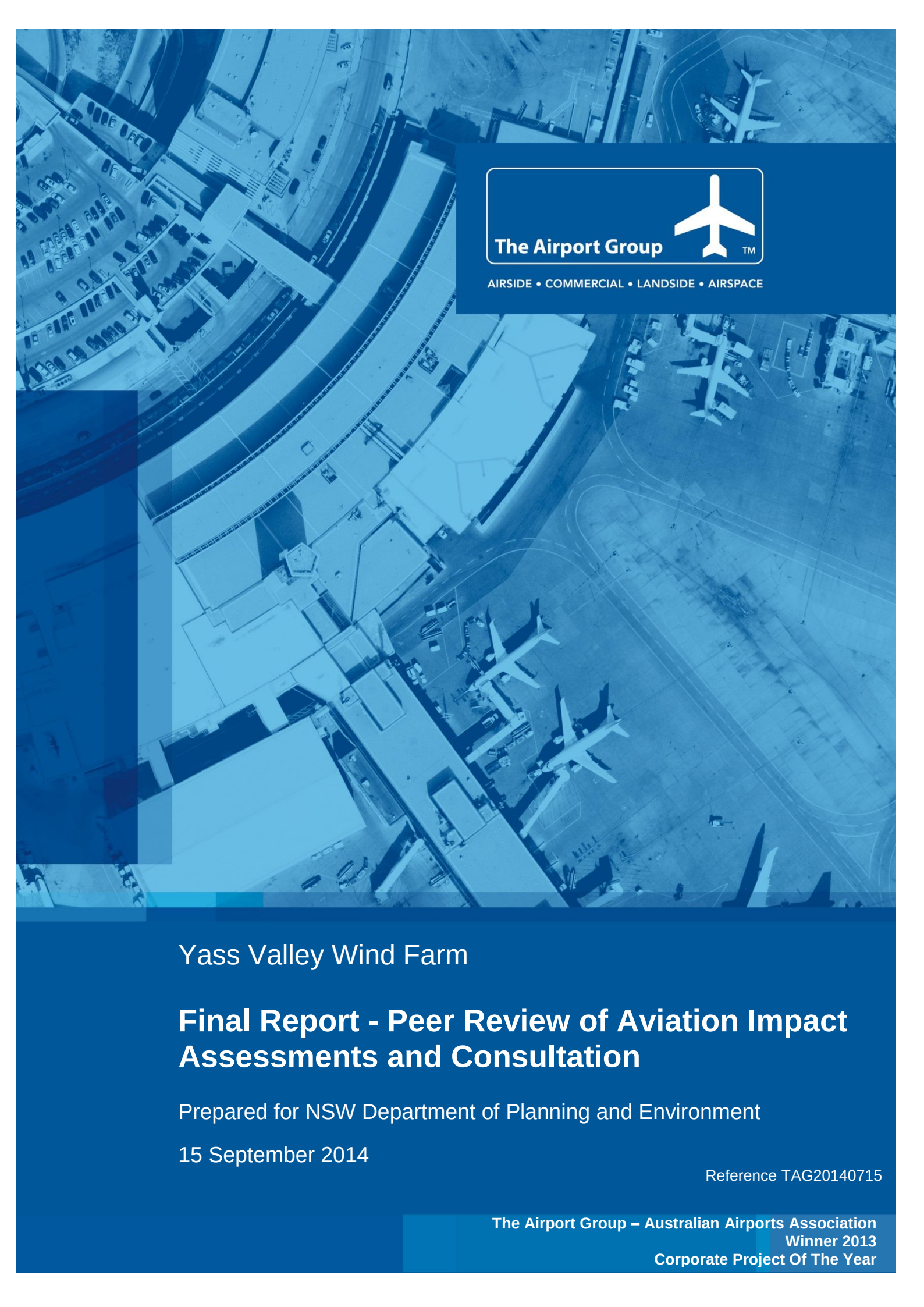




The Airport Group



AIRSIDE • COMMERCIAL • LANDSIDE • AIRSPACE

Yass Valley Wind Farm

Final Report - Peer Review of Aviation Impact Assessments and Consultation

Prepared for NSW Department of Planning and Environment

15 September 2014

Reference TAG20140715

The Airport Group – Australian Airports Association
Winner 2013
Corporate Project Of The Year

DOCUMENT VERSION LISTING

Version	Version Description	Changes/ Actions	Staff	Date
1.0	Initial Draft	Preparation of Draft Report	JN/CT/MF	25 August 2014
2.1	Final Report – Draft	Preparation of Final Report	MF	29 August 2014
2.2	Final Report	Update Final Draft Comments and review of entire document	JN/CT/MT	3 September 2014
2.3	Final Report	Final Amendments	CT/MT	15 September 2014

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1. EXECUTIVE SUMMARY

The Airport Group (TAG) has been engaged to undertake an Independent Peer Review on the quality of the Yass Valley Wind Farm Environmental Assessment (YVWFEA) (EPURON November 2009) and the draft Response to Submissions/Preferred Project Report (RtS) (May 2014) with particular attention to the documentation provided by the NSW Department of Planning and Environment (the Department) in relation to the Director-General's requirements, guidelines regarding *draft NSW planning guidelines wind farms* and industry standards and legislation. TAG was also engaged to perform a consultation, on aviation matters only, with airport/airstrip owners within the vicinity of the wind farm. This consultation has been completed and documented within this report. As per the Department's brief, TAG has also provided recommendations and on the Peer Review and Consultation process and information contained within the reviewed documents.

TAG can confirm that there is no conflict of interest with TAG performing these services for the Department. The peer review involves an impartial and independent assessment and review of the document in its entirety by independent, qualified experts.

For the purposes of this review, independent means independent from stakeholders in the Yass Valley Wind Farm including those from the Department, Epuron (the proponent) and Ambidji.

The peer review performed by TAG has included and documented the outcomes of the review on the following:

- The Proponent's Aviation Impact Assessment;
- Suitability of how stakeholders and community issues were addressed in the YVWFEA;
- Suitability of the proposed mitigation, management and/or any protection measures;
- Changes required for acceptability of the project regarding aerial agricultural spraying; and
- Guidance (broad) with respect to the management of risks to aviation safety resulting from wind farms e.g. spraying and turbulence.

Although TAG has completed the Independent Peer Review and the additional Consultation Process, there are a number of areas which will either require additional assessment, consultation or clarification including:

- Discrepancies identified in the methodology or assessment rationale used to perform the previous reviews; and
- The current 2009 legislative guidelines which TAG believes do not provide appropriate guidance appropriate to wind farm assessments.

This makes the assessments of wind farms in the real world extremely difficult and requires further discussion.

In summary, the following findings have been documented in detail later in this report:

- Whilst the Aeronautical Impact Assessment, prepared by Ambidji on 25 November 2010, included all the recommended assessments and satisfies departmental and legislation guidelines, information that has come to light after the preparation of the Ambidji report should now be included in the assessment.
- TAG does not agree with all the methodologies used and how the subsequent value of these results were attained;
- TAG found the consultation process and results by Ambidji was not accurate enough including missing information supplied to the owners of airstrips, non-effective communication methods used with the owners of air strips and not all air strip owners were consulted;
- Legislative guidelines require some updating; and
- A total of twelve landowners/stakeholders were spoken to directly either in person or via telephone. Owners of airstrips, are not satisfied and are still objecting to the development with

the only resolution of either purchasing their land, assurances that agricultural aviation activities will not be impacted, compensation, recommencement of the application including reviewing all information or not permitting the development to go ahead. Minutes of the discussions were taken and attached in the Appendix.

2. BACKGROUND

The Department has requested this Independent Peer Review be undertaken by TAG. As stated in the Executive Summary, there is no conflict of interest with TAG conducting this independent peer review as TAG has had no prior contact with the Department, the proponent or Ambidji in regard to the proposed YVWFEA. TAG remains completely impartial to the outcome of the Peer Review and the Consultation Process undertaken to the development proposed.

The National Airports Safeguarding Advisory Group (NASAG) is comprised of high level Commonwealth, State and Territory officials to develop a national land use planning regime that applies to airports. NASAG has created guidelines about managing the risk to aviation safety of wind turbine installations. These guidelines were last amended in July 2012 and remain current.

Airservices Australia (AsA) is the Air Navigation Service Provider (ANSP) for Australia. Inevitably AsA will be required to undertake an assessment of any proposed wind farm. In order to lower time constraints which are involved in undertaking such a review, AsA has insisted that all wind farm proposals must include an Aviation Impact Statement (AIS) that is prepared by an aeronautical consultant in accordance with set criteria. This information is current as at 13 February 2014 and is attached to the report as Appendix.

Ambidji is an aeronautical consultant and prepared the Aeronautical Impact Assessment Obstacle Lighting Review and Qualitative Risk Assessment in November 2010.

The Aviation Navigation Services Assessment Coppabella Hills was prepared in May 2009 and the Aviation Navigation Services Assessment Marilba Hills also in May 2009.

The Draft Response to Submissions/Preferred Project Report was prepared by Epuron Pty Ltd in May 2014.

Additional literature and guidelines TAG considered and referred to during the peer review were:

- Man Made Obstacles Located Away From Aerodromes Risk Review, November 2009;
- Eurocontrol Guidelines on How to Assess the Potential Impact of Wind Turbines on Surveillance Sensors;
- ICAO Doc 8168 Vol II Procedures for Air Navigation Services – Aircraft Operations – Construction of Visual and Instrument Flight Procedures;
- NSW Wind Farm Guidelines December 2011;
- ICAO Annex 10;
- Manual of Standards (MOS) Part 139 - Aerodromes;
- MOS Part 171 – Aeronautical Telecommunication and Radio Navigation Services; and
- Airservices Australia Wind Farm Aviation Study – 13 February 2014 e

TAG was also engaged to assess how the community and stakeholder issues were addressed with a consultation process to be undertaken by TAG. TAG has performed both Stage 1; which was to contact all 23 owners, and also Stage 2; which was to meet face to face with any of the 23 owners of airfields who have specific issues to be discussed. All of the contact and meetings have been documented in detail later in this report.

The Department also required TAG to provide recommendations on the findings of both the peer review and also the consultation process.

3. PEER REVIEW

3.1. Methodology and Objectives

The purpose of this peer review is to examine the following documentation including methodologies undertaken by Ambidji in relation to aviation activities only. The following documentation was included in the peer review performed by TAG and supplied by the Department:

- Telecommunications and Aviation Navigation Services Assessment Coppabella Hills (May 2009);
- Telecommunications and Aviation Navigation Services Assessment Marilba Hills (May 2009);
- Aeronautical Impact Assessment Obstacle Lighting Review and Qualitative Risk Assessment by Ambidji (25 November 2010); and
- Draft Response to Submissions/Preferred Project Report (RtS) (May 2014).

TAG reviewed and assessed all the information supplied in relation to aerial agricultural work and turbulence in the vicinity of the proposed YVWFEA. TAG considered other relevant aviation matters as they arose and these have also been identified.

It should be noted that the Airservices Australia Wind Farm Aviation Study TAG reviewed was not supplied to Ambidji at the time they performed their assessment.

The methodology adopted by TAG included reviewing each document, noting the process followed by others in determining each finding including consultation, identification of specific items such as navigation aids, air routes and aerodromes, impacts upon aviation activities and positioning and heights of obstacles.

TAG's understanding of the objectives with regards to aviation specific activities was to include the following:

- Determine whether the information contained in the documents could withstand scrutiny within an administrative process;
- Review the suitability of the consultation process undertaken including stakeholder and community issues addressed, managed, mitigated or protected; and
- Provide broad guidance to the Department in relation to the management of risks to aviation safety resulting from wind farms.

3.2. Assumptions and Limitations

All assumptions identified in the Ambidji report remain.

The peer review by TAG is limited to purely aviation specific matters. It does not address the affects wind turbines may have operationally such as turbulence calculation.

TAG does not possess the legal expertise to advise on legislative matters. For the purposes of this report, issues that have been identified with regard to these matters may require supplementary action by others with the relevant expertise.

3.3. Analysis

3.3.1. Desktop Review – Aviation Impact Statement

A desktop review of the documents was completed in accordance with the relevant policies and procedures available and current at the time of the review.

The following table was completed and has been provided to show whether relative points were included in the AIS completed by Ambidji. This table does not determine the suitability of the content or findings.

Description Point	Included
Obstacles – Co-ordinates in WGS84 (to 0.1 second of arc or better)	Yes / No
Obstacles – Elevations AMSL (to 0.3m)	Yes / No
Drawings – Overlayed on topographical base not less than 1:250,000. Details of datum and level of charting accuracy to be noted	Yes / No
Drawings – Electronic format compatible with Microstation version 8i.	Yes / No
Aerodromes – Specify all registered/certified aerodromes that are located within 30nm (55.56km) from any obstacle referred to above.	Yes / No
Aerodromes – Nominate all instrument approach and landing procedures at these aerodromes.	Yes / No
Aerodromes – Confirmation that the obstacles do not penetrate Annex 14 or OLS for any aerodrome. If an obstacle does penetrate, specify the extent.	Yes / No
Air Routes – Nominate air routes published in ERC-L & ERC-H which are located near/over any obstacle referred to above.	Yes / No
Air Routes – Specify two waypoint names located on the routes which are located before and after the obstacles.	Yes / No
Airspace – Airspace classification – A, B, C, D, E, G etc. where the obstacles are located.	Yes / No
Navigation Aids – Possible impact on navigation aids	Yes / No
Navigation Aids – Possible impact on RADAR	Yes / No
Contingency Procedures – Engine Inoperative	Yes / No
Impact on Military Activity	Yes / No

Description Point	Included
Obstacle Lighting & Reporting of Tall Structures	Yes / No
Consultation	Yes / No
Findings/Recommendations	Yes / No
Qualitative Risk Assessment	Yes / No

Table 3-1: Desktop Review of Ambidji Group Aviation Impact Statement

For all items which were not satisfied (No in above table) within the Ambidji AIS, the following table details what should have been included:

Description Point	Comment
Drawings – Electronic format compatible with Microstation version 8i.	This information will be required for assessment by Airservices. It is preferable to have when reviewing information. However, the listing of the position and height of each turbine mitigates the need as essential.
Aerodromes – Nominate all instrument approach and landing procedures at these aerodromes.	The report does not list the instrument flight procedures for each aerodrome. However, there is an assessment of the 25nm MSA which is the only applicable to PANS-OPS surfaces.
Air Routes – Nominate air routes published in ERC-L & ERC-H which are located near/over any obstacle referred to above.	The reports do not identify specific routes and provides a general overview statement. Whilst the result is agreeable, the identification of the routes could cause unnecessary delay at AsA.
Air Routes – Specify two waypoint names located on the routes which are located before and after the obstacles.	The listing of waypoint locations reduces the area of assessment and assures that obstacles are being placed in the correct location. The report does detail the location of the WTGs but not route waypoints.
Airspace – Airspace classification – A, B, C, D, E, G etc. where the obstacles are located.	Although not stated, the information in the document provides elevations for the obstacles (maximum elevation 3185ft AMSL) and identifies within diagrams, the lower levels of controlled airspace i.e. 8500ft. It is shown that the turbines are located in Class G airspace however there is no statement.

Table 3-2 Items to be Included in AIS for AsA review

From the information contained within the Ambidji report there is sufficient information to draw similar conclusions, findings or recommendations.

As a desktop exercise the Aeronautical Impact Assessment Obstacle Lighting Review & Qualitative Risk Assessment completed by Ambidji does appear to comply with the provisions of current legislation and policy.

A similar review was completed with the Telecommunications and Aviation Navigation Services Assessment Yass Valley Wind Farm – Coppabella Hills Precinct and Marilba Hills Precinct – May 2009. Section 7 of both documents relate to Aircraft Navigation Systems and identify the issue of possible radar interference.

The Executive Summary in each report states “... *it is considered that the wind farm would have minimal effect on telecommunications services.*” However the report does not identify any navigation aids that aircraft could utilise. The reports are based on radio communication to and from the aircraft and not all types of navigation aids that aircraft may use when flying.

The analysis of Aircraft Navigation Systems may require further clarification.

Airservices Australia Wind Farm Aviation Study does not directly specify the identification of any type of navigation aids and only includes radar assessment.

Navigation aids such as a Non-Directional Beacon (NDB), Localiser (LOC) or VHF Omni-directional Range (VOR) omit a signal that can be affected by obstacles. Examples can be seen on published instrument approach and landing procedure plates such as YCKN NDB RWY 29 procedure at Cooktown. The fluctuations are attributed to terrain which is located approximately 4.5nm away from the aerodrome.

No information was located which identified an assessment of navigation aid signals.

As a desktop exercise the Telecommunications and Aviation Navigation Services Assessment for Coppabella Hills Precinct and Marilba Hills Precinct – May 2009, does comply with the provisions of current legislation and policy within the scope identified in each report.

3.3.2. NASAG Guidelines & AsA Aviation Study

3.3.2.1. Area of Identification – 30km or 30nm

The National Airports Safeguarding Advisory Group (NASAG) is comprised of high level Commonwealth, State and Territory official to develop a national land use planning regime that applies to airports. NASAG has created guidelines about managing the risk to aviation safety of wind turbine installations. The document was last amended in July 2012 and remains current.

Airservices Australia (AsA) is the Air Navigation Service Provider (ANSP) for Australia. Inevitably AsA will be required to undertake an assessment of any proposed wind farm. In order to lower time constraints AsA has insisted that all wind farm proposals must include an Aviation Impact Statement (AIS) that is prepared by an aeronautical consultant in accordance with set criteria. This information is current as at 13 February 2014 (updated from March 2012) and is attached to the report in the Appendix.

A noticeable difference between the NASAG guidelines July 2012 and AsA AIS guidelines for set criteria March 2012 is that the NASAG guidelines provides “*When wind turbines over 150 metres above ground level are to be built within 30 kms of a certified or registered aerodrome, the proponent should notify the Civil Aviation Safety Authority (CASA) and Airservices. If the wind farm is within 30km of a military aerodrome, Defence should be notified.*”

Airservices AIS guidelines for set criteria extends this area regarding aerodromes and stipulates that the AIS must provide a detailed analysis covering as a minimum:

- *'Specify all registered/certified aerodromes that are located within 30nm (55.56km) from any obstacle referred to in the wind farm;*
- *Nominate all instrument approach and landing procedures at these aerodromes; and*
- *Confirmation that the obstacles do not penetrate Annex 14 or OLS for any aerodrome. If an obstacle does penetrate, specify the extent.'*

For the purposes of developing or reviewing instrument flight procedures in Australia, obstacles located within 30nm (55.56km) of an aerodrome are considered. This distance is comprised of the 25nm distance from the set point such as a navigation aid or aerodrome reference point (ARP) plus a 5nm buffer. This buffer value is in accordance with ICAO criteria and as such covers a larger area than the 30km (16.2nm) specified by NASAG.

The NASAG guidelines does mention requirements placed upon certain aerodrome operators notifying CASA if they become aware of any developments that will create an obstacle to aviation or will infringe the OLS or PANS-OPS surfaces. It is assumed that the guidelines take into account instrument approach and landing procedures or the OLS for a specific type of aerodrome but fails to recognise that PANS-OPS surfaces commence 25nm from the aerodrome.

Furthermore, in Australia, only certified or registered aerodromes are qualified to have instrument flight procedures (IFPs). These include instrument approach and landing procedures and instrument departures. The requirement for monitoring and reporting obstacles is a main reason why CASA added this element when designing and publishing IFPs.

Unregistered aerodromes including an Aircraft Landing Area (ALA) will not have an instrument flight procedure designed and published for that location and rely upon visual navigation for landings and departures. There are protection areas for these locations listed in MOS Part 139 Chapter 7 – Obstacle Restriction and Limitation and guidelines in CAAP 92-1.

Additionally, operators do not have to report obstacles which may affect IFPs to a Part 173 provider (Part 173 – Design of Instrument Flight Procedures). The OLS may extend up to 15km from a runway end (which leads to the 30km from both ends but this does not include the runway length).

The difference in area between NASAG (30km) and AsA (30nm = 55.56km) is almost doubled (85.2% larger). However, this provides for:

- Early identification of nearby certified or registered aerodromes;
- Early identification of other types of aerodromes i.e. Uncertified/unregistered;
- Immediate consultation with aerodrome owners;
- Confirmation of the extent of the OLS for aerodromes; and
- Consultation with agricultural pilots and nearby unlicensed airstrip owners.

The above points complete 75% of the issues identified within the NASAG guidelines for Consultation. The remaining issues are:

- Preliminary assessment by an aviation consultant of potential issues;
- Registration of all wind monitoring towers on the RAAF AIS database;
- Consultation with CASA and Airservices.

3.3.2.2. Communication, Navigation and Surveillance (CNS)

NASAG and AsA guidelines identify the potential impacts wind farms may have on aviation communications, navigation and surveillance facilities. However, AsA as part of the wind farm aviation study only outlines radar and references guidelines set out within a Eurocontrol document. This may be an oversight or there may be an assumption that since radar has been identified, other means of air navigation will also be included and this is not always the case.

MOS Part 171 – Aeronautical Telecommunication and Radio Navigation Services provides the following list which classifies the kinds of facilities used for the provision of aeronautical telecommunication and radio navigation services. This list is extensive by comparison to the information contained in the NASAG and AsA documents.

- 1) VHF air/ground voice communication facilities;
- 2) HF air/ground voice communication facilities;
- 3) UHF air/ground voice communication facilities;
- 4) Precision approach radio navigation aids;
- 5) Instrument Landing System facilities;
- 6) Non-precision radio navigation aids;
- 7) Distance Measuring Equipment;
- 8) VHF Omni-range (VOR) facilities;
- 9) Non-directional beacons (NDB);
- 10) Flight data processing facilities;
- 11) Flight information facilities;
- 12) Radar data processing facilities;
- 13) Primary surveillance radar facilities;
- 14) Secondary surveillance radar facilities;
- 15) Surface movement radar facilities;
- 16) Precision runway monitor facilities;
- 17) Automatic dependent surveillance system facilities;
- 18) Voice switching and control facilities;
- 19) ATS point to point communication facilities;
- 20) Air/ground data links;
- 21) Ground to ground data interchange networks;
- 22) Human Machine Interface systems, including Tower Consoles, ATS Work Stations, and Display facilities;
- 23) Uninterruptable and emergency power supplies;
- 24) Essential services in buildings and in equipment shelters housing facilities (electrical power supplies, air-conditioning, and security facilities);
- 25) Global Navigation Satellite System ground based augmentation stations or facilities;
- 26) Aeronautical databases used in or by a facility;
- 27) Meteorological Display Systems used for ATS;
- 28) Voice and Data Recording facilities; and
- 29) Any other facilities supporting ATS provided under Part 172.

The identification of navigation aids including radar facilities should be nominated and included with aerodromes and airstrips.

3.3.2.3. Navigation Aid Identification and Assessment

MOS Part 139 – Aerodromes (MOS 139) in relation to navigation aid facilities states that these facilities are not to be compared with radio, television or mobile radio facilities. Although there appears to be separate assessments completed in relation to radar interference that resulted in similar findings, only Ambidji followed up with potential impact on navigation aids. **This does support the separation of the comparison between the navigation aid facilities.**

Not all navigation aids are located at aerodromes. For example Rugby NDB or Wee Jasper VOR and NDB are not located at aerodromes but are used for aircraft navigation purposes.

Navigation aids are operated/maintained by Airservices (as the only Part 171 provider in Australia) or Defence. However not all of these navigation aids are owned by these agencies. For example, Kingaroy NDB is owned by the local council, Macarthur River Mine NDB is owned by the mine. Therefore more than one party may have a vested interest in the operation of a navigation aid. This information should be available from the aerodrome operator or Airservices.

MOS 139 – Aerodromes; Chapter 11 details the requirements for siting navigation aids, including clearance planes for existing facilities. They include specified siting requirements and the dimensions of restricted areas around the sites to ensure that radio transmissions are not unacceptably affected by other aerodrome infrastructure, buildings, hangars, vehicles, personnel or other obstacles.

Given the title of the document and the location of reference (Aerodromes), the specification within that Chapter relate to areas ‘on-field’ or ‘in the immediate vicinity’ and **has been adequately addressed in the report completed by Ambidji (Section 3.10 Potential Impact on Navigation Aids).**

The reports **do not include** possible interference from obstacles away from the areas listed in MOS 139. As mentioned towards the conclusion of section 3.3.1 of this report, obstacles including terrain can interfere with radio navigation services. It does not result in a particular facility being unserviceable, however the function of the facility may be degraded in some instances but remain acceptable for operational use.

The following diagram displays the clearance plane detailed in MOS 139 and assessed as part of the Ambidji report.

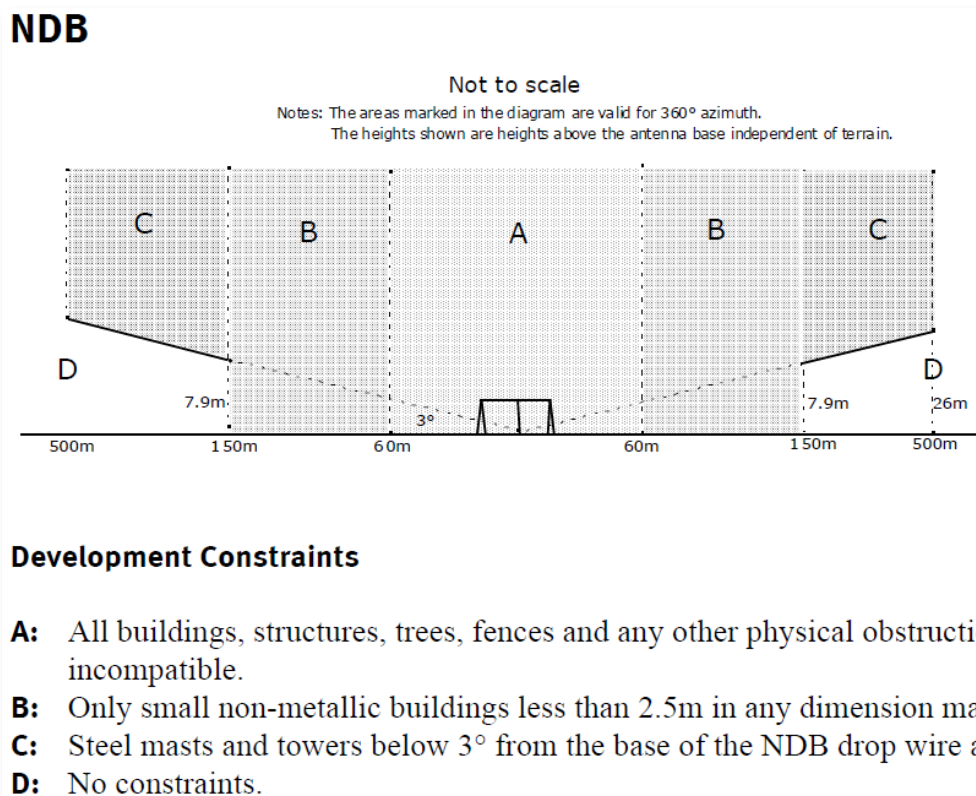


Figure 3-1 Development Constraints NDB as per MOS Part 139

Although the diagram identifies an area up to 500m from the NDB, there is no instruction about what happens after that distance. Point D is located under the plane, however it is not included in the area beside Point C.

Taking into account that the assumed navigation aid is located on the aerodrome, it is reasonable to assume that the 3° slope should continue out to a distance of range of the nav aid. This provides an increased height of 97m for each nautical mile and is based on the elevation of the navigation aid. As

wind turbines are located on ridges or areas of higher elevation, the total obstacle height at each point (turbine) and the elevation of the navigation aid should be considered.

Annex 10 – Aeronautical Communications provides assessment of signals ranging from 0.5° to 5° (excluding radar). There are no defined amounts for assessing against wind turbines however given the aforementioned information TAG recommends a nominal assessment surface of 3° (5.24%) be established in assessing navigation aid interference.

Navigation aids, particularly NDBs, have a published range which can be located in the En Route Supplement Australia (ERSA). The range can vary from 15nm to 200nm and forms part of the flight planning as to when a pilot may receive a signal to use that navigation aid. Furthermore pilots can use navigation aids whilst all phases of flight; departure, enroute and approach.

By providing a consistent area of assessment such as 30nm and utilising a 3° slope from the navigation aid site, the results is an increase in elevation of more than 2900m. This distance should be a sufficient area in order to conduct an assessment regarding the possible interference on a navigation aid. There may be cases where the signal may be interfered with based on this calculation and it is supported by the MOS that such interference may not degrade the signal where it has to be removed. Once identified, the issue will be reviewed by Airservices as the Part 171 Provider at the appropriate time to determine the full impact on the navigation aid.

3.3.2.4. Radar

Radar coverage in Australia is largely limited to what is referred to as the “J-Curve”. It commences on the east coast and runs from Cairns to Brisbane, Sydney, Melbourne and Adelaide. Other radar areas include Perth and Darwin. Automatic Dependent Surveillance – Broadcast (ADS-B) is another form of surveillance and relies upon other equipment on board aircraft to track them in a radar like environment.

In Australia, aircraft operating above FL290 are able to utilise the ADS-B where radar coverage is not available. In other cases, separation based on procedural separation is required. This standard of separation is based upon position reports of the aircraft made by the pilots providing the time the aircraft was at one point, the estimated time it will be at the next reporting point and a level (altitude) of the aircraft. Procedural separation does not rely upon radar return to confirm position and altitude.

The following diagrams which are taken from Airservices website identify the ‘J-Curve’ and various ADS-B sites. Radar coverage is pictured in red.

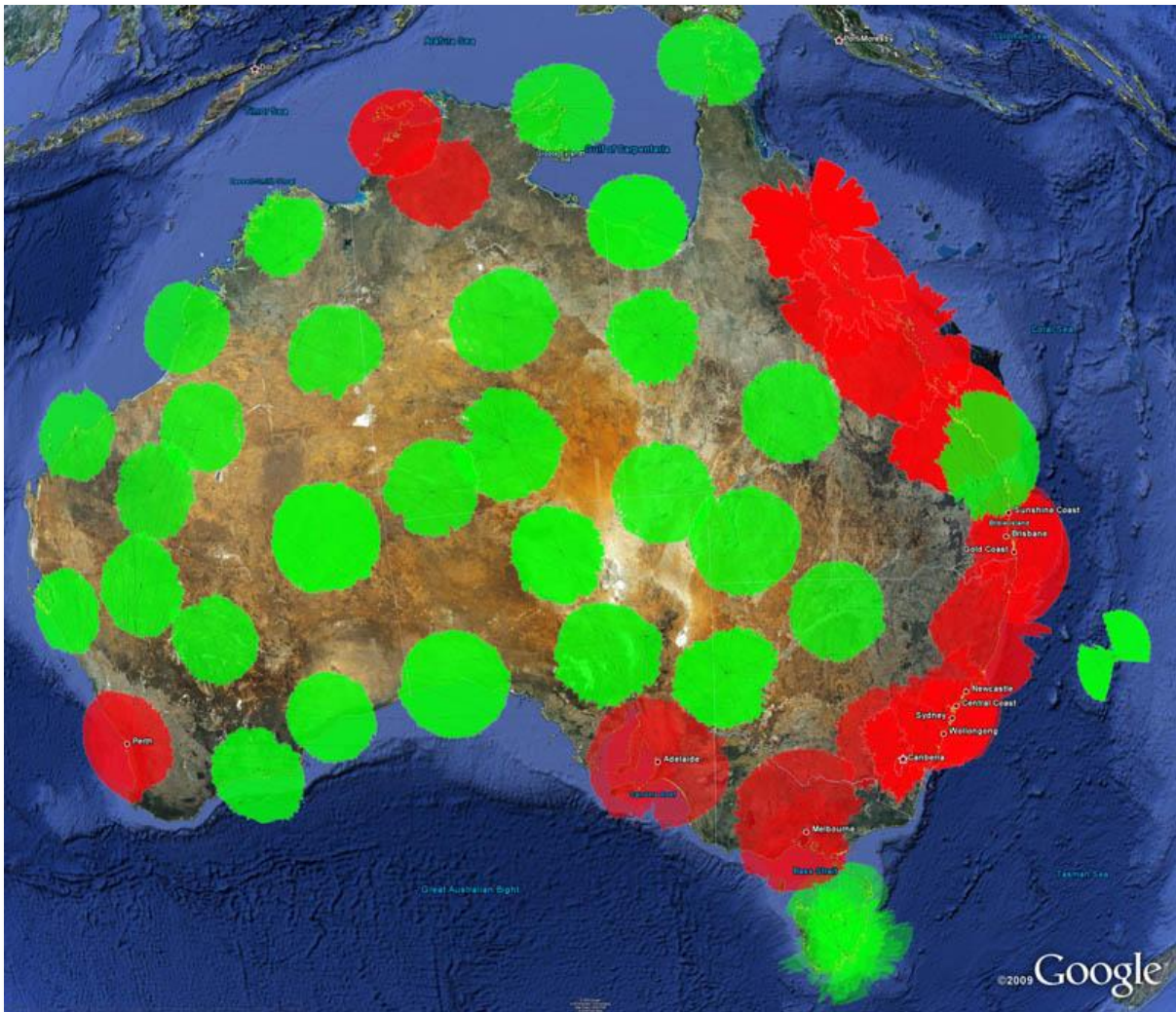


Figure 3-2: ADS-B & Radar Coverage at 5000ft (ref: Airservices Australia)

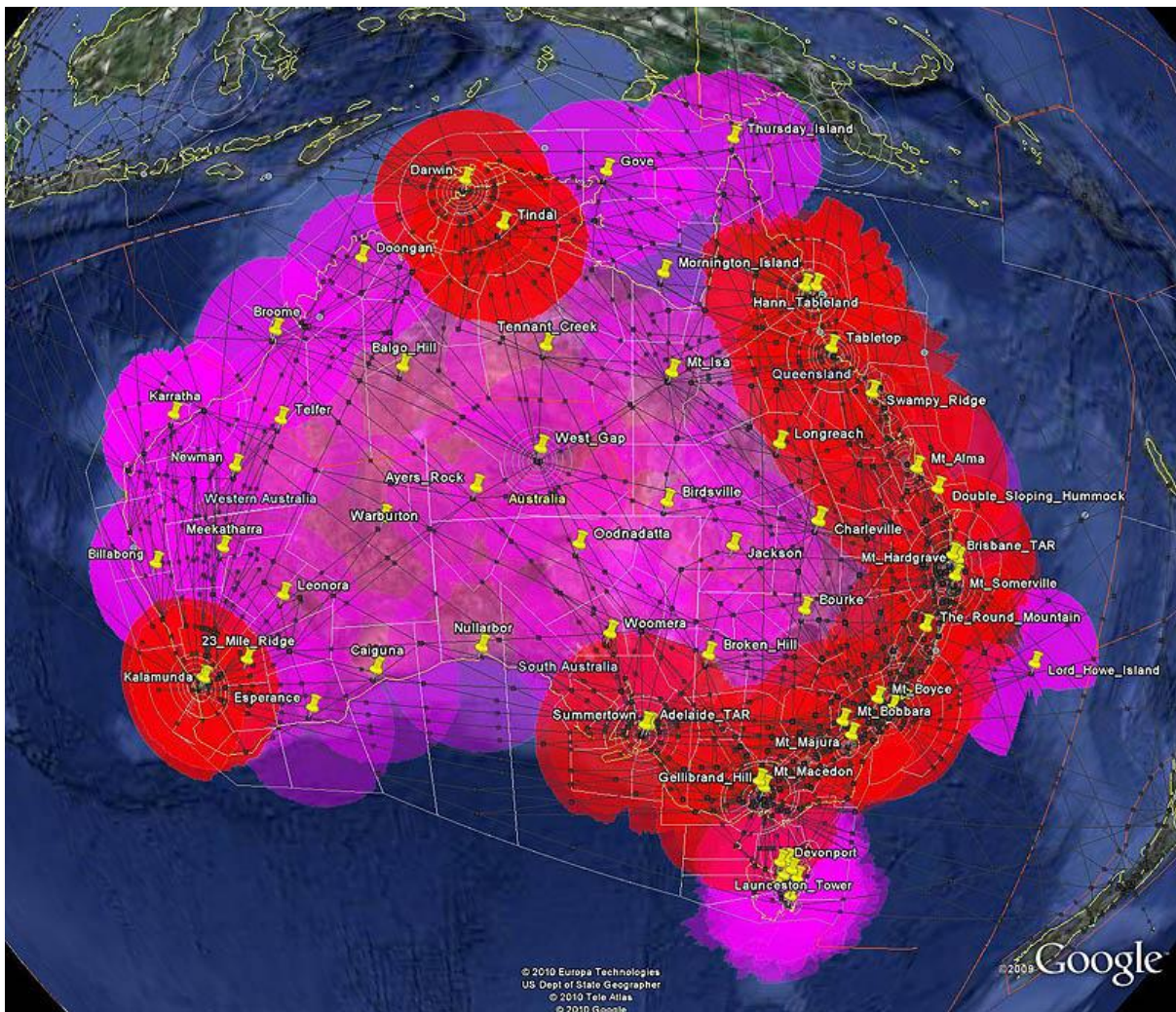


Figure 3-3: ADS-B & Radar Coverage at 30,000ft (ref: Airservices Australia)

NASAG guidelines do not include a review on radar interference.

Airservices Australia Wind Farm Aviation Study (2014) identifies 6 points and includes the point that the analysis is expected to follow the guidelines outlined in the Eurocontrol Guidelines on How to Assess the Potential Impact of Wind Turbines on Surveillance Sensors.

Airservices amended their Aviation Study document in 2014. The additional information added was to ensure that each assessment undertaken in accordance with the same assumptions used Eurocontrol Guidelines i.e. turbines had 3 blades, were between 30m and 200m in height and (operated with a) horizontal rotation axis.

The Eurocontrol Guidelines provide the following tables that enable simple identification of assessment requirements. This is not the only review of the process however it allows the reviewer quick identification on possible impacts.

4.2.1 Primary Surveillance Radar

Zone	Zone 1	Zone 2	Zone 3	Zone 4
Description	0 - 500 m	500 m - 15 km and in radar line of sight	Further than 15 km but within maximum instrumented range and in radar line of sight	Anywhere within maximum instrumented range but not in radar line of sight or outside the maximum instrumented range.
Assessment Requirements	Safeguarding	Detailed assessment	Simple assessment	No assessment

Figure 3-4: Primary Surveillance Radar Recommended Ranges (ref: Eurocontrol)

4.2.2 Secondary Surveillance Radar (classical, monopulse and Mode S)

Zone	Zone 1	Zone 2	Zone 4
Description	0 - 500 m	500 m - 16 km but within maximum instrumented range and in radar line of sight	Further than 16 km or not in radar line of sight
Assessment Requirements	Safeguarding	Detailed assessment	No assessment

Figure 3-5: Secondary Surveillance Radar Recommended Ranges (ref: Eurocontrol)

Radar sites at Mount Majura and Mount Bobbara have been identified. The issue of possible radar interference has also been identified. This matter is believed to be currently with the proponent and Airservices.

Airservices does appear to carry out their reviews consistently with the Eurocontrol guidelines. The guidelines are effective in identifying possible impacts on radar operations and there is nothing to suggest or documented which raises concern about this methodology.

For the purposes of clarification it should be identified that the Eurocontrol Guidelines only relate to surveillance sensors such as radars and that other navigation aids require separate consideration.

3.3.3. Obstacle Limitation Surfaces (OLS), Private Airstrips and Landing Areas

OLS protection areas have been included in the Ambidji report. It is supported by the statement “*that there are no aerodromes that have OLS above the wind farm and therefore the wind farm does not have an impact on the OLS at these aerodromes*”.

Private land owners located within the proposed Yass Valley wind farm have airstrips on their properties. **Not all airstrips** have been identified within the Ambidji report nor does the report detail a process of verification for the airstrip information received.

It should be noted though, that the owners of the airstrips are responsible for the conduct of aviation activities at these locations consequently there is no additional assessment required by the proponent within the regulations. However a determination on the impact on aviation activities such as aerial agricultural work should be included. CAAP 92-1 provides such guidelines for this assessment (refer section 3.3.4 for CAAP information and additional information recommended for consideration).

Furthermore these private airstrips are not required to be registered or reported to CASA and it is up to the pilot to obtain current information on that airstrip from the owner/operator prior to flight planning to assess the suitability for the intended operation. This includes the identification of obstacles and hazards such as wind turbines and turbulence.

3.3.4. Guidelines for Aeroplane Landing Areas and PANS-OPS

CAAP 92-1 provides guidelines for aeroplane landing areas. This CAAP came into effect in July 1992 and has not been updated. The CAAP sets out guidelines that may be used to determine the suitability of a place for the landing and taking off of aeroplanes. The CAAP details the recommended minimum physical characteristics of landing areas. The information is advisory only and there is no legal requirement to observe the details set out in the publication.

CAAP 92-1 was also referred to within the correspondence sent to William Kelly (dated 21 March 2104). The diagram used in that correspondence identifies the Figure 2B – Other Aeroplane (day operations) and details the characteristics that should be clear from obstacles around runway approaches.

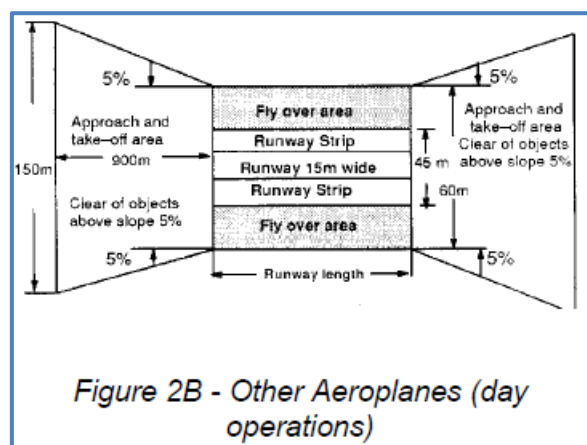


Figure 3-6 CAAP 92-1 diagram of Physical Characteristics of a Runway
Not Intended Solely for Agricultural Operations

In relation to this figure CAAP 92-1 paragraph 5.5 states “*Other Physical Characteristics. Both ends of a runway, not intended solely for agricultural operations, ...*”

From discussions with William Kelly (refer Consultation), the main use for his airstrip is agricultural operations. It is not known if it is used for other purposes however the majority of use is for aerial agricultural purposes.

The following diagrams identify the minimum physical characteristics of a landing area for agricultural purposes, day and night operations.

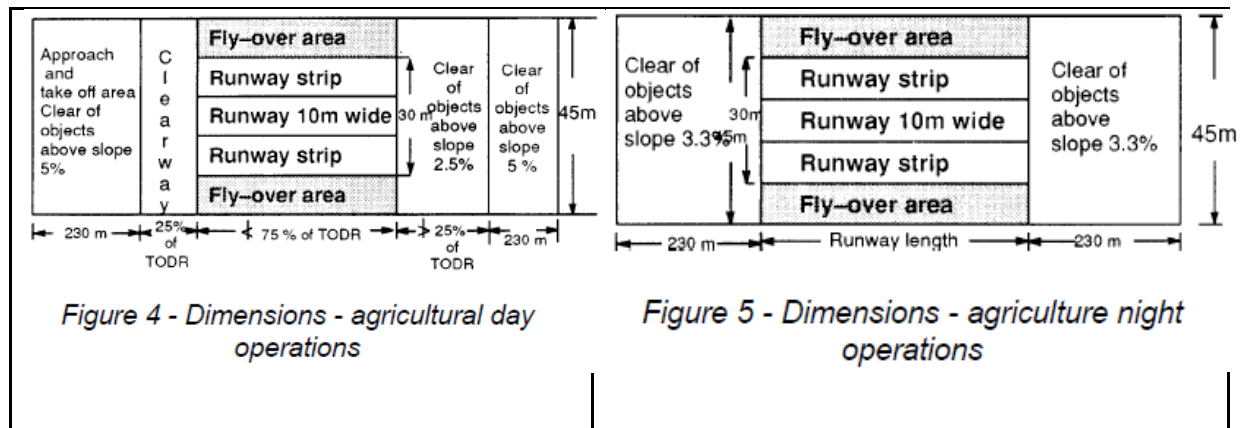


Figure 3-7 CAAP 92-1 diagram of Dimensions a Runway for Agricultural Purposes

PANS-OPS approach procedures normally have a standardised 5.24% (3°) approach path angle. Departure procedures commence with a procedure design gradient (PDG) 3.3%. The Minimum Obstacle Clearance (MOC) is 0.8% less than the PDG therefore creating a 2.5% surface. Furthermore PANS-OPS states that when creating a departure splay there will be no turns before the end of Area 1. Area 1 starts at the departure end of runway (DER) and ends where the aircraft reach 120m (390ft) above the DER (3.5km from DER based on 3.3% PDG). From here aircraft may turn (pending review of obstacle clearance). The area for consideration does not stop at this point. Aircraft will still require forward movement when turning. Referring to Figure 3-6, using 5% at 900m from the DER this provides height gain of 45m above the landing area, which in some cases is still tree height.

Departing aircraft still need climb. The airstrip may have 5% climb area however not all aircraft climb at this rate when loaded. Instrument flight procedures – departures at climb rate of 3.3% (200ft/nm) which can still higher than loaded aircraft for dusting. To achieve a height gain of 500ft equates to 2.5nm = 4.63km. Therefore aircraft will be unable to climb and turn within a 5km area of turbines as heavy and slow climbing aircraft will be unable to complete a 180° turn within 370m. Those mostly affected airstrips that have been identified that should warrant further review on this point include:

Airstrip Number	Airstrip Owner
3	Mark Glover
7	William Kelly
8	Angus Graham
9	Dulcie Arabin
12	Ted McIntosh
15	James Payne
17	Peter Shannon
18	Frances Elsegood
Not previously listed	Marilyn Garry

Table 3-3 Airstrips identified as omitted from Ambidji report and requiring review

Table 3-3 Recommended Airstrip Review for Departing Aircraft

These airstrips take aircraft directly towards wind turbine or power line locations. The impact that could be present at these locations is that aircraft may not achieve sufficient altitude before reaching the wind farm area. This could result in aircraft flying in a target rich environment in amongst obstacles or impacting into one of these obstacles or be effected by turbulence created by the turbines resulting in unsafe operation of the aircraft. **It has been found that the nine airstrips identified in Table 3.3 were not included within the Ambidji report although the first eight outlined were mentioned within the proponent's Preferred Project and Submissions Report dated May 2014. The last airstrip detailed in Table 3.3 was omitted from both the Ambidji report and the proponents report. The Ambidji report did not include any assessment or provide comment on these nine airstrips about the departure gradients required to ensure obstacle clearance/avoidance and include aircraft performance so an aircraft is able to turn safely and conduct aerial activities avoiding the proposed obstacles.**

As ALAs are not a registered or certified aerodrome and obstacle protection surfaces will more than likely be penetrated using the method determined by ICAO and CASA when comparing such landing areas. However, that does not exclude the reviewing of departure and approach areas based on an Advisory Circular published 22 years ago. **Ensuring that due consideration is being monitored, the proponent (or future proponents) should acknowledge their duty of care to pilots and aircraft owners.** This duty of care is recognised within the Ambidji document (Sheather v Country Energy 2007 NSWCA 179).

In order to determine the standard of review to be applied, it is necessary to identify the nature of flying activities when creating a register of aerodromes/airfields/airstrips. Not all airstrips identified in the provided documentation are used solely for agricultural purposes. Additionally the airstrips may only be utilised at various times during the year however these times may be consistent which allows planning to be undertaken e.g. spraying may occur between January to April however the strip may only be needed for a 7-10 day period (not verified – example purposes only). This means that the strip is not needed for 355 days of the year for aviation activity. Also the airstrip may be required for personal use and not aerial work and this type of activity should also be considered.

3.3.5. Airspace

3.3.5.1. Airspace Classification

There are two types of airspace that aircraft operate within – controlled airspace and uncontrolled airspace.

Controlled airspace contains a number of different classifications and each class has a different set of rules that apply. Depending on how high or how far in distance an aircraft that wants to fly will determine the class of airspace in which it will operate. Furthermore the rules under which the aircraft is operating within i.e. visual flight rules (VFR) or instrument flight rules (IFR) will determine the level of service received by the aircraft.

The following is a summary of the controlled airspace classification:

- Class A – High level enroute controlled airspace (Above FL180 in radar & FL245 in non-radar environments). IFR only flights with ATC clearance are permitted to use;
- Class C – Controlled airspace around major airports e.g. Brisbane, Melbourne, Sydney. IFR and VFR flights are able to use and requires ATC clearance to enter the airspace. The airspace is stepped down and is located below Class A airspace;
- Class D – Controlled airspace around general aviation and regional airports that have control towers e.g. Broome, Albury and Coffs Harbour. All flights in this airspace require ATC clearance. At towered locations, when the tower is closed, then the class of airspace will

- change. This is normally Class G airspace when the tower is not operational. Extends from 4500ft above the aerodrome to the ground and is located below Class C airspace;
- Class E – Mid-level enroute controlled airspace. IFR flights need to be able to communicate with ATC and require a clearance. The airspace is open to both IFR and VFR flights. VFR flights are not required to obtain a clearance with ATC and no separation is provided. Within radar environment, Class E commences above 8500ft and in non-radar environments above FL180; and
- Class G – This is uncontrolled airspace. Both IFR and VFR traffic are permitted to use. No ATC clearance is required. Flight Information Service is provided to IFR aircraft.

All aerial agricultural operations within the YVWFEA will be conducted in Class G airspace.

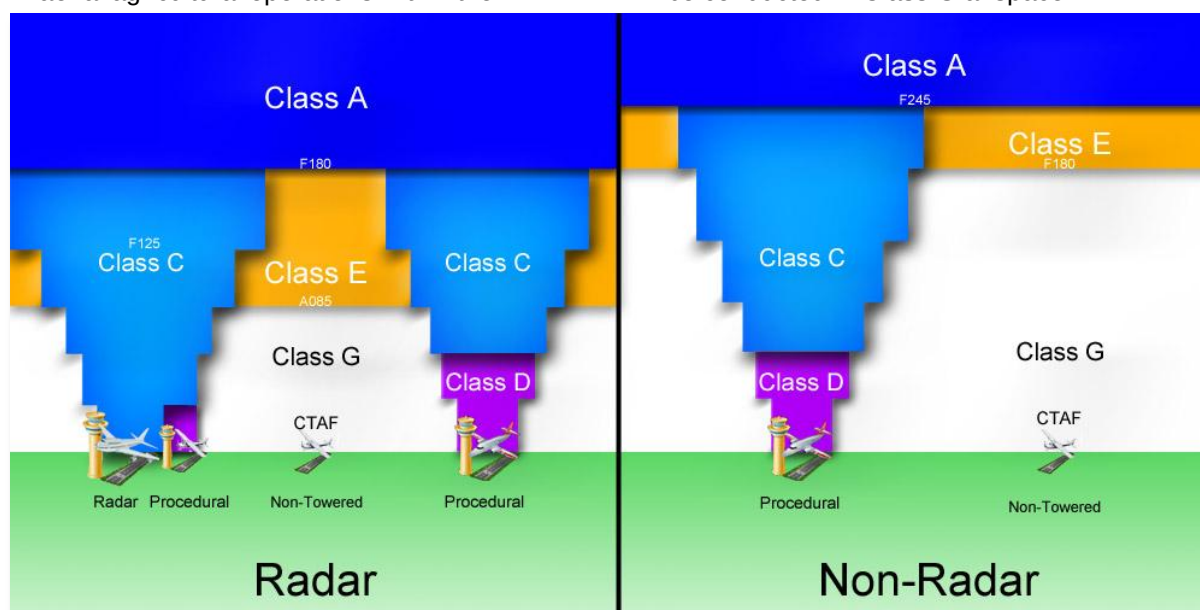


Figure 3-8: Australian Airspace Classification & Depiction (ref: VATPAC Australia)

3.3.5.2. CASA & Airservices Australia

Airservices Australia is the ANSP for Australia and provides air traffic control, fire fighting services and other aviation services to the aviation industry including navigation and surveillance e.g. radar. A significant amount of Airservices income is derived from the provision of air traffic control services from aircraft within controlled airspace.

Airservices does provide a Flight Information Service (FIS) to known IFR aircraft operating in Class G airspace however this does not apply to aerial agricultural pilots. When operating in Class G, pilots maintain a 'see and avoid' watch for other aircraft and obstacles.

Airservices does have an interest regarding the impact wind turbines might have on air routes, the possible impact upon radar returns, navigation aid signals, the effect on instrument flight procedures and the location of the obstacles for mapping purposes. The Eurocontrol Guidelines Airservices recommends to follow in relation to a wind farm study does not address the impact upon low level flying activities such as aerial application, hang gliding, ballooning.

CASA is Australia's safety regulator for civil air operations and for the operation of Australia aircraft overseas. CASA has a role in providing safety training programs, responsibility for licensing of aircraft and pilots and includes the Office of Airspace Regulation (OAR) for airspace regulation.

In relation to aerial applications pilots and to comply with the requirements set by CASA, pilots must:

- Have a commercial pilot's licence (CPL); AND

- Successfully complete agricultural flying and theory course which is approved by CASA; AND
- Pass written examinations and flying examinations conducted by CASA; AND
- Obtain an Agricultural Class 2 Rating; AND
- Operating for a minimum of 1000 agricultural flying hours under the supervision of a CASA approved Chief Pilot; AND
- Achieve a satisfactory level of competence in re-examination to be issued with an Agricultural Class 1 rating; AND
- Hold an Agricultural Chemical License or Rating.

This demonstrates the significant investment and commitment in time and maintaining compliance within the regulatory conditions set for aerial application pilots. It demonstrates their professionalism and expertise within the industry and should be afforded fair hearing when issues arise that directly affects this area.

CASA has also removed themselves from the issue of wind farms and wind turbines. CASA still makes a determination regarding if the turbines are a hazard for aviation purposes however there is little further involvement from them. CASA has maintained the responsibility on the operator and pilot to ensure safe operation of aircraft around wind farm areas. Given the amount of proposed wind farms and the possible effect on low level aviation activities this current stance will be unsustainable for the long term future.

3.3.5.3. Airspace User – Class G – Aerial Application

Airspace users fall into three main areas. Most familiar is commercial airspace users. The number of commercial flights increases each year within Australia and places significant demand at airports. The increase in air traffic can be identified by the major projects work being undertaken at capital city aerodromes. Brisbane, Melbourne and Perth are planning or undertaking construction of additional parallel runways and the recent announcement of Badgerys Creek as the second Sydney airport.

Airservices Australia obtains funds by charging airspace users which is generated by an enroute cost through Air Traffic Control (ATC). As the majority of people use this type of flight, then the majority of funds received by Airservices are derived from commercial flights. Business jets, commercial helicopters and Fly-in/Fly-out (FIFO) operators are included in this area.

The second user is Military. Military aircraft do not operate in accordance with the regulations that govern civilian aircraft which allows aircraft activities including flying low level, conducting abrupt vertical manoeuvres and standard training in areas that may involve numerous aircraft at a time. The Australian Defence Force retains a number of areas which can be activated by a Notice to Airmen (NOTAM). These areas are referred to as Restricted or Prohibited Areas and ensure that civilian aircraft remain outside these areas for military operations. Military ATC units such as those located at Darwin and Townsville, provide Air Traffic Services (ATS) to civil aircraft operating in their airspace.

All other air traffic is known collectively as “General Aviation” (GA). GA includes helicopters, light aircraft, gliders and hot air balloons. Users within this GA operation include pilot training, sight-seeing operators, emergency services including bush fire aerial support, parachute operators and agricultural aerial pilots. A significant amount of GA operators conduct their flights in Class G airspace in Visual Meteorological Conditions (VMC).

Aviation is relied upon more than ever as a practical means of transportation and communication with the surrounding communities. The ability to move people and produce effectively does impact upon the economic viability of any community. All of these areas require consideration when making a decision that may affect the ability to conduct flight operations which could affect the safety within that specific operation.

Pilots operating at/from private airstrips, like agricultural pilots, are required to plan each operation taking into account terrain and obstacles. The pilots are responsible for ensuring that they are aware of the conditions around the private strip and that they are suitable for flying activities. However with

wind turbines may significantly reduce the amount of activity that is able to be performed due to obstacle height, obstacle location or the amount of turbulence detected from the combined total of turbines. This point is not substantiated sufficiently within the documentation.

3.3.6. Wind Turbines & Meteorological Monitoring Masts

Wind turbines are obstacles, however they have only been considered an obstacle in the same way powerlines and trees are considered. Most wind turbines locations are advised however this information does not always translate to aviation mapping or charts. This can result in insufficient information being made available to pilots who undertake low level operations. Information regarding the positioning and height of obstacles such wind turbines and meteorological monitoring towers which are lower than obstacle consider as tall structures should be available. This has been undertaken by Essential Energy in NSW.

Wind Turbines are different to powerlines and trees because generate turbulence and this is irrefutable. Turbulence is a significant issue with AsA in assuring separation. AsA separate aircraft to ensure wake turbulence is addressed giving time or distance between aircraft movements. AsA provides warnings about wind shears, cross winds etc. at airports for aircraft departing or landing.

CASA provides information about turbulence to pilots too and clearly results in the minimising the impact turbulence has on aircraft.

Studies relied upon in the documentation relate to distances, most notably 15 times the diameter of the blade behind, however the information is not clear on the testing and therefore does the reliance of the information relate to one turbine or multiple turbines. There are no lateral or vertical dimensions detailed within the documentation.

The positioning of the turbines in the wind farm does not indicate if this was done so that the turbines behind does not suffer from turbulence from the one in front. What is the turbulence expected from the positioning of all the turbines within a given location? This is also not covered within the documentation.

Basic physics indicates that where there are multiple turbines, the amount of turbulence behind, beside and above will increase exponentially like a rock in a pond. One rock, one splash ripples go out. When multiple rocks are used there are multiple splashes resulting in different pattern interaction and disturbance on the surface.

Aircraft are designed to operate in turbulent conditions however there is no correlation given between the turbulence created by multiple turbines within an area and the impact upon safe operation of an aircraft.

Meteorological monitoring towers are normally lower than the wind turbines contained in a wind farm area. This does not reduce their ability to impact upon low level operations. Most of these towers are dark in colour and have guy wires for support. This is unlike wind turbines that are generally white in colour and do not have guy wires for support.

The towers and guy wires are difficult to see at low level. The following is a tower located south of Swan Hill Victoria. The tower is 994ft (AMSL) and has a number of guy wires for support. There are 21 seconds between the first 2 photographs. This was a known obstacle and was difficult to observe given the position of the sun. As it can be seen below visibility is greater than 10km.



Figure 3-9 Tower South of Swan Hill Victoria photo 01



Figure 3-10 Tower South of Swan Hill Victoria photo 02

This is to demonstrate the difficulty pilots have in identifying obstacles as low levels. The tower is located between the prop blades on the right and is also identified below from a side window photograph taken approximately at the same time as Figure 3-10 and also shows that the guy wires remain difficult to determine.



Figure 3-11 Tower South of Swan Hill photo 03

The Australian Transport Safety Bureau has published investigations undertaken in relation to low level flying operations. One incident involved the inability to see power lines overhead Lake Eildon in Victoria. The same principle applies for guy wires. Some States in the USA have recently passed legislation ensuring that wind monitoring masts are identifiable. No such legislation is currently in Australia. It is recommended that this be reviewed with a view of marking these obstacles sufficiently for visibility during the day. This issue is also identified in the Ambidji report.

3.4. Findings and Recommendations Relating to Reviewed Reports

It is recommended that all wind farm proposals include listing all certified or registered aerodromes, civilian or military within 55.56km (30nm) from the perimeter.

It is recommended that all other identifiable unregistered aerodromes/airstrips within 55.56km (30nm) from the perimeter of the proposed wind farm be nominated.

It is recommended that all known and usable airstrips within 10km (5.4nm) from the perimeter of the proposed wind farm be nominated.

It is recommended that the nature of flying activities at all identified aerodromes and airstrips be listed.

It is recommended that all navigation aids such as VOR, NDB, ILS, DME and LOC and their owners located within 55.56km (30nm) from the perimeter of the proposed wind farm be nominated.

It is recommended that an assessment surface such as 3° (5.24%) be extended from any identified navigation aid and extend to the lesser of 60nm or the range of that aid. It should be noted that the elevation and range of some navigation aids beyond these suggested limits may be impacted. It is upon the proponent to ensure that all navigation aids within range of the proposed wind farm be identified.

TAG has found that it is essential that the nine airstrips in Table 3-3, which were omitted from the Ambidji report, be reviewed in relation to aircraft performance being able to obtain sufficient obstacle clearance when departing those airstrips in order for safety to be maintained. Additional assessment of aircraft performance is required by the proponent.

It is essential that an independent study be undertaken to review the turbulence created by a wind turbine and multiple turbines and the effects this has on the safe operation of aircraft. Safety of aircraft within the vicinity of the wind farm and the impact of the turbulence on aircraft flying in close proximity TAG believes must be included within the assessment.

It is recommended that wind turbine and meteorological monitoring mast information is available for the use of pilots when planning low level operations. This can be a central location held by the NSW Government or available from wind farm operators/proponents.

Below is a table of all items which have been identified and TAG agrees these should be included in the assessment. TAG also has identified items requiring either additional information or clarification from Ambidji.

Also included within this table are issues TAG has identified have been included assessment:

Chapter Number	Chapter Title	Issue	Recommendation
Executive Summary	Qualitative Risk Assessment Summary Table 1	<u>Assessed Level of Risk</u> Private airstrip operations Agricultural Operations Fire Fighting Operations	The assessed levels to be increased to Low/Medium, Medium and Medium. In relation to approved low flying operations for aerial applications and emergency services such as firefighting, it is recommended that the risk be increased to Medium. This is to acknowledge the significance turbulence impacts

Chapter Number	Chapter Title	Issue	Recommendation
			upon these activities. That the overall level in considering all factors remain low to low/medium.
Executive Summary	Recommendations	Notification of operators in the region of the location and height of the existing and any planned meteorological monitoring masts in the area.	Agreed. Information relating to the position and elevation of these obstacles assist in flight planning and identification of obstacles.
Executive Summary	Recommendations	Meteorological monitoring masts in the Yass Valley Wind Farm area be fitted with swing flap reflector markers.	Agreed. Meteorological monitoring masts should be marked sufficiently to be visible during daylight hours. Most aerial agricultural work is conducted during the day in VMC. This provides for identification of obstacles.
3.9	Radar Interference and Shadowing	The issue of possible radar interference has been identified by the report. Using the Eurocontrol Guidelines, the turbines are within those listed and are within the primary and secondary radar assessed areas. It is concluded that advice from Airservices Australia be sought about possible interference.	Agreed.
3.10	Potential Impact On Navigation Aids	The assessment details review around the immediate vicinity of the nav aid ie up to 600m	Recommend that the review include the possible impact upon the signal of the navigation aid. Recommend a plane of 5.24% (3°) which is extrapolated/interpolated from ICAO & CASA criteria
5.1	Impacts on the Operation of Aerodromes and Airstrips in the Region	The statement at the conclusion which indicates that the location of the wind farm and any of its individual turbines will not impact on the approach, circuit work or take-off of aircraft from any of the identified aerodromes, airfields or airstrips in the	Recommend that airstrips be removed from this statement. Recommend that some airstrips in the area will be affected.

Chapter Number	Chapter Title	Issue	Recommendation
		region.	
5.2	Impacts on Agricultural Flying in regard to airstrips used or the safety of actual operations	<i>“Advice from consultations with the operator was that the wind farm would present no operational issues for the agricultural operation.”</i> This quote relates to Ted McIntosh. After discussing this with him, he cannot recall if he said this; however he was firm in the belief that he was not informed about the entire wind farm project and that only a few turbines were to be erected.	Consultation/communication be recorded or able to be corroborated.
5.8	Impacts on Aerial Fire Fighting Services	Ambidji report details discussions for South West Helicopters however there are no points made by any fixed wing operator. The report identifies that the region has had high instances of fire in early 2000's. These instances would have used other aircraft ie fixed wing. It is reasonable to expect comment from such operators	Recommend that where aircraft are used for fire suppression that (at least) comment from the common type of aircraft used be recorded. Comment should include nearest available water source and landing areas.
5.12	Impact from Meteorological Masts	The meteorological monitoring masts will be an acceptable risk provided they have obstacle marking and their location and height is notified to all the aviation operators and stakeholders in the region	Agreed.

Table 3-4 Ambidji Report - Issues Identified

4. CONSULTATION

4.1. Methodology and Objectives

Whilst Ambidji did perform a consultation process, TAG was engaged also to consult with stakeholders in order to ensure all aviation related matters/issues have been identified. TAG was to then provide, if possible, recommendations to resolve these issues. TAG was also to meet with relevant stakeholders particularly those with aviation related issues face to face.

The following steps were taken to ensure all stakeholders were contacted by TAG either by email, telephone or written correspondence. TAG identified stakeholders with specific issues and arranged to meet face to face with these stakeholders to discuss their issues and possible resolutions.

The objectives of consultation review:

- Identify the specific issues that stakeholders may have;
- If possible identify resolutions to their issues; and
- Identify issues that have not been included or adequately addressed.

4.2. Assumptions and Limitations

This consultation process is limited to purely aviation specific matters.

Assumptions used in the review

- The information supplied by the Department is accurate and no stakeholders have been excluded;
- Consultation with stakeholders who have a vested interest in the development either going ahead or being rejected can have a tainted view and may provide information which may or may not be accurate; and
- As the majority of the stakeholders to be contacted and/or spoken with during this process are opposed to the development, a significant amount of information will be negative towards the proposal.

Limitations of this review

- TAG does not possess the legal expertise to advise on legislative matters and for the purposes of this report. matters that have been identified, may require supplementary action by others with such expertise; and
- Time available to conduct the review is limiting. The process and report gathered over the years are being reviewed on aviation specific matters to be completed in a short period of time. Supplementary action by others may be required at the conclusion of this review.

4.3. Analysis

Reviewing the documentation provided by the Department and after undertaking other enquiries such as reviewing the submissions listed on NSW Government Planning and Environment website:

(<http://www.planning.nsw.gov.au/tabid/205/ctl/View/mid/1081/ID/66/language/en-US/Default.aspx>).

The following people were contacted¹ as a result of the review:

People spoken to directly by phone or in person	People contacted via correspondence/email
1. Mark Glover – Airstrip 3	14. Paul Regan – Airstrip 5
2. Ted McIntosh – Airstrip 12	15. Nick & Georgina Hewlett – Airstrip 6
3. Sam Weir – Airstrip 13	16. Dulcie Arabin – Airstrip 9
4. Marilyn Garry – Was not listed on map (recommended by Sam Weir & Mark Glover)	17. Owen & Kathryn Lawrence – Airstrip 10
	18. Gregory Luff – Airstrip 10
5. William Kelly – Airstrip 7	19. Richard Julian – Airstrip 11
6. Frances Elsegood – Airstrip 18	20. Peter & Helen Crisp – Airstrip 14
7. Dr Mary Ann Robinson – No Airstrip	21. James & Kerry Payne – Airstrip 15
8. Matthew Bingley – No Airstrip	22. Anthony (Tony) Reeves – Airstrip 16
9. Jim Hutson (recommended by Col Adams)	23. Peter Shannon – Airstrip 17
10. Col & Scott Adams – No Airstrip	24. Tony Armour – Airstrip 21
11. Terry McKenzie – No Airstrip	25. Tom Johnson – Airstrip 22
12. Phil Hurst (AAAA) – No Airstrip	26. Mick & Louise Agnew – Airstrip 23
13. Angus Graham – Airstrip 8	27. Professor Stephen Frith – Airstrip 20

4.4. Findings and Recommendations Relating to Consultation Undertaken by TAG

The following issues were raised by stakeholders and discussed either face to face or by telephone with meetings documented and attached at Appendix 3.

