Australian Government
Civil Aviation Safety Authority

ADVISORY CIRCULAR
AC 139.E-05 v1.1

Obstacles (including wind farms) outside the vicinity of a CASA certified aerodrome

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Advisory circulars are intended to provide advice and guidance to illustrate a means, but not necessarily the only means, of complying with the Regulations, or to explain certain regulatory requirements by providing informative, interpretative and explanatory material.

Advisory circulars should always be read in conjunction with the relevant regulations.

Audience

This advisory circular (AC) applies to:

- persons involved in the design, construction and operation of wind farms and monitoring masts
- proponents of wind farms and wind monitoring masts
- planning authorities
- aerodrome and aircraft landing area operators
- the Civil Aviation Safety Authority (CASA).

Purpose

The purpose of this AC is to provide guidance on matters that should be considered when assessing a wind farm development and other tall structure so that all necessary measures can be taken to protect aviation safety. Wind farms and monitoring towers (turbine installations) and other tall structures may pose a safety risk to aviation due to their physical characteristics, size and location. Mitigation measures such as warning lights and reporting of tall structures that are at least 100m AGL, are also described.

For further information

For further information, contact CASA's Air Navigation, Airspace and Aerodromes Branch (telephone 131 757 or email Airspace.Protection@casa.gov.au).

Unless specified otherwise, all sub regulations, regulations, Divisions, Subparts, and Parts referenced in this AC are references to the *Civil Aviation Safety Regulations 1998 (CASR)*.

Status

This version of the AC is approved by the Branch Manager, Flight Standards.

Note: Changes made in the current version are annotated with change bars.

Version	Date	Details
v1.1	October 2022	This is the third AC about obstacle marking and lighting of wind farms and contains editorial amendments.
v1.0	May 2021	This is the second AC about obstacle marking and lighting of wind farms which replaces the AC that was withdrawn from circulation.
(0)	September 2004	This was the first AC about obstacle marking and lighting of wind farms. This AC was withdrawn from circulation in 2009.

Contents

1 Reference material

1.1 Acronyms

The acronyms and abbreviations used in this AC are listed in the table below.

Acronym	Description
AC	advisory circular
AGL	above ground level
AIP	aeronautical information publication
ALA	aircraft landing area
ALARP	as low as reasonably practicable
ALoS	acceptable level of safety
AMSL	above mean sea level
CAR	*Civil Aviation Regulations 1988*
CASA	Civil Aviation Safety Authority
CASR	*Civil Aviation Safety Regulations 1998*
ERSA	en route supplement Australia
ICAO	International Civil Aviation Organisation
IFR	Instrument Flight Rules
LSALT	Lowest Safe Altitude
MOS	Manual of Standards
NASAG	National Airports Safeguarding Advisory Group
NOTAM	notice to airmen
OLS	obstacle limitation surface
RPT	regular public transport
VFR	visual flight rules

1.2 Definitions

Terms that have specific meaning within this AC are defined in the table below. Where definitions from the civil aviation legislation have been reproduced for ease of reference, these are identified by 'grey shading'. Should there be a discrepancy between a definition given in this AC and the civil aviation legislation, the definition in the legislation prevails.

Term	Definition
navigable airspace	The airspace above the minimum altitudes of flight, including airspace

Term	Definition
	required to ensure the safety for the take-off and landing of an aircraft. (prescribed by the Civil Aviation Regulations 1988)
obstacle limitation surface (OLS)	A series of planes associated with each runway at an aerodrome that defines the desirable limits to which objects may project into the airspace around the aerodrome so that aircraft operations at the aerodrome may be conducted safely.
outside the vicinity of an aerodrome	For the purposes of this AC, outside the vicinity of an aerodrome is outside the limits of the obstacle limitation surface (OLS) of a CASA certified aerodrome
vicinity of an aerodrome	For the purposes of this AC, the vicinity of an aerodrome is within the limits of the obstacle limitation surface (OLS)

1.3 References

Legislation

Legislation is available on the Federal Register of Legislation website https://www.legislation.gov.au/

