FINAL REPORT
AVIATION RISK ASSESSMENT

GLEN INNES WIND FARM

LB00100.ARA

Report to:

Glen Innes Wind Farm

11 September 2017

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EXECUTIVE SUMMARY

Glen Innes Wind Farm have commissioned Ambidji to undertake an aviation risk assessment of the potential impact to aviation of the proposed changes to increase the Glen Innes Wind Farm (GIWF) wind turbine tip heights from 150m to 180m Above Ground Level (AGL).

An updated Aviation Impact Statement (AIS) completed in June 2017 found that the GIWF development will not impact the use or operation of:

- Published Obstacle Limitation Surface (OLS);
- Navigation Aids,
- Communication facilities, and
- Airspace Surveillance

The GIWF development will however require the 25 nm Minimum Sector Altitude (MSA) for Glen Innes Aerodrome to be increased by 100ft (from 5500ft to 5600ft) which is considered to have minimal impact on flight operations.

This aviation risk assessment considers the proposed changes to the GIWF in terms of potential risk to aircraft, airport operations and airspace in the vicinity of the proposed wind farm development arising from:

- the intention to increase turbine heights from 150m to 180 m AGL (i.e. increased obstacle height);
- any resultant changes to flight procedures and prescribed airspace in the vicinity of the wind farm; and
- any additional risks or considerations which are apparent since the original aviation risk assessment was undertaken.

For VFR flights, no existing highly trafficked routes transit through the wind farm location and sufficient vertical and lateral separation can easily be achieved within the existing surrounding navigable airspace. For operations compliant with Visual or Instrument Flight Rules (VFR/ IFR), the proposed increased height in the turbines has been shown to offer no increase in risk to aviation.

Three threats have been identified and assessed which could lead to a loss of separation event occurring in the vicinity of the wind farm:

- Authorised Low Level Operations;
- VFR flights into Instrument Meteorological Conditions (IMC) conditions; and
- IFR navigational error in IMC.

It is demonstrated that only in the event of Authorised Low Level flights (e.g. aerial application or emergency response) or flights operating outside prescribed rules and conditions (accident / incident conditions) that the increased height of the wind farm turbines offer any potential additional risk to aviation. It is these flights that are the subject of this risk assessment.

Because the outcomes of these events all relate to “severe” outcomes (1 or 2 fatalities), the risk scores cannot be reduced below a Medium on the Civil Aviation Safety Authority (CASA) risk matrix. The inherent risks of aviation activity in the area associated with a loss of separation leading to a collision with terrain (CFIT into the ground) are all assessed as High on the CASA matrix.

Collisions with a turbine or a Loss of Control (LOC) (e.g. due to encountering turbine wake or manoeuvring to avoid a turbine) are also assessed to present a Medium or High risk and therefore do not increase the inherent risk profile for flights in the area. It is therefore concluded that the increased turbine heights do not increase the risk to aviation.

When considering the need for Obstacle Lighting, the accumulative effects of the neighbouring wind farms in close proximity (and the decision to light these) has been taken into account. Assessment of a "non-standard application of aviation obstacle lighting" to these wind farms for night VFR flights concludes that there is potential for confusion if some of the wind turbines (clusters) are lit and others aren't – i.e. a "false negative". It is recommended that the same obstacle lighting regime plan be adopted, (i.e. lighting intensity, type, spacing) to ensure against the "false negative" issue identified in this report.

Other recommendations to further reduce the potential for loss of separation events to occur in the vicinity of the wind farm include:

- Reinforcement with local pilots through consultation with the local flying schools, clubs and companies operating in the area;
- Pilot Education through CASA and RAA regarding the hazards associated with flights in the vicinity of windfarms;
- Pilot Education through CASA and RAA regarding the commonly misunderstood aspect of the aviation regulations with respect to navigable airspace for in VFR flights – i.e. that day VFR flights MUST be conducted with a minimum vertical separation of 500 ft above the ground **and any object on it**; and
- Clearer designation of wind farms on the navigation charts to aid pilot comprehension where multiple wind farms exist.

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1. INTRODUCTION

This report provides the results of the Glen Innes Wind Farm (GIWF) Aviation Risk Assessment recently conducted by Ambidji following a request by Environmental Property Services Pty Ltd.

The Aviation Risk Assessment focuses on the potential impact to aviation of the proposed changes to increase the wind turbine tip height from 150m to 180m AGL.

2. BACKGROUND

Aviation Risk Assessments for the GIWF had been prepared by Aurecon in 2013 and 2014. However, since the 2014 risk assessment, a further increase in the proposed turbine tip height from (150m AGL to 180m AGL) and changes to navigational aids make the review and update of the aviation risk assessment prudent.

The proposed GIWF will comprise 25 wind turbines with a tip height of 180 m AGL. The highest turbine tip is WTG19 at 1446 m AHD rounded up to 4745 ft. AHD

An updated Aviation Impact Statement (AIS) completed in June 2017 finds that the GIWF development will not impact the use / operation of:

- Published OLS;
- Navigation Aids;
- Communication facilities; and
- Airspace Surveillance

However, the GIWF development will require the 25 nm Minimum Sector Altitude (MSA) for Glen Innes Aerodrome to be increased by 100ft (from 5500ft to 5600ft) which is considered to have minimal impact on flight operations.

3. SCOPE

This aviation risk assessment considers the proposed changes to the GIWF in terms of potential risk to aircraft, airport operations and airspace in the vicinity of the proposed wind farm development arising from:

- the intention to increase turbine heights from 150m to 180 m AGL (i.e. increased obstacle height);
- any resultant changes to flight procedures and prescribed airspace in the vicinity of the wind farm; and
- any additional risks or considerations which are apparent since the original aviation risk assessment was undertaken.

There are a series of Australian and International regulatory publications (regulations, standards and guidelines) that either require or apply to aviation risk assessments (impacting airspace, airport and aircraft safety). Tall structures at proposed wind farms (such as turbines and wind monitoring towers) present an aviation obstacle in otherwise navigable airspace and therefore require such assessment.

The following are the most relevant to this assessment of the proposed changes to the GIWF:

- Airservices Australia (AsA) - Aviation Impact Assessment;

- National Airports Safeguarding Framework (NASF). Guideline D "Managing the Risk to Aviation Safety of Wind Turbine Installations (Wind Farms)/Wind Monitoring Towers";
- Airports (Protection of Airspace) Regulations 1996;
- CASA Advisory Circular 139-08 (0) Reporting of Tall Structures;
- International Civil Aviation Organisation (ICAO) Annex 14 – Aerodromes; and
- Relevant State Government planning requirements.

These requirements are taken into account and referenced where relevant in the scoping and assessment of risks.

The objective of the risk assessment is to identify and assess potential safety risks to aviation, determine their acceptability and whether any further risk mitigation is required. Most specifically an Obstacle Lighting Review (OLR) forms part of this risk assessment and establishes the need (or otherwise) and utility of aviation obstruction lighting as risk mitigation.

AsA require an Aviation Impact Statement (AIS) for wind farm developments to be submitted to them for evaluation and consideration. The AIS identifies any impacts on published air routes, instrument procedures, aerodrome OLS / PANS-OPS, LSA's, airspace Communication, Navigation and Surveillance (CNS) facilities. The AIS therefore ensures that any impacts on systems and procedures necessary for the safe flight of aircraft operating under Instrument Flight Rules (IFR) are identified and managed.

An AIS for the proposed changes has been completed and has confirmed that there is no impact on:

- published instrument approaches (including missed approach procedures) for the neighbouring airports (Inverell and Glen Innes);
- published air routes in the vicinity of the wind farm; and
- any communication / navigation facilities.

A small (100ft) increase required in the Minimum Sector Altitude (MSA) over the turbines (from 5500ft to 5600ft) is required to accommodate suitable clearance over the highest proposed wind turbine. It has been concluded that this will have minimal impact on flight operations given that the neighbouring MSA is 6100ft and the Initial Approach Fixes (IAF) for RNAV approaches are 6200ft. (Note: On 4 September 2017, AsA advised the NSW Department of Planning that the proposed airspace changes will be effected on 24 May 2018 and that "After this date the proposed Glenn Innes Wind Farm will have no impact on procedures at Glenn Innes Airport.")

The risk to aircraft operating normally under Instrument Flight Rules (IFR) (including IFR Training Flights) is therefore concluded to be unchanged as a result of the proposed increased turbine height.

Similarly, for flights compliant with the vertical and lateral separation requirements for Visual Flight Rules (VFR), there is no change in risks to the aircraft as a result of the proposed increased turbine height.

It is therefore only in the event of Authorised Low Level flights (e.g. aerial application, emergency response) in the immediate vicinity of the wind farm, or VFR/IFR flights operating outside prescribed rules or normal conditions (accident / incident conditions) that the wind farm obstacles could offer any additional risk to aviation. It is these flights that are the subject of this risk assessment.

4. RISK ASSESSMENT METHODOLOGY

A standard risk assessment methodology as per International Organization for Standardization (ISO) 31000 has been adopted (as indicated in Figure 4-1 below:

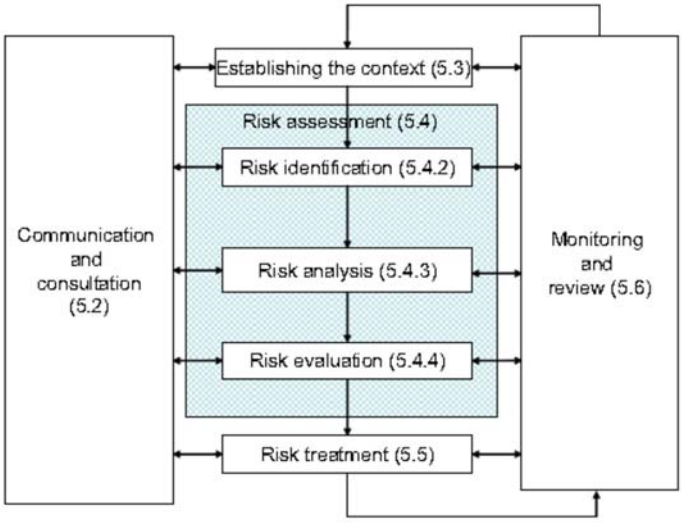


Figure 4-1 Risk Assessment Stages

The following sections describe the process that has been undertaken to identify and assess these aviation risks.

4.1 Hazard Identification

The proposed changes to the height of wind turbines may present a potential hazard to VFR flights operating within the vicinity of the wind farm. In effect, from an aviation safety perspective any obstacles raise the level of clearance above terrain required for safe flight by the height of the obstacle (as per Civil Aviation Regulation (CAR) 157[1]).

For the purpose of this assessment therefore, the hazard is defined as the loss of minimum separation with terrain (including obstacles) in the vicinity of the wind farm.

The scenarios that could potentially lead to a realisation of this hazard (i.e. the threats) have been identified through:

- Identification of the current and near term operational context (i.e. what aviation activities are (and likely to be) undertaken in the area;
- A review of proposed change implications on the previous GIWF Aviation Risk Assessments;
- A review of the recently completed Qualitative Risk Assessment (QRA) for the proposed neighbouring Sapphire Wind Farm;
- Review of current topographical maps to assess the local terrain and identify any local airstrips and any other relevant features;

[1] From CAR 157 – Low Flying. The pilot in command of an aircraft must not fly the aircraft over an (unpopulated) area at a height lower than 500ft where the height is the height above the highest point of the terrain and any object on it.

- Consultation with identified key stakeholders, including local operators, recreational aviation groups, Air Ambulance and Fire Services, local airport representatives, local council;
- A search for any relevant data in the Australian Transport Safety Bureau (ATSB) occurrences database; and
- A review of readily available global wind farm accident information.

4.1.1 Consultation with Stakeholders

Consultation (by telephone) with aviation and other relevant stakeholders was sought in regard to local aviation activity, aviation concerns relating to windfarms and confirmation of local airstrips and their utilisation. For this review, these included:

- Aerial Agricultural Operator;
- Regional Aviation Association of Australia;
- Recreational Aviation Australia;
- Aircraft Owners and Pilots Association;
- State Aircraft Unit;
- Air Ambulance Service;
- General Aviation Operators;
- Aerodrome operator;
- CASA; and
- Local Council

A record of this consultation is provided in Appendix B.

4.2 Risk Assessment Criteria

The CASA Airspace Risk and Safety Management Manual[2] provides a link to a risk assessment template which includes the following qualitative risk assessment matrix and associated consequence and likelihood definitions. These have been applied directly in the assessment of identified risks associated with the GIWF proposed changes.

