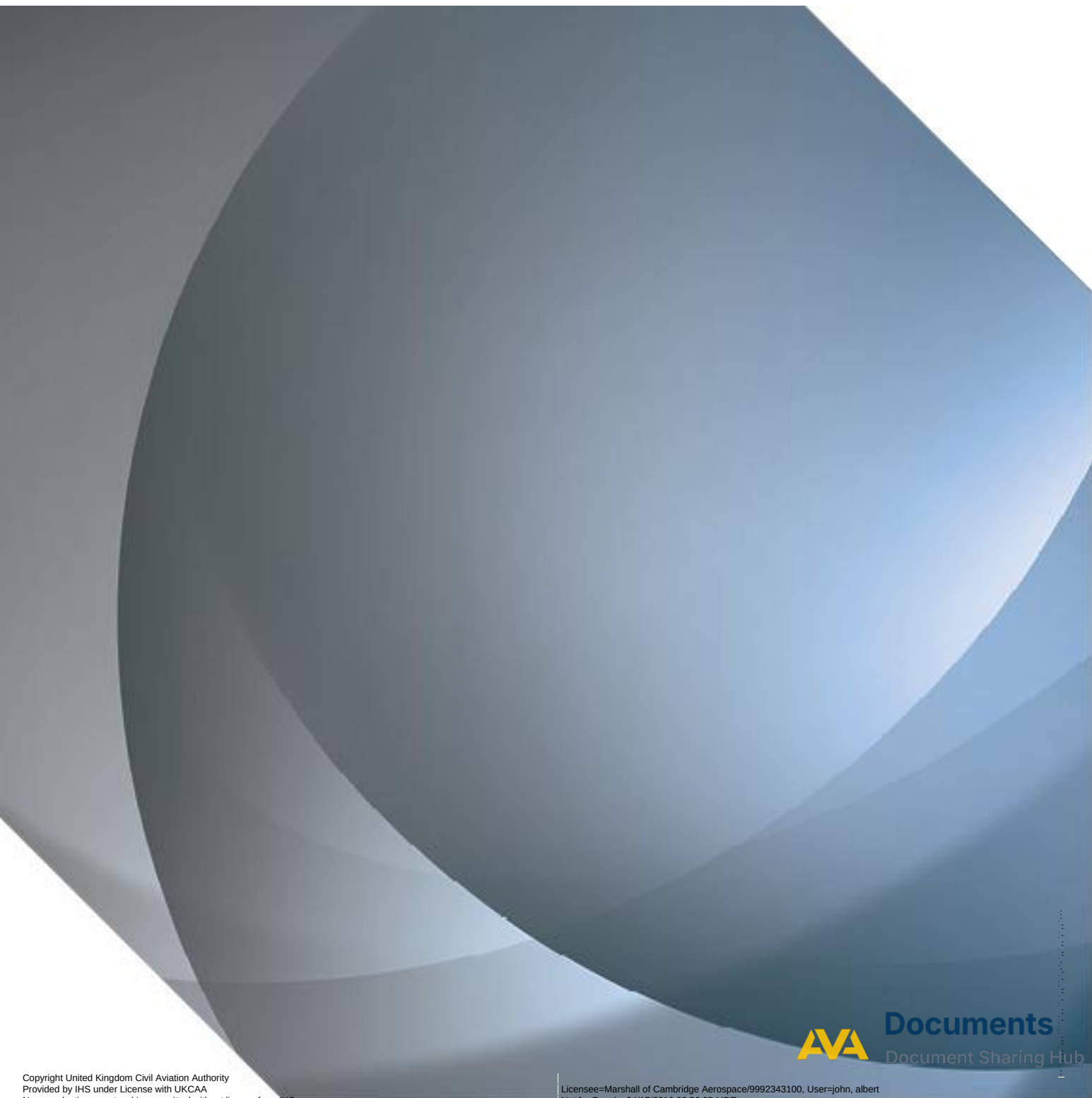


CAA Policy and Guidelines on Wind Turbines

CAP 764



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The latest version of this document is available in electronic format at www.caa.co.uk, where you may also register for e-mail notification of amendments.

