pages 4, 8 and 9, Chapter 3, Pages 6 and 7.

Revisions included in Amendment 1 to Edition 4

This revision includes changes to Offshore Helicopter Operations, Consultation Zones around Offshore Helidecks, Helicopter Main Routes and Facilitation of Helicopter Support to Offshore Installations.

Edition 5 June 2013

This revision is in the new CAA format and as such paragraph numbering has been updated. In addition, previous paragraphs detailing the impact of wind turbines on aviation and specifically radar have been updated. This is supplemented by an updated overview and analysis of the various mitigation techniques available. It replaces Edition 4 completely.

Edition 6 January 2016

Edition 6 is publicised following a lengthy consultation with both external and CAA stakeholders. It simplifies radar effects paragraphs and returns the more complicated radar detail to the CAP 670. Potential Mitigation Measures were also taken directly from the CAP 670 therefore detailed explanations are removed from the CAP 764 with only a summary retained. It replaces Edition 5 completely.

Edition 7 December 2025

Edition 7's most significant change is to reorder text and introduce new chapters on specific topics. The new onshore wind turbine lighting and marking chapter incorporates the CAA Policy Statement on the 'Lighting of Wind Turbine Generators above 150m in United Kingdom Territorial Waters' and adopts ICAO Annex 14 recommended practices on the lighting of wind farm perimeter lighting. It takes account of international standards for wind turbines specified by the International Electrotechnical Commission (IEC) in Technical Standard 61400-29:2023 Wind energy generation systems - Part 29: Marking and lighting of wind turbines, as well as introduces requirements for Aviation Detection Lighting Systems. There are also general editorial updates, including changes to references to the Air Navigation Order (2016) as amended, changes to UK Government departmental structures and updates to the CAA and others' contact details. The proposals contained in the document were subject to an eight-week public consultation.

Revisions included in Amendment 1 to Edition 7 September 2026

This amendment includes guidance material developed and agreed by the Department for Energy Security and Net Zero's Aviation and Defence Management Board on the use of non-disclosure agreements and minor editorials.

Foreword

Introduction and background

1. In June 2019, the Climate Change Act 2008 (2050 Target Amendment) Order 2019 amended the Climate Change Act 2008 by introducing a target for at least a 100% reduction of greenhouse gas emissions (compared to 1990 levels) in the UK by 2050. This is otherwise known as a net zero target because some emissions can remain if they are offset by removal from the atmosphere and/or by trading in carbon units. Scotland enacted legislation in October 2019 that sets a target date for net-zero emissions of all greenhouse gases by 2045.

2. In addition, the Net Zero Strategy and British Energy Security Strategy set out commitments to decarbonise the electricity system by 2035, including targets for 50GW of offshore wind by 2030, while the Scottish Energy Strategy has a target of the equivalent of 50% of the energy for Scotland's heat, transport and electricity consumption to be supplied from renewable sources.

3. The government published its revised plan for meeting the UK's net zero target, the Carbon Budget and Growth Delivery Plan, in October 2025.

4. It is anticipated that wind energy will provide a significant contribution to renewable energy targets. In order to harness this energy supply, both on- and offshore wind turbine developments are being constructed, which range in size from single structures to developments encompassing many wind turbines.

5. New proposed developments must be assessed by aviation stakeholders under aerodrome safeguarding requirements to consider the potential impacts on their operations and provide input into the relevant planning process.

6. Both wind energy and aviation are important to UK national interests and both industries have legitimate interests that must be balanced carefully. Therefore, for both industries there is the need for establishing 'win-win' outcomes; where proposed wind energy developments are identified as potentially impacting aviation operations, mitigation solutions are developed and applied only where absolutely necessary.

7. Those involved in addressing wind energy and aviation issues must do so in a positive, co-operative and informed manner. A realistic and pragmatic approach is essential to achieve successful outcomes for the Government's energy, transport and defence policies.

Civil Aviation Publications

8. Some primary or secondary law in the UK gives the CAA discretion to determine how and whether a requirement in the law has been met. In such cases the CAA will publish criteria that will meet the requirement in the law.

9. For existing UK national law (i.e. the Air Navigation Order 2016 as amended (ANO) and the Regulations published under the powers in the ANO) these criteria will be published in a Civil Aviation Publication (CAP). CAPs may contain means of compliance in the same way as Acceptable Means of Compliance (AMC) to assimilated law or additional general information that supports implementation (note that CAA CAPs are a vehicle for publication of a wide range of information including reports, statistics and other information). In particular, such criteria may be published to meet the UK's obligation under international law, i.e. to meet International Civil Aviation Organisation (ICAO) Standards and Recommended Practices.

About this CAP

10. CAP 764 is published to assist aviation stakeholders to help understand and address wind energy related issues, thereby ensuring greater consistency in the consideration of the potential impact of proposed wind turbine developments. However, it is acknowledged that other users such as planning authorities, wind energy developers and members of the general public may also refer to it. Consequently, some of the issues and questions often posed by these groups have, where appropriate, been addressed.

11. This CAP aims to provide the above stakeholders with an overview of requirements pertaining to aircraft surveillance, lighting and marking of turbines laid down in:

ICAO:

ICAO Annex 10 to the Chicago Convention *Aeronautical Telecommunications*, Volume IV: Surveillance and Collision Avoidance Systems

ICAO Annex 14 to the Chicago Convention *Aerodromes*, Volume I: Aerodrome Design and Operations

UK Legislation and Regulatory Requirements:

UK Regulation (EU) No. 139/2014, assimilated under the Retained EU Law (Revocation and Reform) Act 2023, the *UK Aerodromes Regulation*

Certification Specification CS-ADR-DSN, Aerodrome Design, Issue 4, CS ADR-DSN.Q.851 Marking and lighting of wind turbines

UK Regulation (EU) 2017/373, assimilated under the Retained EU Law (Revocation and Reform) Act 2023, the *UK Air Traffic Management/Air Navigation Services Regulation*

ANO (2016) as amended

Civil Aviation Publications (CAP):

CAP 437 *Standards for Offshore Helicopter Landing Areas*

CAP 670 *Air Traffic Services Safety Requirements*

CAP 738 *Safeguarding of aerodromes*

CAP 785B *Implementation and Safeguarding of IFPs in the UK*

12. In order to provide some clarity on the application of each of the sub-sections within the document, the following terminology is used:

CAA Policy

The CAA is provided with certain powers in law which allows it to make a particular specification (e.g. through the ANO). In addition, the CAA sets out its position in respect of an issue that provides clarity or certainty of what would be acceptable as a means of compliance. It is open to an entity to seek to persuade the CAA that they can achieve the same safe outcomes by an alternative means.

CAA Recommendation

A CAA recommendation is a non-binding action or activity which is considered desirable for the safety and efficiency of aviation planning and operations.

Guidance

Guidance is non-binding explanatory and interpretation material which, in the context of this document, is designed to help the reader understand the various processes that aviation stakeholders may need to undertake and consider in respect of proposed wind turbine developments.

Scope

13. This document provides CAA policy and guidance on a range of issues associated with wind turbines and their effect on aviation that will need to be considered by aviation stakeholders, wind energy developers and planning authorities when assessing the viability of wind turbine developments.

14. Safeguarding requirements remain the responsibility of an Air Navigation Service Provider (ANSP), aerodrome operator or other organisations, while safety of air navigation lies with the aircraft operator. These stakeholders must consider the potential impacts of any proposed development as it affects their operations and provide input into the relevant planning process. Specific circumstances will have

to be addressed on a case-by-case basis, as it is not possible or appropriate to prescribe a standard solution. This document should be read in conjunction with specific policy and/or legislative documentation as referenced in the text, as well as the CAA Windfarms web pages.

15. Civil aviation and military aviation have some similar but also some differing requirements in terms of safeguarding operations. Therefore, the Ministry of Defence (MoD), through Defence Infrastructure Organisation (DIO), must continue to be consulted separately on all developments that may affect their sites (both aviation and others).

Feedback

16. Stakeholders are encouraged to provide feedback on the content and utility of this CAP in order that the information provided in it is up to date and relevant. Interim amendments and supplementary guidance may be published through additional CAA Policy Statements or on the CAA Wind Energy web pages to maintain the currency and relevance of CAA guidance and policy.

Contact details

17. General enquiries concerning this publication can be addressed to windfarms@caa.co.uk.

Glossary

Guidance

A list of specialised words or terms with their definitions follows:

AAA	Airspace, ATM and Aerodromes (CAA)
AD	Air Defence
AGL	Above Ground Level
AIP	Aeronautical Information Publication
AIS	Aeronautical Information Service
AMC	Acceptable Means of Compliance
AMSL	Above Mean Sea Level
ANO	Air Navigation Order
ANSP	Air Navigation Service Provider
APDO	Approved Procedure Design Organisation
AOA	Airport Operators Association
ASU	Air Support Unit
ATS	Air Traffic Services
BEIS	Department of Business, Energy and Industrial Strategy
BGA	British Gliding Association
CAA	Civil Aviation Authority
CAP	Civil Aviation Publication
CFAR	Constant False Alarm Rate
CNS	Communications, Navigation and Surveillance
DfT	Department for Transport
DGC	Defence Geographic Centre
DIO	Defence Infrastructure Organisation
DME	Distance Measuring Equipment
DTM	Digital Terrain Mapping

DVE	Degraded Visual Environment
DVOF	Defence Vertical Obstruction File
DZ	Drop Zone
EASA	European Aviation Safety Agency
ECA	European Communities Act
ECCAIRS	European Co-ordination centre for Accident and Incident Reporting Systems
EM	Electromagnetic
EU	European Union
FAT	Final Approach Track
FIR	Flight Information Region
ft	Feet
GA	General Aviation
GAAC	General Aviation Awareness Council
HMR	Helicopter Main Route
ICAO	International Civil Aviation Organisation
IFP	Instrument Flight Procedure
ILS	Instrument Landing System
IR	Infra-red
km	Kilometre(s)
LIDAR	Light Detection and Ranging
LF	Low Flying
LOS	Line of Sight
m	Metre(s)
MAP	Missed Approach Procedure
MAPt	Missed Approach Point
MATS	Manual of Air Traffic Services
MCA	Maritime and Coastguard Agency
MHz	Mega Hertz

MoD	Ministry of Defence
Mode S	Mode Select
MSA	Minimum Safety Altitude
MSD	Minimum Separation Distance
mW	Milliwatts
MW	Mega Watts
NAFW	National Assembly for Wales
NAIZ	Non-Automatic Initiation Zones
Navaids	Navigation Aids
NDA	Non-Disclosure Agreement
NDB	Non Directional Beacon
NERL	NATS En Route plc
Night	The period of time from half an hour after sunset until half an hour before sunrise (both times inclusive), sunset and sunrise being determined at surface level (defined in Schedule 1 of the ANO)
NM	Nautical mile(s) (1853 m or 1.15 Statute Miles)
NOTAM	Notice to Aircrew
NPAS	National Police Air Service
NVD	Night Vision Device
ODPM	Office of the Deputy Prime Minister
OLS	Obstacle Limitation Surface
PBN	Performance Based Navigation
PLA	Parachute Landing Area
PPG	Planning Policy Guidance Note
PSR	Primary Surveillance Radar
RAL	Reichs-Ausschuß für Lieferbedingungen, (German) translating as "National Commission for Delivery Terms and Quality Assurance
RAM	Radar Absorbent Material
RCS	Radar Cross-Section

RD	Rotor Diameter
RNP	Required Navigation Performance
SAR	Search and Rescue
SARG	Safety and Airspace Regulation Group (CAA)
SID	Standard Instrument Departure
SSR	Secondary Surveillance Radar
STAR	Standard Instrument Arrival Route
TMZ	Transponder Mandatory Zones
VFR	Visual Flight Rules
VHF	Very High Frequency
VOR	VHF Omni Directional Range
VMC	Visual Meteorological Conditions

Chapter 1

CAA Responsibilities

General

Guidance

1.1 The CAA is responsible for safety and airspace regulation of civil aviation in the UK under the Civil Aviation Act 1982, the Transport Act 2000 and the UK Basic Regulation. The CAA's Safety and Airspace Regulation Group (SARG) is responsible for the regulation of licensed aerodromes and Air Traffic Services (ATS) in the UK; the planning and regulation of all UK airspace, including the communications, navigation and surveillance (CNS) infrastructure.

1.2 Planning processes and authorities for wind turbine approvals are different in the devolved administrations.

1.3 Legislative provisions affecting all development, including wind turbines, are set out for England and Wales in Town & Country Planning (Safeguarded Aerodromes, Technical Sites and Military Explosives Storage Areas) Direction 2002 which is annexed to Joint Circular 01/2003 issued on 27th January 2003 by the Office of the Deputy Prime Minister. (ODPM Circular 01/2003)[1]. Similar provisions are set out for Scotland in the Planning Circular 2/2003 (revised): safeguarded aerodromes, technical sites and military explosives storage areas[2], and for Northern Ireland in the Planning Policy Statement 18: Renewable Energy issued August 2009[3]. These provisions only apply formally to those aerodromes and technical sites that are officially safeguarded; moreover, statutory consultees are limited to the MoD, NATS En Route Ltd (NERL) and affected service providers. Different arrangements apply for major renewable energy developments, which is considered under the Nationally Significant Infrastructure Projects system in England and Wales and in Scotland, through the Scottish Government's planning and consent processes.

1.4 At all times, responsibility for the provision of safe services lies with the ATS provider or ANSP.

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[1] https://www.gov.uk/government/publications/safeguarding-aerodromes-technical-sites-and-military-explosives-storage-areas/the-town-and-country-planning-safeguarded-aerodromes-technical-sites-and-military-explosives-storage-areas-direction-2002

[2] https://www.gov.scot/publications/planning-circular-2-2003-scottish-planning-series-town-country-planning-0755923111/

[3] https://www.infrastructure-ni.gov.uk/sites/default/files/publications/infrastructure/PPS18%20Renewable%20Energy.pdf

1.5 The CAA has 3 key mechanisms by which it discharges its safety obligations:

a. Legislation and policy development. We may advise DfT on the need for new or revised legislation (noting that development of law is a UK Parliamentary function). We may develop appropriate policy and guidance that allows individuals and entities to demonstrate compliance with legal or other requirements (e.g. functions or powers granted to the CAA under relevant legislation) and supports implementation or assist with general understanding of the requirements;

b. Oversight of aviation entities to gather intelligence across the industry, sample compliance and, where required, require remedial activity;

c. Publish information to assist the aviation industry and others to meet the highest safety standards. This may include directives, notices and other information and guidance.