Risk Category / Descriptor	Consequence →					
	Insignificant	Minor	Moderate	Major	Severe	Catastrophic
	0	1	2	3	4	5
Aviation Safety	Not having aviation safety implications	Associated with minor breaches of aviation safety regulations	Major issues of compliance with aviation safety regulations but would not in itself lead to a safety incident.	Major issue of compliance with aviation safety regulations and leading to potential for unsafe aviation operations.	Potential for aviation safety incident involving multiple life threatening injuries, or 1/2 fatilities	Potential for aviation safety occurrence(s) causing multiple (>3) fatalities.
Safety of Flight / Training	No operational or safety-of-flight implications.	Deviation with minimal potential to impact safe operation of an aircraft.	Deviation with some potential to impact safe operation of an aircraft.	Deviation impacting the continued safe operation of an aircraft.	Operational Emergency, impacting the immediate safe operation of an aircraft.	Loss of aircraft / multiple fatalities
	Deviation managed by PIC using standard procedures	Managed by PIC using normal procedures	Managed by PIC using non-normal checklist procedures	Managed by PIC using multiple non-normal checklist procedures or additional actions.	Management requires emergency actions by PIC to preserve aircraft integrity and/or life.	
Airspace	No airspace occurrence	Airspace occurrence resulting in minor injury or requiring first aid treatment	Airspace occurrence resulting in serious injury causing hospitilisation or multiple medical cases	Mid Air collision or LOC leading to CFIT - life threatening injuries or multiple serious injuries requiring hospitilisation	Mid Air Collision or loss of control leading to CFIT event, either of which leads to multiple fatalities (1 or 2 persons)	Mid Air Collision or loss of control leading to CFIT event, either of which leads to multiple fatalities (3 or more)

Figure 4-2 Consequence Descriptors

[2] CASA Airspace Risk and Safety Management Manual, September 2016

	ID	Descriptor	Numerical	Historical
Likelihood ↑	5	Almost Certain	>1 in 10	Is expected to occur in most circumstances
	4	Likely	1 in 10 – 100	Will probably occur
	3	Possible	1 in 100 – 1000	Might occur at some time in the future
	2	Unlikely	1 in 1000 – 10000	Could occur but considered unlikely or doubtful
	1	Rare	1 in 10000 - 100000	May occur in exceptional circumstances
	0	Extremely Rare	< 1 in 100000	Could only occur under specific conditions and extraordinary circumstances

Figure 4-3 Likelihood Descriptors

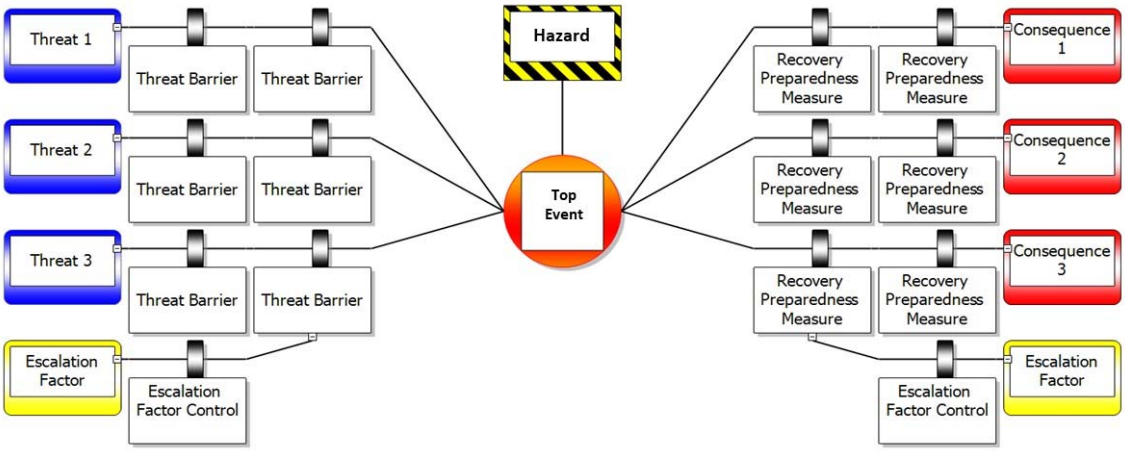
Likelihood / Consequence		Insignificant	Minor	Moderate	Major	Severe	Catastrophic
		0	1	2	3	4	5
Almost Certain	5	5	6	7	8	9	10
Likely	4	4	5	6	7	8	9
Possible	3	3	4	5	6	7	8
Unlikely	2	2	3	4	5	6	7
Rare	1	1	2	3	4	5	6
Extremely Rare	0	0	1	2	3	4	5

Risk Acceptance & Treatment Plan: >7:Extreme risk – detailed treatment plan required; 6&7:High risk – senior management attention /treatment plan; 4&5:Medium risk – manager level attention and monitoring as appropriate; <4:Low risk – manage by local level procedures. Extreme and High risks must be reduced in accordance with the ALARP principle.

Figure 4-4 CASA Risk Matrix

4.3 Bowtie Risk Assessment

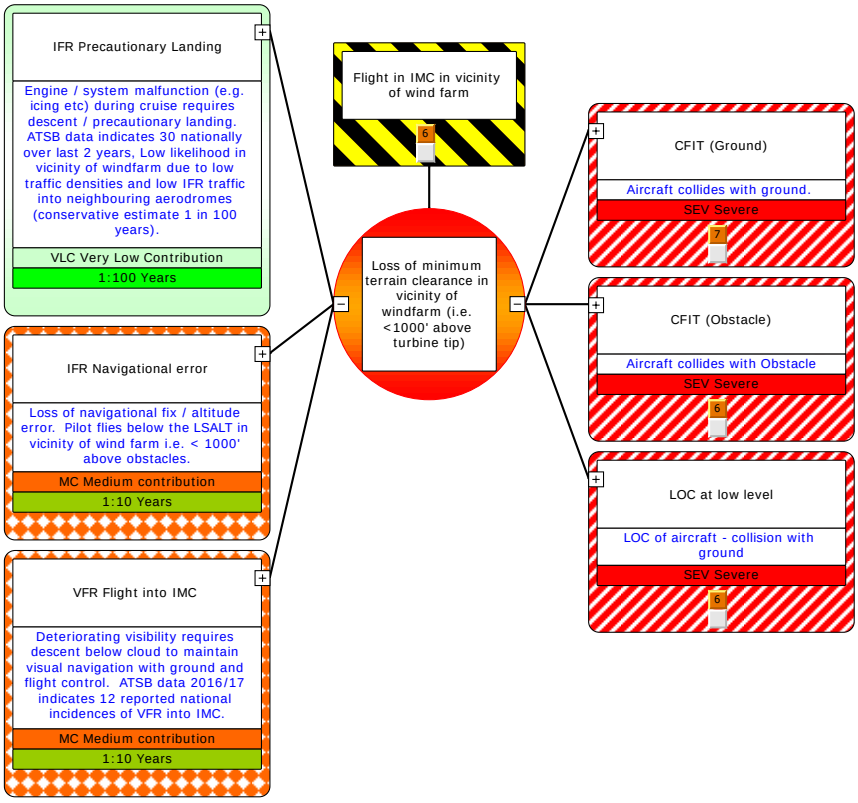
In order to provide a risk assessment which clearly identifies the threats, barriers, potential outcomes and is useful in communicating these, the Bowtie methodology has been chosen. This methodology is based on the "Swiss Cheese" barrier failure theory and simply provides a graphical representation of the timeline between a threat occurring (e.g. low-level VFR flight in vicinity of windfarm), the preventative barriers that need to fail to get to the loss of control point (loss of separation with a terrain / obstacle in this case) and the mitigating barriers that need to then fail before the final outcomes (e.g. collision with turbine) occurs.



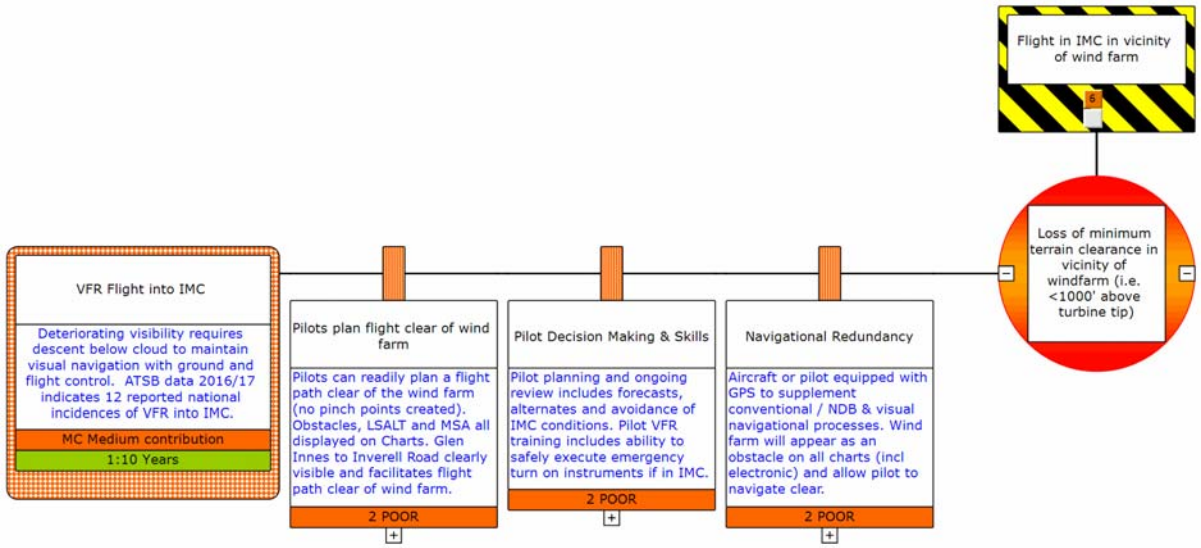
In this way, a systematic review of the independent events, their likelihood and barrier effectiveness is clearly evident – i.e. the likelihood that a collision with terrain occurs.

Similarly, it is important that we define and describe each hazard, threat and consequence sequence accurately so that it is clearly evident which elements of risk are due to the presence of the wind turbines, and which elements exist irrespective of the wind farm.

As an example of this, a collision of an aircraft with a wind turbine requires the failure of a number of preventative barriers to occur before a loss of separation occurs (i.e. aircraft is flying at a low level in close proximity to the wind farm). The two main outcomes of interest and comparison for this assessment are collision with an obstacle (turbine or WMT) and collision with terrain. This scenario is illustrated (at a summary level) in the bowtie diagram below.



If we look in more detail below at one of the LHS threat lines (expand it), we can see the individual preventative barriers that may act to prevent (reduce the likelihood) of the loss of separation occurring:



If it is further expanded, we can now see any escalating factors (yellow boxes) which have been applied to these barriers – i.e. reasons why these barriers may fail to successfully prevent the Loss of Control occurring:

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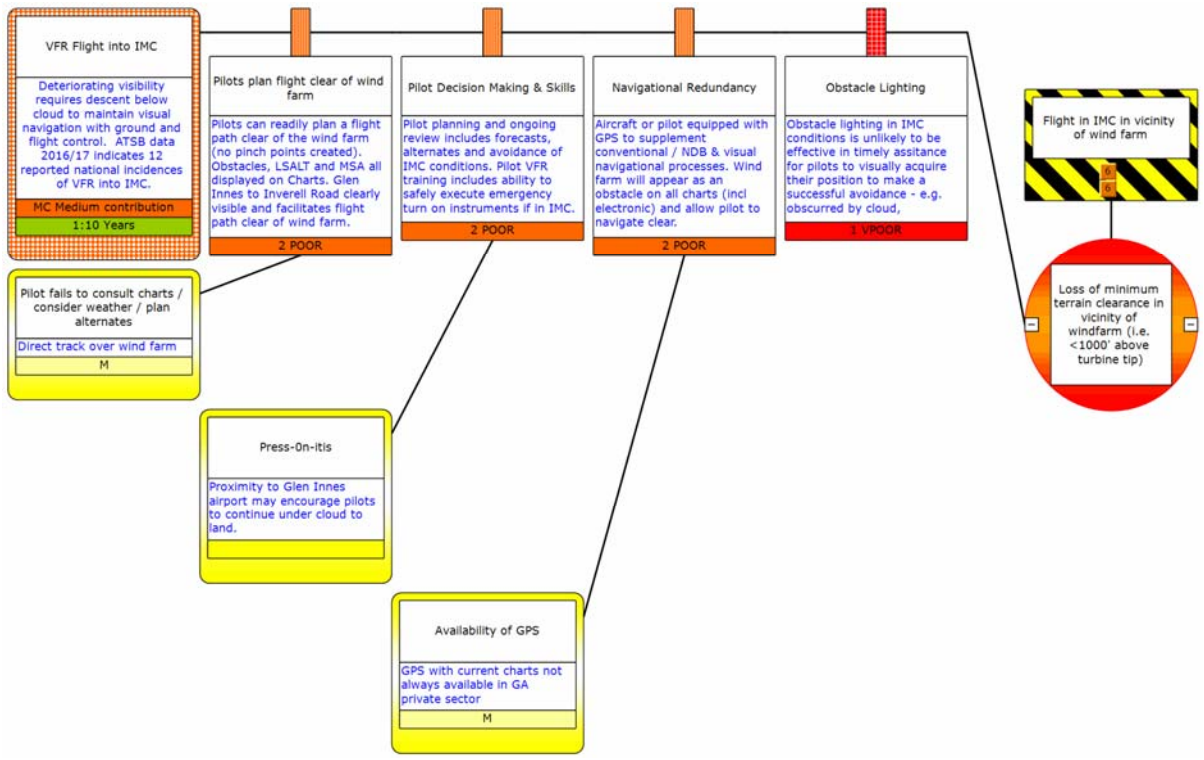


A discussion of the fully developed bowties is provided in Section 5 below.

