9 OBSTRUCTION LIGHTING CHARACTERISTICS

Characteristics of obstacle lighting requirements are defined in the following CASA documents:

- Manual of Standards Part 139 – Aerodromes; and
- Advisory Circular AC139-18(0) – Obstacle Marking and Lighting of Wind Farms

A summary of these requirements is provided below[4]

Obstacle Light Performance

MoS Part 139 Section 9.4.2, Types of Obstacle Lighting and Their Use, defines the types of obstacle lighting requirements; Low Intensity, Medium Intensity and High Intensity.

For Obstacles above 45m (but below 150m) AGL the requirement is for Medium Intensity Obstacle Lighting.

Definition: Medium intensity lighting can be one of three types:

- Flashing White Light;
- Flashing Red Light (known as a hazard beacon); and
- Steady Red Light – may be used where there is opposition to the use of a flashing red light, for example in environmentally sensitive locations.

MOS Pt 139: Characteristics of Medium Intensity Lights (Summary)

- Frequency of flashes is to be between 20 and 60 flashes per minute;
- Peak effective intensity is to be 2,000 +/- 25% cd with a vertical distribution as follows:
- Vertical beam spread is to be 3° minimum (beam spread is defined as the angle between two directions in a plane for which the intensity is equal to 50% of the lower tolerance value of the peak intensity)
- At -1° elevation, the intensity is to be 50% minimum and 75% maximum of lower tolerance value of the peak intensity.
- At 0° elevation, the intensity is to be 100% minimum of the lower tolerance value of the peak intensity.

AC139-18(0)

In the case of Wind Farms, AC139-18(0) further defines the required obstacle lighting as follows:

- Two flashing red medium intensity obstacle lights should be provided;
- Light fixtures to be mounted sufficiently above the surface of the nacelle so that the lights are not obscured by the rotor hub, and at a horizontal separation to ensure an unobstructed view of at least one of the lights by a pilot approaching from any direction;

[4] This summary is considered to provide a comprehensive overview of obstacle lighting requirements. However, it is recommended that Stockyard Hill Wind Farm Pty Ltd fully familiarize themselves with the requirements in conducting their detailed obstacle lighting and system design.

- Both lights should flash simultaneously;
- Characteristics of the obstacle lights should be in accordance with MOS Pt 139; and
- All obstacle lights on a wind farm are to be synchronised so that they flash simultaneously.
- An appropriate monitoring, reporting and maintenance procedure is to be established to ensure outages are detected, reported and rectified.

Visual Impact Minimisation

AC139-18(0) Section 10.4 allows for minimisation of the visual impact on the environment. It allows some shielding provided it does not compromise the operational effectiveness of the obstruction lighting.

Shielding may be provided to restrict the downward component of light to either, or both, of the following:

- Such that no more than 5% of the nominal intensity is emitted at or below 5° below the horizontal
- Such that no light is emitted at or below 10° below the horizontal.

Reflection minimisation is also catered for in the AC. A relatively small area on the back of each blade near the rotor hub may be treated with a different colour or surface treatment, to reduce reflection from the blades of light from obstacle lights, without compromising the daytime conspicuity of the overall turbine.

Other Requirements

Where two lights are mounted on a nacelle, dynamic shielding or light extinction of one light at a time, for the period that a blade is passing in front of the light, is permissible providing that at all times at least one light can be seen, without interruption, from every angle in the azimuth.

Obstacle lights should operate at night, and at times of reduced visibility. All obstacle lights on a wind farm should be turned on simultaneously and off simultaneously.

Where obstacle lighting is provided, it is necessary to establish a monitoring, reporting and maintenance procedure to ensure outages, including loss of synchronisation, are detected, reported and rectified.

10 SUMMARY OF EVALUATION

Obstacle Marking

Obstacle marking of the wind turbines is not considered necessary provided the turbines are of an appropriate colour that will not require painting or marking to increase conspicuity.

Obstacle Lighting

This evaluation proposes an obstacle lighting layout that complies with CASA Advisory Circular AC139-18(0) guidelines.

This evaluation and the aeronautical impact assessment has determined that:

- there is no impact on prescribed airspace;
- the nearest airports permanently equipped for night operations are located at Ararat (approximately 25 km to the west) and Ballarat (approximately 32km to the east) of the wind farm;
- there is no significant general aviation night flying activity in the area;
- considerable higher terrain and obstacles exist to the north and within 30 km or less of the wind farm site, including an unlit tower with an elevation of 3699 ft AHD and a mountain range (Ben Nevis and Mt Buangor) of higher elevation than the wind farm turbines; and
- CASA has withdrawn the guideline material for the assessment of obstacle marking and lighting requirements for wind farms.

Given that Advisory Circulars provide guidelines which, (as indicated in the AC):

> "… *provides a means, but not necessarily the only means, of complying with the Regulations…",*

then, pending the review of the Advisory Circular, alternative solutions to indicate the existence of the wind farm and the "Tall Structure" could be considered in order to meet the relevant Regulations.

An alternative solution to meet CASA requirements for identifying the existence and location of the Stockyard Hill wind farm would be the declaration of the wind farm as a Danger Area and, if necessary, supplement this with obstacle lights to identify the centre of the wind farm, the highest terrain and the extremities of the wind farm. This would significantly reduce the need for extensive obstacle lighting while still meeting the requirement to identify the location and existence of a wind farm and "Tall Structure".

However, should CASA determine that obstacle lighting is required, the proposed lighting layout indicated in this study will meet the CASA objectives of:

- defining the “general definition and extent of the objects” for each Group;
- the requirement for an “interval between obstacle lighted turbines not exceeding 900m” for each Group ; and
- marking the most prominent (highest for the terrain) turbine in each of the Groups.

In some groups, there is more than one high point within the Group and, due to the extent of the Group, it is recommended that each turbine at these highest terrain points be fitted with obstacle lighting.

Reporting of Tall Structures

As the proposed wind farm contains wind turbines which will exceed 110m AGL, the proponent of the wind farm is required to inform CASA of the development in accordance with AC 139-08(0) “Reporting of Tall Structures” and AC 139-18(0) “Obstacle Marking and Lighting of Wind Farms”.

Application to CASA

This evaluation of obstacle marking and lighting requirements can be used as supporting documentation to an application to CASA using CASA Form 406 – “Operational Assessment of Existing and Proposed Structures” and for the “Reporting of Tall Structures” in accordance with AC139-08(0). The application should submit that the proposed declaration of the Stockyard Hill wind farm site as a Danger Area may also be a means of meeting the aviation safety requirements.