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Revision History

Issue 1 July 2006

Neither aviation nor the wind energy industry is at a steady state and both can be expected to evolve in ways that may impact the other. Combining the current drive for renewable energy and the increasing number of wind farms with the finite land resource in the UK, means that wind turbines and aviation are being required to operate closer and closer together. However, providing a suitable environment that allows the co-existence of wind turbines and aviation is extremely complicated 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.

Issue 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.

Issue 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.

Issue 4 July 2011

This revision follows extensive consultation amongst the aviation and renewable energy communities. Whilst remaining an aviation stakeholder-focused document, CAP 764 has been amended in an attempt to broaden its appeal to all interested wind energy parties with the intention of becoming the 'go to' document for aviation and wind energy stakeholders alike. It is important that this document is read in conjunction with the CAA Wind Energy web pages, which provide amplifying information, and which will enable currency and relevancy to be maintained in between the biennial revisions of CAP 764.

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 Issue 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.

Issue 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 Issue 4 completely.

Issue 6 February 2016

Issue 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. Issue 6 also incorporates CAA Policy Statements on the 'Lighting of Wind Turbine Generators in United Kingdom Territorial Waters (22 November 2012)' and the 'Failure of Aviation Warning Lights on Offshore Wind Turbines (27 April 2012)'. CAA Policy Statement 'Lighting of En-Route Obstacles and Onshore Wind Turbines (1 April 2010)' remains extant. Appendices concerning radar assessment methodology and references are removed, the latter being comprehensively covered by hyperlinks and footnotes within the document. It should be noted that hyperlinks were verified on publication. Issue 6 has been comprehensively reviewed and updated where necessary to reflect current information and practices. It replaces Issue 5 completely.

Foreword

Introduction and background

The Department for Transport (DfT) 'Aviation Policy Framework'¹, presented to Parliament in March 2013, provided a high level strategy setting out Government objectives for aviation. The aviation sector is seen as a major contributor to the economy and the Government seeks to support its growth within a framework which maintains a balance between the benefits of aviation and its costs, particularly its contribution to climate change and noise.

Whilst recognising the need for further aviation capacity in the UK in order to promote economic growth, the strategy is also based on the requirement for a balanced approach which addresses the wider impacts of aviation and the need for sustainable development.

The Government is also committed to reducing greenhouse gas emissions within the UK and, in turn, this means there is now a shift towards economically viable renewable energy sources rather than carbon fuels. The 2008 Climate Change Act established the world's first legally binding climate change target which aims to reduce the UK's greenhouse gas emissions by at least 80% (from the 1990 baseline) by 2050. In addition, Directive 2009/28/EC of the European Parliament and of the Council set the national overall target for the share of energy from renewable energy by 2020 as 15% for the UK. However, it is UK Government policy that 30% of the UK's electricity supply should come from renewable sources by 2020; the Scottish parliament has adopted a more ambitious 100% electricity demand equivalent from renewables by 2020.

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 hundreds of wind turbines. Moreover, the installation of Micro Wind Turbines (MWT) is becoming increasingly prevalent. The physical characteristics of wind turbines, coupled with the size and siting of the developments, can result in effects that can have a negative impact on aviation.

Both wind energy and aviation are important to UK national interests and both industries have legitimate interests that must be balanced carefully. Therefore it is important that the aviation community recognises the Government aspiration for wind turbine developments to play an increasing role in the national economy. As such, the aviation community must engage positively in the process of developing solutions to potential conflicts of interest between wind energy and aviation operations. In a similar vein, wind turbine developers

¹ [DfT Aviation Policy Framework March 2013](#)

must understand the potential impact of developments on aviation, both at a local and a national level, and to fully engage with the aviation industry to develop suitable mitigation solutions.

Those involved in addressing wind energy and aviation issues must do so in a positive, co-operative and informed manner. Whilst the aims and interests of the respective industries must be protected, a realistic and pragmatic approach is essential for resolving any conflicts between the Government's energy, transport and defence policies.