4.3.1 Assigning Risk Measures

Given the lack of location specific data (e.g. total flight numbers in the vicinity, flight into cloud occurrences, loss of navigation), it is not possible to accurately determine each of the threat and consequence likelihoods, however based on national incident data in the ATSB incident database, the qualitative description of operations, the absence of reports of incidents from stakeholders, judgement has been used to assign likelihoods in the risk assessment in terms of their likely frequency:

Color legend of Frequencies

- <NULL> <No Value Assigned>
- 1:1000 Years 1000 Years
- 1:100 Years 100 Years
- 1:10 Years 10 Years
- 1:1 Year Yearly
- 2:1 year 6 Monthly
- 4:1 year 3 Monthly
- 1:1 Month Monthly
- Weekly Weekly
- Daily Daily

Based on the assigned frequency and the significance of the threat (i.e. whether it could directly lead to a loss of separation), a contribution ranking has been assigned:

Color legend of Threat Categories

<NULL> <No Value Assigned>
HC High Contribution
MC Medium contribution
LC Low contribution
VLC Very Low Contribution

4.3.2 Control Effectiveness and their Adequacy

Unlike many other major hazard industries, there are very few "automated" controls that can be credited in aviation. The vast majority of controls still currently require human intervention (pilot / ATC).

In applying effectiveness rankings to these identified "human intervention" barriers, consideration has been given to whether the control is a legislated requirement, common practice, the scenario it is required to operate in (e.g. high workload / stress).

Color legend of Effectivenesses

<NULL> <No Value Assigned>
0 NE 0 Non Existent
1 VPOOR 1 V Poor Eff
2 POOR 2 Poor Eff
3 GOOD 3 Good Eff
4 VGOOD 4 V Good Eff

Given that these bowties relate to events that could lead to catastrophic consequences (fatalities, loss of aircraft, turbine loss), we should therefore ideally be looking for a high level of defence in depth (redundant & independent controls). In terms of effective risk minimisation, very strong preventative (LHS) controls to prevent Loss of Separation events occurring should be the priority. These should then be supported by mitigative controls on the RHS of the bowtie to minimise the consequences of the loss of separation.

This differentiation between preventative and mitigative controls is important since controls on the LHS operate in a more controlled environment (many during the planning stage) with less time criticality and hence, since in aviation we are highly reliant on human intervention rather than automation, the reliability of a human action performed in a non-time critical environment will be much higher. Once the loss of control point has been reached (centre of the bowtie), controls on the RHS of the bowtie are now highly time critical and human reliability reduces significantly with increased stress and workload.

So, in practice we are seeking each threat / consequence line (from threat through to each identified consequence) to be protected by at least 1 preventative control with very good effectiveness rating (or 2 independent good effectiveness controls) and, at least one good control on the RHS to mitigate each consequence.

So, as well as comparison of risk outcomes with risk acceptance criteria (incl. As Low As Reasonably Possible (ALARP)), the bowtie methodology also requires some consideration / discussion of the level of defence in depth with a focus on prevention of the loss of control point being reached. Mitigative controls on the RHS of the bowtie are considered to be the last lines of defence and as such are not generally assigned the same level of credit or focus as the preventative controls on the LHS of the bowtie.

A simple non-aviation example would be the focus on the prevention of car collisions through driver education regarding impairment (fatigue, alcohol, drugs) rather than simple reliance on seat belts, air bags and crumple zones to protect the car occupants once the loss of control has occurred. Similarly, another aviation example of this comparison of preventative and mitigative controls is the provision of accurate vertical guidance on runway approach coupled

with excellent pilot decision making skills in the prevention of runway over/under shoots rather than reliance on airport fire-fighting capability to reduce the consequences of a loss of control.

When considering defence in depth and multiple barriers, the level of independence is also considered, so for example for a VFR flight into IMC, we must assume that the pilot may not have properly planned the flight and so similarly subsequent defences (pilot decision making, flight planned clear of the wind farm etc.) are unlikely to be highly effective.

5. RISK ASSESSMENT RESULTS

5.1 Risk Assessment Context

The following section provides a description of the relevant flying environment and types of operations undertaken in the vicinity of the GIWF site. Based on this information, a list of possible hazards has been generated as input into the risk assessment.

5.1.1 Wind Farm Location

GIWF is located on the Waterloo Range about 12 kilometres to the west of Glenn Innes and just south of the Gwydir highway (running from Glen Innes to Inverell) as shown in Figure 5.1. The project area spans approximately 8.5 kilometres from north to south and about 3 kilometres from east to west. The topography across the project site generally decreases in height from the south towards the north. The Aerodrome Reference Points (ARP) for Glen Innes (YGLI) and Inverell (YIVL) are also shown in Figure 5.1.

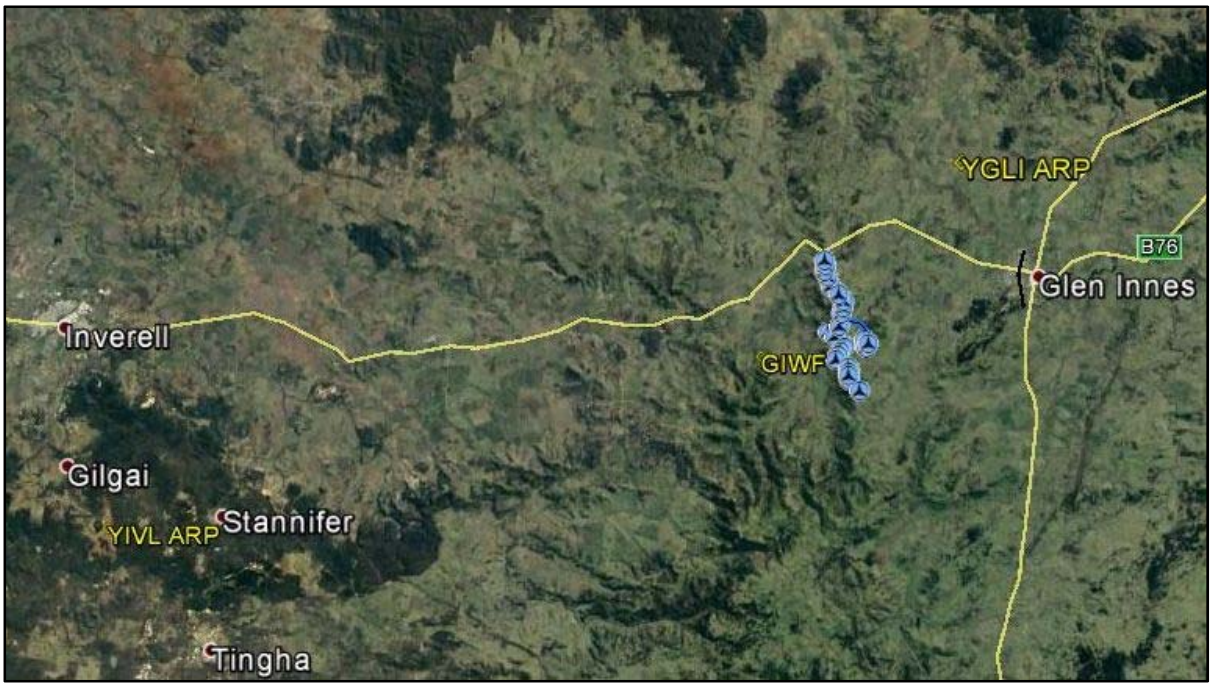


Figure 5.1 General Location of the Proposed GIWF

5.1.2 Aviation Obstacles

As presented in detail in the AIS, the proposed windfarm will consist of 25 180m AGL wind turbines, the highest obstacle, turbine WTG 19 at 1446 m or 4745 ft AHD is shown in yellow shading in Figure 5.2.

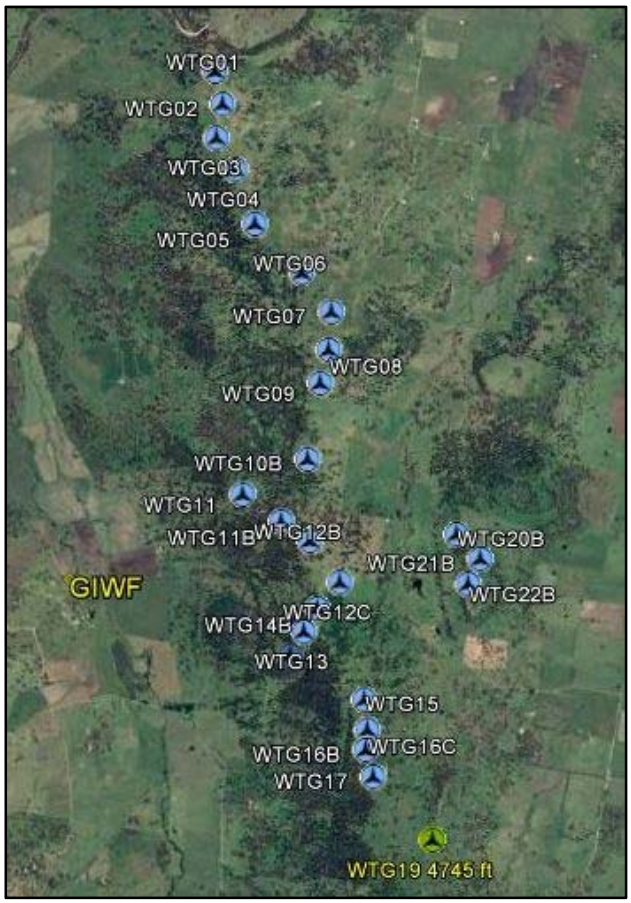


Figure 5.2 Layout of the GIWF showing Wind Turbine Locations

5.1.3 Aerodromes Within 30 Nautical Miles

There are two registered or certified aerodromes within 30 nm of the nearest wind farm turbine:

- Glen Innes (YGLI) 5.67 nm (10.5 km) to the North East of the nearest turbine; and
- Inverell (YIVL) 25.15 nm (46.6 km) to the South West of the nearest turbine.

Fig 5.3 below shows the location of GIWF, nearby wind farms and the Glen Innes airport R_NAV surfaces.

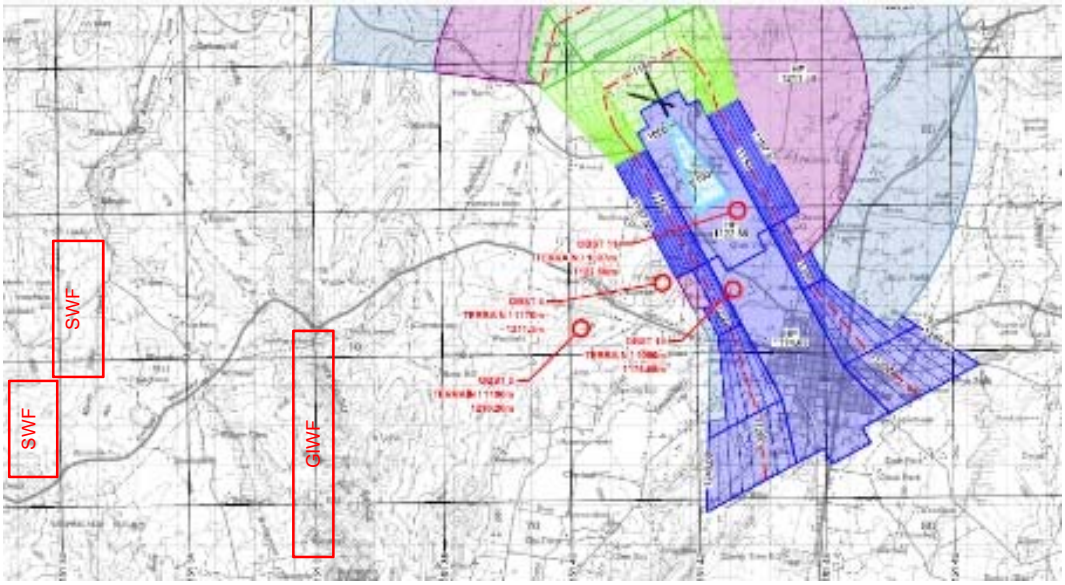


Figure 5-3 Location of Wind Farms and YGLI R-NAV surfaces

5.1.4 Airspace

The GIWF is situated in Class G airspace, beneath Class E airspace with a lower limit of 8500 ft. and there are no Military Restricted airspaces in the vicinity.