TAG has provided a recommendation where possible to provide a solution to the issues raised. These are purely for consideration by the Department and are not the only possible solutions.

Issue	Result	Recommendation
Inability to spray land aerially includes neighbouring properties. There is a lack of understanding on what aerial application involves.	Land unable to be serviced by vehicles; Disease and pests can take over that land and spread to neighbouring properties; Loss of production (significant); Loss of income; Return of native grasses & weeds; Loss of usable land;	It is recommended that the Department undertake a review on impact on wind farms and turbines on aerial applications/activities. The US has such information available and should not be ignored in assessing the impact upon aviation activities; It is recommended that the proponent negotiate turbine

¹ Contact means telephoned, emailed, face to face meeting or correspondence sent via registered post advising review.

Issue	Result	Recommendation
	No feed for stock; Significant economic impact upon land owner/user. Economic impact rolls into community – no money being spent to support businesses, loss of land valuation.	operations when aerial activity is being undertaken similar to the agreement delivered with the CERES Project and Aerotech on the Yorke Peninsula, South Australia; Identify fixed winged and rotary pilots willing to operate in wind farm areas; It is recommended that an independent economic review on reduced land production impact be undertaken in relation to the impact of wind farms.
Aerial support in bushfire	Additional areas face impact during bushfire; Volunteers not willing to enter areas where aerial support might not be available; Additional time required to combat fire; Additional time means more time away from land and this does have economic impact upon the community;	It is recommended that the rural fire service to undertake a safety case/safety risk analysis of aerial activity in bush fires and the impact this may have in a wind farm area. This is to include the risks associated with RFS members on the ground in a wind farm area, requiring air support.
Obstacle Lighting	If all turbines are lit, creates 'light pollution' for the area;	The determination if the wind turbine is a hazardous obstacle for aviation to remain as it currently described. The final determination is made by CASA. The turbine as an obstacle should be reviewed independently from the effect the turbine might generate due turbulence.
Wind Monitoring Masts – Marking	Masts and guy wires are hard to see against land background	It is recommended the masts and guy wires associated with wind monitoring masts or like obstacles are to be identifiable using such items as tiger tail flags so that these are visible during daylight hours.
Ineffective communication	People are misinformed;	Corroboration of

Issue	Result	Recommendation
	Inconsistent information received; Belief that the proponent does what they want.	communication; Record communications; Ensure understanding
Photomontages	No indication that the photomontages show the type of turbine or size of turbine or if it is in the proposed location.	It is recommended that photomontages or the like require statements advising the correctness of the type and positioning of turbines included in the picture.
Wind Turbines are just obstacles	Wind turbines are considered obstacles like power lines and trees. Wind turbines generate turbulence that could impact upon aircraft operations and safety. Wind turbines and meteorological monitoring masts are not always available on aviation maps/charts.	It is recommended that CASA & other Departments undertake full review on wind turbines and the impacts upon aviation safety and aviation activities. This should be undertaken separately by each section. It is recommended that the establishment of a central State reporting system in relation to wind turbines and meteorological monitoring towers and supporting infrastructure be created. It is recommended that this information be made available to low level aircraft operators in a similar manner to what Essential Energy currently provides low level operators.
Loss of airstrip access	Wind farm infrastructure including turbines, substations, powerlines result in the loss of airstrip use. Wind farm infrastructure can interfere with land drainage which can impact upon airstrip usage.	It is recommended that proponents identifying if turbines could be negotiated to be turned off in order for airstrips to be used. This is a similar method of operations undertaken on Yorke Peninsula, South Australia. It is recommended that the proponent's planned infrastructure will not interfere with identified airstrips. Repair to land should not be only to the area where poles and lines are installed. Drainage and surface repair to be considered regarding airstrips and aircraft movement areas on private

Issue	Result	Recommendation
		land.
Wind Turbine Turbulence	There are number of claims regarding turbulence generated by wind turbines and the extent this turbulence can affect aircraft.	It is essential that an independent study into the turbulence generated by wind turbines as a single obstacle and as multiple obstacles within an area similar to a wind farm be completed. It is recommended that the independent study identifies the amount of turbulence and how it relates to the safety of aircraft operations including fixed wing and rotary wing aircraft that would be expected to operate near wind farms.

5. CONCLUSION

As a result of the Peer Review and Consultation Process undertaken by The Airport Group the following conclusions were identified:

- Desktop review of the Ambidji Report reveals that it was completed to a satisfactory standard at the time it was completed. However the findings relating to the impact on airstrips and aerial agricultural services appear to be underestimated. This underestimation does not appear to adversely affect the overall conclusion;
- Desktop review of Telecommunications and Aviation Navigation Services Assessment undertaken by the proponent is acceptable. However the report does not address the kinds of facilities used for the provision of aeronautical telecommunication and radio navigation services listed in MOS Part 171. This does not appear to adversely affect the overall conclusion;
- Airservices Australia as Australia's ANSP has provided guidance on wind farm assessments and relates directly to the control and or navigation services it provides. This is located in the Wind Farm Impact Statement document. This document identifies the requirement for an assessment on the possible impact on radar facilities but does not address the impact on other navigation aids;
- CASA is Australia's safety regulator. CASA has provided advisory publications such as those involving landing strips (CAAP 92-1) and reporting of tall structures. However, this information should be revised and updated. This information should be updated at regular periods to ensure current information is being utilised;
- CASA appears to maintain that wind turbines are obstacles like power lines and trees and that pilots are required to take these into account when flight planning. However this stance will not be sustainable in the future long term. Wind turbines generate turbulence which is not able to be seen;
- Turbulence is a significant safety issue for ASA and CASA with both organisations detailing safety information about this subject. ASA ensures separation between aircraft due (wake) turbulence for arriving and departing aircraft;
- Information in relation to turbulence created from wind turbines should be reviewed immediately. Information reviewed relating to turbulence provides an example of one turbine. This is then translated as turbulence for multiple turbines yet does not address the exponential impact of the turbulence from turbines located behind. Nor does the information include the impact upon the operation of aircraft from this turbulence;

- Wind turbines are normally white in colour in order to easily identify this obstacle. Meteorological monitoring masts are difficult to observe from the air against the terrain background. These masts, including guy wires, should be identifiable during daylight hours. This can be achieved as indicated in the Ambidji report;
- Wind farm operators and aerial agricultural operators are able to reach an understanding when aerial operations are required such as the Yorke Peninsula wind farm. This is not a win-win situation. This is a compromise that will allow some aerial activity near a wind farm. This arrangement should be reviewed in order to address matters at current wind farm locations;
- Effective communication with Ted McIntosh, a significant operator in this region, appears to have been unsuccessful. This operator was of the understanding that only a few turbines were being installed and not the 140 as proposed. The amount of turbines and their location does impact upon his business and the ability to complete the task he has done for some time. He has experienced an issue relating to wind farm turbulence which is the cause of greatest concern. To address this matter further consultation should be made to address this matter such as endeavouring to have a similar agreement as undertaken within the Yorke Peninsula and to undertake a study on the turbulence created by multiple turbines and the impact this has on the safe operation of aircraft; and
- During the time the proponents have had, there has not been a wind study which included the prevailing wind direction or wind speeds. There does not seem to be a justification for the location of the turbines in the area. There have been people opposed to the wind farm and people in favour of the wind farm. A study about the wind within an area where wind turbines are to be located should be included where a wind farm is proposed.

Conclusion – Recommendations

- Assessment and review of wind turbine turbulence must be undertaken. This is to include the turbulence from a single turbine and also multiple turbines and the impact this has on the safe operation of aircraft;
- Proponents of wind farms are to provide a wind study in the area turbines are to be located;
- Meteorological monitoring masts are to be suitably marked in order to be visible during daylight hours;
- The Department should review the CASA advisory publication and update them for their own (the Department's) requirements. This includes:
 - The suggestions for landing strips and amending protection surfaces that enable the obstacle protection for departing aircraft who can climb to 400-500ft (AGL) safely before turning; and
 - Reporting of tall structures and establishing a record where information is available for low level operators such as that established by Essential Energy in NSW;
- That all wind farm proposals include listing all certified or registered aerodromes, civilian or military within 55.56km (30nm) from the perimeter of the wind farm area;
- That all other identifiable unregistered aerodromes/airstrips within 55.56km (30nm) from the perimeter of the proposed wind farm be nominated;
- The assessment must include all usable airstrips within 10km (5.4nm) from the perimeter of the proposed wind farm;
- Assessment on aircraft performance on all known and usable airstrips within 10km (5.4nm) from the perimeter of the proposed wind farm must be included within the assessment;

- That the nature of flying activities at all identified aerodromes and airstrips be listed. This includes private use, aerial agricultural operations for their land and neighbouring properties and rural fire service access;
- That all navigation aids such as VOR, NDB, ILS, DME and LOC and their owners located within 55.56km (30nm) from the perimeter of the proposed wind farm be nominated; and
- That an assessment surface such as 3° (5.24%) be extended from any identified navigation aid and extend to the lesser of 60nm or the range of that aid. It should be noted that the elevation and range of some navigation aids beyond these suggested limits may be impacted. It is upon the proponent to ensure that all navigation aids within range of the proposed wind farm be identified.



Mark Fineran
Airspace Specialist
Senior Designer

6. ABBREVIATIONS

Abbreviations used in this report and the assigned meanings are detailed in the following table:

Abbreviation	Definition
AC	Advisory Circular (document support CAR 1998)
ACFT	Aircraft
AD	Aerodrome
AGL	Above Ground Level
AHD	Australian Height Datum
AHT / ACFT HGT	Aircraft height
AIP	Aeronautical Information Publication
AIRPORTS ACT	Airports Act 1996, as amended
AIM	Aeronautical Information Management
AIS	Aeronautical Information Service
AIS	Aviation Impact Statement
ALA	Aircraft Landing Area
ALT	Altitude
AMSL	Above Mean 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 / Air Traffic Controller
ATM	Air Traffic Management
ATO	Aviation Testing Officer
CAAP	Civil Aviation Advisory Publication
CAO	Civil Aviation Order
CAR	Civil Aviation Regulation
CASA	Civil Aviation Safety Authority
CASR	Civil Aviation Safety Regulation
Cat	Category
CNS	Communication, Navigation and Surveillance (equipment)
DA	Decision Altitude
DA	Development Application
DAP	Departure and Approach Procedures
DER	Departure End of (the) Runway
DEVELPMT	Development
DME	Distance Measuring Equipment
Doc <i>nn</i>	ICAO Document Number <i>nn</i>
DITRDLG	Department of Infrastructure, Transport, Regional Development and Local Government. Also called "Infrastructure". (Formerly Department of Transport and Regional Services (DoTARS))
DoIT	Department of Infrastructure and Regional Development
ELEV	Elevation (above mean sea level)
EMI	Electromagnetic Interference
ENE	East North East
ERSA	Enroute Supplement Australia
FAF	Final Approach Fix
FAP	Final Approach Point
FIS	Flight Information Service
ft	feet
GNSS	Global Navigation Satellite System
GP	Glide Path

Abbreviation	Definition
HF	High Frequency
IAF	Initial Approach Fix
IAS	Indicated Airspeed
ICAO	International Civil Aviation Organisation
IF	Intermediate Fix
IFR	Instrument Flight Rules
IFP	Instrument Flight Procedure
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
LOC	Localiser
LONG	Longitude
LSALT	Lowest Safe Altitude
m	metres
M	Magnetic (degrees Magnetic)
MAPt	Missed Approach Point
MDA	Minimum Descent Altitude
MGA94	Map Grid Australia 1994
MOC	Minimum Obstacle Clearance
MOS	Manual of Standards as published by CASA
MSA	Minimum Sector Altitude
MSSA	Minimum Safe Segment Altitude
MVA	Minimum Vector Altitude
NDB	Non Directional Beacon
NE	North East
NM	Nautical Mile (= 1.852 km)
nnDME	Distance from the DME (in nautical miles)
NNE	North North East
NOTAM	Notice To AirMen
NSW	New South Wales
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
PBN	Performance Based Navigation
PDG	Procedure Design Gradient
PRM	Precision Runway Monitor
PSR	Primary Surveillance Radar
QLD	Queensland
QNH	An altimeter setting relative to height above mean sea level
RAAF	Royal Australian Air Force
REF	Reference
RL	Relative Level
RNAV	aRea NAVigation
RNP	Required Navigation Performance
RNP-AR	Required Navigation Performance – Authorisation Required
RPA	Rules and Practices for Aerodromes (Replaced by the MOS Part 139 — Aerodromes)

Abbreviation	Definition
RPT	Regular Public Transport
RWY	Runway
SA	South Australia
SACL	Sydney Airport Corporation Limited
SFC	Surface
SID	Standard Instrument Departure
SOC	Start Of Climb
SSR	Secondary Surveillance Radar
STAR	Standard ARrival
T	True (degrees True)
TAG	The Airport Group
TAR	Terminal Approach Radar
TAS	True AirSpeed
TAS	Tasmania
THR	Threshold (Runway)
TA	Turn Altitude
TODA	Take-Off Distance Available
TODR	Take-Off Distance Required
TORR	Take-Off Run Required
UHF	Ultra High Frequency
USA	United States of America
VFR	Visual Flight Rules
VHF	Very High Frequency
VIC	Victoria
Vn	aircraft critical Velocity reference
VOR	Very High Frequency Omni directional Range
WA	Western Australia
WGS84	World Geodetic System 84 – reference system currently used for the Global Positioning System (GPS) satellite navigation system
WTG	Wind Turbine Generator

7. APPENDICES

The following appendices have been attached:

- Appendix 1: Landowner Listing as Supplied by the Department
- Appendix 2: Landowner Letters Issued by TAG
- Appendix 3: Landowner Minutes of Meetings/Conversations
- Appendix 4: Airservices Wind Farm Aviation Study - 13 February 2014
- Appendix 5: Eurocontrol Impact Wind Turbines Sur Sensors Guide
- Appendix 6: CAAP 92-1 Guidelines for ALAs
- Appendix 7: 139c08 Reporting of Tall Structures 2005
- Appendix 8: Man Made Obstacles Located Away from Aerodromes
- Appendix 9: Airservices s11-7-5-DME Siting Guidelines
- Appendix 10: Wind Turbine Turbulence
- Appendix 11: Ceres-QA-Aerial Spraying – August 2013
- Appendix 12: Final 2014 AAAA Wind Farm Operational Protocols – May 2014
- Appendix 13: ATSB Avoidable Accidents No.1 – Low Level Flying
- Appendix 14: TAG Chart of the Proposed Yass Valley Wind Turbines and Airfield Locations
- Appendix 15: Discussion on Wind Turbine Interaction

APPENDIX 1

Airstrip	Closest Turbine No.	Distance (km)	Landowner	Contact	Phone	Address	Address	Address	Address
1	69	4.6	Henry Ernest Wilson & Colleen Mary Wilson	Henry Wilson		Kurrajong		Berrema	NSW 2582
2	41	3.8	Kenneth Leo Hall	Kenneth Hall		Lot 116	Hume Highway	Berremangra	NW 2582
3	79	5.3	Mark Berry Glover	Mark Glover	6227 7881	Talbragar	Bogolara Road	Bookham	NSW 2582
4	15	2.6	David James & Robyn Deborah Sykes	David Sykes	0428 274 252	Glendalyn	Sykes Road	Binalong	NSW 2584
5	1	5.2	P.C.R. P/L	Paul Regan	6227 4527		141 Burley Griffin Way	Binalong	NSW 2584
6	11	6.0	Old Bundemar P/L	Nick Hewlett	0427 275 583	Fairview		Binalong	NSW 2584
7	111	4.2	Bryjoi P/L	William Kelly		Emu Flat		Binalong	NSW 2584
8	13	2.7	Nils Taube Ltd	Angus Graham	0418 646 011	Mylora	Illalong Road	Bookham	NSW 2582
9	100	2.0	Dulcie Letsom Arabin	Dulcie Arabin	6227 4345		PO Box 31	Binalong	NSW 2584
10	100	3.5	Kathryn Narelle Lawrence & Owen Francis Lawrence & Gregory William Luff	Kathryn Lawrence			PO Box 2023	Bowning	NSW 2582
11	95	2.3	Richard Julian	Richard Julian	6227 7203	Bogolong	Hume Highway	Bookham	NSW 2582
12	144	4.9	Yass Brahman Co Pty Limited	Ted McIntosh	6227 6007		1079 Black Range Road	Yass	NSW 2582
13	145	9.6	Bertangles (yass) P/L	Sam Weir	0428 486 250	Bertangles	Burrinjuck Road	Bookham	NSW 2582
14	100	3.2	Helen Crisp	Peter Crisp	6227 6073	Crisp Galleries	Gap Range	Bowning	NSW 2582
15	145	2.2	James Gordon Payne & Kerry Ann Payne	James Payne	6227 7244	Springvale	1648 Black Range Road	Yass	NSW 2582
16	41	2.8	Koorynga & Rawont Holdings P/L	Tony Reeves	6227 7843	Koorynga	Beremangra Road	Bookham	NSW 2582
17	77	2.5	Boziga P/L	Peter Shannon	6227 7234	Bookham Station		Bookham	NSW 2581
18	95	2.0	Bogo P/L	Frances Elsegood	6227 7226		32 Burrawong Avenue	Mosman	NSW 2088
19	41	7.7	Caroline Lorna Ainslie Spittle	Caroline Spittle	6227 7833	Kingslea		Bookham	NSW 2582
20	79	10.5	Ponds Creek Pastoral Co Pty Ltd	Stephen Frith		Bogolara	Bogolara Road	Bookham	NSW 2582
21	77	9.5	Anthony John Armour	Tony Armour	6227 7241	Glenrock	848 Childowla Road	Bookham	NSW 2582
22	95	10.9	Thomas Kenrith Johnson	Tom Johnson		Clarville	Talmo Road	Bookham	NSW 2582
23	95	11.6	Louise Agnew	Mick Agnew	0419 804 715	Amakanda	Burrinjuck Road	Bookham	NSW 2582
Airstrip no longer in use									



7 August 2014

Mr M & Mrs L Agnew
PO Box 137
MITCHELL ACT 2911

Dear Mr & Mrs Agnew

Re: Independent Review – Yass Valley Wind Farm

We are writing to inform you that The Airport Group (TAG), one of Australia's largest airport consultancy agencies has been engaged by the New South Wales Department of Planning and Infrastructure to undertake an independent review of the proposed Yass Valley Wind Farm.

This independent review is to focus on the Aviation Impact Assessment including methodology, assumptions and assessments of impacts provided by the Proponent.

The review is scheduled to be completed by late August 2014.

Yours faithfully

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7 August 2014

Mr D Arabin
PO Box 31
BINALONG NSW 2584

Dear Mr Arabin

Re: Independent Review – Yass Valley Wind Farm

We are writing to inform you that The Airport Group (TAG), one of Australia's largest airport consultancy agencies has been engaged by the New South Wales Department of Planning and Infrastructure to undertake an independent review of the proposed Yass Valley Wind Farm.

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7 August 2014

Mr T Armour
848 Childowla Road
BOOKHAM NSW 2582

Dear Mr Armour

Re: Independent Review – Yass Valley Wind Farm

We are writing to inform you that The Airport Group (TAG), one of Australia's largest airport consultancy agencies has been engaged by the New South Wales Department of Planning and Infrastructure to undertake an independent review of the proposed Yass Valley Wind Farm.

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7 August 2014

Mr P & Mrs H Crisp
Crisp Galleries
Hume Highway
Gap Range
BOWNING ACT 2582

Dear Mr & Mrs Crisp

Re: Independent Review – Yass Valley Wind Farm

We are writing to inform you that The Airport Group (TAG), one of Australia's largest airport consultancy agencies has been engaged by the New South Wales Department of Planning and Infrastructure to undertake an independent review of the proposed Yass Valley Wind Farm.

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7 August 2014

Mr A Graham
715 Illalong Road
BINALONG NSW 2584

Dear Mr Graham

Re: Independent Review – Yass Valley Wind Farm

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7 August 2014

Mr N & Mrs G Hewlett
Old Bundemar Pty Ltd
BINALONG ACT 2584

Dear Mr & Mrs Hewlett

Re: Independent Review – Yass Valley Wind Farm

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7 August 2014

Mr T Johnson
Clarville
Talmo Road
BOOKHAM NSW 2582

Dear Mr Johnson

Re: Independent Review – Yass Valley Wind Farm

We are writing to inform you that The Airport Group (TAG), one of Australia's largest airport consultancy agencies has been engaged by the New South Wales Department of Planning and Infrastructure to undertake an independent review of the proposed Yass Valley Wind Farm.

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7 August 2014

Mr R Julian
Bogolong
Hume Highway
BOOKHAM ACT 2582

Dear Mr Julian

Re: Independent Review – Yass Valley Wind Farm

We are writing to inform you that The Airport Group (TAG), one of Australia's largest airport consultancy agencies has been engaged by the New South Wales Department of Planning and Infrastructure to undertake an independent review of the proposed Yass Valley Wind Farm.

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7 August 2014

Mr O & Mrs K Lawrence
PO Box 2023
BOWNING NSW 2582

Dear Mr & Mrs Lawrence

Re: Independent Review – Yass Valley Wind Farm

We are writing to inform you that The Airport Group (TAG), one of Australia's largest airport consultancy agencies has been engaged by the New South Wales Department of Planning and Infrastructure to undertake an independent review of the proposed Yass Valley Wind Farm.

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The review is scheduled to be completed by late August 2014.

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7 August 2014

Mr G Luff
Warrawee
54 Lawrence Lane
BOWNING NSW 2582

Dear Mr Luff

Re: Independent Review – Yass Valley Wind Farm

We are writing to inform you that The Airport Group (TAG), one of Australia's largest airport consultancy agencies has been engaged by the New South Wales Department of Planning and Infrastructure to undertake an independent review of the proposed Yass Valley Wind Farm.

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7 August 2014

Mr J & Mrs K Payne
1648 Black Range Road
YASS NSW 2582

Dear Mr & Mrs Payne

Re: Independent Review – Yass Valley Wind Farm

We are writing to inform you that The Airport Group (TAG), one of Australia's largest airport consultancy agencies has been engaged by the New South Wales Department of Planning and Infrastructure to undertake an independent review of the proposed Yass Valley Wind Farm.

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7 August 2014

Mr T Reeves
Berremangra Road
BERREMANGRA ACT 2582

Dear Mr Reeves

Re: Independent Review – Yass Valley Wind Farm

We are writing to inform you that The Airport Group (TAG), one of Australia's largest airport consultancy agencies has been engaged by the New South Wales Department of Planning and Infrastructure to undertake an independent review of the proposed Yass Valley Wind Farm.

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7 August 2014

Mr P Regan
141 Burley Griffin Way
BINALONG NSW 2584

Dear Mr Regan

Re: Independent Review – Yass Valley Wind Farm

We are writing to inform you that The Airport Group (TAG), one of Australia's largest airport consultancy agencies has been engaged by the New South Wales Department of Planning and Infrastructure to undertake an independent review of the proposed Yass Valley Wind Farm.

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7 August 2014

Mr P Shannon
Bookham Station
BOOKHAM ACT 2582

Dear Mr Shannon

Re: Independent Review – Yass Valley Wind Farm

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SINGAPORE 530212
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1. MARK GLOVER

TAG173 PTY LTD MEETING

Discussion Points

Friday 01 August 2014

Babinda Road, Berremangra, NSW 2581 Time 1.20pm – 2.25pm

In Attendance: Mark Fineran MF Mark Glover MG Catherine Glover CG
Catherine was present during the meeting however Catherine was not involved in all the conversation nor with us when we drove to the strip

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- First time meeting each other and general introductions.
 - Discussions had in office. Catherine joined.
 - Map shown that had airstrip marked. Appears similar to map that I have (dated 20/03/2014 – Attachment 12).
 - Extremely concerned about wind turbines which are positioned to the north of his property. MG reaffirms the point raised by CG during telephone discussion, that due to terrain and already existing power lines, all take-offs and departures must be to and from the North.
 - During the months of February/March MG requires aerial support in order to fertilise his land with super phosphate (super). The airstrip is located (approximately) in the middle of his property and this makes it a cost effective way to fertilise.
 - The topography of the land means that aerial agricultural application is the only method available. The hills located on or surrounding his land ensures that trucks and similar vehicles are unable to reach all parts of his land to apply the fertiliser.
 - No fertiliser means return of native grass which means no feed for stock and loss of land.
 - Neighbours also use his airstrip for similar application to their properties. Believes that neighbours would be left with a similar predicament should they be unable to fertilise.
 - Ted McIntosh is the pilot. Ted has advised MG that due to the positioning of the wind turbines and expected turbulence, he would not be able to fertilise his land.
 - Has used a helicopter previously. This was a one off and costly exercise that he had to incur. If he had not used the helicopter MG would have lost his crop. Loss may have been made however did not lose the land.
 - Helicopters do not carry as much as a fixed wing aircraft and can only do small areas at a time. The cost is not proportionate to a fixed wing aircraft.
 - Winds in the summer period come from the north east and north west. Showed the wind direction using his map (and later outside). Winds come over the hills and down the slopes towards his property. The winds are sometimes katabatic. This would extend the turbulence behind the turbines.

- Point of concern mentioned regarding communication. Advised that one person Marion/Marilyn was not aware of the wind farm. No consultation; appears she found out weeks ago.
- No one to one consultation with him or Catherine. Very suspicious about what they are being told and what is being done. Honestly believes he has been lied to and does not trust proponent's representative.
- Does not believe satisfactory consultation has taken place with airstrip owners. MG can not understand how this wind farm does not impact significantly upon airstrip owners and those that need aerial support for land operations.
- MF background provided that is Air Traffic Control. Discussion regarding turbines and radar had. Advised that Airservices Australia is conducting a review about radar interference, false returns, shadowing. That information should go directly to the Department (Planning and Infrastructure).
- MG advises that he is not aware of any study undertaken in the wind turbine area about turbulence. Point is made that the topography and land use is different to that to the east of his property (towards Canberra).
- MG seriously concerned if unable to fertilise his land, he will lose 100% of his value.
- Inquired about the possibility of moving some turbines away from Ted's route and if that would resolve his issue. MG advised that provided Ted was able to fly without concern, then he would be happy. However given that the take-off could place Ted within 2km of the turbines and possible turbulence as the aircraft would be behind the turbines, it is unlikely to resolve to Ted's concern.
- Issue with rural fire service discussed. This related to aerial support. Vice-Captain Matthew Bingley and mobile number provided. To be followed up with during the weekend. The issue related to aerial support in a bushfire. The turbines and wind monitoring towers would be difficult to see in smoke. Aircraft may not be able to provide aerial support to ground staff who are in or near the wind farm. Last significant bush fire was in 2013. Aircraft were used in combatting that fire. MG is a volunteer for the RFS.
- Drove to airstrip. Observed terrain to the south of the strip and the power lines behind and alongside of strip boundary. This does ensure that take-offs and departures are from the north.
- MG showed where trees had been felled (as requested by Ted McIntosh). At this point MG stated that Ted was at about the tree height. This is due to the weight of the aircraft when loaded with super.
- Aircraft track indicated i.e. after departure aircraft turns right and climbs back around to the rear of the property and then fertilisers. Each trip takes approximately 7 minutes to complete. Numerous trips made.

MEETING CONCLUDED
At approximately 2.25pm

Additional Information Below:

- Photos taken by TAG
- Email received from Mark Glover (requested) with Letter to Mark Glover from Epuron re Aerial Agriculture and Yass Valley Wind Farm dated 8 July 2014

Date & Time: Fri Aug 1 14:02:43 EST 2014
Position: -034.62087° / +148.53887°
Altitude: 1677ft
Azimuth/Bearing: 017° N17E 0302mils (True)
Elevation Angle: -01.7°
Horizon Angle: +01.1°
Zoom: 1X



Glover Airstrip



Glover Airstrip

Date & Time: Fri Aug 1 14:14:25 EST 2014
Position: -034.80903° / +148.54044°
Altitude: 1565ft
Azimuth/Bearing: 138° S42E 2453mils (True)
Elevation Angle: +01.8°
Horizon Angle: +01.5°
Zoom: 1X

As reference, aircraft fully loaded at take off, reaches approximately tree height at this point at the end of air strip.



Glover Airstrip: Northern End Reference Height

2. TED MCINTOSH

TAG173 PTY LTD MEETING

Discussion Points

Friday 01 August 2014

“Jindalee” 1079 Black Range Road, Yass, NSW 2582 Time 4.00pm – 5.05pm

In Attendance: Mark Fineran MF Ted McIntosh TM

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- First time meeting each other and general introductions.
 - Discussions had in lounge area.
 - The Yass Valley Wind Farm will affect most of his work within this area and if it goes ahead it will bankrupt him.
 - Operations mainly in February and March. Maybe April. Also period October/November. Some fertilising. Some seeding. All aerial work at low level.
 - TM been flying for 56 years. 54 years professionally. Has decades of experience as an agricultural pilot.
 - Does not like wind farms. Has experienced unexpected turbulence as a result of a wind farm (strongly held belief). TM did report this matter to the ATSB. The incident involved turbulence at descent at about 500-600ft AGL. Gunning wind farm was 9km's away yet the turbulence came from them. Reported to ATSB. CASA responded however nothing done. Concern that nothing will get done until there is a fatal incident.
 - Turbulence is real and TM will not fly near turbines or turbine locations. His actions and knowledge can not be dismissed due to lack of experience. Very experienced for his task. Very knowledgeable about the conditions suitable for spraying.
 - Turbulence will cause unnecessary delays i.e. delay the application or create no flying opportunities. Farmers book and plan to have fertilisers delivered or seeding land. Delays will cost money or the inability to perform the required task and the farmer could lose his crop. This will mean that TM will lose on income.
 - TM explained that wind is required when spraying. Without wind the spray could rest on top of the ground (inversion) and not settle. TM has experienced such conditions and the spray moved away and settled in a location not sprayed.
 - Ted McIntosh is the pilot. Ted has advised MG that due to the positioning of the wind turbines and expected turbulence, he would not be able to fertilise his land.
 - Is aware that bush fires requires aerial support. The Yass Valley area has been subjected to bush fires where aerial support was essential in limiting damage or injury. The wind farm would result in the prevention of fixed wing aircraft entering the area. Helicopters could be slow and unable to carry similar weight to fixed wing. Pilots would have difficulty in seeing the turbines through the smoke. Difficult to judge relative distance.

- TM does not recall when he was approached about the wind farm. Stated that as the report contains his name, he believes this must have been done however TM recalls some of the detail. TM advises that at no stage was the full extent of the Yass Valley wind farm discussed. TM believed that there may have been 4 or 5 turbines on a nearby hill to his property but was not told the actual location.
- TM advises that if the full extent was provided, his experiences and discussions with other agricultural pilots would have resulted in a clear and unambiguous no.
- TM did not receive any notice or correspondence about the wind farm. Land owners who use his services know his details and it is unreasonable to believe that the proponent did not know of him. There is the possibility that the information may have been incorrectly labelled and therefore returned.
- The proponent's representatives have been less than truthful when speaking about the wind farm. Recalls a discussion about wind monitoring masts. TM was advised by one person (believed to be Andrew Wilson) that there would be a 6 inch red dot marker placed on the mast. This would not make the mast conspicuous from the air. TM was later advised by another person that there would be a 1 metre marker placed on the mast. This marker may be larger than the mast. TM questions if the proponent's representatives are not able to answer a relative simple question with the same answer it displays that individual decisions are being made that affect groups of people. It also depends which person you speak with as to what answer you get.
- Wind monitoring masts are hard to see from the air against the ground. Guy wires extend out. These are not able to be seen until late if at all.
- TM believes that there is no trust with the proponent and that they have acted unethically. Information being relied upon should be reviewed i.e. turbulence. There is a significant impact on aerial operations.
- "There is not point for consultation if you can't reach an agreement. You can't negotiate and reach an agreement and then change it back."
- Aircraft performance in nil wind, operates to maximum capacity of 1 tonne. MTOW 1.3 tonne and does operate at that limit. By applying maximum weight allows maximum coverage. Aircraft can normally travel 100-110kts, the max speed fully loaded with spray gear is about 90kts. This makes climbing and turning slower than standard operations.
- Turbulence and the effect on operations should be reviewed. The reliance on overseas or not current information is resulting in poor decision making (impacting on people).

MEETING CONCLUDED

At approximately 5.05pm

Additional Information Below:

- Photo taken by TAG

Requested information received via email from Ted McIntosh

- Aerial Ag article by Phil Hurst, Australian Aviation October 2013
- Email dated 8 December 2013 – concerns about low level flying around turbines
- Email thread re Incident Report ATSB including CASA response



McIntosh Aircraft and Fuel Truck

3. SAM WEIR

TAG173 PTY LTD MEETING

Discussion Points

Saturday 02 August 2014

256 Woolgarlo Road, Woolgarlo, NSW 2582 Time 9.30am – 11.10am

In Attendance: Mark Fineran MF
Sam Weir SW

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- First met at entrance to property and shown where airstrip is located. We could not drive onto that part of the land due soft wet surface. Sam indicated where super phosphate (super) is normally located and also the land that is around the back of where we were standing which requires aerial spraying to be conducted due topography i.e. the land has a slope.
 - Shown where aircraft lands, takes on super and departs. From where we were standing the aircraft departs to the East and then turns right to go over the hill where the land is sprayed which is located towards Lake Burrinjuck.
 - Relies on aerial spraying for that part of his property as it is not accessible by truck. This is required for top dressing and spraying of weeds. Does use the truck on parts where it is possible.
 - Ted (McIntosh) has stated that he has an issue with the turbines and the associated turbulence caused by them (turbines).
 - Conroy's Gap wind farm is the closest wind farm to his property. Yass Valley wind farm is more than 9km away.
 - There was no in-depth consultation for Conroy's Gap other than initial community consultation. Felt like that was a waste of time as it seemed to be crossing t's and dotting i's. It progressed from there very quietly and very rapidly. SW is on the didn't have the confirmation I'm on the community Epuron opened up the consultation committee and I suddenly see the map and I said well what's doing down there. Why isn't the proposed area at Conroy's Gap doing there (on the map)? He said it's not proposed, it's all been gazetted. It's approved.
 - It would have been there if they knew where to find it but no one came to him to discuss. He believes he should take responsibility for not following up with Conroy's Gap proposal. He stated that if he was doing that sort of thing with that much feeling against them, then he would be doing this a quietly as he could too. It was after it (Conroy's Gap) had been approved and they had been making noise about it that somebody spoke to him about Yass Valley. Nobody has spoken to him one on one.
 - Sure it might be in accordance with the law but that doesn't help the people who are against them. MG would have told you about the survey that we did and the resounding results of that of people against the turbines. So they are very much going against the community feeling.
 - Aviation is vital. Not just an efficient method of getting Australian tax payers money into large international companies' pockets.

- Re conroy's gap assessment - was there as much angst as there is now? Only in the local area because no one else had an understanding. Under certain conditions you may hear them. No one had an understanding of the increased traffic during the construction phase, on the local roads. People are just starting to realise what the impact will be on the whole community
- They (proponent) talk about labour. Well there might be a couple of people employed but they are very low maintenance once they are up (turbines) and they are going to have be specialists labour that is going to do the job. It's not a Johnny Local. It's going to be special fillers to come in and do the job.
- Given the community issue it would be reasonable to assume that the same proponents delivering the same product would have the same issues
- Frances Elsegood's property. Called her this morning and spoke about contact. She told him that I hadn't. He asked if okay to pass on details? Yes. Told him that's okay and I would contact her later.
- SW stated that he had a financial concern about the value of his property. His land is his superannuation and is extremely concerned about the impact the wind farms would have on his property.
- The airstrip has been used for firefighting purposes.
- The implications that they lose a lot of the country to weeds and pests. This would result in a vast drop in production from the inability to spread fertiliser and compensation would be sought.
- Recalls that they (Taurus Energy) did have community consultation for the Conroy's Gap wind farm however did not realise it had progressed. When Epuron opened a community consultation SW saw that Conroy's Gap wind farm was not on the map as part of the proposal. He was then informed that Conroy's Gap had been approved.
- People in the local area didn't know or were not aware of the implications such as increased traffic on the roads etc. that the wind farm brought as part of the development.
- Consultation process and the procedure undertaken in the assessment of the wind farm was shoddy. Does not trust the proponent. Example given – neighbour of SW, who is described as elderly, left school at an early age and worked through his life, had a turbine (Conroy's Gap) located very close to his house (less than 500m). When this was raised by Sam to the proponent, Sam was told that this would not be an issue and the turbine could be moved. At a community meeting he was told that the turbine could not be moved and would remain its location i.e. within 500m of the house.
- SW if the property can not be sprayed he will lose that land for production purposes.
- Rural Fire Service experience and has first-hand experience where aerial support in the bushfire was needed and saved lives.

MEETING CONCLUDED
At approximately 11.10am

Additional Information Below:

- Photos taken by TAG



Weir Airstrip Panoramic View





Weir Airstrip: Below Super Loading Point



4. MARILYN GARRY

TAG173 PTY LTD MEETING

Discussion Points

Saturday 02 August 2014

“Myrana” 847 Illalong Road, Bookham, NSW 2582 Time 11.42am – 12.38pm

In Attendance: Mark Fineran MF Marilyn Garry MG Henry Grogan HG

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- Greeted at front door. Went through to kitchen/meals area.
 - Husband, John Garry, died approximately 3 months ago. Had suffered from dementia for some time before passing. This was an issue as it restricted their movements and ability to attend meetings or updates.
 - Is pleased that others are objecting and knows that others may have already signed to have the turbines on their property.
 - Remembers the first meeting about 6-8 years ago at the Tara Motel in Binalong when the proposal was first discussed. About 12 farmers in total attended the meeting. Recalls that only positives were given to the meeting about the wind farm. They were told about 150 turbines altogether made up the wind farm.
 - Driving home from that meeting her husband told her that he did not want the turbines on his place and that he was not keen on the project. He followed up the next day by contacting the office using the business card provided at the meeting and told them he wasn't interested.
 - However each year the people come out and visit 2-3 times each year to speak about the wind turbines. MG advised that they put them off from speaking to them and constantly reminded the people that they were not interested in the wind farm.
 - About 4 years ago they came out and pulled a map out. On the map was their place and the map showed all the road, power lines and the substation located on their property. Again the Garrys told the people that they were not having them (on their land).
 - MG saw that there was a turbine located near one end of her airstrip and a power line located at the other end. MG questioned the location of the 'stuff' on her property because they were not having them. She was advised by the representatives that her place is the most accessible so they had to have all the 'stuff' on her property.
 - Just before Christmas 2013 they received another call to discuss the wind farm. MG stated that she reminded them again that they were not interested. John said that it wouldn't hurt to see what they had to say because they haven't spoken to them for a couple of years.
 - The meeting took place the next day at 10am. The map that was shown still had all the roads and electricity lines on their property. The location of these also made their airstrip unusable.
 - Her son, Matthew who is a pilot, flies down (from Toowoomba, Qld) to see them and uses the airstrip. The turbines and power lines now make that inaccessible. MG also stated that neighbours use her airstrip to fertilise or seed their property.

- MG said at that meeting why have you still got the power lines there? Our son flies and our neighbours use the airstrip. She was told, "Well, we'll put a light on it."
- MG stated that she wasn't happy about that and didn't want the power line. She was informed that the substation had been moved off her property and put over the fence into Mylora (Angus Graham). MG stated that on the map that she was shown at that meeting, the roads and power lines were still in the same location as last time but the substation had moved. This was against their wishes which had been made clear from the beginning.
- Last week (before this meeting) Mary Ann (Robinson) and Michael (Grogan) came and saw MG. Mary Ann had the latest map which showed the turbine gone from the airstrip however the power line is still there.
- MG then wrote a letter to the Department (Toby) and the letter was also taken by Michael to Pru Goward.
- Was contacted by Toby after her last letter.
- There are farmers that will have the turbines. Her neighbour (John's brother) is having them and is furious with her about not having them. Was told that a local survey showed a majority of people from the community were against the wind farm.
- Recalls a meeting about 2 years ago where a doctor from South Australia spoke about negatives because she had turbines around her in South Australia. This woman (name unknown) believed that there had not been sufficient investigation into wind turbines. Felt justified in their original decision. These were not discussed at the first meeting.
- At the initial meeting there were only positives about the wind farm such as you'll earn some money by having them on your property.
- It was difficult to attend meetings due to John's ill health however MG always maintained that she would not have them (turbines, power lines etc.) on her property. Believes the proponent has not listened to her because maps continue to show these on her property.
- Mylora used her airstrip last year because they have a lot of hills for crop dusting. The turbines prevent the use of her airstrip. This will include any bushfire support. Not possible to move the airstrip. It is located on top of a hill and the surrounding land falls away. It is used to service working properties and is used by neighbours and her family. By comparison to neighbouring airstrips, this one is accessible. The airstrip is a working part of her property.
- Correspondence from the proponent may have been sent however MG has not kept any.

MEETING CONCLUDED At approximately 12.38pm

MF was then taken to Marilyn's airstrip by HG.

Additional Information Below:

- Photos taken by TAG



Garry Airstrip: East Stitch View



Garry Airstrip: West Stitch View



Garry Airstrip: Northern End View North



Garry Airstrip: Northern End View South



Garry Airstrip: Southern End View South

5. WILLIAM KELLY

TAG173 PTY LTD TELEPHONE CONVERSATION

Discussion Points

Wednesday 06 August 2014
Time 11.41am – 12.46pm

Conversation between: Mark Fineran MF William Kelly WK

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- MF introduction provided. As messages had previously been exchanged the purpose and context had already been known. MF reaffirms that the review is to include the aviation specific matters and the impacts the wind farm has on WK business and or livelihood.
 - WK advises that his airstrip is used annually for fertiliser and it has been used for aerial spraying (weeds). His airstrip is also used by his neighbours for crop work including seeding. This is done in between February and April and also September/October.
 - WK has 8500 acres on his property. His major concern is the production of his country which creates his income and living and is a major factor in land value. 3500 acres (approximately 40% of the total land area) is dependent upon aerial application of fertilizer. The rest of the land can be addressed through ground coverage.
 - WK states that should he not be able to fertilise that country (3500 acres) because people refuse to fly in those areas or use his airstrip he is facing a 50% financial loss in total production. This is a significant value reduction and will result in the business struggling to continue operations. If WK states if he has a loss of production which is going to diminish the value of his property, from a production point of view, it is unreasonable to put in a wind farm that will reduce his production capacity without being compensated for the loss of production.
 - WK states that you are not able to drive a truck over the 3500 acres because of the terrain. A 5 tonne fertilizer truck holds 5 tonnes of fertilizer and you need reasonably undulating ground or else the truck will roll over (if the land is greater than undulating). There are a number of places the truck is unable to traverse so an aircraft is required to cover the rest of the ground.
 - WK explains that the fertilizer is required to help the clover grow. Clover adds nitrogen to the soil and the nitrogen makes the grass grow. Without adding fertilizer there isn't any clover and therefore no nitrogen for the soil and no grass will grow on the hills. The result is that native grass returns to that part of the country and you lose that production amount.
 - WK uses Ted McIntosh to conduct the required aerial work. Ted has told WK that he will not fly around turbines. Ted's concerns are his concerns however if people can fly over his land then his concerns are considerably diminished.
 - Discussion had in relation to using helicopters. WK has used helicopters previously however helicopters can not carry same amount of weight as aircraft and therefore takes more time to complete aerial spraying and cost more money. Also WK advises that you can not use helicopters for fertilizers, they are just too heavy (when loaded with fertilizer). Example provided where a Robinson 44 (R440) can carry a few hundred litres but Ted's aircraft can carry approximately 700kg.
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- WK has not had a major bush fire on his land for some time. Last fire was approximately 10 years ago. The use of planes was less prevalent back then in comparison to the present day activity.
- WK does not have any turbines on his property and thinks there are no power lines either.
- WK knows that the wind farm is located on hilly terrain and a number of people who are getting windmills on their land will not be affected by not being able to fertilize their land because of the income they receive for each turbine. The benefits of having turbines outweigh the loss of production value.
- WK has known about the wind farm for a number of years. Stated that he didn't worry about it much and that his concern has come from Ted McIntosh's concerns about flying where the turbines have been established. WK admits that he has never been to meetings about the wind farm and he has never had any real contact with the proponent Epuron. His personal opinion is that he does not like them but there is not much he can really do about them (wind farms).

CALL CONCLUDED
At approximately 12.46pm

Additional Information Below:

Information received via email from William Kelly

- Letter from Epuron to William Kelly dated 21 March 2014
- Letter to Epuron from Andrew Wilson dated 11 April 2014
- Letter to Epuron from Andrew Wilson dated 22 April 2014

EPURON

Level 11, 75 Miller St
NORTH SYDNEY, NSW 2060
Fax 02 9922 6645

21 March 2014

William Kelly
Emu Flat
Henderson Lane
Binalong
NSW 2584

Dear Mr Kelly,

YASS VALLEY WIND FARM AND AERIAL AGRICULTURAL ISSUES

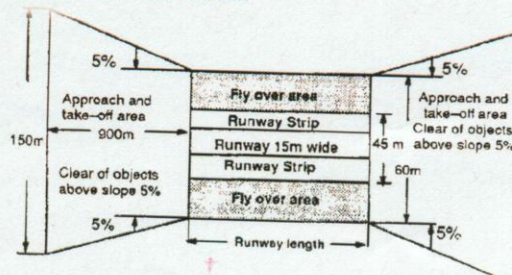
Epuron received a letter from Sam Weir and Mark Glover, two members of the Yass Valley and Conroys Gap Wind Farms Community Consultation Committee, at a meeting of that Committee in Yass on 6th March 2014. The letter expressed their concern about the potential impact of the Yass Valley Wind Farm on aerial agricultural operations. Please see attached a copy of the letter for your information. We are writing to you because your property was listed in the letter as having an airstrip in the vicinity of the Yass Valley Wind Farm.

The potential impact of the proposed wind farm on aerial agricultural operations was assessed in the project Environmental Assessment in November 2009 and in subsequent consultation with aerial agriculture operators such as Yass Air (Ted McIntosh), South West Helicopters and Col & Scott Adam Ag Aerial Spraying.

A wind farm has the potential to impact on aerial agricultural operations in two ways:

1. The use of existing unregistered agricultural airstrips

These airstrips are classed as "Aeroplane Landing Areas" by CASA in accordance with Civil Aviation Safety Regulations Part 139. CASA guidelines for these landing strips are contained in their *Civil Aviation Advisory Publication 92-1 (1) - Guidelines for Aeroplane Landing Areas*. The publication contains physical characteristics that define the 'surfaces' which should be clear from obstacles around the runway approaches. These characteristics are shown below.



A zone extending 900 metres from the approach and take off area is required to be free from obstacles at an angle of 5% extending out from the end of the runway. The proposed wind farm does not encroach on any of the existing landing areas with all of the airstrips being more than 2km from the closest turbine. As these private airstrips rely on visual rather than instrument-based landing techniques, and as the turbines are highly visible, it is expected that pilots will continue to use them.

2. Restriction on aerial spreading and aerial spraying in the immediate vicinity of wind turbines

It is acknowledged that the proposed wind turbines and permanent wind monitoring masts will restrict aerial spreading and aerial spraying in the immediate vicinity (a few hundred metres) of this infrastructure, however

YASS VALLEY WIND FARM PTY LTD

ACN 141 003 161

Submission to the Yass Valley Wind Farm Community Consultation Committee March 2014 meeting

Agricultural Issues Re Yass Valley Wind Farm

Introduction:

Epuron have proposed to construct 150 wind turbines in the Coppabella Hills, Marilba Hills and Conroys Gap region to the west of Yass.

The Environment Assessment (EA) Report was released in November 2009. Section 5 covers Planning Context and section 6 covers consultation.

The State Environment Planning Policy (Rural Lands) 2008 was not addressed in the Environment assessment. The aims of the policy include 'to facilitate the orderly and economic use and development of rural lands for rural and related purposes' and also 'to implement measures designed to reduce land use conflicts'.

Agricultural issues were not sufficiently addressed in the EA and consultation on these matters to date has been inadequate.

Aerial spreading:

Aerial spreading of superphosphate is undertaken on many properties in the area. The application of superphosphate has been shown over many trials to be critical to boosting farm income. The local pilots contracted to carry out this work have expressed a reluctance over flying within the vicinity of the wind turbines and this has been supported by the Aerial Agricultural Association of Australia. Aerial spreading is only undertaken where the terrain prohibits other forms of spreading.

Aerial Spraying:

Weed infestation is a common problem on much of the area. The main infestations are Blue Thistle and Serrated Tussock. It is imperative that these weeds are kept under control and do not spread into other rural areas. Regular spraying for these infestations are carried out over the Coppabella and Marilba Hills. Terrain is also an issue here and aerial spraying is carried out as other methods of application are not possible.

List of Impacted Airstrips/Users:

Xxxxxx

Recommendations:

- 1) Consult with all the airstrip owners/users. Document this at the next cccc.

List of airstrips in vicinity of proposed Yass Valley wind turbines

Tony Reeves Kooryna Berremangra 6227 7843
Mark Glover Talgragar Bogalara Road Bookham 6227 7881
Stephen Frith Bogalara Bogalara Road Bookham
Carline Spittle Kingslea Bookham 62277833
Tony Armour Glenrock Childowla Road Bookham 62277241
Peter Shannon Bookham Station Bookham 62277234
Richard Julian Bogolong Bookham 62277203
Frances Elsegood Bogo Bookham 62277226
Mick Agnew Amakanda Burrinjuck Road Bookham 0419804715
Sam Weir Bertangles Burrinjuck Road Bookham 0428486250
James Payne Sunnyside Black Range Road Bowning 62277244
Ted McIntosh Jindalee Black Range Road Bowning 62276007
Stan Waldren Woodleigh Hume Highway Bowning
William Kelly Emu Flat Binalong
Paul Regan Brundah 405 Garryowen Road Binalong 0417 463938 62274527
Nick Hewlett Old Bundemar Pty Ltd Fairview Binalong 0427275583
David Sykes Glendalyn Binalong 62274377
John Garry Myrana Binalong 62274260
Tom Johnson Clarkville Talmo Road Bookham
Angus Graham Mylora Binalong
Rob Shannon Marilba Bowning 62277281

this impact will be partially offset by the improved vehicular access provided by the wind farm access roads. The wind farm company will also reimburse any affected landowners for any increase in costs of aerial agriculture as a result of having to use alternate means of spreading and spraying.

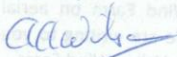
For your information, please see attached map of the unregistered agricultural airstrips that have been identified in the vicinity of the Yass Valley Wind.

For completeness of our records, please let me know:

- If airstrip No. 7 on your land has been correctly identified;
- Whether this airstrip is currently in use and if so how frequently it is used;
- If you are aware of any other airstrips in the area that are not identified on the map; and
- Whether aerial spreading or aerial spraying is currently carried out on your property.
- Whether your airstrip is used by any others to service their land and if so the last date used by another party and if possible their contact details.

Please let me know if there are any other issues you would like to discuss about the wind farm. We look forward to your response.

Sincerely,

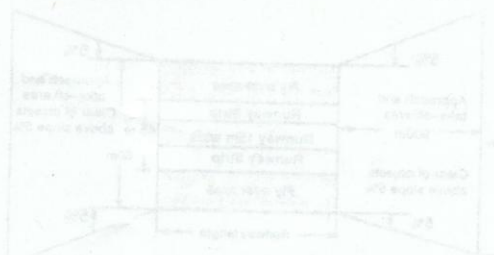


ANDREW WILSON

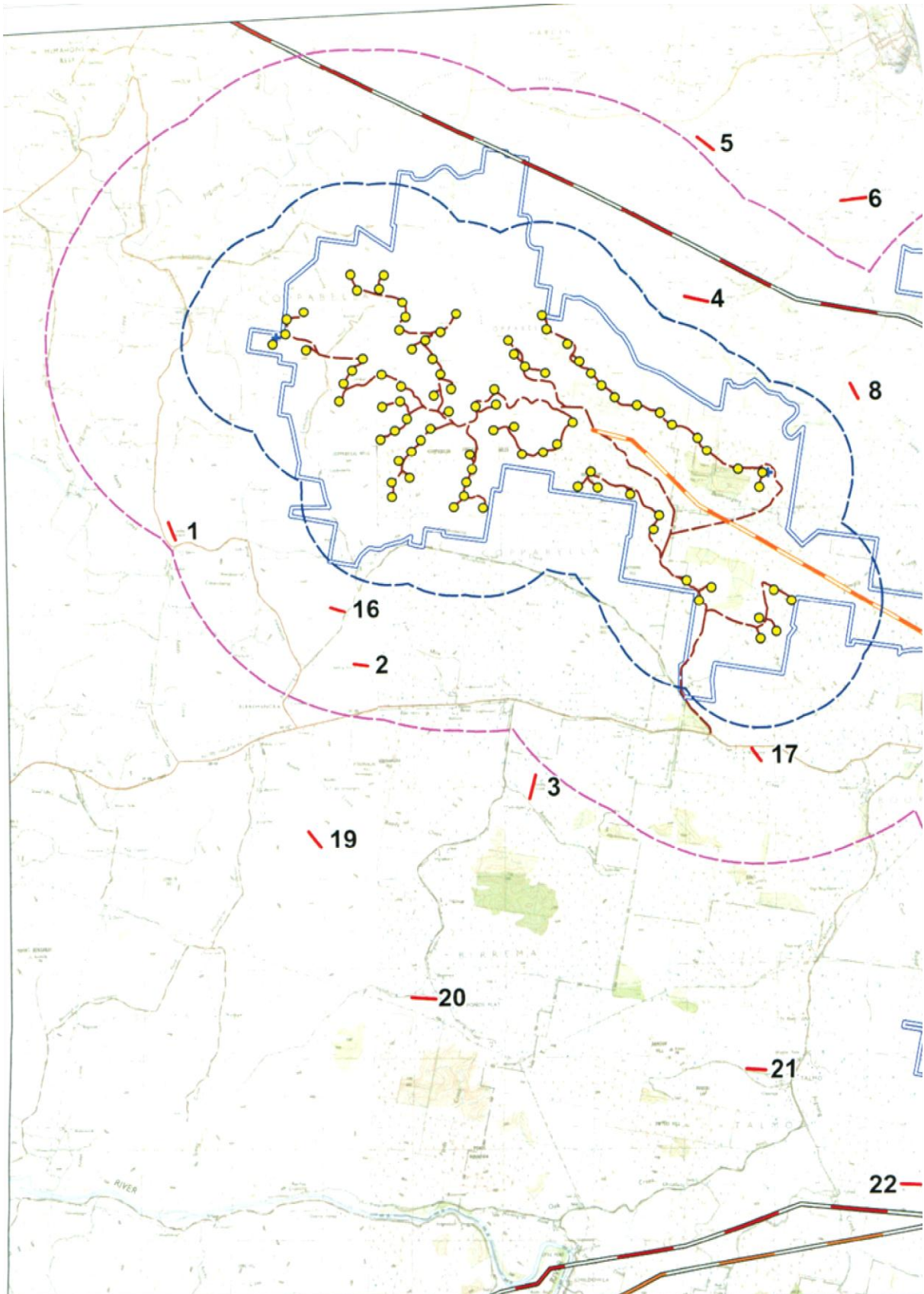
Construction Manager

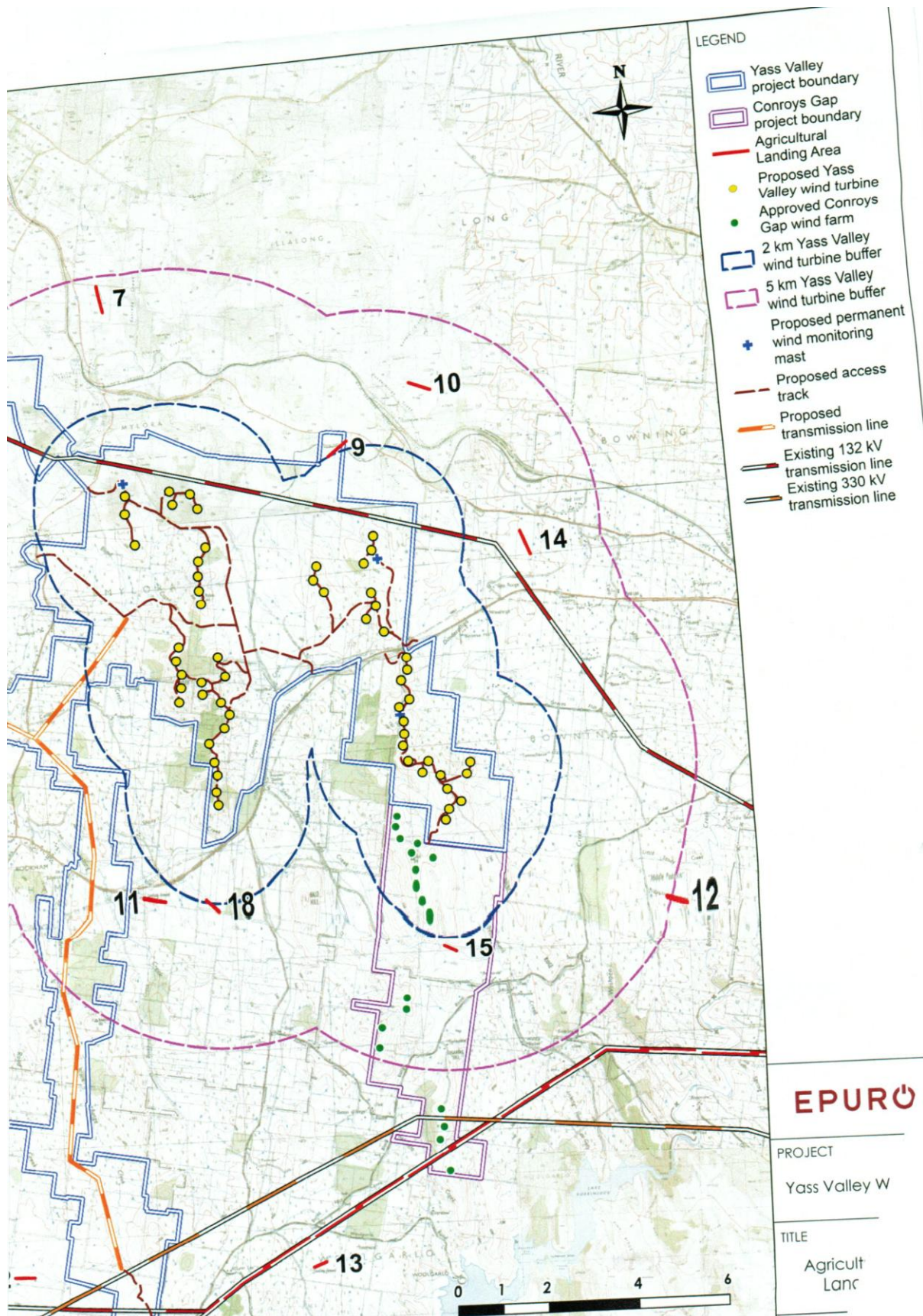
Attachments:

- Letter from Sam Weir and Mark Glover 6th March 2014
- Map of unregistered airstrips



- 2) Commit to controlling all weed infestations within the wind farm area and immediate neighboring areas. Should infestations spread elsewhere the Proponent must take responsibility for eradication.
- 3) Undertake to employ an independent compliance officer to monitor all rural issues.
- 4) Negotiate with all affected farmers and agree to compensation where rural production is adversely affected.
- 5) Document all these agreements in the Revised Preferred Project Report.





6. FRANCES ELSEGOOD

TAG173 PTY LTD TELEPHONE CONVERSATION

Discussion Points

Wednesday 06 August 2014
Time 12.09pm – 12.25pm

Conversation between: Mark Fineran MF Frances Elsegood FE

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- MF introduction and advised that her number was obtained from Sam Weir who suggested I contact her. Confirmed that the property manager is David Hazel who was away at the time of communicating with her.
 - Position of her airstrip confirmed given the identification of the airstrip i.e. to the west of Conroy's Gap but to the south of the proposed wind farm.
 - FE stated that her airstrip is not used a lot now. FE has concerns about the wind farm. Had bad fires through there a few years ago and if it hadn't had been for the helicopters it (bush fire) would have been a lot worse than what it was.
 - The towers sitting on the ridge, a large portion of her eastern boundary would be inaccessible to aerial activity from her understanding. FE doesn't have a concern about the airstrip because it isn't used a lot however the protection of her property from fire is a significant concern.
 - The property is used for farming purposes. The 16 turbines already approved (Conroy's Gap) makes her airstrip unusable. FE has used aerial agricultural work for fertilising and spraying previously however most of her spreading is done on the ground.
 - FE stated that the wind farm makes her so angry she tries not to get involved. Her husband is involved. FE is concerned about the visual impact that the turbines would have on the area and in particular her property. FE states she is contacted occasionally with the last time a couple of months ago. FE was told that they (proponent) was going to send a landscaper to consult. She does not believe that some sort of landscaping is going to disguise the turbines. The landscaper never contacted her.
 - FE states in order to hide the turbines from view she would need shrubs growing right outside her windows. The turbines are located on a 200-300ft escarpment and sit another 120m on top of that so they will be high.
 - You can hear the frustration from FE over the phone and that she is actively trying to remain calm.
 - FE states that their airstrip is a bit redundant for this argument at the moment. FE would love jump on the argument and claim that the airstrip is used regularly however that is not the case. FE shows a level of reasonableness when speaking about this matter.
 - The airstrip is there and it has been used previously however it could cause her problems if it is not available in the future.
-

- FE asks if Defence had been consulted. Advised her that Defence had been consulted. FE was hopeful that the wind farm may stop Defence from flying low over the property and having stock go all over the place.
- FE states that this is an element of Not In My Back Yard but the wind farm seems so intrusive for the good that they do. FE states that the wind farm does distress her.
- FE makes a point about the loss of land value. They can't blindly say that there isn't any loss of land values because she has spoken to people and there are. The result could be a big financial hit for her personally if and when they want to sell.

CALL CONCLUDED
At approximately 12.25pm

7. DR MARY-ANN ROBINSON

TAG173 PTY LTD TELEPHONE CONVERSATION

Discussion Points

Tuesday 05 August 2014
Time 9.30pm – 10.04am

Conversation between: Mark Fineran MF Dr Mary-Ann Robinson DMR

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- Dr Robinson had heard that MF may work for Ambidji and therefore the review was a possible conflict of interest. MF advised that The Airport Group (TAG) is independent from Ambidji. Although review the Ambidji Aviation Impact Statement as part of the review, MF does not work for Ambidji. Dr Robinson was satisfied with the explanation.
 - MF explains that TAG has been engaged by the NSW Department of Planning and Infrastructure to undertake an independent review of the Yass Valley wind farm in relation to aviation. During the review it was identified that Dr Robinson made a submission in relation to obstacle lighting and this is why she was contacted.
 - DMR stated that a major concern she had was the photomontage received about the location of the turbines. An independent reviewer (who attended her residence) on the visual impact regarding the turbines told her that the turbines depicted in the montage are not the right size and that they are smaller than what is proposed. The name of the reviewer is not available at the time of conversation.
 - DMR has approximately 29-32 wind turbines in her line of sight and will see approximately 12 turbines fully from her residence.
 - There is a clear concern about the visual impact this will have on the area.
 - MF advised that this review relates to aviation specific matters.
 - DMR stated that the summer of 2012-2013, the bushfire that came through the area was substantially defeated with aerial bombardment. There is concern that if the turbines are established that this will impact on the ability of aircraft to fight fires.
 - DMR acknowledges that there is going to be some impact on agricultural spraying however queried if there had been any studies undertaken in an area where turbines had gone up to show the impact on activity of aerial work for agricultural purposes. MF stated as this information was not included in the documentation received, he could not comment, however he is not aware of this type of study being undertaken.
 - DMR states that Epuron did not approach her until March 2013. She was told that they had been forgotten about. When questioned about the turbines, DMR stated she did not believe that there are turbines or access roads on her property however knowing that Marilyn Garry does not want any part of the wind farm on her property, DMR is concerned that changes may result in such items being placed on her land.

- DMR had never been approached or contacted before March 2013. Since then, has received 2 visits from Mr Wilson and the photographer regarding the montages. DMR has never been invited or informed about meetings and in the previous 12 months, has read 3 reports and Epuron has produced a flyer.
- MF advised that in relation to having all the turbines lit, there has been previous wind turbines not lit. The regulator, CASA, will make a determination in due course if the turbines are an aviation impact related obstacle. MF advised DMR that in his experience, it is unlikely that the turbines will be lit as the turbines do not impact upon an air route or instrument approach. The issue of radar interference is being addressed by the proponent and Airservices Australia. Obstacle lighting is expected to be known before the obstacle is established however there are precedents where obstacles have been lit after being established.
- DMR made it clear that she does not want the wind farm. DMR also stated that a majority of the people in the area do not want the turbines however understands that some people want them as this helps with their income.
- DMR acknowledged that this did not affect aviation matters however wanted it noted that the flora and fauna assessment that was undertaken that nobody approached her as the local veterinarian for any input about wildlife such as native birds in the area. MF advised that this was out of the scope of the review however this point would be included in the minutes.
- DMR concerned about the impact the overhead high voltage power lines might have on the horses she has on her property. She is unsure the impact the electrical field may have on the animals on her property.
- DMR is also concerned that since Marilyn (Garry) had been put up as host with turbines, access roads and a substation on her property by the proponent despite Marilyn stating that she doesn't want anything to do with the turbines etc. The map DMR had (dated 15 April 2014) showed the substation moved over a fence line away from Marilyn's property but the power lines and roads were still there. The concern is that the plans could change again without addressing concerns from others which could result in powerlines and or the substation being placed across the road from her property.
- DMR would like to see a study done by a party that has no vested interest in the result. DMR stated that the reports and studies which have been completed have been done by people that have a vested interest in the result. If an independent study shows no impact then she will be satisfied however at this stage issues have not been addressed satisfactorily.

CALL CONCLUDED
At approximately 10.04am

8. MATTHEW BINGLEY

TAG173 PTY LTD TELEPHONE CONVERSATION

Discussion Points

Monday 04 August 2014
Time 09.50am – 09.58am

Conversation between: Mark Fineran MF Matthew Bingley MB

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- This was the first time we spoke. I obtained his details from Mark Glover and the reason for calling was to discuss aviation impact issues as a result of the Yass Valley wind farm.
 - MB is a Vice-Captain in the Rural Fire Service (RFS).
 - MB advises that a number of residents in the area are volunteers for the RFS. The area (Bookham etc.) has seen a number of bushfires and there have been situations where aerial support has saved his crew.
 - The last significant bushfire in which he fought burnt up to the base of the Copabella Hills. Smoke from the bushfires does make it difficult to see, both on the ground and in the air and the need to obstacle avoidance is higher when wind turbines are present. Heat and smoke would also add turbulence to aircraft flying in that area.
 - MB knows that wind turbines will prevent aircraft from accessing areas near their position (the wind turbine position).
 - MB stated that it would be irresponsible to place crew members (who are volunteers) in situation where the availability of aerial support was removed or significantly diminished. He would not order nor follow an order to place his crew in such a situation and this could result in a loss of crops, stock, storage facilities and housing.
 - MB is aware of other proposals around the area which are definitely located in known fire areas. Causes of these fires are lightning strikes. A number of people are able to put out these fires before they are too big for one or two people to suppress however this has not always been the case and areas have been burnt out.
 - MB also uses Mark Glover's airstrip for agricultural aerial work. Like Mark, Matthew's land is unable to use trucks to spread super-phosphate.
 - Should aircraft be unable to use Mark's airstrip, he advises that he will see a loss of production from his land and have a significant impact on the ability to use his land.