APPENDIX D

Comparison of International Standards for Obstacle Lighting

APPENDIX D

Comparison of International Standards for Obstacle Lighting

Obstacle Marking Requirements

As the Australian Civil Aviation Safety Authority has determined that provided the turbines are of a colour that enables them to be readily conspicuous (preferably white), then marking of wind turbines for daytime visibility is not considered necessary in the Australian environment. Consequently, the following table not does make a comparison of marking requirements.

Obstacle Lighting Requirements

Table D-1 below has been prepared to indicate the variation between countries as to the obstacle lighting criteria applicable to wind farms. The purpose is to show that these criteria can vary considerably between countries. Only those factors that are pertinent to the Stockyard Hill Wind Farm study have been included in this review. This information is general in nature only and the reference document should be read in full to gain a full understanding of the complete requirements.

Country	*Turbine Height Criteria for Lighting*	*Obstacle Lighting Criteria*	*Reference*
Australia	Turbines 110m AGL.	Objective is to define the extent of the wind farm: a. spacing not more than 900m b. define the extremities and perimeter of the wind farm c. identify the highest terrain obstacle	Advisory Circular AC139-18(0) (Note: Although this AC has been withdrawn and the requirements being reviewed by CASA, the technical requirements can be used as a "risk mitigator" by wind farm developers.

Country	Turbine Height Criteria for Lighting	Obstacle Lighting Criteria	Reference
Canada	Turbines 90m AGL.	Dependent on a number of factors, ".. including direction of air traffic and the nearness of aerodromes..." Longitudinal spacing "in the order of 900m" Deviation not more than 10%. Nav Canada has recently approved the use of the Obstacle Collision Avoidance System (OCAS®) as an alternative to obstacle lighting systems. OCAS® has been approved for use in Norway, USA and Canada.	Transport Canada. CAR621.19 Advisory Circular 1/06 (Draft). NAV CANADA Aeronautical Information Circular 45/08, 20 Nov 08.
Ireland	"potential en route air navigation obstacle" above 45m AGL. Offshore - above 90m AGL.	Onshore - No published regulations, Wind Farms planned away from the vicinity of aerodromes are considered 'case by case', requirement of lighting dependant on size, and vicinity to en-route aircraft. Offshore - "All *Significant Peripheral Structures*, of height = 90m, to the highest point of the structure including the top of blade spin where appropriate, above Mean Sea Level.	S.I No. 423 of 1999. OAM 09/02 - Offshore Wind Farms Conspicuity Requirements Advisory Material for the Protection of Air and Marine Navigation Safety.
New Zealand	Dependent on whether the structure is a hazard in navigable airspace Turbines of >60m AGL.	Selected turbines to be lit, ".. the highest turbines, … those at the extremities … and spacing not to exceed 1NM (1850m).."	Civil Aviation Authority of New Zealand, "Lighting and Marking of Wind Farms , May 2006.

Country	Turbine Height Criteria for Lighting	Obstacle Lighting Criteria	Reference
Norway	Wind turbine overall height greater than 60m AGL.	Norwegian Civil Aviation Authority has approved the use of the Obstacle Collision Avoidance System (OCAS®) as an alternative to obstacle lighting systems.	Norwegian Civil Aviation Authority.
South Africa	Towers of heights over 45m.	Define periphery, not more than 800m spacing.	Civil Aviation Regulations, 1997.
Taiwan	Wind turbines >=60m AGL.	"Objects that are around the airport, airfield, and navigation aids and will affect safety…"	Article 32, Taiwan Civil Aviation Act.
United Kingdom	Various criteria: Depends on location, Onshore, Offshore, vicinity of aerodromes and whether it is assessed as a hazard to aviation. Onshore - within vicinity if an aerodrome, if assessed as a hazard - away from immediate vicinity of an aerodrome, 150m AGL. Offshore - 60m.	Onshore 1. Within vicinity of an aerodrome, obstacle lighting is required if the obstacle is assessed as a hazard to air navigation. 2. Away from the immediate vicinity of an aerodrome – "In general terms, structures less than 150m high, which are outside the immediate vicinity of an aerodrome are not routinely lit; unless by virtue of its nature or location .. it presents a significant hazard to air navigation''. Offshore - "Where wind turbines are located together as a group only those on the periphery are fitted with obstacle lighting.."	CAP764 CAA Policy and Guidelines on Wind Turbines (February 2009).

Country	Turbine Height Criteria for Lighting	Obstacle Lighting Criteria	Reference
United States	Wind turbine overall height greater than 200ft (approx. 61m).	Need to take into account "proximity to airports, VFR routes, extreme terrain and local flight activity… " Spacing "not more than ½ statute mile" (approx. 805m). FAA has recently approved the use of the Obstacle Collision Avoidance System (OCAS®) as an alternative to obstacle lighting systems.	FAA. AC 70/7460-1K (January 2007).

Table D-1. International Comparison of Obstacle Lighting Requirements

Many of the reference documents indicate that in determining the requirement for obstacle marking and/or lighting of a wind farm, an aeronautical assessment should be made to determine whether the wind farm is a hazard to aviation and that, in addition to the height AGL of the wind farm turbines, this will depend on such factors as:

- Number of wind turbines.
- Location and proximity to airports.
- Proximity to aeronautical routes and air operations in the area.
- Nature of terrain in the area.
- Proximity to navigational aids.
- Extent and type of air traffic.
- Environmental restrictions.

Overseas experience appears to be trending towards a more rigorous justification of obstacle lighting of wind farms that are remote from an aerodrome, taking into account "its nature and location" as part of the assessment process.

APPENDIX E

Obstacle Lighting of Wind Farms in Australia

APPENDIX E

Lighting Arrangements - Operating Wind Farms or Wind Farms Under Construction - Australia - July 2009

The following Table E-1 has been prepared from a review of power generation company web sites, submissions to planning authorities and discussions with representatives of power generation companies. The purpose of the table is to identify wind farms in Australia that have been or are planned to be provided with obstacle lighting to meet Civil Aviation Safety Authority requirements. It is not claimed to be an exhaustive survey. No responsibility is accepted for the accuracy of the information contained herein.