5.1.5 Other Airstrips

The previous risk assessment identified 6 unregistered airstrips within the vicinity of the wind farm. SuperAir, (a local aerial application operator) have confirmed July 2017 that as far as they know, they are the only operator that would use any of these airstrips when contracted to do so. No other operations are undertaken here to their knowledge as they are not suitable for use by the average “private pilot” and should be considered as “Ag strips”.

5.1.6 Operational Context

The wind farm will be located at a point where the closest aerodrome will be Glen Innes. Therefore, this section predominantly discusses the VFR aviation activity associated with this aerodrome.

5.1.6.1 *Current Operations*

No significant changes in current aviation operations were identified in comparison with the original aviation risk assessment for Glen Innes or the Sapphire wind farms.

- Currently a freight run is made on a daily basis between Inverell and Glen Innes and is often flown under VFR if conditions permit, including below cloud to obviate the need for an instrument approach on landing at Glen Innes.
- Air Ambulance operations are based out of Glen Innes and they utilise the published R-NAV procedures.
- There is a flying training school at Inverell that conducts ab-initio flying training. They use the route between Inverell and Glen Innes as part of the training and also conduct some low-level training in the vicinity.
- There are flying schools at Tamworth and Armidale who occasionally use the area around Inverell and Glen Innes for navigation training purposes.
- A small number of recreational (RA-Aus) pilots fly from Glen Innes / Inverell airports, plus additional visiting recreational pilots from surrounding areas. These aircraft are limited to VFR flight by day in VMC.

- Aerial Application – Superair have confirmed their continuing desire to operate in the vicinity of the wind farm and that they are the only operator utilising the Ag strips located in close proximity to the wind farm.
- No published or highly trafficked VFR desire line was identified through charts or the consultation process.
- No gliding, micro-light or ballooning activities were identified.
- No scheduled commercial or RPT flights to/from Inverell or Glen Innes airports have been identified.
- The previous risk assessment and current AIS have confirmed that the wind farm is outside of designated military operations / communications.

5.1.6.2 *Planned Future Pilot Training Operations*

Glen Innes Regional Airport Pty Ltd is about to commence construction of a commercial flight academy on the Glen Innes airport (due to start November 2017). The planned capacity is to have 35 aircraft on-line, with up to 600 students which will equate to an aircraft movement every 6 minutes when complete. The flight academy will take international students with no previous flight experience (ab-initio) and offer training from basic through to advanced culminating with students suitably qualified for direct entry into airline pilot positions. This represents a significant future change in aviation activity in the area.

All ab-initio flying training is conducted in accordance with the Visual Flight Rules (VFR) and in Visual Meteorological Conditions (VMC). As the name implies, such flying is conducted by visual reference to the ground or water, at a prescribed distance clear of cloud, with a specified visibility range and a minimum height above the terrain or highest obstacle thereon. VFR operations may be flown in accordance with CAR 157 Low Flying, which states, in part, that an aircraft must not be flown lower than 500ft (152m) above the highest terrain or obstacle on or within a radius of 600m for fixed wing aircraft and 300m for helicopters. This requirement does not apply if the aircraft is engaged in approved low flying activity.

Advanced flying training introduces instrument flying which is conducted in accordance with the Instrument Flight Rules (IFR) allowing flight at night and in cloud. IFR flight is protected by Lowest Safe Altitudes (LSALT) and prescribed airspace associated with published Departure and Approach Procedures (DAP). IFR flight utilises terrestrial radio navigation aids (Navaids) and Global Navigation Satellite System (GNSS) equipment to guide the aircraft at suitably equipped aerodromes. Where there are no published DAP at an aerodrome, IFR flight must revert to VFR flight and be able to see the aerodrome prior to descending below the prescribed airspace. VFR at Night is also governed by LSALT and visual reference to the aerodrome for approach and landing.

Activity generated by the Glen Innes flight academy will be initially circuit area training where the students learn and practice the techniques of aircraft ground handling, take-off and landing within sight of the aerodrome. Progressively students practice emergency procedures such as engine failure, forced landing, dealing with aerodynamic stall and abnormal aircraft attitude recovery. These activities are conducted in specific airspace near the aerodrome, but clear of the circuit area over suitable terrain that is open, flat and clear of obstacles such as trees, powerlines and buildings. Once students have mastered the control of the aircraft they learn to plan and navigate aircraft flights on progressively more complex tasks to achieve the competency required for the granting of a private pilot's licence. All of this training is conducted as VFR flight.

The Glen Innes flight academy will cater for advanced flying training into multi-engine aircraft and Instrument Flying in accordance with the Instrument Flight Rules. IFR training is conducted in suitably equipped aircraft and utilises the published instrument departure and approach procedures for the aerodrome. Consequently, these aircraft will operate above the LSALT and MSA associated with the relevant approach procedure.

5.1.6.3 *Glen Innes Circuit Area Operations*

The Glen Innes aerodrome is at an elevation of 3433ft AHD. Aerodrome Traffic Circuit heights are measured above the aerodrome elevation. The circuit direction at Glen Innes is a standard left hand pattern[3] (see Appendix A). Standard traffic circuit pattern dimensions are dependent on aircraft approach category. High performance aircraft, large turbo-prop or medium jet passenger aircraft operate at a circuit speed over 150 knots and use a larger circuit pattern which is generally no more than 5nm radius at a height of 1500ft above the aerodrome elevation. Most general aviation aircraft use a circuit speed between 55 and 150kts, a circuit radius of no more than 3nm at a height of 1000ft above the aerodrome elevation. Low performance aircraft such as ultralights, trikes, powered parachutes and small fixed wing aircraft operate at a circuit speed below 55kts at a height of 500ft above the aerodrome elevation. From diagrams associated with noise abatement requirements, the depicted circuit patterns for training at Glen Innes will not extend beyond 1.7nm (3km) from the aerodrome.

The circuit patterns at Glen Innes aerodrome, even for high performance aircraft using a 5nm radius, would still remain clear of the closest Glen Innes Wind Farm turbine.

For VFR aircraft departing the Glen Innes circuit the wind turbines will be highly visible due to their contrasting colour and size. For aircraft departing IFR or VFR at night the flight rules applicable ensure the aircraft climbs and tracks to remain clear of obstacles, including terrain and turbines.

5.2 Hazard ID

The following sections summarise the various concerns / hazards raised during the various phases of research and consultation for this project with relation to the proposed increase in height of the turbines.

5.2.1 Review of previous Aviation Risk Assessments

The potential risks to aviation identified previously in the GIWF aviation risk assessment related to a risk of collision with the turbines from:

- Over flying air routes – large vertical separation;
- Flights to and from the neighbouring aerodromes – obstacles clear of OLS;
- Low flying aerial application on land in the vicinity of the wind farm – landowners for wind farm have agreed compensation for additional costs of alternate methods;
- Operations from private airstrips in proximity to windfarm – VFR operations only, not affected;
- Recreational aviation (regular microlight activities) – located some 30 miles west; and
- Defence operations – none identified for the area.

A review of the risk assessment for the neighbouring Sapphire wind farm additionally identified the following collision risks:

- General Aviation Flight Training – undertaken within VFR rules and protected by separation requirements;
- VFR Night flights – aircraft protected by LSALT until within 3nm of the aerodrome to make a visual approach; and
- IFR flights – protected by LSALT and PANS-OPS surface.

It can be seen that the existing assessment of risks refer to “normal operations” where compliance with flight rules and procedural requirements are successfully achieved. This represents the majority of flights, however it is also appropriate in a risk assessment to consider the level of additional risk the turbines may offer to flights in “off-normal operations”, where compliance with flight rules and requirements is not observed and a loss of separation has occurred. Establishing

[3] CAAP 166 – 1(3) Operations on the Vicinity of non-controlled aerodromes, August 2014, Figure 3.

some qualitative feel for the likelihood of these potential off-normal flights or incidents in the vicinity of the wind farm is also desirable and should take into account the operating context described previously.

5.2.2 Review of ATSB Reported Incidents and Accidents

In order to achieve an understanding of any relevant reported incidents / accidents in the vicinity of the wind farm (terrain, weather, pilot behaviour), or other national incidents relevant to the identification of hazards posed by the increased turbine tip height (e.g. descent below cloud, VFR into IMC, wirestrikes), interrogation of the ATSB AvData database[4] was undertaken.

Whilst it is recognised that not all incidents are reported and that statistically the numbers cannot be relied upon as a good predictor of past or future incidents, the consideration of the types of incidents that do occur can help prompt the application of similar situations to the area in question – i.e. flights in the vicinity of the wind farm.

Incident Type	Comments
Incidents in vicinity of Glen Innes Aerodrome (+50km)	Only 4 reported in the last 2 years. One of relevance was the failure of transponder altitude indication.
Unforecast Weather	12 incidences of VFR into IMC incl Charter, Private and 1 training flights. No aerial application flights.
Encountering cloud	7 reported occurrences of flying through cloud during VFR ops.
Loss Of Control (LOC)	Flight training and aerial work are the most common flight types reported.
Flight below minimum altitude	49 total reports for the period with a full mix of private / commercial / RPT flights in VFR and IFR. Many relate to descent below LSALT on approach to an airport (i.e. where there is surveillance). There are a few related to being below min safe altitude in cruise due to a failure in altitude indication, pilot becoming disorientated in cloud.
WireStrike	No collisions with wind turbines have been reported. 73 total incident reports, 69 during aerial work. None reported "visibility, visual, IMC or cloud" within the occurrence details, leading to the conclusion that all wirestrikes occurred during good visibility conditions. Remainder included, private, charter, business and glider operations occurring predominantly on approach to an airport.
Forced landing & collisions with terrain	108 total incidents reported, predominantly on approach or take-off. 30 incidents occurred during cruise.

5.2.3 Stakeholder Consultation

During stakeholder consultation (see Appendix B) the following issues / hazards were identified:

- Collision with WMT – need for marking / lighting;
- Collision with wind turbine – Aerial Application;
- Loss of Control due to Turbine turbulence;
- Day VFR Collision with Turbine - Pilot descending in low visibility conditions;

[4] https://www.atsb.gov.au/avdata/

- Day VFR collision – student pilots;
- Night VFR Collision with Turbine – false negative due to light placement / operation;
- Night VFR – Westpac rescue helicopters performing medical rescue;
- Loss of Control – Turbulence from wind turbines (vertical & horizontal); and
- Cumulative Effect of multiple wind farms.

5.2.4 Review of reported Global Accidents with Wind Farms

It is estimated by the Global Wind Energy Council[5] that there were 341,320 wind turbines generating power around the world at the end of 2016, with Asia, Europe and North America dominating the level of power generated through wind.

A review of the global reported accidents has revealed 6 fatal aircraft accidents associated with wind farms in the US [6], 5 of which are as a result of a collision with a wind monitoring tower, 1 with a wind turbine. Of these, 4 occurred during Low Flying Aerial application operations.

Table 5-5 US Fatal Aviation Accidents at Wind Farms

Date / Location	Activity / Collision	Investigation Ref	Key Facts
2003, Vansycle, OR	Transport (WMT)	NTSB Accident ID SEA04LA027	ATPL pilot in experimental class tail wheel Low Flight in VMC with passenger 50m high WMT, No marking / lights
2005, Ralls, TX	Ag Spray (WMT)	NTSB Accident ID DFW05LA126	VMC No marking or lights
2011, Oakley, CA	Ag Spray (WMT)	NTSB Accident ID WPR11LA094	VMC No marking or lights
2013, Balko, OK	Ag Spray (WMT)	NTSB Accident ID CEN13FA465	VMC No marking or lights
2014, Highmore, SD	Transport (Turbine)	NTSB Accident ID CEN14FA224	Obstacles not marked on charts. Local CPL Ag pilot flying VFR into IMC at night. Collision with blades. Witnesses saw a/c fly over at 200'. Obstacle Light on turbine failed
Aug 19, 2016	Ag Spray (WMT)	NTSB Accident ID CEN16LA326	VMC No marking or lights

A recent collision with a wind turbine in Germany occurred in February 2017. No investigation report is available, but from media reports it seems that there was good VMC conditions and that the recreational aircraft struck the turbine at a height of 40m AGL. The turbine was located 1.5km from an airstrip, but whether the aircraft was operating from this airstrip has not been confirmed.