CALL CONCLUDED
At approximately 09.58pm

9. JIM HUTSON

TAG173 PTY LTD TELEPHONE CONVERSATION

Discussion Points

Friday 01 August 2014
Time 5.30pm – 6.20pm

Conversation between: Mark Fineran MF Jim Hutson JH

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- First time we spoke. I obtained his details from Col Adams. Although not directly involved with the Yass Valley wind farm, the issues regarding aviation were similar and I requested your input.
 - JH makes it clear that he is against wind farms.
 - Studies that JH has read, including consultant's reports about wind farms and the effects on aviation activities, are flawed and make incorrect assumptions such as no impact on aviation operations.
 - The term "Generic Circuit" was discussed as this had been included in a previous document.
 - I agreed that I have not heard this term previously.
 - The description of a generic circuit which was completed in a Cessna 150 (C150) included a turn radius of 200m.
 - As Instrument Procedure Designer, I agreed that such a turn is very small turn for designing purposes.
 - Turbulence issues that you have personally experienced and know other incidents that have been reported/documented such as an incident reported by Ted McIntosh.
 - Turbines also affect helicopter operators and you provided information about an incident that had been discussed with you. The problem of a velocity deficit in front of and at the back of the turbine appeared to be the cause of the helicopter not maintaining lift and resulting in the pilot having to hold the stick all the way back.
 - After approval is given, concern about the type of turbine installed and positioning. Again from your experience, larger turbines were installed than what had been approved and the relocation of turbines i.e. the turbines were not placed in positions that were originally planned. This was an issue for obstacle data information which is used for mapping (for aviation purposes).
 - Information from the United States that included that there had been four fatalities involving aircraft and wind turbines. This has been picked up by media outlets over there. Agricultural pilots are being paid a premium rate by some companies who control wind farms however pilots are becoming increasingly wary and reneging on these payments due safety concerns. This is demonstrating the impact on aviation operations.
 - The turbine that is located near the Crookwell airfield and the impact it has had on operations. Also that the question has been raised in Parliament about the impact it has or may cause.
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- Possible disorientation of pilots who fly near turbines. The visual effects of turbines are disorientating to the pilot. The blades are 90° however appeared to 'bend' causing some disorientation.
- Agricultural pilots, as are all low level pilots, are responsible for avoiding obstacles however judgement is made on the apparent size of known objects. Judging sizes in the air is different to than to ground but without knowing the size of turbine i.e. thinking that a 425ft obstacle (approximately 130m) and it is a 490ft obstacle (approximately 150m) would cause issue which could result in a significant event. JH provided a layman's example about the apparent size of known objects. (This example can be seen on line and demonstrates objects that are the same size, appear to be different sizes; same relates to distance and apparent size of obstacles).
- Has over 40 years' experience flying. JH was aware that CASA did commence a study into wind farms however after some time it was discovered that CASA had removed themselves from the study. No reasoning was providing for the removal.
- Has significant experience including reviewing, researching, providing evidence/testimony on matters relating to wind farms and is known by various agencies for his knowledge.

CALL CONCLUDED
At approximately 6.20pm

10. COL & SCOTT ADAMS

TAG173 PTY LTD TELEPHONE CONVERSATION

Discussion Points

Thursday 31 July 2014
Time 04.43pm – 4.54pm

Conversation between: Mark Fineran MF Col Adams CA Scott Adams SA

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- MF introduction and confirmed that Scott Adams had answered. Asked about the review and the comments regarding turbulence. SA stated that he wasn't sure about that (the comments) and advised that Col would be better to speak to regarding this matter. SA advised that they did not operate in the Yass area.
 - MF advised that the people from Ambidji had spoken to people outside the Yass area including Young Cootamundra (Coota) and Tumut. SA handed call over to CA.
 - MF introduction provided. Advised that as part of the Ambidji Aviation Impact Statement review there was concern listed by him regarding turbulence.
 - CA stated that they (wind farms) are a concern. He hasn't had time to fly behind them however he has heard stories about aircraft flying downwind of the turbines and losing control of a twin engine aircraft.
 - MF advised he was attending the area and would be willing to come out and speak to him about this matter. MF then queried if CA had heard information about the fixed wing aircraft operations around Collector. The issues were more with the turbulence from the terrain rather than the turbines. CA stated that he would not know who the fixed wing operator would be at Collector but then said he believed it may be the Yass guy – Ted McIntosh.
 - MF stated that it appears to be another person. CA provided that the person may be another older ag (agricultural) pilot from Crookwell known as Henry Hudson.
 - CA stated that he recently visited him and he (CA) saw the wind farms around Crookwell. CA said "the first thing I said to him was that somebody is going to get killed here." You've got all these wind farms in the circuit area (around Crookwell). He and I had a good discussion about that the other day. You get a good south-westerly some of these guys flying in the circuit around Crookwell and that with the turbulence so it's just a matter of time.
 - MF used the analogy that if the holes lined up in the Swiss cheese then you are going to get something through there. CA said that it's like a hollow wire sort of thing. It will get somebody one day and it's just a matter of time before the turbines get somebody.
 - MF repeated that he was coming down to Canberra that weekend and asked if CA was free for the weekend. CA stated he was free however believed that he could not help that much (in relation to this matter).
 - CA stated that Ted (McIntosh) has had some experience with turbulence. CA mentioned that there was talk about installing wind turbines in an area west of Gundagai which would have an impact upon aerial application.
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- CA stated that MF should have a discussion with Ted and also the guy in Crookwell as he knows the wind turbine issue inside out. Henry Hudson's phone number obtained. (This was Jim Hutson's number.)
- CA recalls a time when he was flying around a wind monitoring tower (mast) for half a day before he saw it. CA believes that those towers should be identifiable.
- MF advised that this was an issue that had been identified previously.

CALL CONCLUDED
At approximately 4.54pm

11. TERRY MCKENZIE

TAG173 PTY LTD TELEPHONE CONVERSATION

Discussion Points

Thursday 31 July 2014
Time 04.30pm – 4.33pm

Conversation between: Mark Fineran MF Terry McKenzie TM

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- MF introduction and that had spoken with Jenny who advised that TM was in Sydney for an RFS meeting. TM confirmed that information.
 - MF asked about the Yass Valley wind farm. TM stated that he supported the wind farm. He knew that some operators would not fly in an area where turbines were located and this meant the possibility of more work for him (at South West Helicopters).
 - TM stated that he did not have an issue with the turbines.
 - TM email address obtained in case of future contact required.

CALL CONCLUDED
At approximately 4.33pm

12. PHIL HURST

TAG173 PTY LTD TELEPHONE CONVERSATION

Discussion Points

Wednesday 20 August 2014
Time 09.34am – 10.16am

Conversation between:	Mark Fineran	MF	Phil Hurst	PH
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- MF Introduction regarding the Yass Valley wind farm project peer review on aviation specific matters. Reviewed documents including the Aviation Impact Statement and anything to do with aviation. From the information agriculture and aerial support is a big issue for the Yass Valley area.
 - MF told PH that he read his submission that was placed online and then read the comments that I had sent to him. The comments from the report appeared to different or a softening of the stance taken by AAAA. However it appeared to MF that the AAAA position has always been consistent and clarification of the comments from the report and the position of the AAAA is requested. The comments that were sent were taken from the Aviation Impact Statement Section 5.2:

“There are aerial applications carried out in the general area of the proposed wind farm and it includes spraying and dusting.

In particular South West Helicopter conducts pest and weed control in the Yass area around spring time. Col and Scott Adams the proprietors of an aerial agricultural spraying business (a second business) conduct spraying and fertilising during summer and winter. They utilise various airstrips closer to Cootamundra, Jugiong and Sandy Yates. The view of this operator was that it would affect business in the area as they would not spray or dust close to wind farms. This particular view is not in accord with most other agricultural operators views received in regard to other wind farm projects, nor the position of the Agricultural Aviation Association of Australia.”
 - PH stated that he would provide an overview of the policy update and then go into the Yass Valley area. The AAAA website shows the wind farm policy which has been consistent for about 8 years. The AAAA opposes all wind farm development.
 - PH provided background information about the policy. There was a major shift in the policy setting from the early days when the wind energy industry started. AAAA started off with a policy which was along the lines of ‘live and let live’ and we all can work together. They had some significant provisions contained in that policy which stated that if developers are going to install a wind farm then there are certain things the developer should do and this approach meant that a risk assessment was undertaken. This was about 10 years ago.
 - The AAAA believe that policy was taken advantage of by a number of developers who appeared to mislead people on our position by selectively quoting from that policy. As a result the AAAA (about 8 years ago) changed the policy to its current stance of opposing all wind farms. That is unequivocal and that stands. PH noted that the text supplied was not the

position of the AAAA and should be treated with scepticism. Further that “anyone who mentions ‘dusting’ has apparently no competence to discuss current aviation practices.”

- The AAAA starting point is that they are opposed to wind farms and their supporting infrastructure, particularly Met towers (Meteorological towers) that have now killed 2 pilots in the US. PH has done a lot of work with NASAG and the reason that there is a guideline D asking for the marking of wind towers etc.
- PH acknowledges that there is an unknown in relation to the issue of turbulence of a wind farm. PH mentions an aeronautical engineer (later discovered to be Ralph Holland) who had a website with interesting modelling which indicated that turbulence downwind of a wind farm may be a significant issue.
- AAAA’s have asked the Commonwealth and the Clean Energy Council to do research to quantify if this (turbulence) is a real thing. Nobody wants to take it on. At the same time we have CASA washing their hands of the same thing with the CEO John McCormack (who is due to leave the position) advising there are no aviation safety issues related to wind farms and nothing to do with us. PH believes this stance is not sustainable in the longer term and this may change significantly in the next 6 months when there is a new CEO at CASA.
- There are a number of unresolved issues around turbulence around the fact that there is no national reporting system so that genuine low level operators can get access to GIS systems that map where wind towers are.
- AAAA have just started reminding the NSW Planning Department about the DA exemption clause. Most of the wind monitoring towers are built under exemptions from the DA requirements. The requirement is that if the wind tower is built without a DA that it has to be removed after 3 years. (A copy of the email for forwarded to MF and attached to file.)
- AAAA is a small organisation and has a net turnover of \$600k per year, with 3 staff and with those resources they have to cope with the full suite of aviation issues, chemical issues, dangerous goods issues and hazardous chemical substances, aviation security issues which also involves chemical security as well, in addition to professional development which they run and wind farms are somewhere in the mix of aviation safety. They are a small organisation with a fairly big task. PH states that the AAAA can not go off and do this research by ourselves which we have no competence in (turbulence).
- AAAA does a lot of work with chemical application and constantly talking about droplet size and droplet behaviour in an air mass. You always have got to have a breeze with doing liquid chemical work as opposed to granular fertilizer work. Both are different operations.
- PH stated that the AAAA have got sophisticated models that they use to understand how a droplet will behave in certain circumstances. One of the issues that come up from basic physics is that if you have a permeable barrier placed in front of an air flow, the turbulence behind that barrier is generally assumed to extend 15 times the height of the barrier and this is the AAAA Rule of Thumb. So our starting point is to say until proven wrong we can assume some level of turbulence but we can’t quantify what it will be but we will assume that there will be some sort of turbulence effect from a turbine 15 times the height of the turbine.
- Aircraft are designed to operate in turbulent conditions but what is the practical impact on the aircraft with turbulence and wind farms? If the turbulence is equivalent to a normal ambient turbulent day then there is no issue and aircraft can operate right up through the middle of the turbines however what we don’t want to be accused of being reckless and unprofessional by experimenting with aircraft flying around the turbines to see what happens.

- PH believes that the wind industry has done some of the work regarding turbulence because they want to position the turbine in the second row of the array in the optimal position and not suffer from turbulence or choppy air from the turbine in front. He also believes they (wind industry) are doing this work, it's just that they don't want to tell anybody what the answer is because the physics tells you that there will be an exponential effect once you have more than one row of turbines and this will impact upon aircraft.
- Establishing what the turbulence is behind a turbine for its own benefit is useless unless it is directly related to the safety of the aircraft.
- AAAA does not have the resources available to respond to each DA as it is sent through to them. The DA's are usually passed through by a Planning Department or an Aviation Consultant such as Ambidji. PH states they we don't have the resources to comment on individual developments because how can you comment on individual developments from an aviation point of view unless you do an actual site inspection. MF agrees.
- PH recommends that the site inspection should be undertaken by a technically qualified person with lots of experience and preferably an ATO as this gives some assurance that pilot's needs are being considered.
- Our capacity to do individual assessments is zero and that is our response. We can't make individual comment on an individual developments however please note we are opposed to all developments because of their impacts upon aviation safety and the economic impact.
- PH states that the economic impact is a legitimate argument despite the Clean Energy Council of Australia trying to say that it is not a legitimate argument. Where one sector seeks to externalise its costs onto another sector there is an impact and that is what is happening to wind farms and agricultural aviation.
- PH states "Where that leaves us is a policy that is good when you are DA level and when somebody says what do you think about wind farms we can say for all these good reasons we are opposed and also here is a bunch of due diligence items that if you don't do you will be extremely liable should anything hit them.
- The National Agricultural Aviation Association (NAAA) which is the AAAA sister organisation is the USA, has written to wind farm developers and advised them under the legal principle of due diligence and duty of care, if anyone hits another one of your wind farms, you can't say you were not told about the hazard that WTG create.
- The AAAA has created some national operating protocols because in South Australia (SA) there was a conundrum where the AAAA policy stood up well in the DA stage however the needed to come up with a set of operation protocols once the wind farm is built that will protect, as best as possible, the interests of the pilot and the aircraft operator and the business owner at the same time of allowing us to operate around wind farms with some level of safety. These protocols have been adopted by the Board in May 2014. (Copy attached.) The protocols have not been circulated to the planning authorities or the wind industry but it will be in the very near future.
- Discussion had in relation to Yorke Peninsula wind farm, Ceres and Aerotech. Aerotech had to look out for its own economic wellbeing and anybody that says that there is no economic damage cause by wind farms does not understand the question (and roll on impact). The agreement is seen as a compromise and not a win-win situation however it was an example at one place where turbines are located and an agreement has been reached. This shows that options are available; you just need to work through it with the necessary people.

- The operational guidelines are not a roll-over by the AAAA. They are simply recognising the reality presented. It is not a win-win; it is a compromise to limit the economic damage to our members. It is a 2 stage process. That policy identifies what the developer should commit to at the design stage, then moves through the developers operational considerations and then talks about pilot or aircraft owner's operational considerations; it talks about economic compensation and then Appendix 1 is the NASAG guidelines for the marking of wind turbines and Appendix 2 is the aerial application pilots manual excerpts on planning and provides a bit more information.
- The overview says "At the development stage, the AAAA remains strongly opposed to all wind farms that are proposed to be built on agricultural land or land that is likely to be affected by bushfires. However, AAAA realises that some wind farm proposals may be approved in areas where aerial application takes place. In those circumstances, the AAAA has developed the following operational protocols to support a consistent approach to aerial application where wind farms are in the operational vicinity."
- MF advised that he had spoken with Ted McIntosh and Jim Hutson. PH stated that Jim has never been a member of the association (AAAA). Considers him an outlier to the industry from many years and identified him as person who may have an axe grind in relation to wind farms.
- PH advised that the whole Australian industry (Aerial Agriculture) is about the size of one state in the USA. Australia has about 300 pilots and the USA has 3000 ag pilots. Their sister organisation NAAA has more resources available to them to follow up on wind farms and recently there was a significant change where legislation was passed so that Met towers were required to be marked.
- PH stated that No national database that pilots can go to and have current information available to them at that time. RAAF tall reporting database goes nowhere except Airservices and it is not accessible to the public. Airservices after receiving the RAAF data and after 6 months may update charts which depending on the size of the tower may or may not have the tower on it. It certainly doesn't have the wind monitoring towers on it.
- PH spoke about due diligence and the hazards created by the wind industry referencing Sheather v Country Energy. There's the precedent for anybody who puts up a wind tower and they know it's a hazard which none of them can say it isn't because they've done aeronautical studies and also they've seen our policy which identifies the hazard issue. Unfortunately it will take a fatality like it took in the US for that to happen but that's the point we've been trying to avoid where a life is lost before action is taken.
- Essential Energy provides a full GIS service of all of their assets. All of their poles, we know exactly where they are and we can access that information and slave that over Google Earth. When pilots go and plan a job, they can call up the job of Google Earth and put their GIS sheets in over the top. They can see there are power lines there and so when they go out and do their aerial inspection they know that there are at least a certain number of wires to look for. Unfortunately their culture is not replicated in other States with electricity companies.
- Ted's issues can be resolved by having an aeronautical study of the turbulence created by wind farm and the correlation between the level of turbulence and various wind speeds and ability of the aircraft to outperform the turbulence. Also that study needs independent review.

CALL CONCLUDED
At approximately 10.16am

Additional Information Below:

Information received via email from William Kelly

- Email to the NSW Department of Planning dated 5 August 2014
- Final 2014 Aerial Agricultural Association of Australia National Windfarm Operating Protocols Adopted in May 2014

13. ANGUS GRAHAM

TAG173 PTY LTD TELEPHONE CONVERSATION

Discussion Points

Monday 11 August 2014
Time 12.05pm – 12.22pm

Conversation between: Mark Fineran MF Angus Graham AG

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- MF introduction. AG advised that his name came up during a meeting with Marilyn Garry. AG confirmed that they are neighbours.
 - AG confirmed that Mylora (the name of his property) has an airstrip and this is close to Marilyn Garry's airstrip. AG confirms that he generally uses Marilyn's airstrip because it has a better surface and is a bit longer than the one located on his property.
 - Does use aerial application of fertilizer and spraying of chemicals.
 - AG is not a pilot however has flown at low levels. He understands the requirements of obstacle avoidance and the attention needed when conducting low level operations.
 - AG agrees that the wind farm will definitely affect his business from an aerial and general aspect. He believed that there would have been an exclusion zone for aircraft to operate near a turbine.
 - When you have 15-16 turbines in a particular paddock, you can't apply fertiliser within a couple hundred metres of those towers or you have to fly so high that the spread of fertilizer is not accurate. This impacts upon what production you get from the land.
 - AG farm and grazier.
 - Aerial application of fertilizer and spraying is about 30% of his property. Aerial application is required due to terrain.
 - AG is having four (4) turbines towards the back end of his property from the western end. He is in the valley in between the hills of the Yass Valley wind farm and has the lower country along creeks etc. Has a fair bit of infrastructure on his land including one or two substations, power lines (approximately 9km), access roads and the permanent work site.
 - AG stated that the power lines are at or just above application height for aerial work and this is another hazard as far as fertilizer application goes and impacts upon where they can fertilize or how close they can get to the turbines.
 - AG was asked if he was in favour of the wind farm? AG admits he is on the fence. From his understanding the project is big enough to proceed. He is not completely opposed to it however people need to be compensated for the long term impacts of the project which affects their business or livelihood or market value of the land. No everybody wants to live in the middle of a wind farm. If you are a seller of land then it definitely does have a detrimental impact on it. Protecting of the asset or livelihood is important and the impact is different for
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every property. AG considers such an impact as a negative and says there is a need for proper compensation.

- If the wind farm has the ability to provide a substantial alternative income then AG considers the wind farm a positive.
- AG has been very satisfied with the level of communication. Epuron has been very good in communicating with the landholders group. He won't speak on behalf of the committee however his direct dealings have been positive every time he has requested information. Epuron have always been forthcoming. He has never restricted access to his property when requested.
- In relation to the work site and access road, when questioned if the access road will go through Marilyn's property AG replied no.
- Discussion concluded.

CALL CONCLUDED
At approximately 12.22pm



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To Whom It May Concern

Airservices Aviation Assessments for Wind Farm Developments

Guidelines to manage the risk to aviation safety from wind turbine installations (Wind Farms/Wind Monitoring Towers) are under development by the National Airports Safeguarding Advisory Group (NASAG). NASAG is comprised of high-level Commonwealth, State and Territory transport and planning officials and has been formed to develop a national land use planning regime to apply near airports and under flight paths.

The wind farm guidelines will provide information to proponents and planning authorities to help identify any potential safety risks posed by wind turbine and wind monitoring installations from an aviation perspective.

Potential safety risks include (but are not limited to) impacts on flight procedures and aviation communications, navigation and surveillance (CNS) facilities which require assessment by Airservices.

To facilitate these assessments all wind farm proposals submitted to Airservices must include an Aviation Impact Statement (AIS) prepared by an aeronautical consultant in accordance with the AIS criteria set out below.

AIS must be undertaken by an aeronautical consultant with suitable knowledge and capabilities to provide a reliable and comprehensive report. All data is to be supplied in electronic form. If you are not familiar with any aeronautical consultants, you may wish to view the list on the Civil Aviation Safety Authority (CASA) website:

http://www.casa.gov.au/scripts/nc.dll?WCMS:STANDARD::pc=PC_90412

AIS Criteria

The AIS must provide a detailed analysis covering, as a minimum:

Airspace Procedures:

1. Obstacles
 - Co-ordinates in WGS 84 (to 0.1 second of arc or better)
 - Elevations AMSL (to 0.3 metres)
2. Drawings
 - Overlaid on topographical base not less than 1:250,000. Details of datum and level of charting accuracy to be noted.
 - Electronic format compatible with Microstation version 8i.
3. Aerodromes
 - Specify all registered/certified aerodromes that are located within 30nm (55.56km) from any obstacle referred to in (1) above.
 - Nominate all instrument approach and landing procedures at these aerodromes.
 - Confirmation that the obstacles do not penetrate Annex 14 or OLS for any aerodrome. If an obstacle does penetrate, specify the extent.
4. Air Routes
 - Nominate air routes published in ERC-L & ERC-H which are located near/over any obstacle referred to in (1) above.
 - Specify two waypoint names located on the routes which are located before and after the obstacles.
5. Airspace
 - Airspace classification – A, B, C, D, E, G etc where the obstacles are located.

Navigation/Radar:

1. Detect the presence of dead zones
2. False target analysis
3. Target positional accuracy
4. Probability of detection
5. Radar coverage implications
6. We would expect the analysis to follow the guidelines outlined in the EUROCONTROL Guidelines on How to Assess the Potential Impact of Wind Turbines on Surveillance Sensors.

http://www.eurocontrol.int/sites/default/files/field_tabs/content/documents/events/guidelines-to-assess-potential-impact-of-wind-turbines.pdf

NOTE: Within the Eurocontrol Guidelines there are specific assumptions about the type of Wind Turbine for which the Guidelines are applicable (i.e. 3 blades, 30-200 m height, and horizontal rotation axis). For any deviations to the Wind Turbine characteristics listed within the Eurocontrol Guidelines, the proponent should justify to Airservices why the Eurocontrol Guidelines are still applicable.

Airservices Review of AIS

Airservices will review the quality and completeness of an AIS and will undertake limited modelling and analysis to confirm the findings and recommendations of the report.

Provided the AIS is of sound quality and is complete in accordance with the above criteria, there will be no charge for the review or limited modelling and analysis.

If the AIS is not of sound quality or is not complete in accordance with the above criteria, no modelling or analysis will be undertaken. Airservices will advise the proponent that the AIS does not meet the requirements and that the proposal cannot be assessed by Airservices.

If Airservices review of an AIS confirms impacts identified in the report (or identifies additional impacts), Airservices will advise the proponent of the impacts and the required mitigating actions (where mitigation is feasible). The proponent will also be advised that there will be charges for any mitigation actions to be undertaken by Airservices.

These charges may be advised at the time but it is likely that a detailed quote will be needed and this will only be provided on request from the proponent.

Please contact Tony Aiezza on (02) 6268 4331 or alternatively tony.aiezza@airservicesaustralia.com if you have any questions.

Current as at 13 February 2014

EUROCONTROL Guidelines

EUROCONTROL Guidelines on How to Assess the Potential Impact of Wind Turbines on Surveillance Sensors

Guidelines on How to Assess the Potential Impact of Wind Turbines on Surveillance Sensors

Edition Number	:	1.1
Edition Date	:	09/06/2010
Status	:	Released Issue
Intended for	:	General Public

DOCUMENT CHARACTERISTICS

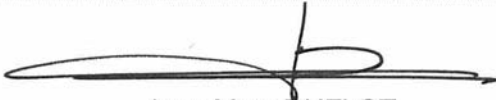
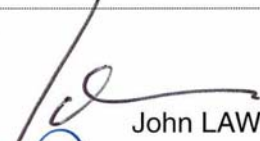
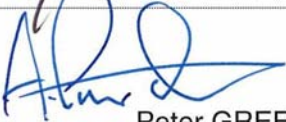
TITLE			
Guidelines on How to Assess the Potential Impact of Wind Turbines on Surveillance Sensors			
Publications Reference:			
Document Identifier EUROCONTROL-GUID-130		ISBN Number	
		Edition Number:	1.1
		Edition Date:	09/06/2010
Abstract			
This document provides guidelines for Air Navigation Service Providers (ANSP), and also wind energy developers, on how to assess whether or not wind turbines could impact upon the provision of surveillance services currently provided and identifies some possible means of mitigation. This document aims at maintaining the necessary levels of safety and efficiency of surveillance related Air Traffic Services whilst supporting to the maximum extent possible the development of wind energy. The proposed process defines different geographical zones, based on simple criteria, for each type of sensors (radar only for the time being). For each of these zones different conditions are defined to ensure that the impact of the wind turbine is tolerable. In the "safeguarding" zone, the closest area to the sensor, wind turbines are not allowed to be built. In the second zone, wind turbines can be built provided that a specific impact assessment analysis demonstrates that the impact can be tolerated. In the third zone, wind turbine can be built on the basis of the results of a simple and generic impact assessment analysis that is further described in this document. In the last zone, the impact is acceptable or even non-existent.			
Keywords			
Wind Radar Engineering MLAT	Turbine SSR Operational ANSP	Surveillance PSR ADS-B	Sensor Mode S WAM
Contact Person(s)		Tel	Unit
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STATUS, AUDIENCE AND ACCESSIBILITY					
Status		Intended for		Accessible via	
Working Draft	☐	General Public	☒	Intranet	☒
Draft	☐	CND Stakeholders	☐	Extranet	☒
Proposed Issue	☐	Restricted Audience	☐	Internet (www.eurocontrol.int)	☒
Released Issue	☒				

ELECTRONIC SOURCE		
Path:	I:\CND\COE\CNS\SUR\SUR\511 Wind Turbine TF\Methodology documents	
Host System	Software	Size
Windows NT	Microsoft Word 10.0	1972 Kb

DOCUMENT APPROVAL

The following table identifies all management authorities who have successively approved the present issue of this document.

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On behalf of the Director General, by special delegation Director CND	 Bo REDEBORN	31/05/10

DOCUMENT CHANGE RECORD

The following table records the complete history of the successive editions of the present document.

EDITION NUMBER	EDITION DATE	REASON FOR CHANGE	PAGES AFFECTED
1.0	17/05/2010	First released issue	All
1.1	09/06/2010	Correction of equation 30	67

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EXECUTIVE SUMMARY

Many countries have set ambitious renewable energy targets for the year 2020. Meeting these targets requires a considerable deployment of renewable electricity generating capacity such as wind turbines. Wind turbines can have a detrimental impact on the functioning of Air Traffic Control (ATC) surveillance.

This document provides an approach based on an early and constructive dialogue promoting reciprocal transparency between Air Navigation Service Providers (ANSP) and wind energy developers to maintain the necessary levels of safety and efficiency of surveillance Air Traffic Services whilst supporting the development of wind energy.

The document provides three elements:

- A framework process further, supported by
- A methodology to assess whether or not wind turbine could impact on the provision of surveillance services
- A (non-exhaustive) list of possible measures to be applied to the air traffic control system or wind farm to mitigate that impact.

The proposed process includes an assessment methodology that defines different geographical zones, based on simple criteria, for each type of sensor (radar only for the time being). For each of these zones different conditions are defined to ensure that the impact of the wind turbine is manageable from an operational point of view. In summary these are as follows, in the “safeguarding” zone, the closest area to the sensor, wind turbines are very likely to cause harmful interferences. In the second zone, wind turbines could be built provided that a specific impact assessment analysis demonstrates that the impact can be managed. In the third zone, wind turbines could be built on the basis of the results of a simple and generic impact assessment analysis that is further described in this document. In the last zone, from a surveillance perspective, wind turbines could be built without any constraints.

The process also foresees wind energy developers and Air Navigation Service Providers mutually assessing possible mitigation options.

The document was written by a group of civil and military surveillance experts from the ECAC countries. The procedures described are a consolidation of practical experiences supplemented by the results of third-party studies.

It is recognised that the state of knowledge and the state of technology is continuously evolving. Therefore it is desirable to keep the document updated by modifying the approach when appropriate and adding new mitigation options when available.

The application of the procedures outlined in this document is not mandatory.

EUROCONTROL makes no warranty for the information contained in this document, nor does it assume any liability for its completeness or usefulness. Any decision taken on the basis of the information is at the sole responsibility of the user.

It is noted that only ATC surveillance related aspects are covered in this document. The readers are advised to ensure that all parties that may be impacted by such deployments are adequately consulted.

1 INTRODUCTION

1.1 Background

Air Navigation Service Providers (ANSP), throughout Europe, are legally responsible for the safe and expeditious movement of aircraft operating within their designated airspace. To undertake this responsibility, each has a comprehensive infrastructure of surveillance sensors (including radars), communication systems and navigational aids.

All these ground systems have an interface with the aircraft through a Radio Frequency (RF) link. Any structure that is located between a ground-based surveillance system and an aircraft has the potential to disturb the RF link between the ground system and the aircraft.

A large number of wind turbines are being deployed within the ECAC countries in order to support the strategy of increasing the share of renewable energy (e.g. 20% by 2020 for EU states).

Both communities of stakeholders have set ambitious development objectives for the next years, and it is therefore essential to ensure that each community achieves its objectives without detrimental impact on the other's.

Recommendations such as European Guidance Material on Managing Building Restricted Areas [RD 3] have been published for protecting an ANSP's Air Traffic Management infrastructure against static structures like buildings, telecommunication masts, etc. However wind turbines are not static structures (blades are turning, blade orientation is changing, nacelle is rotating), the recommendations defined for static structures are not applicable to wind turbines.

In responses to concerns regarding interference between surveillance sensors and wind turbines, the EUROCONTROL Surveillance Team established, at the end of 2005, a Wind Turbine Task Force and gave it the responsibility to develop a recommended methodology that could be used to assess the potential impact of structures such as wind turbines on Surveillance Systems and to provide suggestions for possible mitigation options.

This methodology and the framework process, in which it is embedded, are described in this document. They aim at maintaining the necessary levels of safety and efficiency of surveillance related Air Traffic Services whilst supporting to the maximum extent possible the installation of wind turbines.

1.2 EUROCONTROL Guidelines

EUROCONTROL guidelines, as defined in EUROCONTROL Regulatory and Advisory Framework (ERAF) [RD 5], are advisory materials and contain:

"Any information or provisions for physical characteristic, configuration, material, performance, personnel or procedure, the use of which is recognised as contributing to the establishment and operation of safe and efficient systems and services related to ATM in the EUROCONTROL Member States."

Therefore, the application of EUROCONTROL guidelines document is not mandatory.

In addition, it is stated in [RD 6] that:

“EUROCONTROL Guidelines may be used, inter alia, to support implementation and operation of ATM systems and services, and to:

- complement EUROCONTROL Rules and Specifications;*
- complement ICAO Recommended Practices and Procedures;*
- complement EC legislation;*
- indicate harmonisation targets for ATM Procedures;*
- encourage the application of best practice;*
- provide detailed procedural information.”*

1.3 Objective of this document

The objective of this document is to provide a concise and transparent reference guide for both ANSPs and Wind Energy developers when assessing the impact of wind turbines on ATC surveillance systems.

This reference guide relies on a framework process including an assessment methodology and mitigation options. The assessment methodology is based on establishing when ATC services based on surveillance information could be affected beyond manageable level by the construction of a proposed wind turbine development.

For radar, the key performance characteristics are defined in the EUROCONTROL Standard Document for Radar Surveillance in En-route Airspace and Major Terminal Areas [RD 1]. They are used throughout this document when assessing radar performance.

For the time being the assessment methodology is limited to mono-static ATC radar surveillance sensor (Primary Surveillance Radar – PSR, Secondary Surveillance Radar – SSR); it is the intention to extend it to other technologies like Wide Area Multilateration (WAM), Automatic Dependent Surveillance Broadcast (ADS-B) and Multi-Static Primary Surveillance Radar (MSPSR) if relevant.

Initial studies showed that these technologies, which currently have different levels of maturity¹, are likely to be less susceptible to wind turbines than radars. Therefore, they could be implemented as possible mitigations in certain cases, provided that their deployment has been fully validated in the ATC context. Other currently available mitigations are described in section 4.6.

Wind turbines can also have detrimental impacts upon other aspects of air transport. Such aspects include, but are not limited to, performance reduction of ATM infrastructure (Communication, Navigation), constraints on procedure design, airspace planning and design, minimum safe altitudes, climb rates of aircraft, descent rates of aircraft, procedures to ensure that wind turbine locations are correctly represented on maps and in terrain avoidance tools, procedures to ensure that they are appropriately lit etc.

¹ It should be noted that MSPSR maturity is currently at a research status.

These aspects have to be addressed in accordance with the relevant documents. In particular, the European guidance material on managing Building Restricted Areas (BRA) (ICAO doc 015 [RD 3]) provides some specific recommendations in its Appendix 4 regarding wind turbine assessment for navigation facilities.

The relationships between these guidelines and ICAO doc 015 [RD 3] are further described in section 1.9 below.

1.4 Designing the Assessment Methodology

When producing this methodology the objective was to document a mechanism that was simple in its application and transparent in its structure.

Secondary Surveillance Radars (SSRs) are classified as a cooperative surveillance technique – equipment on board the aircraft receives an interrogation from the ground station and cooperates by replying with a signal broadcast of its own. The need to interface with the transponder carried by the aircraft means that, whilst various technologies can be employed (classical sliding window SSR, Monopulse SSR and Mode S SSR), Secondary Surveillance Radars are well standardised. This high degree of consistency between co-operative surveillance systems allows the prediction of a single range beyond which it is believed that wind turbines would have only a manageable impact upon the performance of an SSR system. Up to that range the deployment of wind turbines would only be permitted if a comprehensive study demonstrates that no detrimental impact will arise.

Primary Surveillance Radars differ in that the aircraft is non-cooperative and the only 'interface' is the electro-magnetic energy reflected from the body of the aircraft. In this sense the technique is classified as non-cooperative. The disparate nature of non-cooperative surveillance systems, such as Primary Surveillance Radar (PSR), requires a more complex approach tailored to the specific technology employed and the environment in which it is operated.

Whilst the basic physics behind non-cooperative target detection are common it can be said that no two designs of Primary Surveillance Radars achieve the same end goal by following the same approach. The following, non exhaustive, list highlights some of the considerations that should be taken into account to carry out a full, detailed and analytical assessment into whether a technical interference would result from the placement of a wind turbine in the proximity of a PSR:

- Antenna Design – ATC PSR systems normally use an antenna with a complex Cossec2 beam pattern, typically with two beams (one Tx/Rx and one Rx only) – each beam with a different pre-set elevation angle. Each antenna has different characteristics, from the electrical elevation, through to gain and Integrated Cancellation Ratio and such parameters impact upon how much of a wind farm would be 'illuminated' by the radar and how much of the return would be passed to the subsequent receiver stage. The horn arrangement may support linear or circular polarized transmission or be switchable between the two. Phased array antennas present a different approach.
- The turning gear rotating the antenna is not an immediate consideration except for the fact that many can apply mechanical tilts to the antenna pattern to optimise either low level detection or minimise ground clutter returns.

- The receiver stages of the PSR would normally permit the application of one or more Sensitivity Time Control (STC) laws to reduce the impact of ground clutter. The STC is normally integrated with multiple beam switch points (switching between the signals received from either the high or low antenna beam).
- The transmitted signal can differ significantly depending upon the technology employed – either a magnetron, a solid state system or a travelling wave tube etc. The choice of driver influences the waveform, the number and characteristics of the pulses, the frequency band, the utilisation of frequency diversity schemes etc. The frequency band selected can also impact upon the susceptibility of the system to anomalous propagation effects.
- The signal processing techniques and capabilities differ – sub-clutter visibility and ground clutter rejection capabilities vary and the rejection capabilities differ significantly between different types of sensor, types of signal processing, such as MTI or Moving Target Detection (MTD) and the system parameter settings established during site optimization and flight trials.
- Plot extraction techniques are often employed to facilitate further processing and to reduce the bandwidth of the data signal to be transmitted from a remote PSR to an ATC control centre. The resulting data reduction also removes the possibility of an ATC to review the ‘raw video’ of the radar and this can impact upon the ability of a controller to monitor flights over areas where wind farms are deployed.
- Some PSRs are equipped with mono-radar track processing capabilities and these could be used to suppress radar returns from over wind farms. Unfortunately this can also often result in suppressing the returns from valid targets as well – the performance of any mono-radar tracker will therefore also need to be taken into account when conducting an assessment of whether wind farms will impact upon the performance of such systems.
- The geographic environment plays a great part in defining radar coverage. Considerations such as radar horizon would obviously drive requirements for tower heights. Proximity to the sea or large areas of flat or marshy land can result in beam ducting whilst the shape of mountains and whether they are sparsely or heavily covered in either snow or vegetation can also increase or decrease the radar returns. The nature of the aircraft to be detected and the airspace in which they fly will also determine design and deployment considerations.

The authors of the document have taken key characteristics into account to produce a simplified approach to be used when conducting an initial assessment of whether wind turbines deployed in the proximity of a PSR would result in performance degradation for the latter.

Whilst this initial assessment may err on the side of caution from the radar operators perspective, the authors also fully support the wind farm applicant in their right to conduct their own detailed assessment and to this end have provided some guidelines for how to perform such an assessment – these guidelines can be found in the supporting annex of this document.

Surveillance providers will be able to assist in the detailed assessment by providing key radar characteristics to be used in the detailed assessment performed by the applicant but, depending upon the PSR, additional support may also need to be sought from the manufacturer of the system.

To summarise, the approach adopted within the methodology is for an initial safeguarding region in the vicinity immediately surrounding the surveillance sensor within which all planning applications would be objected. Beyond this restrictive zone lie regions where progressively reducing levels of proof are required. The approach is common for both the cooperative and non-cooperative surveillance techniques covered within this document.

1.5 Application of the assessment methodology

The methodology is based upon the following zone arrangements:

- **Zone 1: Safeguarding Zone (PSR and SSR):**
An initial restrictive or safeguarding region that surrounds the surveillance sensor. No developments shall be agreed to within this area.
- **Zone 2: Detailed Assessment Zone (PSR and SSR):**
Following the safeguarded region is an area where surveillance data providers would oppose planning applications unless they were supported by a detailed technical and operational assessment provided by the applicant and the results of which are found to be acceptable to the surveillance provider.
The detailed technical assessment shall be based upon the approach detailed in paragraph 4.4.
- **Zone 3: Simple Assessment Zone (PSR only):**
Beyond the detailed assessment zone is a region within which a simple assessment of PSR performance, as detailed in section 4.3, should be sufficient to enable the surveillance data provider to assess the application.
- **Zone 4: Accepted Zone (PSR and SSR):**
Beyond the simple assessment zone are areas within which no assessments are required and within which Surveillance Service providers would not raise objections to wind farms on the basis of an impact to surveillance services.

It is important to note that the zones are based upon a combination of range from the sensor and radar line of sight and therefore are not necessarily annular bands.

If necessary ANSPs and wind energy developers should discuss and agree mitigation options (see paragraphs 2.6 and 4.6) to overcome issues that have been identified in the course of the assessment.

1.6 Structure of the document

This document is structured in 5 chapters and 5 annexes:

- Chapter 1, this chapter provides an introduction to the document describing its background, its objective, its approach, its structure and its use.
- Chapter 2 describes the process flow when assessing the impact of wind turbines on surveillance sensors.
- Chapter 3 defines the required input information needed to undertake the previously defined process.
- Chapter 4 specifies for radar sensors the different zones, the simple impact assessment process, and the issues to be addressed, as a minimum, in the frame of the detailed assessment process. It also contains a table identifying possible mitigation options.
- Chapter 5 provides the lists of referenced documents and the definition of acronyms.
- Annexes A to C justify and describe the different equations that are used in the different assessments described in chapter 4.
- Annex D provides the justification for the selection of the zone 2 range defined for SSR.
- Annex E proposes a wind energy project description pro-forma.

1.7 Use of this document

This document is intended to be read and used by:

- Civil and military Air Navigation Service Provider (ANSP)
- Surveillance data provider
- National Supervisory Authority (NSA)
- Civil and military aviation authority
- Wind energy developer

EUROCONTROL makes no warranty for the information contained in this document, nor does it assume any liability for its completeness or usefulness. Any decision taken on the basis of the information is at the sole responsibility of the user.

1.8 Conventions

The following drafting conventions are used in this document:

- **“Shall”** – indicates a statement of specification, the compliance with which is mandatory to achieve the implementation of these EUROCONTROL Guidelines.
- **“Should”** – indicates a recommendation or best practice, which may or may not be applied.
- **“May”** – indicates an optional element.

1.9 Relationship with ICAO Doc 015 [RD 3]

The aim of this document is to supplement ICAO doc 015 [RD 3]. In particular with respect to § 6.4 where it is stated that: *“For surveillance and communication facilities it is recommended that wind turbine(s) should be assessed at all times even outside the BRA for omni-directional facilities.”*

2 IMPACT ASSESSMENT PROCESS

Figure 1 describes the generic process to be followed by ANSP and the wind energy developers when assessing the impact of a wind turbine project on surveillance infrastructure. This diagram has deliberately been kept at a high level to be compatible with formal and informal requests.

Wind energy developers are invited to initiate this process on the basis of these guidelines as soon as possible in the preparation phase of their project. At the earliest stages of the project, when there is more room for adaptation, it is anticipated that cost effective mitigation options (see section 4.6 for some possible mitigations) could be agreed; whereas at later stages, viable mitigation options could be more difficult to define and to agree on.

In order to facilitate this dialogue, it is recommended that ATM stakeholders (e.g. ANSP, NSA) publish a single point of contact (e.g. a generic email address) through whom initial contact can be established.

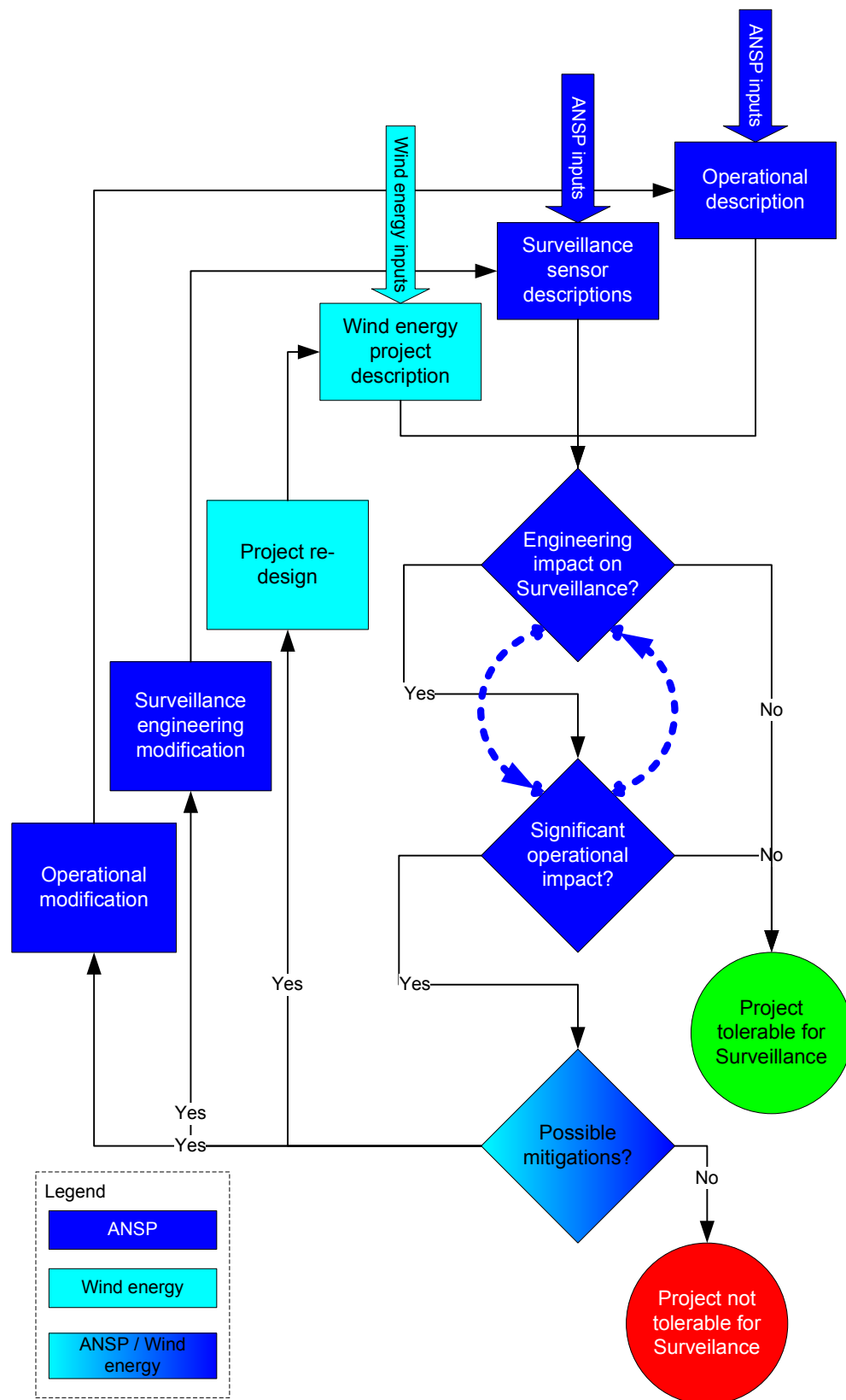


Figure 1: Impact Assessment Process

On Figure 1 the activities have been allocated on the basis of a formal request. In theory any activity can be undertaken by anybody provided that they have all the required pieces of information and the relevant knowledge.

2.1 Wind energy project description

This is a wind energy developer activity; it consists of collecting all the relevant wind energy project information to perform an impact assessment on the proposed development.

The information to be provided is described further in Section 3.1.

This project description shall be provided with any formal request to get a formal advice from the ANSP. It is to be noted that this process only addresses the impact on surveillance infrastructure, whereas the project may have other impacts that the ANSP have to assess. It is also to be noted that formal requests will be governed by state policy and as such will have to respect a number of national rules.

This project description may also be provided through an informal request at the earliest possible stage to avoid any further nugatory works. This is typically an informal approach to gauge reaction to a new development which is still at the exploratory stage of design. This should be encouraged, as early changes to a development proposal, prior to formal submittal to the planning authorities, are much easier to introduce to meet the needs of the ANSP.

By whatever route notification is received, it is important that as much of the relevant information is included as possible. At a pre-planning stage precise details of turbine locations and dimensions are often not fixed therefore any results based on this incomplete information must obviously be caveated such that relevant decision making authorities treat them with caution. Any change in the design proposal will require a re-assessment.

2.2 Surveillance sensor description

This is an ANSP activity; it consists of collecting all the relevant surveillance sensor information to perform an impact assessment on the proposed development.

In case the sensor is associated to a Far-Field Monitor (FFM), information related to that FFM is also needed.

The information to be provided is described further in Section 3.2.

This surveillance sensor description shall, subject to appropriate security and confidentiality considerations, be made available on request for preliminary analysis or site selection to wind energy developer.

2.3 Operational description

This is an ANSP activity; it consists of collecting all the relevant operational information (e.g. aeronautical navigation routes) to perform an impact assessment on the proposed development.

The information to be provided is described further in Section 3.3.

This operational description may, subject to appropriate security and confidentiality considerations, be made available on request for preliminary analysis or site selection to wind energy developer.

This operational description shall, subject to appropriate security and confidentiality considerations, be made available in response to a formal request attributable to a specific planning application

2.4 Engineering impact on surveillance

This is an ANSP activity, which consists of assessing the potential performance impacts that the submitted wind energy project could have on individual surveillance sensors operated by the ANSP, to derive the impact it may create at the output of the surveillance system and to consider possible mitigation mechanisms that could be introduced.

The assessment is described further for each type of radar in Chapter 4.

Although it is recognised that in most cases the sensor outputs will not be provided directly to the Air Traffic Controllers, but will go through further processing stages like Surveillance Data Processing systems; there are still some cases where the sensor output is used operationally (in normal or in fall-back mode). Therefore the maximum effort should be undertaken to minimise the impact of wind turbines at the earliest stages of the surveillance chain i.e. at the surveillance sensor level.

The application of specific features at surveillance data processing level is considered as a possible mitigation. Further mitigation possibilities may also be considered – a range of these are identified in section 4.6.

At this stage, the methodology encourages an ANSP engineering department to initiate discussions with the operational staff (as shown with the curved arrows on Figure 1) to assess the potential technical and operational impacts of the wind energy project in order to identify realistic mitigation measures that, in general, have both engineering and operational implementation aspects.

2.5 Operational impact on surveillance

This is an ANSP activity, which consists of assessing the impacts that the submitted wind energy project could have on the ANSP operations based on surveillance services and/or on the surveillance data service the ANSP is providing to other users.

This activity is described further for each type of radar in Chapter 4.

It is to be remembered that an ANSP is held legally accountable for the safe provision of service at all times.

As stated in paragraph 2.4 above and although the engineering and operational impact assessment stages are shown as two different boxes on Figure 1, a strong cooperation between the operational and engineering departments of the ANSP is needed to ensure that all aspects have been analysed and that all possible mitigations have been identified.

2.6 Possible mitigations

This is a combined ANSP/wind energy developer activity, which consists of identifying potential modifications to the surveillance system **and/or** the operational environment **and/or** the wind energy project that could mitigate to a tolerable level the impact of the wind energy development project.

This activity should be based on a transparent, coordinated and balanced approach with the objective of finding a solution that can be agreed by all parties.

When assessing mitigation options the following criteria shall be taken into account:

- Air traffic safety is maintained
- Cost efficiency based on through life cost over an agreed time period

The detailed assessment required to judge the suitability of such mitigations is beyond the scope of these guidelines due to their site specific nature.

2.7 Project re-design

This is a wind energy developer activity, which consists of taking into account in his project the possible mitigations identified at the previous stage to make the project impacts tolerable.

2.8 Surveillance engineering modification

This is an ANSP activity, which consists of taking into account the possible mitigations identified at the previous stage and that are applicable to the surveillance system to make the project impacts tolerable.

It is desirable that any surveillance engineering modification should be carbon neutral and have no detrimental impact on the environment.

2.9 Operational modification

This is an ANSP activity, which consists of taking into account the possible mitigations proposed at the previous stage and that are applicable to the operational environment to make the project impacts tolerable.

It is desirable that any operational modification should be carbon neutral and have no detrimental impact on the environment (e.g. noise, longer routes, etc.).

3 INPUT INFORMATION

3.1 Wind energy project description

A simple way that an ANSP can ensure that planning authorities and developers understand what information is required prior to an assessment is by making available a pro forma which developers can complete and submit. The following list of requested information has been constructed based on the pro-forma used by different stakeholders and is further developed in Annex - E where a practical pro-forma can be found. The different parts of a wind turbine are identified on Figure 2 below.

The following parameters are needed to perform the simple engineering assessment:

- Hub height (above ground level in m)
- Rotor diameter (m)
- Turbine locations (National Grid system and/or WGS84 including terrain height)

Additional parameters could be needed to perform the detailed engineering assessment, for example:

- Wind turbine model and manufacturer
- Number of blades
- Rotation speed (Rpm) nominal and maximum
- Tower design (tubular/lattice)
- Tower base diameter (m)
- Tower top diameter (m)
- Nacelle Dimensions (width x length x height in m)
- Rotor blade material including lightening conductor

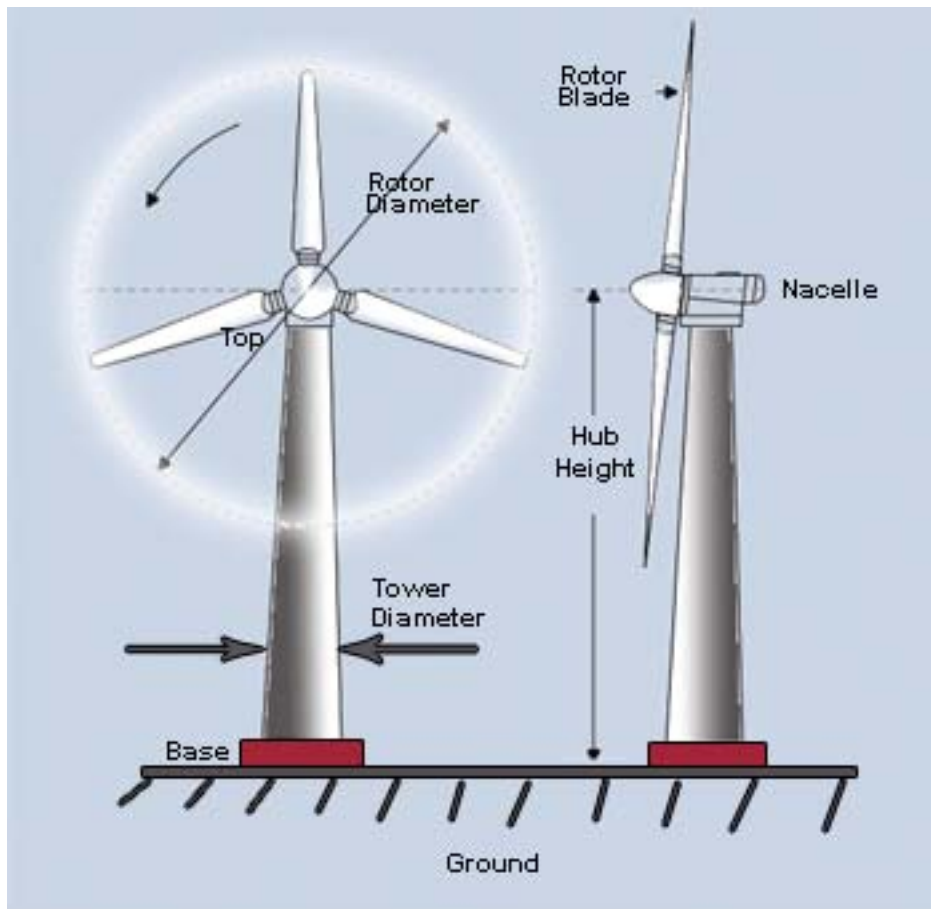


Illustration identifying wind turbine components and key parameters

Figure 2: Wind turbine diagram

3.2 Surveillance sensor description

The list of information needed to undertake the simple engineering assessment is the following:

- Radar line of sight calculation method/tool
- Primary Surveillance Radar:
 - o Antenna 3D position (WGS84 and/or national grid system and height above terrain)
 - o Frequency range (in GHz)
 - o Instrumented range (in NM)
 - o Antenna horizontal beam-width at 3 dB (in °).
 - o Information related to CFAR processing as required to undertake the assessment described in section 4.3.1
 - o Radar processing capacities (e.g. plots, tracks)
 - o Overload prevention technique

- SSR:
 - o Antenna 3D position (WGS84 and/or national grid system and height above terrain).
 - o Antenna horizontal beam-width at 3 dB (in °) – 2.4° by default.
- SSR/PSR far-field monitor:
 - o Position (WGS84 and/or national grid system)

In addition, further parameters could be needed to perform the detailed assessment, for example:

- Primary Surveillance Radar:
 - o Antenna transmit vertical pattern.
 - o Antenna receive vertical pattern.
 - o Antenna tilt (in °).
 - o Frequencies used (in GHz).
 - o Anti-reflection processing capabilities (number of reflectors, number of reflections).
 - o Transmitted power (in dBW).
 - o Receiver, signal and data processing capabilities.
- SSR:
 - o Type: classical sliding window, monopulse, Mode S.
 - o Anti-reflection processing capabilities (number of reflectors, number of reflections).
 - o Receiver, signal and data processing capabilities.
 - o Overload prevention technique.

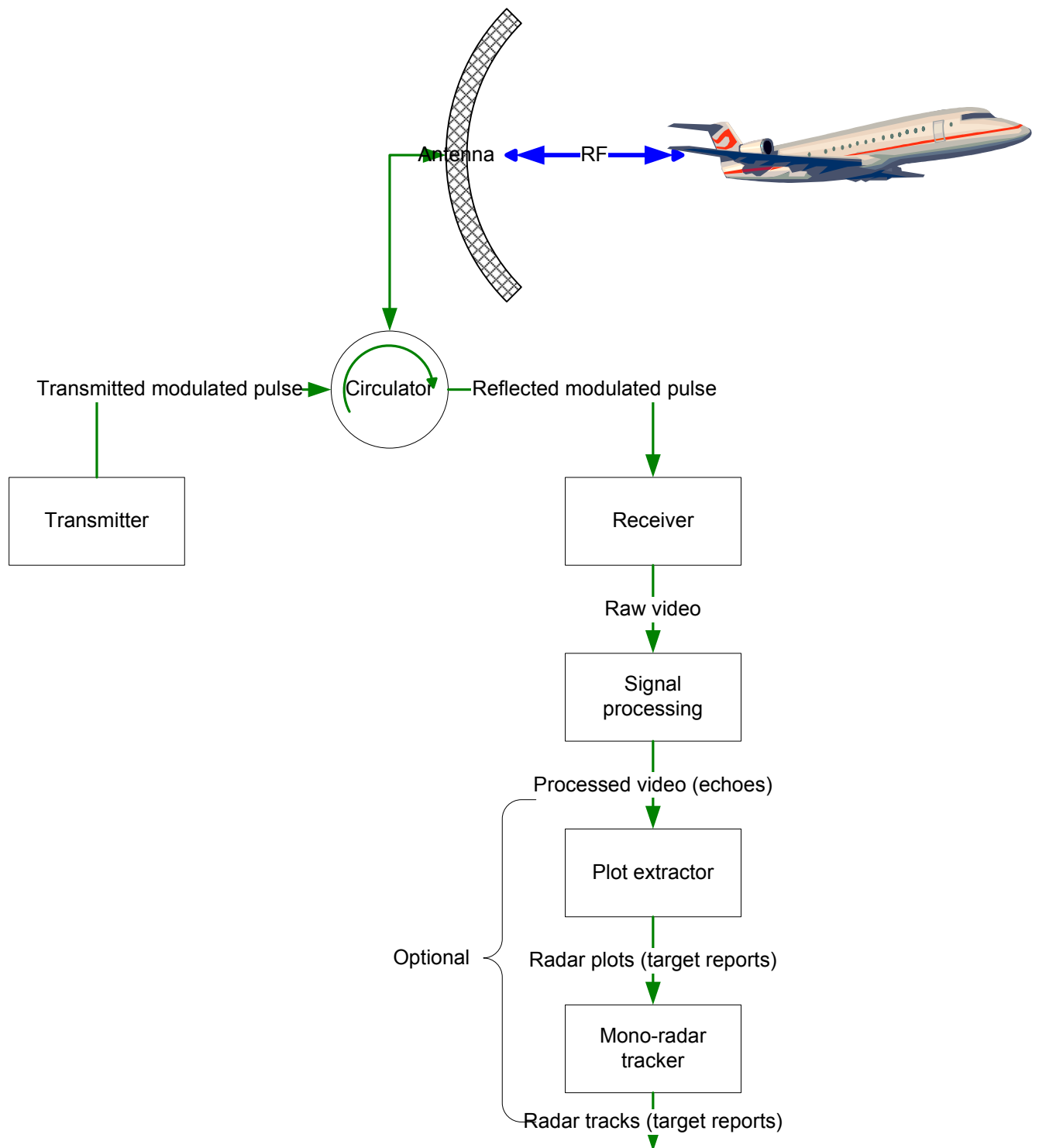


Figure 3: Primary Surveillance Radar diagram

The diagram above illustrates the main components of a modern primary surveillance radar system; the radar output may also be at processed video or at plot level. The radar output may be connected directly to a Controller Working Position or to a multi-sensor tracker for further processing.

The picture below (Figure 4) shows a primary radar antenna co-mounted with a secondary radar antenna (on top).



Figure 4: Primary and secondary co-mounted radar antennas

3.3 Operational description

The information needed to undertake the operational impact assessment is the 3D airspace volume, per ATC service² (e.g. 3 NM horizontal separation, parallel runway monitoring, vectoring), where surveillance information is required to support ATC operations.

² The different ATC services are described in Chapter 8 of [RD 4].

4 RADAR IMPACT ASSESSMENT

Information on how such an assessment can be performed is contained within the following paragraphs. The assessment shall be conducted for each sensor that has at least one wind turbine within its range coverage.

4.1 Radar line of sight assessment

The first assessment that shall take place is to determine whether or not any part of the turbine will be within the line of sight of the radar (i.e. from the electrical centre of the radar antenna). If the turbines are located in a way that does not affect the surveillance sensor performance (e.g. the turbines are fully 'hidden' from the sensors by terrain or the turbines are located further away than the radar instrumented range), then consent for the development can be approved. However if a part of the wind turbine (e.g. a blade) can be in radar line of sight then there is potential for an impact upon the radar.

Tools are available to undertake this assessment. Each of them has some specific features and some limitations. The focus is put on the agreement to be reached between the ANSP and the wind energy developer to select a tool that is familiar to the ANSP and which is parameterised in accordance with the local conditions and/or the type of assessment (e.g. the accuracy of the digital terrain modelling may depend on the distance between the wind turbine and the radar and/or whether a simple or a detailed assessment is being conducted).

4.2 Top-level engineering assessment

In order to facilitate this process, different zones have been defined corresponding to different levels of engineering assessment. They are summarised in the tables below.

It should be noted that Zone 2 is not a No-Go area but indicates where further consideration needs to be applied compared to Zone 3. In any case wind turbines could be placed in zone 2 or zone 3 if no intolerable impact would result from their deployment.

4.2.1 Primary Surveillance Radar

Zone	Zone 1	Zone 2	Zone 3	Zone 4
Description	0 - 500 m	500 m - 15 km and in radar line of sight	Further than 15 km but within maximum instrumented range and in radar line of sight	Anywhere within maximum instrumented range but not in radar line of sight or outside the maximum instrumented range.
Assessment Requirements	Safeguarding	Detailed assessment	Simple assessment	No assessment

Table 1: PSR recommended ranges

The PSR safeguarding range where no wind turbine shall be built is derived from the recommendations provided in the ICAO EUR 015 document [RD 3] which is applicable for any obstacle (r: radius of the first cylinder on figures 2.1 and 2.2).

PSR radar designs vary considerably and the design choices made by PSR manufacturers influence the susceptibility of their radars to wind turbines (see paragraph 1.4 above). The figure for the PSR recommended limit between detailed and simple assessment is therefore derived from the best practices collected from the ECAC member states and it is also a figure recognised in the ICAO EUR 015 document [RD 3] (R: radius of the second cylinder on figures 2.1 and 2.2).

Therefore these figures are applicable to current wind turbine design, e.g. 3-blades, 30-200 m height, horizontal rotation axis. For other types of turbines, it is recommended to undertake the detailed assessment as long as the wind turbine is in radar line of sight.

When outside the radar line of sight of a PSR, the impact of the wind turbine (3-blades, 30-200 m height, and horizontal rotation axis) is considered to be tolerable.

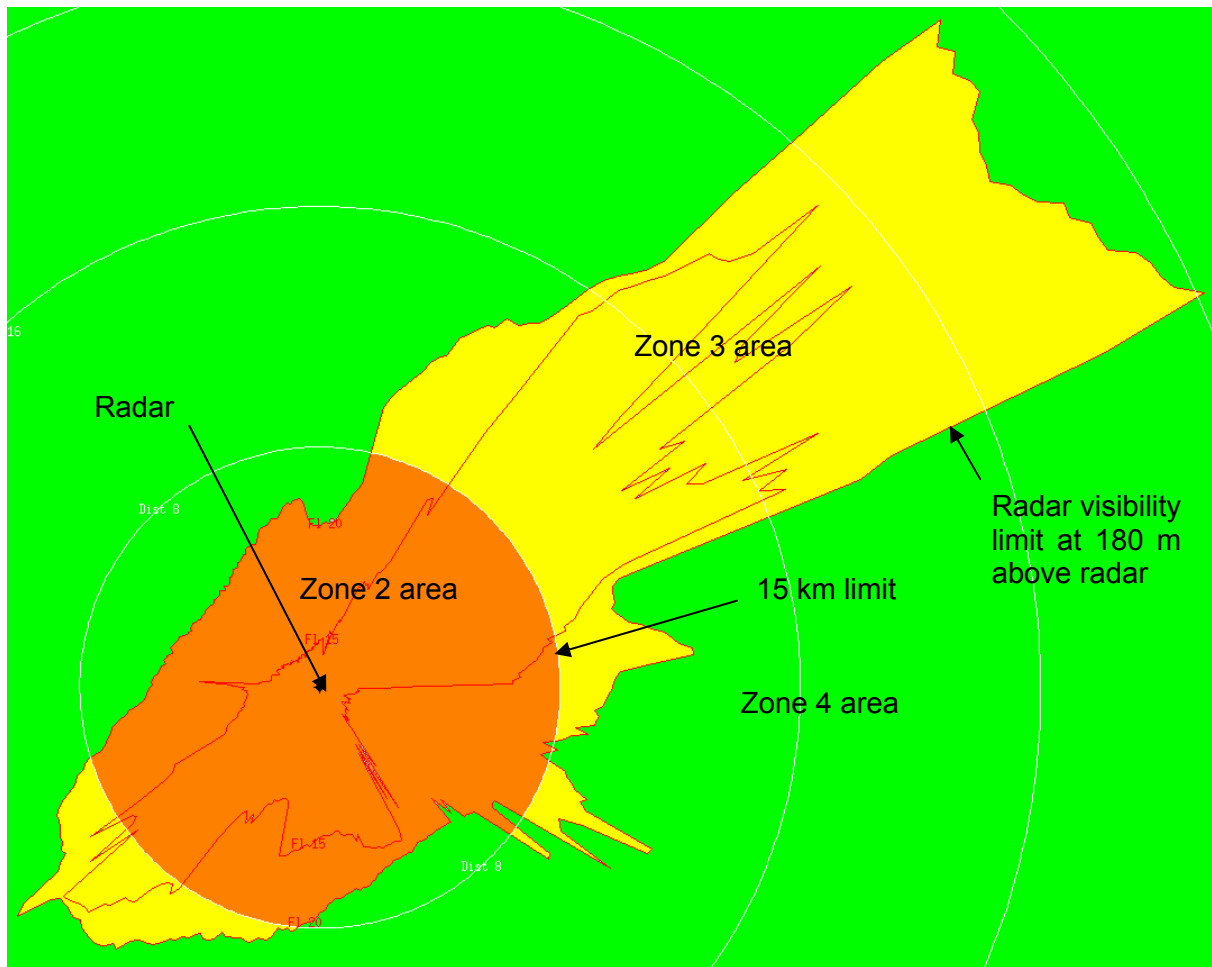


Figure 5: Example of zones at 180 m above a real radar

Figure 5 above shows that the different zones are not annular bands (unless in a theoretical no obstacle environment) and their shape depends on the terrain surrounding the radar. These zones have been calculated on the basis of a real radar and, for this example, at 180 m above the radar ground level.