Document	Title
Regulation 157 of the Civil Aviation Regulations 1988 (CAR)	Low Flying
Regulation 172 of the Civil Aviation Regulations 1988 (CAR)	Flight visibility and distance from cloud
Regulation 174 of the Civil Aviation Regulations 1988 (CAR)	Determination of visibility for VFR flights
Part 139 of CASR	Aerodromes
Part 139 (Aerodromes) Manual of Standards	Part 139 (Aerodromes) Manual of Standards
Subpart 175.E of CASR	Aeronautical information management - objects and structures that affect aviation safety
National Airports Safeguarding Advisory Group (NASF) Framework D	Managing the Risk to Aviation Safety of Wind Turbine Installations (Wind Farms)/Wind Monitoring Towers
ICAO Annex 14 Aerodromes Vol 1, Chapter 6	Aerodrome Design and Operations
ICAO Doc 9774 A3-1	Aeronautical Study

Advisory material

CASA's advisory materials are available at https://www.casa.gov.au/publications-and-resources/guidance-materials

Document	Title
UK Civil Aviation Authority (CAA) Advisory Publication (CAP) 764	CAA Policy and Guidelines on Wind Turbines
UK CAA Policy Statement	Lighting of onshore wind turbine generators in the UK with a maximum blade tip height at or more than 150m above ground level
FAA AC 70/7460-1L	Obstruction Marking and Lighting

2 General guidance

2.1 Introduction

2.1.1 CASA provides advice about the lighting and marking of wind farms and other tall structures in submissions to planning authorities who are considering a wind farm or tall structure proposal.

2.1.2 Regardless of CASA advice, planning authorities make the final determination whether a wind farm or a tall structure not in the vicinity of a CASA regulated aerodrome will require lighting or marking.

2.2 Background

2.2.1 All wind turbine developments and tall structures should be assessed to determine whether they could be a risk to aviation safety. This AC augments the information in the National Aerodromes Safeguarding Framework (NASF) Guideline D and provides additional guidance on the assessment of wind farm developments and guidance for establishing what reasonable measures may be put in place to mitigate any adverse effect the wind farm development could be to aviation safety.

2.2.2 For the purposes of this AC, navigable airspace is considered to be the airspace above the minimum altitudes of VFR and IFR flight, including airspace required to ensure the safe take-off and landing of an aircraft. Generally, minimum altitude limits equate to 500 ft (152 m) or 1 000 ft (305 m) above ground level depending on the situation, i.e., whether or not the flying is over a populous area. The presence of wind turbines, wind monitoring masts and other tall obstacles may create a risk to the safety of flight, due to the risk of collision. An entity that is proposing to introduce a hazard into navigable airspace, such as a wind farm, must mitigate the risk of the hazard on airspace users to ensure an acceptable level of safety is maintained.

2.2.3 If the entity is unable to provide an acceptable level of safety using risk mitigators CASA may consider the risk as unacceptable or provide advice on additional risk control measures.

2.2.4 Part 139 regulations

2.2.4.1 Part 139 of the *Civil Aviation Safety Regulations 1998 (CASR)*, regulates obstacles within the vicinity of certified aerodromes. This is supported by Part 139 (Aerodromes) Manual of Standards (MOS) which provides the definition of an obstacle as well as the standards for marking and lighting of an obstacle. Any wind turbine (where the height is defined to be the maximum height reached by the tip of the turbine blades), wind monitoring mast or other tall structure that penetrates an Obstacle Limitation Surface (OLS) of an aerodrome will be assessed in accordance with the provisions of Part 139 of CASR and the MOS.

2.2.5 Part 175.E regulations

2.2.5.1 Subpart 175.E of CASR specifies standards and legislative requirements for the quality and integrity of obstacle data and information used in air navigation. Specifically, obstacle data published in the Integrated Aeronautical Information Package and on aeronautical charts that Airservices Australia (Airservices) manages.

2.2.5.2 Under Part 175.E of CASR, Airservices may request information about an object or structure anywhere in Australia to confirm ownership, geographic location, dimensions and whether the structure or object is marked or lit. This includes a requirement to report any structure that is at least 100 m in height above ground level, which ensures the more critical of these objects are recorded in the Airservices obstacle database and published on aeronautical charts. The process of reporting tall structures is outlined in AC 139.E-01 - Reporting of tall structures.