1.6 The CAA policy on wind energy is that:

a. Wind turbine developments and aviation need to co-exist in order for the UK to achieve its net-zero emissions targets, enhance energy security and meet national and international transport policies. However, safety in the air is paramount and will not be compromised. As the independent aviation regulator, the CAA provides the policy framework under which the safety of civil air transport is protected, provides oversight and guidance on good aerodrome safeguarding practice, works with stakeholders and suppliers to ensure practicable and cost-effective mitigation approaches are available as well as to provide clarification on implementation issues to both the aviation industry and the wind energy industry;

b. Due to the complex nature of aviation operations, and the impact of local environmental constraints, all instances of potential negative impact of proposed wind turbine developments on aviation operations must be considered on a case- by-case basis;

c. It is CAA policy to provide the best and most timely advice to aviation and wider wind development stakeholders through consultation, the publication of CAPs and other information on the CAA web site;

Aerodrome and CNS site safeguarding

Guidance

1.7 Many civil aerodromes in the UK are certificated in accordance with UK Regulation (EU) No. 139/2014 (Aerodromes) or licensed in accordance with the ANO as amended. Under these provisions, the CAA is responsible for being satisfied that a certificated or licensed aerodrome complies with the relevant requirements and is safe for use by civil aircraft, having regard in particular to the physical characteristics of the aerodrome and its surroundings. Aerodrome operators are required to have procedures for safeguarding, to monitor the changes in the obstacle environment, marking and lighting, and in human activities or land use on the aerodrome and in the areas around the aerodrome. In addition, a requirement is placed on the licensee to take all reasonable steps to ensure that the aerodrome and its surrounding airspace are safe at all times for use by aircraft. Airports/ANSPs will have their own safeguarding assessment process, an example of NATS En-route limited safeguarded technical sites can be found at: https://www.nats.aero/our-solutions/wind-farms/self-assessment-maps/.

1.8 The CAA Aerodromes and ATM Inspectorate Team conduct oversight audits at certified and licensed aerodromes to confirm compliance to the applicable rules. Further information on safeguarding is provided in Chapter 2.

Airspace management

Guidance

1.9 SARG, as the airspace regulatory authority, is responsible for developing, approving, monitoring and enforcing policies for the safe and efficient allocation and use of UK airspace and its supporting infrastructure, taking into account the needs of all stakeholders, national security and environmental issues.

1.10 SARG is directed by the Secretary of State for Transport to act with impartiality to ensure that the interests of all airspace users (including General Aviation (GA) stakeholders) and the community at large are taken into account in respect of how UK airspace is managed. To this end, formal consultation with airspace users, service providers and other relevant bodies is undertaken with the aim of obtaining consensus, wherever possible, before making changes in the planning or design of UK airspace arrangements. The environmental impacts of proposals for change are also taken into consideration.

1.11 The Airspace Change Process is mandatory for the majority of airspace change requests. The process ensures that all appropriate stakeholders are consulted; CAP 1616 Airspace change: Guidance on the regulatory process for changing the notified airspace design and planned and permanent redistribution of air

traffic, and on providing airspace information refers.

Obstacle Notification and Charting

1.12 Article 225A of the ANO requires the notification of existing and planned en-route aviation obstacles if it or they are 100 metres or more above the surface.

Note: There is a distinction between the height specified for the notification of obstacles and the height requirement for the lighting of en-route obstacles, which is set out in Article 222 of the ANO. The former is ground to maximum tip height of 100 m or more, the latter ground to maximum tip height of 150 m or more.

Guidance

1.13 Additional consideration of the aviation obstacle environment may be required during the initial build phase and the temporary use of cranes that may extend above a height of 100 metres or in the case of pre-built turbines being towed from shore to final generating position.

1.14 The CAA works closely with NATS Aeronautical Information Services (providing the relevant information to inform the required publication of UK en-route obstacles in the Aeronautical Information Publication) and the MoD Defence Geographic Centre (obstacle data that the CAA receives is shared and vice versa to support low flying).

CAA Recommendation

1.15 The CAA recommends that aviation obstacles are reported to the CAA even if they are below 100m. This information will be held in the UK obstacle database and used to support civilian and defence low flying planning. Reporting of all aviation obstacles including meteorological and anemometer masts, cranes and wind turbines contributes to ongoing air safety initiatives for the protection of property, infrastructure and aviators

Guidance

1.16 To notify new or existing obstacles, changes to existing obstacles, please register for the Airspace Coordination and Obstacle Management Service (ACOMS) via the CAA customer portal.

Note: Further information is available at: https://www.caa.co.uk/commercial-industry/airspace/event-and-obstacle-notification/obstacle-notification/

1.17 When proving information about existing and planned en-route aviation obstacles the following details may be requested:

a. the obstacle's type and colour;

b. the obstacle's position, represented by geographical coordinates in degrees, minutes and seconds;

c. the obstacle's elevation above mean sea level and height above ground level (AGL) to the nearest metre or foot;

d. the type and colour of any lighting to be fitted to it, or to be removed from it; and

e. the scheduled dates of commencement and completion of the works.

CAA Recommendation

1.18 In order to ensure that aviation stakeholders are aware of the turbines while aviation charts are in the process of being updated, the CAA recommends that developments should also be notified through the means of a NOTAM. If the obstacle falls within an Aerodrome Traffic Zone or Military Aerodrome Traffic Zone, it is the responsibility of that aerodrome to issue the NOTAM. Outside of these areas, to arrange an associated NOTAM, a developer should contact CAA Airspace Regulation (AROps@caa.co.uk) no later than 14 days prior to the commencement of construction with the same information as required above.

Approvals for equipment and service provision

Guidance

1.19 In order to provide an ATS in the UK, a service provider must be granted an approval by the CAA. UK Reg (EU) 2017/373, UK Reg (EC) No. 550/2004 and relevant sections of the ANO (2016) as amended apply.

1.20 Where service providers use a remote feed of surveillance data from a contracted source, they remain responsible for gaining the requisite approvals for the use of data as part of a surveillance service. ANSPs must have effective processes and procedures to:

a. Safeguard their service through being able to recognise when wind turbine developments may affect their service, and by participating in planning activities;

b. Be able to assess the likely effect of a wind turbine development on their service. It is not automatically the case that a wind turbine development will result in a degradation to the service. The service provider must first assess whether the planned development will technically impact upon the CNS systems used. Where it is assessed that there will be a technical impact, the service provider must then assess whether this has any operational significance (see also Chapter 2);

c. Be able to establish what reasonable measures may be put in place to mitigate the effect of a wind turbine development. At all times, a collaborative

approach between the service provider and the wind turbine developer is required to ensure an appropriate (i.e. reasonable, achievable and timely) mitigation is identified.

1.21 Where a service provider has to make a change to equipment or operational procedures in order to safely accommodate a wind turbine development then the following must be addressed:

a. The service provider must perform a safety assessment on the change. The final safety assessment cannot be made until all changes have been implemented and wind turbine developments are operational;

b. As part of the safety assessment, the service provider should at least consider the issues raised in Chapter 2 of this CAP concerning the impact of wind turbines on aviation;

c. Where considering mitigations to address the impact of the wind turbine development, service providers are advised to review the issues and limitations summarised in Chapter 2. Full details are available in the CAA CAP 670;

d. All significant changes to an ATS must be notified by an ANSP to their SARG Regional Inspector who may wish to see evidence that the change has been managed safely and in accordance with the ANSPs change management processes. Where appropriate, an updated or amended safety case or safety support case may be required.

Note: A safety assessment includes consideration of a new or changed safety case or safety assurance documentation, impact(s) on its certification and approvals from the CAA, use of novel technology, changes to operations and engineering manuals and user training requirements, impacts on change management procedures and interoperability compliance.

Consulting the CAA on planning matters

Guidance

1.22 The CAA is a statutory consultee for Nationally Significant Infrastructure Projects where the proposed application(s) relate to airports or which are likely to affect an airport or its current or future operation. Aside from cases that may involve CAA property, we are not routinely a statutory consultee for planning applications. When not a statutory consultee, the CAA will only respond to planning enquiries where there is something definitive to contribute. Further information is available at: Scope of the CAA's role in planning consultations.

1.23 In situations where the CAA responds to planning submissions for wind turbine developments, this may be in respect of:

a. Advice on potential aviation stakeholders who may be affected by the proposed development;

b. Comment on the aviation section of the Environmental Impact Assessment in terms of accuracy and completeness;

c. Applicable regulatory requirements and their application;

d. Advice on whether all other aviation issues known to the CAA have been taken into account (including other potential developments).

CAA advice and facilitation

Guidance

1.24 It is incumbent upon the developer to liaise with the appropriate aviation stakeholder to discuss – and hopefully resolve or mitigate – aviation related concerns without requiring further CAA input. The CAA may provide information to the parties concerned and may facilitate discussions between the parties to seek a positive resolution, particularly relating to regulatory requirements, including a related assessment or approval. The CAA has no powers to either prevent wind turbine developments going ahead or to require that an aviation stakeholder remove their objection.

1.25 The CAA will not typically provide comment on MoD objections or arguments unless such comments have been requested by the MoD.

Advice to Government

Guidance

1.26 In discharging its role as an independent regulator, the CAA provides advice to UK Government and devolved administrations as required.

Chapter 2

Safeguarding and Mitigation

Introduction

Guidance

2.1 The development of sites for wind turbines has the potential to cause a variety of negative effects on aviation. These include (but are not limited to):

- the generation of unwanted returns on Primary Surveillance Radar (PSR)[4] displays;
- adverse effects on the performance of CNS equipment;
- penetration of Obstacle Limitation Surfaces around an aerodrome;
- impacts to Instrument Flight Procedures caused by temporary and permanent obstacles; and
- cumulative impacts of multiple developments on CNS equipment.

Other considerations include:

- Obstacle hazards for low flying aircraft; and
- Turbulence.

2.2 There is detailed information published by Eurocontrol on wind turbine effects on aeronautical surveillance systems[5] and an overview of the issues that aviation stakeholders should consider when assessing the impact of a proposed wind turbine development. These are known to be used throughout Europe by aviation stakeholders.

2.3 Local circumstances may raise issues that are unique to a specific case. For this reason, the local aerodrome operator, ANSP and ATS providers will be best qualified to interpret what this impact might be; however, they must demonstrate a thorough assessment of how it will affect the safety, efficiency and flexibility of their specific operations.

[4] Although radar is a widely used term, technological advances mean that the broader term 'surveillance system' will be used instead throughout this document, where appropriate

[5] https://www.eurocontrol.int/sites/default/files/2019-05/20140909-impact-wind-turbines-sur-sensors-guid-v1.2.pdf

Safeguarding - General considerations

Guidance

2.4 Aerodrome safeguarding ensures the safety of aircraft manoeuvring on the ground, taking off, landing or flying in the vicinity of the aerodrome or undertaking air navigation in receipt of an air traffic control service.

2.5 Safeguarding is a requirement under the ICAO Chicago Convention and is implemented through UK legislation. The safeguarding processes used by aerodromes and ANSPs are regularly audited by the CAA.

2.6 The Government directs planning authorities to consult with officially safeguarded aerodromes and ANSPs with en-route CNS infrastructure. Aerodromes lodge safeguarding maps with the LPAs and whenever a development of a specified height is proposed, a consultation is required. The consultation process enables an aerodrome to comment on any development that may affect its existing or future operation. NATS is a statutory consultee for wind farm developments.

2.7 The purpose of safeguarding is to protect aspects such as:

a. the airspace around an aerodrome to ensure no buildings or structures may cause danger to aircraft either in the air or on the ground. This is achieved through both the ‘Obstacle Limitation Surfaces’ (OLS) and the ‘Instrument Flight Procedure’ (IFP).

b. the integrity of surveillance systems and other electronic aids to navigation by preventing unwanted reflections and diffractions of the radio signals.

c. aircraft from the risk of collision with obstacles through appropriate lighting.

2.8 The safety of aircraft in UK airspace is often dependent on ground-based navigation and radio aids. DfT Circular 1/2003 and Scottish Government Circular 2/2003 (as revised) provides for the safeguarding of civil technical sites, which includes civil en-route facilities (owned and operated by NATS) and military technical sites owned by the Secretary of State for Defence.

Note: Formal safeguarding does not apply to offshore oil and gas platforms (excluding impacts on en-route CNS systems), however impacts to offshore helicopter operations in relation to renewable wind energy developments should be considered as part of the offshore planning process.

2.9 Those aerodromes and CNS sites that are not safeguarded by statutory process can be unofficially safeguarded by agreeing protection measures with their relevant planning authority. CAP 793 Safe Operating Practices at Unlicensed Aerodromes provides guidance for unlicensed aerodromes.

2.10 In all cases, regardless of the status of the aerodrome, any development that causes pilots to experience an increase in difficulty when using an aerodrome may lead to a loss of utility. The CAA considers that if the aerodrome operator advises that the aerodrome's safe and efficient operations would be affected by a development, their advice can be considered as authoritative in the context of the operation of the aerodrome. However, such comment requires robust evidence and may be subjected to scrutiny. Notwithstanding that the CAA has no regulatory oversight of unlicensed aerodromes it is recommended that developers and planning authorities consider comments and evidence from the operators of unlicensed aerodromes in the same way.

2.11 Further information about aerodrome safeguarding can be found under the Combined Aerodrome Safeguarding Team pages on the CAA website and in CAP 738 Safeguarding of aerodromes. Technical safeguarding aspects are detailed in CAP 670 Air Traffic Services Safety Requirements.

Safeguarding maps

Guidance

2.12 Maps of officially safeguarded aerodromes and en route CNS technical sites are produced and submitted to planning authorities. These maps denote the areas where consultation should take place with the aerodrome operator.

2.13 Other aerodromes may produce a safeguarding map and request that their relevant planning authority recognise their wish to be included in consultation for planning purposes. It is the published advice of the Government[6] that all aerodromes should take steps to protect their locations from the effects of possible adverse development by agreeing a safeguarding procedure with the relevant planning authority.