Aim of this publication

Being a CAP, this document is aimed primarily at providing assistance to 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 Local Planning Authorities (LPAs)², wind energy developers and members of the general public will also refer to it.

Consequently, it is hoped that some of the issues and questions often posed by these groups have, where appropriate, also been discussed.

Scope

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 LPAs when assessing the viability of wind turbine developments.

It is not the intention or purpose of this CAP to provide instruction on the need or means to object to wind turbine developments; this must remain the decision of individual aerodrome operators, service providers or other organisations. Furthermore, it should also be noted that within the framework of these guidelines, 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](#).

Significant effort has been spent developing a cohesive approach to wind energy across the civil and military spectrum of aviation. It is an aspiration to create a joint and integrated publication that details both civil and military aviation policy on wind turbines. However, until this is achieved, 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).

² The term 'LPA' throughout this document is used generically to refer to Planning Authorities within England, Scotland, Wales and Northern Ireland.

Feedback

Stakeholders are encouraged to provide feedback on their experiences with wind turbine development so that this CAP can be updated appropriately. This CAP will be reviewed biennially and, due to the lengthy process that must be followed, minor amendments cannot be made. However, interim amendments and supplementary guidance will 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

General enquiries concerning this publication can be addressed to windfarms@caa.co.uk. Additional contact details, including postal addresses, are provided at Appendix B.

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Glossary

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

AAA	Airspace, ATM and Aerodromes (CAA)
ACP	Airspace Change Process
AD	Air Defence
AIP	Aeronautical Information Publication
ANO	Air Navigation Order
ANSP	Air Navigation Service Provider
AOA	Airport Operators Association
ATC	Air Traffic Control
CAA	Civil Aviation Authority
CAS	Controlled Airspace
CAP	Civil Aviation Publication
CFAR	Constant False Alarm Rate
CNS	Communications, Navigation And Surveillance
DECC	Department Of Energy And Climate Change
DfT	Department For Transport
DIO	Defence Infrastructure Organisation (Formerly Defence Estates)
DME	Distance Measuring Equipment
DTM	Digital Terrain Mapping
DVOF	Defence Vertical Obstruction File
DZ	Dropping Zone
EASA	European Aviation Safety Agency
EM	Electromagnetic
FT	Feet
GA	General Aviation

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

HMR	Helicopter Main Route
IFP	Instrument Flight Procedures
ILS	Instrument Landing System
JAR	Joint Aviation Requirements
KM	Kilometre(S)
LF	Low Flying
LOS	Line Of Sight
LPA	Local Planning Authority (also refers to planning authorities of devolved governments)
m	Metre(s)
MAP	Missed Approach Procedure
MATS	Manual of Air Traffic Services
MHz	Mega Hertz
MoD	Ministry of Defence
Mode S	Mode Select
MSD	Minimum Separation Distance
MW	Mega Watts
MWT	Micro Wind Turbine
NAFW	National Assembly for Wales
NAIZ	Non-Automatic Initiation Zones
Nav aids	Navigation Aids
NDB	Non Directional Beacon
NERL	NATS En Route plc
NM	Nautical mile(s) (1853 m or 1.15 Statute Miles)
ODPM	Office of the Deputy Prime Minister
OLS	Obstacle Limitation Surface
PPG	Planning Policy Guidance Note

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

P-RNAV	Precision Area Navigation
PSR	Primary Surveillance Radar
RAM	Radar Absorbent Material
RCS	Radar Cross-Section
RF	Radio Frequency
RNAV	Area Navigation
SARG	Safety and Airspace Regulation Group (CAA)
SID	Standard Instrument Departure
SMS	Safety Management Systems
SSR	Secondary Surveillance Radar
STAR	Standard Instrument Arrival Route
TMZ	Transponder Mandatory Zones
VFR	Visual Flight Rules
VOR	VHF Omni Directional Range