2.2.5.3 Referring tall structures and wind farms during the concept stage to Airservices for assessment of the potential impact to airspace procedures, communication/navigation/surveillance facilities and air traffic control operations, should be sent to the email Airport.Developments@AirservicesAustralia.com. Early referral for assessment is important to ensure that all tall structures are reported to Airservices in a timely manner, particularly as the construction timeframe can be several years.

2.2.6 Risks

2.2.6.1 Outside the vicinity of an aerodrome, which is defined as being outside the OLS of an aerodrome, wind farms and other tall structures may constitute a risk to low-flying aviation operations which may be conducted down to 500 ft above ground level (AGL) over non-populous areas. Additionally, wind monitoring masts can also be hazardous to aviation, given they are very thin and difficult to see.. Wind farms can also affect the performance of communications, navigation and surveillance (CNS) equipment operated by Airservices or the Department of Defence.

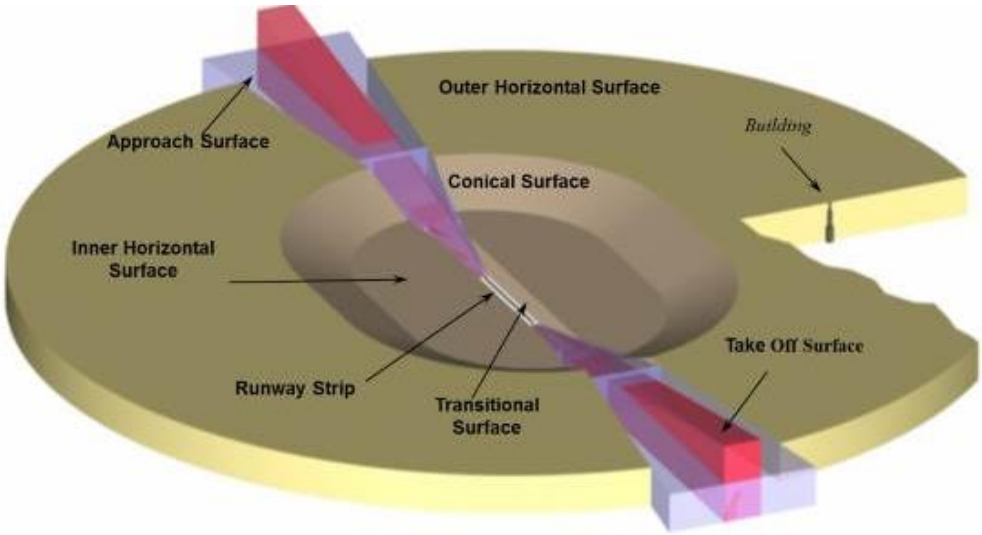

Figure 1 - Typical OLS configuration

2.2.6.2 The dimensions of an OLS as displayed in Figure 1 vary with each aerodrome location, the aerodrome physical characteristics and the function of the aerodrome. The detailed description and dimensions of each section of the OLS can be found in Chapter 7 of the MOS.

2.2.6.3 Turbulence is a risk to aircraft and aerodrome operations. Studies have proven that for wind turbines of less than 30 m Rotor Diameter (RD) the wake vortices will impact aircraft located up to 5 RDs downwind and 2 RDs vertically. Turbulence is site specific and information on wake vortices for different turbines may be available from the turbine manufacturer. Wind farm operators should be aware that depending on size, wind turbines may create turbulence noticeable up to 16 RDs from the turbine. The level of turbulence and the potential impact on aircraft and aerodrome operations at this distance is not known with certainty.

2.2.6.4 Planning authorities should consider wake vortices when assessing the location of wind turbines in proximity to an aerodrome, airstrip and associated circuit patterns. The risk to the safety of air navigation from wind turbine turbulence should be mitigated to an acceptable level of safety particularly during the critical phases of flight such as landing and taking off. Mitigation may include relocation of turbines away from the aerodrome or airstrip sensitive areas, such as the take off and approach areas, reduction in size of the turbines in question or removal of individual turbines that may cause a turbulence hazard.