Wind turbine safeguarding maps

Guidance

2.14 In order to assist the consultation process with wind turbine developers and in providing a diagrammatic illustration of the related aviation issues in discussion with planning authorities, a number of aerodromes have developed specific wind turbine safeguarding maps, which graphically depict the aviation operator's assessment of the desirability and feasibility of wind turbine developments. Areas are shown where development would be either undesirable, undesirable but possible, or acceptable (potentially with constraints to address cumulative

[6] The Town and Country Planning (Safeguarded Aerodromes, Technical Sites and Military Explosives Storage Areas) Direction 2002

effects). Other aerodromes have simply prepared radar consultation zone maps, given the dynamic nature of cumulative effects.

Surveillance service impact assessment

Guidance

2.15 Prediction of the effect of wind turbines on any particular surveillance system site is a complex task depending on many factors including terrain, the weather, the maximum height of both surveillance system and wind turbines, density radar line of sight (LOS), the operational range of affected surveillance systems, diffraction and antenna beam tilt.

2.16 There are a number of models that are employed to demonstrate potential impacts of wind turbine developments on surveillance systems. Such models are constantly developing and will offer some guidance as to the likelihood of wind turbines presenting a return; although the nature of wind turbine operations vary due to the unpredictability of different turbine types, variable turbine rotation speed and the times of operation of individual turbines. Therefore, the degree of certainty as to whether a turbine, or group of turbines, will be displayed or not in marginal 'radar/radio LOS' cases cannot be guaranteed. In such cases, and where aviation safety is a potential issue, safety considerations must remain the priority.

2.17 The CAA does not endorse any one specific radar modelling tool. Nor, given the multitude of factors affecting RCS, can a 'standard' RCS be identified for micro, medium and large wind turbines. It is strongly suggested that developers engage with the appropriate ANSP prior to commissioning a propagation assessment in order to ensure that the proposed model is suitable.

2.18 If the surveillance system likely to be affected by a proposed wind turbine development belongs to NATS, useful self-assessment guidance is available at: http://www.nats.aero/services/information/wind-farms/self-assessment-maps/.

2.19 If the wind turbine development is likely to affect an MOD surveillance system, it is recommended that the MOD should be contacted at the earliest opportunity. Further guidance can be found on the MOD Windfarms Safeguarding web site[7]

Mitigation

Guidance

2.20 The following paragraphs give a summary of some of the mitigation methods that are available to help counter the effects of wind turbines, primarily on PSR and SSR related issues. More detailed explanations and analysis of mitigation

[7] https://www.gov.uk/government/publications/wind-farms-ministry-of-defence-safeguarding

techniques are contained within the CAA CAP 670 SUR 13. Not all the mitigation methods will be suitable in all circumstances and more than one method may be required to mitigate risks to an acceptable level. The definition of 'acceptable' will have to be made on a case-by-case basis. As a minimum, all relevant hazards and resultant safety risks must be mitigated to an As Low As Reasonably Practicable (ALARP) level.

2.21 It is the responsibility of the developer to consult with the aviation stakeholder to discuss whether mitigation is possible and, if so, how it would best be implemented. It must also be noted that most mitigation methods would be subject to a standard safety assessment process by the ANSP who, in turn, would need to demonstrate that the system is safe in order to gain CAA approval. Accordingly, where a wind turbine development is likely to impact upon the provision of an ATS, then the developer and ANSP should co-operate to mitigate such impacts.

Summary of mitigation techniques

Guidance

2.22 Mitigation techniques can be categorised into several key types. This section provides a summary of each category. More detailed explanation is available in the CAP 670. Mitigation techniques may lead to secondary impacts (e.g. shadowing, desensitisation etc.) and these aspects need to be considered as part of the overall mitigation assessment.

Work-rounds

2.23 Work-rounds are measures which would enable an ANSP to continue providing an ATS using the surveillance system, such as sector blanking.

In-fill radars

2.24 In this situation, the infill radar supplements the main radar to remove / reduce the impact of radar line of sight of the wind farm to the overall processed radar output.

3-Dimensional radars

2.25 Some PSRs can provide 3-dimensional information and can therefore be used above wind farm affected areas.

High Pulse Repetition Frequency radars

2.26 Some manufacturers may use a high transmitter pulse repetition frequency (often referred to as PRF). This technique makes it possible to discriminate between aircraft and wind turbines by analysing their Doppler signatures and remove the turbine clutter from the display.

Spectrum filters

2.27 Some manufacturers have attempted to develop a solution that is based on modifying their existing radars by incorporating software to compare target return Doppler signatures with the aim of giving the system the ability to discriminate between turbines and aircraft.

Transponder Mandatory Zones (TMZ) and surveillance by co-operative ground sensor

2.28 Under current UK regulations, an aircraft does not need to be equipped with, and operate, a device that provides information on the location and height of the aircraft (e.g. transponder) in all areas of UK airspace, only in airspace that is notified as such. In certain circumstances and in certain areas, mandatory transponder carriage can provide significant safety benefits. The CAA has regulatory powers to create transponder mandatory zones (TMZ) for a number of reasons, one of which may be to remove the need for a PSR in a given area. External bodies can also request TMZs; however, the Airspace Change Process (detailed in CAP 1616) must be followed. This process ensures that the requirement for a TMZ is fully justified and that the effect upon all airspace users, the environment and people on the ground impacted by noise is fully assessed and consulted. Proposals for a TMZ should be submitted to CAA Airspace Regulation[8]. A CAA case officer will be assigned to a specific change proposal to provide clarification and advice to the airspace change sponsor on how to implement the change process and related guidance. Consideration of the feasibility of a TMZ to mitigate a specific and identified risk should include: effect on other airspace users; the creation of 'choke points' and other changes to traffic patterns within Class G airspace; whether the affected ATS system is capable of PSR blanking; and the basis for CAA approving SSR-only operations. Early engagement with the CAA is recommended to consider the efficacy of any proposed TMZ airspace change proposal.

Note: The UK's Airspace Modernisation Strategy sets objectives for aircraft to operate safely within shared airspace. One element of this is standardising electronic conspicuity technology and its use. This may assist in reducing the impacts of wind turbine effects on a PSR.

2.29 Offshore SSR only and TMZ. CAP 1616H[9] provides specific guidance on Offshore wind farm airspace change proposals.

2.30 Effect of TMZ on ATS Provision. TMZs are only viable when it is acceptable that the use of a non-co-operative surveillance technique (such as PSR) is not

[8] Contact via AROps@caa.co.uk

[9] https://www.caa.co.uk/CAP1616H

necessary for security reasons or for the detection of targets that are possibly undetected by SSR or other co-operative surveillance technique being used. Therefore, TMZs may not be suitable in all areas.

Risk assessment and mitigation of possible hazards introduced by wind turbines

Guidance

2.31 Any new hazards should be identified and assessed to determine if mitigations are adequate to reduce risks to an acceptable level; this should be in accordance with the CAA-approved ANSP's safety management system risk assessment and mitigation process. Ultimately, failure to address such issues may result in withdrawal or variation of the Article 180 / 205 Approval/Designation thereby preventing the provision of the air navigation service.

2.32 In assessing proposed developments and mitigations submitted by wind turbine developers, it is not unreasonable for an aviation stakeholder / ANSP to request sufficient technical information from the developer that would support the production of an adequate safety case. The responsibility for completing the safety case lies with the ANSP. However the developer should cooperate with the ANSP to provide any evidence requested to support its completion, with any necessary commercial considerations subject to agreement.

Aeronautical navigation aids and communication systems

Guidance

2.33 A wide range of systems, including aids such as ILS, VOR/DME, and Direction Finders, together with air-ground communications facilities, could potentially be affected by wind turbine developments. Wind turbines can affect the propagation of the radiated signal from these navigation and communication facilities because of their physical characteristics, such as their situation and orientation in relation to the facility. As a result, the integrity and performance of these systems can, potentially, be degraded.

2.34 Wind turbines may adversely affect the quality of radio communication between Air Traffic Controllers and aircraft under their control. Issues concerning wind turbines and VHF communications should be dealt with on a case-by-case basis and reference made to the guidance contained in Section GEN-01 of CAP 670. Information regarding the technical safeguarding of aeronautical radio stations at aerodromes and a methodology for the prediction of wind turbine interference impact on aeronautical radio station infrastructure is contained in GEN-02 of CAP 670. Further, more specific, studies are likely to be required for more complex situations, such as where there are multiple developments; aerodrome

operators and ANSPs are advised to consider each proposal carefully and if necessary, seek specific technical advice.

Instrument Flight Procedures

Guidance

2.35 The UK has implemented amendment 50 of ICAO Annex 11, Air Traffic Services (including Appendix 7) which became applicable in November 2016. The amendment required a State to approve and remain responsible for Instrument Flight Procedures (IFPs) for aerodromes and airspace under the authority of the State.

2.36 The CAA is the regulator with respect to Instrument Flight Procedures (IFP), setting the associated policy and issuing approvals to individuals and organisations for the purpose of designing Instrument Flight Procedures.

2.37 Article 187(1) of the ANO (2016) as amended states that an instrument flight procedure within the United Kingdom must not be notified unless that procedure has been designed or approved by the CAA.

2.38 The procedures allow aircraft to descend safely towards the runway and to allow aircraft to depart the airport on prescribed routes that allow them to integrate into the en-route airspace structure. One of their functions is to ensure the separation of aircraft from natural or artificial obstacles through the introduction of Obstacle Protection Areas. The geometry of these Obstacle Protection Areas is determined by factors such as: aircraft category, speed, bank angle, procedure type (conventional, RNP, etc.), altitude, wind, etc. and there are internationally agreed processes for protecting these areas. Where wind turbines are proposed which breach these Obstacle Protection Areas, generally the only mitigation to allow their construction is the adjustment of the existing procedures or the development of alternatives.

2.39 IFPs are included in safeguarding activity to determine whether obstacles have any impact on the IFPs and allows the IFP sponsor to determine the most appropriate mitigations to ensure their IFPs remain safe. The protection areas for IFPs are complex and each IFP type has a different set of criteria that needs to be considered, with any obstacle penetration potentially impacting the minimum altitude an aircraft may descend to when conducting an approach, or the minimum gradient they must meet on approach, or exceed on departure, to remain sufficiently clear of obstacles. These IFPs are particularly important during adverse weather conditions when flight visibility is reduced as they provide the pilot with assurances that there are no obstacles on the defined flight path.

2.40 Due to the differences between the IFP protection areas and the Obstacle Limitation Surfaces (OLS) both laterally and vertically, obstacles that do not

penetrate the OLS may have an impact on IFPs. Aerodrome operators are required to establish procedures for continuous monitoring of the obstacle environment. After identification of a new obstacle penetrating OLS or IFP surfaces, the aerodrome operator is required to arrange for the aerodrome obstacle data sets to be updated as soon as practically possible. These data sets must meet data quality requirements (which includes accuracy, resolution, integrity and traceability) as required by UK Regulations (EU) 2017/373 and 139/2014.

2.41 As each APDO employs unique design software and design processes, the CAA does not mandate a specific process for the safeguarding of IFPs. If the APDO carrying out the IFP safeguarding assessment is the same APDO as that who designed or carried out the periodic review for the IFP (which is approved and published in the AIP), then the safeguarding assessment can be conducted using the existing (approved) IFP constructions/calculation methodology/tools without the drawings/constructions being re-checked by an Independent Approved IFP designer.

2.42 If the APDO carrying out the IFP safeguarding assessment is not the APDO who designed or carried out the periodic review for the IFP that is approved and currently published in the AIP; they will need to re-construct the IFPs and carry out a compliance check on the calculations and constructions of the IFPs in accordance with the organisation's Quality Management System.

Note: The safety accountability for the IFP rests with the aerodrome operator.

Air Traffic Services

Guidance

2.43 Where an ANSP determines that it is likely that a planned wind turbine development would result in any of the above effects on their CNS infrastructure, this may not, in itself, be sufficient reason to justify grounds for rejection of the planning application. The ANSP must determine whether the effect on the CNS infrastructure has a negative impact on the provision of the ATS. The developer should pay for an assessment of appropriate mitigating actions that could be taken by the ANSP and/or wind energy developer to deal with the negative impact. The position of an ANSP at inquiry would be significantly degraded if they had not considered all potentially appropriate mitigations. It is essential that wind energy developers form a relationship with the relevant ANSP in order to deal with the impact that their development may have, prior to making an application.

2.44 Where possible, it can be beneficial for the ANSP to record or plot real traffic patterns over a period of time using the surveillance system, and to use this to identify the prevalent traffic patterns. This can then be compared to the location

of the proposed wind turbine development. Where appropriate and feasible, the recorded traffic data above a particular project may be released for further analysis.

2.45 When examining the effects of wind turbines on ATS, particular attention should be paid to the following:

a. Departure Routes including Standard Instrument Departures;

b. Standard Instrument Arrival Routes;

c. Airspace Classification.

d. Performance Based Navigation requirements;

e. Sector Entry and Exit points;

f. Holding points (including the holding areas);

g. Missed Approach Routes;

h. Radar Vectoring Routes;

i. Final Approach Tracks;

j. Visual Reporting Points;

k. Published Instrument Flight Procedures for the aerodrome;

l. Potential impact on navigation aids and voice communications;

m. Future airspace and operational requirements where aerodrome growth is anticipated; and

n. Delegated air traffic services.

2.46 Factors such as the type of radar service being applied and the airspace classification must also be considered when trying to assess the adverse impact of wind turbine effects.

Cumulative effects

Guidance

2.47 Cumulative impact of wind turbine developments on aviation systems may occur because of the combined effect of a series of developments that impact the provision of services.

2.48 In the absence of mitigation, large developments of turbines, including multiple separate wind farms in close proximity, can have a greater impact on aviation operations due to these cumulative effects. Increased numbers of turbines do not

necessarily increase the impact on aviation operations proportionally. The relevant factors affecting the impact may include:

a. The number and relative positions of each wind farm area;

b. The density of the wind farm as perceived by the radar;

c. The probability of detection over each wind farm area;

d. The positions of each wind farm area relative to operations;

e. The types of airspace, services provided and operations in those areas.