Wind Farm	*No. of Turbines*	*Height AGL (Approx.)*	*Location*	*Obstacle Lighting*
Albany Wind Farm (Grasmere)	12	100m	WA	No Lighting
Alinta /Walkaway Wind Farm	54	118m	WA	No information
Blayney Wind Farm	15	67.5m	NSW	No Lighting
Bremer Bay Wind Farm	1	69m	WA	No Lighting
Canunda Wind Farm	23	108m	SA	No Lighting
Capital Wind Farm (Bungendore)	63	125m	NSW	Due to be complete mid 2009. CASA submission indicated obstacle lighting not required.
Cathedral Rocks Wind Farm	33	100m	SA	No Lighting
Challicum Hills Wind Farm	35	100m	VIC	No Lighting
Clements Gap Wind Farm	27	123m	SA	Under construction – will have approx 50% turbines lit
Cocos Island	4	25m	AUS	No Lighting
Codrington Wind Farm	14	81m	VIC	No Lighting
Coober Pedy Wind Farm	1	43.5m	SA	No Lighting
Coral Bay Wind Farm	3	71m	WA	No Lighting
Crookwell Wind Farm	8	67m	NSW	No Lighting

Wind Farm	No. of Turbines	Height AGL (Approx.)	Location	Obstacle Lighting
Cullerin Range Wind Farm	15	125m	NSW	Planning submission indicated 5 turbines to be lit. 9 have been lit
Denham Wind Farm Turbines - 1,2,3 Turbine - 4	4	 65m 62.5	WA	All 4 Turbines lit Tourist Area
Emu Downs Wind Farm	48	80m	WA	No Lighting
Exmouth Advanced Mini Wind Farm	3	35.2m	WA	No Lighting
Hallett Wind Farm 1 – Brown Hill	45	124m	SA	17 of 35 Turbines lit
Hallett Wind Farm 2 – Hallett Hill	34	124m	SA	40% of Turbines lit
Hampton Park Wind Farm	2	98m	NSW	No Lighting
Hopetoun Wind Farm	1	69m	WA	No Lighting
Huxley Hill Wind Farm (King Island)	5	44m - 86m	TAS	1 of 5 Turbines lit 5kms from airport
Kalbarri Wind Farm	2	74m	WA	No Lighting
Kings Creek Hotel	1	Approx. 30m	VIC	No Lighting
Kooragang, Newcastle	1	>110m	NSW	No Information
Lake Bonney – Stage 1	46	106m	SA	No Lighting
Lake Bonney – Stage 2	53	125m	SA	No information
Longwood Wind Power Station	2	36m	VIC	No Lighting
Mawson – Antarctic	2	49m	AAD	No Lighting
Moorooduc Wind Farm	1	>110m	VIC	No information

Wind Farm	No. of Turbines	Height AGL (Approx.)	Location	Obstacle Lighting
Mount Millar Wind Farm	35	120m	SA	11 of 35 Turbines lit
Nine Mile Beach Wind Farm (Esperance)	6	69m	WA	No Lighting
Portland Project				Stage IV is the only section lit. 16 out of 26 turbines lit. Have reduced number by one, since 2008 plan.
Stage I - Yambuk	29	106m	VIC	
Stage II - Cape Bridgewater	20	109.9m		
Stage III - Cape Nelson South,	22	109.9m		
Stage IV - Cape Nelson North and	11	126m		
Sir William Grant	16	110-126m		
Rottnest Island	1	69m	WA	No Lighting
Snowtown (Barunga Ranges) Stage 1	47	124m	SA	Stage 1 - 24 of 47 Turbines lit Up to 83 turbines planned to be installed
Starfish Hill Wind Farm	23	100m	SA	No Lighting
Ten Mile Lagoon (Esperance)	9	45m	WA	No Lighting
Thursday Island	2	>110m	QLD	No Information
Toora Wind Farm	12	100m	VIC	No Lighting
Wattle Point Wind Farm	55	109.5m	SA	No Lighting
Waubra Wind Farm	128	110m - 120m	VIC	48 of 128 Turbines lit
Windy Hill Wind Farm	20	69m	QLD	No Lighting
Wonthaggi Wind Farm	6	103m	VIC	No Lighting.
Woolnorth Wind Farm Staged development	62	99m -125m	TAS	No information

Table E-1: Australian Wind Farms – Obstacle Lighting Provision

APPENDIX F

Aircraft Operations in the Vicinity of Stockyard Hill Wind Farm

APPENDIX F

1. AIRCRAFT OPERATIONS IN THE VICINITY OF STOCKYARD HILL WIND FARM

The Civil Aviation Safety Authority (CASA) has specified standards for the altitudes at which aircraft are permitted to operate in Australian airspace. Determination of these altitudes is quite complex, but for the purpose of this Stockyard Hill Wind Farm review of obstacle lighting, is best explained by:

i. Consideration of the category of operation i.e. whether the aircraft is operating to instrument flight rules (IFR) or visual flight rules (VFR);

ii. Consideration of the type of operation the aircraft is involved in i.e. passenger transport operations, aerial work operations, private or recreational operations;

iii. Consideration of the type of airspace the aircraft is operating in i.e. controlled airspace, military controlled airspace, special use airspace or non-controlled airspace; and

iv. Consideration of the phase of operation; i.e. approach, departure or en route.

i. Category of Operation

All aircraft in Australia are categorised according to the method of navigational capability that both the aircraft and pilot are qualified for. There are only two (2) categories (and rule sets) available, namely:

a. Instrument Flight Rules (IFR); and
b. Visual Flight Rules (VFR).

a. IFR Operations.

Aircraft operating under IFR category are primarily navigating by reference to aircraft instruments only. This capability allows aircraft to operate without reference to ground features and, as such, enables the aircraft to fly and navigate safely in cloud and during adverse weather conditions (formally known as Instrument Meteorological Conditions or IMC) during both day and night hours.

Aircraft operating under IFR are required to maintain an altitude (expressed as feet above mean sea level) not below the published Lowest Safe Altitude (LSALT) or the Minimum Sector Altitude (MSA) for the route or segment being flown. The LSALT and MSA provide for 1,000 feet (305m) of clearance from all obstacles and terrain. During an approach or departure to or from an aerodrome, an IFR category aircraft may operate below the published MSA or LSALT provided it is following a prescribed instrument flight approach or departure procedure or has elected to follow Visual Flight Rules and Visual Meteorological Conditions exists (see below). Published instrument flight procedures incorporate the necessary clearance from obstacles and terrain in order to account for the fact that the aircraft may be operating in cloud and, therefore, the pilot would be incapable of maintaining visual separation from obstacles and terrain. However obstacle/terrain avoidance is a pilot responsibility when an IFR aircraft elects to operate below the LSALT or MSA under VFR in VMC.

b VFR Operations.