So, it can be concluded that collisions with wind turbines have been very rare events. Whilst not statistically relevant, the two collisions noted above are however informative, since the 2014 collision in Highmore appears to have several contributing factors relevant to the identification of hazards. The cause of the accident sequence seems to be the continuation of a VFR flight into IMC conditions, resulting in a very low-level flight. Complicating factors are that the pilot was aware of the wind turbines, that they were not recorded on the navigational charts and that obstacle lights were installed but reportedly not operating on this particular turbine at the time of the accident. NTSB investigators stated in their report that "[if] the pilot observed the lights from the surrounding wind turbines, it is possible that he perceived a break in the light string between

[5] http://www.gwec.net/global-figures/interactive-map/#

[6] https://www.masterresource.org/windpower-safety-issues/wind-aviation-safety-v/

the wind turbines as an obstacle-free zone". This potential effect is what we refer to as a "false negative" in this risk assessment.

5.2.5 Consideration of Cumulative Wind Farm Risks

UK CAA CAP 764 offers guidance in relation to considerations when assessing the aviation impacts from wind farms. One recommendation is that consideration to the potential cumulative effect of multiple wind farms co-located in an area is given.

There are two other proposed wind farms in the region (White Rock and Sapphire), and the Sapphire Wind Farm is located north of the Gwydir Highway between Glen Innes and Inverell and at a close distance west of the GIWF (see Figure 5-3). The Sapphire wind farm consists of 3 clusters of turbines.

The White Rock Wind Farm is located to the South West of the GIWF as shown in Figure 5-6 below (as presented in the White Rock Wind Farm Environmental Impact Assessment).

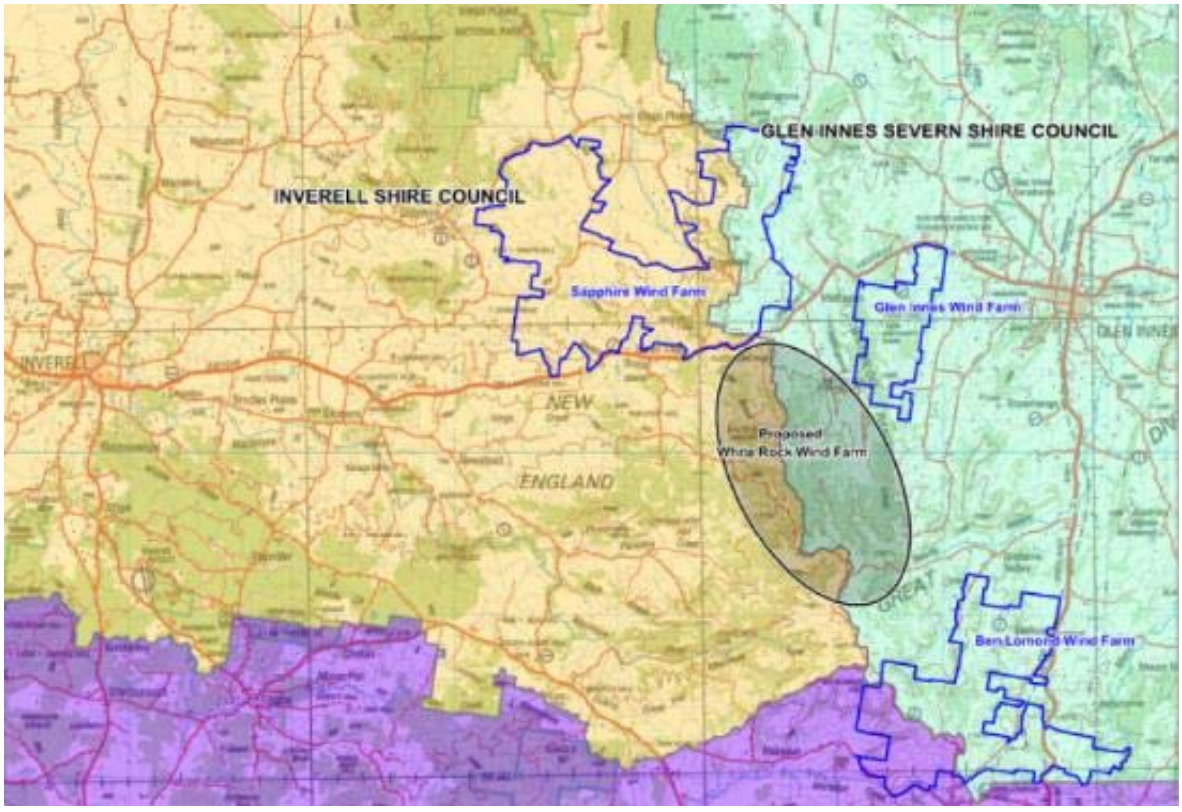


Figure 5-6 Location of neighbouring wind farms

There are two concerns identified related to the cumulative risks of these wind farms:

- Potential for navigational "Pinch Points"; and
- Human Factors implications for a Non-Standard approach to Obstacle Lighting.

VFR aircraft travelling between Glen Innes and Inverell, in the event of reduced visibility, aircraft can visually follow the Gwydir highway. The wind farms are located sufficiently far away from each other that aircraft undertaking this method of visual navigation will have sufficient room to navigate clear of the wind farms whilst maintaining visual contact with the road. It is therefore concluded that no "pinch point" exists to hinder visual navigation in VMC.

For the non-standard application of aviation obstacle lighting it is considered that for night VFR flights, there the potential for confusion if some of the wind turbines (clusters) are lit and others aren't – i.e. a "false negative" can be created whereby pilots feel they are clear of all

obstacles when in fact they are not. This potential threat has been added to the scenarios for risk assessment.

5.3 Bowtie Risk Analysis

The following hazards to aviation in the vicinity of the wind farm were identified for detailed analysis:

1 VFR Flights in VMC in vicinity of wind farm;
2 Night VFR flights in vicinity of wind farm;
3 Flights in IMC in vicinity of wind farm;
4 Authorised Low Level Operations in VMC in vicinity of wind farm.

Each of these have been developed as a Bowtie.

The potential consequences of concern from these loss of separation hazards are:

- Loss Of Control (LOC) of the aircraft (due to collision avoidance manoeuvring or turbine wake turbulence); and
- Controlled Flight Into Terrain (CFIT), where an aircraft, still under effective control by the pilot, collides with terrain or an obstacle.

When considering these hazards, it is important to make sure we are focussed on the additional risk that the wind turbines pose to an aircraft already in these identified ”accident” conditions, where collision with terrain or loss of control is a potential risk, irrespective of whether the turbines exist or not. The majority of the identified threats that could lead to an aircraft loss of separation event with the turbines can only occur once a system or compliance failure with existing aviation requirements has occurred:

- Precautionary Landing due to system failure;
- Pilot / System Navigational error;
- Pilot Training Activities;
- VFR Flight into IMC; and
- Authorised Low Level Operations.

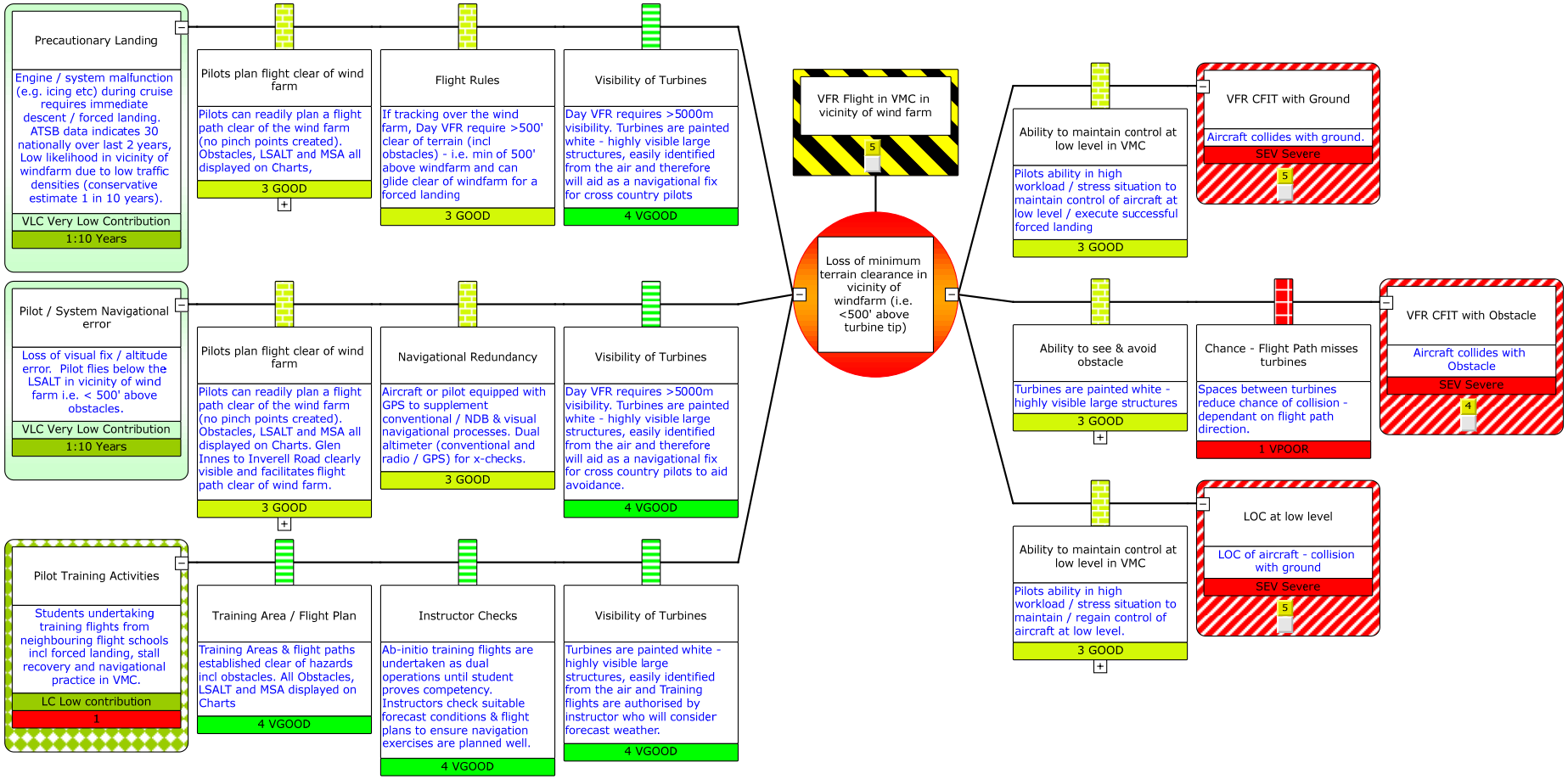
The main effect that the presence of the wind turbines has is to raise the level of minimum terrain separation (LSALT) required, which has not been identified as a cause for any threat sequences.

Hence for these Bowties, the two outcomes or consequences relating to CFIT (into ground or collision with an obstacle) are intended to provide a relative comparison of the risks for the event outcomes dependant on whether a wind turbine is present (CFIT -obstacle collision) or not (CFIT – ground).