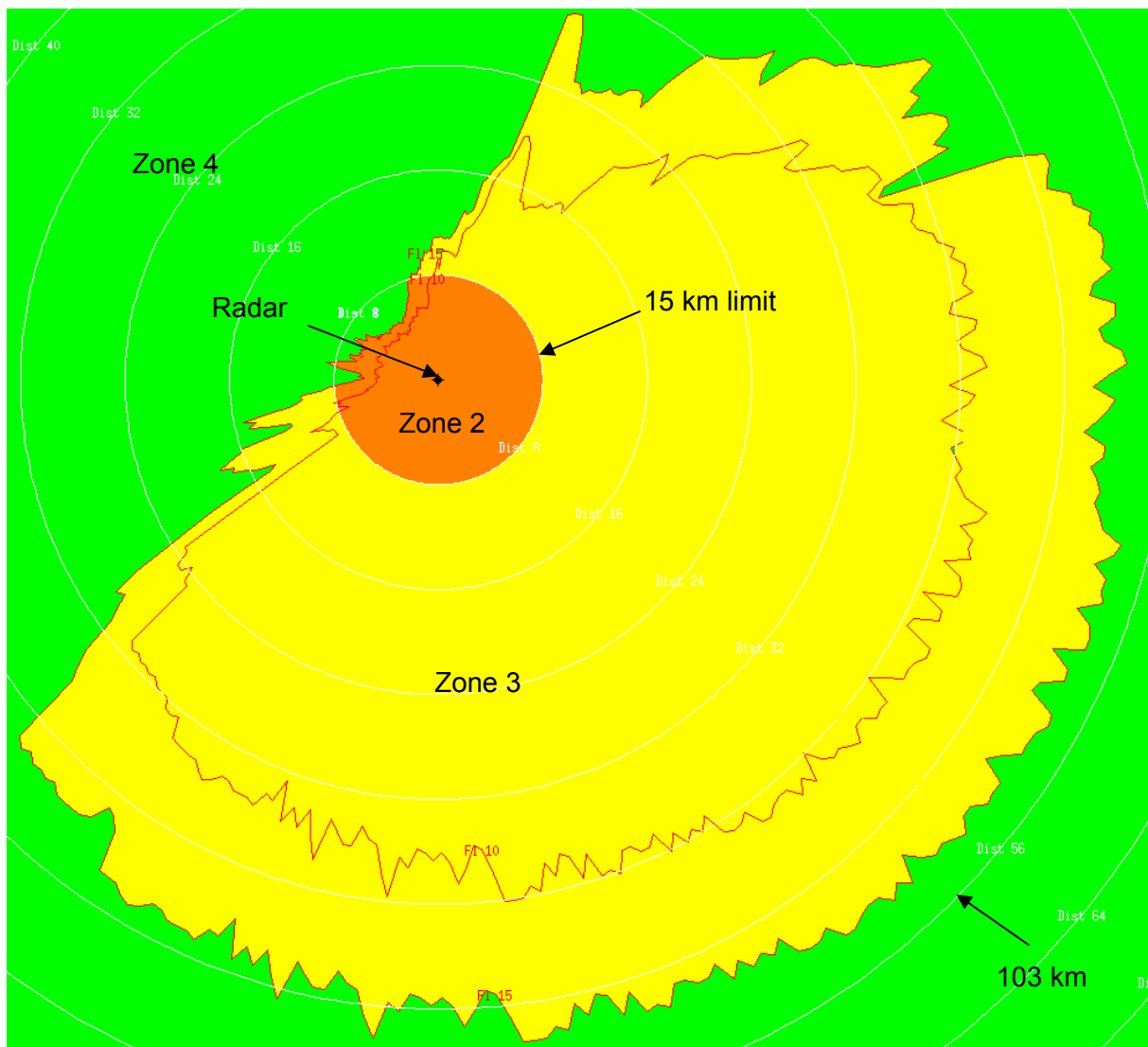


Figure 6: Example of zones at 320 m above a real radar

Figure 6 above shows another example of the different zones around a real radar at 320 m above the ground level at the radar site.

4.2.2 Secondary Surveillance Radar (classical, monopulse and Mode S)

Zone	Zone 1	Zone 2	Zone 4
Description	0 - 500 m	500 m - 16 km but within maximum instrumented range and in radar line of sight	Further than 16 km or not in radar line of sight
Assessment Requirements	Safeguarding	Detailed assessment	No assessment

Table 2: SSR recommended ranges

The SSR safeguarding range where no wind turbine shall be built is derived from the recommendations provided in the ICAO EUR 015 document [RD 3] which is applicable for any obstacle (r : radius of the first cylinder on figures 2.1 and 2.2).

The figure for the recommended limit of SSR detailed assessment is further justified in Annex - D based on the SSR specifications provided in ICAO Annex 10 Volume IV [RD 2].

As the justifications developed in Annex - D are based on current wind turbine design, e.g. 3-blades, 30-200 m height, horizontal rotation axis. For other types of turbines, it is recommended to undertake the detailed assessment as long as the wind turbine is in radar line of sight.

It is to be noted that in the case of SSR there is no simple assessment zone.

When outside the radar line of sight of an SSR the impact of the wind turbine is considered to be tolerable.

When further than 16 km from an SSR the impact of a wind turbine (3-blades, 30-200 m height, and horizontal rotation axis) is considered to be tolerable.

4.2.3 Radar Far-Field Monitors (FFM)

In addition, irrespective of the zone in which the wind turbine falls, it is recommended to protect the radar far-field monitor as described below.

Wind turbines shall not be built in a sector of 2 times the radar antenna horizontal beam-width at 3dB, centred on the far-field monitor azimuth and limited up to the range of the far-field monitor (as illustrated on Figure 7 below). This is applicable to far-field monitors of primary or secondary surveillance radar.

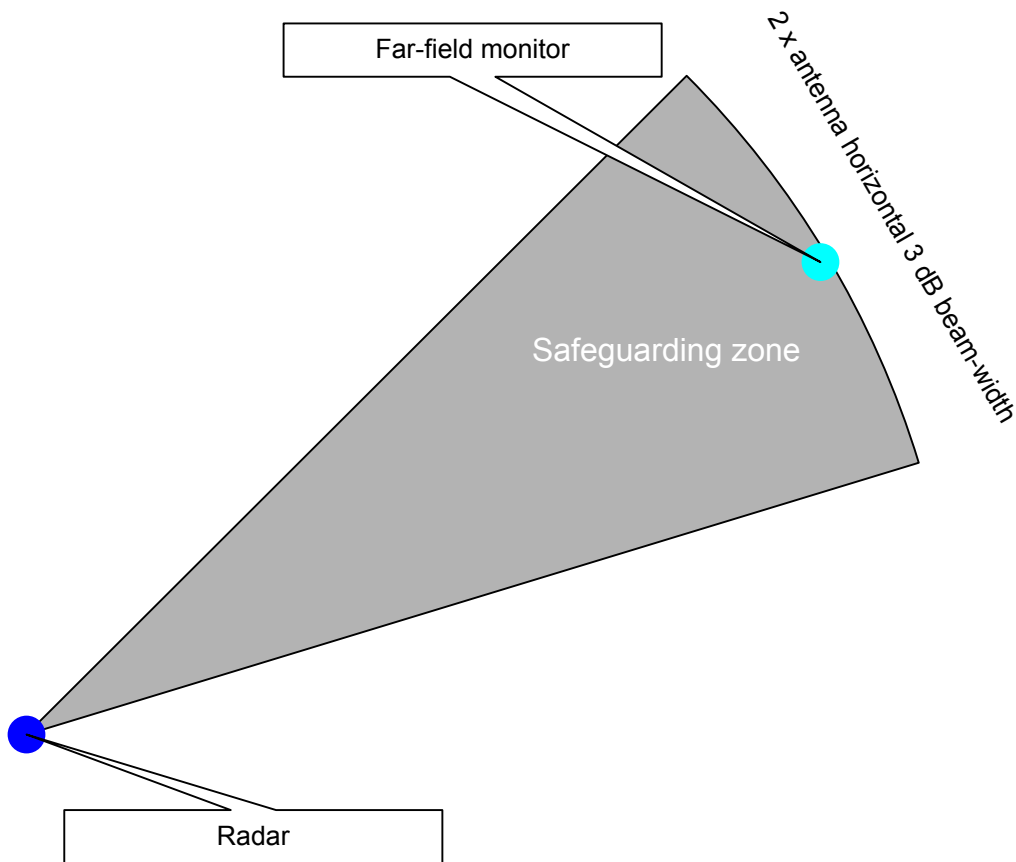


Figure 7: Recommended protection zone for far-field monitor

Possible mitigations are to move either the wind turbine or the far-field monitor.

4.2.4 Radar data sharing

In case the surveillance data provided by the impacted radar is shared, the radar data user should be informed of the wind turbine project. If applicable, the engineering assessment process shall take into account any radar data quality requirements imposed by the SLA (Service Level Agreement) associated to this radar data sharing.

4.2.5 Cumulative impact

As further detailed in the following sections, the impact of wind turbines on the operational service provided by a radar depends on the number of wind turbines located in the radar line of sight. Therefore it is strongly recommended that ANSP's keep an accurate tracking of all the approved wind energy projects. With this information they will be able to conduct the impact assessment of the new project in conjunction with the neighbouring approved projects that may already affect the performance of radars.

4.3 Simple engineering assessment for PSR

4.3.1 PSR Probability of detection

One of the key performance characteristic of a Primary Surveillance Radar, as defined in § 6.2.2.2 of the EUROCONTROL Standard Document for Radar Surveillance in En-route Airspace and Major Terminal Areas [RD 1], is the probability of detection.

When a wind turbine lies in the line of sight of the PSR, the probability of detection can be reduced in two ways:

- In a shadow region directly behind the turbine (region 1 on Figure 8).
- In a volume located above and around the wind turbine (region 2 on Figure 8).

The first effect is caused by the attenuation due to the wind turbine being an obstacle for the electromagnetic field. The second effect is caused by the large amount of energy reflected back by the wind turbine, causing an increase in the radar's detection threshold (CFAR) in the range-azimuth cell where the wind turbine is located and also in some adjacent cells.

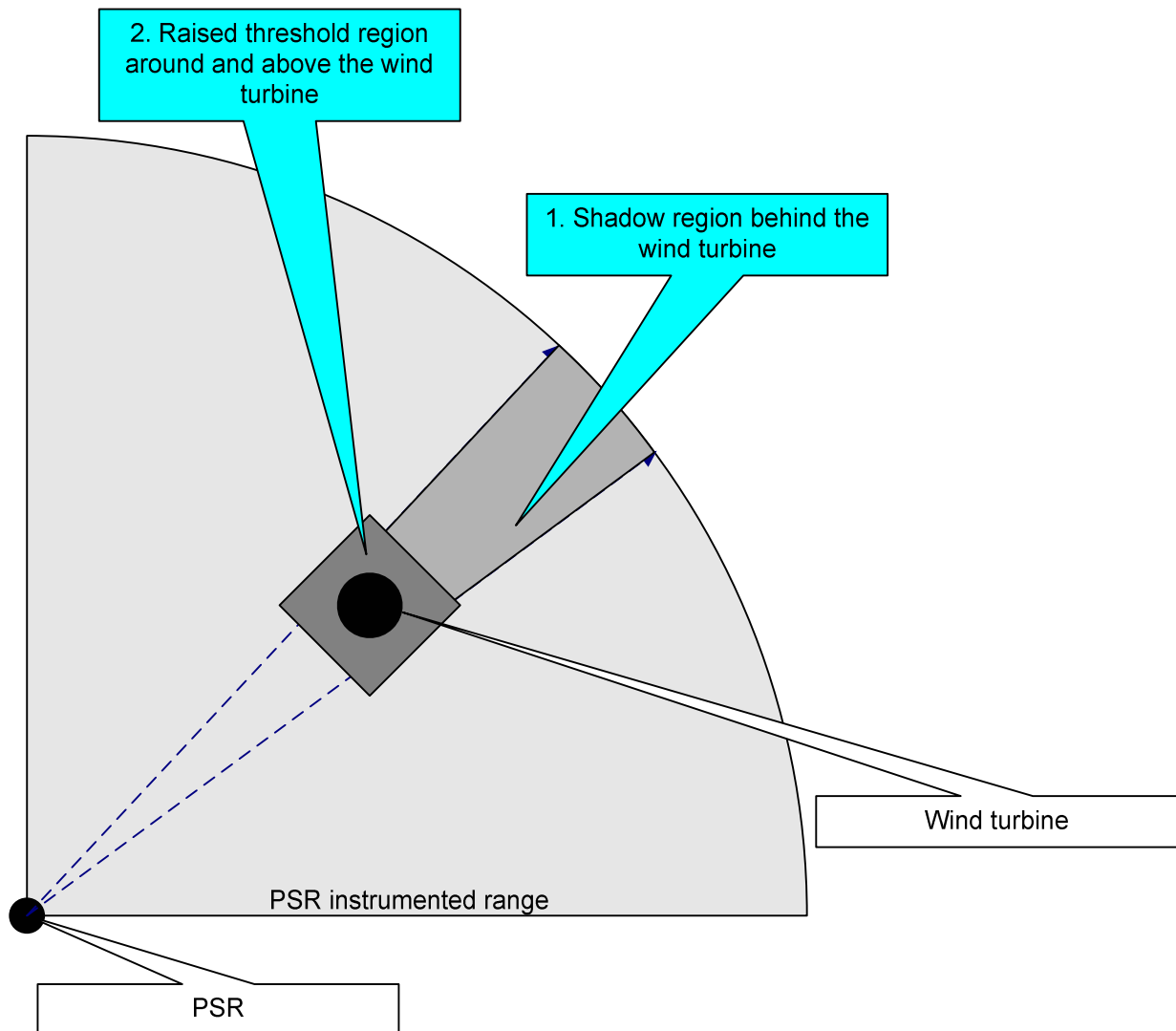


Figure 8: Shadow region behind a wind turbine and raised threshold region around and above a wind turbine

A simple way to estimate the 2 regions indicated on Figure 8 is as follows:

1. Dimensions of the shadow region (1) can be determined using Equation 4 in annex A - 3 to calculate its width and Equation 1 annex A - 2 to determine its height.
2. The region (2) located directly above the wind turbine³ is typically one to sixteen⁴ clutter cells large, depending on the exact CFAR algorithm.

These calculations have to be repeated for each wind turbine of a wind farm and the global impact is the sum of the individual impacts. This may be achieved by overlaying the shadow zones from individual wind turbines to give an overall shadow representation.

³ The effect has been observed for wind turbines at any range from the radar. Placing the wind turbines further away from the radar is therefore not necessarily a solution to this problem.

⁴ The column of airspace can extend out from the turbine position if smearing algorithms are used in clutter map generation.

4.3.2 PSR false target reports (due to echoes from wind turbines)

One of the key performance characteristic of a Primary Surveillance Radar, as defined in § 6.2.2.3 of the EUROCONTROL Standard Document for Radar Surveillance in En-route Airspace and Major Terminal Areas [RD 1], is the number of false target reports.

Due to their large radar cross section and moving parts turbines can be directly detected by a PSR and may generate false target reports.

If the highest point of the wind turbine (hub height + half the rotor diameter) is within the radar line-of-sight, it is assumed that the turbine will be detected by the PSR. This may manifest itself in the raw/processed video that may be presented to an ATCO, in plot reports, additionally they may be promoted to a mono or multi-sensor track due to their strength or when multiple plot reports correlate to form a track.

Further radar processing techniques (see Annex B - 2) may provide protection against the generation of target reports corresponding to wind turbines.

These calculations have to be repeated for each wind turbine of a wind farm and the global impact is the sum of the individual impacts.

4.3.3 PSR processing overload

When PSR is including a plot extractor and/or a mono-radar tracker there will be a limitation in the number of inputs that it can process. If the number of PSR echoes, including those due to wind turbines, is too high, the plot processor may need to apply anti-overload techniques. Similarly, if the number of plots, including false plots due to wind turbines, is too high, the tracker may need to apply overload prevention techniques. Both may have an operational impact (e.g. reducing the operational capability of the radar).

It is to be noted that in this case the affected areas do not depend on where the wind turbines are located but on the internal design of the system (i.e. the applied overload prevention techniques).

It is assumed that the next stages of the surveillance chain (e.g. communication network and multi-sensor tracker) are compatible with the maximum PSR output capacity.

4.4 Detailed engineering assessment for PSR and SSR

4.4.1 Generalities

When a wind turbine is located close to a radar (less than 15 km for a PSR, less than 16 km for an SSR) a detailed impact assessment shall be undertaken unless the potential impact of the wind turbine does not cause an operational issue (e.g. if the wind turbine is not located under an ANSP operational area). This detailed impact assessment shall, at least, address the topics identified in the following paragraphs.

Moreover, in case of a wind farm the detailed impact assessment shall be made for each individual wind turbine and globally for all the visible wind turbines of the wind farm as the global impact may not be equal to the sum of the individual impacts.

As a summary, the detailed engineering assessment is a complex and lengthy process; it requires identifying a large number of cases corresponding to different parameter values each of them corresponding to different external conditions (wind speed and direction, terrain configuration, etc.). Therefore it is recommended to avoid impacting operational areas or to remain within the simple assessment conditions in order to facilitate the impact assessment and the discussions between the ANSP and the wind energy developer.

At this stage, a more accurate assessment of the visibility of the wind turbines by the radars may be undertaken, to concentrate the detailed assessment efforts on the relevant issues.

The following paragraphs specify the requirements that shall be included, as a minimum, in the detailed engineering assessment statement of work.

4.4.2 PSR shadowing

The detailed assessment shall include:

- A calculation of the (two-way) attenuation caused by the wind turbines in three dimensions
- The impact in the three dimensions of this attenuation on the radar detection performance.

The detailed assessment shall address this topic in terms of impact on the PSR probability of detection.

4.4.3 PSR false target reports (due to echoes caused by wind turbines)

The detailed assessment should include:

- A calculation of the amount of energy reflected back to the radar by the wind turbine taking into account:
 - o Different nacelle orientations,
 - o Different blade orientations,
 - o Different radar frequencies,
 - o Different surface conditions (wet, moisture, etc), materials, etc are correctly incorporated in the study,
 - o The different elements of the wind turbine located at different heights,
 - o Appropriate terrain attenuation calculation based on the use of an agreed tool using appropriate parameters.
- The impact of this energy in terms of false target reports taking into account:
 - o Radar receiver capability,
 - o Radar signal processing capability,
 - o Radar data processing capability

If some of the above aspects cannot be taken into account in a reliable way, it may be agreed by all parties to replace them by mutually agreed assumptions (e.g. worst case).

The detailed assessment shall address this topic and assess the region where these false target reports may appear and their density.

4.4.4 PSR false target reports (due to secondary or indirect reflections from the wind turbines)

In addition to the case reported above, another potential mechanism providing spurious false target reports is through reflection of true target echoes on wind turbines and through reflection of wind turbine echoes on aircraft.

Four different cases of reflections may happen; they are summarised below and are further described in Annex - C.

True aircraft echoes reflected from the wind turbine: aircraft located in the vicinity of a wind turbine (for cases 1 and 2) or in the vicinity of the radar (only for case 2) will produce a genuine target report at their actual position and may produce a reflected target report in the azimuth of the wind turbine.

Wind turbine echoes reflected to the aircraft: aircraft located in the vicinity of a wind turbine or radar (both cases 3 and 4) will produce a genuine target report at their actual position and may produce a second, reflected target report in the azimuth of the aircraft.

The different cases (1, 2, 3 and 4) and examples of calculation based on simplified equations are provided in Annex - C.

The detailed assessment of false target reports due to reflections shall include:

- A calculation of the aircraft locations where reflections can occur.
- A calculation of where the corresponding false target reports due to reflections will be located.

4.4.5 PSR range and azimuth errors

When there is a small path difference between the direct and reflected signals the received signal will be a combination of both, which can result in a range and/or bearing measurement error.

In the case where there is a large path difference the two can be separated, which can lead to a false target - as discussed in paragraph 4.4.4 (reflection case).

This effect may occur to targets located further away than the wind turbine and in the same azimuth region.

The detailed assessment shall address this topic and assess the region where these errors may occur and the impact on PSR position accuracy performance in this region.

4.4.6 PSR processing overload

When PSR is including a plot extractor and/or a mono-radar tracker there will be a limitation in the number of inputs that it can process. If the number of PSR echoes due to wind turbines (clutter and reflections) is too high, the plot processor may need to apply anti-overload techniques. Similarly, if the number of false plots due to wind turbines is too high, the tracker may need to apply overload prevention techniques. Both may have an operational impact (e.g. reducing the operational capability of the radar).

The detailed assessment shall address this topic.

It is to be noted that in this case the affected areas do not depend on where the wind turbines are located but on the internal design of the system (i.e. the applied overload prevention techniques).

It is assumed that the next stages of the surveillance chain (e.g. communication network and multi-sensor tracker) are compatible with the maximum PSR output capacity.

4.4.7 PSR raised thresholds

In addition to the generation of false target reports the amount of energy reflected back to the radar by the wind turbine (see paragraph 4.4.3 above) will have an impact on the radar CFAR.

The detailed assessment shall address this topic in terms of impact on the PSR probability of detection.

4.4.8 PSR receiver saturation

In certain cases, the amount of energy reflected back to the radar from the wind turbine (see paragraph 4.4.3 above) can be so large that it saturates the radar receiver.

The detailed assessment shall address this topic in terms of impact on the PSR probability of detection.

4.4.9 SSR Probability of detection and probability of Mode A and Mode C code detection

If a wind turbine is located close to an SSR, the detection of aircraft located close to the wind turbine and within the same azimuth may be impacted. The impact shall be calculated in the three dimensions independently for the uplink (aircraft located in the shadow region behind the wind turbine) and the downlink transmissions (SSR located in the shadow region behind the wind turbine). In the case of the downlink transmission, the aircraft position detection may not be affected whereas the Mode A or Mode C code detection may be affected.

The detailed assessment shall address this topic and shall predict the impact in the 3 dimensions on position detection and Mode A and C code detection performance.

4.4.10 SSR false target reports

Most SSR systems build up maps of static reflectors (e.g. tower, buildings) to reject reflected replies; but because wind turbines are not seen as static objects, this technique is not as efficient.

Therefore SSR false target reports may appear due to reflection on the wind turbine of the uplink signal, of the downlink signal and/or of both.

The detailed assessment shall address this topic and shall predict where the false target reports will be located.

4.4.11 SSR 2D position accuracy

SSR bearing errors may occur when there is a small path difference between the direct and reflected signals. In the case where there is a large path difference the two can be separated which can lead to a false target - as discussed in paragraph 4.4.10.

Effects can be seen in MSSR, Mode S and classical 'sliding window' SSR systems.

An MSSR or Mode S system calculates the bearing of an aircraft using the orientation of the EM wave as it reaches the antenna. Reflections of the transponder signal from nearby objects (such as wind turbines) will combine with the direct signal in such a way that the wave-front is distorted. This can lead to errors in the bearing calculation.

In sliding window systems, the reflected energy arriving back at the antenna will be dispersed in azimuth, such that it is no longer centred on the true target azimuth. This will 'fool' the algorithms used by many SSRs to determine azimuth, and an error will occur.

Under these conditions (small path difference) range measurement errors may also occur due to the combination of the direct and reflected signals and the measurement of the time of arrival of the SSR reply may be altered.

This effect may occur to targets located further away than the wind turbine and in the same azimuth region.

The detailed assessment shall address this topic and shall predict the impact in the 3 dimensions on the SSR position accuracy performance.

It is to be noted that in case of a Mode S radar a single reply is sufficient to generate a target report.

4.5 Operational assessment

4.5.1 Generalities

Once an adverse engineering impact has been predicted, the next phase will be to assess whether this effect will be operationally tolerable or not. The process can be made quicker if certain 'ground rules' can be established, or areas of known sensitivity are published in advance which precludes the need for engineers to approach ATC operational staff. Certain applications may have such dramatic effects that the need to enter a dialogue with ATC is nugatory. However, the majority of cases will normally involve discussions with ATC Operations representatives who are familiar with the airspace being affected and/or Human Factors specialists.

4.5.2 PSR Probability of detection

The operational assessment will be based on the location of the affected 3D zones with respect to the operational volume of airspace and the criticality of the PSR surveillance information in these zones.

4.5.3 PSR false target reports

The operational assessment will be based on the location of the false target reports due to the presence of the wind turbines with respect to the operational volume of airspace.

4.5.4 PSR 2D position accuracy

The operational assessment will be based on the location of the affected 2D zones with respect to the operational volume of airspace and the criticality of the PSR surveillance information in these zones.

4.5.5 PSR plot/track processing capacity

The operational assessment will be based on the location of the affected 2D zones with respect to the operational volume of airspace and the criticality of the PSR surveillance information in these zones.

4.5.6 SSR probability of detection

The operational assessment will be based on the location of the affected 3D zones with respect to the operational volume of airspace and the criticality of the SSR surveillance information in these zones.

4.5.7 SSR false target reports

The operational assessment will be based on the location of the false target reports due to the presence of the wind turbines with respect to the operational volume of airspace.

4.5.8 SSR 2D position accuracy

The operational assessment will be based on the location of the affected 2D zones with respect to the operational volume of airspace.

4.6 Possible mitigations

4.6.1 Generalities

It may be possible that a certain amount of reduced performance is tolerable, either because it is in an area of minimal concern to the end user or sufficient operational procedures are in place to address any surveillance short fall.

Otherwise, in order to accommodate the wind turbine application, mitigation options may be investigated. The following options should be considered individually and/or in combination:

1. Wind energy developer mitigations: Can the wind turbine proposal be modified to eradicate or minimise the effects on ATC surveillance systems and operations?
2. ANSP technical mitigations: Can the sensor and/or surveillance system architecture be modified or configured to accommodate the wind energy project to within a level of tolerable degradation of service to ATC?
3. ANSP operational mitigations: Can ATC modify procedures to accommodate the expected reduction in surveillance quality?

An important consideration for choosing the mitigation options should be maintenance of ATC safety and cost-effectiveness, while at the same time taking into account that the global project (wind energy and associated mitigations) should result in an overall net reduction in carbon over an agreed time period.

4.6.2 Mitigation option table

The table below lists different mitigation options that may be applied alone or in combination with others. The table provides for every mitigation option the issues that it can potentially solve.

Applicable to	Mitigation option	When mitigation could be applied							Consideration regarding the mitigation option
		Lack of PSR Pd	PSR false targets	PSR position accuracy i	Overload of PSR capacities	Lack of SSR Pd	SSR false targets	SSR position accuracy	
Non cooperative surveillance sensor	Blank PSR transmission in an azimuth sector		☒		☒				May need to be combined with in-fill PSR/MSPSR in blanked sector(s).
	Suppress PSR radar returns in range-azimuth sector		☒		☒				May need to be combined with in-fill PSR/MSPSR in blanked sector(s).
	Improve PSR anti wind turbine clutter capabilities		☒		☒				
	Strengthen primary track initiation conditions		☒						At mono-radar tracker or at multi-sensor tracker level.
	Adapt PSR overload prevention facilities				☒				
	Upgrade PSR processing capabilities				☒				
	Upgrade PSR output interface capabilities				☒				
	In-fill PSR	☒	☒	☒					
	In-fill MSPSR	☒	☒	☒					Provided that MSPSR concept is validated.

Applicable to	Mitigation option	When mitigation could be applied							Consideration regarding the mitigation option
		Lack of PSR Pd	PSR false targets	PSR position accuracy i	Overload of PSR capacities	Lack of SSR Pd	SSR false targets	SSR position accuracy	
Cooperative surveillance system	Blank SSR transmission in an azimuth sector						☒	☒	May need to be combined with in-fill SSR/WAM/ADS-B in blanked sector(s)
	In-fill SSR					☒	☒	☒	
	In-fill WAM ⁵					☒	☒	☒	
	In-fill ADS-B ⁵					☒	☒	☒	Provided that aircraft are ADS-B equipped
	Improve SSR anti-reflection capabilities						☒		At SSR level and/or at multi-sensor level
Operation	Move ATC route	☒	☒	☒		☒		☒	
	Change airspace classification or apply MTZ ⁶	☒	☒	☒					Note that PSR may still be required to detect aircraft without a functioning SSR Transponder.
Wind turbine	Move wind turbines out of radar line of sight	☒	☒	☒	☒	☒	☒	☒	
	Move wind turbines out of critical areas	☒	☒	☒		☒	☒	☒	
	Change wind farm layout	☒							Affects Region 2 only, see § 4.3.1.
	Reduce number of wind turbines in radar line of sight				☒				
	Reduce wind turbine radar reflectivity		☒		☒		☒		If wind turbine is in radar line of sight of several radars, the mitigation is only applicable if they operate in the same frequency band.

Table 3: Mitigation options

⁵ This version of the guidelines does not address the assessment of wind turbine impacts on WAM or ADS-B.

⁶ Mandatory Transponder Zone: a portion of the airspace where all aircraft are required to be equipped with a transponder.

5 REFERENCES AND ACRONYMS

5.1 Referenced documents

- [RD 1]** EUROCONTROL Standard for Surveillance in En-route Airspace and Major Terminal Areas – SUR.ET1.ST01.1000-STD-01-01 dated March 1997 edition 1.0
<http://www.eurocontrol.int/surveillance/gallery/content/public/documents/SURVSTD.pdf>
- [RD 2]** ICAO Annex 10 Volume IV 4th edition July 2007
- [RD 3]** ICAO European Guidance Material on Managing Building Restricted Areas Second Edition 2009 ICAO EUR Doc 015
http://www.paris.icao.int/documents_open/show_file.php?id=188
- [RD 4]** ICAO Procedures for Air Navigation Services Air Traffic Management (PANS ATM) Doc 4444 ATM/501 Fifteenth Edition 2007
- [RD 5]** EUROCONTROL Regulatory and Advisory Framework – Regulatory Provisions dated November 2005 Edition 3.0 ERAF/04-002/3.0
http://www.eurocontrol.int/enprm/gallery/content/public/docs/eraf_04_002_v_3_0.pdf
- [RD 6]** EUROCONTROL Regulatory and Advisory Framework – Advisory Material dated November 2005 Edition 3.0 ERAF/04-002/ADV/3.0
http://www.eurocontrol.int/enprm/gallery/content/public/docs/eraf_04_002_adv_v_3_0.pdf

5.2 List of acronyms

Acronym	Definition
ADS-B	Automatic Dependent Surveillance - Broadcast
ANSP	Air Navigation Service Provider
ATC	Air Traffic Control
ATM	Air Traffic Management
BRA	Building Restricted Areas
CFAR	Constant False Alarm Rate (primary radar technique)
DTED	Digital Terrain Elevation Data
EC	European Commission
EM	Electro Magnetic
ERAF	EUROCONTROL Regulatory and Advisory Framework
FFM	Far-Field Monitor
ICAO	International Civil Aviation Organisation
IFR	Instrument Flight Rules
MDS	Minimum Discernable Signal
MLAT	Multi LATeration
MSPSR	Multi Static Primary Surveillance Radar
MSSR	Monopulse Secondary Surveillance Radar
MTD	Moving Target Detector (primary radar technique)
MTI	Moving Target Indicator (primary radar technique equivalent to MTD)
MTZ	Mandatory Transponder Zone
NSA	National Supervisory Authority
PSR	Primary Surveillance Radar
RCS	Radar Cross Section
RF	Radio Frequency
Rx	Receiver
SES	Single European Sky
SESAR	Single European Sky ATM Research
SLA	Service Level Agreement
SSR	Secondary Surveillance Radar
STC	Sensitivity Time Control (primary radar technique)
Tx	Transmitter
UNFCCC	United Nations Framework Convention on Climate Change
WAM	Wide Area Multilateralisation
WGS84	World Geodetic System 1984

Table 4: Acronym list

ANNEX - A PSR reduction of probability of detection – Assessment of Region 1 dimensions

A - 1 Introduction

When a turbine lies directly between the transmitting and receiving antenna the strength of the signal reaching the receiver is lower than it would otherwise be. When the transmitter and/or receiver are part of the surveillance sensor under assessment the shape and severity of this 'shadow region' will determine the impact of the turbine on how the equipment can be used. In the case of the PSR it is considered that region 1 extends up to the PSR maximum range. The basic features of the shadow are:

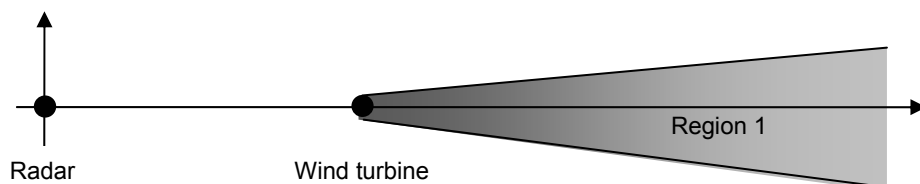


Figure 9: Top-view of wind turbine shadow

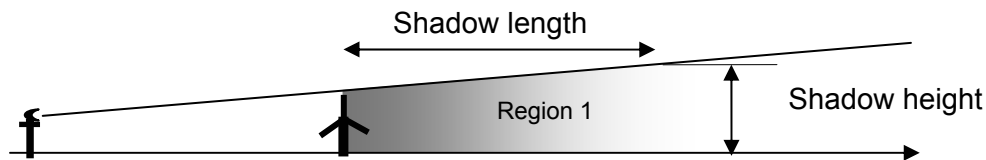


Figure 10: Side-view of wind turbine shadow

A - 2 Shadow Height

The shadow height is calculated by simply considering the geometry of the wind turbine and the transmitter as shown on Figure 10 above, taking into account the maximum height of the turbine, the earth curvature (see Figure 11 below), the earth radius (R) and the fact that EM waves do not propagate in straight line above earth, therefore a factor k (typically 4/3) is applied to calculate the central angle.

$$C' = \frac{D_{rw} + L_{shadow}}{R.k}$$

$$B' = B$$

$$A' = \pi - B' - C'$$

$$b' = a' \cdot \sin(B') / \sin(A')$$

Where D_{rw} is the distance between the radar and the wind turbine, R is the radius of the earth and L_{shadow} is the length of the shadow zone.

The height of the shadow zone can be calculated as follow:

$$H_{shadow} = b' - k.R \quad \text{Equation 1}$$

The symbols used in this Annex have the following meanings

R	The radius of the earth (m) at the position of the radar
H_{radar}	Geodetic height of the radar (m)
$H_{turbine}$	Geodetic height of the wind turbine (m)
H_{shadow}	Geodetic height of the shadow of the wind turbine at shadow length (m)
L_{shadow}	Shadow length (m)
k	Factor (typically 4/3) to take into account that EM waves do not propagate in straight line above the earth.
D_{rw}	Distance radar to wind turbine (m)

A - 3 Shadow Width

Figure 9 above shows a very simplistic representation of the shadow width, it is possible to calculate a more realistic estimate using the following argument. A typical cross-range section of the shadow effect is shown in the following Figure 12 where a reflection from a metallic object is assumed; hence the direct and reflected signals will be in anti-phase.

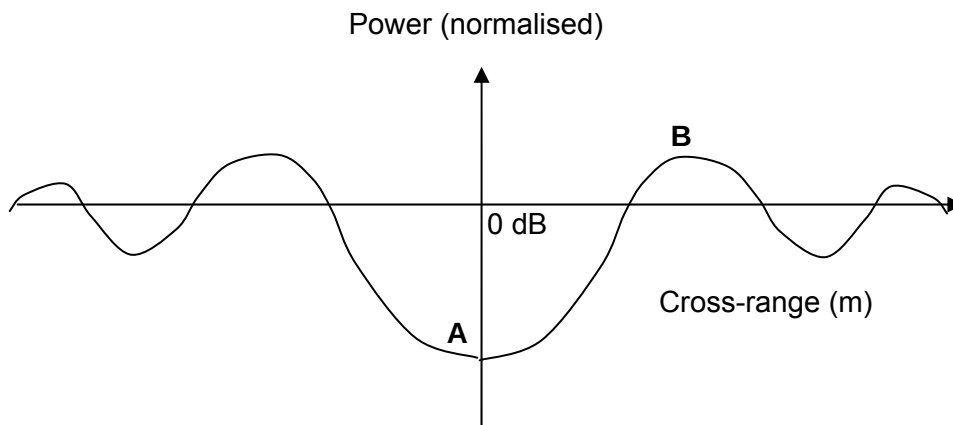


Figure 12: Diagram of a cross-section of a shadow

At point “A” the path difference is zero and so the signals combine de-constructively causing the deepest shadow; at point “B”, where path difference = $\lambda/2$, they combine constructively to give a maxima. Note that successive maxima are odd multiples of $\lambda/2$, where path difference = $(2n+1)\lambda/2$. The maxima get weaker because the interfering signal is weaker at larger angles off the forward-scatter direction.

A conservative estimate of shadow width is the locus of points formed by point B as a function of down-range; the geometry is as shown in Figure 13 below:

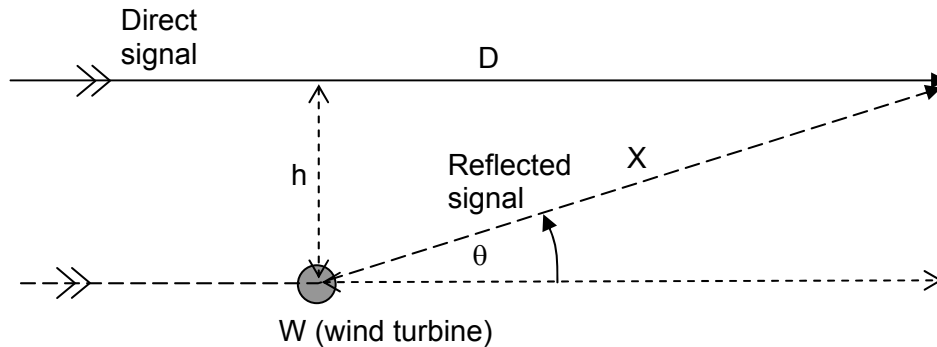


Figure 13: Path difference geometry for shadow width calculation

The path difference, Δ , between the direct and reflected signals at the receiver is given by:

$$\Delta = X - D = \sqrt{h^2 + D^2} - D \quad \text{Equation 2}$$

and so the locus of points which define the width of the shadow at a distance D beyond the turbine is found by setting path difference = $\lambda/2$ and solving for the half-width, h:

$$\frac{\lambda}{2} = \sqrt{h^2 + D^2} - D \quad \text{Equation 3}$$

$$h = \sqrt{\left(\frac{\lambda}{2} + D\right)^2 - D^2} \quad \text{Equation 4}$$

If λ is much smaller than D, which is the case here, Equation 4 can be simplified:

$$h = \sqrt{\lambda \cdot D} \quad \text{Equation 5}$$

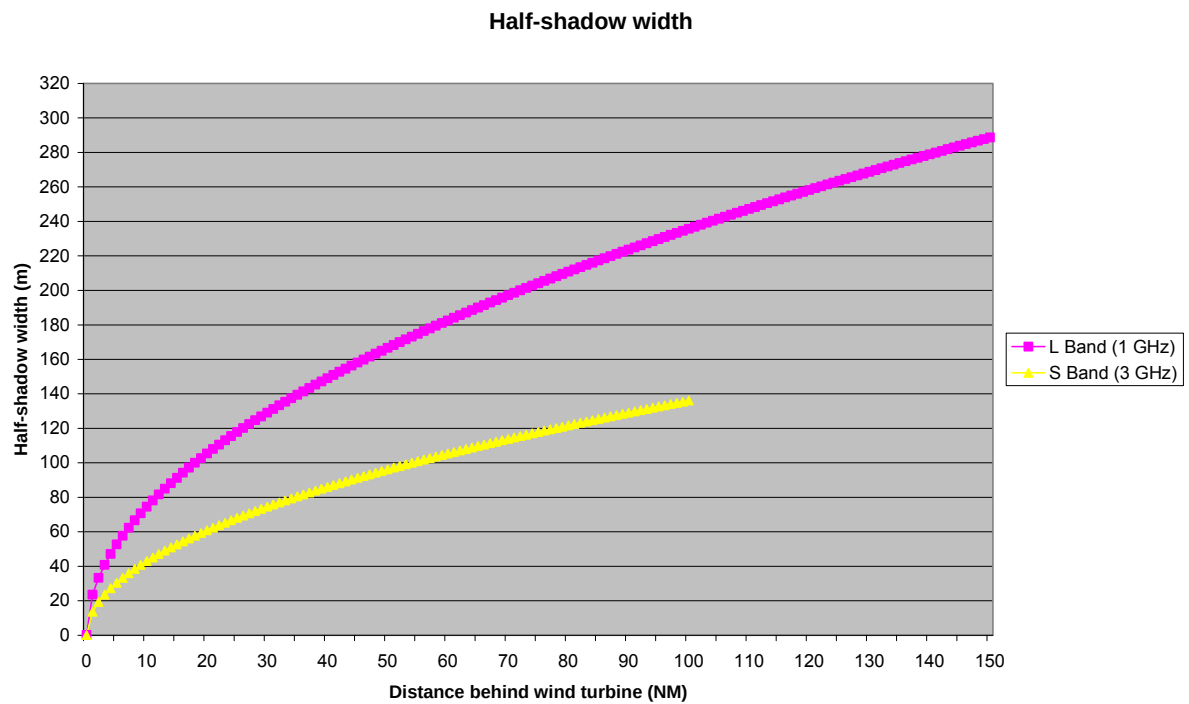


Figure 14: Half-shadow width as a function of D

ANNEX - B PSR Equations (no reflection)

B - 1 Basic Radar Equation

In normal PSR operation, the power reflected back from the wind turbine will be equal to:

$$P_{ref} = \frac{\sigma \cdot F^2 \cdot G_t \cdot P_t \cdot G_r \cdot \lambda^2}{(4 \cdot \pi)^3 \cdot D^4} \quad \text{Equation 6}$$

where the symbols have the following meanings

P_{ref}	The power of the reflected signal arriving at the radar (W)
P_t	Transmitted power
G_t	Transmit antenna gain
G_r	Receive antenna gain
σ	The mono-static RCS of the wind turbine ⁷ (m ²)
F	Terrain induced attenuation factor between radar and wind turbine.
D	Distance radar to wind turbine (m)
λ	Signal wavelength (m)

B - 2 Further Processing

Whilst at its most basic the remainder of the radar can be modelled as a simple threshold detector by comparing P_{ref} , above, to a defined threshold for the radar under test this is a huge simplification for a modern radar system.

Other than to state that where possible as much of the radars internal processing should be taken into account, it is not intended to go further within this document as data processing varies so widely from radar to radar and the relevant algorithms are often difficult to obtain or model. Some of the issues which may affect the probability of wind turbine detection include the following items:

- **Sliding window** - Most systems determine detection using a statistical M detections from N pulses algorithm.
- **MTI-MTD Filtering** – Most PSR systems now employ MTI or MTD to discard returns from stationary objects based on Doppler filtering.
- **Tracking Algorithms** - Plot-extracted systems will only provide plot information should a series of echoes over a number of scans pass certain tracking criteria.

⁷ The radar cross section of the wind turbine, although the term is not fully relevant because the wind turbine is not in free space but put on the ground, represents the fraction of EM power transmitted by the radar that is reflected back (mono-static) or scattered in another direction (bi-static) by the wind turbine. This parameter depends a lot on the attitude of the wind turbine with respect to the direction of the EM wave transmitted by the radar, in particular on the orientation of the nacelle and on the orientation of the blades that are varying in accordance with the wind conditions. Furthermore in the case of the bi-static RCS, it depends on the considered directions (incidental and scattered)

ANNEX - C PSR Equations (reflection)

C - 1 Radar Equations in case of reflected signals

There are 4 cases of configuration radar/wind turbine/aircraft where additional echoes due to reflected signal can be detected by the radar. They are illustrated on Figure 15 to Figure 18.

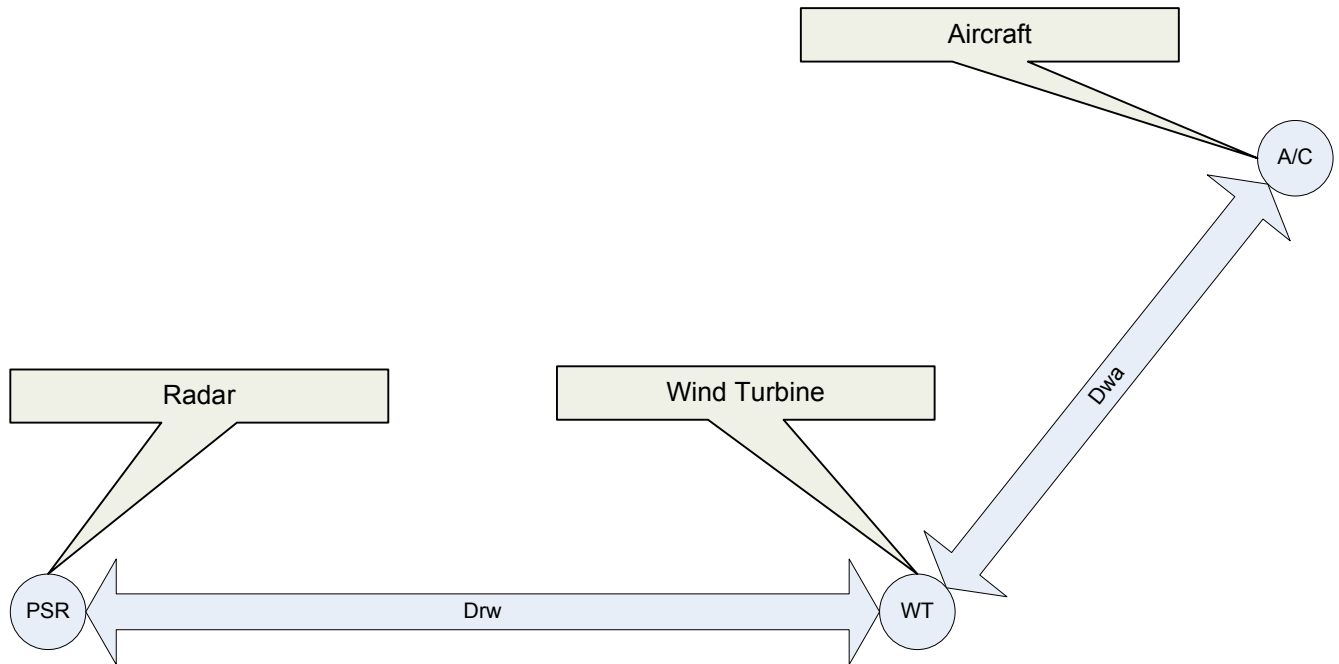


Figure 15: PSR reflection case 1

In case 1, the reflection is located in the azimuth of the wind turbine, the reflected signal is received through the radar antenna main beam.

In this case, the power reflected back will be equal to:

$$P_{ref} = \frac{\sigma_a \cdot \sigma_{w1} \cdot \sigma_{w2} \cdot F_{rw}^2 \cdot F_{wa}^2 \cdot G_t \cdot P_t \cdot G_r \cdot \lambda^2}{(4\pi)^5 \cdot D_{rw}^4 \cdot D_{wa}^4} \quad \text{Equation 7}$$

Comparing this power to the radar receiver detection threshold one can derive the volume around a wind turbine where aircraft must be located to cause a reflection.

$$R_1 = \sqrt[4]{\frac{\sigma_a \cdot \sigma_{w1} \cdot \sigma_{w2} \cdot F_{rw}^2 \cdot F_{wa}^2 \cdot G_t \cdot P_t \cdot G_r \cdot \lambda^2}{(4\pi)^5 \cdot D_{rw}^4 \cdot P_{thresh}}} \quad \text{Equation 8}$$

Worst case estimation can be calculated assuming $F_{rw} = F_{wa} = 1$, $G_t = G_r = G$ and $\sigma_{w1} = \sigma_{w2} = \sigma_w$.

$$R_1 = \sqrt[4]{\frac{\sigma_a \cdot \sigma_w^2 \cdot G^2 \cdot P_t \cdot \lambda^2}{(4\pi)^5 \cdot D_{rw}^4 \cdot P_{thresh}}}$$

Equation 9

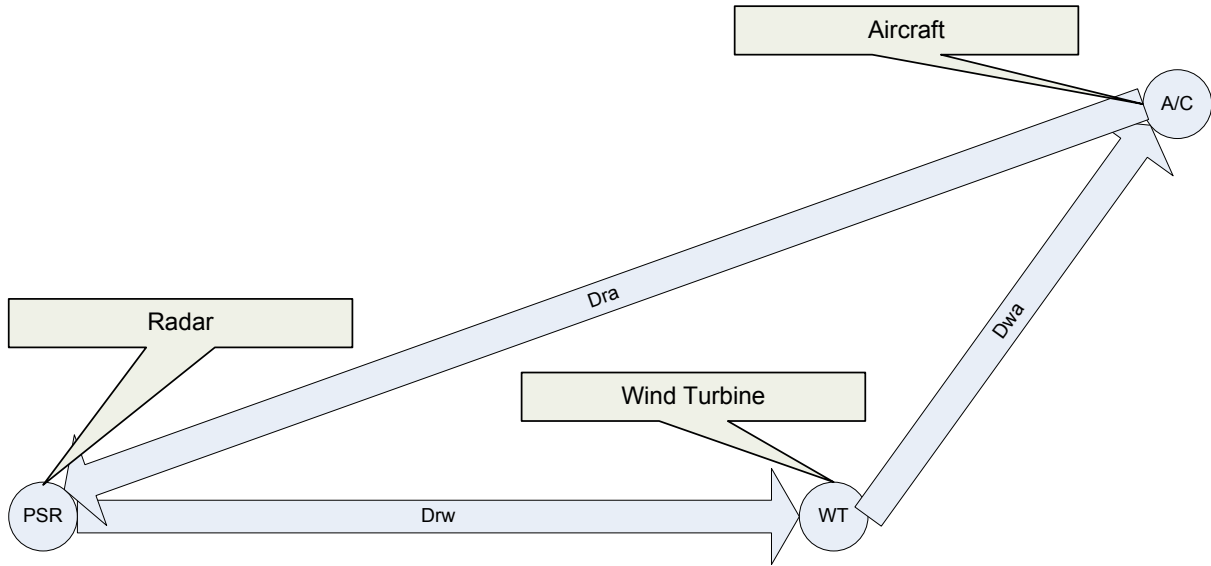


Figure 16: PSR reflection case 2

In case 2, the reflection is located in the azimuth of the wind turbine, the reflected signal is received through the radar antenna sidelobes.

In this case, the power reflected back will be equal to:

$$P_{ref} = \frac{\sigma_{a2} \cdot \sigma_{w1} \cdot F_{rw} \cdot F_{wa} \cdot F_{ar} \cdot G_t \cdot P_t \cdot G_{rs} \cdot \lambda^2}{(4\pi)^4 \cdot D_{rw}^2 \cdot D_{wa}^2 \cdot D_{ra}^2}$$

Equation 10

Comparing this power to the radar receiver detection threshold one can derive the volume around a wind turbine where aircraft must be located to cause a reflection.

$$R_2 = \sqrt[2]{\frac{\sigma_{a2} \cdot \sigma_{w1} \cdot F_{rw} \cdot F_{wa} \cdot F_{ar} \cdot G_t \cdot P_t \cdot G_{rs} \cdot \lambda^2}{(4\pi)^4 \cdot D_{rw}^2 \cdot D_{ra}^2 \cdot P_{thresh}}}$$

Equation 11

Worst case estimation can be calculated assuming $F_{rw} = F_{wa} = F_{ar} = 1$, $\sigma_{a2} = \sigma_a$ and $\sigma_{w1} = \sigma_w$.

$$R_2 = \sqrt[2]{\frac{\sigma_a \cdot \sigma_w \cdot G_t \cdot P_t \cdot G_{rs} \cdot \lambda^2}{(4\pi)^4 \cdot D_{rw}^2 \cdot D_{ra}^2 \cdot P_{thresh}}}$$

Equation 12

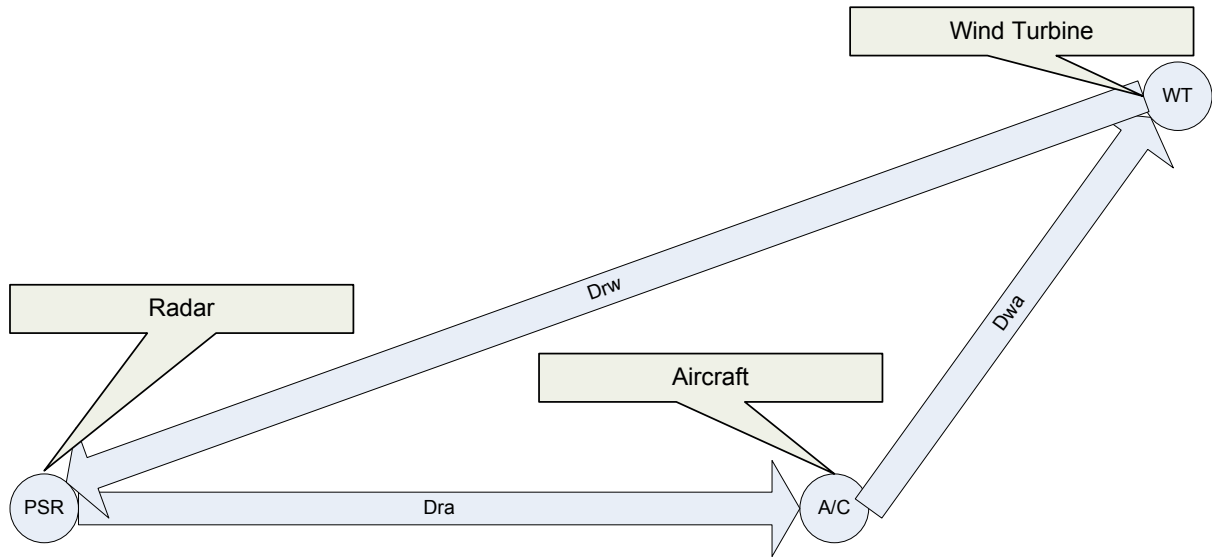


Figure 17: PSR reflection case 3

In case 3, the reflection is located in the azimuth of the aircraft, the reflected signal is received through the radar antenna sidelobes.

In this case, the power reflected back will be equal to:

$$P_{ref} = \frac{\sigma_{a1} \cdot \sigma_{w2} \cdot F_{ra} \cdot F_{aw} \cdot F_{wr} \cdot G_t \cdot P_t \cdot G_{rs} \cdot \lambda^2}{(4\pi)^4 \cdot D_{ra}^2 \cdot D_{wa}^2 \cdot D_{rw}^2} \quad \text{Equation 13}$$

Comparing this power to the radar receiver detection threshold one can derive the volume around a wind turbine where aircraft must be located to cause a reflection.

$$R_3 = \sqrt[2]{\frac{\sigma_{a1} \cdot \sigma_{w2} \cdot F_{ra} \cdot F_{aw} \cdot F_{wr} \cdot G_t \cdot P_t \cdot G_{rs} \cdot \lambda^2}{(4\pi)^4 \cdot D_{ra}^2 \cdot D_{rw}^2 \cdot P_{thresh}}} \quad \text{Equation 14}$$

Worst case estimation can be calculated assuming $F_{ra} = F_{aw} = F_{wr} = 1$, $\sigma_{a1} = \sigma_a$ and $\sigma_{w2} = \sigma_w$.

$$R_3 = \sqrt[2]{\frac{\sigma_a \cdot \sigma_w \cdot G_t \cdot P_t \cdot G_{rs} \cdot \lambda^2}{(4\pi)^4 \cdot D_{ra}^2 \cdot D_{rw}^2 \cdot P_{thresh}}} \quad \text{Equation 15}$$

Note that there exists a certain volume around the radar and wind turbine where these types (types 2 and 3) of reflections could occur (see Figure 19). There also exists a critical distance between radar and wind turbine for which these volumes start to merge.

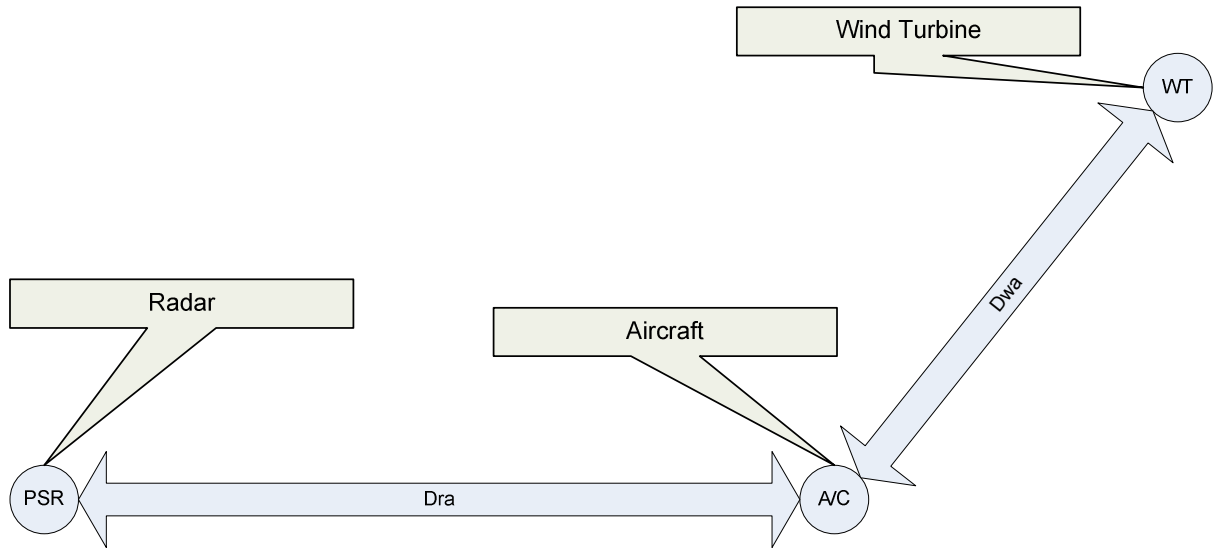


Figure 18: PSR reflection case 4

In case 4, the reflection is located in the azimuth of the aircraft, the reflected signal is received through the radar antenna main beam.

In this case, the power reflected back will be equal to:

$$P_{ref} = \frac{\sigma_w \cdot \sigma_{a1} \cdot \sigma_{a2} \cdot F_{ra}^2 \cdot F_{aw}^2 \cdot G_t \cdot P_t \cdot G_r \cdot \lambda^2}{(4\pi)^5 \cdot D_{ra}^4 \cdot D_{wa}^4} \quad \text{Equation 16}$$

Comparing this power to the radar receiver detection threshold one can derive the volume around a wind turbine where aircraft must be located to cause a reflection.

$$R_4 = \sqrt[4]{\frac{\sigma_w \cdot \sigma_{a1} \cdot \sigma_{a2} \cdot F_{ra}^2 \cdot F_{aw}^2 \cdot G_t \cdot P_t \cdot G_r \cdot \lambda^2}{(4\pi)^5 \cdot D_{ra}^4 \cdot P_{thresh}}} \quad \text{Equation 17}$$

Worst case estimation can be calculated assuming $F_{ra} = F_{aw} = 1$, $G_t = G_r = G$ and $\sigma_{a1} = \sigma_{a2} = \sigma_a$.

$$R_4 = \sqrt[4]{\frac{\sigma_a^2 \cdot \sigma_w \cdot G^2 \cdot P_t \cdot \lambda^2}{(4\pi)^5 \cdot D_{ra}^4 \cdot P_{thresh}}} \quad \text{Equation 18}$$

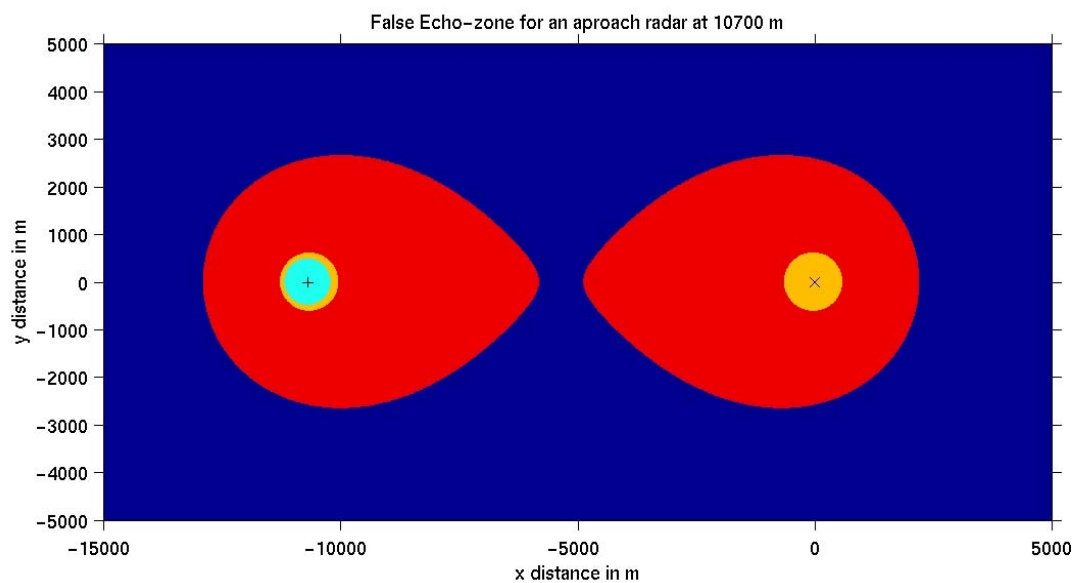


Figure 19: Example of calculation of aircraft locations where reflection can occur (horizontal)

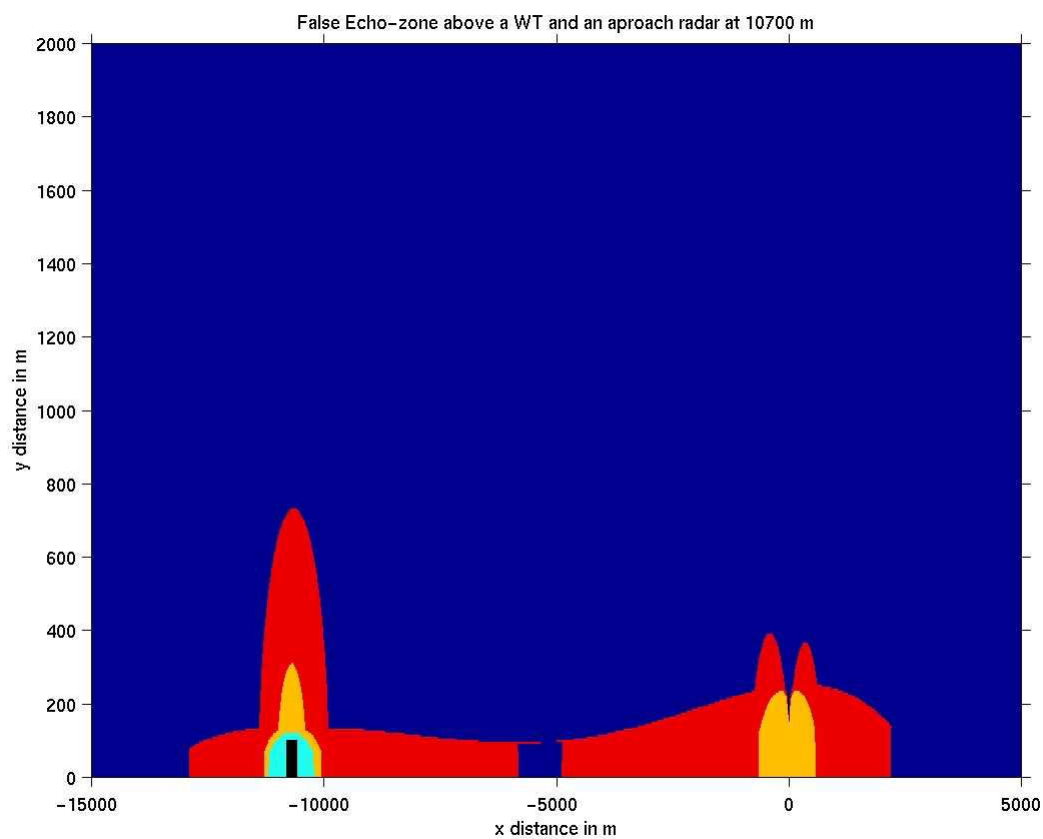


Figure 20: Example of calculation of aircraft locations where reflection can occur (vertical)

Figure 19 and Figure 20 provide a typical example of the computation of the different reflection zones (radar location marked with x; wind turbine location marked with +). The cyan area corresponds to aircraft locations where case 1 can happen. The orange areas correspond to aircraft locations where case 4 can happen. The red areas correspond to aircraft locations where case 2 or 3 can happen.

In equations 6 to 17 the symbols have the following meanings

P_{ref}	The power of the reflected signal arriving at the radar (W)
P_t	Transmitted power (W)
P_{thresh}	Radar receiver detection threshold (W)
G_t	Transmit antenna gain
G_r	Receive antenna gain (main beam)
G_{rs}	Receive antenna gain (side lobes)
σ_a	The mono-static RCS of the aircraft (m^2)
σ_w	The mono-static RCS of the wind turbine ⁷ (m^2)
σ_{a1}	The bi-static RCS of the aircraft from radar to wind turbine (m^2)
σ_{a2}	The bi-static RCS of the aircraft from wind turbine to radar (m^2)
σ_{w1}	The bi-static RCS of the wind turbine ⁷ from radar to aircraft (m^2)
σ_{w2}	The bi-static RCS of the wind turbine ⁷ from aircraft to radar (m^2)
$F_{rw} = F_{wr}$	Terrain induced attenuation factor between radar and wind turbine.
$F_{wa} = F_{aw}$	Terrain induced attenuation factor between wind turbine and aircraft.
$F_{ra} = F_{ar}$	Terrain induced attenuation factor between radar and aircraft.
D_{rw}	Distance radar to wind turbine (m)
D_{wa}	Distance wind turbine to aircraft (m)
D_{ra}	Distance radar to aircraft (m)
λ	Signal wavelength (m)

C - 2 Further Processing

Whilst at its most basic the remainder of the radar can be modelled as a simple threshold detector by comparing P_{ref} , above, to a defined threshold (P_{thresh}) for the radar under test this is a huge simplification for a modern radar system.

Other than to state that where possible as much of the radars internal processing should be taken into account it is not intended to go further within this document as data processing varies so widely from radar to radar and the relevant algorithms are often difficult to obtain or model. Some of the issues which may affect the probability of detection of aircraft reflection include the following items⁸:

- **Sliding window** - Most systems determine detection using a statistical M detections from N pulses algorithm;
- **Tracking Algorithms** - Plot-extracted systems will only provide plot information should a series of echoes over a number of scans pass certain tracking criteria.