Chapter 1

CAA Responsibilities

General

- 1.1 The CAA is responsible for safety and airspace regulation of civil aviation in the UK under the Civil Aviation Act 1982 and the Transport Act 2000. 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, and also has the lead responsibility within the CAA for all wind turbine related issues. Within SARG, wind turbine related issues are addressed by CAA Infrastructure.
- 1.2 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 (ODPM Circular 01/2003). Similar provisions are set out for Scotland in the Town & Country Planning Safeguarded Aerodromes, Technical Sites and Military Explosives Storage Areas (Scotland) Direction 2003 (Scottish Planning Circular 2/2003), and for Northern Ireland in the Planning Policy Statement 18: Renewable Energy. 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.
- 1.3 At all times, responsibility for the provision of safe services lies with the ATS provider or Air Navigation Service Provider (ANSP). It should be noted that the CAA does not have regulatory powers to approve or reject planning applications.
- 1.4 The CAA policy on wind energy is that:
 1. Wind turbine developments and aviation need to co-exist in order for the UK to achieve its binding European target to achieve a 15% renewable energy commitment by 2020, and enhance energy security, whilst meeting national and international transport policies. However, safety in the air is paramount and will not be compromised. As the independent aviation regulator, the CAA is well placed to provide clarification to both the aviation industry and the wind energy industry;
 2. 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;

3. It is CAA policy to provide the best and most timely advice to aviation and wider wind development stakeholders through consultation, the publication of CAP 764 and its associated web pages on the CAA web site;
4. Such clarification, advice and guidance is provided through the publication of this and associated official CAA and government documents, along with the [CAA Windfarms web pages](#).

Aerodrome and Communications Navigation and Surveillance (CNS) site safeguarding³

- 1.5 Many civil aerodromes in the UK are certificated in accordance with EU Regulation 139/2014 (Aerodromes) or licensed in accordance with the Air Navigation Order (ANO) 2009 as amended. Under either of 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.
- 1.6 'Statutory' or 'official' safeguarding is a process of obligatory consultation between an LPA and consultees and is designed to safeguard technical sites and certain aerodromes in the UK. However, the same process of consultation can take place for aerodromes and technical sites that are not given this statutory protection; this process is known as unofficial safeguarding.
- 1.7 Certain civil licensed aerodromes (selected by Government on the basis of their importance to the national air transport system) are officially safeguarded. All EASA certificated aerodromes are deemed to be officially safeguarded. In particular, such safeguarding ensures that the operations and development of the aerodromes are not inhibited by buildings, structures, erections or works which infringe protected surfaces, obscure runway approach lights or have the potential to impair the performance of aerodrome CNS. A similar official safeguarding system applies to certain military sites, including aerodromes,

³ Further information can be found in:

- England and Wales: [Joint ODPM, DfT, Planning Circular 1/2003 guidance on Safeguarding, Aerodromes, Technical Sites and Military Explosives Storage Areas](#)
- Scotland: [Planning Circular 2 2003](#)
- Graphics of safeguarded technical sites can be found at:
- <http://www.nats.aero/services/information/wind-farms/self-assessment-maps/>

selected on the basis of their strategic importance.

- 1.8 In general, aerodrome safeguarding is limited to the vicinity of the aerodrome (the definition of 'vicinity' will vary depending upon the activity that takes place at that aerodrome). The CAA Aerodromes Team conducts oversight audits at certified and licensed aerodromes to confirm compliance to the applicable rules.
- 1.9 [CAP 793 \(Safe Operating Procedures at Unlicensed Aerodromes\)](#) provides guidance for unlicensed aerodromes.
- 1.10 Where an Instrument Landing System (ILS) is used at an aerodrome, safeguarding criteria are used to protect the ILS radio signals from corruption. Technical safeguarding aspects are detailed in [CAP 670 \(Air Traffic Services Safety Requirements\)](#) GEN 02.
- 1.11 Aerodrome operators are responsible for liaising with LPAs to prevent operational airspace being infringed by new development. One significant consideration is the protection of the Obstacle Limitation Surface (OLS)⁴ that should be applied for aerodrome safeguarding. The CAA may be required to explain technical matters to local or central government if a contested development proposal is referred to Ministers for decision.
- 1.12 The safeguarding of unlicensed aerodromes falls within the advice promulgated in the aforementioned national circulars, which, at Paragraph 13 of Annex 2 state: "Operators of licensed aerodromes which are not officially safeguarded and operators of unlicensed aerodromes and sites for other aviation activities (for example gliding or parachuting) should take steps to protect their locations from the effects of possible adverse development by establishing an agreed consultation procedure between themselves and the local planning authority or authorities. Local planning authorities are asked to respond sympathetically to requests for non-official safeguarding."
- 1.13 The safeguarding of unlicensed aerodromes is therefore a matter of discussion between the operator and the LPA and the need for constructive liaison from an early stage is evident. CAP 793 provides guidance. Both official and unofficial safeguarding are discussed further in Chapter 3 of this document.
- 1.14 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