Pilots flying aircraft operating under VFR category are primarily navigating by referencing the aircraft's position against known geographic features supported, as required, by reference to aircraft navigation instrumentation provided both the pilot and aircraft are certified to use same. Because of the prime requirement to navigate visually, VFR aircraft are NOT PERMITTED TO FLY IN CLOUD and there are published standards with respect to the minimum distances a VFR aircraft must maintain from cloud and the amount of forward visibility (expressed in metres) that must exist before the aircraft is permitted to operate. These standards are collectively known as Visual Meteorological Conditions or VMC.

Because they are operating in VMC and can, therefore, navigate by visual reference to ground features, VFR aircraft operating by day have the flexibility to operate at a range of altitudes to ensure the appropriate height clearance from obstacles and terrain; the only restriction being that civilian aircraft must operate no lower than 500 feet (152m) above ground level in areas outside urban development and no lower than 1000 feet (305m) above ground level when operating over built-up areas; unless they are conducting take-off and landing manoeuvres.

Altitude restrictions for VFR operations at night are similar to those applicable to IFR category aircraft in that they must only operate at altitudes that provide for a minimum of 1,000 feet clearance from the highest obstacle or terrain located within an area up to 10 nautical miles either side of their proposed flight route.

ii. Type of Operation

a. Passenger Transport Operations.

Passenger Transport Operations (PTO) includes all scheduled airline operations and those aircraft operations chartered by client on a specific requirement basis.

All airline PTO are conducted under IFR for both day and night. The majority of Charter PTOs are also conducted under IFR.

b. Aerial Work Operations.

Aerial Work Operations include airborne operations such as ambulance services, as well as surveying, crop spraying, firefighting and search and rescue activities.

Aerial ambulance and search and rescue activities invariably tend to fly IFR whereas the lower level activities such as crop dusting, cattle mustering, pipeline or power line surveys, fire fighting and helicopter operations generally fly VFR due to the fact that they are operating with reference to geographic features (see Low Flying Operations).

c. Low Flying Operations.

i. Civilian aircraft operations.

Civilian VFR flight operations below 500ft (152m) AGL may be carried out by specifically endorsed pilots conducting crop dusting, cattle mustering, pipeline or power line surveys, fire fighting, helicopter operations, search and rescue, and other low level operations. Pilots undertaking these low level operations undergo special training, are endorsed for these operations, and are required to take obstacles into account when planning and conducting low flying operations.

ii. Military low level flight operations.

Low level flight operations are conducted by Australian Defence Force aircraft throughout Australia. These flights are subject to precise planning by military aircrew to enable them to avoid population centres, noise sensitive areas, terrain and obstacles, and areas of intensive civil aviation activity and airfields. Defence maintains a data base of "Tall Structures" (i.e. any obstacle in excess of 110m AGL) and the existence of these tall structures are included on aeronautical charts. Defence has a requirement for inclusion in their aeronautical information publications of structures that exceed 45m AGL. Once construction of a wind farm is approved, and the wind farm reported to CASA under the "Notification of Tall Structure" provisions, the wind farm will be shown on aeronautical charts and included in military obstruction databases, accessible by all military aircrew.

d. Private Flying Operations

Private flying operations include those flights which are conducted for private transport purposes and involve no charging for carriage of personnel.

Private flying is conducted under two (2) separate regulatory regimes, namely the civil aviation safety regulations (and CASA) if registered as a General Aviation aircraft (i.e. the aircraft must have a "VH and 3 letter designator") or under the regulatory auspices of Recreational Aviation Australia (RAA), a self-administering body.

Private aircraft registered as GA aircraft under the civil aviation safety regulations can fly under both IFR and VFR. RAA aircraft can only fly under VFR.

e. Recreational Operations

Recreational and private operations include aerial activities such as gliding, hang gliding, aerobatic, ballooning and parachuting. All these operations can only be conducted under VFR and when VMC exists.

iii. Type of Airspace

Australian airspace is broadly classified as:

a. Controlled Airspace
b. Special Use Airspace
c. Non-Controlled Airspace

a. Controlled Airspace.

Controlled airspace encompasses the major capital city airports and the busier major regional cities.

Both IFR and VFR operations are permitted in controlled airspace and aircraft are required to be in constant contact with air traffic control whilst operating in controlled airspace. Some of the higher level controlled airspace only permits IFR operations but this is not pertinent in this analysis.

b. Special Use Airspace.

Special Use Airspace (SUA) is prescribed airspace that may present a hazard to aircraft operations. SUA is classified as Prohibited, Restricted or Danger Areas and, through their classification, they provide the necessary level of hazard alerting and protection to aircraft either operating, or intending to operate, within these areas. Typical SUA prescriptions account for activities such as flying training, weapons firing, parachuting activities, high plume rise, explosives areas or ground based radiation hazards.

Flights within Prohibited Areas (e.g. atomic testing sites) are not permitted under any circumstances whilst flights within Restricted Areas (e.g. weapons firing) are permitted subject to the pilot obtaining the necessary transit approvals from the controlling authority. Flights within Danger Areas (e.g. parachuting) are permitted without prior authorisation but are conducted by the pilot on an "at own risk" basis.

iv. Consideration of the phase of operation; i.e. approach, departure or en route.

Stockyard Hill Wind Farm is located remote from registered or certified airports. For aircraft operating in other than authorised low level operations, aircraft operating in the vicinity of the wind farm will have achieved cruise levels and will normally be operating in an en route mode and not configured for approach or departure. This aspect is important when assessing the risks to aviation as accident rates are much lower for aircraft in cruise mode.

2. LIKELY HEIGHT OF AIRCRAFT OPERATIONS IN THE VICINITY OF THE STOCKYARD HILL WIND FARM

Application of the CASA standards as outlined above can assist in assessing the likely height of aircraft operations in the vicinity of the Stockyard Hill Wind Farm as follows:

2.1 IFR Operations

The nearest airport with instrument approach and associated Obstacle Limitation Surfaces (OLS) and Procedures for Air Navigation Services – Aircraft Operations (PANS OPS) surfaces is Ballarat, which is approximately 32.5 km from Stockyard Hill Wind Farm. Ararat airport is located approximately 25 km from the wind farm, but this airport does not have PANS OPS surfaces and the wind farm is outside the Approach and Take-off Protection Surfaces. There are other airports within 30km of the proposed wind farm, but as these airports are not equipped for instrument approaches, the wind farm will not impact on their prescribed airspace.

The maximum tip height of a wind turbine at Stockyard Hill Wind Farm, as advised by Origin Energy, is 567m (1861 ft) AMSL.