⁸ MTI-MTD filtering is not applicable in this case as the reflected signal will have the same Doppler characteristics as the direct aircraft echo.

ANNEX - D Justification of the recommended SSR protection range

D - 1 Introduction

The selection of the recommended SSR protection range is based on the assessment of 3 impacts that a single wind turbine could have on the SSR performance:

- Position detection and Mode A/Mode C code detection performance characteristics.
- Multiple target reports performance characteristic.
- Azimuth accuracy performance characteristic.

D - 2 2D position detection and Mode A/Mode C code detection

As for PSR (see Annex - A), SSR is affected by a shadow region behind the wind turbine where the 2D position detection and the Mode A and Mode C code detection may be degraded. In the case of SSR the shadow length can be calculated.

The protection range has been calculated in such a way that the volume represented by region 1 (width, height and length) remains tolerably small.

SSR interrogations/responses can all be modelled as one-way communication links and probabilities of signal detection can be derived by from received signal power, P_r , and receiver sensitivity. P_r can be found by initially determining the power density, P , at a range of D from a transmitter radiating a signal with a power of P_t :

$$P = \frac{F.G_t.P_t}{4.\pi.D^2} \quad \text{Equation 19}$$

The radar's ability to collect this power and feed it to its receiver is a function of its antenna's effective area, A_e , and P_r is therefore given by the equation;

$$P_r = P.A_e \quad \text{Equation 20}$$

Replacing A_e with its actual value gives:

$$P_r = \frac{P.G_r.\lambda^2}{4.\pi} \quad \text{Equation 21}$$

Replacing P with the terms of Equation 19 gives:

$$P_r = \frac{F.G_t.P_t.G_r.\lambda^2}{(4.\pi.D)^2} \quad \text{Equation 22}$$

when this signal is reflected off an object with bi-static radar cross section of σ , e.g. a wind turbine, rather than received directly, this equation can be modified to

$$P_{r\ ef} = \frac{\sigma.F_{tw}.F_{wr}.G_{tw}.P_t.G_{rw}.\lambda^2}{(4.\pi.)^3.D_{tw}^2.D_{wr}^2} \quad \text{Equation 23}$$

where the symbols have the following meanings

P_{ref}	The power of the reflected signal arriving at the receiver
P_t	Transmitted power
G_{tw}	Transmit antenna gain in the direction of the wind turbine
G_{rw}	Receive antenna gain in the direction of the wind turbine
σ	The bi-static RCS of the wind turbine ⁷ as in Figure 21.
F_{tw}	Terrain induced attenuation factor between transmitter and wind turbine.
F_{wr}	Terrain induced attenuation factor between wind turbine and receiver.
D_{tw}	Distance transmitter to wind turbine
D_{wr}	Distance wind turbine to receiver
λ	Signal wavelength

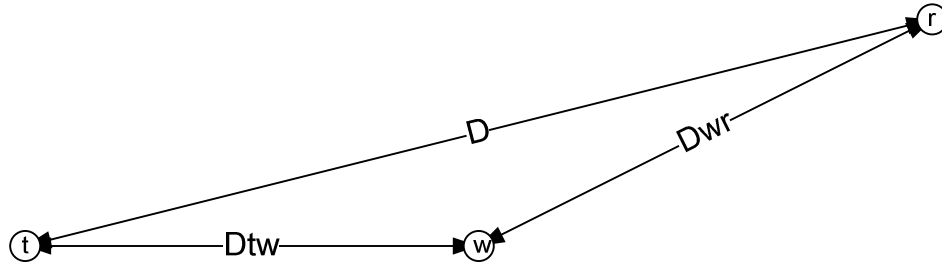


Figure 21: Direct and reflected signal paths

By replacing the power received, P_{ref} , with the threshold of the receiving system, P_{thresh} , the range from the turbine for a given turbine/transmitter geometry where the reflected signal is likely to be detected is given by:

$$D_{wr} = \sqrt{\frac{\sigma \cdot F_{tw} \cdot F_{wr} \cdot G_{tw} \cdot G_{wr} \cdot P_t \cdot \lambda^2}{(4\pi)^3 \cdot D_{tw} \cdot P_{thresh}}} \quad \text{Equation 24}$$

For certain assessments the ratio of the power received via the direct path D has to be compared to the power received via the indirect path. Combining Equation 19 and Equation 23 yields:

$$\frac{P_{direct}}{P_{ref}} = \frac{F_{dir} \cdot G_t \cdot G_r \cdot 4\pi \cdot D_{tw}^2 \cdot D_{wr}^2}{\sigma \cdot G_{tw} \cdot G_{wr} \cdot D^2 \cdot F_{tw} \cdot F_{wr}} \quad \text{Equation 25}$$

By inverting Equation 25 we get the ratio between direct signal and reflected signal behind a turbine:

$$\frac{P_{ref}}{P_{direct}} = \frac{\sigma \cdot G_{tw} \cdot G_{wr} \cdot D^2 \cdot F_{tw} \cdot F_{wr}}{F_{dir} \cdot G_t \cdot G_r \cdot 4\pi \cdot D_{tw}^2 \cdot D_{wr}^2} \quad \text{Equation 26}$$

For point "A", directly behind the turbine, we can use the following relationships:

$$G_{tw} = G_t$$

$$G_{wr} = G_r$$

$$D = D_{tw} + D_{wr}$$

$$F_{dir} = F_{tw} \cdot F_{wr}$$

$$\sigma = \frac{4 \cdot \pi \cdot L^2 \cdot S^2}{\lambda^2}$$

$$L^2 = \frac{\lambda}{\frac{1}{D_{tw}} + \frac{1}{D_{wr}}}$$

Where L is the dimension of the 1st Fresnel zone and S is the diameter of the mast, this gives us:

$$\frac{P_{ref}}{P_{direct}} = \frac{S^2 \cdot D}{D_{tw} \cdot D_{wr} \cdot \lambda} \quad \text{Equation 27}$$

Using the relationship between field strength and power loss, PL, we get:

$$PL = \left(1 - \sqrt{\frac{P_{ref}}{P_{direct}}}\right)^2 = \left(1 - S \cdot \sqrt{\frac{D}{D_{tw} \cdot D_{wr} \cdot \lambda}}\right)^2 \quad \text{Equation 28}$$

Which can be rearranged to give:

$$D_{wr} = \frac{D_{tw}}{\left(\frac{D_{tw} \cdot \lambda}{S^2} \cdot (1 - \sqrt{PL})^2 - 1\right)} \quad \text{Equation 29}$$

Which is the length of the shadow region for a given acceptable 1-way power loss PL.

Assuming that a 3 dB power loss is tolerable in the case of an SSR and a mast diameter of 6 m and taking into account $D_{tw} \geq 16$ km, the maximum length of the shadow region is equal to 1600 m.

At 1600 m behind the wind turbine the shadow height (see Annex A - 2) is equal to 310 m assuming a wind turbine height of 200 m (nacelle height + half rotor blade diameter) and that the wind turbine altitude is 50 m higher than the SSR.

Using Equation 4 the width of the shadow region can be calculated and is equal to 45 m.

Under these conditions and assumptions the volume of the SSR shadow region behind a wind turbine (l 1600 m x w 45 m x h 310 m) is sufficiently small to be operationally tolerable.

The above assessment has been performed for a single wind turbine. Would there be multiple wind turbines located in a radar beam-width, the resulting shadow zone would be larger. Nevertheless it is believed that the 16 km limit is a valid figure for the border between SSR zone 2 (detailed assessment) and SSR zone 4 (no assessment).

D - 3 Multiple target reports

Here the calculation is based on the conditions to get a reply from a transponder when the interrogation has been reflected onto a wind turbine.

Because of the ISLS implementation, the transponder will be insensitive during a 35 μ s (see § 3.1.1.7.4 [RD 2]) period after the reception of a radar interrogation through radar sidelobes. Therefore any aircraft/transponder located closer than 5250 m (half of the distance corresponding to 35 μ s) will not reply to reflected interrogations because in this case the path difference between the direct (through sidelobes) and the reflected signal will always be smaller than 35 μ s.

When the aircraft transponder is located further than 5250 m from the wind turbine, the minimum power received by the transponder from a reflected interrogation can be calculated (using Equation 23) and can be compared with the minimum transponder receiver threshold (smaller specified value -77 dBm § 3.1.1.7.5 [RD 2]). Therefore the minimum distance between the SSR and the wind turbine can be calculated as follows:

$$D_{tw} = \sqrt{\frac{\sigma \cdot F_{tw} \cdot F_{wr} \cdot G_{tw} \cdot G_{wr} \cdot P_t \cdot \lambda^2}{(4\pi)^3 \cdot D_{wr}^2 \cdot P_{thresh}}} \quad \text{Equation 30}$$

$$P_{thresh} = -77 \text{ dBm} = 10^{-10.7} \text{ W}$$

$$P_t = 2 \text{ kW} = 2000 \text{ W}$$

$$F_{tw} = F_{wr} = 1$$

$$\sigma = 35 \text{ dBm}^2 = 10^{3.5} \text{ m}^2$$

$$G_{tw} = 27 \text{ dB} = 10^{2.7}$$

$$G_{wr} = 1$$

$$D_{wr} = 5250 \text{ m}$$

$$\lambda = 0.2913 \text{ m (corresponding to 1030 Mhz)}$$

It gives:

$$D_{tw} = 15698 \text{ m}$$

Therefore when the wind turbine is 16 km away from the SSR if the aircraft/transponder is located closer than 5250 m from the wind turbine the transponder will not reply to reflected interrogations because of ISLS implementation and when further than 5250 m the power of the reflected interrogation will be below the transponder receiver threshold and the transponder will not reply either.

It must be noted that the rationale above is only valid for Mode A/C operations.

D - 4 Azimuth accuracy

Here the calculation is based on the azimuth error due to a wind turbine for aircraft located behind the wind turbine.

As explained in paragraph 4.4.11, azimuth error may happen when there is a small path difference (less than $0.25 \mu s = 75 \text{ m}$) between the direct and the reflected signals as illustrated on Figure 22 below.

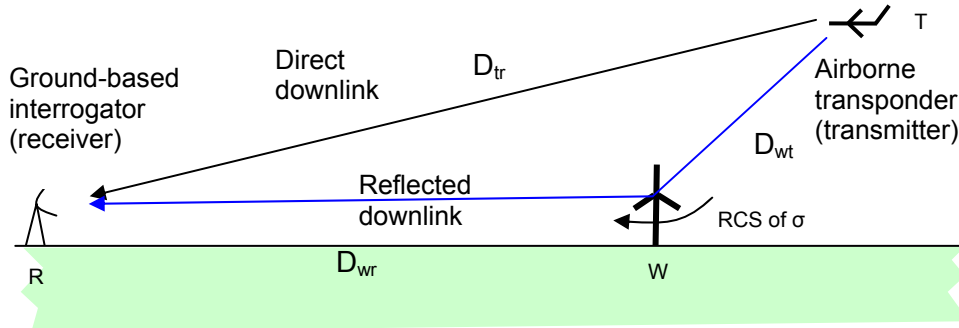


Figure 22: SSR downlink reflection

If the above criterion on path difference is met, this will have an impact on the azimuth measurement if the ratio C/I between the direct signal (C – Carriage) and the reflected signal (I – Interference) is smaller than a given threshold.

The C/I ratio can be calculated as follows assuming that:

- The propagation losses to the wind turbine and to the aircraft from the SSR ground system are the same;
- The propagation losses between the transponder and the wind turbine and the transponder and the SSR ground system are the same;
- The transponder gain in the direction of the wind turbine is the same in the direction of the SSR ground system;
- The SSR ground system receive gain is the same in the direction of the wind turbine as in the direction of the transponder.

If the above assumptions are met then:

$$\frac{C}{I} = \frac{D_{tw}^2 D_{wr}^2}{D_{tr}^2} \frac{4\pi}{\sigma} \quad \text{Equation 31}$$

Where σ is the wind turbine bi-static RCS⁷ as in Figure 22.

As $D_{tw} \leq D_{tr}$, it can be derived that:

$$\frac{C}{I} \leq \frac{4\pi}{\sigma} D_{wr}^2 \quad \text{Equation 32}$$

Therefore, taking into account that a C/I ratio of 50 dB is largely sufficient to ensure a good discrimination between the direct signal and the reflected signal, one can derive the minimum D_{wr} for a given (maximum) bi-static wind turbine RCS (e.g. $\sigma = 35 \text{ dBm}^2$).

$$D_{wr} = 5016 \text{ m}$$

Consequently, when the wind turbine is more than 16 km away from the SSR, the impact on azimuth accuracy is tolerable irrespective of the path difference between the direct and the reflected signal.

The above assessment has been performed for a single wind turbine. It should be noted that would there be multiple wind turbines located in a radar beam-width and at a larger distance than 5 km, the resulting SSR azimuth error could be significant.

ANNEX - E Wind energy project description pro-forma

The pro-forma below is based on a form currently in used; it can be adapted in accordance with national regulations and practice (see yellow shaded cell).

Wind Farm Name	
Also known as:	
Developers reference	
Application identification No.	
Related/previous applications (at or near this site): Provide reference names or numbers	

Developer Information	
Company name:	
Address:	
Contact:	
Telephone:	
Facsimile:	
e-mail:	

Relevant Wind Turbine Details			
Wind turbine manufacturer:			
Wind turbine model:			
Wind farm generation capacity (MW)		Number of turbines	
Blade manufacturer			
Number of blades			
Rotor diameter			Metres
Rotation speed (or range)			Rpm
Blade material including lightning conductors			
Wind turbine hub height			Metres
Tower design (* delete as required)	* Tubular	* Lattice	
Tower base diameter/dimensions			Metres
Tower top diameter/dimensions			Metres

Comments
Are there any details or uncertainties that may be helpful to add?

Turbine Locations	
Please provide as much information as you can. The base position and tower height above sea level of every wind turbine if available, the site boundary if not. Please number the turbines or boundary points on the map, to correlate with the information provided below. Copy this page as necessary to account for all turbines or boundary points	
Wind farm Name & Address:	

Turbine no.		Height above a known reference (m) of tower base				
	Degrees		Minutes		Seconds	
Latitude						
Longitude						
Turbine no.		Height above a known reference (m) of tower base				
	Degrees		Minutes		Seconds	
Latitude						
Longitude						
Turbine no.		Height above a known reference (m) of tower base				
Grid Reference			100 km square letter(s) identifier			
Latitude						
Longitude						
Turbine no.		Height above a known reference (m) of tower base				
	Degrees		Minutes		Seconds	
Latitude						
Longitude						



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CIVIL AVIATION AUTHORITY**CIVIL AVIATION
ADVISORY PUBLICATION**

Date: July 1992 No: 92-1(1)

SUBJECT: GUIDELINES FOR AEROPLANE LANDING AREAS**IMPORTANT**

The information in this publication is advisory only. There is no legal requirement to observe the details set out in this publication. The Civil Aviation Regulations set out the legal requirements that must be complied with in relation to the subject matter of this publication. There may be a number of ways of ensuring that the requirements of the Civil Aviation Regulations are met. This publication sets out methods that may be used and which experience has shown should, in the majority of cases, ensure compliance with the Regulations. However, before using the information in this publication the user should always read the Civil Aviation Regulations listed in the reference section below to ensure that he or she complies with the legal obligations of the Regulations.

PURPOSE

Civil Aviation Regulation 92 (1) states that: "An aircraft shall not land at, or take-off from, any place unless: ...(d) the place....is suitable for use as an aerodrome for the purposes of the landing and taking-off of aircraft; and, having regard to all the circumstances of the proposed landing or take-off (including the prevailing weather conditions), the aircraft can land at, or take-off from, the place in safety."

Regulation 92 (1) does not specify the method of determining which "circumstances", other than the prevailing weather conditions, should be considered in any particular case. These matters are the responsibility of the pilot

in command and, in some circumstances, are shared with the aircraft operator.

These guidelines set out factors that may be used to determine the suitability of a place for the landing and taking-off of aeroplanes. Experience has shown that, in most cases, application of these guidelines will enable a take-off or landing to be completed safely, provided that the pilot in command:

- (a) has sound piloting skills; and
- (b) displays sound airmanship.

CANCELLATION

This is the second issue of CAAP 92-1, and supersedes CAAP 92-1(0).

REFERENCES

This publication should be read in conjunction with: Civil Aviation Regulations 92 (1), 93, 233 and 235; Civil Aviation Orders; and the Aeronautical Information Publication.

HOW TO OBTAIN COPIES OF THIS PUBLICATION

Copies of this publication may be obtained from:

Civil Aviation Authority Publications
Centre
607 Swanston Street
Carlton
Victoria 3053

Telephone (008) 331676
 (008) 334191
 (03) 342 2000

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1 - DEFINITIONS

1. In these guidelines, unless the contrary is stated:

“clearway” means an area in which there are no obstacles penetrating a slope of 2.5% rising from the end of the runway over a width of 45m;

“float plane” means any aeroplane designed for landing or taking-off from water;

“fly-over area” means a portion of ground adjacent to the runway strip which is free of tree stumps, large rocks or stones, fencing, wire and any other obstacles above ground but may include ditches or drains below ground level;

“landing area” (LA) means an area of ground suitable for the conduct of take-off and landing and associated aeroplane operations under specific conditions;

“lateral transitional slope” means a desirable area around all LA's which provides greater lateral clearance in the take-off and landing area and may reduce wind-shear when the runway is situated near tall objects such as trees and buildings. The dimensions of a suitable lateral transitional slope are shown in the following diagram;

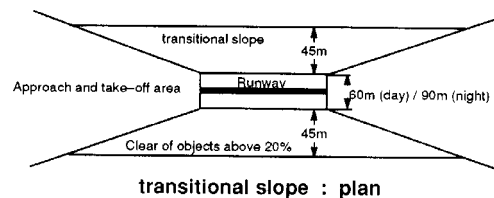


Figure 1 - Transitional Slope

“obstacle free area” means there should be no wires or any other form of obstacles above the approach and take-off areas, runways, runway strips, fly-over areas or water channels;

“runway” means that portion of the landing area which is intended to be used for the landing or take-off of aeroplanes;

“runway strip” means a portion of ground between the runway and fly-over area which is in a condition that ensures minimal damage to an aeroplane which may run off a runway during take-off or landing;

“water alighting area” means a suitable stretch of water for the landing or taking-off of a float plane under specific conditions.

2 - CONVERSION TABLE

2. Landing area gradients and splays expressed as a percentage, in accordance with ICAO practice, may be converted into ratios or angles using the following table:

Percentage	Ratios	Degrees & Minutes
1	1:100	0 34'
2	1:50	1 09'
2.5	1:40	1 26'
2.86	1:35	1 38'
3	1:33.3	1 43'
3.33	1:30	1 55'
5	1:20	2 52'
12.5	1:8	7 08'
20	1:5	11 18'

3 - WHICH AIRCRAFT MAY USE A LANDING AREA?

3. Use of landing areas other than aerodromes is not recommended for aircraft with a MTOW greater than 5700 kg.

4 - WHICH TYPES OF OPERATIONS MAY BE CONDUCTED FROM A LANDING AREA?

4. Aeroplanes engaged in the following operations may use a landing area:

- (a) private;
- (b) aerial work—excluding student solo flying and student dual flying prior to successful completion of the General Flying Progress Test; and
- (c) charter.

5 - RECOMMENDED MINIMUM PHYSICAL CHARACTERISTICS OF LANDING AREAS AND WATER ALIGHTING AREAS

5.1 Runway Width. For other than agricultural operations, a minimum width of 15 metres is recommended although aeroplanes with a MTOW below 2000kg can be operated safely on runways as narrow as 10 metres provided there is no or only light cross-wind. For agricultural operations, a 10 metre wide runway is the recommended minimum.

5.2 Runway Length. For other than agricultural operations by day, a runway length equal to or greater than that specified in the aeroplane's flight manual or approved performance charts or certificate of airworthiness, for the prevailing conditions is required (increasing the length by an additional 15% is recommended when unfactored data is used). For agricultural day operations, the minimum runway length is the greater of 75% of the take-off distance specified in the aeroplane's flight manual or approved performance chart for the prevailing conditions with the balance as clearway or the landing distance so specified.

5.3 Longitudinal Slope. The longitudinal slope between the runway

ends should not exceed 2%, except that 2.86% is acceptable on part of the runway so long as the change of slope is gradual. For agricultural operations, the slope should not exceed 12.5% for day and 2% for night operations: where the overall slope exceeds 2% the runway should only be used for one-way operations — downhill for take-off and uphill for landing.

5.4 Transverse Slope. The transverse slope between the extreme edges of the runway strip should not exceed 2.5% or 12.5% upward slope over the fly-over area. For agricultural day operations, the transverse slope should not be more than 3% over the runway and 5% over the runway strip.

5.5 Other Physical Characteristics. Both ends of a runway, not intended solely for agricultural operations, should have approach and take-off areas clear of objects above a 5% slope for day and a 3.3% slope for night operations. Other recommended landing area physical characteristics are shown on the following diagrams:

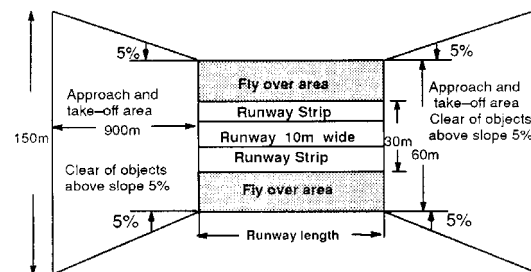


Figure 2A - Single engine and Centre-Line Thrust Aeroplanes not exceeding 2000 kg MTOW (day operations)

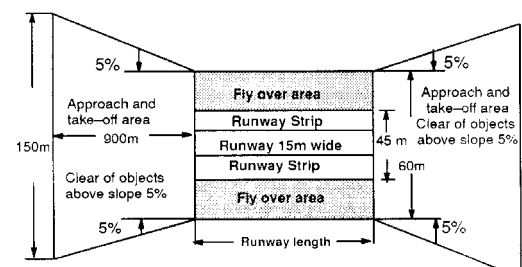


Figure 2B - Other Aeroplanes (day operations)

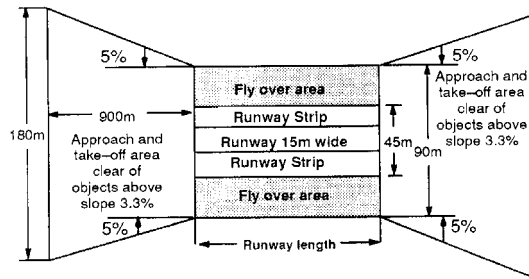


Figure 3 - Dimensions (night operations)

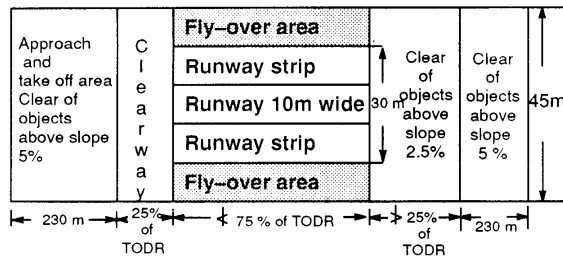


Figure 4 - Dimensions - agricultural day operations

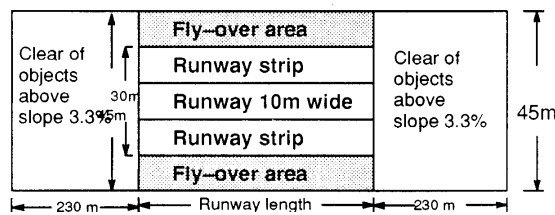
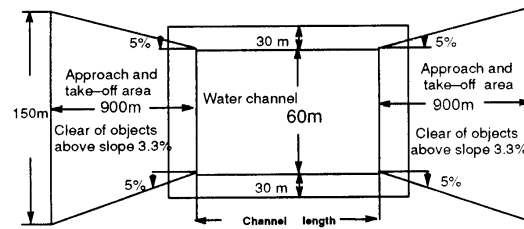


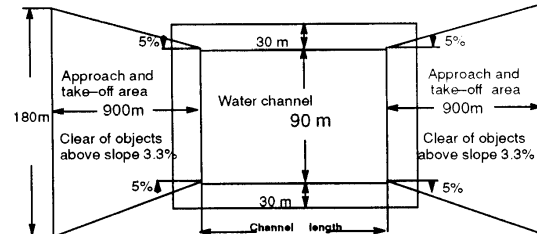
Figure 5 - Dimensions - agriculture night operations

5.6 Float plane alighting areas. For water operations, a minimum width water channel of 60 metres for day operations and 90 metres for night operations is recommended. The depth of water over the whole water channel should not be less than 0.3 metres below the hull or floats when the aeroplane is stationary and loaded to maximum take-off weight. An additional area, as shown in the following diagrams, provides a protective buffer for the water channel but need not consist of water. Where the additional area consists of water then it should be clear of moving objects or vessels under way. The centre line of a water channel may be curved, provided that the approach and take-off areas are calculated from the anticipated point of touchdown or lift-off.



Single Engine and Centre - Line Thrust Aeroplanes not Exceeding 2000 kg MTOW

Dimensions (day operations)



Single Engine and Centre - Line Thrust Aeroplanes not Exceeding 2000 kg MTOW

Dimensions (night operations)

Figure 6 - Float planes

6 - MARKING OF LANDING AREAS

6.1 Where extended operations are expected to be conducted at a landing area, the owner/operator is encouraged to provide markings similar to those found at government and licensed aerodromes. If markings are provided, they should follow the colours and specifications set out in AIP AGA. A suitable layout is shown at Figure 7.

6.2 Where runway markers are provided which are not flush with the surface, they should be constructed of a material that is not likely to damage an aircraft.

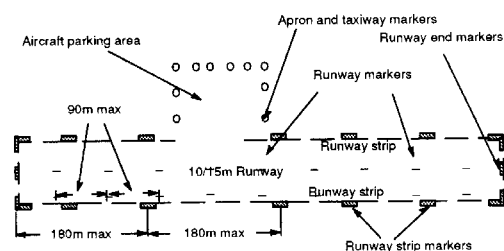


Figure 7 - Typical ALA layout and marking

7 - LIGHTING FOR NIGHT OPERATIONS

7.1 The recommended minimum lighting and layout is as follows:

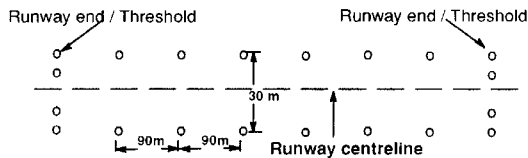


Figure 8 - Lighting for Night Operations

7.2 The lights should, under the weather conditions prevailing at the time of the flight, be visible from a distance of no less than 3000 metres.

7.3 Substitution of runway lights with reflectorised markers is permitted but not recommended by the Authority.

7.4 The different types of reflectorised markers vary in efficiency. Their luminosity can be affected by a number of factors, including equipment cleanliness/layout, the position/strength of the aircraft landing light(s) and meteorological conditions — especially cross winds on final.

7.5 The following lights should not be substituted by reflectorised markers:

- (a) runway end/threshold corner lights;
- (b) lights 90m from each runway end/threshold; and
- (c) lights nearest to the illuminated runway mid-length point.

8 - OTHER FACTORS THAT SHOULD BE CONSIDERED PRIOR TO USING A LANDING AREA

8.1 A pilot should not use a landing area or have an aeroplane engine running unless the aeroplane is clear of all persons, animals, vehicles or other obstructions.

8.2 A pilot should not use a landing area without taking all reasonable steps to ensure the physical characteristics and dimensions are satisfactory. For aerial work and charter operations the operator should provide evidence to the pilot on the suitability of a landing area prior to its use.

8.3 Runway lengths calculated for take-offs and landings should be increased by 50% for agricultural operations on one-way runways at night.

8.4 **Geographic Location.** A landing area should not be located:

- (a) within the area or in such close proximity as to create a hazard to aircraft conducting a published instrument approach, excluding the holding pattern; or
- (b) within any area where the density of aircraft movements makes it undesirable; or
- (c) where take-off or landing involving flight over a populated area creates an unnecessary hazard.

8.5 Except in an emergency, the consent of the owner/occupier is required before a landing area may be used.

8.6 If the proposed landing area is located near a city, town or populous area or any other area where noise or other environmental considerations make aeroplane operations undesirable, the use of such a landing area may be affected by the provisions of the *Commonwealth Environment Protection (Impact of Proposals) Act 1974* and parallel State legislation as well as other legislation. It is the responsibility of the pilot and/or operator to conform with these requirements.

8.7 A method of determining the surface wind at a landing area is desirable. A wind sock is the preferred method.

8.8 The surface of a landing area should be assessed to determine its effect on aeroplane control and performance. For example, soft surfaces or the presence of long grass (over 150mm) will increase take-off distances while moisture, loose gravel or any material that reduces braking effectiveness will increase landing distance.

9 - SURFACE TESTING OF A LANDING AREA

9.1 **Rough Surfaces.** The presence of holes, cracks and ruts will degrade aeroplane performance and handling and increase the possibility of structural damage. The smoothness of a runway

can be tested by driving a stiffly sprung vehicle along the runway at a speed of at least 75 kph. If this is accomplished without discomfort to the occupants, the surface can be considered satisfactory.

9.2 Soft, Wet Surfaces. A test vehicle as indicated in the table below should be driven in a zig-zag pattern at a speed not exceeding 15 kph along the full length and width of the runway. Particular attention should be paid to suspect areas with possibly three passes over these areas. If tyre imprints exceed a depth of 25mm the surface is not suitable for aircraft operations represented by the test vehicle. Experience may prove that for a certain type of aircraft (eg, an aircraft with small

wheels or high tyre pressure) operations are unsafe with a lesser imprint. Testing with a crowbar should also be done in several places along the runway to ensure that a dry surface crust does not conceal a wet base.

USER AIRCRAFT WEIGHT	SUGGESTED VEHICLE TO BE USED FOR TEST
1. MTOW not exceeding 2000kg	Fully laden utility, Landrover, station sedan.
2. MTOW 2001 kg to 3400kg	Fully laden 1.5 tonne truck or lightly laden 3 tonne truck.
3. MTOW 3401 kg to 5700kg	Fully laden 3 tonne truck
Attention should also be given to the remainder of the strip as this area is provided for run-off in the event of an abnormal take-off or landing.	



Australian Government
Civil Aviation Safety Authority

Advisory Circular

AC 139-08(0)

APRIL 2005

REPORTING OF TALL STRUCTURES

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1. REFERENCES

- CASR 139.360 and CASR 139.365
- MOS – Part 139-Aerodromes, Chapter 7-Obstacle Restriction and Limitation, Section 7.1 – General
- Airports (Protection of Airspace) Regulations 1996

2. PURPOSE

2.1 The purpose of this AC is to provide some guidance to those authorities and persons involved in the planning, approval, erection, extension or dismantling of tall structures so that they may understand the vital nature of the information they provide.

2.2 Information on tall structure is held centrally by the Royal Australian Air Force (RAAF) Aeronautical Information Service (AIS) who maintain a tall structure database. Information is also provided to a range of aviation organisations so that they can be identified on aeronautical charts, etc.

3. STATUS OF THIS AC

3.1 This is the first AC to be issued on this subject, however the content of this AC updates information previously published in CAAP 89W-2(0) — Reporting of Tall Structures.

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.

Where an AC is referred to in a 'Note' below the regulation, the AC remains as guidance material.

ACs should always be read in conjunction with the referenced regulations.

4. BACKGROUND

4.1 The Australian aviation community has identified a need to have information on tall structures available for publication on aeronautical charts.

4.2 The RAAF Aeronautical Information Service (AIS) has been assigned the task of maintaining a database of tall structures, the top measurement of which is:

- 30 metres or more above ground level — within 30 kilometres of an aerodrome; or
- 45 metres or more above ground level elsewhere

4.3 The database of tall structures will generally capture more information than what is required to be reported by the regulations.

4.4 The database will also be available for use by mapping agencies such as Australian Surveying and Land Information Group, and domestic and international aviation organisations.

5. WHY REPORT TALL STRUCTURES

5.1 Inadvertent collision with tall structures is a significant cause of aircraft accidents involved in low level flying operations. The risk posed by a tall structure to aircraft safety can be minimised if information on the tall structure is conveyed to pilots so that they can fly at a safe margin above the structure.

5.2 Low level flying operations are typically conducted during:

- approach, landing and take-off operations
- specialist flying activities (such as crop-dusting, cattle mustering, pipeline inspection, fire-fighting)
- search and rescue operations
- military low-level flying operations

5.3 Except for approach, landing and take-off operations (which are normally conducted in the vicinity of an aerodrome) low level operations can be conducted anywhere across Australia (subject to regulatory conditions/limitations).

5.4 In addition to the safety of aircraft operations, an inadvertent collision with a tall structure poses a number of other risks:

- business continuity if the services provided from the tall structure are unavailable e.g. communications services
- costs associated with the erection of a new structure
- liability issues

5.5 In the event of an aircraft hitting a tall structure, the role of persons and/or organisations associated with the operation of the tall structure would be a matter for the courts.

6. WHAT ARE THE AVIATION REGULATIONS THAT APPLY TO TALL STRUCTURES?

6.1 CASR 139.360 requires the operator of a certified or registered aerodrome to notify CASA of any development or proposed construction in the vicinity of the aerodrome (normally 15km) that is likely to be a hazard to air navigation.

6.2 In the vicinity of major capital city airports, the *Airports (Protection of Airspace) Regulations 1996* also apply. Under these regulations, the operator of such an aerodrome has to notify the Department of Transport and Regional Services (DOTARS) of any potential infringement to the prescribed airspace established for that aerodrome. DOTARS has the power to prohibit or limit erection of tall structures within the prescribed airspace of a Federal Airport covered by the *Airports (Protection of Airspace) Regulations*.

6.3 In areas remote from an aerodrome, CASR 139.365 requires the owner of a structure (or proponents of a structure) that will be 110m or more above ground level to inform CASA. This is to allow CASA to assess the effect of the structure on aircraft operations and determine whether or not the structure will be hazardous to aircraft operations.

7. WHAT DO I NEED TO REPORT?

7.1 Details should be provided on the construction, extension or dismantling of tall structures the top of which is:

- 30 metres or more above ground level (within 30 kilometres of an aerodrome); and
- 45 metres or more above ground level elsewhere.

7.2 Information provided to the database should be accurate and readily interpreted. The “TALL STRUCTURE REPORT FORM” at Attachment A has been designed to help owners and/or developers in this respect.

8. WHERE WILL THE INFORMATION BE HELD?

8.1 The information on all tall structures is held in a central database that is managed by the RAAF AIS.

9. HOW DO I REPORT?

9.1 Information on tall structures and any queries in regard to the database should be directed to:

Aeronautical Data Officer

RAAF AIS (VBM-M2)

Victoria Barracks

St Kilda Road

Southbank Vic 3006

Tel: (03) 9282-5750

Fax: (03) 9282-6695

Email: ais.charting@defence.gov.au

9.2 To assist all organisations to provide all of the necessary and complete information, use of the standard “Tall Structure Report” form attached to this AC (Attachment A) is encouraged.

Richard Macfarlane

Acting Executive Manager

Aviation Safety Standards

ATTACHMENT A TALL STRUCTURE REPORT FORM

To: Aeronautical Data Officer
Date:
Tel: (03) 9282-5750
Fax: (03) 9282-6695
Email: ais.chartering@defence.gov.au

NOTIFICATION OF New
Removal of
Change made to Tall Structures
(Delete As Appropriate)

LOCATION and DESCRIPTION OF STRUCTURE

Site Name: _____

Identification of the Structure (if known) e.g. Company Reference No.	State or Territory
--	--------------------

Site Address:

Nearest town or prominent landmark: _____ Locality or feature name: _____

Municipality / Shire Council: Postcode:

Description (type) of structure: _____

(e.g. 45m Guyed Mast, 38m Concrete Monopole, 60m Lattice Tower, Lighthouse, Beacon, Building, Chimney, Elevated Tank)

Owner of structure:

SURVEY DATA

Survey Datum: (Note: The use of the wrong datum will misplace obstructions by around 200 m)

WGS 84 / GDA 94

11

AGD 66

7

AGD 84

7

Latitude: S Longitude: E

(Degrees, minutes and seconds to 1/100th of a second) (if available) (DD:MM:SS.SS) or (DD.DDDD)

Or UTM Grid Reference: Easting / X (m) Northing / Y (m)

Zone: _____ Positional Accuracy $\pm$ (metres) (if available) : _____

Date of last survey (if known): _____ / _____ / _____ Year of erection: _____ / _____ / _____

Height of structure: _____ Height Accuracy $\pm$ FT (if available): _____

Ground level elevation* at the base of the Structure (if known): _____

Height from ground level to the top most point of the obstruction in metres (including all antennae, aerials and other attachments) : _____

Elevation* to the top of the structure in metres, including all antennae, aerials and other attachments: _____

Note: *Elevation values are referenced to Mean Sea Level (AMSL) or the Australian Height Datum (AHD) and values are requested in feet or to 1/10th of a metre.

Value Code: How was the data captured? (1) (2) (3) (4) (5) (6) (*Please circle*)

- | | |
|------------------------------|---------------------------|
| 1. 1st order survey | 2. Stereo photogrammetric |
| 3. Mono photogrammetric | 4. Chart/map derived |
| 5. Handheld GPS (non survey) | 6. Reported |

Guy-wire footprint: _____ metres (*Lateral distance from structure*)

MARKING

Obstacle marking (e.g. painted red or orange and white) Yes / No

Obstacle lighting (e.g. flashing red obstacle light) Yes / No

Other obstacle markers (e.g. orange balls on guy wires) Yes / No

Is the Obstacle Permanent or Temporary ? Perm / Temp

If Temporary, what is the intended removal date:

_____ / _____ / _____

OTHER REMARKS

CONTACT DETAILS

Name of person making report: _____

Organisation and position within organisation: _____

Tel or Fax contact : Tel: . _____ Fax: _____

Email: _____

ELECTRONIC SUBMISSION OF DATA

An online Vertical Obstruction Report Form is available at www.raafais.gov.au/obstr_form.htm or via the RAAF Web site at www.raafais.gov.au

☐ Products ☐ Vertical Obstruction Report Form.

SITE SKETCH

Site sketch showing the proximity to roads, streets, tracks, buildings, creeks, trig points and any other suitable or relevant features to locate the obstruction.

Will forward details to AIS website:

Yes / No

If you are able to provide RAAF AIS with site drawings or construction plans in a zipped format, it would add to data integrity and completeness whilst lessening the need to make follow up calls to confirm any missing data.

Attachment Data can be sent to: ais.charting@defence.gov.au



Man Made Obstacles Located Away From Aerodromes Risk Review

November 2009

Developed for CASA by AeroSafe Risk Management.

DEVELOPED BY



DEVELOPED FOR:



Australian Government
Civil Aviation Safety Authority



Developed by:
Developed for:
Date:
Version:

Aerosafe Risk Management
Civil Aviation Safety Authority (CASA)
November 2009
Draft 1.1

November 2009

Man Made Obstacles Located Away From Aerodromes

The identification and management of risks associated with man made obstacles located outside the vicinity of certified and registered aerodromes.

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Published by Aerosafe Risk Management

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It has been identified that the legislative framework in Australia may not provide the Civil Aviation Safety Authority (CASA) with the appropriate authority with which to identify and manage the risk to aviation safety that is posed by man made obstacles that are located away from the vicinity of certified and registered aerodromes. This report provides a comprehensive review of how those risks associated with man made obstacles are identified and managed. The terms of reference of this report specifically relate to identifying the ICAO standards and recommended practices that address the identification and management of man made obstacles. Having identified these ICAO requirements the report provides a comparative analysis of the various international regulatory frameworks and identifies how other jurisdictions are satisfying the ICAO requirements. The report also examines the environment within Australia with respect to how those stakeholders, such as wind farm developers, are affected by the current legislative and regulatory framework relating to man made obstacles.

This report provides a review of the International Civil Aviation Organisation (ICAO) Standards and Recommended Practices (SARPS) and identifies those ICAO requirements concerning the issue of man made obstacles located away from the vicinity of aerodromes. The report identifies the legislative frameworks that exist outside Australia and how other aviation regulators are satisfying the ICAO requirements. The report also examines the local stakeholders within Australia that are concerned with the issue of man made obstacles that are located away from the vicinity of aerodromes, specifically the wind farm industry. This report was developed using a number of methods such as face to face interviews, document and legislative reviews, industry surveys, and research using information extracted from the public domain. The assessment process used to conduct the risk assessment was consistent with the AS/NZS 4360:2004 Risk Management standard.

This report identifies 7 key findings in relation to identifying and managing the risks associated with man made obstacles that are located away from the vicinity of aerodromes. The principle finding of this report is that, while the inherent aviation safety risk relating to this issue (in the context of the whole aviation industry in Australia) is within the low range, the current Australian aviation legislative framework does not satisfy the ICAO requirements with respect to the identification and management of man made obstacles that are located away from the vicinity of aerodromes. Annex 14 provides specific recommendation that require the Authority to have in place 'arrangements' that ensures that they are consulted with respect to constructions outside the limits of the Obstacle Limitation Surface OLS, or away from the vicinity of aerodromes. Current legislation in Australia does not allow CASA to satisfy this ICAO Requirement.

Further to this finding it has been found that current legislation (Civil Aviation Act 1988) does not specifically allow for the making of regulations concerning obstacles that are located away from the vicinity of aerodromes. The scope of the current regulations are restricted to the management of man made obstacle that are located within the vicinity of aerodromes and do not provide CASA with adequate powers to identify and manage these obstacles. There is also a high level of uncertainty around the existing data concerning man made obstacles located away from the vicinity of aerodromes and this level of uncertainty means that CASA and other interested agencies do not have an accurate picture of the aviation risks that might be associated with those man made obstacles.

Based on the key findings, this report provides 10 key recommendations that are designed to bring Australian legislation, regulations and practices in line with the best practices used internationally and ensure that the appropriate ICAO standards and recommended practices are satisfied. The principle recommendation of this report is the development of legislation that allows for the making of regulations surrounding the issue of man made obstacles that are located away from the vicinity of an aerodrome. Given that this legislative power is ratified, it is recommended that all regulations concerning objects that might affect the safety of navigable airspace should be contained within one Civil Aviation Safety Regulation (CASR) i.e. CASR Part 77 Objects that Affect the Navigable Airspace. And that all regulations pertaining to obstacles contained within CASR 139 should be rolled into CASR Part 77.

Current regulations surrounding the provision of compensation for proponents for any expenses that they incur as a result of installing mitigation measures is not consistent with international practices and provides a barrier for CASA to make further regulations regarding man made obstacles and it recommended that this compensation legislation should be repealed.

The report concludes that, notwithstanding the relatively low risk to the overall aviation industry posed by man made obstacles located away from the vicinity of aerodromes, there remains a gap in the legislative framework that means CASA does not have the authority to manage the issue appropriately, and that local stakeholder such as wind farm developer are not provided with appropriate direction as to their requirements and obligations to aviation safety. By providing the appropriate legislation, regulatory framework the authority, in this case CASA, will be in a position to implement appropriate systems and processes for the identification and management of man made obstacles whether they are located in and around aerodromes or away from the vicinity of aerodromes.

The report has been structured to represent separately the findings and recommendations of the project team. The Findings and Recommendations are represented in the Executive Summary section in order to allow the quick and easy access to the information. There is a total of 7 findings and 10 key recommendations. A more detailed list of findings can be found in Annex D of this report.

Findings

NO.	FINDING
F1	ICAO REQUIREMENTS The current Australian legislative framework does not satisfy the standards and recommended practices in relation to man made obstacles as set out in ICAO Annex 14 Volume I Chapter 4 and Chapter 6.
F2	INTERNATIONAL LEGISLATION The USA and New Zealand have developed a legislative framework that groups the regulations pertaining to the management of man made obstacles, wherever they are located, into one rule set (Part 77 – Objects that Affect the Navigable Airspace). Part 77 sets out the requirement for notification heights and the standards with which the regulator is required to assess objects that affect the navigable airspace.
F3	AUSTRALIAN LEGISLATION The current Australian legislation does not allow the making of regulations concerning man made obstacles that are located away from the vicinity of an aerodrome.
F4	AUSTRALIAN REGULATORY FRAMEWORK The absence in Australia of a formal or legislated framework for conducting Aeronautical Studies on man made obstacles located away from the vicinity of aerodromes means that CASA is not suitably equipped with the appropriate options for making obstacle determinations. The current Australian legislation and rule set does not address man made obstacles that are located away from the vicinity of aerodromes and is restricted to dealing with man made obstacles that are located on or within the vicinity of an aerodrome.
F5	CURRENT AUSTRALIAN PROCESS The RAAF AIS is the organisation in Australia charged with the responsibility to collect man made obstacle data, however the data is collected for information and charting purposes only. No Aeronautical Studies are done to determine whether the man made obstacle is a hazard to aviation. There is a high level of uncertainty around the current information that is held on man made obstacles. It can be reasonably assumed that this is due to the fact that legislation in Australia does not require the mandatory reporting of tall structures that could potentially be obstacles to navigable airspace.

F6

ADVISORY MATERIAL

CASA have one current publication, AC 129-08(0) that sets out the reporting requirements for tall structures, and a repealed AC 139-18(0) Obstacle Marking and Lighting of Wind Farms. AC 139-18(0) provided guidance specifically relating to wind farms, however did not address other man made obstacles.

F7

WIND ENERGY INDUSTRY

The wind energy industry in Australia is concerned that CASA do not have the mandate to consider options that offer alternatives to the lighting of wind farms. The wind energy industry is required to deal with the visual amenity issues caused by the requirement for lighting on wind turbines. ICAO Annex 14 Volume I Chapter 6 provides clear requirements for the marking and lighting of wind farms in the case that they are determined to be a hazard to aviation, however there is potential that a formal Aeronautical Study may determine that a wind farm in a certain location offers no hazard to aviation, thus removing the requirement for marking and lighting.

Recommendations

NO.

RECOMMENDATION

R1

AUTHORITY TO MAKE REGULATIONS

That the Civil Aviation Act is reviewed in the context of ensuring that CASA has the power to make regulations specifically concerning buildings, structures and objects that are located away from the vicinity of a certified or registered aerodrome.

R2

REMOVAL OF COMPENSATION REQUIREMENTS

That the Civil Aviation Act 1988 is reviewed in the context of removing the requirement to provide compensation for the installation of marking and/or lighting on buildings, structures and objects that have been determined to be a hazard to aviation.

R3

OPTION 1 – CREATION OF PART 77 OBJECTS THAT AFFECT NAVIGABLE AIRSPACE

This option is designed to group all obstacle related regulation within one CASR Part. It is proposed that this CASR Part is designated CASR Part 77. This brings the regulation of obstacles in Australia in line with the regulatory structure applied in the United States and New Zealand.

OPTION 2 – EXPANSION OF PART 139 TO INCLUDE OBSTACLES THAT ARE LOCATED AWAY FROM THE VICINITY OF AERODROMES

This option is designed to ensure that the current CAR Part 139 – Aerodromes sufficiently satisfies the ICAO requirements both for obstacles within the vicinity of aerodromes and for obstacles located away from the vicinity of aerodromes.

R4**ADVISORY PUBLICATION – NOTIFICATION REQUIREMENTS**

That an Advisory Circular that outlines the obligations for reporting structures, buildings or objects that may affect aviation safety is published in accordance with the requirements set out in the updated Regulations.

R5**ADVISORY PUBLICATION – MARKING AND LIGHTING REQUIREMENTS**

That an Advisory Circular that sets out the standards for the marking and lighting of obstacles is published in accordance with the standards set out in the updated Regulations.

R6**ONGOING EDUCATION PROGRAM FOR INDUSTRY AND PLANNING AUTHORITIES**

That an ongoing education program directed to industry developers and local planning authorities is established in order to highlight the responsibility for proponents to report their developments initially to the RAAF AIS, and ultimately to CASA for the purpose of an Aeronautical Study.

R7**INTERNAL CASA CAPABILITY**

That CASA develop a capability under the Office of Airspace Regulation that manages the submission of obstacle notifications and industry submitted Aeronautical Studies, and that the establishment of this capability is based on the estimated number of submissions that would be generated by the new Regulations.

R8**SHARING OF OBSTACLE DATA**

That CASA enter into a Memorandum of Understanding between RAAF AIS, GeoScience Australia and ASA in order to ensure that information on man made obstacles that constitute a hazard to aviation is shared between the organisations in a timely manner.

R9**ONLINE OBSTACLE DATABASE**

That the feasibility of developing an online obstacle database is explored. The online obstacle database would be developed to allow proponents to submit proposed developments that meet the notification requirements. The database would be used by the proponents to submit any Aeronautical Studies and by CASA internally to record their determination. The results of any determinations could be released via the database and made searchable online.

R10**NATIONAL PLANNING GUIDELINES**

That CASA develop a national planning policy to provide guidance to local, state and federal planning authorities on the issues relating to man made obstacles and the process for notifying CASA of any proposal that meets certain requirements.

PART 1:

Introduction and Context

Background

1. In the Australian context there are a number of legislative instruments and publications that concern themselves with the management of man made obstacles that affect navigable airspace and potentially the safe operation of aircraft using the airspace. This legislation and the associated publications however are confined to dealing with man made obstacles that are situated in the vicinity of a certified or registered aerodrome.
2. Until a recent legal challenge and subsequent judgement, CASA has historically considered that any man made object that exceeds a height of 110m is assessed as an obstacle and as such, subject to an internal assessment as to the obstacles impact on aviation safety. Where this assessment determined that the obstacle had a negative impact on aviation safety, the obstacle was required to be lit in accordance with the standards set out in CASR Part 139 MOS Section 9.4 Obstacle Lighting.
3. The legal basis for this historical practice is CASR 139.365 – Structures 110 metres or more above ground level, which requires that CASA must be informed of any object of a height of 110m or more. However, a level of ambiguity exists as to whether this regulation applies to structures that are away from the vicinity of aerodromes. The regulation itself is not specifically limited to structures that are located within the vicinity of an aerodrome, however by virtue of the fact that the regulation is placed within Part 139 – Aerodromes, it can be reasonably implied that the regulation is restricted to those structures that are located within the vicinity of an aerodrome. Part 139 – Aerodromes specifically states in CASR 139.005 that the Part as a whole applies to “... *obstacles and hazards at aerodromes*”.
4. This legal challenge and the subsequent judgement has identified the fact that there is a high level of ambiguity around whether current regulations allow for CASA to mandate or recommend any mitigation options for objects that affect navigable airspace, that are located outside the vicinity of a certified or registered aerodrome.

Purpose

5. The purpose of this review is to examine how risks associated with man made obstacles, including Wind Farms, which are located outside of the vicinity of certified and registered aerodromes are identified and managed.

Objectives

6. The objective of the review is to generate recommendations surrounding the content and issue of new legislation and advisory material covering planning, identification and illumination of man made obstacles.
7. The review has two primary objectives:
 - Determine how other aviation regulatory jurisdictions, such as the UK CAA, CAA NZ and FAA are handling the identification of man made obstacles and in particular their legislative framework and recent advisory material.
 - Deliver recommendations that are based on best practice from other aviation regulatory jurisdictions and informed by the results of stakeholder interviews and forums

Assumptions

8. The following assumptions have been made in relation to CASA's requirements of the review:
 - CASA is looking to achieve ICAO compliance in this area

-
- CASA is looking to maximise proven practices from other regulatory authorities and better practice standards around the world, and thus not developing a separate Australian only approach
 - that the recommendations from this report provides advice to CASA that may act as the basis on which legislation and advisory material will be updated
 - ICAO Annex 14, Aerodromes, Volume 1 – Aerodromes has been used as the basis for evaluating the standards and practices of Australian and International practices

Limitations

9. The following limitations were encountered in researching and developing this review:
 - Aerosafe does not possess the appropriate legal expertise to advise on legislative matters and for the purposes of this report have identified areas that may require this additional expertise
 - Although there was a great focus on industry consultation during this project, there may be a number of stakeholders who did not participate in this process. Any Notice of Proposed Rule Making (NPRM) subsequent to this report will satisfy industry consultation requirements.
 - The review is limited to examining the identification and management of man made obstacles which are deemed to be located outside the control of Part 139 – Aerodromes Chapter 7 which defines the standards that control airspace around aerodromes.
 - This report does not address the affects that wind turbines may have on the operational effectiveness of navigational aids and other electronic equipment.
 - The project duration was eight weeks.

Report structure

10. This report consists of 5 parts:
 1. **Part 1: Introduction & Context**

This section provides background to the report and sets the context under which the review is conducted.
 2. **Part 2: International Regulatory Comparative Analysis**

This section compares the current situation in Australia with the practices and standards applied in other 'like-type' aviation regulatory jurisdictions and makes recommendations on implementing best practice in the Australian context.
 3. **Part 3: Risk Assessment**

In the context of the regulatory comparative analysis outlined in Part 2, this section sets out in table format the corporate risk issues associated with the management of man made obstacles located away from aerodromes
 4. **Part 4: Findings and Recommendations**

Using the Regulatory Comparative Analysis and the Risk assessment, this sections details the findings and recommendations associated with the management of man made obstacles located away from aerodromes
 5. **Annexes**

Outlining supporting documentation.

PART 2:

International Regulatory Comparative Analysis

Overview

11. The International Regulatory Comparative Analysis examines the way that other Regulators are handling the identification and management of the risks associated with man made obstacles that are located away from the vicinity of certified and registered aerodromes. In particular this section examines the legislative framework within which other Regulators operate and looks at recent advisory material on the issue.
12. This section also examines the specific International Civil Aviation Organisation (ICAO) standards and recommended practices in relation to obstacles and visual aids denoting obstacles.

International Civil Aviation Organisation (ICAO)

13. The Convention on International Civil Aviation, signed in Chicago on 7 December 1944 (the Chicago Convention), came into force on 4 April 1947. The International Civil Aviation Organisation (ICAO) is a specialised agency of the United Nations whose mandate is to ensure safe, efficient and orderly evolution of international civil aviation¹. The Chicago Convention provides (Article 37) for the Council of ICAO to make standards and recommended practices dealing with a wide range of matters concerned with the safety, regularity and efficiency of air navigation. ICAO Signatory States are required to comply with the standards and recommended practices, published by ICAO as Annexes to the Chicago Convention. Article 38 of the Convention requires, where a State finds it impracticable to comply in all respects with a standard, or to bring its own regulations or practices into full accord with a standard, that notification be given to ICAO.

Annex 14 – Aerodromes Volume I

14. Chapter 4 of Volume 1 of Annex 14 deals specifically with “*obstacle restriction and removal*” in the airspace around aerodromes. The objectives of the specifications found in Chapter 4 are “... *to define the airspace around aerodromes*” and states that *this airspace is to be “... free from obstacles so as to permit the intended aeroplane operations at aerodromes ...”*. This specification deals with identifying and managing man made obstacles that are within the vicinity of aerodromes using the concept of an Obstacle Limitations Surface (OLS). An OLS defines a series of imaginary surfaces around an aerodrome. This surface defines the limits to which obstacles may project into the airspace around the aerodrome.
15. The primary purpose of Annex 14 Volume 1 and specifically Chapter 4 – Obstacle Restriction and Removal is to ensure that obstacles around aerodromes are managed appropriately based on standard specifications. While a significant portion of Chapter 4 is concerned with outlining the specifications of an OLS, Section 4.3 – Objects Outside the Obstacle Limitation Surfaces, provides two recommendations that address the issue of obstacles that may be situated away from an aerodrome and any OLS that is associated with that aerodrome.
16. Recommendation 4.3.1 states:

“Arrangements should be made to enable the appropriate authority to be consulted concerning proposed construction beyond the limits of the obstacle limitation surfaces that extend above a height established by that authority, in order to permit an aeronautical study of the effect of such construction on the operation of aeroplanes.”
17. This recommendation could be interpreted as requiring the authority, in this case CASA, to establish a process that ensures they are consulted when there is a proposal to build a structure that is beyond the limits of the OLS. There may be some argument around the meaning of the term ‘beyond the limits’, however using the context set by the title of Section 4.3 – Objects Outside the Obstacle Limitation Surfaces, the term ‘beyond the limits’ can reasonably be interpreted as meaning objects that are located outside the outer limits of an OLS. Or in the context of this report, objects located away from the vicinity of an aerodrome.

18. The recommendation further introduces the concept of an aeronautical study. According to Australian regulations² an Aeronautical Study is defined as “... an investigation of a problem concerned with some phase of flight, and aimed at identifying possible solutions and selecting the one most acceptable from the point of view of flight safety.”

19. Recommendation 4.3.2 states:

“In areas beyond the limits of the obstacle limitation surfaces, at least those objects which extend to a height of 150m or more above ground elevation should be regarded as obstacles, unless a special aeronautical study indicates that they do not constitute a hazard to aeroplanes. Note.— This study may have regard to the nature of operations concerned and may distinguish between day and night operations.”

20. This recommendation could be interpreted as requiring that the authority consider all man made objects that extend to a height of more than 150m above the ground level as obstacles by default. The recommendation allows the authority to have in place a process that ensures these objects are subject to an aeronautical study to determine if in fact they are a hazard to the navigable airspace in which the object is situated.

21. At the time of writing this report there is a published proposed amendment to the international standards and recommended practices for Annex 14 Volume 1 – Aerodromes. The proposed amendment seeks to remove any ambiguity that provides opportunity to interpret Annex 14 as not dealing with obstacles outside of the OLS. The ambiguity is removed by stating in the Introductory Note that Annex 14 “... contains specifications dealing with obstacles outside those limitation surfaces”. This amendment does not change the substance or content of the standards or recommended practices contained within Annex 14, it simply clarifies that the scope Annex 14 includes the specifications for dealing with objects that are beyond the limits of the OLS.

22. The amendment also seeks to update the definition of an obstacle as:

“All fixed (whether temporary or permanent) and mobile objects, or parts thereof, that:

a) Are located on an area intended for the surface movement of aircraft; or

b) Extend above a defined surface intended to protect aircraft in flight; or

c) Stand outside those defined surfaces and that have been assessed as being a hazard to air navigation.”

23. The anticipated timing for the implementation of this amendment is that it will become applicable in November 2009.

The current ICAO definition of an obstacle outlined in ICAO Annex 14 Volume I does not include those obstacles that stand outside of the OLS and have been assessed as being a hazard to air navigation. However when considering Recommendations 4.3.1 and 4.3.2 and in light of the proposed amendment, it is clear that the intention of the Standards and Recommended Practices set out in Annex 14 include obstacles located outside the OLS and thus away from certified and registered aerodromes.

² CASR Part 139 - aerodromes

Marking and Lighting of Obstacles

24. ICAO Annex 14 Chapter 6 – Visual Aids for Denoting Obstacles sets out the Standards and recommended Practices for the marking and/or lighting of obstacles. Being part of Annex 14 – Aerodromes, the context of Chapter 6 is the marking and/or lighting of obstacles that are located within the vicinity of an aerodrome, however Section 6.2 Marking of Objects and Section 6.3 Lighting of Obstacles provides standards that can be applied to obstacles that are located away from the vicinity of aerodromes.
25. Section 6.2 provides guidance on the use of colours, use of markers, and use of flags and provides examples of the marking and lighting of tall structures (Figure 1). Section 6.3 provides guidance on the use of obstacle lights, location or obstacles lights, and provides details on the characteristics of low, medium and high intensity lights.

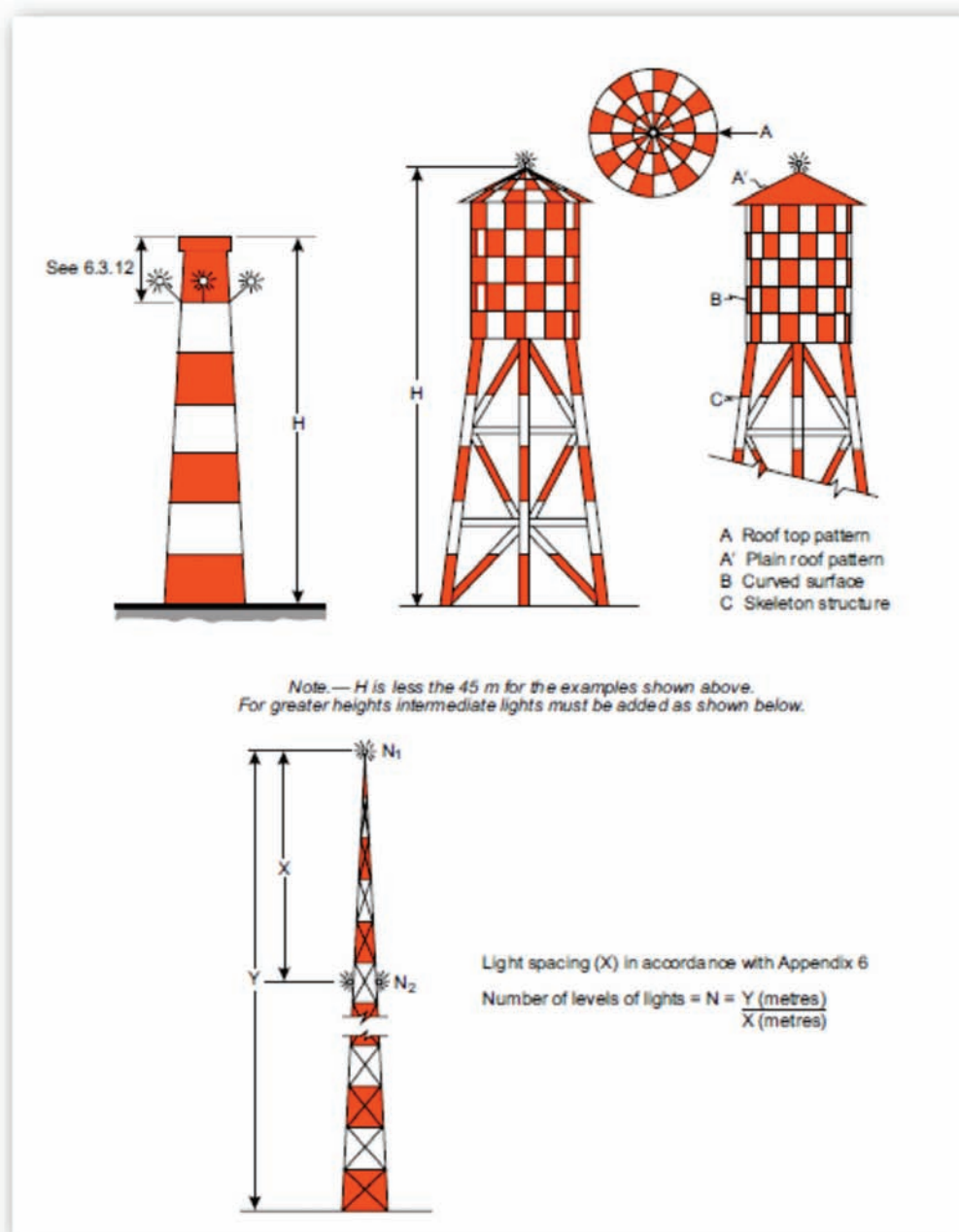


Figure 1: Examples of marking and lighting of tall structures (source: ICAO Annex 14)

-
26. In March 2009 Annex 14 Chapter 6 was amended to require that “... a wind turbine shall be marked and/or lighted if it is determined to be an obstacle”. The amendment inserts Section 6.4 and provides for the marking and lighting requirement for wind farms in the event that the aeronautical study applied by virtue of Recommendation 4.3.1 and 4.3.2 determines that the wind farm is an obstacle to aircraft.
27. Recommendation 6.4.2 states:
“The rotor blades, nacelle and upper 2/3 of the supporting mast of wind turbines should be painted white, unless otherwise indicated by an aeronautical study.”
28. Recommendation 6.4.3 states:
“When lighting is deemed necessary, medium intensity obstacle lights should be used. In the case of a wind farm, i.e. a group of two or more wind turbines, it should be regarded as an extensive object and lights should be installed:
- a) to identify the perimeter of the wind farm;*
 - b) respecting the maximum spacing, in accordance with 6.3.14, between the lights along the perimeter, unless a dedicated assessment shows that a greater spacing can be used;*
 - c) so that, where flashing lights are used, they flash simultaneously; and*
 - d) so that, within a wind farm, any wind turbines of significantly higher elevation are also identified wherever they are located.”*
29. Recommendation 6.4.4 states:
“The obstacle lights should be installed on the nacelle in such a manner as to provide an unobstructed view for aircraft approaching from any direction.”

The standards and recommended practices set out in Chapter 6 of Annex 14 Volume I are unambiguous in their requirement for lighting and marking of wind farms in the event that they are determined to be a hazard to aviation. There does not seem to be any option for alternative mitigation options. If a wind turbine is a hazard to aviation it must be marked and light according to the standards set out in Section 6.4.

Annex 15 – Aeronautical Information Services

30. Annex 15 is concerned with establishing the Standards and Recommended Practices for ensuring that the safety, regularity and efficiency of international air navigation is maintained by providing a standard set of aeronautical information services. Chapter 10 is concerned with establishing the standards and recommended practices for the collection of obstacle and terrain data and states the specifications for the collection of that data.
31. A range of new electronic terrain and obstacle data (eTOD) requirements were set out in Amendment 33 to Annex 15. The purpose of requiring the collection of eTOD is to ensure that terrain and obstacle data is collected in a standard format that can support the following applications:
- ground proximity warning system with forward looking terrain avoidance function and minimum safe altitude warning (MSAW) system;
 - determination of contingency procedures for use in the event of an emergency during a missed approach or take-off;
 - aircraft operating limitations analysis;
 - instrument procedure design (including circling procedure);

- determination of en-route “drift-down” procedure and en-route emergency landing location;
 - advanced surface movement guidance and control system (A-SMGCS);
 - aeronautical chart production and on-board databases;
 - flight simulator;
 - synthetic vision; and
 - aerodrome/heliport obstacle restriction and removal.
32. The sets of terrain and obstacle data are collected in accordance with the following coverage areas:
- Area 1: Entire territory of a state;
- Area 2: Terminal control area;
- Area 3: Aerodrome / heliport area; and
- Area 4: Category II or III operations area.
33. The implementation Schedule set down for members states to be in a position to collect eTOD became applicable in 2008 for Area 1 and Area 4 coverage. 2010 was the applicable date set down for the implementation of Area 2 and Area 3 requirements. A number of member states have since indicated to ICAO that the requirements relating to Area 2 will be difficult and costly to implement. Concerned that the difficulties with implementing these eTOD requirements may lead to wide-spread non-compliance, ICAO are currently reviewing the Standards and Recommended Practices relating to eTOD and expect that the outcome of this review will significantly reduce the implementation difficulties and costs, mainly through the amendment of requirements for proposed Area 2. As a result of this review it has been proposed in the latest amendment proposal that the applicability date for Area 2 and Area 3 be extended to November 2012.

The collection of obstacle data for use in the applications mentioned above and the collection of data in order to determine the level and nature of their hazard to air navigation has some synergies that might potentially allow these processes to be aligned. Chapter 10 sets out some very specific criteria for the structure and nature of the data that is collected for Aeronautical Information purposes and the nature of this data would be in line with being used for the purpose of conducting aeronautical studies.