2.49 Issues associated with cumulative impact include:

a. Potential surveillance system performance reduction, such as probability of detection in areas of frequent traffic;

b. Surveillance system processing system capacity limitations; a surveillance system data processor only may be able to cope with additional false detections up to a point;

c. False tracks – surveillance system processor tracking algorithms interpret successive turbine detections as a realistic aircraft track, despite sophisticated false target removal algorithms;

d. Impacts on air traffic controllers – a controller's capacity to safely manage a cluttered display has tipping points and non-linearities where it may become a safety issue; this will be context dependent with airspace designation, current traffic levels and historic infringement levels all major factors;

e. Instrument Flight Procedures (IFP) – potential limitations to the adjustment of the existing procedures or development of alternatives.

2.50 ANSPs must consider the feasibility of being able to mitigate the effects of subsequent developments in areas where they had previously been able to accommodate proposed wind turbine developments. Factors affecting mitigation may include:

a. Blanking the area where the degradation on surveillance system performance manifests itself. On most non-cooperative systems height information is not available and this means blanking a column at all altitudes. The cumulative assessment in this case is based on keeping the blanks small enough that aircraft transit them quickly and far enough apart that in balance the missing detections are outweighed by the solid detection performance in between. The exact size and separation parameters will depend on surveillance system performance (such as beamwidth and range cell size, distance from the radar and the wind turbine size and size and density of the wind farms) and expected aircraft speeds among other factors;

b. Micro-blanking – The same concept also applies to mitigation solutions that rely on high resolution micro-blanking. In this case the analysis shifts from how many scans an aircraft will be lost to when the probabilistic impact of scattered single-scan losses lowers average detection performance below required levels and may increase the risk of plot and track loss;

c. In-fill sensor. This requires an acceptable level of coverage in the presence of the turbines and its data has to be stitched together with that of the blanked sensor to provide a seamless picture. The technology doing the stitching; there will be limits on the number of sensors they can safely handle. Safety assurance of the service is required and consideration of failure scenarios of an in-fill sensor required e.g. the in-filled areas become simple blanks within which no surveillance is available.
Note: Within controlled airspace, in the event of a temporary PSR failure, the CAA permits SSR-only air traffic services to be provided for the minimum time necessary to establish procedural separation.

2.51 For aerodrome operators or en-route service providers, there may be difficulty in protecting aviation activity from these cumulative effects, in part because planning applications are generally dealt with on a ‘first come, first served’ basis. All approved applications[10] must be taken into account when considering future applications. This could lead to a situation whereby viable applications are objected to on the grounds of cumulative effect even though other, potentially less viable, projects have not been completed due to the inability, for a variety of reasons, to satisfactorily resolve suspensive conditions.

2.52 The basis for an objection based on cumulative effect would be that the safety and efficiency of the aerodrome or en-route service may not be maintained or that the growth of an aerodrome or en-route service may be constrained. However, the decision concerning how firm these future plans have to be in order to be considered would be within the remit of the relevant planning authority. Nevertheless, airports are encouraged to produce ‘Master Plans’ indicating their future development plans. It is anticipated that these may be taken into consideration by the relevant planning authority.

2.53 It is recognised that many potential developments fail to reach maturity within the formal planning stage. Nevertheless, it is in the interests of aviation stakeholders to take all developments about which they are aware into account until they have been formally notified that a proposal has been abandoned. Therefore, it is in a

[10] Including developments subject to 'suspensive conditions': where planning approval is granted subject to final agreement between an aviation stakeholder and a developer concerning an appropriate mitigation solution.

wind turbine developer's interest to inform all involved parties when such developments are abandoned or postponed.

2.54 The Overarching National Policy Statement for Energy (EN-1), applicable in England and Wales, paragraph 5.5.27 states "As existing CNS infrastructure reaches the end of its operational life, replacement options that are more tolerant of wind turbines, if available, should be installed by CNS owners/operators to futureproof, so far as is practicable, aerodromes against possible future turbine installations in order to maintain or enhance aviation safety. This should be considered on a case-by-case basis, so that the correct solution(s) are identified which strike the balance between surveillance quality/needs and reasonableness of costs being achieved, whilst maintaining safety."

Turbulence

Guidance

2.55 Turbulence is caused by the wake of the turbine which extends down-wind behind the blades and the tower, from a near to a far field. The dissipation of the wake and the reduction of its intensity depend on the convection, the turbulence diffusion, the topography (obstacles, terrain etc.) and the atmospheric conditions.

2.56 There is evidence of considerable research activity on modelling and studying the wake characteristics within wind developments, using computational fluid dynamics techniques, wind tunnel tests and on site LIDAR measurements. A literature survey was recently conducted by the University of Liverpool and CAA[11] to establish the scale and the advances of current research on this front.

2.57 It is recognised that aircraft wake vortices can be hazardous to other aircraft, and that wind turbines produce wakes of similar, but not identical, characteristics to aircraft. Although there are independent bodies of knowledge for both of the above, currently, there is little or no known method of linking the two. Published research suggests a distance of 8-12 rotor diameters downstream of the wind turbine is a distance at which the turbulence effects are not expected to affect conventional aircraft flying [12] [13]. Measurement work has been focused on the near wake due to technical challenges of the experimental set up, while modelling studies are capable of examining the wake turbulence further

[11] https://livrepository.liverpool.ac.uk/3012539/1/TN_Wind_Turbine_wake_encounter_by_light_aircraft%20final.pdf

[12] Wind Turbine Wake Analysis, L.J. Vermeer, J.N. Sorenson, A Crespo, Progress in Aerospace Sciences, 39 (2003) 467-510.

[13] NLR Technical Publication 2019-083 Determining a safe-distance guideline for helicopters near a wind turbine and wind park, February 2019

downstream[14] [15].

2.58 There were no occurrence reports or aircraft accident reports related to wind turbines in the UK between 2000 and early 2022[16]. A light aircraft crash occurred in March 2022, which the pilot suggested might have been "associated with wake turbulence downstream of a wind turbine installation." The Air Accidents Investigation Branch[17] noted that "the available literature would suggest that the possibility of encountering wake turbulence from the wind farm at this airfield is remote. However, it cannot be entirely ruled out." The CAA has also received anecdotal reports of aircraft encounters with wind turbine wakes. The effects of these wakes on a wide variety of aircraft types are not yet known.

2.59 The CAA investigated the effects of small wind turbine wakes on GA aircraft[18]. The results of this study show that wind turbines of rotor diameter (RD) of less than 30m should be treated like an obstacle and GA aircraft should maintain a 500ft clearance.

2.60 Pilots of any air vehicle who believe that they have encountered significant turbulence, which they believe to have been caused by a wind turbine, should consider the need to report this through the existing MOR scheme.

2.61 Until the result of further research is known, analysis of turbulence can only be undertaken on a case-by-case basis, taking into account the proximity of the development and the type of aviation activity conducted. Whilst being a consideration for all aircraft (particularly in critical stages of flight), turbulence is of particular concern to those involved in very light sport aviation such as gliding, parachuting, hang-gliding, paragliding or microlight operations as in certain circumstances turbulence could potentially cause loss of control that is impossible to recover from.

Wind turbine wake physics

Guidance

2.62 Wind turbine wake is dependent on many parameters. The thrust generated by rotor, the tip velocity ratio (blade tip velocity to wind speed), wind direction and

[14] Calculating the flow field in the wake of wind turbines, J.F. Ainslie, Journal of Wind Engineering and Industrial Aerodynamics, 27 (1988) 213-224.

[15] Turbulence characteristics in wind-turbine wakes, A Crespo and J Hernandez, Journal of Wind Engineering and Industrial Aerodynamics 61 (1996) 71-85.

[16] This is based on a search of the ECCAIRS database containing occurrence reports made under Regulation 376/2014 between 1 January 2000 and 28 February 2022

[17] https://assets.publishing.service.gov.uk/media/620bb596e90e0710aa4b69f3/Piper_PA-22-150_G-ARDS_03-22.pdf

[18] http://www.liv.ac.uk/flight-science/cfd/wake-encounter-aircraft/

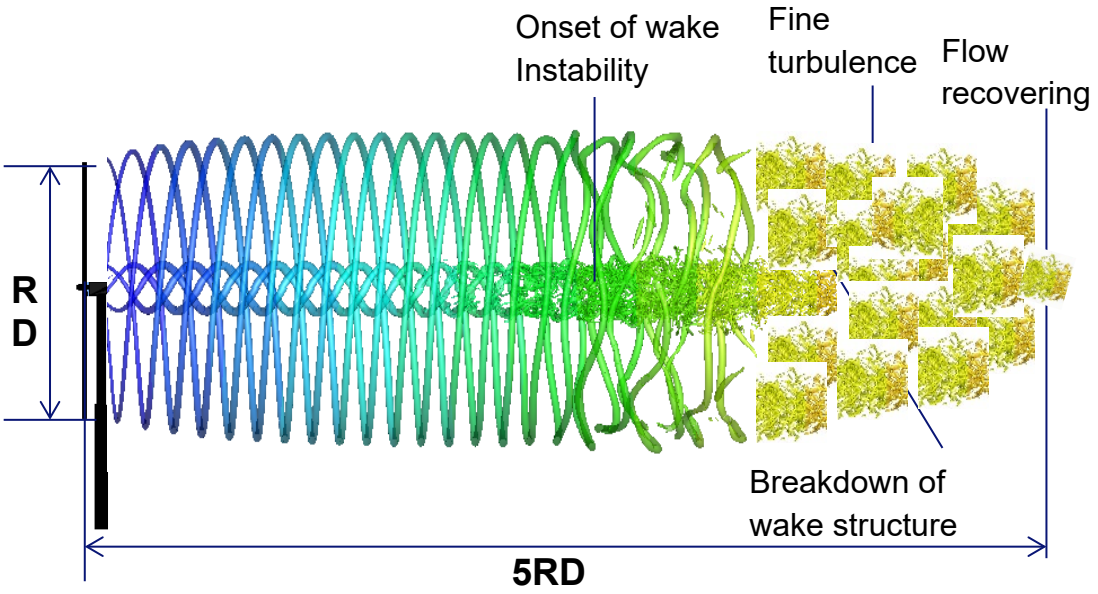
speed, turbulence level in free stream, weather condition and the geometry of wind turbine all have impacts on the characteristics of the wake.

2.63 The wake of a wind turbine can be divided into a near and a far region. The near wake is the area just downstream of the rotor up to one RD, where the effect of the rotor properties, including the blade aerodynamics and geometry determine the flow field. Near wake research is mainly focused on the wind turbine's performance and the physics of power extraction. The far wake is the region beyond the near wake, where the details of the wake are less dependent on the rotor design. The main interest in this area is the wake interference with other wind turbines (e.g. in a wind farm) or passing-by aircraft (wind turbine wake encounter). Here, flow convection and turbulent diffusion are the two main mechanisms that determine the flow field.

2.64 LIDAR field measurements on a WTN250 wind turbine at East Midlands Airport, UK, indicated that statistically, the wake velocities recovered to 90% of the free stream velocity at the downstream distance of 5 RD.

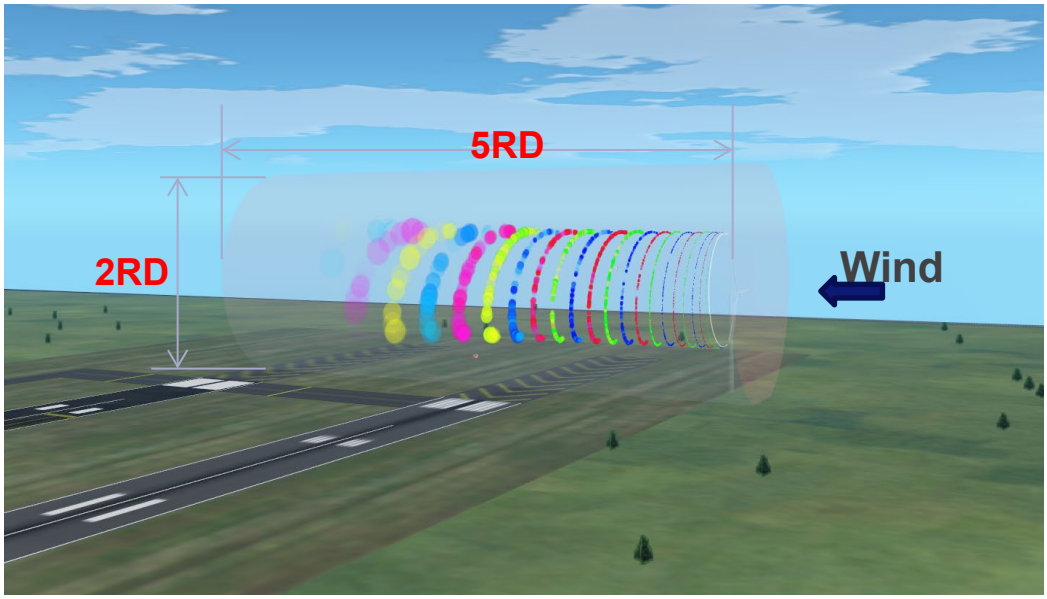
2.65 Based on the models described in the Liverpool University Research Paper[19], schematics of the wake region for small wind turbines are given in the following figures. The figures show the zone where wake encounter has potential to cause severe impact on the encountering GA aircraft.

Figure 1: Schematic of the wind turbine wake. The effect of wake is weaker beyond 5-RD downwind for the wind turbines of diameter < 30m.



[19] http://www.liv.ac.uk/flight-science/cfd/wake-encounter-aircraft/

Figure 2: The cylindrical region downwind the rotor should be avoided. Its size is 5RD (downwind) by 2RD (vertical). Coloured helices indicate wake vortices and decay.



Economic issues

Guidance

2.66 As a result of the role and responsibilities of the CAA and aviation stakeholders, action will be taken to maintain the high standards of safety, efficiency and flexibility. However, it is possible that aviation activity might have to be constrained as a consequence of proposed wind energy developments. Even in circumstances where a proposed development may not affect a current activity, future expansion (for example, as listed in an Aerodrome Master Plan) may be restricted were it to go ahead. This could eventually have an economic impact on the aerodrome, ANSP or activity, and this aspect should be taken into consideration when assessing the impact of any proposed wind turbine development. Therefore, it is considered entirely appropriate for an aerodrome to include an assessment of the economic impact that may arise from a proposed wind turbine development. However, it is important to note that comments made in this respect need to be unambiguous in order to allow a planning authority to ensure that this important aspect is taken into account appropriately.