⁴ OLS is the hypothetical boundary which indicates the extent of a volume of airspace which should be kept free of obstacles, so far as is reasonably practicable, to facilitate the safe passage of aircraft. It is used collectively to refer to other terms which are fully defined in Chapter 4 of Annex 14 to the Chicago Convention and incorporated into UK civil aviation regulation within CAP 168. OLS comprises of: approach surface, balked landing surface, conical surface, inner approach surface, inner horizontal surface, inner transitional surface, take-off climb surface and transitional surface.

advises that the aerodrome's established amenity would be affected by a development, their advice can generally be considered as expert testimony in the context of the operation of the aerodrome. However, such comment requires robust evidence, and may be subjected to scrutiny by the CAA (or any other party with equivalent expertise), should disagreement between the aviation operator and the wind energy developer arise. Notwithstanding that the CAA has no regulatory oversight of unlicensed aerodromes it is recommended that developers and planning authorities give similar consideration to comments and evidence from the operators of unlicensed aerodromes.

- 1.15 It is recommended that aerodrome operators that are not officially safeguarded have agreed unofficial safeguarding maps with LPAs.
- 1.16 The safety of aircraft in UK airspace is often dependent on ground-based navigation and radio aids. DfT Circular 1/2003 and Scottish Circular 2/2003 provides for the safeguarding of civil technical sites currently owned by NERL and military technical sites owned by the Secretary of State for Defence.

Airspace management

- 1.17 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.
- 1.18 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 shall be conducted with the aim of obtaining consensus, wherever possible, before making changes in the planning or design of UK airspace arrangements. The environmental impact of proposals for change shall be taken into consideration by ensuring that consultation is conducted with the appropriate authorities, to lessen or mitigate such impact to the maximum extent possible.
- 1.19 The Airspace Change Process (ACP) is mandatory for the majority of airspace change requests. It is a robust process that ensures that all appropriate stakeholders are consulted; CAP 725 refers.

Approvals for equipment and service provision

- 1.20 In order to provide an ATS in the UK, a service provider must be granted an approval by the CAA. EC 1035/2011, EC 550/2004 and relevant sections of the ANO (2009) as amended apply.
- 1.21 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:

1. Safeguard their service through being able to recognise when wind turbine developments may affect their service, and by participating in planning activities;
2. 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);
3. 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.

1.22 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:

1. 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;
2. 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;
3. 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;
4. 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 may be required;
5. ANSPs that fail to properly address the effects of a wind turbine development on a service may have the existing Certificate withdrawn by the CAA, or

variations applied to the Designation which may result in the closure of that service.

Advice to Government

- 1.23 In discharging its role as an independent regulator, the CAA is required to provide advice to Government as required. To this end, the CAA is proactive with appropriate Government departments in respect of wind energy related issues. The CAA is a member of the DECC (Department of Energy and Climate Change) Aviation Management Board and its sub-groups to provide expert input on aviation aspects of the Government's renewable energy programme. Details of these groups are contained in Appendix A.