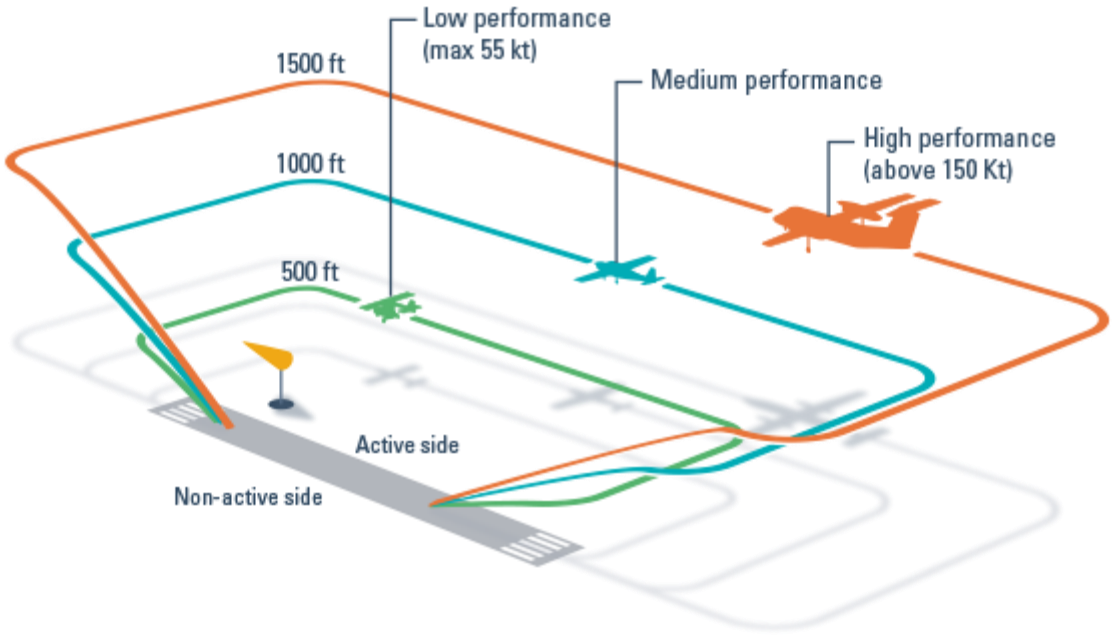

Figure 2 - Typical circuit configuration

2.2.7 Additional guidance material

2.2.7.1 The Department of Infrastructure, Transport, Regional Development and Communications and the Arts has developed a safeguarding framework that contains guidelines to improve safety outcomes in relation to developments which may impact on navigation of flight (aviation safety). Specifically, NASF Guideline D '*Managing the risk to aviation safety of wind turbine installations (wind farms) / wind monitoring towers'* provides information on managing the risk to aviation safety presented by the construction and operation of wind farms and wind monitoring masts.

2.3 Obstacles within the vicinity of a CASA Certified aerodrome

2.3.1 Mitigation by marking obstacles within the vicinity of an aerodrome is described within Chapter 8, Division 10 of the MOS.

2.3.2 Mitigation by lighting obstacles within the vicinity of an aerodrome is described within Chapter 9, Division 4 of the MOS.

2.4 Obstacles outside the vicinity of a CASA Certified aerodrome

2.4.1 The methodology for assessment of wind farms and other tall structures that are located outside the vicinity of a certified aerodrome and recommended mitigation measures for consideration are described below.

2.4.2 Early review by proponent

2.4.2.1 In the early stages of planning for a wind farm or tall structures, it is recommended that the proponent engages an aviation consultant to conduct an aeronautical study to determine if the proposed development will create a risk to aviation safety. It is critical for the proponent to consult with relevant aviation operators nearby to the proposed wind farms or tall structures to prevent potential adverse impacts to aviation. For example, the proposed location might be situated close to:

- a certified aerodrome or military aerodrome
- a high-density VFR lane or VFR reporting point
- an uncertified aerodrome(s) or landing area(s) used by the local community.

2.4.2.2 An aeronautical study will identify aviation safety risks, and the need for mitigation of those risks. The study should provide a detailed assessment of the potential impacts of the proposed development on aviation activities and demonstrate how an acceptable level of aviation safety can be maintained. The aeronautical study should:

- assess the impact of the wind farm on any aviation activity
- conduct a risk analysis using AS/NZS ISO 31000:2018 *Risk Management and Guidelines*
- consult with nearby aerodrome (certified and un-certified) operators and aircraft operators known to fly in the area (including those operators who carry out low flying activities that may include fire spotting and control)

- consult with Airservices and the Department of Defence to determine whether any nearby aeronautical communications, navigation or surveillance equipment may be affected
- provide details of proposed mitigations to ensure an acceptable level of safety and an analysis of the effectiveness of each risk control measure
- recommend operating procedures/restrictions or other means to mitigate risks.