En-route obstructions

Guidance

2.67 It is possible that an existing or proposed wind turbine development that does not infringe an aerodrome OLS may nevertheless have a potential impact upon local aviation activity. For example, a development beyond an OLS, but only

marginally clear (laterally or vertically) of controlled airspace, might be assessed as having a potential adverse impact upon operations within Class G (uncontrolled) airspace due to the potential for the creation of 'choke points' where aircraft are forced into a reduced volume of available airspace.

2.68 Whilst the CAA will highlight such issues away from the immediate vicinity of aerodromes, aerodrome operators/licensees should be cognisant of these issues when engaging with other parties on wind turbine associated matters.

Figure 3: Difficulties in visually acquiring anemometer masts



2.69 Wind turbine developers should be aware that anemometer masts are often difficult for pilots to acquire visually (see Figure 3 above), and so aviation stakeholders may assess that individual masts should be considered a significant hazard to air navigation and may request (either during the planning process, or post-installation) that masts be lit and/or marked. Typically, there is no legal mandate for structures onshore smaller than 150 m (492 ft) to be lit. Whilst the CAA would not in isolation make any case for lighting and/or marking of structures that is not required under existing regulation, the CAA would typically support related aviation stakeholder proposals to aid the visual conspicuity of anemometer masts on a case by case basis. Individual cases should not set a precedent for future requests. Onshore masts have the potential to pose a risk to general aviation. To that end, the General Aviation Awareness Council (GAAC) (on behalf of other GA representative bodies) and a number of helicopter operators, with the in-principle agreement of RenewableUK, have asked that the following request be relayed by the CAA on their behalf:

"Anemometer masts and/ or their guy wires should be equipped with aids to increase their daytime visual conspicuity where a risk based proposal demonstrating specific need for such measures has been submitted by the aviation stakeholder. Noting that the deployment of any such measure can only be mandated by the relevant Planning Authority, it is acknowledged that such visual conspicuity aids should not impact upon the integrity of the structure itself, the data generated or risk to personnel these aspects are for the developer to consider/assess.

The most effective means of achieving this may be the use of orange marker buoys on the guy wires, such as those that may be fitted to overhead power cables (the use of which has some basis in international regulatory direction). However it is noted that in some locations the structural loads imposed by such markers may be unacceptable. In such cases, the goal of increasing the visual conspicuity of masts and supporting guys might be achieved by different means, which generally place little or no additional structural load on the mast/guy combination. Such means include:

1. *Painting all or part of the mast; options could include alternate contrasting stripes, such as orange and white, or a single contrasting colour (noting that it may need to contrast with terrain, or sky, or both) and/or,*
2. *Reflective bird flight deflectors of minimum 120mm diameter fitted to the guy wires at intervals, and/or*
3. *High visibility sheaths enveloping the supporting guy and/or*
4. *Ground mats, or construction such as a box, of a contrasting colour scheme to the ground at the foot of the mast.*

Whichever method is chosen it will need to satisfy all other relevant planning considerations. For example, bird deflectors may be required for bird protection reasons, and visual intrusion concerns may need to be taken into account. It is envisaged that the norm would be that one method would suffice."

It is recommended that agreement should be sought, through dialogue between the aviation stakeholder, the developer and the planning authority regarding the most appropriate method of mitigation. However, should the planning authority require further input regarding the general requirement for increasing the visual conspicuity of lattice masts or the specific need in any particular case, enquiries should be forwarded to the GAAC at planning@gaac.org.uk).

2.70 Where such obstacles affect operations on an aerodrome, it is the responsibility of the aerodrome operator to ensure appropriate publication in the UK Aeronautical Information Publication (AIP), and to ensure that they establish an effective working relationship with their relevant planning authority to ensure that they are consulted when appropriate.

Specific Aircraft Operations

Guidance

Emergency Services Aviation Support Units (ASUs)

2.71 Due to their unique operating nature, it is difficult to predict the impact of wind turbine developments on emergency services ASUs. It is important, therefore, for emergency service ASUs to engage with all relevant planning authorities within their operating area to ensure that they are consulted when planning applications are made. The CAA encourages developers and planning authorities to consult with local ASUs, and would be supportive of claims to mark or light turbines that do not fall under Article 222 of the ANO where a case by case assessment demonstrates there is a justifiable benefit.

2.72 Emergency services ASUs are permitted by the CAA to operate below 500 feet AGL or highest obstacle in close proximity to the aircraft in order to carry out their duties. Helicopters will routinely follow main roads and motorways but may also transit along open land, sometimes in difficult weather conditions, during their operations and may need to land anywhere, although they will also have specifically designated landing sites. It should be noted that while some emergency services ASUs fly with NVDs, their use is not currently universal.

2.73 Police Aviation in England and Wales is centrally coordinated by the National Police Air Service (NPAS) which is administered by the West Yorkshire Constabulary. Maps showing NPAS helicopter bases can be found on the NPAS Website[20]. NPAS has a single email address for wind farm consultations and advice: npas.obstructions@npas.pnn.police.uk which should be used for correspondence. The Scottish Police ASU, based in Glasgow, is not part of NPAS and should be contacted directly where appropriate.

2.74 SAR operations are described in Chapter 5. Other operators may be more locally based, such as a regional air ambulance service.

Parachute drop zones

2.75 Parachutists drop from heights up to 15,000 ft AGL within a published Drop Zone (DZ), normally out to a minimum of 1.5 NM/2.8 km radius from the centre of the Parachute Landing Area (PLA).

Note: CAP 660 Parachuting refers

2.76 Hazards to PLAs are categorized as:

(1) Special Hazard. A hazard which could constitute a special risk to parachutists and if parachutists were to come into contact with may result in

[20] http://www.npas.police.uk/bases

serious or fatal injury" e.g. stretches of open water, deep rivers, electricity power lines, wind turbines of a height greater than 15 m to blade tip at its highest point, densely built up areas, cliffs and quarries.

(2) Major Hazard. Obstacles, either natural or artificial, which because of their size may be difficult to avoid and which, if struck by a parachutist, may result in injury; i.e. large hangars, buildings, woods etc.;

(3) Minor Hazard. Any object, either natural or artificial, which should be easily avoided but which if struck by a parachutist may result in injury; i.e. hedges, fences, ditches etc.).

2.77 Wind turbines pose a special risk to parachutists, with serious or fatal injury risks; those over 15 m high are considered by British Skydiving to be a Special Hazard. Wind turbines of 15 m or below are considered Major Hazards.

2.78 PLAs to be used by all designations of parachutists should provide a large open space of reasonably level ground, which can contain a circle of 250 m radius free from Major Hazards and largely free from Minor Hazards. These PLAs should be bordered on at least three sides by suitable overshoot areas, where parachutists may land if they are unable to land on the PLA: these overshoot areas should be free from Special Hazards and largely free of Major Hazards.

2.79 Wind turbines over 15 m high (50 feet) are considered a rotating special hazard and as such if located within the designated DZ would likely result in restrictions being placed upon any parachute activity within that DZ.

2.80 It is worthy of note that any obstacle over 300 ft (91.4 m) in height is no longer considered by British Skydiving to be just a ground obstacle to parachutists, but also an air obstacle, given that it protrudes into airspace within which parachutists (particularly in an emergency situation) may not yet have taken control of their canopies, and so could result in an aerial collision.

Very Light Aircraft

2.81 Due to the potential for sudden loss of lift within areas of turbulence, very light aircraft are operated away from areas of known turbulence or only in areas where turbulence is consistent and predictable (such as hill sites used by hang-gliding/paragliding clubs). Introducing a wind turbine to a location that is frequented by very light aircraft may result in that location becoming unviable or less attractive to visiting pilots if the turbine generates turbulence that may exceed the aircraft’s operating limits.

Gliders

2.82 Many modern gliders have a glide ratio of at least 50:1 and the most modern gliders can exceed that, with further progress expected in future. Developments of wind turbines within 10 km of a gliding site or where the maximum height of the

structure is within a 50:1 angle of a gliding site will present additional considerations beyond those associated with powered aircraft. Therefore, notwithstanding the CAA recommended distances quoted above, the British Gliding Association (BGA) requests that relevant gliding sites and the BGA are consulted where proposed developments are within 10 km of any charted glider launch site.

Military impact

2.83 Wind turbine developments can have a detrimental effect on military operations. Military aviation operations predominantly take place in Class G airspace and can differ markedly from civil operations, particularly with respect to operational low flying, and the sensitivity of military CNS facilities. The DIO are to be consulted in all cases where a proposed wind turbine development may affect military operations.

2.84 Low flying is a vital element of military operations in areas of conflict, and a large proportion of the flying will be undertaken at night. Low flying training across the UK can take place as low as 100 ft for fast jet aircraft in Tactical Training Areas, and 250 ft in Low Flying Areas. Helicopters fly tactically down to 50 ft and routinely down to100 ft during training sorties in all areas.

2.85 The MoD has developed its own Obstruction Lighting Guidance. The majority of night time flying by MoD aircraft is undertaken by crews equipped with NVDs; therefore IR vertical obstruction lights will be suitable in most occasions.

2.86 An application for onshore wind turbines will receive notification from DIO indicating whether IR lights will be suitable. In some cases a combination IR / red lighting will be required, for example geographical choke points or to denote the extremities of a larger wind farm.

2.87 Careful attention needs to be taken to ensure that the IR light chosen by the wind developer meets the MoD's requirements, as some IR (Light Emitting Diode) lights are not compatible with military NVDs.

2.88 Requests for clarification should be addressed to the DIO. More information is available from the DIO Website[21] and contact details are included in Appendix A.

[21] www.gov.uk/government/publications/wind-farms-ministry-of-defence-safeguarding/wind-farms-mod-safeguarding

Chapter 3

Wind turbine development planning process

Planning frameworks

Guidance

3.1 The establishment of devolved administrations in Scotland, Wales and Northern Ireland has resulted in new legislative frameworks through which planning is enacted. As a result, there are different consenting processes that may apply under each devolved administration. The material in this chapter is not intended to provide a comprehensive guide to planning requirements but is designed to highlight the common aviation themes and issues that may require consideration under the relevant consenting processes.

3.2 Guidance for planners is provided, although this is a devolved function. For example, the National Planning Policy Framework (NPPF)[22], applicable in England, is primarily used for decisions made under the Town and Country Planning Act (as opposed to Nationally Significant Infrastructure Projects). The Scotland National Planning Framework[23] sets policy principles for energy, national developments statements of need and planning priorities.

3.3 Under the devolved functions, specific planning guidance for onshore and offshore developments is available from the web pages of the contacts in Appendix A.

Pre-planning and consultation

Guidance

3.4 Developers may undertake their own pre-planning assessment of potential civil aviation related issues. NATS, the MoD and certain airports also offer pre-planning services. Three aviation environments are described below, aerodromes and their surroundings, en-route and offshore, and a respective overview of the considerations that may need to be addressed:

a. Aerodromes

(i) CNS facilities

- Safeguard PSR and SSR

[22] https://www.gov.uk/government/publications/national-planning-policy-framework--2

[23] https://www.gov.scot/publications/national-planning-framework-4/documents/

- Safeguard Approach Aids
- Safeguard Navigation Beacons
- Safeguard VHF
- (Consultation required with aerodrome licensee/manager)

(ii) Obstacle Considerations

- Obstacle Limitation Surfaces
- Impact on instrument flight procedures
- Need for lighting to aid night-time conspicuity
- Anemometer masts.
- (Consultation required with aerodrome licensee/manager)

(2) En-Route

(i) CNS facilities

- Safeguard PSR and SSR
- Safeguard Navigation Beacons
- Safeguard VHF
- (Consultation required with NERL)

(ii) Obstacle Limitation Surfaces

- ≥100 m Chart and entry to AIP
- ≥150 m (492 ft) Lighting in accordance with article 222 of ANO (2016) as amended
- Marking of turbine (upper 2/3 white/grey in accordance with ICAO guidance)
- Potential for additional lighting requirements where turbines may be considered as a significant hazard to air users.
- Anemometer masts.
- Emergency Services (e.g. Police Air Service ASUs, Helicopter Emergency Medical Service and SAR)

(3) Offshore

(i) CNS facilities

- Safeguard PSR and SSR

- Safeguard Navigation Beacons
- Safeguard VHF
- (Consultation required with NERL)

(ii) Obstacle Limitation Surfaces

- Offshore Lighting in accordance with Article 223 of ANO (2016) as amended
- CAA guidance on offshore lighting specifications
- HMR
- Operations around oil and gas platforms
- Anemometer masts
- Search and Rescue requirements

Considerations during planning

Guidance

3.5 There are standard periods that planning consultations are open for comment. Aerodrome operators and ANSP undertake technical safeguarding against the proposed development. However, if an understanding and/or agreement has been reached between the aviation stakeholder and developer, a formal planning objection may not be required to be raised in any response and instead can refer to the understanding/agreement.

3.6 Aerodromes. Whilst not definitive, it should be anticipated that any wind turbine development within the following criteria[24] might have an impact upon civil aerodrome[25] - related operations:.

a. Unless otherwise specified by the aerodrome or indicated on the aerodrome's published wind turbine consultation map, within 30 km of an aerodrome with a

[24] Aerodrome criteria are generically based upon the safeguarding requirements and guidance contained in UK Regulation (EU) 139/2014, CAP 168 and CAP 793 (both current and historical). The ranges quoted are for guidance only. If proposed developments lie marginally outside the ranges highlighted, but nevertheless in close proximity to other developments, developers are advised to consider the potential cumulative impact issues. The object of any pre-planning process is to identify all possible aviation concerns to the developer at an early stage and as such, the assessment should err on the side of caution.