Stockyard Hill Wind Farm is located beneath several designated air routes. Critical altitude minima for these routes are:

Air Routes W245 and W191 – 4100ft (1249m) AMSL

Applicable aeronautical charts for the area indicate the Grid Lowest Safe Altitude is 4700ft (1433m) AMSL.

Thus it can be seen that the minimum clearance above the turbine tip height for IFR operations will be some 2239ft or 683m. It is considered that most IFR operations in the area will in fact be at much higher altitudes.

2.2 VFR Operations

In accordance with CASA regulations, the minimum altitude (under normal operation) applicable to VFR operations is 500ft (152m) AGL during daylight hours and 1000ft (304m) AGL at night[7]. However, there are many other factors that need to be taken into consideration by pilots when planning their flights. Aeronautical charts provide details of obstacles and it is the responsibility of the pilot to ensure that he fully understands the extent and location of obstacles in the area of operations.

The World Aeronautical Chart (WAC) for the Stockyard Hill Wind Farm area indicates that due to the presence of mountainous terrain in the area, there is a "Grid maximum elevation for Obstacle" of 3699ft (approximately 1027m) AHD, which means that this is the maximum obstacle height in the area and may be used in determining altitude for safe clearance.

The concept of lowest safe altitude is shown diagrammatically in the following diagram Fig. F-1. (Note: This pictorial presentation needs to be taken in context as the required lowest altitude depends on numerous factors as explained above. For a full understanding of applicable lowest safe altitude, the reader should refer to the relevant CASA regulations and the VFR Guide.)

[7] The actual requirement is a minimum of 1000ft above the highest OBSTACLE 10nm either side of track where the height of the obstacle is more than 110m AGL. If obstacle within the 10nm envelope is less than 110m then pilot must maintain a minimum of 1,360ft clearance AGL.

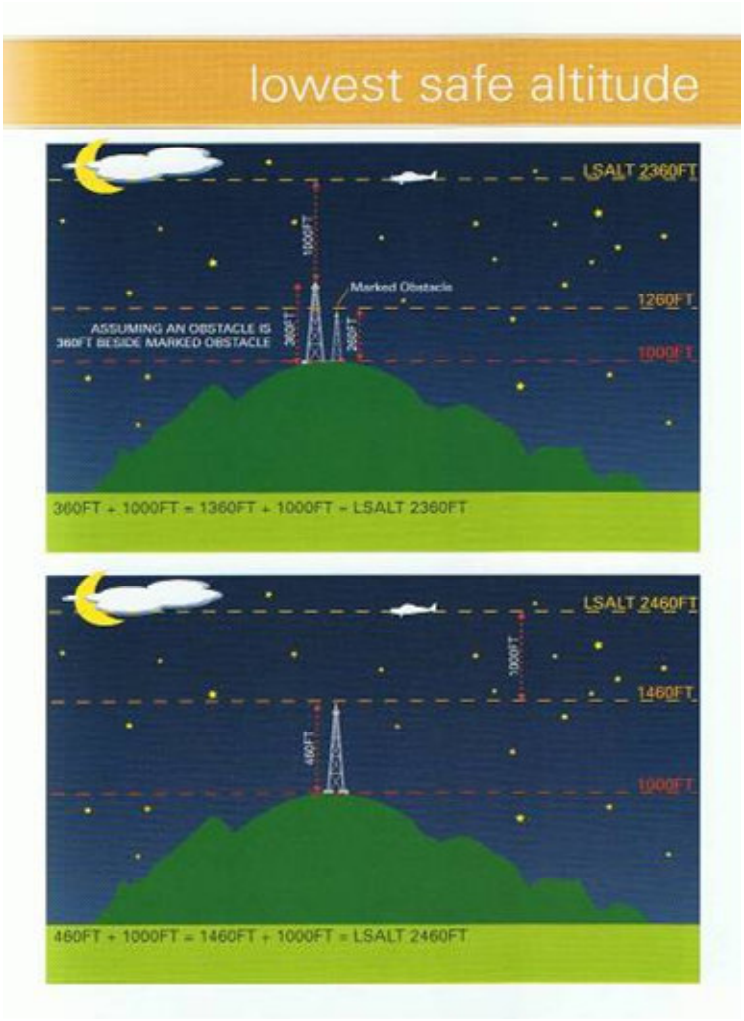

Fig F-1: Diagrammatic presentation of Lowest Safe Altitude (LSALT)[8]

(NOTE: LSALT's apply to IFR procedures. The above diagram is a general presentation only. Pilots using LSALT for obstacle clearance are responsible for determining the allowance for navigation error that should be applied and the highest Grid LSALT falling within the area covered by the determined navigation error must be used.)

Aircraft operating under VFR are required by regulation to fly in VMC which requires the pilot to maintain a minimum forward in-flight visibility of 5000m. At the maximum allowable speed of 250knots (jets), this means a pilot should still have some 39 seconds to avoid the turbines at first sighting. At a typical multi-engine aircraft speed of 180 knots, the visual response time extends out to 54 seconds and, for a typical single engine speed of 150 knots, the response time is 65 seconds. Providing the pilot is maintaining the minimum required visibility of 5000m, and the

[8] Source: Civil Aviation Safety Authority, Visual Flight Rules Guide, V2, July 2007

wind turbines are conspicuous, avoidance of wind turbines should not present an avoidance problem.

Stockyard Hill Wind Farm is generally located in a high terrain area, and there is higher natural terrain within 10 – 15km from the wind farm site. As shown in the World Aeronautical Chart[9] for the area, the Mt Cole State Forest located 10 – 15 km from the wind farm includes a mountain range to the north-west of the wind farm that contains mountains up to 966m (3170ft) AMSL; i.e. Mt Buangor at 966m (3170ft) AMSL and, further to the west, Mt Langhi Ghiran at 922m (3024ft), some 399m (1309 ft) and 354m (1163 ft) respectively higher than the highest wind turbine at Stockyard Hill Wind Farm. Additionally, given that the "Grid maximum elevation for Obstacle" is 3699ft, pilots are required to use this Obstacle elevation as the determining height for operations in the area. Given that the wind turbine tip height exceeds 110m, VFR night operations are to be at a minimum of 1360ft (415m) clearance above the wind farm and, when considered in conjunction with the nearby high terrain, implies that all VFR operations should be well above the wind farm site.

Further, it is generally recognised that aircraft operations in the vicinity of mountains requires extra caution. This is explained in general terms in CASA aeronautical publications and the American Air Safety Foundation recommends that as mountainous or high terrain areas are known to be subject to greater turbulence and meteorological phenomena, the minimum height and visibility conditions should be doubled when aircraft are operating in these areas.[10] Observation of these recommendations by pilots would further reduce the risks to aircraft operations in the vicinity of Stockyard Hill Wind Farm.