2.4.2.3 All proposed mitigation measures should be assessed to demonstrate they are adequate to reduce aviation risks to an acceptable level.

2.4.2.4 Cumulative effects of other wind farms in close proximity to a new wind farm development should also be considered.

2.4.3 Planning authority process

2.4.3.1 CASA understands that the proponent of a wind farm or tall structure is required to submit a development application to the relevant planning authority for approval. The planning authority will assess the proposal and review the detailed aeronautical study that should be provided as part of the development application.

2.4.3.2 The planning authority may seek advice from CASA on the risk to aviation created by the development or the proposed mitigation plan if a risk has been identified.

2.4.3.3 CASA has no authority or regulatory powers in relation to a wind farm or tall structure approval outside the vicinity of a certified aerodrome but advice from CASA will inform the planning authority in regard to any decisions or conditions on any approval the planning authority might place on a development.

Regardless of any CASA advice, planning authorities make the final determination via conditions of consent as to whether a wind farm or tall structure not in the vicinity of a CASA regulated aerodrome will require lighting or marking.

2.4.3.4 Typically, aeronautical studies are reliant on proponent engaged consultants preparing reports and other information for the proponent to submit to the relevant planning authority for consideration who may then refer to CASA for advice.

2.4.3.5 The reliability of these consultant prepared reports is highly dependent on several factors, such as the accuracy and precision of the assumptions used, correct application of any calculations, the accuracy of the data used and the skills of the consulting expert in interpreting and analysing data.

2.4.3.6 Once a wind farm has been approved and constructed, a further audit should be undertaken of the aviation safety requirements, as prescribed and issued by the planning authority, to ensure that they have been implemented in accordance with the relevant planning permit requirements.

2.4.4 CASA assessment process

2.4.4.1 The CASA assessment process reviews identified potential airspace risks or risks to the safety of air navigation.

Step 1: Assessment of Aeronautical Studies

2.4.4.2 The assessment by CASA considers:

- location, height, and number of the wind turbines / monitoring masts / tall structures
- terrain in the vicinity of the development
- volume and type of flying operations in the vicinity of the development
- proximity to aerodromes
- urban (built up area) or rural setting
- potential for wind turbine turbulence effects
- ability to see the development in low visibility conditions
- prevailing local weather conditions
- inclusion of light management systems in the proposal - radar detection or visibility monitoring
- international best practice.

Step 2: Mitigation associated with proposals impacting air navigation or aircraft safety

2.4.4.3 If potential risks to the safety of air navigation or aircraft safety are identified, these should be reduced to As Low As Reasonably Practicable (ALARP) to achieve an Acceptable Level of Safety (ALoS) using mitigation and control measures. Examples of the measures that could be undertaken include:

a. obstacle lighting and marking of the turbines
b. technology solutions, such as radar activated alerting/lighting systems
c. advice to local operators (information bulletins)
d. notification to Airservices: as-constructed obstacle database email (vod@airservicesaustralia.com)
e. Notice to Airmen (NOTAM)
f. Advice in En Route Supplement Australia (ERSA) (particularly in ERSA entries for nearby aerodromes)
g. Chart symbols.

Step 3: Advice

2.4.4.4 Finally, CASA will provide advice on the outcomes of its assessment to the relevant planning authority.

2.5 Aviation hazard lighting - International best practice

2.5.1 This section describes the science behind aviation hazard lighting.

2.5.2 Australian regulations state that aircraft in uncontrolled airspace may operate under visual flight rules (VFR), which requires the pilot to remain clear of clouds and to adhere to visibility minima. CAR 172 and CAR 174 and the Aeronautical Information Publication (AIP) ENR 1.2 prescribe the following requirements:

- in Class G airspace below 3000 ft Above Mean Sea Level (AMSL) or 1000 ft AGL (whichever is the higher) – remain clear of cloud with minimum visibility of 5000 m.