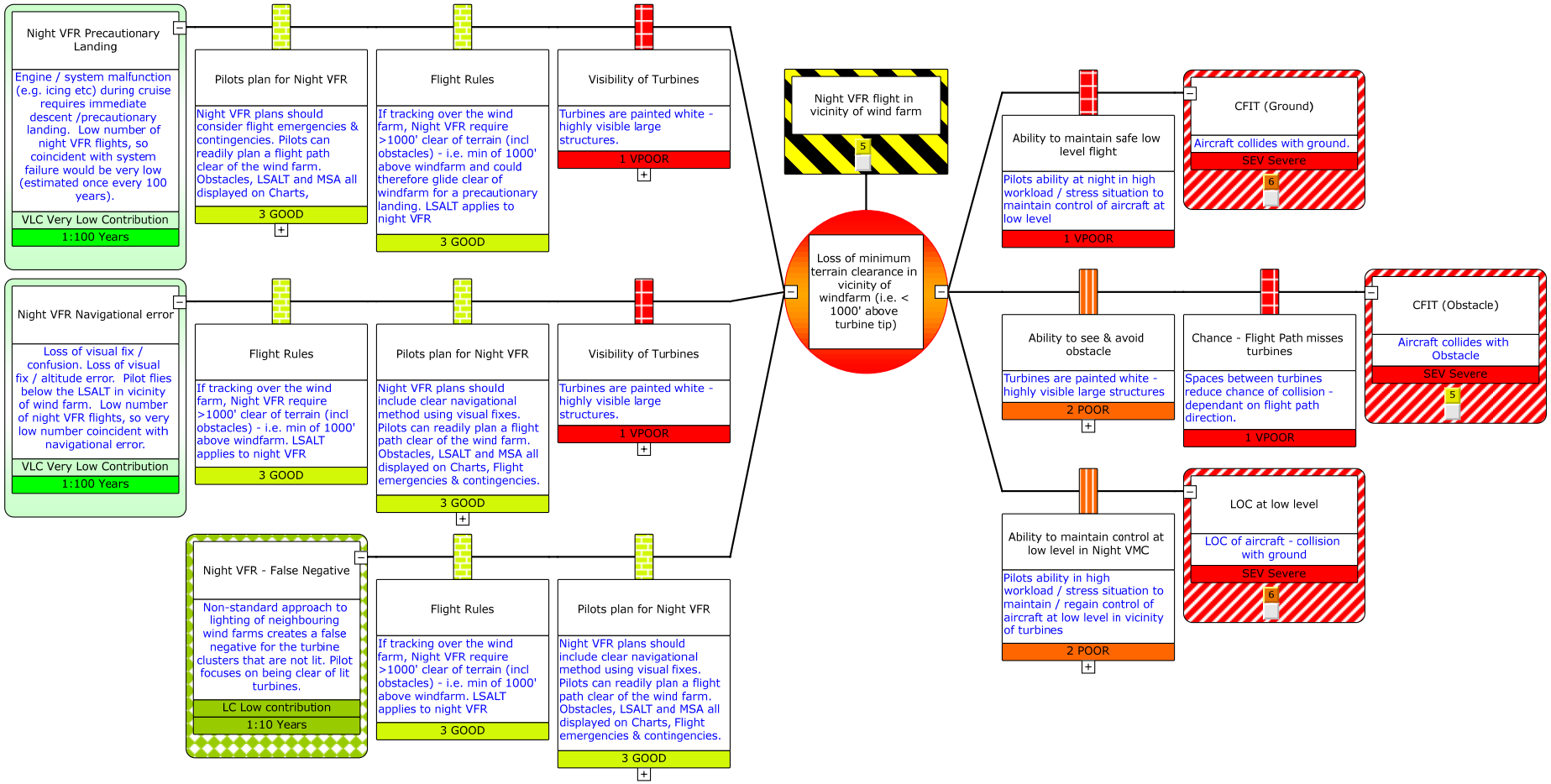
When considering the cumulative effect of this wind farm with other neighbouring ones in close proximity (in particular the Sapphire wind farm clusters), an additional hazard has been identified which relates to the recent determination that obstacle lighting should be provided on the Sapphire wind farm. There is potential to create confusion for Night VFR pilots if the GIWF is not lit – i.e. the potential for what is described as a “false negative” (i.e. a VFR pilot believes that the end of a string of obstacle lights indicates that they are clear of all turbines and hence in an obstacle free zone. This is discussed further in the Obstacle Lighting review.

The full expanded Bowties are provided as Appendices C and D to this report, but the top level summary Bowties are provided on the following pages.

5.4 VFR Flights in VMC in vicinity of wind farm



5.5 Night VFR flights in vicinity of wind farm



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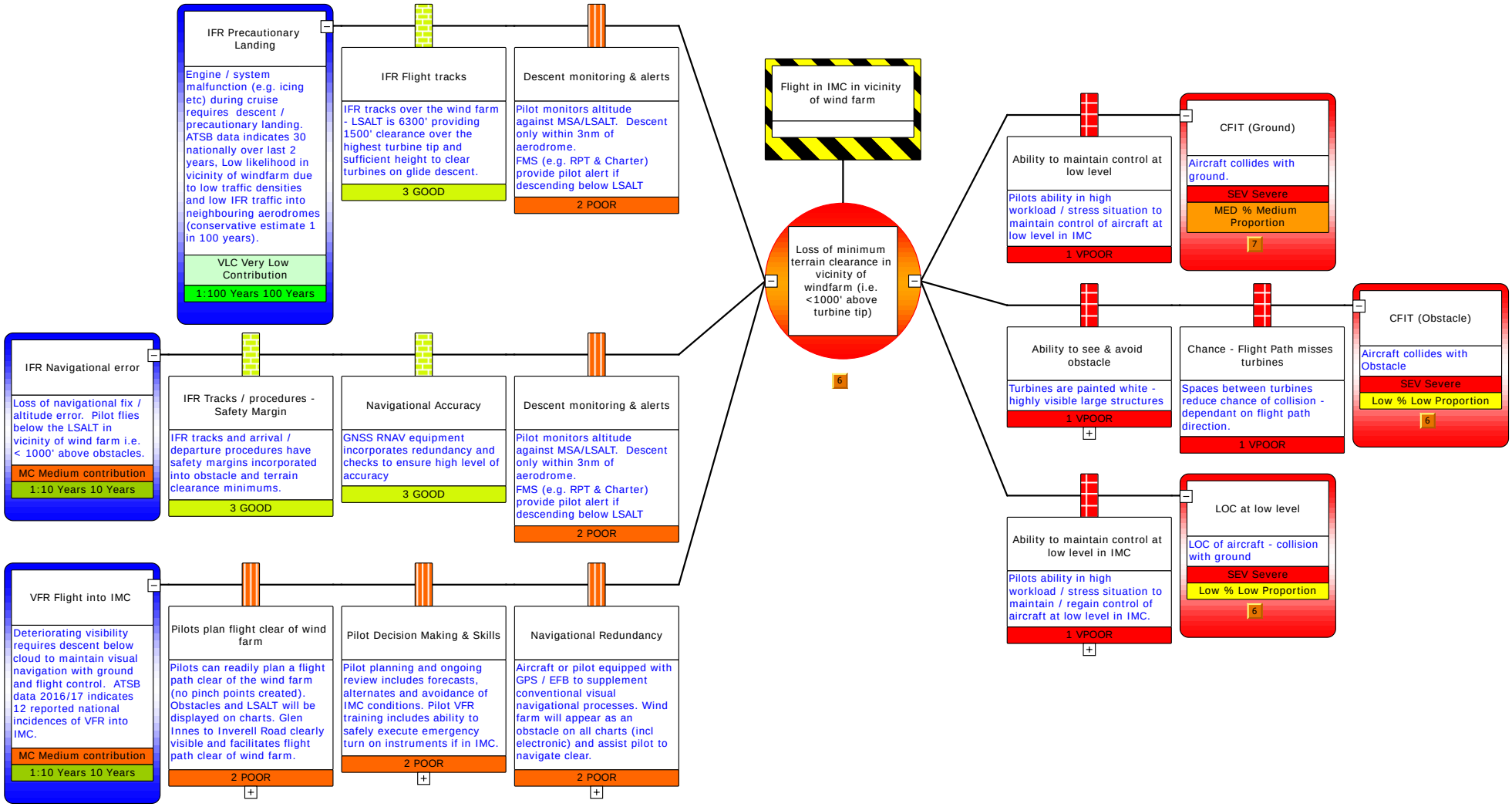
5.6 Flights in IMC in vicinity of wind farm



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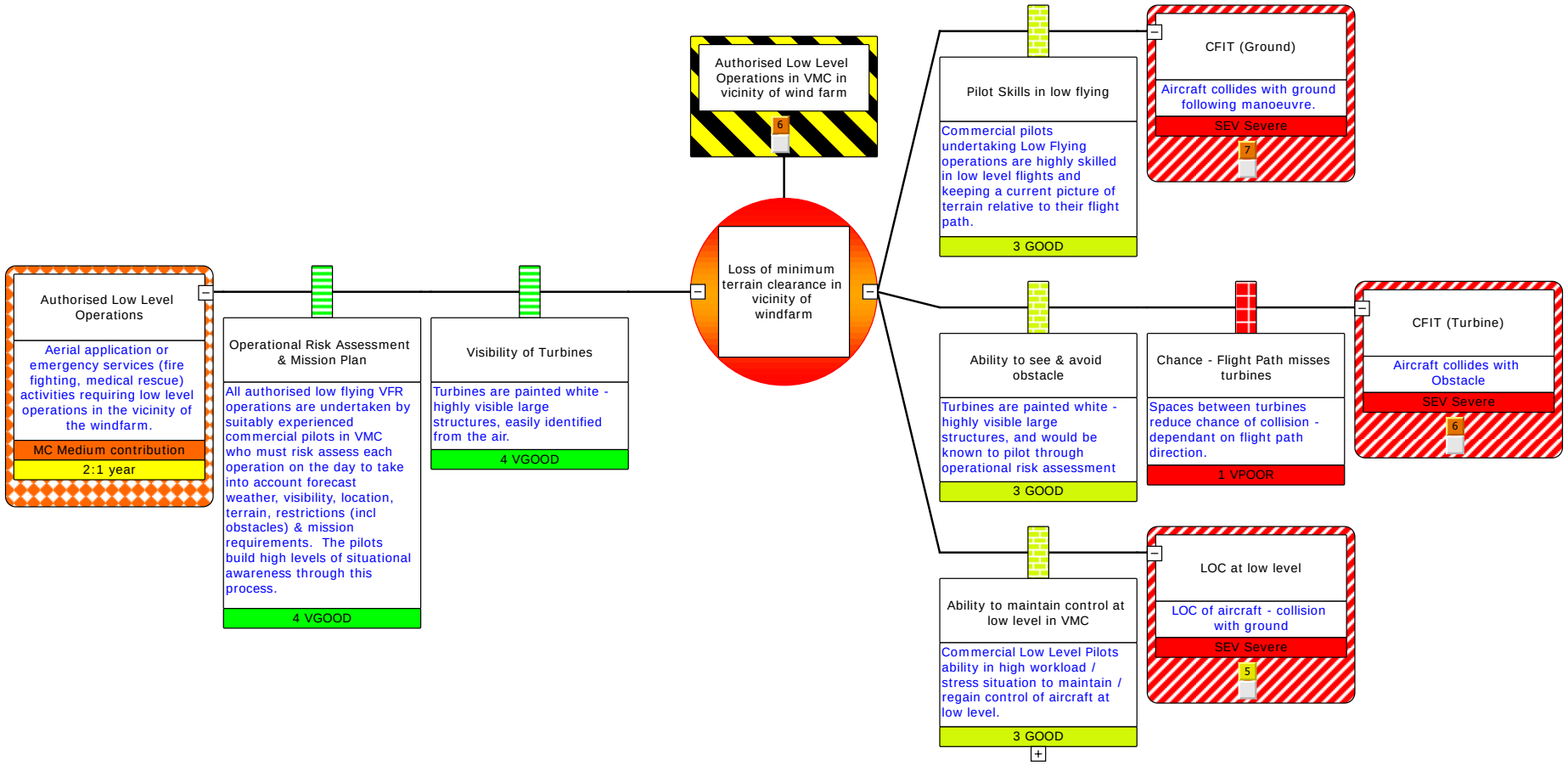
5.7 Authorised Low Level Operations in VMC in vicinity of wind farm.



5.8 Risk Acceptability

It can be seen from these summary level bowties, that there are three threats which are considered to be Medium Contributors to a loss of separation event occurring in the vicinity of the wind farm:

- Authorised Low Level Operations;
- VFR flights into IMC conditions; and
- IFR navigational error in IMC.

There are 7 risk outcomes that have an inherent high risk ranking. Because the outcomes all relate to severe outcomes (1 or 2 fatalities), the risk scores cannot be reduced below medium on the CASA risk matrix. The 7 high risk outcomes relate to:

- Night VFR – CFIT ground;
- Night VFR – LOC at low level;
- Flight in IMC – CFIT ground;
- Flight in IMC – CFIT Obstacle;
- Flight in IMC – LOC at low level;
- Authorised Low Level Flights - CFIT ground; and
- Authorised Low Level Flights - CFIT obstacle

	0	1	2	3	4	5
GIRF Safety [Baseline]	Insignificant	Minor	Moderate	Major	Severe	Catastrophic
5 Almost Certain						
4 Likely					**[4]**	
3 Possible					**[2]**	
2 Unlikely					**[5]**	
1 Rare					**[4]**	
0 Extremely Rare					**[1]**	

Of these 7scenarios, 3 are inherent risks associated with a loss of separation with the terrain (CFIT into the ground). The other 4 outcomes relate to collisions with a turbine (obstacle) or a LOC due to encountering turbine wake or manoeuvring to avoid a turbine during IMC flights or during Low Level Operations.