2.3 Approved Low Level Operations

The extent of low flying civil operations in the area is expected to be minimal due to the nearby mountainous terrain. Crop dusting, cattle mustering and the like require specifically endorsed pilots. Operations such as search and rescue, emergency services and fire fighting, may require low level operations and, although not to be ignored, tend to be an occasional activity in the vicinity of wind farms. Again, these pilots require specific endorsement for these operations.

In the discussion with local operators, including pilots endorsed for low level operations, it was indicated that they are well aware of other wind farms and the mountainous terrain in the vicinity, and that the proposal for Stockyard Hill Wind Farm was known to them. They did not indicate any major concerns over the proposal provided that the wind farm location was clearly identified in relevant aeronautical charts.

Military low level operations are rigidly controlled and undertaken by specially trained pilots, and RAAF aircraft are fitted with terrain following radar or pilots use night vision goggles to undertake these low flying activities. In accordance with relevant CASA and Defence requirements, Origin Energy is required to notify the aviation authorities of the existence of the wind farms as a "Tall Structure" and the location of the wind farms will be included on relevant civil and defence aeronautical charts and publications. The area around Stockyard Hill Wind Farm is not a regular training area for military operations.

2.4 Likelihood of Aircraft Being Below Permitted Height

[9] World Aeronautical Chart WAC 3469 (Hamilton)
[10] United States Aircraft Insurance Group, Piper Cherokee and Arrow Safety Highlights.

As indicated above, civil aircraft operating in the vicinity of Stockyard Hill Wind Farm are required to be at an altitude greater than the tip height of the highest wind turbine. Reasons for which an aircraft may be operating at a height lower than the highest wind turbine are summarised in the following Table F-1.

Factor	*Typical Reason*	*Comments*
Deliberate and unauthorised low flying.	Deliberate decision by pilot.	Breach of regulations.
Pilot disorientation.	Navigational error (lost) inadvertent flight into IMC, illness.	Pilot operating outside of map reference or not in visual contact with ground features. Pilot descends to low altitude to regain situational awareness or to execute precautionary search and landing.
Weather avoidance.	Inadvertent flight into IMC	Pilot is still required to maintain VMC. If not VMC, should land. If continuing flight, pilot is in breach of regulations.
Loss of control of aircraft.	Aircraft malfunction, failure.	Aircraft malfunction or failure may lead to pilot being unable to maintain altitude.
	Meteorological conditions; e.g. turbulence, storms, cloud, rain, ice.	Pilot unable to maintain altitude due to possible aircraft damage or loss of control resulting from updrafts, wind shear, icing, etc.
	Pilot error.	Pilot fails to maintain altitude.
Authorised low flying operations.	E.g. crop dusting, search and rescue, helicopter operations, emergency services, Military operations, fire bombing.	Pilot is required to be endorsed for low flying activities and is responsible for knowledge of obstacles in area.

Table F-1: Reasons for Flight Operations at below legal height

2.5 Summary of likely heights of aircraft operations

The minimum safe altitude for IFR operations in the vicinity of the Stockyard Hill Wind Farm is 4100ft (1250m) AMSL. This is some 2239ft (683m) clear of the highest wind turbine.

For night VFR operations, based on a minimum clearance of 1000ft directly above the highest turbine tip height, the minimum altitude for night VFR operations over the wind farm site will be

approximately 2861ft (871m) AMSL. Additionally, allowing for operations at a minimum height of 1000ft above the highest terrain in the vicinity, and given that there is higher terrain within 10-15km of the wind farm site, then the minimum altitude for night VFR operations would be approximately 4168ft (1270m) AMSL.

Therefore, other than those flights for authorised low level operations, the height of all aircraft operations in the vicinity of the wind farms, is required to be well clear of the highest turbines at Stockyard Hill Wind Farm.

Low level operations in the area are permitted by specially endorsed pilots who, before conducting operations, are required to fully familiarise themselves with all obstacles and terrain in the area of flight operations.

For other than authorised low level operations, aircraft operating at heights that could lead to a risk of collision with the wind farm turbines will be operating either in breach of civil aviation safety regulations or due to a failure by the pilot to maintain the required altitude. Failure to maintain the requisite altitude can arise from a number of factors, including pilot error, loss of aircraft control due to meteorological conditions, aircraft malfunction or pilot disorientation.

2.6 Extent of aircraft operations at night and low visibility conditions in the vicinity of Stockyard Hill Wind Farm

A review has been undertaken of aircraft and airport operations in the general area of Stockyard Hill Wind Farm. The wind farm is sited beneath prescribed airspace (e.g. in the vicinity of the Melbourne – western Victoria and Melbourne – Adelaide air routes), and there is general aviation (GA) activity in the area. Discussions with operators in the area have indicated that there are some night GA operations, specifically circuit training at Ballarat and some cross country navigation training which may include traversing the wind farm site. In general however, it appears that there is minimal GA activity at night in the area of the wind farm.

Appendix G provides a summary of the discussions and the airports considered. There are other airports in the vicinity of the Stockyard Hill Wind Farm, but they are not equipped for night operations.

It is extremely difficult to make an assessment of the extent of operations in the area in low visibility conditions due to weather or other factors such as smoke and haze. Pilots operating in these conditions are required to exercise caution and allow for minimum height and visibility conditions.

2.6.1 IFR Operations

Aircraft operating under IFR rules in the vicinity of the Stockyard Hill Wind Farm are required to maintain a minimum altitude of 4100 ft (1250m). IFR operations are not dependent on visual contact for navigation; i.e. in the case of operations at night or low visibility near wind farms, they are not dependent on visual contact (obstacle lighting) for avoidance action. The cause of collision with a wind turbine for aircraft operating under IFR conditions would most likely be due to pilot error or aircraft failure.

Stockyard Hill Wind Farm is located beneath several PTO air routes – but the number of these operations is estimated to be not more than 8 – 10 per night. Non-PTO IFR operations are

assessed at approximately 3 per night. The majority of these would be at high level and the "exposure" of these operations to the wind farm would be significantly less.

Following discussions with local airports and operators, the number of IFR operations at night in vicinity of the Stockyard Hill Wind Farm is assessed at approximately 13 per night for IFR operations and approximately 2 – 3 per night for VFR operations. Adopting a conservative approach, it is suggested this be increased to 5 per night for VFR operations. Tables F-2 and F-3 below assess the extent of night IFR and night VFR operations in the vicinity of the wind farm.