- in Class G airspace below 10 000 ft AMSL (subject to the above) – remain 1000 ft vertically and 1500 m horizontally from cloud and with 5000 m visibility.

Note: Helicopters may be permitted to operate in lower visibility and that further exemptions may apply to special cases such as military, search and rescue, medical emergency, agricultural and fire-fighting operations.

2.5.3 ICAO Annex 14, Volume 1, Chapter 6.2 states that obstacles penetrating navigable airspace (which starts at the minimum flight altitude of 500 ft (152.4 m) AGL) outside of a built-up area, should be equipped with 2000 candela medium intensity obstacle lights.

2.5.4 2000 candela medium intensity obstacle lighting recommendation satisfies the 5000 m VFR visibility requirements, according to practical exercises undertaken by the FAA and documented in AC 70/7460-1L (FAA, 2015).

2.5.5 In Australia, CASA has accepted the use of 200 candela lighting in some circumstances due to a lack of back lighting in rural and remote areas, meaning that a lower intensity light is still visible to pilots at an acceptable distance to permit a pilot to see and avoid the obstacle.

Table 1: Light Visible Distances from FAA AC70/7460-1L

Time Period	Meteorological Visibility (m)	Distance (m)	Intensity (Candelas)
Night	4800	4700	1,500 (+/- 25%)
		4900	2,000 (+/- 25%) (ICAO medium intensity light)
		2200	32

2.6 Hazard lighting

2.6.1 This section describes the reasoning behind CASA's preference to recommend aviation hazard lighting for tall structures and aircraft detection systems for wind farms.

2.6.2 Hazard lighting for wind farms and other tall structures is intended to alert pilots, flying at low altitude, to the presence of an obstacle allowing them sufficient awareness to safely navigate around or avoid it. The pilot is responsible for avoiding other traffic and obstacles based on the "alerted" see-and-avoid principle.

2.6.3 Unless the wind farm or tall structure is located near an airport, it is not expected to pose a risk to regular public transport operations. The kind of air traffic that is usually encountered at low altitude in the vicinity of a wind farm or tall structure includes light aircraft (e.g., private operators, flight schools, sport aviation, agricultural, survey, and fire spotting and control) and helicopters (military, police, emergency services, survey, and fire spotting and control). Hazard lights are therefore designed to provide pilots with sufficient awareness about the presence of the structure(s), so they can avoid it. This means that the intensity of the hazard lights should be such that the acquisition distance is sufficient for the pilot to recognise the danger, take evasive action and avoid the obstacle by a safe margin in all visibility conditions. This outcome considers the

potential speed of an aircraft to determine the distance by which the pilot must become aware of the obstacle to have enough time and manoeuvrability to avoid it.

2.6.4 Light management systems to regulate hazard lights and their intensity are acceptable options in Australia. The two primary options are the use of visibility meters to reduce light intensity during high visibility conditions and the use of a radar detection system to allow the lights to activate when an aircraft is in the vicinity of the wind farm. Permanent light shielding is also an option to reduce impact on residences within six kilometres of the installation.

2.6.5 A visibility meter intensity regulation system can reduce the intensity of hazard lights depending on the level of visibility determined by the sensors. Visibility meters detect real time visibility conditions and are mounted as near to the hazard lights as possible and in the case of wind farms, on turbines every 1.5 km.

2.6.6 A radar detection system activates the hazard lights when aircraft are detected in the vicinity of the wind farm or tall structure. The system does not require additional equipment to be carried by aircraft. CASA does not approve radar detection systems but provides advice of 'no objections' to the system manufacturers if an FAA Technical Note concludes that the system “performed according to the manufacturer’s specifications and met the performance requirements identified in AC 70/7460-1L".

2.7 CASA's commitment to aviation safety

2.7.1 CASA will consider the lighting intensity management and systems that achieve an acceptable level of aviation safety on a case-by-case basis during its assessment.

2.7.2 A CASA determination will consider the environmental setting when determining the need and level of lighting required on a wind farm or tall structure. This may include consideration of lower lighting intensities for obstacles away from an aerodrome. The backlighting of some locations is almost non-existent, meaning the risk of an aviation hazard light being compromised by background lighting from a rural and remote town is lower than would otherwise apply in a residential area closer to a city.