The presence of the wind turbines therefore does not increase the risk of accidents beyond the inherent (high) level associated with these loss of separation events occurring in these particular conditions.

5.8.1 Obstacle Lighting Review

The risk assessment finds that the addition of obstacle lighting will not significantly benefit in the prevention of the identified dominant threat lines which contribute to the high risks (higher likelihood collision events) which are flights in IMC and authorised low flying.

Similarly, obstacle lighting will not benefit day VFR flights in VMC, since the turbines themselves are already highly visible. Hence the addition of obstacle lighting is unlikely to significantly further reduce the likelihood of these rare events caused by the siting of the wind turbines.

However, when considering the effect of obstacle lighting in terms of reducing the identified risks associated with Night VFR aviation activities in the vicinity of the wind farm, it has been determined that lighting would offer some benefit, mainly because they will act to assist night VFR pilots in avoiding the area (act as a navigational fix) so that aircraft are not at risk in the rare event of needing to descend (system failure / weather) (i.e. the RHS of the bowtie).

As a barrier on the RHS of the Bowtie, (i.e. a final mitigation measure), once required obstacle separation has been lost, lighting as a collision avoidance mechanism will be less effective for the following reasons:

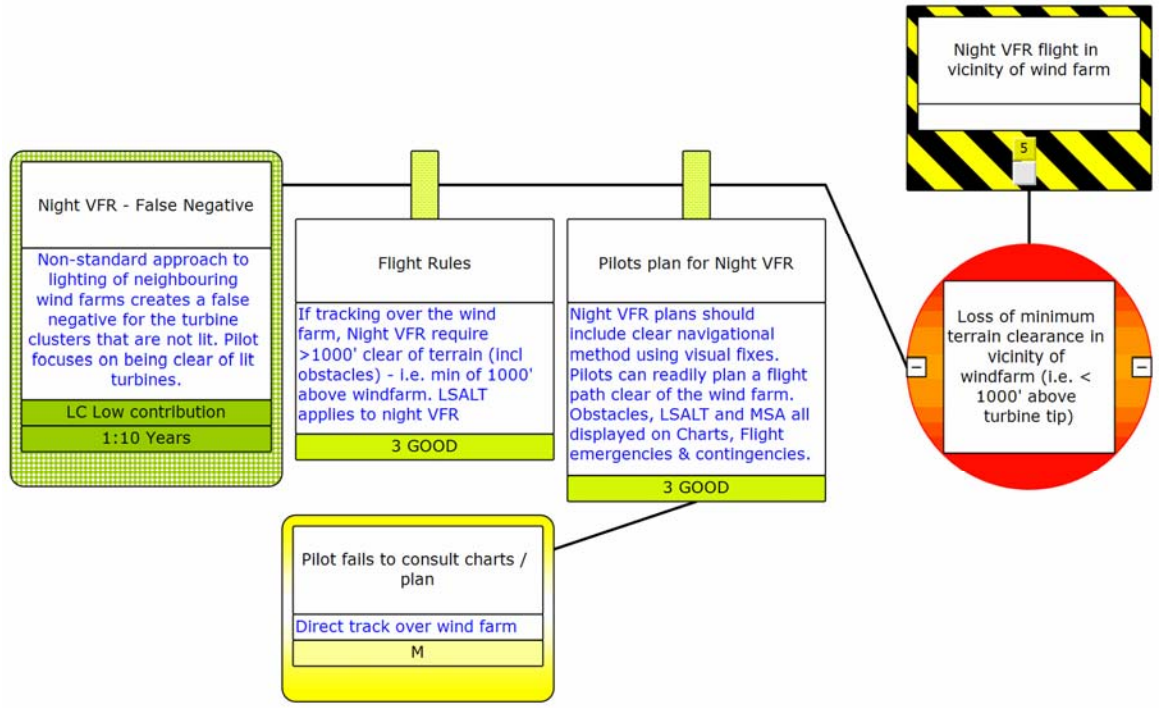
- Pilot ability to see, avoid and react during night-time low level flying would be poor;
- Lights are not an accurate representation of obstacle height (not mounted on the highest point); and
- Lights are not provided on every individual turbine;

Therefore, it is concluded that avoidance actions reliant on sighting and avoiding the lights (once separation is lost) would have a low success rate.

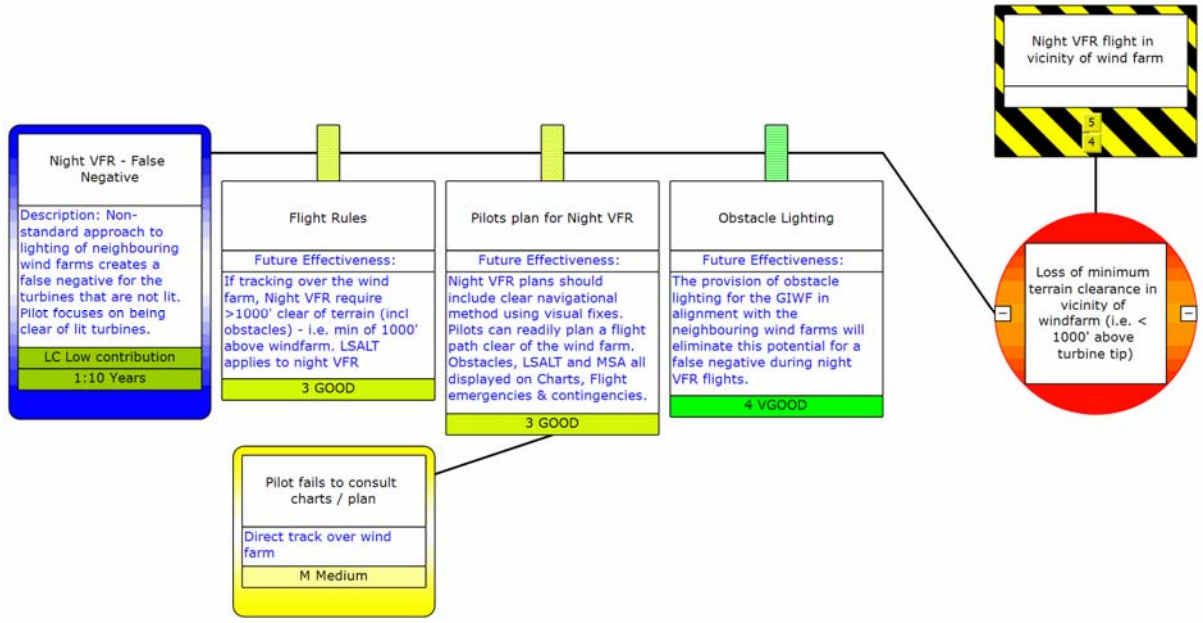
When obstacle lighting is applied as a barrier in the Bowties, the reduction of risk associated with potential accident outcomes is marginal and overall risk remains at a high level overall due to the remaining inherent risk of collision with terrain.

Collision with an obstacle at night was determined to be a Medium risk and remains as a Medium risk following application of the obstacle lighting, however the risk of a LOC due to an encounter with wake turbulence reduces from High to Medium.

When considering the cumulative effect of neighbouring wind farms, one of the loss of separation threat lines identified for aircraft undertaking night VFR flights was the potential for a “false negative” to be generated if (as is the case) the planned neighbouring wind farms are to incorporate obstacle lighting:



The addition of obstacle lighting will eliminate the above potential issue of a navigational "false negative".



No benefits were derived for authorised low flying activities (in VMC) or VFR flights in VMC.

The overall cumulative risk reduction is illustrated on the following risk matrix:

	Risks	**0**	**1**	**2**	**3**	**4**	**5**
	[Baseline] Residual	Insignificant	Minor	Moderate	Major	Severe	Catastrophic
5	Almost Certain						
4	Likely						
3	Possible					**[2]2**	
2	Unlikely					**[5]4**	
1	Rare					**[4]4**	
0	Extremely Rare					**[1]2**	

It can be seen that there is a marginal reduction in risk, with one outcome reducing from a high to a medium risk.

5.8.2 Wind Monitoring Towers

Whilst outside the scope of this risk assessment (the proposed turbine height increase will not affect the placement or height of WMT), the majority of aviation accidents associated with wind farms relate to the collision with WMT during low flying activities. This is because they are narrow tall structures that are very difficult to see from the air.

WMT's may be permanent or temporary and hence their presence is not always apparent to aviation operators.

Marking and lighting of WMT's is specified in NASF Guideline D.

5.9 Summary of Findings

For operations compliant with Visual or Instrument Flight Rules (VFR/ IFR), the proposed increased height in the turbines has been shown to offer no increase in risk to aviation.

The Aviation Impact Assessment has confirmed there is no impact on the protected obstacle free surfaces required to maintain the safety of IFR flights.

For VFR flights, no existing highly trafficked routes transit through the wind farm location and sufficient vertical and lateral separation can easily be achieved within the existing surrounding navigable airspace.

It is therefore only in the event of Authorised Low Level flights (e.g. aerial application, emergency response) in the immediate vicinity of the wind farm, and flights operating outside prescribed rules and conditions (accident / incident conditions) that the wind farm obstacles can be shown to offer any additional risk to aviation. It is these flights that are the subject of this risk assessment.

6. RECOMMENDATIONS

6.1 Obstacle Lighting Plan & Maintenance

Primarily as a result of the decision to install obstacle lighting on the neighbouring Sapphire wind farm (rather than collision risk per se), it is recommended that the same obstacle lighting regime plan be adopted, (i.e. lighting intensity, type, spacing) to ensure against the false negative issue identified in this report.

Once turbines are constructed and lights installed, it is critical to aviation safety that continuous monitoring of light status and the detection of failures is guaranteed, such that the prompt reporting and rectification of a failed obstacle light is achieved.

The lighting plan for the GIWF should be developed with reference to CASA Manual of Standards (MOS) 139 and NASF Guideline D (as outlined in Appendix F).

6.2 Avoiding Low Level flights in vicinity of wind farms

Whilst obstacle lighting may assist in the avoidance of the area for night VFR flights, it is worth reviewing other available mechanisms for strengthening the prevention of the loss of separation events that may be effective in all conditions. The key to prevention of a collision with a turbine is to ensure that pilots, when planning flights, avoid overflying the wind farms.

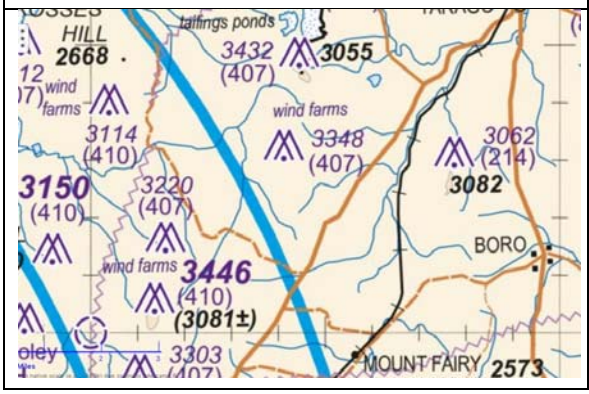
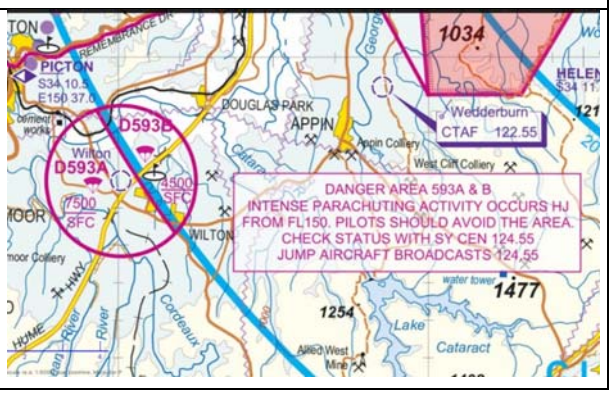
This could be achieved through a combination of:

- Reinforcement with local pilots through consultation with the local flying schools, clubs and companies operating in the area;
- Pilot Education through CASA and RAA regarding the hazards associated with flights in the vicinity of windfarms;
- Pilot Education through CASA and RAA regarding the commonly mis-understood aspect of the aviation regulations with respect to navigable airspace for in VFR flights – i.e. that day VFR flights MUST be conducted with a minimum vertical separation of 500’ above the ground **and any object on it**; and
- Clearer designation of wind farms on the navigation charts to aid pilot comprehension where multiple wind farms exist.

It is considered that for those itinerant pilots who are planning cross country flights, within an area occupied by multiple tall structures (wind farms), that it is important that these are as obvious as possible when consulting the navigation charts (paper or digital). To this end, Ambidji recommend that CASA consider designation of wind farms, particularly where there are multiple wind farms) as Restricted Access areas (SFC – LSALT).