[25] In this context the term 'aerodrome' includes any site used regularly by aircraft (including helicopters and gliders) for take-off and landing. The UK VFR charts depict all such sites known to the CAA, although effects on uncharted aerodromes must still be considered.

surveillance system facility. The distance can be far greater than 30 km depending upon a number of factors including the type and coverage of the surveillance system and the particular operation at the aerodrome;

b. Within airspace coincidental with any published Instrument Flight Procedure (IFP) to take into account the aerodrome's requirement to protect its IFPs;

c. Within 17 km of a non-surveillance system equipped licensed[26] aerodrome with a runway of 1100 m or more;

d. Within 5 km of a non-surveillance system equipped licensed aerodrome with a runway of less than 1100 m;

e. Within 4 km of a non-surveillance system equipped unlicensed aerodrome with a runway of more than 800 m;

f. Within 3 km of a non-surveillance system equipped unlicensed aerodrome with a runway of less than 800 m.

The figures above are for initial guidance purposes only and do not represent definitive ranges beyond which all wind turbine developments will be approved or within which they will always be objected to. These ranges are intended as a prompt for further discussion between developers and aviation stakeholders in the absence of any other published criteria.

3.7 Non-aerodrome related activity. Developers should also consider the potential for wind turbines to impact upon known general aviation activity that are annotated on CAA-sponsored, NATS-produced VFR charts, but which are not related to a recognised or single aerodrome (for example, charted free-fall parachute DZ and hang/ para-gliding winch launch sites). Typically, developers will need to engage direct with relevant aviation operators where a development would be within 3 km of any such site.

3.8 Cross-boundary. In order to delineate responsibility for the provision of flight information services to aircraft, airspace is divided up into internationally recognised Flight Information Regions (FIRs). Airspace in the UK is divided into the London and Scottish FIRs which together form the UK FIR. Coordinates for these boundaries are listed in the UK Aeronautical Information Publication Section ENR 2.1. Offshore developments have the potential to straddle these boundaries, e.g. the East Anglia ONE development, part of which is in the Dutch FIR. Airspace outside the UK FIR is the responsibility of other European aviation authorities, whose regulations may differ from those that apply in the UK. Accordingly, wind turbine developers should contact the CAA for specific

[26] Licensed in accordance with Part 8 Chapter 1 of ANO (2016) as amended.

guidance in all instances where developments are likely to approach the limits of the UK FIR.

Referrals and inquiries

Guidance

Referrals

3.9 In England, under section 77 of the Town and Country Planning Act 1990, the Secretary of State for Housing, Communities and Local Government (DHCLG) can call-in any planning application for their own determination. While the aviation industry has no powers of veto, there is a legal obligation placed upon planning authorities in England to give warning if they are minded to grant planning permission against advice given by a statutory safeguarding consultee (ODPM/DfT/ NAFW Circular 1/2003. This process offers an opportunity for the CAA to establish whether a solution is apparent or, if it fails to resolve the issue, to refer the matter for a decision by central Government. In Scotland, local planning authorities must notify Scottish Ministers if they intend to grant planning permission for certain categories of development including electricity generation.[27] These are known as notified applications. Scottish Ministers have a general power that allows them to call-in an application to take on the decision-making role; the circumstances in which Ministers will do so were set out by Ministers in June 2023.[28]

Consistency, accuracy and use of consultants

Guidance

3.10 When aviation stakeholders are consulted over wind turbine developments, either at the pre-planning stage or once the formal planning application process has begun, it is critical that the responses made are consistent, factually accurate and cover all relevant aspects. It should be noted that these responses may be subject to challenge.

3.11 In submitting a wind turbine development proposal, developers will regularly employ subject matter experts in the form of consultants to prepare reports to identify potential issues and address any issues raised by aviation stakeholders. This may be in the pre-application stage or to seek to address aviation concerns following aviation objections. In addition, as part of the formal process, developers are often required to submit an Environmental Impact Assessment

[27] Circular 3/2009: Notification of Planning Applications

[28] Planning applications call-in: Ministerial statement – 28 June 2023

which will include an assessment of aviation issues and mitigations, often based on supporting reports commissioned by the developers.

Non-Disclosure Agreements for Radar Mitigation Schemes

Guidance

3.12 A Non-Disclosure Agreement (NDA) offers several important benefits for individuals and organisations. These include:

- Protection of sensitive information, including intellectual property, business strategies and financial data;
- Who can access sensitive information and how it may be used;
- Support business relationships in respect of partnerships, potential mergers and investment decisions; and
- Data protection, including client or supplier information.

3.13 Specifically in respect of radar mitigation scheme agreements, NDAs may be used to:

- Protect information regarding proprietary mitigation algorithms and technologies, radar coverage gaps and site-specific radar configurations and vulnerabilities;
- Develop and implement cost-sharing models for radar upgrades or relocations and commercial terms for matters such as long-term maintenance, system upgrade and support;
- Consider and evaluate mitigation options that might affect land use, public perception, or investment decisions that would be premature to make public.

3.14 The use of NDAs for Radar Mitigation Schemes may have potential drawbacks:

- They may hinder wider collective or strategic action e.g. Government or regulator intervention resulting in legislative or regulatory action.
- They may limit cross-industry collaboration and knowledge sharing e.g. assessment of mitigation options or successful interventions, which are essential for developing scalable, cost-effective solutions.
- They may limit understanding on how funding is spent, and therefore perception of value for money and trust.
- They may reduce clarity of accountability and oversight e.g. detailing exactly how the fund is being used to cover capital expenditure and operational expenditure both now and in the future.

- They may reduce clarity of how other developments could benefit from existing radar mitigation schemes and enable developers to share costs more equitably.

3.15 The following principles should be considered if NDAs are used for Radar Mitigation Schemes:

- They should be used to the minimum extend possible to protect sensitive technical and commercial information.
- They should consider using tiered confidentiality to protect only what is necessary (e.g. technical proprietary algorithms), while allowing broader information sharing.
- They may include clauses for partial disclosure to regulators, planning authorities, or appropriate Government and non-government bodies.

3.16 The use of NDAs should be considered against the wider public interest aspects of:

- Cost of mitigation schemes over the lifetime of the proposed development;
- How radar mitigation schemes funding is planning to be spent, and how aerodrome and ANSPs can demonstrate value for money and trust to electricity consumers;
- Multi-stakeholder collaboration;
- Understanding the benefits and uptake of types of mitigation schemes;
- Supporting competition and development of mitigation solutions;
- Open and standardised approach to mitigation;
- Future renewable energy developments;
- Information already in the public domain or non-sensitive.

Chapter 4

Onshore Wind Turbine Obstacle Lighting and Marking

CAA Specification

Introduction

Guidance

4.1 Aircraft obstacle lights are attached to tall structures as a collision avoidance measure. Although aviation rules of the air mean that aircraft should plan to fly above the height of the tall structure(s) along its path with an additional height margin, some civil operators are provided with permissions or exemptions to fly below these minimum height rules. Military operators may operate at low levels as well and typically specify their own specific lighting requirements.

4.2 Aircraft obstacle lights make the location and height of structures visible to aircraft. In the UK, they must be used at night and although other countries may require them to be used during the day also, there is no requirement for this in UK airspace. As a general principle, the light fittings and placement on the structure should be such that they are visible to enable flight crew to recognise the hazard and take appropriate action. However, specific obstacle lighting variations may be considered on a case-by-case basis.

Marking

CAA Policy

4.3 Wind turbine marking refers to the colours used on the tower, nacelle and blade. In the UK, the rotor blades, nacelle and upper 2/3 of the supporting mast of wind turbines that are deemed to be an aviation obstruction should be painted white or a grey colour to be discernible from the air during the day. The CAA will accept a white paint colour that is pure white, RAL 9010 or an equivalent, through to light grey, RAL 7035, which is the darkest acceptable off-white colour allowed. Any shade of white between these two RAL specifications will also be accepted. The use of any other colour should be supported by an aeronautical study that can demonstrate the use of that colour does not impact the discernibility of the wind turbine.

Onshore Obstacle Lighting

4.4 Obstacle lighting of structures located close to licensed aerodromes are covered under Section 47 of the Civil Aviation Act 1982. Government aerodromes are similarly covered. Article 222 of the ANO (2016) as amended details the requirement for the lighting of land-based tall structures located outside of the safeguarded areas of licensed and government aerodromes. Such lighting must be displayed at night and be visible from all directions. Night is defined in the ANO (2016) as amended in Schedule 1 (Interpretation) as the time 30 minutes after sunset until 30 minutes before sunrise (both times inclusive), sunset and sunrise being determined at surface level.

4.5 Article 222 of the ANO (2016) as amended requires structures away from the immediate vicinity of an aerodrome (and which have a height of 150 m (492 ft) or more AGL) are fitted with medium intensity steady red lights[29] positioned as close as possible to the top of the obstacle, and also equally spaced at intermediate levels, so far as practicable, between the top lights and ground level with an interval not exceeding 52 m.

CAA Policy

4.6 In accordance with Article 222(6) of the ANO (2016) as amended and considering ICAO Annex 14 Volume 1 Chapter 6, the CAA has determined the following specific lighting requirements apply to wind turbines:

a. The requirement to fit lights is based on the maximum height from the ground to the tip of the blades, but the requirement for the positioning of lights is based on the fixed structure (nacelle and tower).

b. One medium intensity (2000 candela) red light must be placed on the nacelle of the turbine; a second 2000 candela red light serving as an alternate should be provided in case of failure of the operating light.

c. At least three (to provide 360 degree coverage) low-intensity Type B[30] lights (32 candela) lights must be provided at an intermediate level of half the nacelle height ± 10 m.

d. The lights required by sub-paragraphs 5.6(b) and 5.6(c) above must be so fitted to show when displayed in all directions without interruption[31].

[29] 'Medium intensity steady red light' means a light that complies with the characteristics described for a medium intensity type C light as specified in Annex 14 Volume 1 (Aerodrome Design and Operations) (Eighth edition July 2018) to the Chicago Convention.

[30] As specified in Annex 14 Volume 1.

[31] The term 'without interruption' does not include blade flicker as a result of the rotating blades.

e. For a group of two or more wind turbines, obstacle lighting must be fitted and operated when required to identify the corners and perimeter of the wind farm.

f. Additionally, if the height of other turbine nacelle(s) in the wind farm exceed the height of a plane extending at an elevation of 10 degrees above the horizontal from the nacelle of a turbine that is required to be lit, then obstacle lighting must be fitted and operated in accordance with sub-paragraphs 5.6(b) and 5.6(c) on these wind turbines.

g. Any wind turbine that is located at a distance greater than 1800 m from the nearest lit turbine must also be lit.

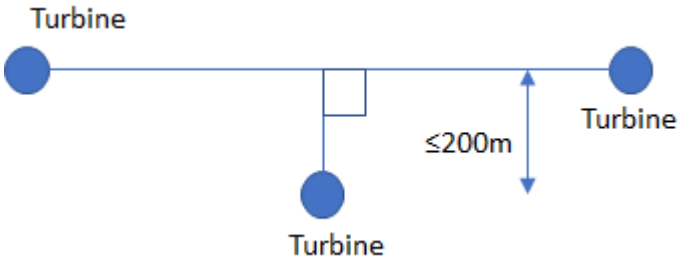
h. Obstacle lighting may be omitted on individual turbines that are on the perimeter of the wind farm if it can be demonstrated that:

   i. the maximum distance between lit turbines does not exceed 900 metres;

   ii. the corners of the wind farm are lit; and

   iii. any significant change of direction of the perimeter of the wind farm can be recognised.

Note: An intermediate wind turbine can be considered to lie along the perimeter if it is at a distance equal to or less than 200 m of a perpendicular line extending from a line connecting the two outer wind turbines, protruding outwards from the wind farm, as per the following diagram:



i. Lights may be operated by a suitable control device (e.g., photocell, timer, etc.). In the event that a photocell is used, in lieu of the 30 minutes after sunset until 30 minutes before sunrise requirement, the CAA will accept a solution that turns the lights on whenever illuminance reaching a vertical surface falls below 500 LUX. The control device should turn the lights off when the illuminance rises to a level of 500 LUX or more.

j. If visibility in all directions from every wind turbine generator in a group is more than 5 km, the light intensity for any visible light required by Article 222 of the ANO (2016) as amended to be fitted to any generator in the wind farm

and displayed may be reduced to not less than 10% of the minimum peak intensity specified for a light of this type.

k. For turbines that are more than 315 m AGL in overall height, the above requirements apply and, the developer must consider whether additional marking and lighting may be required. This typically would be expected to include a consultation with aircraft operators, or their representative organisation(s), who might be reasonably expected to operate in the vicinity of the turbines.

l. Developers may apply to the CAA for other specific obstacle lighting designs/layouts. Any lighting scheme that reduces the overall lighting provision requires additional justification for such a layout, consideration of the airspace and types of operation in that airspace at night as well as possible additional mitigation measures issues.

Note: Prior to the introduction of paragraph 5.6, the previous requirement for the lighting of wind turbines above 150 m was for all turbines in the wind farm above 150 m AGL to be lit. Therefore, for a period of time, aircraft operators should be aware that some wind farms may continue to light all turbines while new wind farm developments will only potentially light the perimeter turbines. The CAA will support existing planned or operational wind turbine operators with structures 150 m or above to benefit from the revised lighting requirements, but lighting may be subject to planning consent conditions and we would recommend wind turbine operators/owners seeking advice on such matters from the planning authority.

4.7 Wind farm operators should monitor the serviceability of the aviation obstacle lighting in order to meet the requirements of Article 222(3) of the ANO (2016) as amended. For any outage that is expected to be or is greater than 12 hours, the operator should request a NOTAM to be issued by informing the NOTAM section (operating 24 hours / 7 days) of the UK Aeronautical Information Service (AIS) by telephoning +44 (0) 1489 61 2488 / 2489 as soon as possible. This NOTAM is to specifically state (with justification) if the repair/replacement of the light will exceed 72 hours. AIS will copy the details of the NOTAM to the operator and to the CAA.

4.8 Wind farm operators should also consider enhancing the notification process of a lighting outage by making direct contact with adjacent airports, the National Police Air Service, and the Maritime and Coastguard Agency.

Guidance

4.9 In addition, the MCA, emergency service ASU or a local aerodrome may request additional lighting requirements for aviation obstruction purposes where, owing to the nature or location of the structure, it presents a significant hazard to air navigation. In such circumstances the requester must provide a suitable

justification for the requirement i.e. by virtue of its/their location and nature, it could be considered a significant navigational hazard. However, in general terms, structures less than 150 m (492 ft) high, which are outside the immediate vicinity of an aerodrome, are not routinely lit.