Characteristic	*Comments*	*Results*
Number of IFR operations in the vicinity of the wind farms at night	Based on discussions with local airports and operators, night operations would be minimal. Allow 13 flights per night.	Assume 13 operations at night
Duration of aircraft in the area of the wind farm at night	Allow 10 mins to overfly the wind farm (i.e. "exposure" to wind farm)	Total time in the vicinity of the wind farm per annum approx. 790 hrs per annum

Table F-2. IFR Operations in the vicinity of Stockyard Hill Wind Farm

2.6.2 VFR Operations

Characteristic	*Comment*	*Results*
Number of VFR operations in the vicinity of the wind farms at night	Based on discussions with local airports and operators, night operations in the vicinity of the wind farm would be minimal. Allow 5 flights per night.	Assume 5 operations at night
Duration of aircraft in the area of the wind farm at night	Allow 15 mins to overfly the wind farm	Total time in the vicinity of the wind farm per annum approx. 456 hrs per annum

Table F-3. VFR Operations in the vicinity of Stockyard Hill Wind Farm

3. MILITARY OPERATIONS

The Stockyard Hill Wind Farm area is not a regular training or operational area for military flying; however, the RAAF may conduct occasional low level military operations in the vicinity. As the proposed wind farm development will be classified as a "Tall Structure", location and height details are to be provided to the RAAF to enable inclusion in relevant aeronautical charts and data bases. This information is to be provided prior to commencement of construction and confirmed after construction is complete.

4. WIND FARM ACCIDENTS

A review has been made of wind farm accidents, particularly those relating to or involving aviation activities. The Caithness Wind Farm Information Forum provides regular statistics on wind farm accidents, which provides some interesting information insofar as aviation accidents are concerned. It is believed that aircraft accidents involving wind farms would attract considerable attention, yet the following summary appears to indicate very few aviation-related accidents over the 35 year period.

WIND FARM ACCIDENTS - AVIATION RELATED

The Caithness Windfarm Information Forum maintains a global data base on wind farm accidents. This database, which commenced in 1975, has recorded a total of 652 accidents to 30 June 2009. Over this period of nearly 35 years, six (6) of these accidents were aviation related as follows:

- USA 2000. A small aircraft with four people on board flew into a wind turbine in fog; i.e. a breach of regulations.
- USA 2000. Pilot flying in wind farm and power line area, hit power lines. Report indicates that the aircraft "should not have been operating in the area"; i.e. a breach of regulations.
- USA 2005. Crop duster hit an anemometer mast guy wire. Anemometer mast had only recently been installed and had not been notified to the authorities.
- UK 2008. Paraglider had a "near miss" and crashed into wind farm site.
- Germany 2000. Parachutist missed the drop zone by 4km and drifted into a wind turbine.
- USA 2008. Helicopter stringing powerlines to wind farm crashed from wind gust; i.e. an aviation related accident but not relevant to aircraft collision with wind farms.

The data base, which can be viewed at www.caithnesswindfarms.co.uk, has limited information on causes of accidents, but it appears that each of these aviation related accidents was the result of human error and was not related to the existence or otherwise of obstacle lighting.

5. SUMMARY - EXTENT OF NIGHT OPERATIONS IN THE VICINITY OF STOCKYARD HILL WIND FARM

In summary, this paper has attempted to assess the extent of aircraft operating at night in the vicinity of Stockyard Hill Wind Farm and has determined that:

- The number of VFR aircraft operations at night in the vicinity of the wind farm is considered to be low at approximately 20 - 30 operations per week. Allowing for an aircraft to overfly the wind farm in 10 - 15 minutes this would result in a total "exposure" to, or transit time over, the wind farm of approximately 456 hours per annum. The majority of these operations are likely to be at altitudes well in excess of the highest turbine at Stockyard Hill Wind Farm; and

- The number of IFR aircraft operations at night in the vicinity of the wind farm is considered to be low at approximately 90 - 100 operations per week. Allowing for an aircraft to overfly the wind farm in 5 - 10 minutes this would result in a total "exposure" to, or transit time over, the wind farm of approximately 790 hours per annum. The majority of these operations are likely to be at altitudes well in excess of the highest turbine at Stockyard Hill Wind Farm.

APPENDIX G

Night Operations in Vicinity of Stockyard Hill Wind Farm

APPENDIX G

Night VFR Flights: 30km vicinity of Stockyard Hill Wind Farm site – July 2009

Airport	*Approx Distance to Wind Farm*	*Operators Contacts*	*Total number of "Night VRF Flights" per week*	*Operations*	*Aircraft Type*
Ballarat	32.5 km East	STATA Field Air	Currently approx. 10 per week, which will increase over next 12 months to up to 20 per week. Mainly circuit training (north of Ballarat) and some cross country navigational night VFR flights. No Gliding or Paragliding in this area	Flight Training RFDS & Air Ambulance - IFR	Cessna 172's Piper Seneca's Piper Arrow's
Ararat	25km WNW	Airport Manager	Currently the occasional Air Ambulance. Soon to be used by STATA for night flights, mainly circuit training	Flight Training RFDS & Air Ambulance - IFR	Cessna 172's Piper Seneca's Piper Arrow's
Raglan - Private	15km North		Privately owned aircraft Day VFR only		Various
Bacchus Marsh	94km ESE	Bacchus Marsh School of Aviation	Approx 10 night flights per month. Only a few would be cross-country navigational night VFR.	Flight Training	Cessna 172's Piper Seneca's Piper Arrow's
Trawalla - Private	3km NE		Not equipped for night operations		

Discussions with operators at Ballarat and Ararat indicated that they did not believe there would be a great amount of night VFR operations over the Stockyard Hill Wind Farm area at night. The wind farm is sited to the south of the main route between Ballarat and Ararat. In addition, it was indicated that the presence of high terrain (particularly Mt Buangor and Mt Langhi Ghiran) between Ballarat and Ararat, which are significantly higher than the wind turbines, requires pilots operating at night to fly at a sufficient height to clear these higher terrain points. Night operations in the area of the wind farm are likely to be at altitudes well in excess of the highest turbines.

For the purpose of this study, it is suggested allow for up to 5 VFR operations per night in the vicinity of the wind farm.

APPENDIX H

Bibliography

APPENDIX H

Bibliography

Aeronautical Information Circular 45/08, November 2008, NAV Canada.