Federal Aviation Administration (FAA)

34. The Federal Aviation Administration (FAA) is the agency that is responsible for civil aviation safety in the United States of America. The FAA issue and enforce regulations and minimum standards covering manufacturing, operating, and maintaining aircraft. This includes the certification of airmen and the airports that serve air carriers. The FAA are also responsible for the safe and efficient use of navigable airspace, operating a network of airport towers, air route traffic control centres, and flight service stations. The FAA achieve this by developing air traffic rules, assigning the use of airspace, and controlling air traffic.
35. The United States Code (USC) is the codification by subject matter of the general and permanent laws of the United States based on what is printed in the Statutes at Large. The USC is divided into 50 broad subject areas with Title 49 – Transportation being the specific code that deals with Aviation Statutes. Title 49 Subtitle VII – Aviation Programs gives the authority to the FAA to develop the rules and regulations required to ensure aviation safety within the United States.

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36. In the same fashion the United States Federal Regulations are codified using the Code of Federal Regulations (CFR). Title 14 of the CFR deals specifically with the area of Aeronautics and Space. The regulations that are encompassed by Title 14 of the CFR are also known as Federal Aviation Regulations (FAR's) and these FAR's are administered by the FAA. The FAR's are organized into sections, called parts which are aligned to their organization within the CFR.
37. 49 USC Section 44718 states that *"The Secretary of Transport shall require a person to give adequate public notice ... of the construction or alteration, establishment or extension, or the proposed construction alteration, establishment, or expansion of any structure ... when notice will promote; a) safety in air commerce, and b) the efficient use and preservation of the navigable airspace and of airport traffic capacity at public-use airports."*
38. As a result of this legislation 14 CFR Part 77 – Objects Affecting Navigable Airspace was issued. 14 CFR Part 77 (FAR Part 77) is structured to provide direction in the following areas:
- a) The establishment standards for determining obstructions in navigable airspace;
 - b) Set out the notification requirements to the Administrator of certain proposed construction or alteration;
 - c) Provide for the use of Aeronautical Studies of obstructions to determine their effect on the safe and efficient use of airspace;
 - d) Provide for the use of public hearings to determine the hazardous effect to air navigation by any proposed construction or alteration; and
39. FAR Part 77 is concerned with all objects that might potentially affect the safety of navigable airspace. The scope of FAR Part 77 is not limited to objects that are within the vicinity of an aerodrome. FAR Part 77 sets out two criteria for determining the types of objects that may be affected by the regulation.

FAR Part 77 applies to:

- a) Any object of natural growth, terrain, or permanent or temporary construction or alteration, including equipment or materials used therein, and apparatus of a permanent or temporary character; and
- b) Alteration of any permanent or temporary existing structure by a change in its height (including appurtenances), or lateral dimensions, including equipment or materials used therein.

FAA Regulations (FAR Part 77) is comprehensive and sets the standards for notification and assessment of obstacles whether they are located in the vicinity of an aerodrome or away from an aerodrome (including OLS). The FAR Part 139 deals exclusively with aerodrome specifications and certification.

40. Guidance Material in the form of Advisory Circulars are published by the FAA.
- AC 70/7460-1K – Obstruction Marking and Lighting
 - AC 70/7460-2K – Proposed Construction or Alteration of Objects that May Affect the Navigable Airspace
 - AC 150/5190-4 – A Model Zoning Ordinance to Limit Height of Objects Around Airports
 - AC 150/5200-33 – Hazardous Wildlife Attractants on or Near Airports
 - AC 150/5345-43 – Specification for Obstruction Lighting Equipment

41. AC 70/7460-2K – Proposed Construction or Alteration of Objects that May Affect the Navigable Airspace sets out in detail the reporting requirements of FAR Part 77. The FAA also publish a specific page on their website that deals specifically with the requirements and use of FAR Part 77³. This web page details the following information:
- Relevant FAA Contacts
 - Purpose of filing a Notice
 - Who Must File
 - On-Airport Construction Vs Off-Airport Construction
 - Airport Owners and Operators
 - Permanent Vs Temporary Modifications
 - Form of Notice
 - Notification; Timing and Submittal
 - FAA Determination
 - Applicable Resources
 - o Advisory Circulars
 - o Forms
 - o Policy
42. Part 77 sets out the Notifications requirements as:
Any person/organization who intends to sponsor any of the following construction or alterations must notify the Administrator of the FAA:
- a) *Any construction or alteration exceeding 200 ft above ground level*
 - b) *Any construction or alteration*
 - i. *within 20,000 ft of a public use or military airport which exceeds a 100:1 surface from any point on the runway of each airport with at least one runway more than 3,200 ft.*
 - ii. *within 10,000 ft of a public use or military airport which exceeds a 50:1 surface from any point on the runway of each airport with its longest runway no more than 3,200 ft.*
 - iii. *within 5,000 ft of a public use heliport which exceeds a 25:1 surface*
 - c) *Any highway, railroad or other traverse way whose prescribed adjusted height would exceed that above noted standards*
 - d) *When requested by the FAA*
 - e) *Any construction or alteration located on a public use airport or heliport regardless of height or location*
43. The first point in these requirements sets a notifiable height of 200 ft (60m) regardless of the location. Thus in the context of the scope of this report it can be established that the requirement of FAR Part 77 is that any obstacle away from a certified and registered aerodrome is notifiable to the FAA for the purpose of conducting an Aeronautical Study that determines whether the obstacle is in fact a hazard to navigable airspace.
44. A sponsor proposing any type of construction or alteration of a structure that meets the above notification requirements is required to submit the notification at least 30 days prior to the date of the proposed construction or alteration, or on or before the date that an application for a construction permit is required, whichever date is the earliest. The FAA will acknowledge in writing the receipt of each submission.

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45. Once the submission is received by the FAA it will make an assessment as to the need of an aeronautical study. An aeronautical study may also be requested by the sponsor of the proposed construction or alteration. FAR Part 77 also sets out the process by which the FAA is required to undertake the Aeronautical Study:

To the extent considered necessary, the Regional Manager, Air Traffic Division or his designee:

- a) Solicits comments from all interested persons;*
 - b) Explores objections to the proposal and attempts to develop recommendations for adjustment of aviation requirements that would accommodate the proposed construction or alteration;*
 - c) Examines possible revisions of the proposal that would eliminate the exceeding of the standards in subpart C of this part; and*
 - d) Convenes a meeting with all interested persons for the purpose of gathering all facts relevant to the effect of the proposed construction or alteration on the safe and efficient utilization of the navigable airspace.*
46. In the case that an aeronautical study is determined to be necessary the submission is assessed against the standard that is outlined in FAR Part 77 Subpart C:

An existing object, including a mobile object, is, and a future object would be, an obstruction to air navigation if it is of greater height than any of the following heights or surfaces:

- a) A height of 500 feet above ground level at the site of the object.*
 - b) A height that is 200 feet above ground level or above the established airport elevation, whichever is higher, within 3 nautical miles of the established reference point of an airport, excluding heliports, with its longest runway more than 3,200 feet in actual length, and that height increases in the proportion of 100 feet for each additional nautical mile of distance from the airport up to a maximum of 500 feet.*
 - c) A height within a terminal obstacle clearance area, including an initial approach segment, a departure area, and a circling approach area, which would result in the vertical distance between any point on the object and an established minimum instrument flight altitude within that area or segment to be less than the required obstacle clearance.*
 - d) A height within an en route obstacle clearance area, including turn and termination areas, of a Federal airway or approved off-airway route, that would increase the minimum obstacle clearance altitude.*
 - e) The surface of a takeoff and landing area of an airport or any imaginary surface established under §77.25, §77.28, or §77.29. However, no part of the take-off or landing area itself will be considered an obstruction.*
47. Once the FAA has completed an aeronautical study, a determination is made regarding the impact to air navigation. One of three responses is typically issued:
- a) **No Objection** – The subject construction did not exceed obstruction standards and marking/lighting is not required.
 - b) **Conditional Determination** – The proposed construction/alteration would be acceptable contingent upon implementing mitigating measures (Marking & Lighting, etc.)
 - c) **Objectionable** – The proposed construction/alteration is determined to be a hazard and is thus objectionable. The reasons for this determination are outlined to the proponent.
48. If at any time during the aeronautical study, the proposed alteration is determined to be a hazard, the study is halted with no further consideration and an objectionable determination is issued.
49. In the case of a Conditional Determination the marking and lighting standards as set out in Advisory Circular AC 70/7460-1K Obstruction Marking and Lighting. As a standard this Advisory Circular states that any temporary or permanent structure that exceeds an overall height of 200 feet (61m) above ground level should normally be marked or lit. The standard further sets out that an aeronautical study may either determine that the absence of marking and lighting will not adversely affect aviation safety, or in some cases the determination may find that there is an extraordinary hazard to aviation safety and require higher marking and lighting standards.

50. Advisory Circular AC 70/7460-1K Obstruction Marking and Lighting also provides for the requirement for reporting of lighting failure to the appropriate flight service station in order to ensure that a Notice to Airman (NOTAM) can be issued as soon as possible. Advisory Circular AC 70/7460-1K sets out the marking requirements providing guidance on paint colours, paint standards, paint patterns, markers and sets out some alternatives to marking that include; low and medium intensity white flashing lights under specific conditions. The lighting guidelines set out in Advisory Circular AC 70/7460-1K provide guidance on lighting systems, catenary lighting, inspection, repair and maintenance, non standard lights, placement factors, and the monitoring of obstruction lights. The specifications of lighting equipment is set out in Advisory Circular AC 150/5345-43E.
51. The notifications that are submitted to the FAA by virtue of the FAR Part 77 requirements are managed internally at the FAA by the Obstruction Evaluation Service. The Obstruction Evaluation Service manages approximately 60 000 notifications per year and is staffed by approximately 35 staff who are located in various offices in the USA.
52. It is anticipated that over the coming two to three years the volume of applications will increase to approximately 100,000. One of the factors driving this anticipated change is the government's incentives for alternate power source generation.

European Aviation Safety Agency (EASA)

53. The European Aviation Safety Agency (EASA) was established in order to harmonise the aviation safety requirements and practices of the different European member countries. EASA was established by the European Parliament and Council in 2008 by virtue of what is termed the 'Basic Regulation'. The 'Basic Regulation' establishes common requirements for the regulation of safety and environmental sustainability in civil aviation. It gives the European Commission powers to adopt detailed rules for the Regulation's implementation.
54. As a result of this 'Basic Regulation', the EASA was formed to address the Regulation's need for '*a single specialised expert body*', which delivers appropriate expertise to EU institutions to prepare these rules and verify their implementation at national level. Thus the Agency acts as an enabler to the legislative and executive process, a body which '*is independent in relation to technical matters and has legal, administrative and financial autonomy*.'⁴
55. As EASA is a relatively new agency, it's responsibility for regulating aviation safety in the European Community is being phased in, based on the agencies ability and competency in the areas that it is responsible for regulating. In those areas that EASA considers itself not yet competent, the responsibility for civil aviation regulation and safety is left with the various national administrations of the member countries.
56. Currently The main tasks of the Agency currently include:
 - Rulemaking: drafting aviation safety legislation and providing technical advice to the European Commission and to the Member States;
 - Inspections, training and standardisation programmes to ensure uniform implementation of European aviation safety legislation in all Member States;
 - Safety and environmental type-certification of aircraft, engines and parts;
 - Approval of aircraft design organisations world-wide as and of production and maintenance organisations outside the EU;
 - Authorization of third-country (non EU) operators;
 - Coordination of the European Community programme SAFA (Safety Assessment of Foreign Aircraft) regarding the safety of foreign aircraft using Community airports;
 - Data collection, analysis and research to improve aviation safety.

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57. EASA are not currently looking at the issue of managing man made obstacles away from registered and certified aerodromes, however in a few years, the Agency will be responsible for safety regulations regarding airports and air traffic management systems. It is anticipated that the issue of identifying and managing the risks associated with man made obstacles situated away from registered and certified aerodromes may be addressed by EASA in the future.

United Kingdom Civil Aviation Authority (UK CAA)

58. The United Kingdom Civil Aviation Safety Authority (UK CAA) are responsible for aviation regulation in the UK. Its activities include economic regulation, airspace policy, safety regulation and consumer protection. The National Air Traffic Service (NATS) is the organisation in the UK responsible for airspace management within the UK. NATS operates the UK's en-route air traffic service on licence to the UK CAA.
59. The primary act of parliament that regulates aviation in the United Kingdom is the Civil Aviation Act 1982. The Civil Aviation Act 1982 is supported in the UK by the Air Navigation Orders (ANO's). With respect to man made obstacles that are situated away from the planning controls of aerodromes, ANO Article 133 and ANO Article 134 deal with the lighting requirements of the obstacles that meet specific specifications. ANO Article 133 and 134 deal solely with the issue of lighting these obstacles. The issue of notification of proposed obstacles and the requirement for subsequent aeronautical studies are not addressed in these orders.
60. ANO Article 133 defines an "en-route obstacle" as any building, structure, or erection which is 150m (492 feet) or more above ground level. ANO Article 133 however specifically excludes from this definition, any building, structure or erection:
- a) which is in the vicinity of a licensed aerodrome, and
 - b) to which Section 47 of the Civil Aviation Act 1982 applies.

NB. Section 47 of the Civil Aviation Act 1983 is specifically concerned with the buildings, structures or erections that are within the vicinity of licensed aerodromes.

61. Further to the above definition, the UK AIP Part 2 En-route (ENR) Section 1.1.5.4 – Air Navigation Obstacles defines an air navigation obstacle as *"... any building or work, including waste heaps, which attains or exceeds a height of 300 ft agl". With the legal obligation to have buildings, structures or erections lit if they exceed 150m (492 feet) above ground level, the UK CAA do not have any regulatory power to require lighting below 150m. However AIP ENR 1.1.5.4 recommends that obstacles are lit if "... they are less than 150 metres (492 feet) agl in height, but are by virtue of their nature and location considered never-the-less to present a significant hazard to air navigation"*.

The UK CAA does not have any regulatory power to mandate the lighting of obstacles less than 150m (492 feet) that are located away from the vicinity of aerodromes. The UK CAA operate under a policy that sees them take on an 'honest broker' role, taking a neutral position as a mediator between developers, local planning authorities and low level airspace users such as the Ministry of Defence in order to achieve a workable outcome for all parties.

62. The lighting requirements set out by ANO Article 133 are applied to objects which extend to a height of 150m or more above ground elevation. Other objects of a lesser height assessed as hazards to aviation and thus treated as obstacles are required to be marked according to the standards set out in CAP 168 – Licensing of Aerodromes. CAP 168 – Licensing of Aerodromes Chapter 4 addresses the Assessment and Treatment of Obstacles. This Chapter, as per the scope of the CAP is concerned specifically with obstacles in the vicinity of aerodromes and in particular defines those areas confined by the OLS. However, Section 12 of Chapter 4 sets out the *"... requirements for the marking and lighting of obstacles ... and for the standards applicable to en-route obstacles"*. The marking and lighting requirements set out in CAP 168

– Licensing of Aerodromes is very closely aligned with the marking and lighting standards set out in ICAO Annex 14 Chapter 6 – Visual Aids for Denoting Obstacles.

63. There is a UK Department for Transport Aviation Policy⁵ in place that requires developers to notify the UK CAA of any building or works extending 91.4 metres (300 feet) or more above ground level. The ostensible purpose of this notification is to ensure that obstacles of a height more than 91.4m (300 feet) above ground level are published for pilots' information and noted on aeronautical maps and charts.
64. The Department of Transport Policy sets out the obstacle information that is to be supplied to the UK CAA:
 - Position
 - Height
 - Description, and
 - Developer
65. Information from the UK CAA Off-Route Section suggests that this information is passed directly to the Defence Geographic Centre. The Defence Geographic Centre is managed by the UK Ministry of Defence (MOD) Defence Geographic and Imagery Intelligence Agency (DGIA). The DGC is responsible for managing and providing the information required for the production of Aeronautical Charts in the UK.
66. If a building, structure or erection is more than 150m (492 feet) above ground level then it is automatically deemed to be a hazard to aircraft and lighting is required by virtue of ANO Article 133. For buildings, structures or erections less than 150m (492 feet) and more than 91.4m (300 feet) above ground level, the UK CAA may make recommendations for the lighting of the obstacle, however these recommendations are not enforceable. As a result the UK CAA work closely with Local Planning Authorities and the developers concerned to facilitate a workable solution.

The reporting of Wind Farm developments is handled in the same way that other high structures away from aerodromes are handled, however early notification of both the UK CAA and the MOD is encouraged. Wind Farm developments in the UK as with other countries around the world are increasing. The Off-Route Airspace Section has indicated that they receive approximately 1300 notifications per year. These notifications are generally in the form of an email or letter advising of a proposed development.

67. CAP 764 – CAA Policy and Guidance on Wind Turbines was first issued in July 2006 in response to a 2003 Department for Transport white paper *"The Future of Air Transport" which identified "... potential conflicts of interest between wind energy and aviation operations"*⁶. The second, and current issue of CAP 764 was released in February 2009 in order to take into account the *"... way in which Aviation Stakeholders and Wind Turbine Developers interact has matured since the release of CAP 764 in 2006"*.
68. CAP 764 sets out the responsibilities of the UK CAA on this issue as:
 - aerodrome and CNS Site Safeguarding⁷
 - En-route CNS Safeguarding
 - Airspace Management
 - Approvals for Equipment and Service Provision
 - Advice to Government

⁵ <http://www.dft.gov.uk/pgr/aviation/safety/safeguarding/safeguardingaerodromestech2988?page=3#a1018>

⁶ CAP 764 – CAA Policy and Guidance on Wind Turbines

⁷ Safeguarding is a process of consultation between a Local Planning Authority (LPA) and consultees (CAP 764)

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69. While the above regulations and guidance material provide the criteria under which obstructions are required to be lit, there is no regulatory requirement in the UK that requires that developers notify the UK CAA of man made obstacles away from licensed aerodromes in the UK. The UK CAA relies on close consultation with developers and the relevant Local Planning Authority to ensure they are notified of man made obstacles.
70. Further to the lack of any requirement to notify, there is no documented process or legislated standards that might be used to assess the hazards associated with man made obstacles. The Off-Route Airspace Section of the UK CAA is responsible for the policy and planning for lower and upper airspace within the UK. One of the functions of this section is the development of policy for the lighting of obstacles outside aerodrome safeguarding areas. This responsibility is predominantly managed by one person within this section who is also responsible for a number other activities. This responsibility was not specifically designed however it developed over a period of time.
71. There is no specific process set up within the Off-Route Airspace Section. The office is informed of the construction or alteration of obstacles via local planning authorities. Local planning authorities will generally inform the UK CAA and the Ministry of Defence, via the Defence Geographic Centre, in the early stages of planning and approvals, however there is no mandated process in place requiring them to do so.
72. The British Wind Energy Association (BWEA) is the trade and professional body for the UK wind and marine renewable energy industries. The BWEA is working with UK Department of Business, Enterprise & Regulatory Reform (BERR), NATS En Route, the CAA and the UK Ministry Of Defence (MOD) to address aviation concerns. The two principles instruments that have been set up to deal with the aviation issues associated with wind farm developments are:
- Memorandum of Understanding (MOU) to demonstrate a shared commitment to remove aviation and radar barriers in wind farm development signed by the BWEA, BERR, Department for Transport (DfT), MOD, NATS and the CAA.
 - An Aviation Plan outlined in the MOU that identifies individual work-streams that are needed to develop and implement workable solutions.
73. The MOU and Aviation Plan are largely concerned with the effects of wind farm installations on aviation radars, however the Aviation Plan explores the process of consultation between developers and industry stakeholders and offers two potential solutions for improving the consultation process⁸:
- An e-consultation website to facilitate an easier site screening process
 - A change in CAA UK remit to allow the CAA UK to take a formal facilitation role in finding solutions for specific projects.

These two projects have been initiated, however are still in the early stages of development and have not reached an operational level of maturity.

Civil Aviation Authority New Zealand (CAA NZ)

74. The legislation governing civil aviation operations in New Zealand is covered in the Civil Aviation Act 1990. Part 3 of the Civil Aviation Act 1990 sets out the authority of the appropriate New Zealand government minister for the making of rules (regulations) under the Act. Section 29A – Rules Relating to Airspace, specifically provides the authority to make rules regarding “... things affecting navigable airspace”.
75. The New Zealand Civil Aviation Rules (CAR's) are organised into specific groupings or Parts. The specific Part that deals with Man Made Obstacles is Part 77 – Objects and Activities Affecting Navigable Airspace.

⁸ UK BWEA Aviation Plan 30th September 2008

CAR Part 77 is composed with sections dealing with the following issues:

- Notification Requirements
- Requirement for Aeronautical Study
- Standards for Aeronautical Study
- Determination Options
- Petitions for Review of Determinations

76. CAR Part 77 imposes legal obligations on any “... person within the territorial limits of New Zealand ... proposing 1) to construct or alter a structure that could constitute a hazard in navigable airspace”. CAR Part 77 also imposes obligations relating to the proposed use of lights, lasers, weapons or pyrotechnics. CAR Part 77 defines navigable airspace as “... airspace at or above the minimum flight altitude prescribed by or under the Civil Aviation Rules, including all legitimate low level operations but not including restricted, danger, and military operations areas activated for use by the New Zealand Defence Force.”

77. CAR Part 77 covers the following types of obstacles:

- **Structures** – such as buildings or masts
- **Efflux from a structure** – exhaust plumes in excess of 4.3 m/second
- **Lights** – searchlights and lasers, if these can adversely affect aircraft safety
- **Weapons firing** – projectiles
- **Pyrotechnics** – fireworks displays

78. The notification requirements as set out in CAR Part 77 specific to each of the above hazards are set out below ⁹:

A structure that is to be built, or altered, that is:

- 60 m (200 ft) or higher, or
- within a Low Flying Zone (LFZ Locations), or
- within an aerodrome/heliport obstacle protection area (contact the aerodrome/heliport operator - see below).

A structure proposed to discharge efflux greater than 4.3 m/second that is:

- 60 m (200 ft) or higher, or
- within an aerodrome/heliport obstacle protection area (contact the aerodrome/heliport operator - see below).

A light, searchlight, or laser, if it can:

- adversely affect the pilot, the aircraft operation, or be mistaken as an aeronautical light.

A weapon or pyrotechnic, if the projectile has a trajectory of:

- 45 m (150 ft) or higher and within 4 km (2.25 NM) of an aerodrome or heliport, or
- 120 m (400 ft) or higher and is more than 4 km (2.25 NM) from an aerodrome or heliport.

79. CAR Part 77 sets out the specific set of standards which set the limits within which obstructions must be determined to be a hazard to navigable airspace. The Standard also sets the relevant criteria that must be considered when making a determination. This criterion includes having a consideration for issues such as instrument flight procedures, IFR obstacle clearance areas, low flying areas, and aerodrome Obstacle Limitation Surfaces. CAR Part 77 also sets the effective dates and periods of which notifications are to be made, determinations come into affect, and when determinations expire. And CAR Part 77

makes provision for determinations to be reviewed under certain circumstances. A review will only be granted in order to “... *present new information or facts not previously considered or discussed during the aeronautical study*”. Annexure B of CAR Part 77 provides standards on the marking and lighting of obstacles. These standards are consistent with the standards that are set out in ICAO Annex 14 Chapter 6 – Visual Aids for Denoting Obstacles.

The New Zealand Aviation Safety rule set is harmonised with the United States aviation safety rule set and as such CAR Part 77 is very much aligned with the United States FAR Part 77.

80. CAR Part 77 is administered within the NZ CAA by the Aeronautical Services Unit. The Aeronautical Services Unit has the responsibility for the oversight of the services supporting the New Zealand aviation system. Included in these supporting services is the responsibility for administering objects that affect navigable airspace, such as structures, fireworks, unmanned balloons, kites and model aircraft.
81. The Aeronautical Services unit conducts an Aeronautical Study on all notifications that are submitted to the unit. At the time of writing this report in the previous 12 months approximately 38 submissions were received by the Aeronautical Services Unit. In terms of staff loading it is estimated that 1 person spends approximately 1 day every two weeks dedicated to administering CAR Part 77 obstacle notification submissions and aeronautical studies. There is an increasing trend in the number of obstacle submissions due to the proliferation of wind farms in New Zealand.
82. The following process is used when conducting a CAR Part 77 Aeronautical Study:
 - Public invited to comment
 - Consultation with Airways New Zealand
 - Consultation with local Councils
 - Consultation with aerodrome Operators
 - Assessment Determination is made

Transport Canada

83. Civil aviation in Canada is controlled by the Aeronautics Act 1985. The Act is administered by the Minister of transport and Transport Canada. In 1996 Transport Canada consolidated the Air Regulations and the Air Navigation Orders into the Canadian Aviation Regulations (CAR's).
84. CAR 601.19 is the regulation that provides the authority for the Minister of Transport to order the marking and/or light any building, structure or object that is likely to be hazardous to aviation safety. Coupled with CAR 601.19, CAR 621.19 sets out the Obstruction Marking and Lighting Standards.
85. CAR 621.19 establishes that the responsibility for compliance with standards rests with “... *the persons planning to erect a building, structure or object ...*”. The responsibility for continued compliance is also specifically stated. Notification is required within 90 days prior to the erection of the building, structure or object via the appropriate Transport Canada Civil Aviation Office.
86. The Transport Canada Aeronautical Information Manual (TC AIM) further sets out the requirements for obstacle marking and lighting in Section AGA - 6.0 OBSTRUCTION MARKINGS. With respect to the objects that CAR 621.19 refers to the TC AIM states, “Except in the vicinity of an airport where an airport zoning regulation has been enacted, Transport Canada has no authority to control the height or location of structures. However, all objects, regardless of their height, that have been assessed as constituting a hazard to air navigation require marking and/or lighting in accordance with the CARs and should be marked and/or lighted to meet the standards specified in CAR 621.19”

87. The TC AIM also sets out the standards for the lighting and marking of objects:
- a) any obstruction penetrating an airport obstacle limitation surface as specified in TP 312, aerodrome Standards and Recommended Practices;
 - b) any obstruction greater than 90 m (300 ft) AGL within two nautical miles of the imaginary centre-line of a recognized VFR route, including but not limited to a valley, a railroad, a transmission line, a pipeline, a river or a highway;
 - c) any permanent catenary wire crossing where any portion of the wires or supporting structures exceeds 90 m (300 ft) AGL;
 - d) any obstructions greater than 150 m (500 ft) AGL; and
 - e) any other obstruction to air navigation that is assessed as a likely hazard to aviation safety.
88. The requirement for marking and lighting is voluntary, but can be enforced by an order from the minister.

Australian Experience

Regulatory Framework

89. The Civil Aviation Act 1988 is the principle legislative instrument in Australia that empowers the Governor General to make regulations with respect to aviation safety issues. There are currently two sets of regulations in effect; Civil Aviation Regulations 1988 (CAR), and the Civil Aviation Safety Regulations 1998 (CASR's). The CAR's are gradually being replaced by CASR's. Until they are completely replaced, both sets of regulations are applicable, however as the CAR's predate the CASR's, if there is any inconsistency between these two legislative instruments, the CASR's will prevail.
90. Section 98 of the Civil Aviation Act 1988 provides for the making of aviation regulations. Specific to the regulation of obstacles, Section 98(3)(g) provides for the making of regulation that prohibits, or restricts, the construction of buildings, structures or objects. The legislation also provides for the making of regulations that require the "... *marking or lighting of buildings, structures or objects (including trees or other natural obstacles) that constitute or may constitute obstructions, hazards or potential hazards to aircraft flying in the vicinity of an aerodrome.*"
91. There is no specific provision under Section 98 that allows for the making of regulations that apply to objects away from the vicinity aerodromes. However, there is a general regulation power that is outlined under Section 98(1)(c) that allows the making of regulations "*for the purpose of carrying out and giving effect to the provisions of the Chicago Convention relating to safety*". In light of the ICAO requirements discussed above, it is reasonable to assume that Section 98(1)(c) could be used in order to make regulations concerning man made obstacles that are located away from the vicinity of aerodromes.
92. Section 98(3)(g) of the Civil Aviation Act 1988 provides the basis on which CASR Part 139 – Aerodromes empowers CASA to deal with objects. However as mentioned above the scope of CASR Part 139 is specifically concerned with obstacles that are located within the vicinity of certified and registered aerodromes. Other legislative instruments that deal with obstacles that are situated within the vicinity of aerodromes include; CAR 95, Civil Aviation (Buildings Control) Regulations, Airports Act and State Planning and Land Use Legislation. None of these legislative instruments address the issue of man made obstacles that are located away from the vicinity of aerodromes.
93. Section 98(4) of the Civil Aviation Act 1988 requires that any regulation made by virtue of Section 98(3)(g) requiring the removal or restriction of buildings, structures or objects shall "... provide for the payment of compensation to any person who suffers loss or damage or incurs expense in or as a direct result of the removal, marking or lighting". This requirement to provide compensation to those affected by a determination that marking or lighting is required has created reluctance within CASA for initiating any regulation that empowers them to prohibit or remove obstacles, or mandate the marking and/or lighting of obstacles. CASA funding does not cover the costs associated with such compensation.

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94. CASR Part 139 defines obstacles as, *“all fixed (whether temporary or permanent) and mobile objects, or parts thereof, that are located on an area intended for the surface movement of aircraft or that extend above a defined surface intended to protect aircraft in flight”*. In line with the scope of CASR Part 139 this definition is specific to obstacles that are located in the vicinity of an aerodrome.

Advisory Publications

95. There are two publications that CASA have used to support the legislation surrounding man made obstacles:
- AC 139-08(0) Reporting of Tall Structures – April 2005
 - AC 139-18(0) Obstacle Marking and Lighting of Wind Farms – December 2005 (Repealed)
96. AC 139-08(0) Reporting of Tall Structures sets out the requirements that tall structures located away from certified and registered aerodromes are to be notified directly to the Royal Australian Air Force (RAAF) Aeronautical Information Services (AIS) section. This requirement to report tall structures is based on the need to have information on tall structures available for publication on aeronautical charts.
97. The RAAF AIS requires that all tall structures that meet the following height criteria are to be reported:
- 30 metres or more above ground level for structures within 30km of an aerodrome; or
 - 45 metres or more above ground level for structures located elsewhere.
98. The current process requires that sponsors of buildings, structures or objects that meet the above reporting requirements submit the details of the proposed building, structure or object via a Vertical Obstruction Report Form on the RAAF AIS website¹⁰. Once received the obstruction data is placed into the database and distributed on request to the Geo Science Australia, Air Services Australia and appropriate industry stakeholders. Assessment of obstacle data is limited to the height specification of each submission. No aeronautical assessment is conducted to determine whether the building, structure, or object is in fact a hazard to aviation safety. The primary users of the tall structure information collected by the RAAF AIS is Geoscience Australia and Air Services Australia.
99. Geoscience Australia is a prescribed agency within the portfolio of the Department of Resources, Energy and Tourism and one of its primary activities is the provision of key spatial information of Australia. The Tall Structures database administered by the RAAF AIS is one of the inputs to the spatial information compiled by Geoscience Australia.
100. As a result of the recent challenge to its legal validity, AC 139-18(0) was repealed in September 2008. The premise of AC 139-18(0) was that CASA was to be notified of any wind farm developments that:
- Is to be constructed near an aerodrome and will infringe the OLS of the aerodrome
 - Is to be of a height of 110m or more above ground level.
101. AC 139-18(0) also set out a process by which CASA would conduct an assessment of the proposed wind farm development at the cost of the developer and make a determination as to whether the wind farm represents a hazard to aviation. The determination options set out by the Advisory Circular were:
- Not hazardous to aviation
 - Not hazardous to aviation provided that approved marking and/or lighting is installed
 - Hazardous to Aviation, but the risks to aircraft safety are adequately reduced with the provision of approved marking and/or lighting.
102. With the repealing of AC 139-18(0), there is no provision for the undertaking of an aeronautical study to determine whether a wind farm development is in fact a hazard to aviation. The requirements for reporting wind farm developments revert to the requirements under AC 139-08(0) Reporting of Tall Structures, which

¹⁰ http://www.raafais.gov.au/frame.htm?obstr_form2.htm

as stated above do not make any provision for conducting aeronautical studies to determine whether it is a hazard to aviation.

Electronic terrain and Obstacle Data (eTOD)

101. In response to the ICAO eTOD requirements set out in a previous section, Australian authorities have instigated a high level working group to examine how Australia can satisfy the eTOD requirements in its current regulatory framework. The high level working group is represented by:
 - Department of Infrastructure, Transport, Regional Development and Local Government
 - Civil Aviation Safety Authority
 - AirServices Australia
 - Geoscience Australia
 - RAAF Aeronautical Information Section
102. In support of this high level working group a technical working group has been set up to examine the technical and operational issues with regard to satisfying the ICAO eTOD requirements. The technical working group is represented by:
 - Civil Aviation Safety Authority
 - AirServices Australia
 - RAAF Aeronautical Information Section
103. At the time of writing the eTOD working groups had met once and no specific recommendations concerning Australia's response to the eTOD requirements had been made.

Industry stakeholders within Australia

Wind Energy Industry

104. With the growing evidence that human activity is changing the climate patterns of the world and Australia, there have been considerable efforts by governments, including the Australian Government, to put in place policies and strategies designed to reduce the impact to the economy, society and the environment caused by climate change. In 2001 the Australian Government established the Mandatory Renewable Energy Target (MRET) which is designed to reduce greenhouse gas emissions by encouraging additional generation of electricity from renewable energy sources. There has been significant industry pressure in recent times for the expansion of the Renewable Energy Targets established in 2001¹¹. At the time of writing the Australian Government was proposing the Renewable Energy (Electricity) Amendment Bill 2009 that requires that 20% of Australia's electricity usage will be supplied by renewable energy by 2020.
105. Wind power in Australia currently provides 0.5% of Australia's electricity requirements. It is however reasonable to expect that this figure will increase in the future given the push for increased Renewable Energy Targets and the suggestion by the Clean Energy Council that the current distribution network in Australia could accommodate as high as 20% wind power generation. The international trend suggests that wind power provides 20% of Denmark's electricity usage, 5% of Germany's electricity usage, and Europe has a target to get 12% of its total electricity consumption from wind by 2010¹². The UK's renewable energy targets require that 10% of its electricity usage is supplied by renewable energy by 2010 and 20% of the electricity usage in the UK is supplied by renewable energy by 2020¹³.

¹¹ Response of the Clean Energy Council to the Inquiry into the Renewable Energy (Electricity) Amendment Bill 2009

¹² Auswind – Wind Energy in Australia – Fact Sheet

¹³ CAP 764 – CAA Policy and Guidelines on Wind Turbines, Appendix 2 – UK Government Renewable Energy Policy

106. With the height of wind turbines commonly ranging from 200 to 300 feet (60 to 90 metres) to the nacelle and 150m at the maximum blade height wind farms have the real potential to extend into navigable air-space. The inherent height characteristics of wind farms mean that they often meet the criteria that define them as an obstacle to the safe operation of aircraft. This in turn brings them under legislation that requires at the very least an aeronautical study, and in some cases mandatory marking and lighting requirements.

With the latest push for the increase of renewable energy targets and the corresponding trend internationally, it can reasonably be expected that the number of developments that could potentially affect aviation airspace will increase. Indeed this is the experience of other Regulators.

107. When conducting an aeronautical study on obstacles and in particular wind farms, the authority responsible for conducting the study has the primary concern of aircraft safety when making its determination. It is the contention of the Wind Energy industry in Australia that a “... *potential for conflict with CASA arises because responsible developers and planning decision-makers must balance several potentially conflicting beneficial values and CASA is limited by its charter to focus on one, to the exclusion of others*”. Wind energy developers and planning decision-makers are required to take into account the environmental impacts of any proposed wind farm development.
108. These impacts include the consideration of the visual amenity in the context of the surrounding landscape. ‘Visual Amenity’ is a measure of the visual quality of a wind farm site experienced by local residents. Wind Farm developers are often in a position of being required to satisfy the ‘visual amenity’ concerns of local residents, while in turn satisfying the lighting requirements of CASA and the local planning decision-makers, who in Australia have shown a tendency to take their lead from CASA. The principle concern of the Wind Energy industry seems to be that mitigation options other than lighting are not being considered by CASA.
109. Until recently the advice from CASA with respect to the marking and lighting of wind farms was provided by virtue of AC 139-18(0) Obstacle Marking and Lighting of Wind Farms. AC 139-18(0) was repealed in September 2008, and this has left a regulatory and policy void with respect to the requirements of wind farms that are developed in areas that are situated away from certified or registered aerodromes.
110. The position of the wind energy industry is that wind farms should be assessed on an individual basis as to whether they pose a hazard to aviation. And in the case that they do not pose a hazard to aviation then there should be no requirement for lighting or marking of the wind farm.

Regional Operators

111. Regional operators within Australia consist of regional airlines, charter operators, aeromedical operators and other aerial work operators. The operators that fly under Instrument Flight Rules (IFR) are generally considered to be flying beyond the heights where man made obstacles would be considered a significant risk. However it is the operators that fly under Visual Flight Rules (VFR) in adverse weather conditions who may be exposed to a high level of exposure to man made obstacles located away from aerodromes.
112. For example the Canberra to Goulburn route is approximately 70-80km in distance. A recent wind farm development is situated in the area north east of Lake George. This route is known for its frequent adverse weather conditions and VFR operators are known to scud run in these conditions. This situation is one that highlights the importance of ensuring that aircraft operators have access to the latest information on any obstructions that may affect the safe operation of their aircraft.
113. Another issue for regional operators is that for a variety of reasons they are sometimes in a position that requires the declaration of an emergency. In this situation it is important that the pilot of an aircraft has access to the most up to date information regarding obstacles in the area. An emergency situation is one that

requires a pilot to manage a very high workload and make decisions based on information that charts and electronic devices can provide. Having to deal with an obstacle that is located in a position that was not previously known by the pilot has the potential to adversely affect the outcome of an emergency situation.

Electricity Industry

114. The average height of a high voltage power line pylon depends on the electrical company who installs them, however the heights range from between 35m (115ft) to 40m (130ft). The Electricity Industry does not usually consult with the aviation industry when planning, developing and constructing these installations.
115. Since the judgement of *Sheather vs Country Energy* where it was found that Country Energy had a duty of care to the community with respect to ensuring that its wire network was appropriately protected from the potential for an aircraft to strike its network, some electricity suppliers have taken action to assess the risk exposure of their networks against an aircraft strike. These activities however are not consistent within the electricity supply industry. This decision might have implications with respect to the proponents of other man made obstacles.

Aerial Agriculture

116. Aerial agriculture predominantly involves the application of pesticides and fertilisers to specific crops by use of over flying aircraft fitted with spraying equipment. By its nature flying for the purpose of spraying, seeding, and fertilising crops involves operating the aircraft at very low levels. Due to the low flying nature of aerial agriculture operations the industry is concerned about the impacted that the construction of man made obstacles might have on the safe operation of their aircraft.
117. In the context of man made obstacles the aerial agricultural industry are concerned with three particular hazards that are presented to low flying pilots:
 - Wires
 - Wind Monitoring Masts
 - Wind Turbine Generators
118. The aerial agricultural industry in Australia is represented by the Aerial Agriculture Association of Australia (AAAA). The AAAA have adopted a risk based approach to aerial agricultural operations and have integrated risk management practices into their pilot training programs. The primary obstacle hazards represented above are managed on an operation by operation basis through the risk management process, however this process relies on the availability of accurate information. Of particular concern to the aerial agricultural industry is the rapid installation of the wind monitoring masts and the adhoc reporting of the installations.
119. Wind Monitoring Masts are installed to evaluate the wind resource potential at a potential site for a wind farm development. Wind Monitoring Masts generally range from a height of 10m to 80m (262 feet). Wind monitoring masts are generally supported by multiple guy wires. The aerial agricultural industry takes the view that using the risk based approach allows them to effectively manage any man made obstacles that are situated within their area of operation, however when obstacles are erected without notification this significantly increases the risk to their operations.
120. The AAAA have in place some informal arrangements with wind energy companies, however these arrangements are not widespread within the wind energy industry and notification is often given after the installation of the masts. In the same context, the AAAA are also working with the electricity industry on the issue of the marking of wires.
121. It is the position of the AAAA that any recommendations on this issue that involve the establishment of 'trigger' heights for notification and lighting requirements will not satisfy the needs of the aerial agricultural industry as the heights that they general fly are so low as to fall under these triggers.

Local Planning Authorities

122. Planning and Development approvals in Australia are administered by the various state government planning departments. Discussions with representative from the state planning authorities indicate that at a state level the issue of man made obstacles that are located away from the vicinity of an aerodrome is not specifically a factor in the planning and development approval process. Where it does become a development issue the planning authorities would take their lead from CASA.
123. The Australian Government Department of Infrastructure, Transport, Regional Development and Local Government advises the Government on the policy and regulatory framework for Australian airports and the aviation industry, manages the administration of the Government's interests in privatised airports under the Airports Act 1996, and provides policy advice to the Minister on the efficient management of Australian airspace. The Department recently published a Discussion Paper titled Safeguards for Airports and the Communities Around Them. While the scope of the Discussion Paper is restricted to the safeguarding of airports, there is some comment on issue of Wind Turbines. It is suggested in the report that *"... all proposed wind turbine sites should be notified to CASA prior to application for planning."* The Australian Government Department of Infrastructure, Transport, Regional Development and Local Government does not have jurisdiction for applying planning restrictions for man made obstacles that are outside the vicinity of a certified or registered aerodrome.

PART 3:

Risk Assessment

Purpose

124. The purpose of this risk assessment is to identify and where possible quantify the risk exposure in regard to the issue of man made obstacles that are located outside the vicinity of certified and registered aerodromes. The risk assessment component of this body of work seeks to clarify the methods by which the operational risks associated with man made obstacles could be determined. That same risk assessment methodology could also be used to examine CASA's current risk exposure with respect to the requirements outlined in ICAO standards and recommended practices. By looking at the ICAO requirements and the way in which other Regulators are addressing the issues of man made obstacles located away from the vicinity of aerodromes a comparative risk decision can be made by CASA.
125. There is a high degree of uncertainty around the level of risk that is associated with man made obstacles located away from aerodromes in Australia. This is due to the absence of any dependable information relating to the quantity and nature of man made obstacles in Australia. The lack of any legislative framework that requires the compulsory reporting of potential obstacles has meant that there is a high level of uncertainty around the information that is currently held on man made obstacles located away from Aerodromes.
126. As stated in AS/NZS 4360:2004 where no reliable data or relevant past data is available, subjective estimates may be made that reflect the degree of belief that a particular event or outcome will occur. In the case of this risk assessment that event is man made obstacle affecting navigable airspace. In order to build a suitable picture of the level of risk associated with man made obstacles located away from the vicinity of aerodromes it is important to look at how risk is defined.

Methodology

Risk Equation

127. There are many ways in which it is possible to quantify the level of risk associated with any given context. When considering the level of risk in the context of the impact that man made obstacles located outside the vicinity of aerodromes might have to aviation safety, the logical starting point would be to consider the risk equation as represented in AS4360:2004. AS4360:2004 defines risk as a function of both likelihood and a measure of consequence. In its simplest form the risk equation can be represented as:

Risk = A Function of (Consequence and Likelihood)

128. Analysis of this risk equation can be used in order to obtain an understanding of the factors that affect the level of risk. Looking at the consequence element of the equation it can be stated that consequence in the context of aviation may be represented on a scale that flows from no affect to navigable airspace, through to an extreme event that may involve a significant loss of life, in that case of an event involving regular public transport (RPT).

Consequence

129. So when making an estimate as to the consequence there are some factors that will inform any estimate that might be made. The primary factor that will inform the consequence is the type of aviation activity or flying that might bring an aircraft into the height range of a man made obstacle. The type of flying that would bring an aircraft into the height range of a man made obstacle that are located away from the vicinity of an aerodrome would be activities that involve low flying away from any point of departure or arrival. These activities may include:
- Aerial agriculture
 - Cattle mustering
 - General aviation pilots flying at a height that is below legal minimums
 - Pipeline inspection
 - Powerline inspection
 - Fire fighting
 - Search and rescue operations
 - Military low-level flying operations
130. It can be seen that these activities are predominately represented by one or two crew operations in aircraft that might reasonably be considered to be in the smaller class of aircraft size. When considering the consequence scale that was mentioned above it can be seen that the level of consequence of an obstacle affecting navigable airspace might reasonably be estimated to be low.

Likelihood

131. Likelihood can be considered to be a function of both the exposure to the source of risk and the probability that the outcome will occur. This relationship can be expressed in the following way:

Likelihood = A function of (Exposure and Probability)

132. The two factors that best represent exposure and probability and must be considered in order to estimate the likelihood are the number of man made obstacles that affect navigable airspace, and the number of aircraft that may be operating at a height where they may be affected by the presence of the man made obstacle. As stated previously there is a high level of uncertainty around the number of man made obstacles that affect navigable airspace. However it is reasonable to assume, with respect to the aviation activities that are represented above that the number of aircraft and flights conducted in the height range where they may be affected is quite low.
133. Given the uncertainty around the number of obstacles that exist, and the reasonable estimation of a low level of aircraft activity in the height ranges applicable to man made obstacles, it can reasonably be estimated that the likelihood of an aircraft being impacted by a man made obstacle located away from the vicinity of an aerodrome is in the low range.

Risk Level

134. Given that the estimations for both the consequence of a man made obstacle located away from the vicinity of an aerodrome affecting aviation safety and the likelihood of an aircraft being affected by a man made obstacle away from the vicinity of an aerodrome are in the low range, it can reasonably be asserted that, in the context of the wider aviation industry, the level of risk posed by man made obstacles that are located away from a certified or registered aerodrome is in the low range.
135. Notwithstanding this assessment it is to be recognised that CASA operate under a public and political climate that deems any loss of life due to aircraft accident to be unacceptable and this factor should be taken into account when determining treatment strategies.
136. This assessment is based on the assumptions detailed in the above analysis and a more accurate assessment of the risk level would be obtained given more certainty surrounding the number of man made obstacles and the number of flying operations that occur within their height range.

Corporate Risk Issues Table

137. While the above risk assessment looks at the risk to aviation safety, there are a number of issues that need to be considered after comparing the current regulatory framework in Australia with the various regulatory frameworks in the UK, US, NZ and Canada. With this in mind the following table has been developed to detail the corporate risk issues that need to be considered in order to bring the Australian legislative framework in line with international standards and ICAO requirements.

CORPORATE RISK ISSUES

NUMBER	RISK ISSUE	ASSOCIATED RECOMMENDATIONS (REFER PART 4)
1	That CASA is required to pay compensation to sponsors of buildings, structures or objects that have been determined to be a hazard to aviation due to the existence of Section 98(3)(g) that requires the payment of compensation for any expense incurred by the installation or removal of marking or lighting	Recommendation 2
2	That the current Civil Aviation Act does not provide the appropriate authority to make regulations concerning man made obstacles that are located away from the vicinity of aerodromes leaving it open for inconsistent application of risk mitigators.	Recommendation 1
3	The lack of any height trigger that provides a clear requirement for proponents of man made obstacles to consult / notify CASA in order to determine the affect of the structure on aviation safety	Recommendation 3
4	That there is no formal process within CASA to adequately assess whether a proposed or existing structure is a hazard to aviation	Recommendation 7
5	That the current level of uncertainty around the number and nature of man made obstacles is not providing CASA with an accurate understanding of the level of risk associated with man made obstacles that are located outside the vicinity of certified and registered aerodromes	Recommendation 6
6	That current legislation within Australia does not satisfy the Standards and Recommended Practices as set out in ICAO Annex 14 Chapter 4	Recommendation 1, Recommendation 3
7	The absence of a regulatory instrument that provides CASA with the power and authority to appropriately identify and manage the risks associated with man made obstacles that are located away from the vicinity of certified and registered aerodromes.	Recommendation 1, Recommendation 3
8	The potential that any legislation implemented may not capture or cover those buildings, structures or objects that have already been established, but have not yet been assessed by an appropriate authority as to their level of impact on aviation safety	Recommendation 3
9	Ambiguity around the ownership and accountability of the aviation risks associated with man made obstacles due to the lack of clarity around legal and regulatory responsibility of the regulator, proponents and planning authorities.	Recommendation 10
10	The current ambiguity around the aviation safety requirements of Local, State and Federal Planning authorities in the Development Approval Process	Recommendation 10

CORPORATE RISK ISSUES

NUMBER	RISK ISSUE	ASSOCIATED RECOMMENDATIONS (REFER PART 4)
11	The potential that sponsors of developments that meet reporting criteria for man made obstacles that are located away from the vicinity of aerodromes are not aware of their obligations to report and as a result do not make the appropriate submission.	Recommendation 6
12	The potential that the appropriate authority does not have the capacity or capability to conduct the obstacle evaluations that are required to satisfy any new legislation	Recommendation 7
13	The potential that new legislation developed to support the identification and management of man made obstacles away from aerodromes may not implemented in a timeframe that allows CASA to adequately provide the Government and the public with the assurance that the risk exposure in the near to medium future is being managed appropriately	Recommendation 11
14	The risk that aircraft operating in an area away from an aerodrome do not have access to accurate obstacle data, including charting, lighting and marking, due to inadequate systems collecting, assessing and mitigating obstacles that can affect navigable airspace	Recommendation 1, Recommendation 2, Recommendation 8
15	The potential that new man made obstacle regulation will use a blanket approach to the mitigating the impact on aviation safety of man made obstacles.	Recommendation 4, Recommendation 5
16	The potential that any advances in technology in relation to mitigation options are not addressed in the regulations and practices surrounding man made obstacles.	Recommendation 3
17	The potential for mitigation options that require Lighting and Marking of man made obstacles to affect the visual amenity of local communities.	Recommendation 4, Recommendation 5

PART 4:

Summary of Findings and Recommendations

Findings

There are a total of 7 key findings and they are represented below in the following groupings:

- ICAO Standards and Recommended Practices
- Legislation
- Regulatory Framework
- Administration
- Publications
- Wind Farms

ICAO Standards and Recommended Practices

F - 1 ICAO Requirements: The current Australian legislative framework does not satisfy the standards and recommended practices in relation to man made obstacles as set out in ICAO Annex 14 Volume I Chapter 4 and Chapter 6..

Legislative Framework

F - 2 International Legislation: The USA and New Zealand have developed a legislative framework that groups the regulations pertaining to the management of man made obstacles, wherever they are located, into one rule set (Part 77 – Objects that Affect the Navigable Airspace). Part 77 sets out the requirement for notification heights and the standards with which the regulator is required to assess objects that affect the navigable airspace.

F - 3 Australian Legislation: The current Australian legislation does not allow the making of regulations concerning man made obstacles that are located away from the vicinity of an aerodrome.

F - 4 Australian Regulatory Framework: The absence in Australia of a formal or legislated framework for conducting Aeronautical Studies on man made obstacles located away from the vicinity of aerodromes means that CASA is not suitably equipped with the appropriate options for making obstacle determinations. The current Australian legislation and rule set does not address man made obstacles that are located away from the vicinity of aerodromes and is restricted to dealing with man made obstacles that are located on or within the vicinity of an aerodrome.

Administration

F - 5 Current Australian Process: The RAAF AIS is the organisation in Australia charged with the responsibility to collect man made obstacle data, however the data is collected for information and charting purposes only. No Aeronautical Studies are done to determine whether the man made obstacle is a hazard to aviation. There is a high level of uncertainty around the current information that is held on man made obstacles. It can be reasonably assumed that this is due to the fact that legislation in Australia does not require the mandatory reporting of tall structures that could potentially be obstacles to navigable airspace.

Publications

F - 6 Advisory Material: CASA have one current publication, AC 129-08(0) that sets out the reporting requirements for tall structures, and a repealed AC 139-18(0) Obstacle Marking and Lighting of Wind Farms. AC 139-18(0) provided guidance specifically relating to wind farms, however and did not address other man made obstacles.

Wind Farms

- F - 7 The wind energy industry in Australia is concerned that CASA do not have the mandate to consider options that offer alternatives to the lighting of wind farms. The wind energy industry is required to deal with the visual amenity issues caused by the requirement for lighting on wind turbines.

ICAO Annex 14 Volume I Chapter 6 provides clear requirements for the marking and lighting of wind farms in the case that they are determined to be a hazard to aviation, however there is potential that a formal Aeronautical Study may determine that a wind farm in a certain location offers no hazard to aviation, thus removing the requirement for marking and lighting.

Recommendations

Using the findings listed above and the treatment strategies outlined in the Risk Assessment Table the following recommendations have been developed. There are a total of 10 recommendations. The complex nature of the issues outlined in this report and the potential solutions are such that the recommendations have been represented in the following format:

- Legislative Framework
- Regulatory Structure
- Advisory Material
- Administration

Legislative Framework

- R - 1 Authority to make Regulations:** That the Civil Aviation Act is reviewed in the context of ensuring that CASA has the power to make regulations specifically concerning buildings, structures and objects that are located away from the vicinity of a certified or registered aerodrome.
- R - 2 Removal of Compensation Requirements:** That the Civil Aviation Act 1988 is reviewed in the context of removing the requirement to provide compensation for the installation of marking and/or lighting on buildings, structures and objects that have been determined to be a hazard to aviation.

Regulatory Structure

R - 3 Option 1 – Creation of Part 77 Objects that Affect Navigable Airspace

This option is designed to group all obstacle related regulation within one CASR Part. It is proposed that this CASR Part is designated CASR Part 77. This brings the regulation of obstacles in Australia in line with the regulatory structure applied in the United States and New Zealand.

For this option it is recommended that:

- CASA to start the process of developing new a CASR Part 77 that satisfies the recommendations outlined in ICAO Annex 14 Chapter 4
- the scope of the new CASR Part 77 includes all obstacles whether within the vicinity of an aerodrome or outside the vicinity of an aerodrome and the obstacle requirements and marking and lighting standards set out in CASR Part 139 be transferred to the new CASR Part 77
- the new CASR Part 77 include the standards for the notification of structures, buildings and objects that are in line with FAR Part 77

- the new CASR Part 77 include the following elements:
 - o requirement for a proponent to notify CASA of any structure, building or object and where required by CASA, to conduct an Aeronautical Study, that addresses key criteria that allows CASA to make an appropriate determination prior to any building approval.

Recommended Notification trigger height of 60m

- o provides the appropriate mechanism for allowing CASA to make a determination as to the level of impact of the building, structure or object and the determination options for CASA are in line with the determination options used by the FAA; i.e. No Objection, Conditional Determination, and Objectionable
- o provides CASA with the appropriate authority to mandate mitigation options such as marking and lighting in accordance with published standards.

Recommended Obstacle height standard of 150m

- o requires that owners and sponsors of buildings, structures or objects that have previously been determined to require marking and lighting, notify CASA and AirServices Australia as soon as they become aware of a defective device and requires that the sponsor or owner of a building, structure or object is required to ensure the rectification of the defective device
- o provides a mechanism to allow CASA to make determinations on any existing buildings, structures or objects that meet the notification requirements but have not yet undergone an Aeronautical Study
- o does not restrict CASA to making determinations that only include permanent marking and lighting and takes into account the possibility of future developments in technology

R- 3 Option 2 – Expansion of Part 139 to include Obstacles that are located away from the vicinity of aerodromes

This option is designed to ensure that the current CAR Part 139 – Aerodromes sufficiently satisfies the ICAO requirements both for obstacles within the vicinity of aerodromes and for obstacles located away from the vicinity of aerodromes.

For this option it is recommended that:

- That CASA to start the process of updating CASR Part 139 to ensure it satisfies the recommendations outlined in ICAO Annex 14 Chapter 4
- That the scope of CASR Part 139 is expanded to include all obstacles whether within the vicinity of an aerodrome or outside the vicinity of an aerodrome.
- That CASR Part 139 Subpart E is expanded to include the standards for the notification of structures, buildings and objects that are in line with FAR Part 77
- That CASR Part 139 Subpart E is expanded to include the following elements:
 - o requirement for a proponent to notify CASA of any structure, building or object and where required by CASA, to conduct an Aeronautical Study, that addresses key criteria that allows CASA to make an appropriate determination prior to any building approval.

Recommended Notification trigger height of 60 m

- o provides the appropriate mechanism for allowing CASA to make a determination as to the level of impact of the building, structure or object and the determination options for CASA are in line with the determination options used by the FAA; i.e. No Objection, Conditional Determination, and Objectionable
- o provides CASA with the appropriate authority to mandate mitigation options such as marking and lighting in accordance with published standards.

Recommended Obstacle height standard of 150m

- o requires that owners and sponsors of buildings, structures or objects that have previously been determined to require marking and lighting, notify CASA and AirServices Australia as soon as they become aware of a defective device and requires that the sponsor or owner of a building, structure or object is required to ensure the rectification of the defective device
- o provides a mechanism to allow CASA to make determinations on any existing buildings, structures or objects that meet the notification requirements but have not yet undergone an Aeronautical Study
- o does not restrict CASA to making determinations that only include permanent marking and lighting and takes into account the possibility of future developments in technology

Advisory Material

- R - 4 Advisory Publication – Notification Requirements:** That an Advisory Circular that outlines the obligations for reporting structures, buildings or objects that may affect aviation safety is published in accordance with the requirements set out in the updated Regulations
- R - 5 Advisory Publication – Marking and Lighting Standards:** That an Advisory Circular that sets out the standards for the marking and lighting of obstacles is published in accordance with the standards set out in the updated Regulations
- R - 6 Ongoing Education Program for Industry and Planning Authorities:** That an ongoing education program directed to industry developers and local planning authorities is established to in order to highlight the responsibility for proponents to report their developments initially to the RAAF AIS, and ultimately to CASA for the purpose of an Aeronautical Study

Administration

- R - 7 Internal CASA Capability:** That CASA develop a capability under the Airspace and Aerodromes Regulation that manages the submission of obstacle notifications and industry submitted Aeronautical Studies, and that the establishment of this capability is based on the estimated number of submissions that would be generated by the new Regulations
- R - 8 Sharing of Obstacle Data:** That CASA enter into a Memorandum of Understanding between RAAF AIS, GeoScience Australia and ASA in order to ensure that information on man made obstacles that constitute a hazard to aviation is shared between the organisations in a timely manner.
- R - 9 Online Public Obstacle Database:** That the feasibility of developing an online obstacle database is explored. The online obstacle database would be developed to allow proponents to submit proposed developments that meet the notification requirements. The database would be used by the proponents to submit any Aeronautical Studies and by CASA internally to record their determination. The results of any determinations could be released via the database and made searchable online.
- R - 10 National Planning Guidelines:** That CASA develop a national planning policy to provide guidance to local, state and federal planning authorities on the issues and legislation relating to man made obstacles and the process for notifying CASA of any proposal that meets certain requirements.