4.10 Airports are exempt from the statutory nuisance regime for artificial light. Aerodrome and aircraft operators are encouraged to recognise that obstacle lights can impact people, particularly those living in or visiting intrinsically dark landscapes.

4.11 While anemometer masts are likely to remain below the threshold that requires they be lit, there may be instances where their lighting is prudent in the interests of air safety.

Infra-Red (IR) lighting

CAA Policy

4.12 There are an increasing number of civil operators who use NVDs while operating at night. Use of NVDs by operators requires the integration of them with other aircraft components, training and ensuring continuing airworthiness. Operators may need to obtain regulatory approvals for the aircraft airworthiness and their operating procedures.

4.13 Most obstacle lights operating in the visible part of the spectrum fall outside the spectrum range of NVDs due to the precision electronics used in Light Emitting Diode lights.

4.14 Where IR lighting is installed, this is in addition to the requirements for medium intensity steady red lights stated above in paragraph 4.6. The CAA recommends the use of combined visible and IR obstacle lighting on the turbine perimeter. However, where IR lighting is installed throughout the wind farm, no additional visible lighting within the wind farm is required i.e. the requirements set out in 4.6 h) are waived.

4.15 IR lighting should all operate at a wavelength of between 750 and 900 nanometres and ideally concentrated between 800 and 850 nanometres for optimum detection. It should provide 360 degree coverage. IR lighting should have a flash pattern of 60 flashes per min at 100-500 ms duration (ideally 250 ms). It should have a minimum radiant intensity of 600 milliwatts per steradian (mW/sr) between 15 degrees below the horizontal plane and 30 degrees above the horizontal plane with up to 50% reduction between 10 and 15 degrees below the horizontal plane and 25 to 30 degrees below the horizontal plane permitted. Vertical overspill is acceptable.

4.16 Clarification of military requirements for IR lighting should be addressed to the Defence Infrastructure Organisation.

Aviation Detection and Obstacle Lighting System (ADLS)

4.17 ADLS may be considered as a system that only switches on aviation obstacle lights when an aircraft is detected within a certain volume around a wind farm. Depending on where the wind farm is located, this may result in the obstacle lights only being illuminated for a small percentage of the time that they might otherwise be lit to comply with the ANO obstacle lighting requirements.

4.18 Implementation of ADLS is not a mandatory requirement and its deployment may act as a mitigation to the visual impact of aviation obstacle lighting operating on wind turbines at night in light sensitive areas but continue to comply with the law and reduce the risk of the obstacles to aircraft operations.

4.19 ADLS for wind turbine obstruction lighting will not be permitted within the obstacle limitation surfaces of a licensed aerodrome due to issues concerning the potential late detection of aircraft.

4.20 In operation, the default position for an ADLS is to have the obstacle lights switched on, with the ADLS switching off the lights when aircraft are not within the pre-defined detection volume of airspace. Consequently, failure of the ADLS would result in the obstacle lights remaining switched on.

4.21 There are two key types of ADLS; one using ‘active’ sensors to determine whether an aircraft is within the pre-defined detection volume of airspace, the other using ‘passive’ sensors to receive information sent from the aircraft. Irrespective of the type, such systems will typically comprise of a central processor, power supply, alarms, and communication signals to individual turbines to activate or deactivate lights, and communication links from the sensors to the central processor for processing returned signals to determine whether deactivation of lights may occur.

4.22 In some parts of UK airspace, there are no legal requirements for aircraft to carry and operate radios and/or devices that broadcast an aircraft’s location in space and in most cases its altitude (e.g. transponders or ADS-B). Therefore, the use of passive sensors for ADLS in these areas may require additional mitigation. An example might be the use of a Transponder Mandatory Zone (TMZ), although this would be subject to the CAA’s Airspace Change Process (further information available in CAA publication 1616).

4.23 An example of an active sensor to detect aircraft might be a surveillance system e.g. radar. Coverage area of the surveillance system and available radio spectrum frequencies will need careful consideration. In some circumstances, it may not be possible to meet the full volume area specified below, because the terrain may mask the detection signal from acquiring an aircraft target before penetrating to the defined boundaries of the airspace volume around and on top of the wind turbines. The type of solution to implement, and if full coverage is not

achievable, the areas that cannot be illuminated by radar based on-demand lighting activation system must be recognised.

4.24 In some situations, lighting not controlled by the ADLS may be required when the defined volume of coverage is not achievable to ensure pilots have sufficient warning before approaching the wind turbine obstructions.

4.25 The following paragraphs set the minimum requirements for the operation of ADLS. While there will be differences between an active and passive sensor system, the requirements should be read as applicable and appropriate to the system being used. The commissioning, testing and verification of the correct operation of such systems, and their on-going maintenance to ensure continuous compliance are applicable to all.

CAA Policy

4.26 The CAA will not approve the installation or operation of the ADLS, nor will it undertake continuous regulatory oversight of such systems. However, the CAA will need to provide a permission under point 6 of Article 222 of the ANO to operate ADLS at a wind farm and a declaration of the system meeting minimum requirements must be submitted to the CAA prior to its operational use. The CAA may request additional information from the wind farm operator with regards to the performance of the system demonstrated during its commissioning or as necessary for the purpose of ensuring safety.

4.27 Sections 4.28 to 4.31 deal with surveillance sensor performance where this is used for the operation of an active sensor wind turbine obstruction lighting activation system.

4.28 **Range**

a. The horizontal coverage of the surveillance system shall extend to at least 4 nautical miles (NM) away from the perimeter of the wind farm/group of wind turbines.

b. It is recommended that a single sensor surveillance solution to have an 8 NM range or a range sufficient to cover 4 NM away from the perimeter of the wind farm, whichever is greater. Where a sensor network is used, this may vary to provide coverage for at least 4 NM horizontally from the perimeter of the wind farm. The range should be limited to avoid unnecessary RF transmissions beyond the range required for the detection of targets prior to entry to the zone within which the obstacle lights must be switched on.

4.29 **Vertical coverage**

The vertical coverage should extend up to at least 600 m AGL measured above the highest part of the turbine or group of turbines.

Note: Paragraph 4.35 describes the volume in which the lights are required to be activated.

4.30 **Probability of Detection**

a. The system shall successfully detect targets entering the zone between 4-3 NM away from the perimeter of the wind turbines with 99% Pd of detecting the target when entering or within this zone.

b. Where targets are continuously tracked by the radar-based On-Demand Lighting Activation System, the targets shall be tracked until leaving the 4NM horizontal distance away from the perimeter of the wind farm and the vertical boundary with a 90% Pd.

c. The required Pd shall be achieved for a target with a radar cross section of $1m^2$.

4.31 **Parameters to be determined**

a. The surveillance system used for the on-demand activation of wind turbine lighting shall be able to determine the following parameters:

(i) Probability of detection
(ii) Horizontal position of the target
(iii) Target height above ground level
(iv) Speed

b. It is recommended that where possible, the descent rate for descending flights and heading be also determined as these provide useful early indication of the likelihood of the aircraft penetrating to the 3 NM / 1000 ft volume where lights must be activated.

4.32 General requirements

a. Airspace use shall be considered as part of the design specification of an on-demand light activation radar-system. Where frequent flying activities occur close to a part of a wind farm, it may be appropriate to leave the lights illuminated during night-time hours in these known frequent flying activity areas, while the remainder of the wind turbine obstruction lighting can be controlled by the radar-based on-demand activation system.

b. The update rate of the system shall be once every 2 seconds or higher rate[32]:

c. Radio frequencies used by systems designed to detect aircraft shall not use Wireless Telegraphy Act licence-exempt spectrum due to the lack of formal

[32] Every 2 seconds means an aircraft travelling at 250 knots will travel a distance of 257.2 meters in this period which is 0.1388 NM, giving approximately 29 updates to expect within a 4NM distance

protection from interference. Frequencies used for the operation of an aviation detection system for obstruction lighting must be individually licensed through Ofcom, the UK's national telecommunications regulator.

d. The ADLS shall not cause harmful interference to the systems on-board aircraft or other transmitting and receiving systems operating within its coverage.

e. The communication signals from the processor output to the light activation control system must be suitable for the operation in terms of reliability, resilience and latency. Communication links used in the system shall be reliable connections with sufficient system resilience.

f. The equipment must comply with the Radio Equipment Regulations (2017).

g. The system must have sufficient battery backup supply to enable communications to turn on the lights in case of external power supply failure.

4.33 Testing of Correct On-going Operation

a. Unless the system has been activated at least once within a 24-hour period by aircraft, the system must be activated for self-test at least once within a 24-hour interval to verify the operational status.

4.34 Commissioning tests - the system shall be subject to a commissioning test to verify that the system:

a. Meets the performance requirements stated above.

b. Correct activation of lighting as per the signals to activate or deactivate lighting.

c. Correct timing to activate and illuminate the obstruction lights, timers used for automatic deactivation, time to reach full-intensity of lights etc.

4.35 The ADLS must illuminate the obstruction lights in sufficient time to allow the lights to illuminate prior to an aircraft penetrating 1000 ft (304m) above the tallest point of the wind turbine or group of wind turbines in the vertical coverage volume specified above, and prior to, at least, 3 NM horizontally from the perimeter of the wind farm.

4.36 For systems that are capable of continuously monitoring aircraft while they are within the 3 NM / 1000 ft volume, the obstruction lights should stay on until the aircraft exits this volume.

4.37 In the event that the aircraft detection is completely lost while being continuously monitored within the 3 NM / 1000 ft volume, the ADLS must activate obstruction lights and should be continuously illuminated for 10 minutes. Occasional loss of target detections while being tracked in this volume should not switch off

obstruction lights until the aircraft has exit the area of vertical coverage limit and horizontal coverage limits specified (1000 ft and 3 NM).

4.38 The lights must be re-activated, if the aircraft re-enters the specified volume of coverage either while remaining or re-entering.

4.39 For systems without the capability to continuously track aircraft targets in the 1000 ft / 3 NM defined volume, the obstruction lights should stay on for 10 minutes once the obstruction lights are illuminated be switched off when the timer expires.

4.40 Light operation during complete or partial failure of ADLS

Note: This section deals with a complete or partial failure of an ADLS. Failure of one or more of the obstacle lights is covered under separate guidance specified in Chapter 5.

a. Where a network of sensors are deployed at strategic locations in the wind farm, some sensors can fail permanently or temporarily. Partial degradation or complete system failure could occur due to several reasons such as power supply failure or surveillance sensor failure.

b. In the event of failure of the ADLS, the system should operate as if the lighting was not controlled by such a system during night-time hours, as defined by the ANO. The obstruction lighting must remain in this state until the system and its components can be restored.

c. In the event that a partial system failure occurs and one or a group of lights cannot be controlled by the ADLS, but the rest of the system is functional, the obstruction light or several lights that cannot be controlled by the ADLS should automatically be switched on during hours of darkness and operate as if they were not controlled by such a system. The remaining lights that can be controlled by the ADLS should continue to be controlled by that system. The obstruction lighting may remain in this state until the system and its components can be restored.

4.41 Records

a. Each ADLS shall maintain a continuous data log of activity for a minimum of 30 days. This should be an automated process (or with minimal human intervention). The data recorded shall include as a minimum, date, times and duration of all system activations / deactivations and, where the system has such capability, the track of aircraft activity.

b. The operator of a system shall record maintenance issues, system errors, communication and operational issues as well as lighting outages/issues, etc. The operator shall maintain a record of the rectification carried out and

time taken to repair faults. There should also be a trend monitoring system in place.

Chapter 5

Offshore Wind Turbines

Introduction

Guidance

5.1 This section covers the following topics:

- UK Search and Rescue considerations
- Marking of Offshore Wind Turbines
- Lighting of Offshore Wind Turbines
- Aviation operations to/from and in the vicinity of offshore wind farms

5.2 Wind turbine developments (including anemometer masts) within a 9 NM radius of an offshore helicopter installation could introduce obstructions that would have an impact on the ability to safely conduct essential instrument flight procedures to such facilities in low visibility conditions. Consequently, any such restrictions have the potential to affect not only normal helicopter operations but could also threaten the integrity of offshore installation safety cases where emergency procedures are predicated on the use of helicopters to evacuate the installation.

Maritime and Coastguard Agency (MCA)

Guidance

5.3 The MCA's mission is to deliver safety at sea, counter pollution response, the coordination and arrangements for the provision of maritime Search and Rescue (SAR) throughout the UK SAR Region and UK Pollution Control Zone.

5.4 The increasing numbers and geographical extent of offshore wind farms not only has the potential to increase the probability of a maritime SAR incident but also could constrain the MCA's ability to respond to such an incident. It is therefore strongly recommended that developers consult with the MCA at the earliest opportunity such that mitigating measures can be designed in from the outset. Guidance on issues to consider has been provided by the MCA but should not be taken as being exhaustive and does not remove the recommendation to consult; further detail can be found in Marine Guidance Note 654 on Safety of Navigation: Offshore Renewable Energy Installations (OREIs) – Guidance on UK Navigational Practice, Safety and Emergency Response.

5.5 The nature of SAR activity necessitates the requirement to conduct SAR within the confines of offshore wind turbine developments. Given the distance offshore

of some UK wind farms, helicopters may be the only viable means of SAR. While in clear weather, searches can be conducted from above the maximum blade tip height, operations in poor weather and rescues themselves may necessitate SAR operations within a wind farm below blade tip height. As technology progresses and turbine heights increase, the issue is exacerbated. In addition, when faced with the prospect of long transits to a SAR area, the presence of adjacent wind farms along the transit route can provide obstacles to SAR helicopters if weather conditions do not permit transits to be flown above maximum wind turbine blade height.

5.6 The MCA has provided the following guidance to mitigate SAR risks:

(1) Turbines are positioned in straight lines with a common orientation across the whole development, creating safe lanes for SAR access.

(2) Safe lanes are constructed across the width of the development rather than the length.

(3) Curved or non-linear designs should be avoided.

(4) High density perimeter turbines can compromise the safe lanes and should be avoided.