Chapter 2

Impact of wind turbines on aviation

Introduction

- 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): physical obstructions; the generation of unwanted returns on Primary Surveillance Radar (PSR); adverse effects on the overall performance of CNS equipment; and turbulence. Whilst it is generally the larger, commercial turbines that have the greatest impact on aviation, the installation of other equipment may also affect operations. Smaller turbines, and the preliminary activities for larger turbines (such as the erection of anemometer masts on potential development sites), could have a negative impact on aviation and so require assessment. Moreover, the cumulative effects of wind turbines on aviation need to be assessed if developments proliferate in specific areas.
- 2.2 This chapter aims to provide a summary of the issues that aviation stakeholders should consider when assessing the impact of a proposed wind turbine development. It is not intended to be exhaustive because local circumstances may raise issues that are unique to a specific case. For this reason, the local aerodrome operator, ANSP and ATS providers may 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. Robust evidence may be required: see also para 1.14.

Wind turbine effects on PSR⁵

- 2.3 The following section describes the various effects that wind turbines have caused on Air Traffic Control (ATC) PSRs during the trials conducted as part of many research projects around the UK and the rest of the world.
- 2.4 ANSPs must therefore consider the possibility that their radars be affected by each of these phenomena as a result of wind turbines within the coverage range of their surveillance systems.
- 2.5 In basic terms, a PSR transmits a pulse of energy that is reflected back to the radar receiver by an object that is within its Line of Sight (LOS)⁶. The amount of reflected energy picked up by the receiver will depend upon a number of factors

⁵ The following paragraphs are intended as a summary only. Full explanations and detailed technical discussion are available in the [CAA CAP 670: ATS Safety Requirements](#) at SUR 13.

⁶ Note radar line of sight is different to visual line of sight.

such as the size, shape and orientation of the object⁷, as well as receiver sensitivity and the weather. In general terms, the larger a wind turbine is, the more energy will be reflected and there is an increased chance of it creating false returns to radar (i.e. returns that are not aircraft). These unwanted returns are known as 'clutter'⁸. Issues may be compounded by increasing numbers of wind turbines which could potentially cause greater areas and densities of clutter.

- 2.6 Providing that it remains within radar LOS, generally the closer a wind turbine is to a radar station, the greater the likelihood its reflected energy will be picked up by the radar receiver. It also follows that the taller a turbine is, the greater the distance from the radar that it will remain within radar LOS (unless the turbine is hidden by terrain). A characteristic that makes wind turbines more unpredictable is the fact that because the turbines rotate to follow the wind, the cross-sectional area presented to the radar at any given time, and therefore the RCS of the turbine, will vary depending upon wind direction. This presents challenges to generating a 'standard' turbine RCS for radar modelling purposes. Given that aviation safety issues are involved, a conservative approach should generally be adopted.
- 2.7 Typically, radar returns from a wind turbine comprise reflections from both stationary and moving elements: these provide different challenges for the radar. While the reflected radar signal from stationary elements, such as the tower, can be removed using stationary clutter filters in the radar processor, rotating wind turbine blades can impart a Doppler shift to any radar energy reflecting off the blades. Doppler shifts are used by a number of radars to differentiate between moving objects, namely aircraft, and stationary terrain with the latter being processed out and not displayed to the operator. The radar may therefore detect Doppler returns from moving wind turbine blades and display them as returns on the radar screen. Furthermore, at sites with more than one turbine, the radar may illuminate a blade or blades from one turbine on one antenna sweep, then illuminate the blades of a different turbine on the next sweep. This can create the appearance on the radar screen of returns moving about within the area of the wind farm, sometimes described as a "twinkling" appearance or "blade flash effect". These moving returns can appear very similar to those that would be produced by a light aircraft. The appearance of multiple false targets in close proximity can trick the radar into initiating false aircraft tracks. False PSR returns can also 'seduce' real aircraft tracks away from their true returns as the radar attempts to update an aircraft track using the false return. This can lead to degradation of radar tracking capability.

⁷ Which together contribute to the Radar Cross Section (RCS) of the obstacle.

⁸ Note that the term 'clutter' refers simply to unwanted false returns and can be generated by a number of means, not simply from wind turbines.