PART 5:

Annexures

Annex A – Abbreviations

AC	Advisory Circulars
AGL	Above Ground Level
ANO	Air Navigation Orders
A-SMGCS	Advanced Surface Movement Guidance Control System
BERR	Business, Enterprise and Regulatory Reform
BWEA	British Wind Energy Association
CAA NZ	Civil Aviation Authority New Zealand
CAR (NZ)	Civil Aviation Rules
CAR (Canada)	Canadian Aviation Regulations
CASA	Civil Aviation Safety Authority
CASR	Civil Aviation Safety Regulations
CFR	Code of Federal Regulations
DGC	Defence Geographic Centre
DGIA	Defence Geographic and Intelligence Agency
EASA	European Aviation Safety Agency
eTOD	Electronic Terrain and Obstacle Data
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulations
ICAO	International Civil Aviation Organisation
LFZ	Low Flying Zone
MOD	Ministry of Defence
MOU	Memorandum of Understanding
MOS	Manual of Standards
MSAW	Minimum Safe Altitude Warning
NATS	National Air Traffic Service
NOTAM	Notice to Airman
OLS	Obstacle Limitation Surface
RAAF	Royal Australian Air Force
SAFA	Safety Assessment of Foreign Aircraft
TC AIM	Transport Canada Aeronautical Information Manual
UK CAA	United Kingdom Civil Aviation Authority
USC	United States Code
VFR	Visual Flight Rules

Annex B – Document Register

#	Document Name
1	AIS-AIMSG.1.SN.021.en
2	Aleks Pavlovic-Annex15Chapter10
3	CAR Part 77 – Objects and Activities Affecting Navigable Airspace
4	Civil_Aviation_Act_1990
5	Determination_Slopedown
6	Lighting_and_marking-of_wind_turbines
7	Part 77 Determination - Roxburgh_Determ
8	Part 77 Determination - Castle_Hill_Determ
9	Part 77 Determination - Gateway_Determ
10	Part 77 Determination - Nth_Wairarapa_Determ
11	Part 77 Determination - Ruakokoputuna_determ
12	Tall Structures Notification Form
13	AC139-08 Reporting of Tall Structures
14	AC139-018 (repealed) Obstacle Marking and Lighting of Wind Farms
15	CAAP 89W-2 Reporting of Tall Structures
16	CAR 139 – Aerodromes
17	17- CASA - Civil Aviation Regulation (Building Control)
18	MOS Part 139 - Aerodromes
19	MOS Part 139 Aerodromes Chapter 7 - Obstacle Restriction and Limitation
20	Obstacles Briefing SCC
21	Cost-Benefit-Analysis-Procedures-Manual
22	AC 70-7460-1K Obstruction Marking and Lighting
23	AC 70-7460-2K Proposed Construction or Alteration of Objects that May Affect the Navigable Airspace
24	AC 150-5345-43E Specifications for Obstruction Lighting Equipment
25	FAR Part77
26	Form 7460-1 Notice of Proposed Construction or Alteration
27	Form 7460-2 Notice of Actual Construction or Alteration
28	OE-AAA External User Guide V3
29	OES Audio Visual Warning System - Memorandum
30	Sample Determination
31	Ammendment to Annex 14 - En-Route Obstacles
32	Annex-14-Vol1

Annex B – Document Register Continued

#	Document Name
33	Annex-15 - Chapter 10
34	Annex-15
35	Land Use Proposal Submission Form
36	Product Sheet
37	Questions for Stakeholders - Industry
38	CAR Part 621
39	Air Navigation Order 2005
40	CAP 168 Licensing of Aerodromes
41	Correspondence Relating to Civil Development
42	GUIDE ON WIND TURBINES Cap764
43	Off-Route Airspace Section
44	Policy - Lighting of Enroute Obstacles
45	UK AIP ENR (12 Feb 09)
46	Planning Correspondence
47	Windfarms Mitigation Paper
48	WEBLINKS
49	Fact Sheet 20% target AWEA
50	Fact Sheet - Wind Energy and Reliability - AWEA
51	Aviation Environmental Assessment - Capital Wind Farm
52	Aviation Environmental Assessment - Kyoto Energy Park
53	Aviation Hazard Assessment - The Sisters Wind Farm
54	Aviation Plan - In respect to the interaction between wind turbines and aviation interests
55	AWEA Siting Handbook - Chapter 4 Regulatory Framework
56	Best Practice Guidelines for the Implementation of Wind Energy Projects in Australia
57	Best Practice Guidelines for the Implementation of Wind Energy Projects in Australia - Annexures
58	58- Wind Farm - NATS Mitigating the effects of Wind Turbines on NATS
59	Obstruction Evaluation for Hounsfield Wind Farm
60	Report on Impediments to Wind Farm Development
61	Clean Energy Australia - CASA letter
62	Clean Energy Australia - Response to Inquiry into the Renewable Energy (Electricity) Amendment Bill 2009
63	Mandatory Renewable Energy Target (MRET)

Annex C – Stakeholder Register

#	Organisation
1	CASA
2	FAA
3	CAA NZ Aeronautical Services Unit
4	UK CAA Off Route Policy Section
5	Airservices Australia
6	RAAF / AIS
7	Clean Energy Australia
8	Sustainability Victoria
9	Australian Constructors Association
10	Aerial Agricultural Association of Australia
11	Regional Aviation Association of Australia
12	Australian Airports Association
13	Aircraft Owners and Pilots Association
14	Recreational Aviation Australia
15	Origin Energy
16	RePower Australia
17	Integral Energy
18	NSW Department of Planning
19	QLD Department of infrastructure and Planning
20	Australian Government Department of Infrastructure, Transport, Regional Development and Local Government

Annex D: Detailed Findings

The following findings have been derived from the report in order to allow those responsible for implementation of recommendations to have an appropriate reference. The findings are sorted according to the following categories:

- Operational
- ICAO Standards and Recommended Practices
- Legislation
- Regulatory Framework
- Publications
- Industry Stakeholders

Operational

- F - 1 The principle operational issue that concerns both VFR and IFR pilots is one of knowledge. Knowing the location of a man made obstacle whether by virtue of marking, lighting, or charting, is the primary mitigator against adverse events concerning man made obstacles

ICAO Standards and Recommended Practices

- F - 2 The Proposed amendment to Annex 14 Aerodromes Volume I, while seeking to clarify the scope of Annex 14, does not change the substance of the existing standards and recommended practices
- F - 3 ICAO Annex 14 Volume I Chapter 4 Recommendation 4.3.1 and Recommendation 4.3.2 taken together require that member states set a height limit above which an Aeronautical Study may be taken to establish whether it is a hazard to aviation safety and in the case of Recommendation 4.3.2 requires that any object of a height greater than 150m above ground level should automatically be considered a hazard unless an aeronautical study determines otherwise
- F - 4 ICAO Annex 14 Volume I Chapter 6 has recently been updated to include the marking and lighting standards for wind turbines that have been found to be a hazard to aviation by virtue of an Aeronautical Study conducted under ICAO Annex 14 Volume I Chapter 4 Recommendation 4.3.1 and Recommendation 4.3.2
- F - 5 ICAO Annex 15 Chapter 10 sets out the standards for the collection of electronic Terrain and Obstacle Data (eTOD)

Legislation

- F - 6 The USA legislation is compliant with ICAO Annex 14 Volume I Chapter 4 Recommendation 4.3.1 and Recommendation 4.3.2 by virtue of FAR Part 77 which sets out the rules for all objects that might affect navigable airspace. The scope of FAR Part 77 is for objects both within the vicinity of aerodromes and away from aerodromes
- F - 7 While the legislation in the UK mandates the lighting of structures with a height greater than 150m, there is no legislation in the UK that requires the notification of existing or future objects below this height
- F - 8 Canadian legislation sets out the requirements for the marking and lighting obstacles, however the responsibility for compliance rests with the person planning to erect the building, structure or object
- F - 9 Legislation in NZ provides for the making of rules regarding things that affect navigable airspace and is based on United States regulations
- F - 10 Current legislation in Australia does not allow the making of rules and regulations that concern man made obstacles that are located away from the vicinity of aerodromes

Regulatory Framework

- F - 11 FAR Part 77 sets out specific limits for which sponsors of structures, buildings or objects are required to notify the FAA
- F - 12 FAR Part 77 requires that for objects outside the vicinity of aerodromes the notification height is 200 feet or above
- F - 13 FAR Part 77 includes a 'catch all' notification requirement that states that a sponsor of a construction or alteration is required to notify 'when requested by the FAA' regardless of any height limitation
- F - 14 FAR Part 77 sets out a specific process that the FAA is required to take (refer Paragraph 45) when conducting an Aeronautical Study
- F - 15 FAR Part 77 sets out standards under which existing and future objects would automatically be determined to be an obstruction to navigable airspace
- F - 16 Consistent with ICAO Annex 14 Volume I Chapter 4 Recommendation 4.3.2 one of the standards set down by FAR Part 77 determines that any object above 500 feet at its site is considered to be an obstruction to navigable airspace.
- F - 17 There are some rules in the UK AIP that recommend the lighting of objects that are less than 150m (492 feet) but are otherwise considered to be a hazard to air navigation, however this is voluntary as there is no legal power for the UK CAA to mandate marking and lighting
- F - 18 The EASA do not currently address the issue of obstacles located away from the vicinity of aerodromes. The responsibility for which falls to the local Regulator
- F - 19 There is no notification height requirements in Canada, the height at which Canadian standards require the lighting of a man made obstacle located away from the vicinity of an aerodrome is 150m
- F - 20 Similar to FAR Part 77 the Canadian standards set that if any object is determined to be a hazard to aviation regardless of its height then it is required to be lit according to the standards
- F - 21 The Canadian standards also require that any wire crossing where any portion of the wire or its supporting structure exceeds 90m (300 feet) must be marked and lit according to the standards
- F - 22 NZ CAR's have been harmonised with USA FAR's
- F - 23 CAR Part 77 is modelled off FAR Part 77 and addresses issues such as notification requirements, standards for determining an obstacle as a hazard, and Aeronautical Studies. Appendix B of CAR Part 77 sets out the marking and lighting requirements and standards
- F - 24 CAR Part 77 Marking and lighting requirements are based in the ICAO marking and lighting standards
- F - 25 CAR Part 77 was introduced in 1997 and does not allow for retrospective determinations for structures constructed prior to 1997
- F - 26 CAR Part 77 does not require the ongoing maintenance of existing marking and lighting
- F - 27 CAR Part 77 sets the notification height in NZ for man made obstacles located away from the vicinity of aerodromes is 200 feet, or any height within a designated Low Flying Zone (LFZ)
- F - 28 CAR Part 77 sets the height that a structure is to be determined to be a hazard to aviation as 120m (approx 400 feet)
- F - 29 It is important that the Australian legislation provides for the regulatory framework that allows the collection, assessment and determination of man made obstacle data
- F - 30 The absence in Australia of a formal or legislated framework for conducting Aeronautical Studies on man made obstacles located away from the vicinity of aerodromes means that CASA is not suitably equipped with the appropriate options for making obstacle determinations
- F - 31 The current Australian legislation and rule set does not address man made obstacles that are located away from the vicinity of aerodromes and is restricted to dealing with man made obstacles that are located on or within the vicinity of an aerodrome

- F - 32 The current Australian legislation does not allow the making of regulations concerning man made obstacles that are located away from the vicinity of an aerodrome
- F - 33 Legislation exists in Australia that requires the payment of compensation to sponsors structures that are required have marking and lighting. This requirement for the state to provide compensation does not exist in any of the jurisdictions examined in this report
- F - 34 The requirement in Australia to provide compensation has caused a reluctance by CASA to pursue legislative and regulatory changes concerning man made obstacles located away from the vicinity of aerodromes
- F - 35 Current Australian legislation and regulations is not compliant with ICAO Annex 14 Volume I Chapter 4 Recommendation 4.31 and Recommendation 4.3.2
- F - 36 Current Australian Regulations and standards (MOS 139) for the marking and lighting of obstacles are not compliant with Annex 14 Volume I Chapter 6 Recommendation 6.4.2 and Recommendation 6.4.3

Administration

- F - 37 The Federal Aviation Administration (FAA) is responsible in the USA for both aviation safety regulation and airspace management
- F - 38 The FAA Manages approximately 60 000 notification submissions per year (both within the vicinity of an aerodrome and outside the vicinity of an aerodrome) with an expected increase to 100 000 over the next two to three years.
- F - 39 FAR Part 77 is managed internally by the FAA Obstruction Evaluation Section. The OE Section is staffed by approximately 35 members who are located various offices within the USA
- F - 40 The FAA Obstacle Evaluation Section use the following model for making obstacle determinations; No Objection; Conditional Objection; Objectionable
- F - 41 The UK CAA is responsible for aviation safety regulation in the UK. The National Air Traffic Service (NATS) is responsible for Airspace Management in the UK
- F - 42 The UK CAA takes on a role as the mediator local planning authorities, government agencies and developers
- F - 43 Similar to the current Australian arrangements, the UK Ministry of Defence (MoD) Defence Geographic Centre collects tall structure information for charting purposes
- F - 44 There is no formal or legislated process in the UK CAA for conducting an Aeronautical Study
- F - 45 A multi-agency Memorandum of Understanding (MOU) has been established in the UK to address aviation issues associated with wind farms, however the primary focus of this MOU is the affect that wind farms have on radar and radio installations. The issue of wind farms as a hazard to aviation safety is not specifically addressed in the MOU with regard to wind farms that are located away from the vicinity of aerodromes.
- F - 46 The issue of wind farms a hazard to aviation safety that are located away from the vicinity of an aerodrome is handled internally by the UK CAA Directorate of Airspace Policy - Off-Route Airspace Section and is largely a consultative process due to the lack of legal empowerment to mandate
- F - 47 CAR Part 77 is managed internally by the CAA NZ Aeronautical Services Unit who process approximately 38 notification submissions per year
- F - 48 The RAAF AIS is the organisation in Australia charged with the responsibility to collect man made obstacle data, however the data is collected for information and charting purposes only. No Aeronautical Studies are done to determine whether the man made obstacle is a hazard to aviation
- F - 49 Australian agencies are currently examining the legal and organisational implications of how to satisfy the ICAO eTOD requirements. There is scope to align the data collection process of eTOD with the data collection process of obstacle evaluation

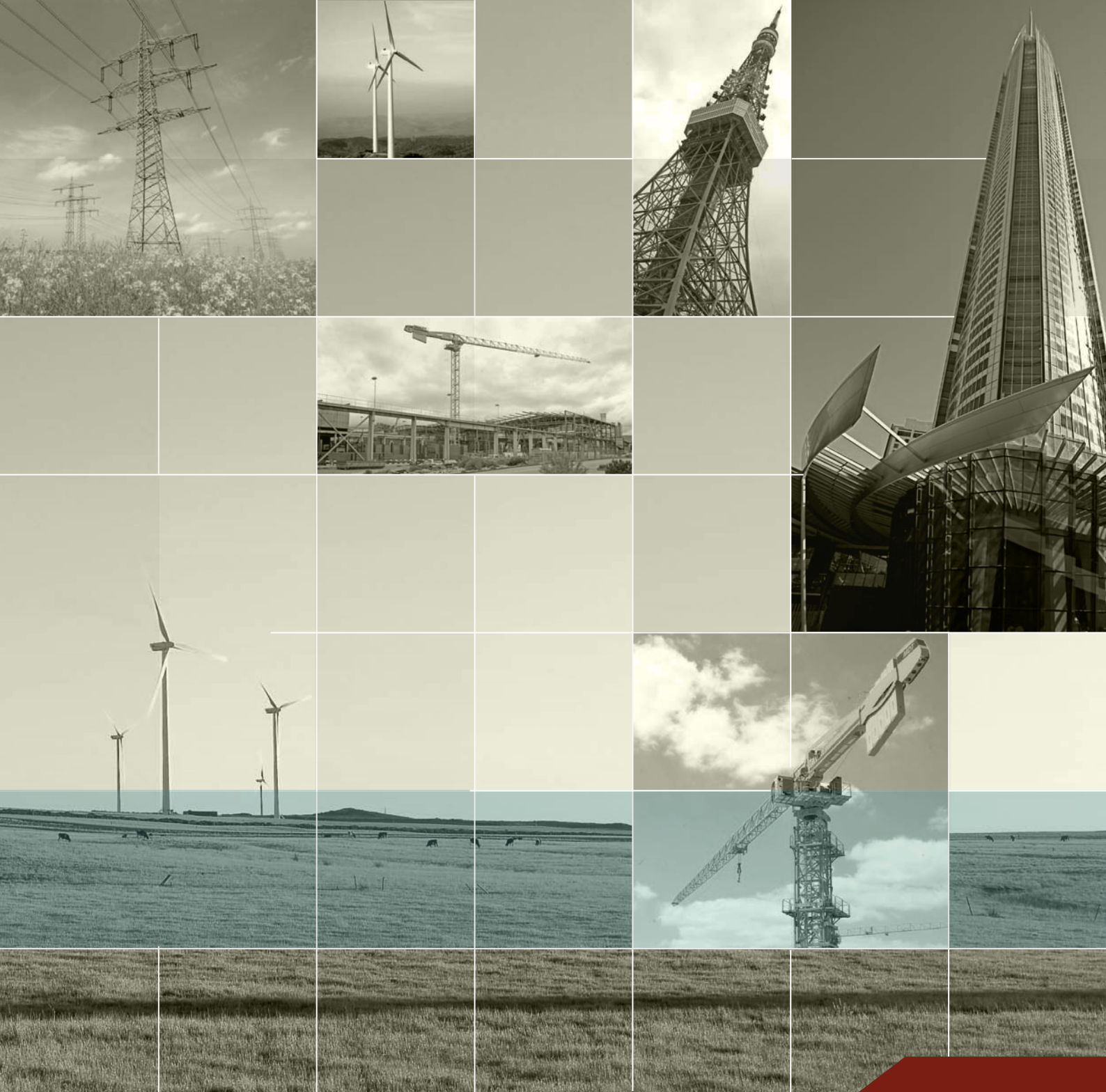
-
- F - 50 Some regulators expressed a concern that sponsors were not adequately aware of their legal requirement to notify the Regulator of their construction or alteration
- F - 51 The ICAO Requirements for the collection of electronic Terrain and Obstacle Data (eTOD) is currently the subject of an inter-agency review into how Australia can satisfy the requirements. The ICAO obstacle requirements require that a member state has in place a process for ensuring they are consulted concerning objects constructed outside the OLS. There exists an opportunity to align the process concerning the collection of obstacle data.

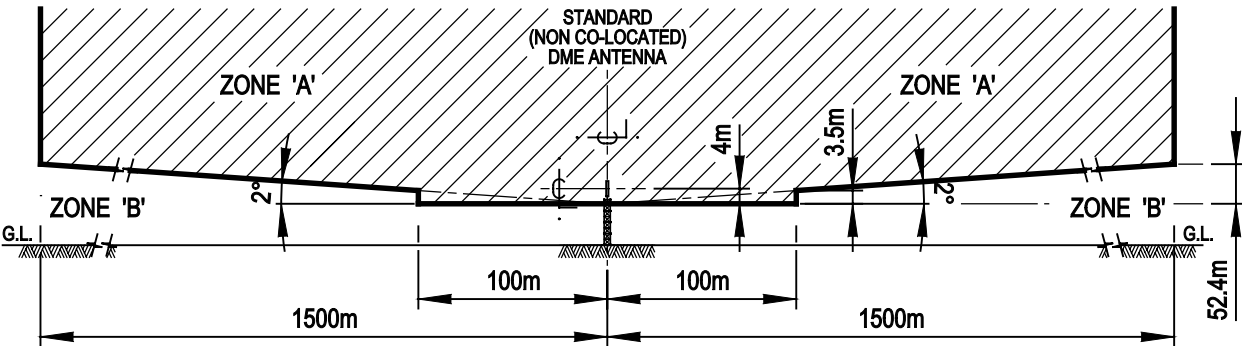
Publications

- F - 52 The two key publications produced by the FAA in relation to man made obstacles are Advisory Circular AC 70/7460-1K Obstruction Marking & Lighting and Advisory Circular AC 70/7460-2K Proposed Construction or Alteration of Objects that May Affect the Navigable Airspace
- F - 53 Publications concerning CAR Part 77 and Objects that Affect the Navigable Airspace are published on the CAA NZ website. There are no specific Advisory Circulars relating to the requirements of CAR Part 77

Industry Stakeholders

- F - 54 The primary issue with wind farms in the UK is their impact on radar and radio installations
- F - 55 While renewable energy (including wind farms) in Australia currently provide 0.5% of electricity usage, with the current push for renewable energy targets in Australia and the trend overseas for increased renewable energy targets it is reasonable to assume that the number of wind farm developments in Australia will increase over time
- F - 56 The wind energy industry in Australia is concerned that CASA do not have the mandate to consider options that offer alternatives to the lighting of wind farms
- F - 57 The wind energy industry is required to deal with the visual amenity issues caused by the requirement for lighting on wind turbines
- F - 58 ICAO Annex 14 Volume I Chapter 6 provides clear requirements for the marking and lighting of wind farms in the case that they are determined to be a hazard to aviation, however there is potential that a formal Aeronautical Study may determine that a wind farm in a certain location offers no hazard to aviation, thus removing the requirement for marking and lighting.
- F - 59 While regional operators are generally considered to operate outside the height range of man made obstacles that are located away from the vicinity of aerodromes, there is some risk to VFR operators who might find themselves in a situation where weather has forced them to operate in this height zone.
- F - 60 The principle concern for aerial agriculture operators is the rapid and unreported erection of wind monitoring masts. The AAAAA is active in attempts to establish relationships with the wind energy industry and the electricity industry in order to ensure that the aerial agricultural industry is informed of man made obstacles that might affect the safety of their operations.
- F - 61 Local, State and Federal planning authorities, like CASA have no authority to mandate the use of measures that mitigate aviation safety issues for man made obstacle that are located away from the vicinity of aerodromes. Aviation safety issues do not generally factor into the planning and approval process and when it does become an issue they generally take their lead from CASA.





BUILDING RESTRICTED AREA:

IF THE DME ANTENNA IS CO-LOCATED WITH A VOR, LOCALISER OR GLIDEPATH FACILITY, THE BUILDING RESTRICTED AREA OF THE RESPECTIVE CO-LOCATED FACILITY SHOULD BE USED AS THE DME BUILDING RESTRICTED AREA. OTHERWISE THE FOLLOWING RESTRICTIONS APPLY:

- ZONE 'A' -** ALL DEVELOPMENT PROPOSALS WITHIN 100m OF THE DME ANTENNA WHICH EXCEED A HORIZONTAL PLANE LOCATED 4m BELOW THE CENTRE OF THE DME ANTENNA AND DEVELOPMENT PROPOSALS BETWEEN 100m AND 1500m FROM THE DME ANTENNA THAT EXCEED AN ANGLE OF ELEVATION OF 2.0°, MEASURED FROM THE ABOVE HORIZONTAL PLANE BENEATH THE DME ANTENNA, REQUIRE ASSESSMENT BY A DME TECHNICAL AUTHORITY.
- ZONE 'B' -** UNRESTRICTED.

DME SITING GUIDELINES:

- 1. GENERALLY THE CENTRE OF THE DME SHOULD BE AT LEAST 6m ABOVE THE GROUND LEVEL AND SHOULD PROVIDE CLEAR LINE OF SIGHT COVERAGE IN ALL DIRECTIONS. FOR A DME THAT IS FREQUENCY PAIRED WITH AN ILS FACILITY, THE CENTRE OF THE DME ANTENNA SHOULD BE 4.5m ± 0.5m ABOVE GROUND.
- 2. GENERALLY NO OBSTACLES, EXCEPT ESSENTIAL INFRASTRUCTURE SUCH AS THE EQUIPMENT BUILDING, ASSOCIATED FACILITIES, SITE FENCING ETC WITHIN 100m OF THE DME ANTENNA ABOVE A HORIZONTAL PLANE LOCATED 4m BELOW THE CENTRE OF THE DME ANTENNA.
- 3. GENERALLY TAXIWAYS, RUNWAYS, ROADS AND RAILWAY LINES SHOULD BE AT LEAST 100m FROM THE DME ANTENNA. TAXIWAYS AND RUNWAYS WITH CODE 'E' AND 'F' TYPE AIRCRAFT SHOULD BE AT LEAST 150m FROM NON ILS FREQUENCY PAIRED DME.
- 4. OVERHEAD LOW VOLTAGE POWER LINES AND TELEPHONE LINES SERVING THE DME SHOULD BE KEPT AT LEAST 100m FROM THE DME ANTENNA. POWER AND PHONE LINES SHOULD BE UNDERGROUND WITHIN 100m OF THE DME ANTENNA.
- 5. HIGH VOLTAGE OVERHEAD POWER LINES, 33kV OR GREATER, WHICH EXCEED AN ANGLE OF ELEVATION OF 2.0° MEASURED FROM 4m BELOW THE CENTRE OF THE DME ANTENNA, SHOULD BE AT LEAST 300m FROM THE DME.

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NAVIGATION AIDS RADIO DISTANCE MEASURING EQUIPMENT (DME) STANDARD (NON CO-LOCATED) INSTALLATION BUILDING RESTRICTED AREA & SITING GUIDELINES LAYOUT DIAGRAM									A4	
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Attachment A. Wind turbines Wake Turbulence and Separation

Introduction

This paper is a summary of research extracted and credited to the references included at the end of this paper.

The summary is the opinion of the author Ralph Holland, B Sc., Dip Ed., Dip Com. Sc.

Assumptions

Certain assumptions were made during the construction of this data:

- The blade tip speed for the wind-turbines employed in the Crookwell proposal,
- and that the turbines are operating at the Betz limit when operating at the max rpm.

These two assumptions were used to arrive at the expected max operating speed and used to calculate the subsequent wind-speeds for the turbines under consideration, and as itemised in table-1.

Blade Diameter m	Total height m	Max RPM	max tip speed kph	Max tip speed knots	tip speed ratio	wind speed at max tip speed Knots	wind speed at max tip speed m/s	16 * blade diam. m
93	126.5	17	298.0	160.9	6.0	26.8	13.8	1488
120	195	17	384.5	207.6	6.0	34.6	17.8	1920

Table-1 Proposed wind-turbine parameters for Crookwell

Turbine wake turbulence

There are two contributions to the wake of a wind turbine:

- The reduction to airflow due to power extraction, where the free airflow speed is reduced to 1/3 of the free-flow rate (e.g. from 26.8 Knots to 9.9 Knots) behind the turbine
- The generation of blade-tip vortices due to the air counteracting the blade torque, and in part to aerodynamic effects due to the finite extent of the blades.

Attachment A. Wind turbines Wake Turbulence and Separation



Figure 1. Smoke trail passed over blade-tips showing vortices [Ref 1]

The blade-tip vortices are caused by the blade rotation, so vortex cells have rotational components caused by the blade tips travelling at the tip speed, e.g. 160 Knots in the case of the smaller turbine operating at the maximum designed tip speed. Further the blade-tip vortices are pushed down-stream and start to mix with the downstream air-flow, and additional rotational components can be observed to form parallel with that downstream air flow. These vortices will eventually dissipate as energy is lost due to mixing and through the generation of heat.

Attachment A. Wind turbines Wake Turbulence and Separation

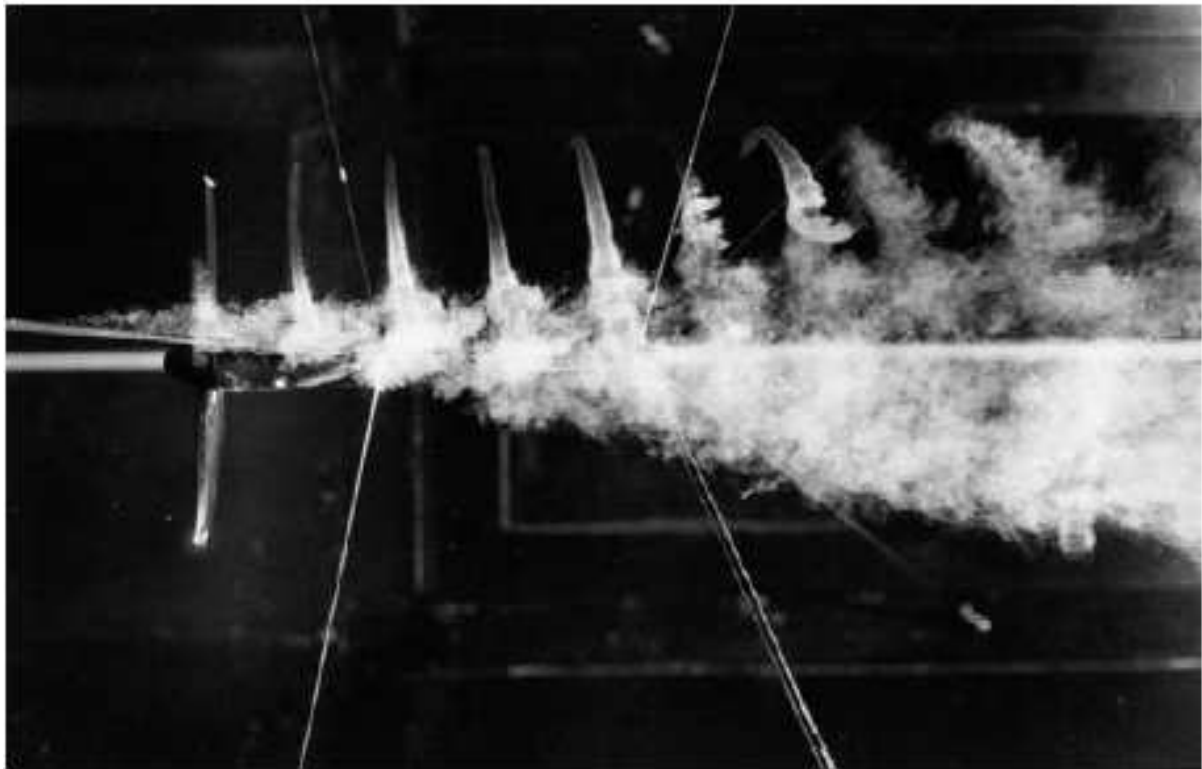


Figure 2. Smoke trail injected through centre of turbine showing expansion [Ref 1]

Studies show that the near-field wake turbulence behind a horizontal axis turbine extends downstream to 3 to 7 blade diameters. The exact extent depends on the blade torque coefficient and the tip speed ratio. Traditionally the near-field wake is considered to be 3 blade-diameters, but Figure 2 shows that it extends further.

The airstream is turbulent until at least this distance, and it is no coincidence that turbine separation in wind-farms clusters is 6 to 7 diameters in the direction of the prevailing wind direction, and 3 diameters perpendicular to the prevailing conditions. The more powerful the turbine, (i.e. bigger) this spacing is typically greater.

Attachment A. Wind turbines Wake Turbulence and Separation



Figure 3 down-stream containment of the wake with low thrust [ref 2]

From NASA Ames wind-tunnel tests , where the turbine was operating at low thrust, you can see that the wake field is contained behind the turbine for up to 8 or 9 blade rotations, showing the extent of the near field propagation.

At higher thrust (or power recovery) the wake field expands and more mixing occurs and the wake field is not as contained, but rather spreads out. The turbulence being generated is in proportion to power captured via aerodynamic surfaces and represents drag.

Clearly the effect of a wind turbine reduction in wind speed behind it will extend beyond the near turbulence field, and the 3 to 7 blade diameter separation employed by wind-farm designers may be inadequate. The affect of additional blades is to alter the frequency of the turbulence components, but the same, if not potentially more turbulence may be present because in general a three-blade turbine has more drag than a two-blade turbine.

In aviation terms air-traffic control is required to provide 2 minute separation of aircraft taking off and landing to avoid wake-turbulence, so wake turbulence is considered a very real danger to aircraft.

Attachment A. Wind turbines Wake Turbulence and Separation

COMPARISON BETWEEN THE MEASURED AND PREDICTED TURBULENT VELOCITY PROFILES IN THE WAKE OF A SINGLE MACHINE OPERATING AT TSR= 4.0.

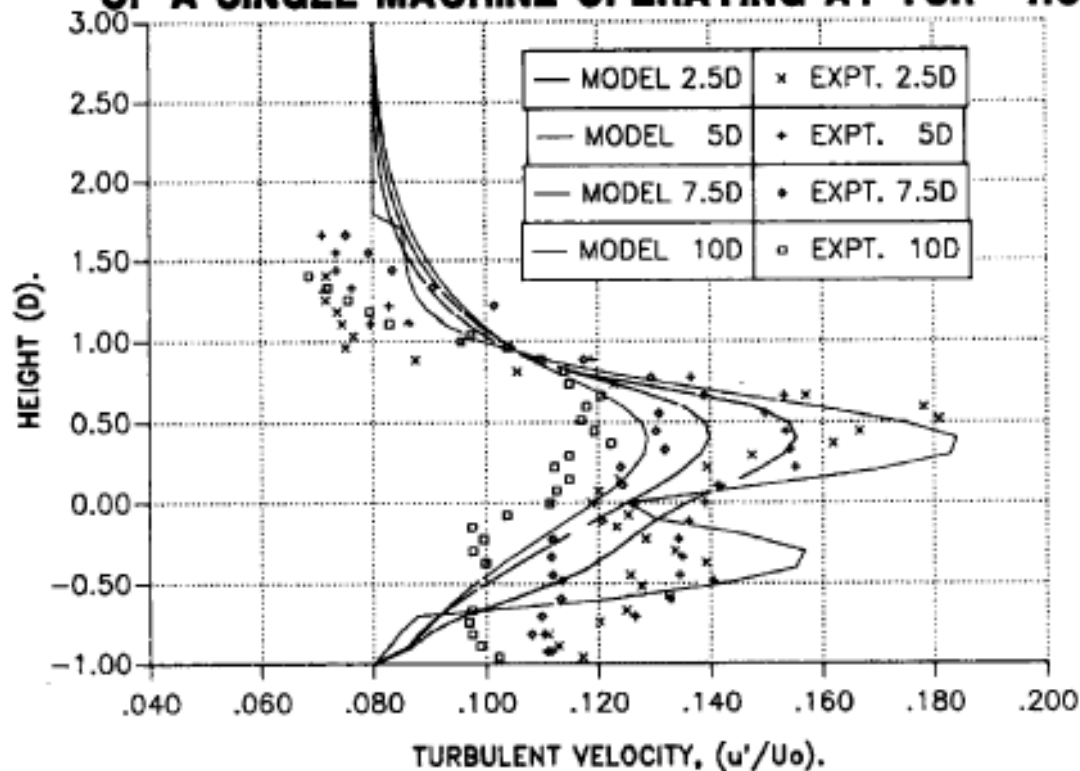


Figure 4 Downstream turbulence from various model and experimental measurements [ref 3]

Note in figure 4 that the velocity stream behind a turbine has been measured and is still prevalent at 10 times the blade diameter for a wind-turbine operating at a tip speed ratio of 4.0. It also shows the variation of the velocity profile with height, the zero height being the centre of the turbine. Note that the upper-half has more turbulence than the lower half of the distribution and this is backed by other references found in the further reading material at the end of this report. (Note u' is actually the square-root of the difference between the measured velocity and the free-flow velocity.)

Attachment A. Wind turbines Wake Turbulence and Separation

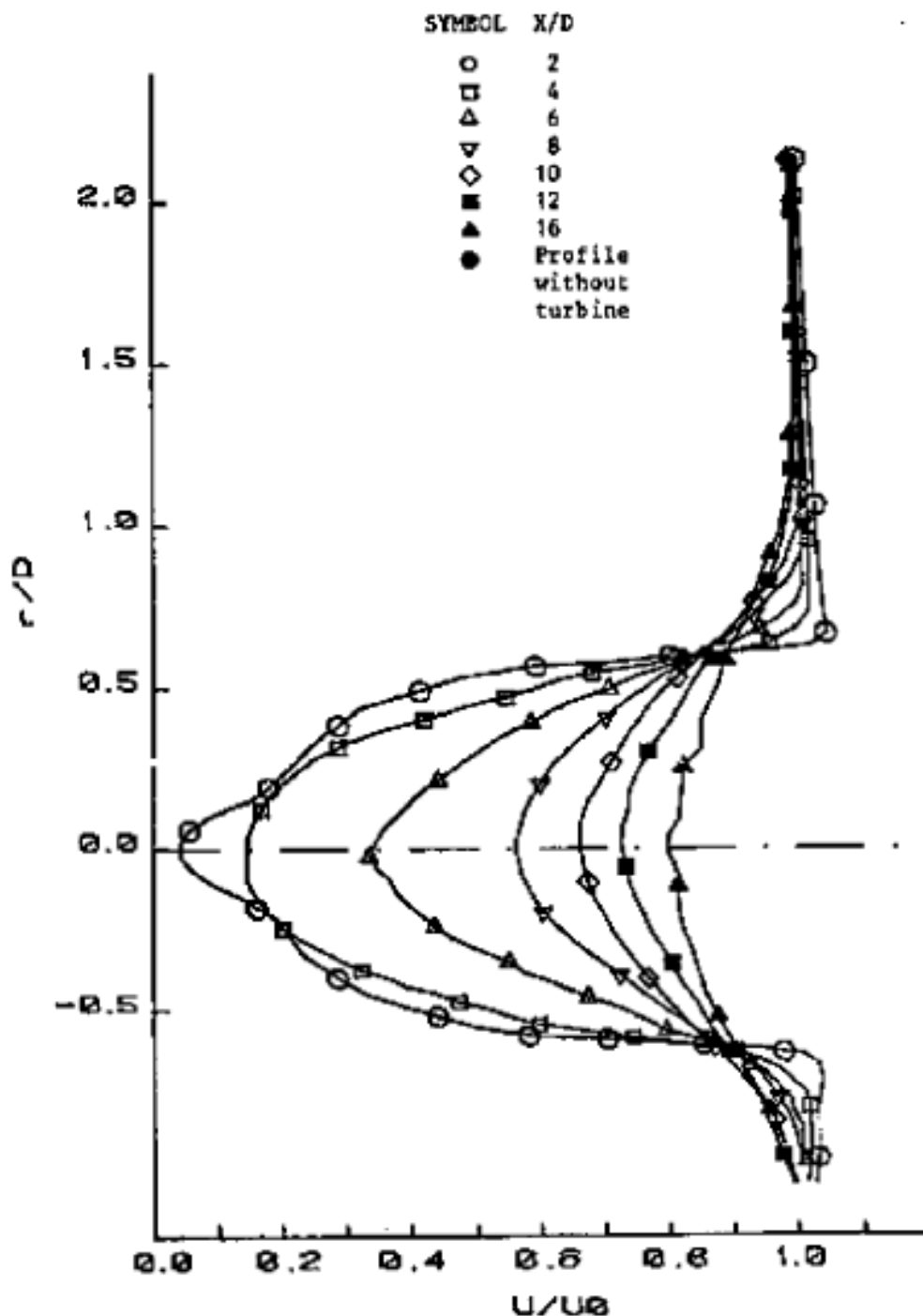


Figure 5 – mean velocity behind a turbine [Ref 3]

Figure 5 shows that the disruption to wind-velocity occurs even at 16 times the blade diameter. This is largely due to the extraction of power from the air-stream, and the time it takes the airstream to recover back to the free-airflow. So it may be necessary to require separation beyond 16 blade diameters. (This represents 1.488 kilometres for the smaller turbine, and 1.92 km for the larger turbine measurements used in Table 1.)

Attachment A. Wind turbines Wake Turbulence and Separation

Summary

Wake turbulence behind a single wind turbine can extend beyond 16 blade diameters, being composed of both blade-tip vortices and the reduction of wind speed due to power extraction. It takes time for the airstream to become laminar, and further time for it to recover to the original free airstream velocity.

There is a tendency for the downstream to rotate initially at the blade rate, and it has been shown that this rotation moves downstream to extents that are not insignificant.

The near-field turbulence is coupled with a significant down-stream reduction in wind velocity, which represents wind-shear, a phenomenon that is known to be dangerous to flight.

The wind velocity typically decreases to $\frac{2}{3}$ of the free-stream velocity just in front of the turbine, and is further reduced to $\frac{1}{3}$ of the free stream flow behind the turbine when the turbine is operating at maximum power extraction i.e. the Betz limit.

So an observer crossing such a stream would see an abrupt variation in wind speed between $\frac{2}{3}$ to $\frac{1}{3}$ less than the surrounding free-flow airspeed. For a 27 knot wind this would represent a variation of 17.9 Knots below the ambient wind speed, and couple this with the rotational velocity of the blade-tip vortices, then there is the capacity to be caught in what started out as a 160 Knot rotational field - from the smaller turbine operating at 17 rpm.

In the case of aircraft flying into such a wake, this represents a significant reduction in airspeed and flying conditions that might easily cause an aircraft to tip and stall.

I also believe that when wind-turbines are arranged into wind-farm clusters, that there is more chance of wake-turbulence interaction between turbines, and greater potential for interaction of the wake-turbulence with the surrounding environment, such as mechanical turbulence induced by the very hills on which they are located, under adverse wind conditions.

Strangely, studies show that the turbulence can be greater when the turbine is operating at lower wind-speeds.

Credit and References:

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Attachment A. Wind turbines Wake Turbulence and Separation

[wake+dispersion+in+various+flow+conditions](#)

2. Wind turbine wake aerodynamics, L.J. Vermeer, J.N. Sorensen, A. Cresp. Progress in Aerospace Sciences 39.
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3. Hand M, Simms D, Finger L, Jager D, Coteril J, Schreck S, Larwood S Unsteady aerodynamics experiments phase VI: Wind tunnel test configuration and available data campaigns. Technical report BREL/TP-500-29955, NREL, December 2001.
http://www.google.com.au/search?sourceid=navclient&ie=UTF-8&rlz=1T4DAAU_enAU230AU230&q=Unsteady+aerodynamics+experiments+phase+VI
4. Wind Turbine Wakes – Control and Vortex Shedding by Davide Medici. Technical Reports from KTH Mechanics Royal Institute:
http://www.vindenergi.org/Vindforskrapporter/Medici_2004_Wakes.pdf

Further Reading

- <http://www.sandia.gov/wind/2007ReliabilityWorkshopPDFs/Mon-6-DanBernadett.pdf> shows wind-turbine spacing versus turbulence and wind-speed.
- http://www.risoe.dk/vea/recoff/Documents/Sec_3/RECOFFdoc068.pdf turbulence inside and outside wind farms
- <http://people.clarkson.edu/~visser/research/wind/> Renewable Energy Research
- <http://www.stereovisionengineering.net/mod-2.htm> wake turbulence flow visualizations by rocket smoke trials
- http://www.sciencedaily.com/videos/2005/1012-wind_farms_impacting_weather.htm windfarms affect local weather
- <http://149.222.198.151/~nummech/pdf-files/DEWEK2002.pdf>, A.P. Schaffarczyk, New Model for Calculating Intensities of Turbulence in the Wake of Wind-Turbines
- <http://ams.confex.com/ams/pdfpapers/120352.pdf> Impact of Wind Farms on Weather Radar
- <http://www.ilr.tu-berlin.de/WKA/technik/free.wake.html> Free wake models for Vortex Methods
- http://www.ewec2006proceedings.info/allfiles2/290_Ewec2006fullpaper.pdf

Attachment A. Wind turbines Wake Turbulence and Separation

- http://pubs.acs.org/subscribe/journals/esthag-w/2005/jan/tech/kc_turbulence.html
- http://www.osti.gov/energycitations/product.biblio.jsp?osti_id=6342731
- <http://adsabs.harvard.edu/abs/2006WiEn....9..219M>
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- <http://www.fluid.ntua.gr/wind/wakes/wakes.html>
- <http://www.nrel.gov/docs/fy01osti/29132.pdf>

Updates

- 1.1 20080923 Correction to statements of rotational field and wind shear.
- 1.0 20080922 Initial Draft.



August 2013

Aerial Spraying Questions and Answers

Background information

Yorke Peninsula Wind Farm Project Pty Ltd (YPWFP) the owner of the CERES project, has signed an Agreement with Aerotech Australasia Pty Ltd (the sole provider of aerial spraying services on the Yorke Peninsula) that ensures that the wind farm will have no impact on the ability for adjacent landowners to continue to receive fixed wing agricultural spraying services without change to service, quality and cost.

Wind farms generally do not operate in low wind conditions, which is when aerial spraying is undertaken to avoid spray drift. However as further safeguards, the Agreement provides that when aerial spraying is undertaken on land adjacent to the Ceres wind farm, wind turbines near the boundaries of the relevant adjacent non-involved landowner properties will be turned off with the blades aligned to be parallel to the flight path of the fixed wing aircraft.

The Agreement specifically provides for:

- Clearance between turbine blades and the boundary of the land being sprayed of at least 60 metres, and typically more including roadways between properties
- At Aerotech's election, wind turbines within 500 metres of the boundaries of the land being sprayed to be turned off to eliminate any risk of turbulence.

Here we answer the most common questions about what the Agreement means for adjacent and nearby landowners:

1. Will my aerial spraying service prices increase as a result of the CERES wind farm being built, or as a result of the agreement with Aerotech?

No. There will be no increase in your aerial spraying prices as a result of the CERES wind farm being built, nor as result of the agreement with Aerotech.

2. Will my aerial spraying services change in terms of timing, delivery or quality?

No. There will be no change to your aerial spraying services in terms of timing delivery and quality arising from the CERES wind farm being built, nor from the agreement with Aerotech.

3. Is the Aerotech agreement binding? And if so for how long?

The Aerotech agreement is legally binding and will apply for the lifetime of the wind farm which is planned to be 25 years.

4. What happens if Aerotech on-sells its business?

Aerotech may sell or assign its agreement rights and obligations to another party that is deemed suitable to provide the aerial spraying services. This is designed to ensure continuity of service and meeting the agreement's objectives of no change to service, quality and cost.

5. What happens if YPWF sells the CERES project?

The rights and obligations of the Aerotech agreement will transfer to the new owner ensuring no change for adjacent landowners.

6. Why is the agreement with Aerotech and not with the adjacent landowners?

The agreement is with Aerotech as its staff are the aviation experts with the expertise to undertake the risk assessment and determine the safe operating protocols required to undertake and maintain the aerial spraying services adjacent to the wind farm.

7. What happens if other aerial spraying contractors/service providers wish to provide an alternative service? And what does this mean for adjacent/nearby landowners?

Currently Aerotech is the sole provider of services in the region. Should other aerial spraying contractors enter the market to provide an alternative service, we will offer the same terms as in the Aerotech agreement.

8. What, if any, impact will the Ceres wind farm have on ground spraying?

The wind farm will have no impact on ground spraying.

9. What consultation has been undertaken in relation to aerial spraying by the CERES project with key stakeholders (including landowners - involved and adjacent/nearby)?

The matter was first raised in sessions held in Community Open Days in October 2011 and then again in December 2011.

Preliminary consultation with adjacent and nearby landowners occurred with a formal request for submissions in January 2012. This was followed by providing the Ambidji Report (on aerial agricultural impact from fixed winged aircraft) to those parties in January 2013.

That report and an update of that report were made public as part of the Development Assessment Commission's consultation process.

Since January 2013 submissions made to DAC have been reviewed and have been incorporated into the solution embodied in the agreement with Aerotech signed in late July 2013. A letter informing landowners of no change to their current practices was then sent.

10. What is the planning policy principle in relation to impacts on aerial agricultural services (aerial spraying) and how does the CERES project comply?

The planning policy principle that applies to aerial agricultural services provides that wind farm developments should ".....avoid or minimize interference with low altitude aircraft movements associated with agriculture".

The CERES project more than satisfies that principle through the combination of a fundamental design that employs 600 metres spacing between turbines, no overhead lines and an operational agreement with Aerotech that turns nearby turbines off and re-aligns them parallel to the flight path of fixed winged aircraft.

This ensures that the development of the wind farm results in no change to the aerial spraying practices of adjacent landowners.

11. How can I be confident the above agreement will be honoured by current and future owners of the wind farm and current and future aerial spraying contractors?

YPWFP has proposed to the Development Assessment Commission that the wind farm operational constraints covered in the Aerotech agreement be encapsulated as a condition of approval for the CERES Project. This ensures ongoing certainty for adjacent landowners.

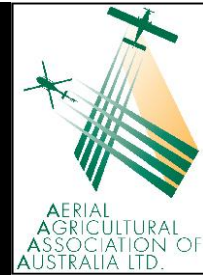
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Aerial Agricultural Association of Australia



National Windfarm Operating Protocols

Adopted May 2014

Introduction

Windfarms and their pre-construction wind monitoring towers are a direct threat to aviation safety – and especially aerial application. They also pose an economic threat to the industry where the costs of windfarm development—including those of compensation for loss of income—are externalized onto other sectors such as aerial application.

There are two distinct phases in the relationship between aerial applicators and wind farms:

1. Development approval
2. Operation once built

AAAA has a detailed policy available from its website – www.aerialag.com.au/resourcecentre/policy – that covers its views and the safety risks inherent in windfarm operations and the costs that are likely to be externalised onto the aerial application industry by the windfarm industry.

At the development stage, AAAA remains **strongly opposed** to all windfarms that are proposed to be built on agricultural land or land that is likely to be affected by bushfire. These areas are of critical safety importance to legitimate and legal low-level operations, such as those encountered during crop protection, pasture fertilisation or firebombing operations.

However, AAAA realises that some wind farm proposals may be approved in areas where aerial application takes place. In those circumstances, AAAA has developed the following national operational protocols to support a consistent approach to aerial application where windfarms are in the operational vicinity.

Developer's Design/Build Considerations

Where possible, the developer should commit to:

- placement of turbines in straight lines
- setback of turbines at least 100 metres from any boundary
- all powerlines to be underground
- all MET towers are marked in accordance with NASAG Guidelines and notified to the local aerial applicators – see Appendix I to these Protocols

Developer's Operational Considerations

- Wind farm locations, including any attendant MET towers, have been notified to local aerial applicators.
- The wind farm developer/operator is to develop an agreed set of protocols with the local aerial applicators for all relevant operational issues, including notification of applications.
- Wind farm operators are to stop blades during application operations and align them as required by the aerial operator.
- MET towers are marked in accordance with NASAG guidelines and notified to local aerial applicators.

Pilot/Aircraft Operator's Operational Considerations

Once a wind farm has been built, the following protocols are to apply:

- The operator or pilot will conduct a risk assessment of the block to be treated as per usual – considering tower hazards / placement etc – including for operations that require treatment within the wind farm area – with operating at normal spray height underneath the blades to be acceptable.
- The risk assessment is to result in an aerial application management plan in accordance with the principles of an application management plan as outlined in the AAAA publication, the Aerial Application Pilots Manual. An overview of an aerial application plan is to be found at Appendix II.
- The aerial applicator is to notify the wind-farm operator of application operations at least by 9 pm the night before via an agreed notification method.

Economic compensation

The following national protocols are suggested by AAAA as a starting point for the payment of economic compensation to aerial applicators:

- Should a wind farm result in additional operational costs to the aerial applicator for treatment of an area that either neighbours or is the host property for the windfarm, then the windfarm company will compensate the aerial applicator directly for reasonably calculated additional costs.
- Such costs would include, but not be limited to:
 - Additional administration required for notification, liaison, planning
 - Additional treatment costs (additional flying time calculated at the normal charge out rate of the aircraft to be used) due to flight lines that are not

the 'normal' or most efficient treatment.

- Costs related to additional product to be applied to compensate for any increase in height or loss of accuracy of the application to avoid towers.

Appendix I – National Airports Safe-guarding Advisory Group - NASAG - Guidelines for Marking of Wind Turbines

See—http://www.infrastructure.gov.au/aviation/environmental/airport_safeguarding/nasf/

Appendix II – AAAA Aerial Application Pilots Manual – excerpts on planning.

Appendix I

NASAG Guideline D

NATIONAL AIRPORTS SAFE-GUARDING FRAMEWORK

Wind Turbine Guidelines

Purpose of Guideline

This document provides guidance to State/Territory and local government decision makers, airport operators and developers of wind farms to jointly address the risk to civil aviation arising from the development, presence and use of wind farms and wind monitoring towers.

Why it is important

The *Principles for a National Airports Safeguarding Framework* acknowledge the importance of airports to national, state/territory and local economics, transport networks and social capital.

Wind farms can be hazardous to aviation as they are tall structures with the potential to come into conflict with low flying aircraft. Temporary and permanent wind monitoring towers can be erected in anticipation of, or in association with, wind farms and can also be hazardous to aviation, particularly given their low visibility. These structures can also affect the performance of Communications, Navigation and Surveillance equipment operated by Airservices Australia (Airservices) and the Department of Defence (Defence).

How it should be used

Some States/Territories already have planning guidelines or policies in place and this document provides guidance for review. For those without policies in place, these Guidelines (in addition to the associated Safeguarding Framework) will provide input to new policies.

These guidelines provide general information and advice to:

- proponents of wind farms (including single wind turbines); and
- planning authorities with jurisdiction over the approval of such structures.

These guidelines also provide specific advice on measures to reduce hazards to aviation, and how to implement them.

The guidelines are intended to provide information to proponents of wind farms and planning authorities to help identify any potential safety risks posed by wind turbine and wind monitoring installations from an aviation perspective.

The guidelines rely on an approach of risk identification and management to ensure risks to aviation are minimised in the most effective and efficient manner possible. It is not the intention to adopt an overly restrictive approach to wind farm development, rather to ensure risks are identified early and mitigation measures are able to be planned and implemented at an early stage.

Roles and Responsibilities

State/Territory and local governments are primarily responsible for land use planning in the vicinity of all airports.

Australia's 19 major airports are under Australian Government planning control and are administered under the Airports Act 1996 (the Airports Act). Planning on other airports is undertaken by State, Territory Governments and Local Governments or private operators.

Commonwealth airports are protected from tall structures in the vicinity of airports based on standards established by the International Civil Aviation Organization (ICAO). These standards have been implemented in Australia by the Airports Act 1996 and the Airports (Protection of Airspace) Regulations 1996 which apply at leased Commonwealth airports, and by the Defence (Areas Control) Regulations 1989 which apply at Defence airports.

This legislation can be used to ensure wind farms hazardous to aviation are not erected in the vicinity of Commonwealth airports. The implementation of these guidelines will have the outcome of conferring a similar level of protection to non-Commonwealth airports.

Australia is a signatory to the Convention on International Civil Aviation. Signatories are obliged to implement ICAO Standards unless they lodge a formal difference. ICAO Annex 14 specifically addresses the issue of wind turbines. In summary,

ICAO has recommended the need for lighting of wind turbines if determined to be an obstacle.

Annex 14 includes a provision for an aeronautical study as to the need, or otherwise, for marking and/or lighting. This is consistent with provisions in Australia for risk-based assessments of potential hazards to aviation safety. These guidelines are consistent with ICAO Annex 14.

Key considerations for managing risks to aviation safety of wind turbine installations (wind farms)/wind monitoring towers

The guidelines apply to:

- (a) a single wind turbine;
- (b) a group of wind turbines, referred to as a wind farm, which may be spread over a relatively large area; and
- (c) wind monitoring towers.

The height of a wind turbine is defined as the maximum height reached by the tip of the turbine blades at their highest point above ground level. The marking and lighting described in this document addresses aviation requirements only. For offshore wind farms, in addition to these requirements, separate lighting and marking may be required for the safety of marine navigation.

Implementation of the guidelines will have the additional benefit of being applicable in areas away from airports to address the risk posed by wind farms to air navigation in those areas.

Adoption of the guidelines will ensure that aviation safety agencies can examine and address the risk to aviation safety from proposed wind turbine farms at the planning stage. This will enable the use of wind energy to continue to grow, while protecting aviation safety.

Wind farm operators should check if proposed wind turbines and wind monitoring towers will be located near areas where low flying operations are likely to be conducted, and if so, consider their duty of care to such activities.

GUIDELINES FOR LAND USE PLANNERS AND DEVELOPERS TO MANAGE THE RISK TO AVIATION SAFETY OF WIND TURBINE INSTALLATIONS (WIND FARMS) /WIND MONITORING TOWERS

When wind turbines over 150 metres above ground level are to be built within 30 kms of a certified or registered aerodrome, the proponent should notify the Civil Aviation Safety Authority (CASA) and Airservices. If the wind farm is within 30km of a military aerodrome, Defence should be notified.

CASA should be notified through the nearest CASA Regional or Field Office. Location and contact details of CASA Aerodrome Inspectors may be obtained by calling CASA on 131 757. Airservices should be notified through the Airports Relations Team on 02-6268-4111. Defence should be notified through the Defence Support Group on 02-6266-8191.

The Aeronautical Information Service of the Royal Australian Air Force (RAAF AIS) maintains a database of tall structures in the country. The RAAF AIS should be notified of all tall structures meeting the following criteria:

- 30 metres or more above ground level for structures within 30km of an aerodrome; or
- 45 metres or more above ground level for structures located elsewhere.

The contact details for the RAAF AIS are: Tel- 03-9282-5750; ais.charting@defence.gov.au.

Operators of certified aerodromes are required to notify CASA if they become aware of any development or proposed construction near the aerodrome that is likely to create an obstacle to aviation, or if an object will infringe the Obstacle Limitation Surfaces (OLS) or Procedures for Air Navigation Services –Operations (PANS-OPS) surfaces of an aerodrome. Operators of registered aerodromes should advise CASA if the proposal will infringe the OLS; CASA will ask Airservices to determine if there is an impact on published flight procedures for the aerodrome.

Note: <i>Obstacle Limitation Surfaces are a complex of virtual surfaces associated with an aerodrome. They are designed to protect aircraft flying in good weather conditions from colliding with tall structures. PANS-OPS surfaces are designed to protect aircraft flying in poor weather conditions from colliding with tall structures. Aerodrome operators can provide details for their particular aerodrome.</i> Consultation Consultation with aviation stakeholders is strongly encouraged in the early stages of planning for wind turbine developments. This should include: • early identification of any nearby certified or registered aerodromes; • immediate consultation with any nearby aerodrome owners; • preliminary assessment by an aviation consultant of potential issues; • confirmation of the extent of the OLS for any nearby aerodromes; • registration of all wind monitoring towers on the RAAF AIS database; • consultation with local agricultural pilots and nearby unlicensed airstrip owners; and • consultation with CASA and Airservices. Risk assessment Following preliminary assessment by an aviation consultant of potential issues, proponents should expect to commission a formal assessment of any risks to aviation safety posed by the proposed development. This assessment should address any issues identified during stakeholder consultation. The risk assessment should address the merits of installing obstacle marking or lighting. The risk assessment should determine whether or not a proposed structure will be a hazardous object. CASA may determine, and subsequently advise a proponent and relevant planning authorities that the structure(s) have been determined as: (a) hazardous, but that the risks to aircraft safety would be reduced by the provision of approved lighting and/or marking; or (b) hazardous and should not be built, either in the location and/or to the height proposed as	an unacceptable risk to aircraft safety will be created; or (c) not a hazard to aircraft safety. If CASA advice is that the proposal is hazardous and should not be built, planning authorities should not approve the proposal. If a wind turbine will penetrate a PANS-OPS surface, CASA will object to the proposal. Planning decision makers should not approve a wind turbine to which CASA has objected. In the case of military aerodromes, Defence will conduct a similar assessment to the process described above if required. Airservices or in the case of military aerodromes, Defence, may object to a proposal if it will adversely impact Communications, Navigations or Surveillance (CNS) infrastructure. Airservices /Defence will provide detailed advice to proponents on request regarding the requirements that a risk assessment process must meet from the CNS perspective. Marking of wind turbines in the vicinity of an aerodrome During the day, large wind turbines are sufficiently conspicuous due to their shape and size, provided the colour of the turbine is of a contrasting colour to the background. Rotor blades, nacelle and upper 2/3 of the supporting mast of wind turbines should be painted white, unless otherwise indicated by an aeronautical study. Other colours are also acceptable, unless the colour of the turbine is likely to blend in with the background. Lighting of wind turbines in the vicinity of an aerodrome Siting of wind turbines in the vicinity of an aerodrome is strongly discouraged, as these tall structures can pose serious hazards to aircraft taking-off and landing. Where a wind turbine is proposed that will penetrate the OLS of an aerodrome, the proponent should conduct an aeronautical risk assessment. The risk assessment, to be conducted by a suitably qualified person(s), should examine the effect of the proposed wind turbines on the operation of aircraft. The study should be made available to CASA to assist assessment of any potential risk to aviation safety. CASA may determine that the proposal is: (a) hazardous and should not be built, either in the location and/or to the height proposed,
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as an unacceptable risk to aircraft safety will be created; or (b) hazardous, but that the risks to aircraft safety would be reduced by the provision of approved lighting and/or marking. Lighting of wind turbines not in the vicinity of an aerodrome, with a height of 150m or more Where a wind turbine 150m or taller in height is proposed away from aerodromes, the proponent should conduct an aeronautical risk assessment. The risk assessment, to be conducted by a suitably qualified person(s), should examine the effect of the proposed wind turbines on the operation of aircraft. The study must be submitted to CASA to enable an assessment of any potential risk to aviation safety. CASA may determine that the proposal is: (a) hazardous, but that the risks to aircraft safety would be reduced by the provision of approved lighting and/or marking; or (b) not a hazard to aircraft safety. Obstacle lighting standards for wind turbines When lighting has been recommended by CASA to reduce risk to aviation safety, medium-intensity obstacle lights should be used. Where used, lighting on wind farms should be installed: (a) to identify the perimeter of the wind farm; (b) respecting a maximum spacing of 900m between lights along the perimeter, unless an aeronautical study shows that a greater spacing can be used; (c) where flashing lights are used, they flash simultaneously; and (d) within a wind farm, any wind turbines of significantly higher elevation are identified wherever located. To minimise the visual impact on the environment, obstacle lights may be partially shielded, provided it does not compromise their operational effectiveness. Where obstacle lighting is provided, 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, proponents should establish a monitoring, reporting and maintenance procedure to ensure outages, including loss of synchronisation, are detected, reported and rectified. This would include making an arrangement for a recognised responsible person from the wind farm to notify the relevant CASA office, so that CASA can advise pilots of light outages. Alternatives to fixed obstacle lighting In some circumstances, it may be feasible to install obstacle lights that are activated by aircraft in the vicinity. This involves the use of radar to detect aircraft within a defined distance that may be at risk of colliding with the wind farm. When such an aircraft is detected, the wind farm lighting is activated. This option may allow aviation safety risks to be mitigated where obstacle lighting is recommended while minimising the visual impact of the wind farm at night. Marking and lighting of wind monitoring towers Before developing a wind farm, it is common for wind monitoring towers to be erected for anemometers and other meteorological sensing instruments to evaluate the suitability or otherwise of a site. These towers are often retained after the wind farm commences operations to provide the relevant meteorological readings. These structures are very difficult to see from the air due to their slender construction and guy wires. This is a particular problem for low flying aircraft including aerial agricultural operations. Wind farm proponents should take appropriate steps to minimise such hazards, particularly in areas where aerial agricultural operations occur. Measures to be considered should include: - the top 1/3 of wind monitoring towers to painted in alternating contrasting bands of colour. Examples of effective measures can be found in the Manual of Standards for Part 139 of the Civil Aviation Safety Regulations 1998. In areas where aerial agriculture operations take place, marker balls or high visibility flags can be used to increase the visibility of the towers; - marker balls or high visibility flags or high visibility sleeves placed on the outside guy wires; - ensuring the guy wire ground attachment points have contrasting colours to the surrounding ground/vegetation; or
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- a flashing strobe light during daylight hours.

Reporting of structures less than 150m in height

There is no requirement for CASA to be notified if a proposed wind turbine or wind monitoring tower is less than 150m in height and does not infringe the OLS of an aerodrome. However, they should still be reported for inclusion in the national database of tall structures maintained by the Royal Australian Air Force (RAAF). Information on reporting of tall structures may be found in an advisory circular issued by CASA 'AC 139-08(0) Reporting of Tall Structures'.

Voluntary provision of obstacle lights

CASA's regulatory regime for obstacle lighting provides an appropriate level of safety for normal aircraft operations. Certain flying operations, by their nature, involve lower than normal flying, for example aerial agricultural spraying, aerial mustering, power line inspection, helicopter operations including search and rescue, some sports aviation, and some military training. Pilots conducting such operations require special training and are required to take obstacles into account when planning and conducting low flying operations.

In making decisions regarding the marking and lighting of wind farms and wind monitoring towers, wind farm operators should take into account their duty of care to pilots and owners of low flying aircraft.

Turbulence

Wind farm operators should be aware that wind turbines may create turbulence which noticeable up to 16 rotor diameters from the turbine. In the case of one of the larger wind turbines with a diameter of 125 metres, turbulence may be present two kilometres downstream. At this time, the effect of this level of turbulence on aircraft in the vicinity is not known with certainty. However, wind farm operators should be conscious of their duty of care to communicate this risk to aviation operators in the vicinity of the wind farm. CASA will also raise awareness of this risk with representatives of aerial agriculture, sport aviation and general aviation.

Appendix II

Aerial Application Plan Guide

AERIAL APPLICATION MANAGEMENT TOOLS

Application Management Plan (AMP)

An application management plan provides the aerial applicator with a generic application management tool.

Some application management plans are developed by the client in consultation with the applicator and agronomist before the season commences. This is the case with those growers who participate in Cotton Australia's 'Best Management Practice Program'.

In some situations a pre-season meeting with each regular client will be the best way of developing such a plan.

In other cases, especially top-dressing, this may simply be impractical or unachievable, but nonetheless, every application should have a plan.

Planning an application

The key components of an AMP are:

- recent confirmed map, with special attention paid to power lines, other hazards, dwellings, public roads, environmentally sensitive areas and susceptible crops downwind.
- the map is checked against the standard application order form.
- contingencies for different wind directions.
- chemical label or product advice checked to ensure the application is legal and can be carried out in the current conditions.
- equipment required (droplet size needed) to ensure control of drift.
- other considerations such as the possibility of workers in the field, neighbours etc.

Operational planning then follows. This includes the safety issues raised in this manual, such as potential 'escape' routes, position of the sun etc.

Establish an awareness zone around every paddock – potential problems can often be some distance away.

There are CASA requirements, as well as laws in many states and on some labels, regarding mandatory buffers, no-spray zones and neighbour notification, especially around schools and dwellings.

The AMP is used in conjunction with the agricultural chemical label, the completed standard spray order form and a detailed map to ensure the application can take place safely, legally and effectively.

An accurate map is essential

The importance of an accurate and up-to-date map cannot be over-emphasised.

Prior warning of the existence of hazards and all other relevant information pertinent to the application is the lynch-pin of sound planning and risk management.

If, for whatever reason, you are operating without a good map you are really leaving your future to chance. Maps must be as comprehensive as possible and must be checked before each application to ensure they are a true reflection of what really exists. This can only be achieved by interrogating the client or their representative as to any changes that might affect the application.

Pilots should also consider other tools now available, such as GIS information or Google Earth to help them create a mental picture of the job and build situational awareness.

Pre-Application Aerial Inspection

The last opportunity to ensure safe operations is the pre-application aerial inspection, conducted from a safe height.

The pilot conducting the aerial inspection should confirm all hazards on the map, and then look for any additional hazards or relevant issues that did not make it onto the map. Only by constantly checking and rechecking can the conscientious application pilot be comfortable that they have

taken all the necessary precautions to ensure a safe job.

Your Key Aerial Application Checklist

The following key aerial application checklist has been used for many years and incorporates the issues you must check before proceeding with an application task, during an application, and when returning to an application after reloading, refuelling or some other break, no matter how short.

Many of the items in 'WISHSTANDE' can be completed at the planning stage of an application, in order to free up maximum attention by the pilot. If you have already dealt with many of these issues at the planning stage, you will be better able to focus on the matters that are critical to safety during the execution phase of an application.

W wind direction and strength

I Identification of treatment area

S sun position and possibility of glare

H hazards, wires, obstruction, turbulence

S susceptible crops

T terrain, surface, slope, contour banks

A application equipment, alignment (gps)

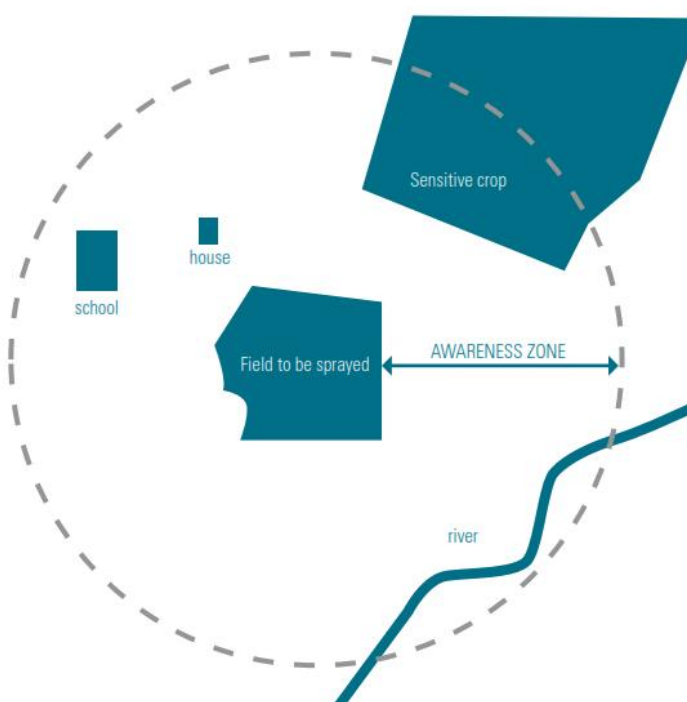
N nuisance to stock and occupied buildings

D direction of treatment

E emergency landing areas

EXTRA the extra treatment area safety inspection after refuelling or reloading.

ESTABLISH A SPRAY AWARENESS ZONE FOR EVERY JOB



Reproduced from Spray Drift Management – Principles, Strategies and Supporting Information, Primary Industries Standing Committee Report B2, CSIRO Publishing

FURTHER INFORMATION

If you would like more information on the vital and responsible role the aerial application industry plays:

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Australian Government
Australian Transport Safety Bureau

Avoidable Accidents No. 1

Low-level flying



Australia's national transport safety investigator

AVIATION | MARINE | RAIL

Research
AR-2009-041

Publication title

Avoidable Accidents No. 1
Low-level flying

Report No. AR-2009-041

Publication date reprinted March 2013

ISBN 978-1-74251-289-1

Publishing information

Published by: Australian Transport Safety Bureau
Postal address: PO Box 967, Civic Square ACT 2608
Office: 62 Northbourne Avenue Canberra, Australian Capital Territory 2601
Telephone: 1800 020 616, from overseas +61 2 6257 4150 (24 hours)
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Introduction

This publication is the first in a pilot education series by the Australian Transport Safety Bureau (ATSB) on avoidable accidents. In this report, we will focus on accidents involving unnecessary and unauthorised low flying; that is, flying lower than 1,000 ft (for a populous area) or 500 ft (for any other area) above ground level without approval from the Civil Aviation Safety Authority (CASA).

Between 1999 and 2008, there were 147 fatal accidents reported to the ATSB involving aerial work, flying training, private, business, sport and recreational flying in Australia. Of those fatal accidents, at least six were associated with unauthorised and unnecessary low flying. Those six accidents, along with a seventh non-fatal accident, presented here as case studies, were chosen by aviation safety investigators at the ATSB to highlight the inherent dangers of unauthorised low flying and to offer some lessons learnt from each case. It is hoped that these lessons learnt will help pilots make more accurate risk assessments and better decisions before electing to fly at low levels.

At low altitudes, there are many obstacles to avoid and there is a lower margin for error. Recognising the risks and hazards of low-level flying, CASA requires pilots to receive special training and endorsements before they can legally conduct low-level flying. In the accidents described in this booklet, most of the pilots had neither of these, and none had a legitimate reason to be flying below 500 ft. Some legitimate reasons for flying at low level include aerial stock mustering, crop spraying, and fire fighting operations. For most private pilots, there is generally no reason to fly at low levels, except during takeoff and landing, conducting a forced or precautionary landing, or to avoid adverse weather conditions.

What is sad and unfortunate about the accidents described in the following case studies is that they were all avoidable.

Tragedy on Christmas morning

On Christmas morning 2008, witnesses in Kernot, Victoria reported hearing an aircraft '....flying very low over the house' and that the aircraft appeared to have landed on a nearby hill. When the witnesses arrived at the hill, they discovered the aircraft was burning and was seriously damaged. The pilot, who was the sole occupant, was killed.

Powerlines can creep up on you

The aircraft had hit powerlines after flying over the house. The powerlines were only 86 ft (26 m) above the ground. Since the pilot was familiar with the area around the property, he was probably aware of the location of the powerlines. However, powerlines are naturally difficult to see. Normal powerlines are not required to be marked for aviation and are usually unmarked, as was the case in this accident.

Research by the ATSB (2006) found that 39 per cent of the wirestrike accidents studied between 1994 and 2004 involved low-level operations. Additionally, 63 per cent of pilots involved in wirestrike accidents who were surveyed, reported that they were aware of powerlines before hitting them.

No reason to fly low

The private pilot was also the owner of the Cessna 172M aircraft. Information from witnesses suggested that the pilot had a history of low flying, especially over the property every Christmas. In addition, the pilot was under investigation by CASA at the time of the accident for previous occasions of low flying. He also did not have any low-level ratings or endorsements from CASA. There was no operational reason, such as avoiding adverse weather, for the pilot to be flying so low. Given his history of a variety of unsafe acts, including flying low, and no evidence that the aircraft suffered engine or flight control failure, it was likely that the pilot made a deliberate decision to fly low.

Lessons learnt

Just because you know the area and the associated wires, doesn't mean you will always avoid powerlines and other hazards of flying at low level. It only takes a minor distraction to draw your attention from a vigilant lookout. If there is no reason to fly below 500 ft, then don't.



Section of the struck powerline caught in the horizontal stabiliser

Source: ATSB

Crashing the party

In March 2008, a Bell Helicopter 206B Jetranger III was being used to conduct joy rides at a birthday party over a property in Hornsby, New South Wales.

Witnesses reported that the helicopter was making low-level passes, about 100 ft above the ground, over the property. After one of the low passes, the helicopter banked steeply to the left, rolled out and descended. As the helicopter was being operated at a height at which recovery was not possible, it impacted surrounding trees. The helicopter was severely damaged and broke into several parts on impact.

The pilot was not endorsed for low-flying operations and his pilot's licence was suspended by CASA after the accident pending a review.

Seat belts save lives!

It was reported that only one passenger seated in the back had their seat belt secured during the flight. All five occupants survived the accident with varying degrees of serious injuries, but at least one was thrown from the helicopter during the impact. The pilot reported that he had briefed all passengers on seat belt use before departing.

Weighty issues

The helicopter had been maintained and inspected appropriately and no mechanical defects were found that would have affected the safe flight of the helicopter. However, it was found that the helicopter was 28 kg over its maximum take-off weight limit (MTOW) at the time of the accident. One of the passengers confirmed they were not weighed prior to departing Bankstown airport.



Wreckage of the Bell Helicopter 206B Jetranger III

Source: ATSB



The Bell 206B helicopter during a turn

Lessons learnt

The pilot would have had more time to assess and react to the loss of control situation had he operated the helicopter at the manufacturer's weight limitations and at 500 ft or more above ground level in accordance with civil aviation regulations.

Civil Aviation Advisory Publication (CAAP) 235-1(1) recommends using actual weights of occupants and baggage for light aircraft and helicopters with less than seven seats to avoid overloading www.casa.gov.au/wcmswr/_assets/main/download/caaps/ops/235_1.pdf.

In addition, the injuries to the occupants may have been reduced if all had been wearing their seat belts.

Sightseeing over Lake Eildon

In February 2004, a private pilot was conducting a sight-seeing flight over Lake Eildon, Victoria, with three passengers on a family trip. Witnesses reported that their attraction was drawn to the aircraft because it was so close to the lake's surface. Again, there was no evidence that environmental or operational factors contributed to the choice of flying height.

The Piper PA-28 Cherokee Arrow aircraft struck high-voltage powerlines suspended over the lake. The aircraft was destroyed by the impact with the wire and with the water. All three passengers were fatally injured and the pilot's body could not be found.

Take a long line

The power line involved in the accident spanned a 2 km length across Lake Eildon. The aircraft struck the power cable at the lowest point of the span, which was only 133 ft (40 m) above the water. Under relevant Australian Standards, the power line was not required to be fitted with marker devices as it was less than 295 ft (90 m) in height.