(5) The wind farm should be fitted with lighting that is controllable from the development control room and which is Night Vision Device (NVD) compatible.

(6) The control room for the development should be equipped with VHF (air and maritime) communications with remote antennas in the wind farm to facilitate SAR communications.

(7) Turbines should be marked with geographically logical numbering to facilitate navigation within the wind farm.

(8) Substations and meteorological masts should be aligned with turbines so as not to impede SAR lanes.

(9) Where possible, SAR lanes should be aligned with those of adjacent wind turbine developments or buffer zones created.

Marking of Offshore Wind Turbines

CAA Policy

5.7 Wind turbine marking refers to the colours used on the tower, nacelle and blade. In the UK, the rotor blades, nacelle and upper 2/3 of the supporting mast of wind turbines that are deemed to be an aviation obstruction should be painted white or a grey colour to be discernible from the air during the day. The CAA will accept a

white paint colour that is pure white, RAL 9010 or an equivalent, through to light grey, RAL 7035, which is the darkest acceptable off-white colour allowed. Any shade of white between these two RAL specifications will also be accepted. The use of any other colour must be supported by an aeronautical study that can demonstrate the use of that colour does not impact the discernibility of the wind turbine.

Note: There are specific marking requirements for offshore wind turbine blades given by the MCA to provide a SAR helicopter pilot with a reference point when hovering over a nacelle during a rescue

Branding and Logos on Offshore Wind Turbines

5.8 There are no specific requirements regarding branding and logos on offshore assets where helicopter operations are also present. The manufacturer and/or developer should ensure that installation identification panels are highly visible in all light conditions and from all directions of approach by helicopters with the aim of ensuring that:

a. branding and logos do not detract from early recognition of the turbines;

b. flight crew do not mis-identify turbines; or

c. flight crew are not confused by lots of visual cues, particularly if the branding is elaborate.

Offshore Obstacle Lighting

Guidance

5.9 While the mandated requirement for the lighting of wind turbines generators in UK territorial waters[33] is set out at Article 223 of the UK ANO (2016) as amended, additional guidance is provided below.

5.10 Article 223 requires medium intensity steady red lighting mounted on the top of each nacelle and requires for some downward spillage of light. It also allows for the CAA to permit that only turbines on the periphery of any wind farm need to be equipped with aviation warning lighting. Such lighting, where achievable, shall be spaced at longitudinal intervals not exceeding 900m[34]. Where turbines are spaced more than 900 m apart, then all peripheral turbines should be lit. There is

[33] Taken to apply to any wind turbine generator or meteorological mast that is situated in waters within or adjacent to the United Kingdom up to the seaward limits of the territorial sea. However, the CAA recommends that this policy is applied beyond the limits of UK Territorial Waters up to the edge of the exclusive economic zone

[34] ICAO Annex 14 Volume 1 paragraph 6.3.14.

no requirement for offshore obstacles to be fitted with additional intermediate spaced aviation obstacle lighting, solely to meet the above criterion.

5.11 To resolve concerns from the maritime community, work has been undertaken to develop an aviation warning lighting standard which is clearly distinguishable from maritime lighting. Where it is evident that the default aviation warning lighting standard (Article 223) may generate issues for the maritime community, a developer can make a case, that is likely to receive CAA permission, for the use of a flashing red Morse Code Letter 'W' instead.

5.12 Where the Flashing Morse W standard is approved by the CAA and utilised, the recommendation is for a 5-second-long sequence, visually synchronised across aviation and maritime lighting sequences.

5.13 Article 223 offshore obstacle lighting light intensity and distribution specification for medium intensity, type B (flashing red) or type C (fixed red) differs from the ICAO recommended practice specified in ICAO Annex 14 Table 6-3 specification for Type C medium intensity obstacle lights as follows:

(1) Less than or equal to 1.5° below the horizontal plane:

- No minimum light intensity is specified
- Maximum peak light intensity 200 cd

(2) At 0° (on the horizontal plane):

- Minimum peak light intensity 400 cd
- Maximum peak light intensity 900 cd

(3) At and between 3° and 4° above the horizontal plane:

- Minimum average peak light intensity 2000 cd, applicable to the intensity at the elevation of the peak of the beam.
- No maximum peak light intensity is specified

Note: The minimum light intensity is 1500 cd, i.e. no single measurement at the elevation of the peak of the beam should be less than 1500 cd.

(4) Greater than 4° above the horizontal plane:

- No minimum or maximum light intensity is specified

(5) A minimum continuous beam width of 3 degrees in the azimuth where the light intensity exceeds 750 cd.

5.14 Attention is drawn to the provisions that already exist within Article 223 that require the reduction in lighting intensity at and below the horizontal plane and allow a further reduction in lighting intensity when the visibility in all directions

from every wind turbine is more than 5 km. All offshore wind turbine developers are expected to comply fully with the requirement aspect and to make full use of the additional allowance that exists within Article 223.

5.15 In addition to the Article 223 mandated lighting, there may also be lighting requirements associated with winching and SAR operations. The lighting needed to facilitate safe helicopter hoist operations to wind turbine platforms is set out in CAP 437[35]. Information on SAR Requirements can be found in Marine Guidance Note 654 on Safety of Navigation: Offshore Renewable Energy Installations (OREIs) – Guidance on UK Navigational Practice, Safety and Emergency Response. It is recommended that SAR lighting requirements are agreed with the MCA at the earliest possible opportunity.

CAA Recommendation

5.16 As offshore wind farms are developed, meteorological masts may be deployed to ascertain the wind resource characteristics. These masts can be in excess of 100 m tall and are extremely slender rendering them potentially inconspicuous to aviators flying over the sea, particularly when there are no other structures nearby. This is potentially hazardous, particularly during helicopter operations when it may be necessary to descend in order to avoid icing conditions. Consequently, the CAA recommends that all offshore meteorological masts (regardless of their location within or outside of territorial waters) that are over 60 m (197 feet) above sea level should be fitted with one medium intensity steady red light positioned as close as possible to the top of the obstacle.

5.17 For turbines that are more than 315 m AGL in overall height, the above requirements apply and, in addition, the CAA recommends that the developer undertakes a study to determine whether additional marking and lighting may be required. This typically would include a consultation with aircraft operators, or their representative organisation(s), who might be reasonably expected to operate in the area. Any such requirements for marking and lighting must be clearly distinguishable from maritime lighting.

Guidance

5.18 The CAA does not typically request specific marking and lighting for offshore obstacles beyond that described above.

5.19 For military aviation purposes the MoD may suggest an additional offshore lighting requirement. Whilst it is possible that the lighting standard described above will meet the MoD needs, it is recommended that in all cases developers additionally seek related input from the DIO.

[35] https://www.caa.co.uk/CAP437

Failure of offshore lighting

5.20 Point 7 of Article 223 of the ANO (2016) as amended states "In the event of the failure of any light which is required by this Article to be displayed by night the person in charge of a wind turbine generator must repair or replace the light as soon as reasonably practicable."

5.21 Wind farm operators should monitor the serviceability of the aviation obstacle lighting. For any outage that is expected to be or is greater than 12 hours, the operator should request a NOTAM to be issued by informing the NOTAM section (operating 24 hours / 7 days) of the UK Aeronautical Information Service (AIS) by telephoning +44 (0) 1489 61 2488 / 2489 as soon as possible. Proposals may also be submitted to the AIS generic email address: notamprop@ead.eurocontrol.int.

5.22 Further information can be found in the UK Aeronautical Information Publication (AIP) General (GEN) 3.1. A lighting outage NOTAM template is provided on the CAA Wind farms Web Page.

5.23 Wind farm operators should also consider enhancing the notification process of a lighting outage by making direct contact with adjacent airports and the Maritime and Coastguard Agency.

Guidance

5.24 The CAA accepts that, particularly in the case of offshore obstacles there may be occasions when meteorological or sea conditions prohibit the safe transport of staff for repair tasks.

5.25 The following information should be provided when requesting a NOTAM:

a. Name of wind farm (as already recorded in the AIP[36]).

b. Identifiers of affected lights (as listed in the AIP) or region of wind farm if fault is extensive (e.g. north-east quadrant / south-west quadrant/ entire or 3 NM centred on position 515151N 0010101W).

c. Expected date of reinstatement.

d. Contact telephone number.

Note: If the turbine or wind farm does not have a listing in the AIP then it will not be possible to issue a NOTAM. Typically, all offshore turbines of a maximum blade tip height of 100 m or more will be recorded within the AIP.

[36] UK Aeronautical Information Publication (www.ais.org.uk) En Route Supplement 5.4

5.26 To expedite the dissemination of information during active aviation operations the wind farm operator may also consider establishing a direct communication method with aviation operators in the area. These may include:

a. Air Traffic Service Units e.g. Aberdeen Radar or Anglia Radar

b. Local airports.

c. Local helicopter operators

Note: The information will be the same as in the NOTAM request and should also include a note that a NOTAM has been requested, or if available, the NOTAM reference.

5.27 If an outage is expected to last longer than 14 days, then the CAA shall also be notified directly at windfarms@caa.co.uk (normal working hours) to discuss any issues that may arise and longer-term strategies.

Aviation operations to/from and in the vicinity of offshore wind farm

Guidance

5.28 Considerations for helicopter operators and flight crew include:

a. Helicopter Main Routes (HMRs) are essentially used by air traffic service providers and helicopter operators for flight planning and management purposes. They are also promulgated for the purpose of signposting concentrations of helicopter traffic to other airspace users, including military airspace users. However, operationally, helicopters are mostly given direct routes between onshore aerodromes and oil and gas platforms or wind farms. HMRs have no special airspace status and assume the type of background airspace classification within which they lie (an airspace classification determines whether an air traffic service clearance is required and how aircraft are kept clear of each other). HMRs have no lateral dimensions. Vertically the HMRs extend from 1500 feet AMSL to Flight Level 60 (effectively 6000 feet AMSL). However, where helicopter icing conditions or other flight safety considerations dictate, helicopters may be forced to operate below 1500 feet AMSL. In these circumstances, where possible, pilots are asked to follow HMRs. This is typically because in some areas the helicopters may be outside of the range of coverage of the air traffic service's communications and aeronautical surveillance infrastructure and thus aircraft can be kept apart procedurally (i.e. without knowing the precise location of a helicopter at any given time).

b. Overflight of a wind farm while in Instrument Meteorological Conditions (IMC) - while operating in IMC, aircraft operate above the Minimum Safe Altitude (MSA). An increase in the MSA may impact the ability of helicopters without full icing protection to descend to warmer air. Therefore, there may be an

increased number of winter days when sufficiently warm air at safe altitudes will not be available. An alternative solution, where feasible, may be to route around wind farms. This may extend track mileage and reduce payload.

c. When a helideck is within a wind farm there may be operational difficulties when manoeuvring for a stabilised approach. Obstacle clearance around a helideck within a wind farm should allow aircraft to achieve Final Approach Track (FAT) and 0.5 NM stabilised approach Visual Meteorological Conditions (VMC) gate. For operations in a Degraded Visual Environment (DVE) a second stabilised approach gate is introduced at 1 NM. DVE is determined to exist when visibility is below 4000m. The minimum visibility of 5000m gives a margin above DVE ensuring there is no requirement for the extended FAT.

d. Engine failure on take-off from an offshore oil and gas platform.

e. A ‘land immediately’ emergency.

Chapter 6

Contact Information

CAA Wind Farm Contact

CAA Wind Farms

Wind Farms

Airspace Regulation

Safety and Airspace Regulation Group

Aviation House

Beehive Ring Road

Crawley

West Sussex

RH6 0YR

www.caa.co.uk/windfarms

windfarms@caa.co.uk

Other CAA Contacts

For the CAA departments listed below, the postal address given under CAA Wind Farms may be used and marked for the attention of the CAA department concerned.

CAA Aerodromes - for information on aerodrome licensing criteria, obstacle limitation surfaces and call-in procedures

aerodromes@caa.co.uk

CAA Air Traffic Standards - where a service provider has to update the safety documentation for a service as a result of a wind turbine development, then they should follow standard practice and contact their regional inspector for approval as necessary.

ats.enquiries@caa.co.uk

ats.southern.regional.office@caa.co.uk

ats.northern.regional.office@caa.co.uk

Other Contacts

Defence Geographic Centre

UK DVOF & Powerlines

Defence Geographic Centre

Elmwood Avenue

Feltham

Middlesex

TW13 7AH

DVOF@mod.gov.uk

Ministry of Defence – Defence Infrastructure Organisation

Safeguarding Team

St George's House

DMS Whittington

Lichfield

Staffordshire

WS14 9PY

dio-safeguarding-wind@mod.uk

Defence Infrastructure Organisation

Maritime and Coastguard Agency

Offshore Energy Liaison Officer

HM Coastguard

Maritime and Coastguard Agency

Southampton

UK

oelo@mcga.gov.uk

NATS Safeguarding

NATS Corporate and Technical Centre

4000-4200 Parkway

Whiteley

Hants

PO15 7FL

NATSSafeguarding@nats.co.uk

National Assembly for Wales

Planning Division

Cathays Park

Cardiff

CF10 3NQ

Email: Planning.division@wales.gsi.gov.uk

http://gov.wales/topics/planning/?lang=en

Department for Infrastructure Northern Ireland Planning

Responsibility for planning in Northern Ireland is shared between the 11 local councils and the department.

DfI Planning

Clarence Court

10-18 Adelaide Street

Belfast

BT2 8GB

planning@infrastructure-ni.gov.uk

RenewableUK

6 Langley Street

London

WC2H 9JA

http://www.renewableuk.com/

Scottish Government

Energy Consents Unit

4th Floor

5 Atlantic Quay

150 Broomielaw

Glasgow

G2 8LU

Econsents_Admin@gov.scot

http://www.energyconsents.scot/

Scottish Government

Planning

Architecture & Regeneration Division,

Decisions Team,

Area 2-F,

Victoria Quay,

Edinburgh

EH6 6QQ,

Planning.Decisions@gov.scot.

Scottish Government

Marine Directorate - Licensing Operations Team

Marine Directorate

375 Victoria Road

Aberdeen

AB11 9DB

MD-LOT contact email: MS.MarineRenewables@gov.scot

Website link: https://www.gov.scot/collections/marine-licensing-and-consent/