Aeronautical Impact Assessment, December 2008, Stockyard Hill Wind Farm, The Ambidji Group Pty Ltd.

Airspace Restrictions, Danger Areas and Hazards to Flight, January 2007, ENR 1-1-5-1, Civil Aviation Authority, United Kingdom.

General Administrative Regulation for the Marking and Lighting of Obstacles to Air Navigation, May 2007, German Aviation Regulation.

Guidance on Environmental Considerations for Offshore Wind Farm Development, OSPAR Convention for the Protection of the Marine Environments of the North-East Atlantic, Ref. No. 2008-3.

ICAO Annex 14 (Aerodromes), International Civil Aviation Organisation

Lighting and Marking of Wind Farm Turbines, May 2006, Civil Aviation Authority of New Zealand.

Obstacle Marking of Wind Turbines, October 2005, International Energy Association, 46th Topical Expert Meeting, Stockholm, Sweden.

Obstacle Limitations and Markings Outside of Aerodrome or Heliport, Document SA-CATS-AH, Department of Transport, South Africa.

Obstacle Marking and Lighting of Wind Farms, July 2007, Advisory Circular AC139-18(0), Civil Aviation Safety Authority, Australia, (Withdrawn September 2008).

Obstacle Marking and Lighting, June 2007, Group of Aerodrome Safety Regulators, Europe, Document WP 109.

Obstacle Marking and Lighting Evaluation, December 2008, Stockyard Hill Wind Farm, The Ambidji Group Pty Ltd.

Obstruction Marking and Lighting, January 2007, Advisory Circular AC70/7460-1K, US Department of Transportation, Federal Aviation Administration.

Offshore Wind Farms Conspicuity Requirements Advisory Material for the Protection of Air and Marine Navigation Safety, August 2002, Operations Advisory Memorandum, Irish Aviation Authority.

Policy and Guidelines on Wind Turbines, February 2009, CAP764, Civil Aviation Authority, United Kingdom.

Regulations for placing aviation obstacle signals and lights, Civil Aviation Act 32, Taiwan Civil Aeronautical Administration.

Reporting of Tall Structures, April 2005, Advisory Circular AC139-08(0), Civil Aviation Safety Authority, Australia.

Safeguards for Airports and the Communities around them, July 2009, Discussion Paper, Department of Infrastructure, Transport, Regional Development and Local Government.

Statutory Instrument No.423 of 1999, En Route Obstacles to Air Navigation, Irish Aviation Authority.

Visual Flight Rules Guide, Civil Aviation Safety Authority, V2, July 2007

Windturbine and Windfarm Lighting, CAR 621.19 Advisory Circular 1/06, (Draft) Transport Canada.

APPENDIX I

Glossary of Terms and Abbreviations

APPENDIX I

GLOSSARY OF TERMS and ABBREVIATIONS

Abbreviations used in this report, and the meanings assigned to them for the purposes of this report are detailed in the following table:

Abbreviation	Meaning
AC	Advisory Circular (document support CAR 1998)
ACFT	Aircraft
AD	Aerodrome
AGL	Above Ground Level
AHD	Australian Height Datum
AHT	Aircraft height
AIP	Aeronautical Information Publication
AIRPORTS ACT	Airports Act 1996, as amended
AIS	Aeronautical Information Service
ALT	Altitude
AMSL	Above Minimum Sea Level
A(POFA)R	Airports (Protection of Airspace) Regulations, 1996 as amended
APARs	Airports (Protection of Airspace) Regulations, 1996 as amended
ARP	Aerodrome Reference Point
AsA	Airservices Australia
ATC	Air Traffic Control(ler)
ATM	Air Traffic Management
CAO	Civil Aviation Order
CAR	Civil Aviation Regulation
CASA	Civil Aviation Safety Authority
CASR	Civil Aviation Safety Regulation
Cat	Category
DACR	Defence Area Control Regulations
DAP	Departure and Approach Procedures (charts published by AsA)
DER	Departure End of (the) Runway
DEVELMT	Development
DME	Distance Measuring Equipment
Doc nn	ICAO Document Number nn
DITRDLG	Department of Infrastructure, Transport, Regional Development and Local Government. Also called “Infrastructure”. (Formerly Department of Transport and Regional Services (DoTARS))
DOTARS	See DITRDLG above
ELEV	Elevation (above mean sea level)

Abbreviation	Meaning
ERSA	Enroute Supplement Australia
FAF	Final Approach Fix
FAP	Final Approach Point
ft	feet
GNSS	Global Navigation Satellite System
GP	Glide Path
IAS	Indicated Airspeed
ICAO	International Civil Aviation Organisation
IHS	Inner Horizontal Surface, an Obstacle Limitation Surface
ILS	Instrument Landing System
ISA	International Standard Atmosphere
km	kilometres
kt	Knot (one nautical mile per hour)
LAT	Latitude
LLZ	Localizer
LONG	Longitude
m	metres
MAPt	Missed Approach Point
MDA	Minimum Descent Altitude
MGA94	Map Grid Australia 1994
MOC	Minimum Obstacle Clearance
MOS	Manual of Standards, published by CASA
MSA	Minimum Sector Altitude
MVA	Minimum Vector Altitude
NDB	Non Directional Beacon
NM	Nautical Mile (= 1.852 km)
nnDME	Distance from the DME (in nautical miles)
NNE	North North East
NOTAM	NOtice To AirMen
OAS	Obstacle Assessment Surface
OCA	Obstacle Clearance Altitude
OCH	Obstacle Clearance Height
OHS	Outer Horizontal Surface
OIS	Obstacle Identification Surface
OLS	Obstacle Limitation Surface
PANS-OPS	Procedures for Air Navigation Services – Operations, ICAO Doc 8168
PRM	Precision Runway Monitor
PTO	Passenger Transport Operation
QNH	An altimeter setting relative to height above mean sea level
REF	Reference
RL	Relative Level

Abbreviation	Meaning
RNAV	aRea NAVigation
RNP	Required Navigation Performance
RPA	Rules and Practices for Aerodromes — replaced by the MOS Part 139 — Aerodromes
RPT	Regular Public Transport
RWY	Runway
SACL	Sydney Airport Corporation Limited
SFC	Surface
SID	Standard Instrument Departure
SOC	Start Of Climb
STAR	Standard ARrival
TAR	Terminal Approach Radar
TAS	True AirSpeed
THR	Threshold (Runway)
TNA	Turn Altitude
TODA	Take-Off Distance Available
V_n	aircraft critical Velocity reference
VOR	Very high frequency Omni directional Range
WAC	World Aeronautical Chart