Lessons learnt

Do not rely on marker devices to alert you to the presence of powerlines. Powerlines under 295 ft (90 m) in height, as was the case in this accident, are not required under Australian Standards to be fitted with marker devices.

Familiarise yourself with the location of power lines by studying maps of the area before flight.

This is another accident in which hazards at low altitudes (in this case powerlines) can be difficult for pilots to spot until it is too late. If flying in a nose-high attitude to allow a slower airspeed, powerlines level with or below the aircraft are going to be even more difficult to sight.



Lake Eildon, Victoria



Source: ATSB

Buzzing on Christmas Eve

On Christmas Eve, 2006, following a maintenance inspection, the owner of an Auster J1/A1 aircraft planned to return the aircraft to his property from a private airstrip at Nelson. Three people had positioned themselves between two hangars near the airstrip to observe the takeoff and to bid the pilot farewell. Just after the aircraft lifted off the runway, the pilot made a low-level turn to the right towards the hangars with the apparent intention of 'buzzing' his friends.

As the aircraft approached the hangars, it climbed suddenly and hit powerlines that passed across the gap between the hangars. Investigation of the wreckage found that the aircraft propeller took the full force of the wirestrike, causing the propeller to disintegrate and the engine to stop. The aircraft aerodynamically stalled at a low altitude, possibly due to the pilot's attempt to avoid trees directly behind the powerlines. Due to the pilot's low altitude, he had little margin to recover from the stall, and the aircraft impacted the ground almost vertically. The pilot sustained serious head injuries, and did not survive.

A pass too low

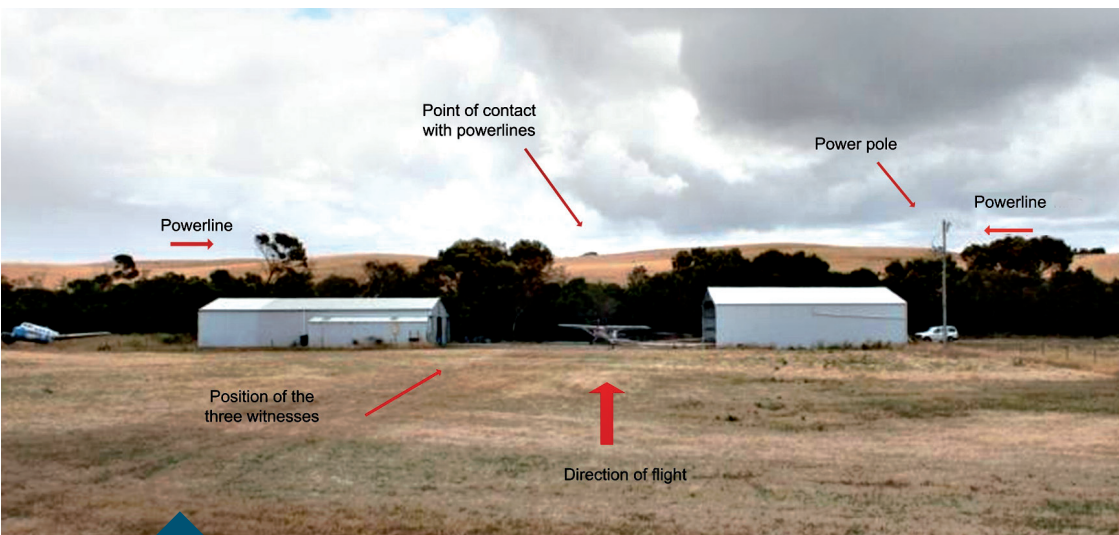
The witnesses' descriptions suggest that the pilot had deliberately initiated a low-level turn shortly after takeoff with the intention of flying directly over them. It was likely that the pilot was focussed on the low-level flight over his friends and anticipated a pull-up manoeuvre to avoid the trees behind the hangars but subsequently forgot about the powerlines.

Although the pilot was familiar with the airstrip and was aware of the location of the powerlines, research by the ATSB has shown that an awareness of powerline location does not guarantee avoidance. The powerline involved was not fitted with high-visibility markers, nor was it required to be, as it was only 39 ft (12 m) above ground level and well away from the runway or any likely flight path. Had the pilot maintained the runway track until 500 ft above the terrain, he would have greatly reduced the risk of contact with obstacles such as the hangars, trees or powerlines.

Lessons learnt

Flying at low level gives very little or no margin to recover from unexpected events, such as aerodynamic stalls or engine failures.

This accident also illustrates that pilot awareness of powerlines while on the ground doesn't always equate to awareness of them whilst in the air. Powerlines are difficult to see as they can blend in with the background vegetation or the sky and this is especially true while flying at low level.



Accident location

Source: ATSB



Wreckage of the Auster J1/A1

Source: ATSB

Looking out for your mates

In March 2006, the wreckage of a Cessna 188B Agwagon was found in a paddock near Narrandera, New South Wales. The wreckage showed that the aircraft hit the ground heavily, in a nose-down, right wing low position. The pilot was fatally injured. There were no powerlines or other obstacles in the area near the accident site which may have contributed to the accident.

Water skiing

Although there were no witnesses to the accident itself, a number of people witnessed the pilot's flying activities prior to the accident. The pilot had landed in a paddock adjacent to a water-skiing area on a local river, where a large group of local people had gathered and a number of ski boats were operating. The pilot announced an intention to do some low passes over the water-ski area. Before taking off for those low passes, the pilot handed his camera to a friend (also a pilot) so he could take pictures of him flying over the water-ski site. After making four very low passes, the pilot landed in the paddock and retrieved his camera. One of the recovered camera images showed the aircraft's main wheel touching the surface of the water during at least one of the low passes.

Later that evening, the pilot returned to his aircraft just as some of his friends were about to leave the area in their car. The pilot took off to the west, turned back towards



Images from the pilot's camera of the day's flying activities



 Wreckage of the Cessna 188B Agwagon

Source: ATSB

the east and conducted a very low pass over the car. The witnesses reported being startled by the pass and so had stopped their vehicle. After overflying the vehicle, the pilot ‘...banked hard...’, turned back to the west and overflew the vehicle again. During that second pass, the pilot flew directly toward the front of the vehicle at about ‘...double the fence height...’. He then conducted two more low passes over the water-ski site before departing in the direction of his property. During both those low passes over the river, the aircraft’s main wheels were again reported to have touched the surface of the water.

The occupants of the car continued their drive home and reported that they observed the aircraft to be ‘...ducking and weaving...’ over the water-ski area. It was then seen to head towards the pilot’s property in a level attitude and shortly after to be in an attitude described as ‘...all up on one side...like an X in the sky...and coming around...’. The last time the aircraft was seen, it was described as having ‘...climbed ...up into the air on its side and then banked around pretty hard and ducked down again...’.

There is no evidence that the pilot was trained or approved to conduct aerobatic flight. Moreover, aerobatic flight was prohibited in the Cessna Agwagon aircraft. The pilot was known to conduct ‘high-risk’ aerial activities such as aerobatic flight in an agricultural aircraft, even when the aircraft was not being used for agricultural operations. Investigation of the wreckage and maintenance records found no evidence of mechanical defects that might have contributed to the crash.

Lessons learnt

This accident serves as a salient reminder of the dangers of conducting unauthorised low-flying activities and aerobatic manoeuvres if you are not approved to do so and/or in an aircraft for which those manoeuvres are prohibited.

If you are a pilot and you witness unsafe flying, use your influence to discourage it, and if necessary report it — you may never get a chance later.

Wedding day gone wrong

The pilot borrowed an Agusta/Bell 47G helicopter to fly his sister to her wedding at the family property near Holbrook, New South Wales in February 1999. Witnesses reported that the helicopter was flying very low. As it traversed Chinaman's Gap, several kilometres from its destination, the helicopter struck powerlines and impacted the ground. The impact and subsequent fire destroyed the helicopter — brother and sister were killed.

'He was a careful pilot'

Holding a Commercial Pilot Licence, the pilot also had significant low-level helicopter flying experience with the Australian Defence Force. Friends and colleagues said that he was a careful pilot. His civilian logbook showed that he had undertaken civilian helicopter low-flying training to allow him to operate below 500 ft, however he was not yet approved to do so (and had not sought permission from CASA to fly low on this occasion). Part of this training alerts pilots to the dangers posed by powerlines during low-level flight and the need to conduct a prior survey of the area.

The pilot had not flown the route before and despite his low-level flying training, there was no evidence that he had conducted a reconnaissance of the area prior to the flight.

Other pilots, who have regularly flown in the area, reported that the powerline involved (which was 102 ft (31 m) above the ground) was difficult to see because the poles were a long way apart and partially obscured by trees and that the cables blended with the background vegetation.

Lessons learnt

Although the pilot was trained and experienced in low-level flying, he did not conduct a survey of the hazards before flying low over the area.

Powerline poles often provide good visual cues to enable a pilot to see the powerline itself. However, when the span between poles is large, and in particular when the poles are partially obscured by vegetation or other obstacles, this important cue is diminished or unavailable. Pilots should therefore never rely on sighting poles as a sole method for detecting powerlines.



Wreckage of the Agusta/Bell 47G helicopter

Source: ATSB

In the middle of nowhere

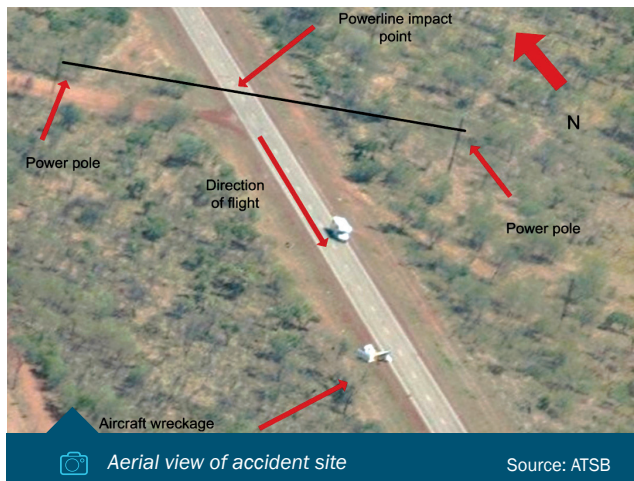
In November 2007, three German tourists, who had hired a Cessna 172N Skyhawk Aircraft as part of a contingent of three aircraft for an around Australia trip, were flying from Katherine to Tennant Creek in the Northern Territory.

There were no eyewitnesses to the accident, but the occupants of a car that was travelling on the Stuart Highway reported seeing the aircraft flying low above the highway moments before the accident. The witnesses recalled seeing an aircraft that was flying about 4 to 5 km to the west of the highway, about 150 ft above ground level. The Cessna made a slow, deliberate turn to line up with the highway, before it disappeared from sight behind a crest in the highway some distance in front of them. Shortly after, they saw the wreckage beside the highway.

Another wirestrike

The aircraft's tail section hit a powerline that spanned the Stuart Highway, breaking the tail, which rendered the aircraft uncontrollable. The aircraft impacted the highway in a steep nose-down attitude and came to rest upside down about 150 m from the point where it had impacted the powerline. The aircraft was destroyed and the accident was not survivable.

Investigation of the aircraft wreckage determined that the aircraft's ground speed at the time of the accident was at least 72 kts. The powerline involved in the accident was only 49 ft (15 m) above the road surface.





Earlier low flying by the group of tourists

Conscious decision to fly low

Evidence from images and video footage recovered from cameras found among the wreckage, suggests that there was a history of low flying by the group. One week before the accident, camera images show that the aircraft was flown low along a Western Australian beach by the same occupants with the pressure altimeter indicating an altitude of 70 ft above sea level. Video footage showed the aircraft flying below 100 ft along the beach for about 5 minutes.

Examination of the wreckage and previous pilot behaviour suggested that the pilots made a conscious decision to fly low, and were not conducting a forced landing at the time of the accident.

Earlier low flying by the group of tourists

Two of the three occupants held German private pilot licences and were sitting in the front seats. Neither of the pilots were approved to conduct low-level operations, and there was no evidence that either had undertaken any low-level flying training. Without approval to fly low and with no low-level training, the pilots probably had limited awareness of the hazards associated with flying low, such as impact with powerlines. Considering the remoteness of the area where the accident occurred, the pilots may not have expected to encounter man-made obstacles.

Lessons learnt

Don't forget that powerlines can be anywhere — even in the desert.

Don't give in to the temptation to get down low for a better view of the scenery. Passengers may request you to fly lower but they probably don't understand the risks. As the pilot, you are the one who needs to set the height limits.

Conclusion

These case studies serve as salient reminders of the risks associated with low-level flight. Out of the seven accidents documented in this report, only one had survivors. Low-level flying is inherently unsafe for a number of reasons, so it should be avoided at all costs when there is no operational reason to do it (regardless of whether you have been trained and/or approved to do so).

Flying at low level is unsafe because:

- ▶ there are more obstacles to avoid, many of which are hard to see until it is too late (e.g. powerlines and birds)
- ▶ pilots have a higher workload because there are more hazards to negotiate in the environment
- ▶ there may be turbulence and windshear that pilots do not encounter at higher levels and
- ▶ there is very little time to recover control of the aircraft if something goes wrong.

From the accidents described here, it is apparent that the two major hazards of low flying are wirestrikes and pilots' reduced opportunity to recover their aircraft from a stall or loss of control.

It is important to keep in mind that powerlines also exist in remote areas where you least expect. For example, the pilots of the Stuart Highway accident probably did not expect powerlines in the remoteness of the Northern Territory, and the pilot of the Lake Eildon accident probably did not expect to encounter powerlines above the expanse of a large lake.

The effects of wirestrikes at low level are obvious — significant damage to the aircraft, usually leading to a loss of control and, because of the lower margin for recovery, subsequent impact with the ground or water. Pilots must keep in mind that not only do powerlines exist at low levels and in remote areas, they are also not easy to identify. Even against a clear blue sky, wires are difficult to spot for a number of reasons. Wires can oxidise to a blue/grey tinge and may blend into the background (ATSB, 2006), or the wire may be obscured by terrain. Single wires are difficult to detect from the air and can be encountered in the most unexpected places in rural areas. Even if a pilot has spotted a powerline, his or her ability to judge its distance from the aircraft can be distorted by optical illusions or a lack of nearby visual reference points.

Pre-flight assessment and planning is an important part of any flight. Make sure you have maps of your intended flight path with you when you fly, and study them before you get into your aircraft to identify any terrain, wire, or other obstacles that you need to avoid should operational circumstances necessitate flight at low level. If you have been trained and are qualified for low flying, and *low flying is necessary*, ensure that you conduct an aerial survey of the area from an appropriate height before you conduct any low flying.

Low-level flying also presents fewer opportunities to recover from a loss of control compared to flight at higher altitudes. It takes time to react and to regain control of an aircraft, and the closer to the ground you are, the less time and distance you have. Flying at low altitudes is not only risky when things are going right; it becomes downright perilous when things are going wrong.

Before you decide to conduct low-level flying, ask yourself whether there is a legitimate or operational reason for you to do so.

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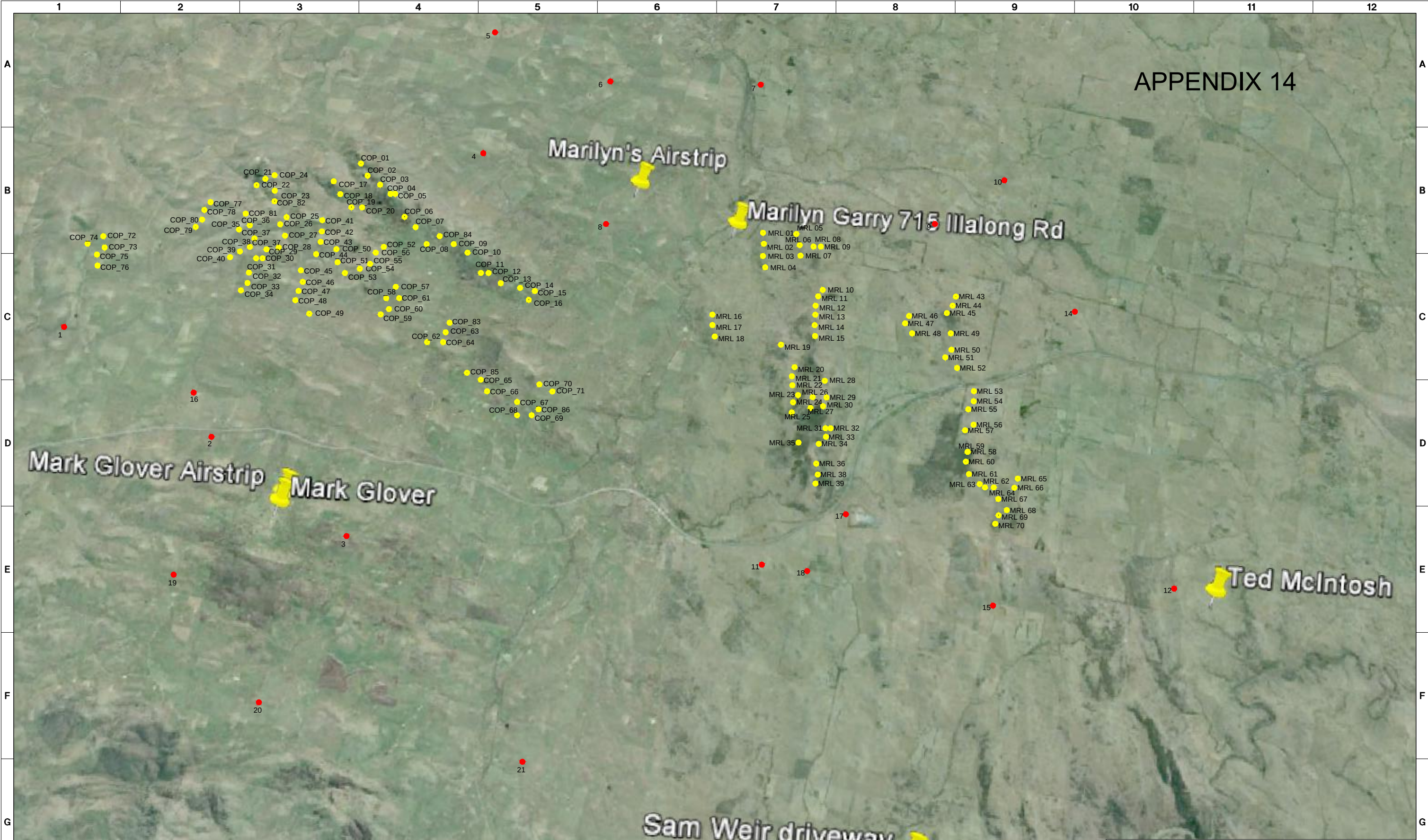
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APPENDIX 14

LEGEND

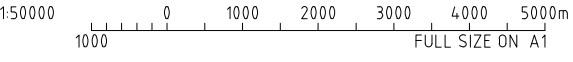
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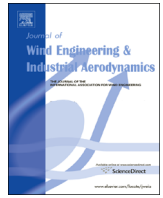
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TITLE:	WIND TURBINE LOCATIONS
SCALE	AS SHOWN
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DRAWING No	GEN-PW-PA-001
Rev.	A

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Contents lists available at ScienceDirect

Journal of Wind Engineering and Industrial Aerodynamics

journal homepage: www.elsevier.com/locate/jweia

A discussion of wind turbine interaction and stall contributions to wind farm noise



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ARTICLE INFO

Article history:

Received 13 August 2013

Received in revised form

6 January 2014

Accepted 19 January 2014

Keywords:

Wind energy

Wind farm noise

Thumping

Turbulent inflow

Dynamic stall

ABSTRACT

Wind farms have recently been reported to produce a noise signature that is described as possessing a “thumping” quality. Measurements of these signatures are limited and their effects are debated but their effect on public opinion and complaints make them a concern for researchers in this field. Proposed reasons for these noise signatures include amplitude modulation, interference patterns and wake–rotor interaction. This paper discusses these effects and concludes that wake–rotor interaction plays a role by causing variations in turbulent-inflow noise and dynamic stall. The current state of research into stall noise and wind turbine wake structure is also reviewed and it is concluded that the available information and collected data on wind turbine wake are insufficient to determine how strong this role is. More information on the velocity and turbulence fields in the wake of horizontal-axis wind turbines as well as a characterisation of the noise produced by an airfoil experiencing dynamic stall is required in order to make a full assessment of rotor–wake contributions to wind farm noise.

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1. Introduction

In the past few years there has been substantial growth in the non-hydroelectric areas of the renewable energy sector, with production capacity globally increasing by 21.5% between 2011 and 2012 (Sawin, 2013). Some elements of these technologies result in reduced economic viability or public acceptance which limits growth. Advancements that address these concerns, such as improvements to efficiency and better noise control, are necessary in order for rapid growth to continue.

Wind power was the fastest growing renewable in 2012, accounting for 39% of global added capacity (Sawin, 2013). Given that wind speed increases with distance from the ground, larger wind turbines are constantly being developed in order to take advantage of this. A greater swept area enables more wind energy to be captured and the increase in height gives them more reliable access to high wind-speeds. Being able to access higher wind speeds more reliably increases the capacity factor of large turbines resulting in a lower levelised cost of energy compared to smaller models (Bolinger and Wiser, 2012). However this increase in size can have adverse effects on the turbine's noise spectrum and its efficiency in an array configuration.

Wind turbine noise control is becoming increasingly problematic as wind turbines grow larger, as they individually emit more noise and the low frequency component of their spectrum grows (Møller

and Pedersen, 2011). Low frequency sound is attenuated less by the atmosphere than high frequency sound which makes large wind turbines audible from further away (ISO, 1993). There is a significant amount of negative public opinion with regards to wind turbine sound emissions due to the reported “annoying qualities” they possess. These are qualities of the sound that would increase the annoyance of wind turbine noise above that of equivalent A-weighted broadband noise level (Persson Waye and Öhrström, 2002). Low-frequency sound with these qualities will therefore have a greater effect on a wider area than high-frequency noise sources. Many regulations require that an extra 5 dB is added to the noise level to compensate for increased annoyance if these qualities are present (EPA South Australia, 2009; NSW Department of Planning & Infrastructure (NSW DPI), 2011). These legal restrictions on sound pressure level/exclusion zones near residential areas encourage shorter distances between turbines in a wind farm. However close spacing creates the possibility that the wind turbines in a farm will adversely interact with each other, which can lead to unsteady blade loading, reducing power output and increasing noise level and blade fatigue (Högström et al., 1988; Thomsen and Sørensen, 1999). An understanding of the mechanisms of wind farm noise production is required in order to continue to comply with noise limits and understand adverse interactions between turbines in a wind farm.

Unsteady blade loads stem from variations in velocity and turbulence. Incoming wind will always possess these qualities, so wind turbines will always experience unsteady loading to some extent. Understanding how higher levels of unsteady inflow resulting from operating in the wake of another turbine affect this loading is important.

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The authors posit that inflow turbulence due to wake-interaction is a significant source of noise with these reported qualities. This can manifest as periodic increases in noise level due to changes in angle-of-attack and separation effects, dynamic stall and blade–vortex interaction. Several questions need to be answered before a conclusion can be reached on this matter.

- Are large-scale turbulent structures present in the far wake of a wind turbine?
- How are the wake and its parameters affected by wind gusts?
- Will the blades of downstream turbine(s) be adversely affected by these structures?
- Will this interaction generate noise and what qualities will that noise have?

Once the answers to these questions are known whether wake–rotor interaction is contributing significantly to wind turbine noise can be determined.

Determining the loading due to unsteady flow requires definition of the flow-field, but wake structure is complicated. Due to this complexity most studies only analytically model parameters in a one-dimensional or axisymmetric fashion (Vermeer et al., 2003). These simplified models are suitable for typical power prediction and layout optimisation but are too simple to properly predict unsteady loading and noise. Understanding of how the wake affects downstream turbine is greatly hindered unless computational or experimental data is used. Computational simulations often implement actuator line, actuator disc or blade element momentum models, which approximate the blades as lines or discs that apply a force to the fluid. This approach is much faster than full modelling of the blades, and suitable for most applications but occasionally insufficient. Recently large-eddy simulations (LES) of the wakes of horizontal-axis wind turbines have been conducted (Bazilevs et al., 2011; Jimenez et al., 2007; Hsu et al., 2014; Porté-Agel et al., 2011; Sezer-Uzol and Long, 2006). This is a turbulence model that directly resolves large-scale eddies and models smaller ones, eliminating the extra computational cost of simulating very small scale turbulence. There is often cross-over in these approaches, with LES studies using actuator line or disc methods (Jimenez et al., 2007; Porté-Agel et al., 2011). Using simplified approaches instead of modelling the blades directly may lead to missed details in the wake flow-field and airfoil noise. Differences in the approaches are largest in the near-wake, but may result in other changes in wake structure further downstream (Réthoré et al., 2011). Investigations of far-wake turbulence line actuator methods are currently appropriate because such downstream differences are not known to occur in wind turbine wake simulations (Shen et al., 2012). If any discrepancies are found between the full rotor and actuator line or actuator disc models the new information can be added to these models in the form of corrections.

LES enables high fidelity simulations on a range of scales without prohibitive computational cost. Resolving structure in the velocity field in the downstream region where other turbines operate requires high fidelity models such as LES. If there is a large amount of large scale structure in the wake in this region then angle-of-attack and blade–vortex interaction effects will become significant. Changes in airfoil spectra due to these effects are understood well enough to suggest that they will increase the low frequency component of wind turbine noise. However characterisation of the noise due to dynamic stall is still required, which presents a significant challenge to determining the contribution of wake–rotor interaction.

2. Adverse wind farm noise characteristics

Most wind farm noise is broadband—that is its spectrum contains a wide range of frequencies with no large spectral peaks.

While some tonal noise is produced in the mechanical components of the turbine it is drowned out by the stronger aerodynamic noise sources.

Studies into how this noise affects humans show that under certain conditions the annoyance rating by test subjects will increase. In addition the closer the subject is to the source the greater this effect becomes and a greater decrease in the ability to perform cognitive tasks occurs. Qualities of the noise such as frequency content have also been found to have an effect, with low-frequency noise being reported as more annoying (Nobbs et al., 2012).

Other factors also need to be considered as visual stimuli have been found to mitigate these effects, and parameters such as turbine colour have also been weakly linked to the reported annoyance (Iachini et al., 2012; Maffei et al., 2013; Ruotolo et al., 2012). This is of concern as many studies report that exposure to high enough levels of noise can disturb sleep leading to increases in stress (Pedersen et al., 2009). When trying to sleep there is a lack of visual stimuli which may result in disturbance from noise that is not disturbing at other times of day.

Despite these factors many residents near wind turbines report no ill-effects. In addition to this some aspects of wind turbine noise complaints suggest psychosomatic elements (Farboud et al., 2013). It is not currently known whether this is the case, but as the noise signatures can vary with location it is possible that only some households are affected.

Other studies of the characteristics of wind turbine noise report complaints of subjective or descriptive measures. These studies report complaints due to qualities referred to as “swishing”, “thumping” or “throbbing” (among others), which often occur at the blade pass frequency (Oerlemans and Schepers, 2009; Pedersen et al., 2009; Pedersen and Persson Waye, 2004; Persson Waye and Öhrström, 2002; Van den Berg, 2004). Characterisation of these noise qualities is hindered by the subjective and interchangeable use of the terms “throbbing”, “swishing” and “thumping” in the literature. This is due to the terms being used by residents near wind turbines to describe their experiences. Amplitude modulation, which is a periodic variation in sound level is defined by a modulation frequency (the distance between peaks) and a modulation depth (the size of the amplitude change), is considered the cause of these effects. These qualities are hard to categorise as few studies report on both the descriptors used by residents and the properties found in the noise recordings. It is likely that some, if not all, of the aforementioned characteristics stem from amplitude modulation of different noise sources but to the authors' knowledge there is no standard quantitative definition of each descriptor.

These descriptors are useful for targeting further research into some of the poorly understood intermittent phenomena that may go unnoticed in large-scale experiments. Measurements have found that short periods of amplitude modulated noise sometimes occur at night in the signature of the Rhodes Park wind farm, as shown in Fig. 1, but this variation has not been observed to this degree in a single turbine (Van den Berg, 2004). Mechanisms for the production of this noise have been suggested; including velocity gradients, turbulent inflow, interference patterns and blade–tower interaction but the cause is still disputed and will be discussed further in the next section.

It is possible that the use of different descriptors in qualitative studies is due to the changes in the characteristics of amplitude modulated noise over time. Fig. 2 shows a turbine spectrogram that transitions from modulated low-frequency to modulated high-frequency noise (Smith et al., 2012).

To summarise, there are a large number of descriptors that have been used when people living near wind farms report their experiences listening to turbine noise. As they have stemmed from subjective surveys they are not yet well quantified which both hinders and assists attempts to classify the noise that people in

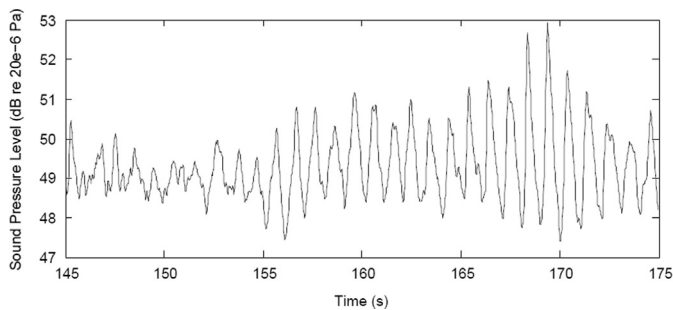


Fig. 1. Sound pressure level per 50 ms due to Rhodes Park wind farm, measured at 750 m from nearest turbine (adapted from Van den Berg, 2004).

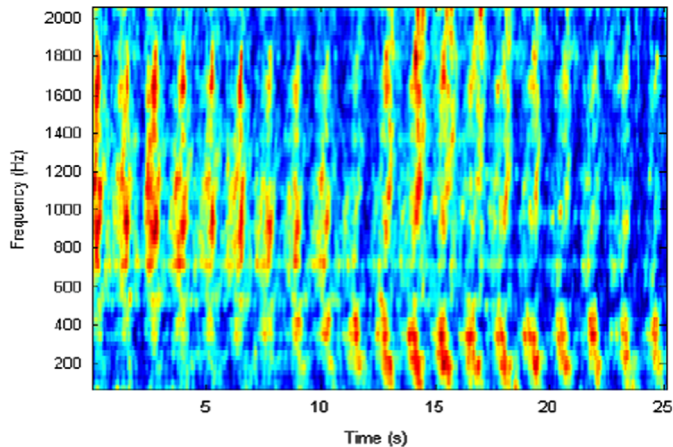


Fig. 2. Wind turbine spectrogram from 80 m (Smith et al., 2012).

nearby communities report as annoying. The noise cannot be properly classified from these descriptions alone but by comparing the use of these descriptors to the noise signals and atmospheric conditions at the time patterns may begin to emerge. It is likely that noise modulated by wind variability and directivity changes will result in sounds that could be described differently depending on the spectrum of the modulated noise, which can only be determined using recordings.

3. Possible noise mechanisms

There have been many reports of a “thumping” noise intermittently being produced by wind farms, but its cause is not understood (Bowdler, 2008; Thorne, 2011; Van den Berg, 2004). It has been argued that this is due to amplitude modulation, unsteady turbulent-inflow, interference patterns, and blade–tower interaction. Due to its intermittency and similarity to the “thumping” noise emitted by helicopters unsteady turbulent-inflow is likely to be a key contributor but all of these effects are present and will play a role in forming the overall acoustic signature of the wind farm.

Turbulent-inflow noise occurs when an airfoil encounters an unsteady inflow which changes the pressure distribution across the airfoil resulting in sound (Brooks et al., 1989). The sound spectrum produced by this pressure can be predicted analytically if the energy spectrum of the incoming turbulence is known. Turbulent-inflow noise is a problem in helicopters, where the blade tip vortices interact with subsequent blades causing impulsive noise (Schlinker and Amiet, 1983). This effect is called blade vortex interaction or rotor–vortex interaction noise and is responsible for giving helicopters their distinctive “blade-slap” sound during flight, which is easily discernible above the trailing-edge noise (Widnall, 1971). While there are major differences in

airspeed and separation distance in the case of helicopter blade–vortex interactions, the possibility of blade–vortex interaction occurring in wind farms is not discussed in the literature. This is likely due to the lack of evidence of large-scale eddies in the far wake, as research in this area is ongoing. The authors hypothesise that this is a significant contributor to “thumping”, and a later section will focus on this source.

It has also been proposed that blade–tower interaction is responsible for “thumping” as it is in downwind turbine configurations where the rotor is situated behind the tower. Once a popular design, downwind turbines have fallen out of favour as they produce large amounts of impulsive noise during operation. As the blades pass the tower they interact with the wake vortices shed by the tower and this leads to a “thumping” noise (Kelley et al., 1985). As upwind type wind turbine blades do not pass through the tower wake they do not interact with these vortices, however the tower still causes a deformation of the flow immediately upstream, which the blade does pass through and it has been proposed that this is significant enough to result in impulsive noise (Doolan et al., 2012a). A study investigating the effect of the tower on unsteady blade loads found them to be insignificant compared to stochastic load variations from turbulence under most conditions (Kim et al., 2011). In addition, increasing mean wind speed and yaw error leads to a larger variation in wind speed around a wind turbine rotor, which increases modulation depth. Conversely the relative levels of load fluctuations due to the tower decrease with increasing wind speed and yaw error (Kim et al., 2011). This indicates that blade–tower interaction noise is lower in conditions favourable to high noise levels from other sources.

Another proposed explanation is that turbines in a wind farm are causing areas of large constructive interference (Cand et al., 2011). It was thought that if the depth of amplitude modulation is large enough, amplitude-modulated noise would approach an impulsive signal which could be described as “thumping” and several studies report that “thumping” noise in horizontal axis wind turbines is most likely due to extreme instances of amplitude modulation (Bowdler, 2008; Lee et al., 2011). Local variations in mean wind speed results in each turbine operating at a different rotational speed, which was thought to produce variations in far-field sound pressure as they move in and out of phase, amplifying the effects of amplitude modulation (Van den Berg, 2004). But this is not the case as the sound pressure level variations of two turbines being in phase will not increase modulation depth (Bowdler, 2008). However being in phase will raise the average sound level, which can make qualities of the turbine noise temporarily audible at distances where they otherwise would not be (Bowdler, 2008). Because of this the role of interference should not be completely dismissed.

Similarly the role of sound propagation cannot be overlooked. Lower frequency sound, which as stated previously may be perceived as annoying, travels further than higher frequencies and will increase in dominance over distance. In addition velocity or temperature gradients result in refraction of noise which can lead to changes in audible distance (Cummings, 2013). When downwind of a turbine the sound refracts downwards and reflects off of the ground. This refraction is pronounced at low frequencies, with 8 Hz sound levels at 5000 m reaching up to 20 dB higher than expected for spherical spreading (Willshire, 1985). A temperature inversion, where the temperature at ground level is lower than the temperature higher in the atmosphere, also causes downward refraction of sound and will lead to similar effects. This indicates that wind turbine noise will in general propagate further at night, when temperature inversion is a common occurrence. The properties of the ground also affect the sound propagation, as acoustic impedance changes both the reflection coefficient and phase change at reflection. As such noise will propagate further over acoustically harder ground, where more of the noise is reflected.

ISO 9613 suggests that farmland and similar terrain, where wind turbines are most often situated should be considered acoustically soft, however field measurements have found that this underpredicts noise levels at 500 m (ISO, 1993; Plovsing and Søndergaard, 2011). Additionally in Australia the grass around farmland is dry in summer and often short due to grazing, which will increase its acoustic hardness.

Smaller scale effects will also result in changes in the sound. This difficulty in predicting noise propagation is amplified by the presence of complex terrain, as it will obstruct and reflect sound, as well as introducing changes to the local flow and temperature field which further affect how the sound will propagate (Kaliski et al., 2011). This may be contributing to the audibility of adverse noise qualities but it is unlikely that variations in propagation are coherent enough to cause the “thumping” signatures themselves.

In summary while the cause of these characteristics is disputed some potential causes are more probable explanations. Interference patterns and other propagation effects may make low frequency amplitude modulation patterns more audible, but this requires an existing signature, the cause of which is still unknown. Helicopters produce similar noise signatures due to the interaction between the rotor and the blade tip vortices and this sound is audible over the trailing edge noise. Determining whether this could occur in horizontal-axis wind turbines requires knowledge of the structure of the wake downstream turbines are operating in and the amount of noise produced by these events. This discussion focuses on effects due to rotor–wake interaction, which included amplitude modulation of turbulent inflow noise, blade–vortex interaction and dynamic stall.

4. Wake structure and propagation

In order to best predict loading and noise on wind turbine blades the following parameters are required in the plane of the rotor

- Velocity
- x, y and z turbulence intensities
- Turbulence energy spectrum
- Turbulence length scale

This is problematic when investigating wake operation as existing studies of horizontal axis wind turbine wakes have a different focuses or use simplifications that can disrupt the wake structure. For example most wind turbine wake research focuses on the magnitude of the axial velocity deficit and the magnitude of turbulent intensity as these are the parameters that most influence power output (Chamorro and Porté-Agel, 2009). Additionally, wake parameters are often reported as one-dimensional averages or axisymmetric distributions, which render them useless for determining how blade loading changes during a revolution.

The study of wind turbine wake structure has been focused on experimental and numerical investigations. Wind tunnel testing is more controlled than field experiments, giving a faster turnaround and better resolution and characterisation of inflow. Field experiments are preferable however, as it is not known how much of an effect flow confinement has on wind turbine wake structure. Computational models are also valuable as they produce finer data sets, but they are difficult to produce and the other methods are still required for validation.

Experimental measurements of the structure of the flow field are mostly concentrated on the near wake, which only extends a few rotor diameters downstream due to the costs associated with large scale experiments. Typically wind farms have a turbine spacing of approximately 7–10 rotor diameters and so the wake

structure at this distance is of interest (Ahmed, 2011; Hirth and Schroeder, 2013; Meyers and Meneveau, 2012). One of the most comprehensive wind tunnel tests of a horizontal-axis wind turbine was performed by the National Research Energy Laboratory (NREL) and gathered very little far wake data (Simms et al., 2001). Concentrating on the near wake enables the helical vortices shed from the blade tips to be resolved with smoke probes and studied as shown in Fig. 3. In the far wake these vortices break down, and the smoke trails do not yield much useful data. Some experiments have been conducted using particle image velocimetry but these are also currently focused on near-wake measurements (Vermeer et al., 2003). Wind tunnel tests have also been performed to show the effects of the tower on wake development, but measurements across the whole turbine were not taken (Nygard, 2011).

Field experiments have similarly not been conducive to determining the significance of wake–rotor interaction. A turbulence cross-section in the near wake (at 2 rotor diameters) of a full-scale turbine has been captured using SODAR, but further work was hampered by variability in the wind direction (Högström et al., 1988). Most studies focus on the distribution of parameters in vertical lines at various stations behind the tower, which is a limitation currently shared by many reports detailing computational models.

Computational models to investigate the structure of wind turbine wakes are also lacking in number and detail. Many large-eddy simulation (LES) simulations do not model the area of the wake in which other turbines operate (Bazilevs et al., 2011; Hsu et al., 2014; Sezer-Uzol and Long, 2006). Actuator disc models which model the rotor as a porous disc are often used but these simplifications can result in the loss of the desired accuracy (Norris et al., 2010). When investigating wake structure, actuator line, actuator surface or full-rotor models should be used where possible, as they capture some details of the flow that actuator disc models may not. Some models have used larger domains but the region of interest is still close to the exit (at approximately 10 rotor diameters) which may affect the results (Trolborg et al., 2010). These studies can still provide other useful information about the formation of the far wake. Vorticity isosurfaces reveal



Fig. 3. NREL Phase IV experiment with smoke trail (Hand, 2001).

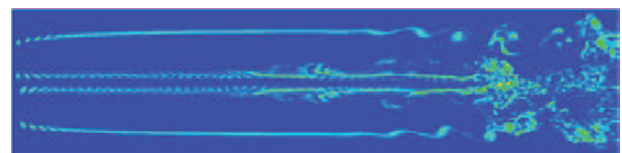


Fig. 4. Vorticity isosurfaces in horizontal plane (Trolborg et al., 2010).

that as wind speed increases the helical tip vortices break down at larger downstream distances. At a free-stream speed of 10 m/s the tip vortices have only just broken down at 7 rotor diameters (7D) as shown in Fig. 4. Other simulations used sufficiently large domains but reported data in a longitudinal plane, which does not give much information about wake structure (Jimenez et al., 2007; Porté-Agel et al., 2011; Zahle and Sørensen, 2007). However when using longitudinal data the turbulence intensity can be still be seen to change at least 3% across the rotor at 7 rotor diameters in wind tunnel measurements, indicating some level of increased unsteady loading (Porté-Agel et al., 2011).

A recent large-eddy simulation of the NREL experiment observed that after the collapse of the helical tip vortices, large stream-wise vortices were formed, as shown in Fig. 5 (Mo et al., 2013). The regions containing these vortices also contained most of the vorticity and turbulence intensity in the region indicating they are the main source of unsteady loading.

How the wakes of turbines in a wind farm interact must also be considered. Full rotor simulations of wind farms are not common due to the size of the domain that must be considered resulting in an impractical computational cost for little benefit. Actuator-disc/line or analytical methods are more common as are wind tunnel experiments with the choice of method depending on application (Christiansen and Hasager, 2005; Frandsen et al., 2006). For systems larger than two turbines, analytical models are often used, and while these are adequate for optimising a wind farm layout for power output, they cannot give insight into how the flow structure is affected as each turbine interacts with the combined wakes of the upstream turbines. Experiments performed on scale wind farms yield some useful information about the flow but are limited by the data that can be collected (Lebrón et al., 2009). Some studies have been conducted using line-actuators and periodic boundary conditions and these show the velocity deficit and turbulence increasing due to each row of turbines (Sørensen et al., 2007). Most of these are focused on the velocity deficit behind the turbines and report little or one-dimensional information about the turbulence or vorticity in the wake.

In a simulation of a tandem wind turbine system, it has been found that the turbulence in the incoming wind has a large effect on the system's wake structure, with high incoming turbulence resulting in the downstream rotor ingesting still higher levels of turbulence, and its wake in turn breaking down closer to the turbine (Troldborg et al., 2010). This results in smaller scale turbulent structures for downstream turbines, which may reduce the generated turbulent inflow noise (Troldborg et al., 2010). However if two turbines are laterally offset and turbulence is low then ingesting the upstream turbine wake results in an asymmetric near-wake with high levels of turbulence on the side of the upstream turbine and a flow still dominated by tip vortex structures on the other, which may contribute to variation in noise level over time (Chamorro and Arndt, 2011; Troldborg et al., 2010).

Upon comparing several studies it is apparent that simulations of the wakes of horizontal-axis wind turbines vary with modelling, conditions and turbine design. Common elements are present however, the most notable of which is a series of helical tip vortices which break down further downstream. A recent simulation suggests the existence of large stream-wise vortices downstream but more simulations and experiments are needed in order to confirm the existence of large-scale coherent vortices in the far wake. In addition to this, the large effects that placing wind turbines in an array can have on their respective wakes means that structures found in the wake of a single turbine may only be applicable to some turbines in an array or none at all. Once the properties of horizontal-axis wind turbine wakes are more defined the effect that operating in the wake has on turbine noise can be assessed.

5. Turbulent-inflow noise

Turbulent-inflow noise is a form of aerodynamic noise that arises when an airfoil encounters an unsteady flow. It is characterised by its low-frequency dominant spectra and dipole-like

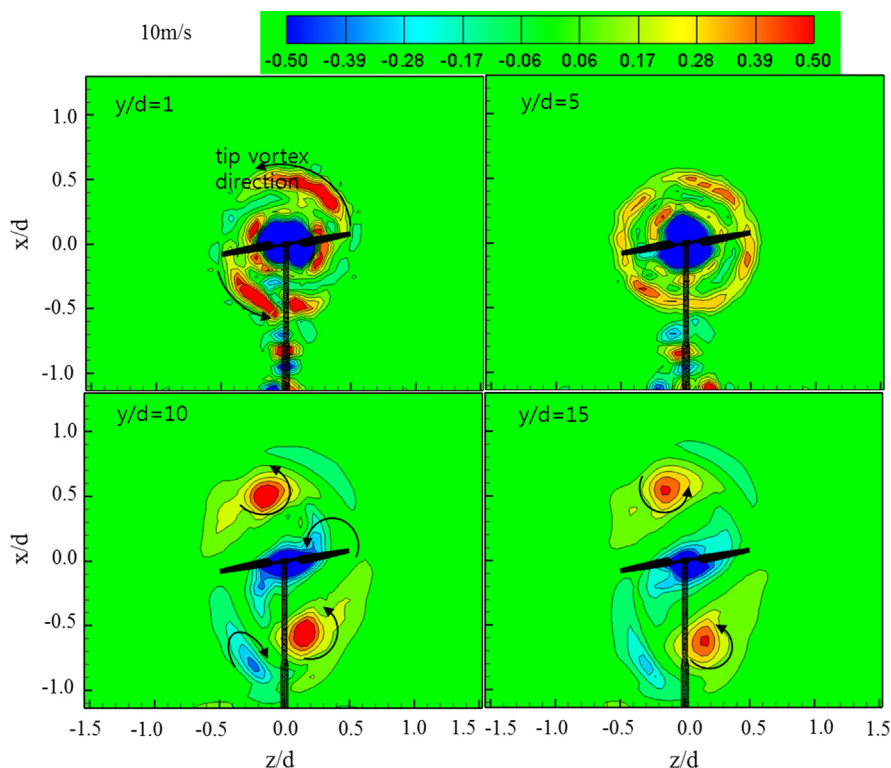


Fig. 5. Simulated wake vortices in NREL experiment (adapted from Mo et al., 2013).

directivity pattern. The production of large amounts of turbulent-inflow noise will contribute to wind turbine noise at large distances as it is dominated by low frequencies. Blade–vortex interaction is a related effect that is of some concern. However it seems likely that if it occurs it will not do so under ideal conditions and is likely to be insignificant compared to more general turbulent-inflow effects.

When an airfoil encounters unsteady flow there is a transient disruption to its surface pressure, resulting in a change in lift and noise signature. This noise is known as turbulent-inflow noise and it is responsible for giving helicopters their distinctive sound (Widnall, 1971). It is usually predicted using analytical models since simulations of aerofoil noise require extremely fine spatial and temporal resolution along the sound's path in order to resolve the spectrum. Analytically predicting the spectrum due to turbulent inflow requires, at a minimum, the distributions of turbulent length scale and intensity, but is most accurate if the turbulent energy spectrum is used.

Analytical work describing how vortices and turbulence affect airfoil noise was pioneered by Amiet using a model that was originally applied to rotor–vortex interaction in helicopters but still sees widespread use for more general applications (Amiet, 1975, 1978, 1986). The model determines the surface pressure fluctuations using the airfoil's lift response and the turbulent energy spectrum normal to the blade and these fluctuations are then propagated to the far-field as sound. It uses a large aspect-ratio, thin airfoil approximation, and while corrections for airfoil shape, thickness and backscattering have been developed they are not yet widely implemented (Moriarty et al., 2005, Roger and Moreau, 2005; Zhu et al., 2005). Predicted and experimental spectrum differ by less than 6 dB for frequencies below 1.5 kHz, above this however the accuracy of the model appears to decline rapidly (Amiet, 1975; Schlenger and Amiet, 1983).

Using Amiet's model and an appropriate turbulent energy spectrum, equations can be produced that relate turbulence intensity, turbulence length scale and airfoil geometry to third-octave spectrum. This is mostly performed using the Von Karman turbulent energy spectrum, as this is a good approximation to atmospheric turbulence. It has been shown that if the turbulence is non-uniform then the turbulence field can be discretised to yield results that also agree with experiment to within about 3 dB until 1500 Hz (Doolan et al., 2012b). Results are further expected to improve if the actual energy spectrum of the turbulence can be measured—especially if the assumption of Von Karman turbulence is not valid. Amiet's model is also used predict to the spectrum of blade–vortex interaction (Schlenger and Amiet, 1983). Using this technique the turbulent-inflow noise due to operating in a wind turbine wake can be determined if the turbulence spectrum or intensity and length scale are known.

Blade–vortex interactions are a subset of inflow turbulence noise that are of some concern due to the possibility of vortices in the wake. These interactions are divided into parallel, oblique and perpendicular configurations, describing the angle of the vortex line in the chordal plane of the airfoil. Parallel and perpendicular configurations are when this angle (referred to as the rotor-plane angle in the context of helicopters) is 0° and 90° respectively. The other main orientation parameters are the shaft-plane angle and the miss distance which are shown in Fig. 6.

Beyond the initial studies little experimental parameterisation of blade–vortex interaction noise has been performed. Sensitivity analyses of blade–vortex interaction noise have instead been performed by calculating spectra using the existing model (Gallman, 1994; Malovrh and Gandhi, 2005). Increases in circulation strength, which is proportional to both the tangential velocity and radius, increase noise levels, but when radius is increased noise levels decrease (Gallman, 1994). This suggests that changing the peak tangential velocity has a greater effect on the noise than the radius. Increases in local Mach number also found increase in generated noise levels (Malovrh and Gandhi, 2005). Parallel interactions are the loudest due to maximising the affected area, and perpendicular interactions are the quietest (Malovrh and Gandhi, 2005). Increasing the angle between the chord plane and the vortex line also reduces noise level, as does increasing the perpendicular distance between vortex line and chord plane (Gallman, 1994; Malovrh and Gandhi, 2005). The effects of changing these parameters is summarised in Table 1. Loud interactions therefore occur when a small, strong vortex undergoes a parallel interaction with an airfoil in high Mach number flow. This indicates that large, stream-wise vortices are unlikely to contribute much to wind turbine sound level through blade–vortex interaction.

In summary it is possible to predict the noise due to blade–vortex interaction if the spectrum of the incoming turbulence is known. If the spectrum is not known then the turbulence can be assumed isotropic and a grid of turbulence intensities can be used to estimate the noise level. Interaction with wake vortices also generates noise, but current wake structure research indicates that if vortices are formed they will interact in a way that is unfavourable for loud noise generation. However interaction with vortices can result in local variations in angle-of-attack, which is another avenue that must be explored to determine the extent to which wake interaction affects wind farms.

6. Changes in angle-of-attack and directivity

In addition to inflow turbulence noise, non-uniform flow can affect noise due to changes in the angle-of-attack and directivity. Changes in the angle-of-attack modify the overall sound level, whereas changes in directivity result in the largest portion of sound power radiating to different locations at different points during a cycle. Large angle of attack variations can also result in the blades experiencing stall, which is likely to further increase sound levels through boundary layer growth and vortex shedding.

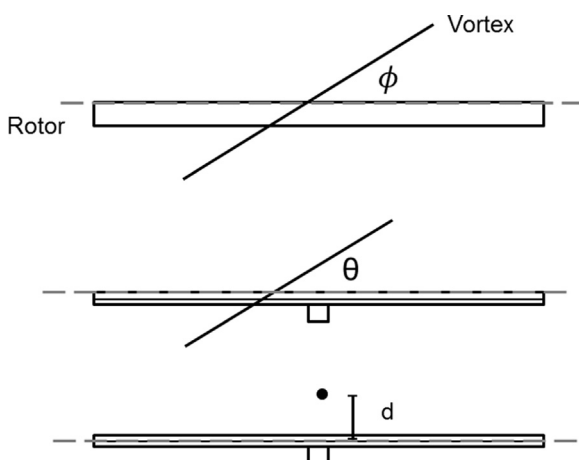


Fig. 6. Vortex orientation parameters. ϕ : rotor-plane angle, θ : shaft-plane angle, and d : miss distance.

Table 1
Summary of blade–vortex interaction parameters.

	Change in parameter	Noise level
Circulation strength	Increasing	Increasing
Core radius	Increasing	Decreasing
Rotor-plane angle	Towards 0°	Increasing
Shaft-plane angle	Towards 0°	Increasing
Miss distance	Increasing	Decreasing
Mach number	Increasing	Increasing

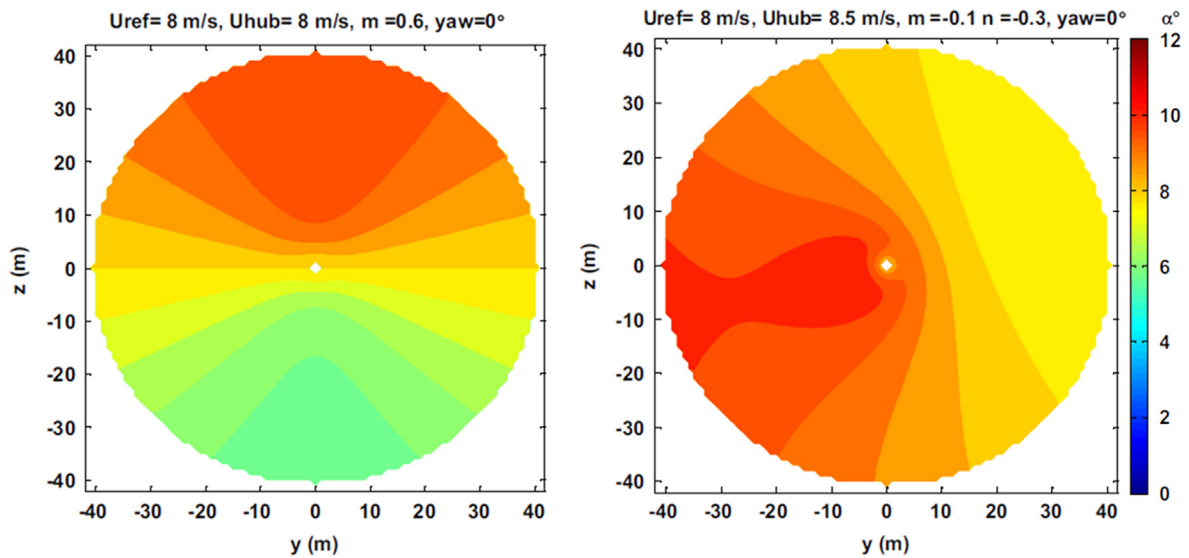


Fig. 7. Estimated variation in angle of attack due to wind shear; vertical (left) and combined horizontal and vertical (right) (Smith et al., 2012).

Non-uniform velocity and turbulence intensity across a wind turbine rotor result in the blades experiencing a different angle of attack at different points of the cycle. The distribution of angles of attack will indicate how each section of the airfoil will behave during a cycle. Fig. 7 shows that it is possible to predict the changes in angle-of-attack due to wind shear; factors m and n are the vertical and lateral wind shear exponents respectively. As the flow field in the wake of a horizontal-axis wind turbine is not currently well defined, true angle-of-attack distributions have not been produced.

It is evident that operating an airfoil at different angles of attack results in variation in boundary layer thickness at the trailing edge which in turn produces a variation in noise level. As the thickness of the boundary layer and the trailing edge increases with angle-of-attack so does the overall noise level of the airfoil (Brooks et al., 1989). Dynamic stall will also result if the angle-of-attack variation is large and frequent enough and this is likely to cause further increases in noise level as large eddies are formed and subsequently collapse which will be discussed in the next section.

Changes in directivity have been proposed as an additional factor in far-field low-frequency noise (Smith et al., 2012). Noise due to separation or turbulent-inflow has dipole directivity which makes it strongest normal to the airfoil. In contrast, trailing edge noise directivity is cardioid-like—strongest diagonally forward of the leading edge as shown in Fig. 8 (Oerlemans and Schepers, 2009). A change from low-frequency dominant to high-frequency dominant noise will result in a change in directivity of the overall blade turbine noise as shown in Fig. 9. It has been suggested that this results in turbulent-inflow and separation noise being more prominent normal to the rotor plane (Lee et al., 2011).

As previously mentioned, much of the trailing edge noise is then directed into the atmosphere on the upstroke and the ground on the downstroke. Sound in the atmosphere is also refracted depending on the temperature and wind speed gradient. The speed of sound decreases with temperature and thus distance from the ground (on a warm day), upwind sound is refracted upwards and downwind sound may be refracted upwards or downwards (Bies and Hansen, 2003). It has been suggested that these effects result in a decreased contribution from trailing-edge noise to far-field measurements (Smith et al., 2012). It is difficult to correlate these predicted directivities of wind turbine noise with complaints due to a lack of data regarding the observer's locations

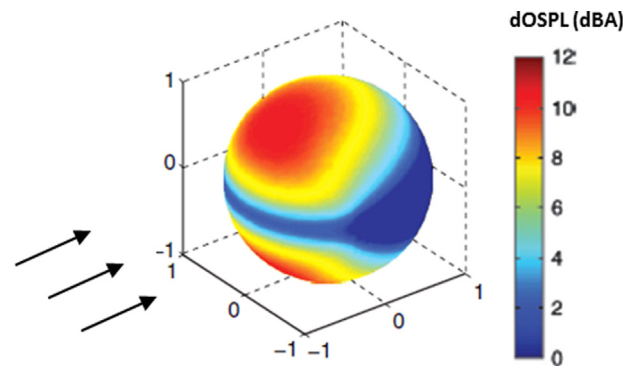


Fig. 8. Trailing-edge noise directivity (adapted from Oerlemans and Schepers, 2009).

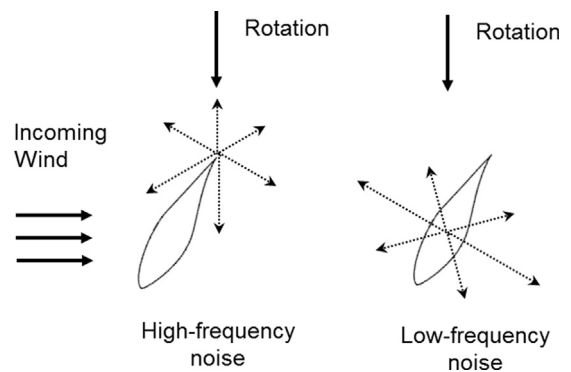


Fig. 9. Change in directivity with noise frequency.

and the wind direction at the time of complaint. This data should be more often reported in future to assist in determining if these effects are responsible for complaints.

In summary, as a wind turbine blade undergoes each revolution it is subjected to a cyclic variation in angle of attack. High angles of attack result in increased noise levels due to louder trailing-edge noise and subsequently the occurrence of stall. In addition, as the spectrum transitions from trailing-edge noise dominated to stall and turbulent-inflow noise dominated there is a change in directivity. When trailing-edge noise dominates, the noise is directed approximately in the direction of blade movement. When

Table 2
Influence of parameters on dynamic stall (adapted from McCroskey et al., 1976).

	Reynolds Number	Oscillation amplitude	Reduced frequency	Leading edge geometry
Effect on vortex shedding	Negligible	Major in isolated cases	Small	Moderate
Effect on lift	Small	Major in isolated cases	Major	Major
Boundary layer separation	Small	Moderate	Major	Major

stall and turbulent-inflow noise dominate, the noise is directed orthogonal to the rotor plane. Correlating this with noise complaints is difficult due to lack of data. Combinations of amplitude and directivity variations can lead to amplitude modulation, depending on the level of non-uniform flow and ground temperature.

7. Dynamic stall noise

Airfoils experience dynamic stall when they are subjected to a large and rapid variation in angle of attack. This results in the formation of large vortices which increase the unsteady loads on the airfoil followed by a drop into deep stall (McCroskey, 1981). It is thought that these vortices may also result in increased noise generation but while current dynamic stall models can predict their size they are insufficient to predict finer details.

Dynamic stall is a major source of unsteady loading on horizontal-axis wind turbines. Under normal operational conditions dynamic stall can occur on up to half the cycles of a turbine (Shipley et al., 1995). The occurrence of dynamic stall is dependent on span-wise location, free-stream velocity, yaw error, as well as tilting and coning of the rotor. Of these, highly yawed flow is the major contributor to the occurrence of dynamic stall (Shipley et al., 1995). Increases in unsteady inflow due to operation in the wake of another turbine are thought to increase the probability of dynamic stall (Choudhry et al. 2012). This increase in dynamic stall occurrence will change the noise signature of the turbine and may contribute to complaints.

The properties of dynamic stall are affected by the Reynolds number and the reduced frequency ($k = c\Omega/2U$)—where c is the airfoil chord (m), Ω is the oscillation frequency (rad/s) and U is the fluid velocity (m/s). These parameters affect the strength of vortex shedding and lift hysteresis as shown in Table 2.

Fig. 10 shows a comparison of the reduced frequency along the blade between the NREL turbine and some large scale turbines. As many commercial turbines use a simplified version of the optimal chord vs span-wise location curve these can be taken as representative of large-scale turbines. The curve shows that for the large turbines approximately half the blade is in the unsteady flow regime ($k > 0.05$), above which unsteady flow effects cannot be neglected. This indicates that these regions of the blade are susceptible to dynamic stall if angle of attack variations are large enough. This reduced frequency will increase further if the blade is experiencing unsteady inflow from other sources.

Detailed analysis of the flow field when dynamic stall occurs is restricted to experimental data and computational models. Existing semi-empirical models are limited to predicting the variation in aerodynamic coefficients with angle of attack (Holierhoek et al., 2013; Leishman, 2002). Some models—such as the Leishman–Beddoes model—explicitly account for the formation and shedding of the dynamic stall vortex but cannot be used to predict the structure of the vortex. Semi-empirical models of dynamic stall are therefore currently unsuitable for acoustic predictions.

To the authors' knowledge noise measurements have not been made on an airfoil experiencing dynamic stall. Some papers reporting on computational simulations suggest that their models could be adapted to predict the spectrum, but this has not been

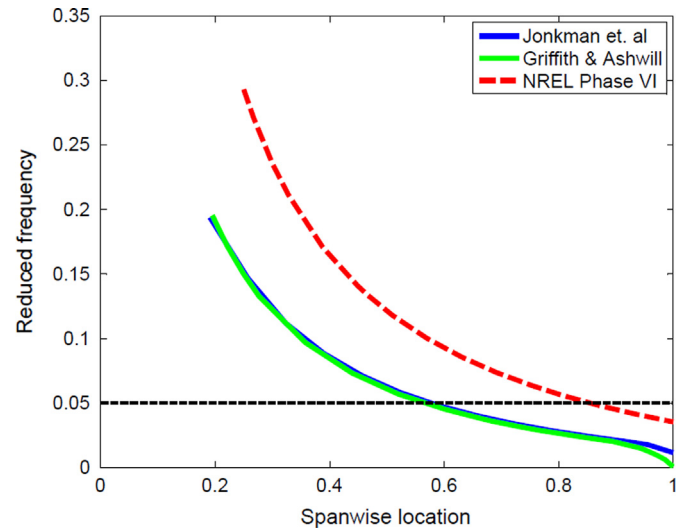


Fig. 10. Reduced frequency k vs span-wise location for several turbine blades.

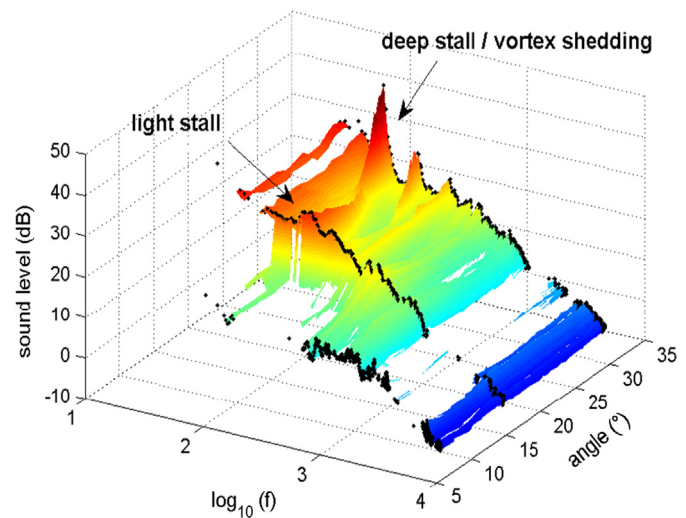


Fig. 11. Noise due to stall on a NACA 0012 airfoil at $Re \sim 1.5 \times 10^5$ (Moreau et al., 2009).

performed. Despite this there is sufficient information about similar phenomenon to make some predictions about the nature of noise produced during dynamic stall.

From experiments on stall it is known that the onset of vortex shedding will increase the amplitude of the main spectral peak as shown in Fig. 11 (Moreau et al., 2009). As the angle-of-attack grows the main peak also shifts to slightly lower frequencies as vortex shedding begins to occur (Moreau et al., 2009). Experiments on flat-plates and axial fans have shown similar spectral peaks at the during vortex shedding (Longhouse, 1977; Roger et al., 2006).

Noise is also produced when counter-rotating vortices interact. Direct numerical simulation of interacting vortex pairs has shown that a large pulse of acoustic pressure is produced when two vortices interact, followed by a period of less intense noise (Zhang

et al., 2013). This indicates that dynamic stall noise may have a periodic impulsive component due to interaction between vortices shed from the leading and trailing edge.

Dynamic stall flow features are dominated by large vortices which are shed from the leading and trailing edge and interact as they move downstream. Vortex shedding and interaction are both sources of low frequency noise and so dynamic stall events are likely to have similar spectra. More research into dynamic stall is required in order to determine the extent to which wind farms may be affected by this noise, but the authors hypothesise that large amounts of turbulent inflow noise and dynamic stall due to wake operation are the primary source of “thumping” noise.

8. Discussion and conclusion

Wind turbines in wind farms have been seen to produce rapidly varying noise levels, which are not well understood. Reasons that have been proposed to explain this include:

- Amplitude modulation of trailing-edge noise due to wind gradients and changes in directivity
- Amplitude modulation of turbulent-inflow noise due to the wake of upstream turbines
- Turbulent inflow noise changes due to wind gusts
- Dynamic stall noise due to unsteady inflow
- Blade–vortex interaction noise
- Interference patterns from multiple turbines
- Atmospheric refraction and frequency-dependent attenuation
- Interaction between the blades and upstream deformation from the tower

These effects are all present in wind farms but it is currently unclear to what extent they contribute to the overall noise signatures. Interference patterns may increase the overall noise level but not the depth of modulation and atmospheric effects will filter out some frequencies. This may amplify existing noise signatures but it does not provide an explanation for their root cause. Blade–tower interaction can also occur in single turbines where these noise patterns are not observed and so it is likely not the cause of the “thumping” patterns. Due to lack of consistency in measurements even the existence of disturbances due to wind turbine noise is disputed. Measurement and simulation of horizontal-axis wind turbine wakes is currently underdeveloped with regard to this application and cannot provide enough insight into flow structure to determine the strength of these effects. Turbulent-inflow noise depends on the size, strength and orientation of wake vortices. Large changes in angle of attack due to non-uniformities in the flow field result in dynamic stall which increases noise level due to vortex shedding and collapse. High fidelity simulations of wind turbine wake development are required in order to determine the extent to which these phenomena contribute to noise level. More experimental measurements of wind turbine wake flow fields are also needed to compare with simulations.

Records of the noise produced during dynamic stall have not been published, but it can be inferred from prior research into noise due to vortex shedding and stall that the noise during dynamic stall will likely be louder than during normal operation. Due to the large surface pressure fluctuations and vortex shedding during dynamic stall it is likely that there will be an increase in noise level over normal operation. Unsteady flow affects the noise signature in horizontal-axis wind turbines and with more research, the significance of these noise sources can be determined.

Acknowledgements

The authors would like to thank Sophie Hollitt and Amelia Thomas for their contributions to editing.

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