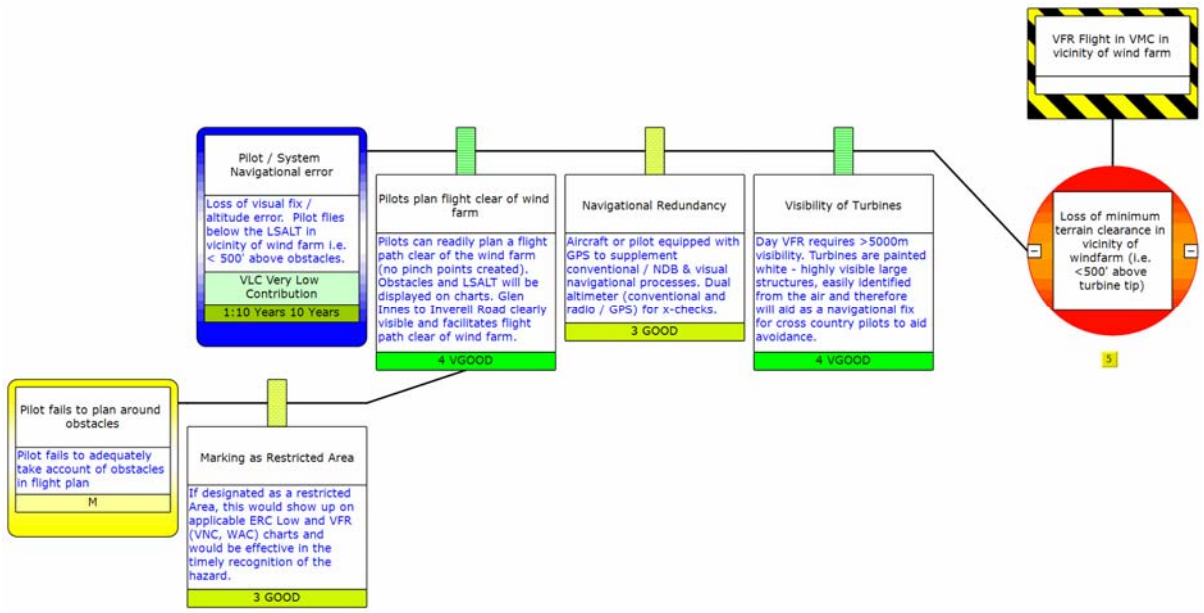
Restricted and Danger areas are defined more clearly on the navigation charts (VFR and IFR) than obstacles and would assist in more immediate pilot recognition of their presence (particularly during time critical identification hazards during flights where flight abnormalities must be managed). With each wind farm marked as a restricted area, Ambidji believes that

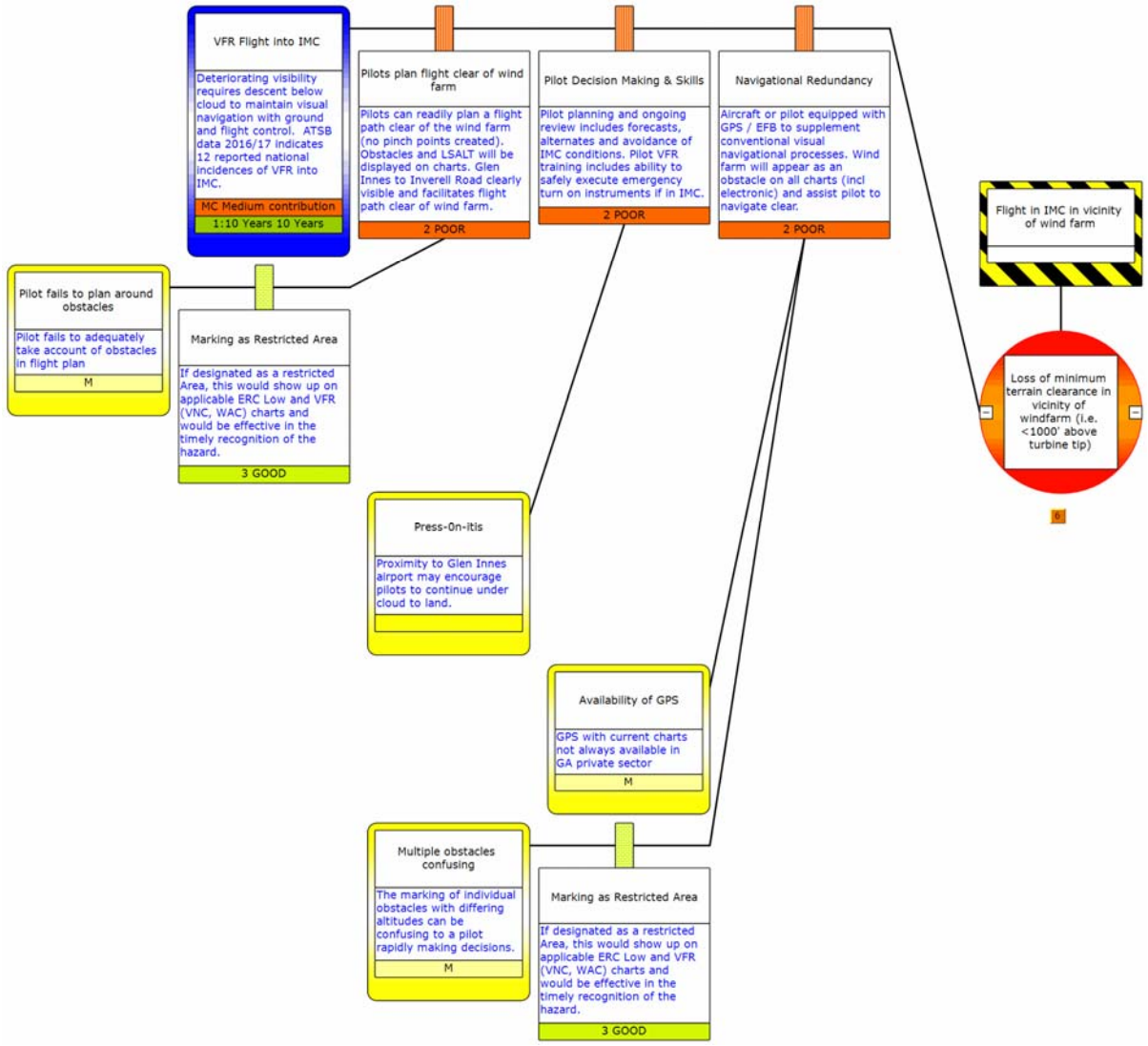
pilot recognition of the hazard, and options for navigation clear of them would therefore be more readily apparent. The level of compliance with maintaining necessary clearance from a restricted area may also be higher than that of marked individual obstacles.

Hazard Marked as Obstacles	Hazards marked as Danger Area
	

Access for authorised low flying activities would then be agreed through consultation with the wind farm operator.

These preventative measures (i.e. preventing a pilot choosing to fly in the vicinity of the windfarm), will further reduce the unlikely chance that a pilot would collide with a wind turbine in VMC (abnormal operations) and VFR flight into deteriorating conditions:





It is considered that collectively these measures should further reduce the likelihood of these collision scenarios and are justifiable as they are low cost measures to implement, with no ongoing maintenance costs.

6.3 Notification and Update of Charts

The wind farm must be reported to aviation authorities in accordance with AC 139-08(0) “Reporting of Tall Structures” and marked on the appropriate aeronautical charts e.g. the World Aeronautical Chart (WAC) 3357 Armidale, Enroute Chart (ERC L3 Eastern NSW), Visual Navigation Chart (Brisbane VNC), published by Airservices Australia cover the windfarm area.

Prior to the commencement of construction and operation of the wind farm, Glen Innes Power Pty Ltd must provide the following information to CASA, Royal Australian Air-Force-Aeronautical Information Service and Airservices Australia:

- As constructed coordinates in latitude and longitude of each wind turbine;
- Final height of each wind turbine in AHD; and
- Ground level at the base of each wind turbine in AHD.

A Notice to Airmen (NOTAM) will be issued (by AsA) until this change is accurately reflected in the WAC.

Additionally, formal notification of the location and height of the turbines should be made to:

- Local aviation operators;
- Local Aerial Agricultural Applications Operators at Armidale and surrounding area;
- NSW Police Air Wing;
- NSW Ambulance Service;
- NSW Rural Fire Service;
- Aerial Agricultural Association of Australia (AAAA); and
- Recreational Aviation Australia (RA-Aus).

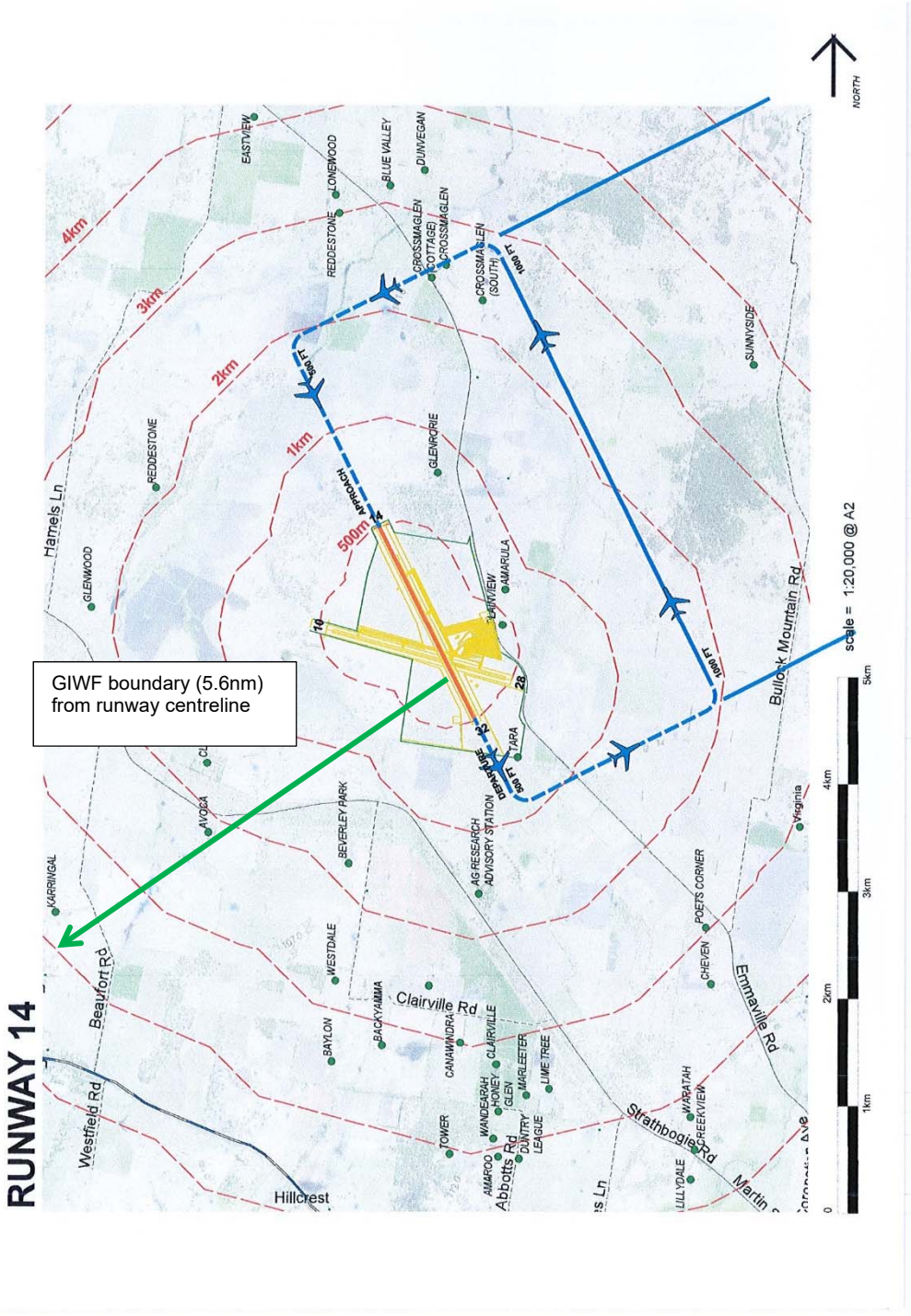
6.4 Marking of Wind Monitoring Towers

Ambidji recommend that as per MOS 139 Section 8.10 Obstacle Markings (as modified by the guidance in NASF Guideline D), any WMT's deployed on the GIWF be suitably marked and notified through NOTAM's. This should include the marking of masts, poles and towers in contrasting bands and the attachment of three-dimensional coloured objects such as spheres and pyramids to wires or cables.

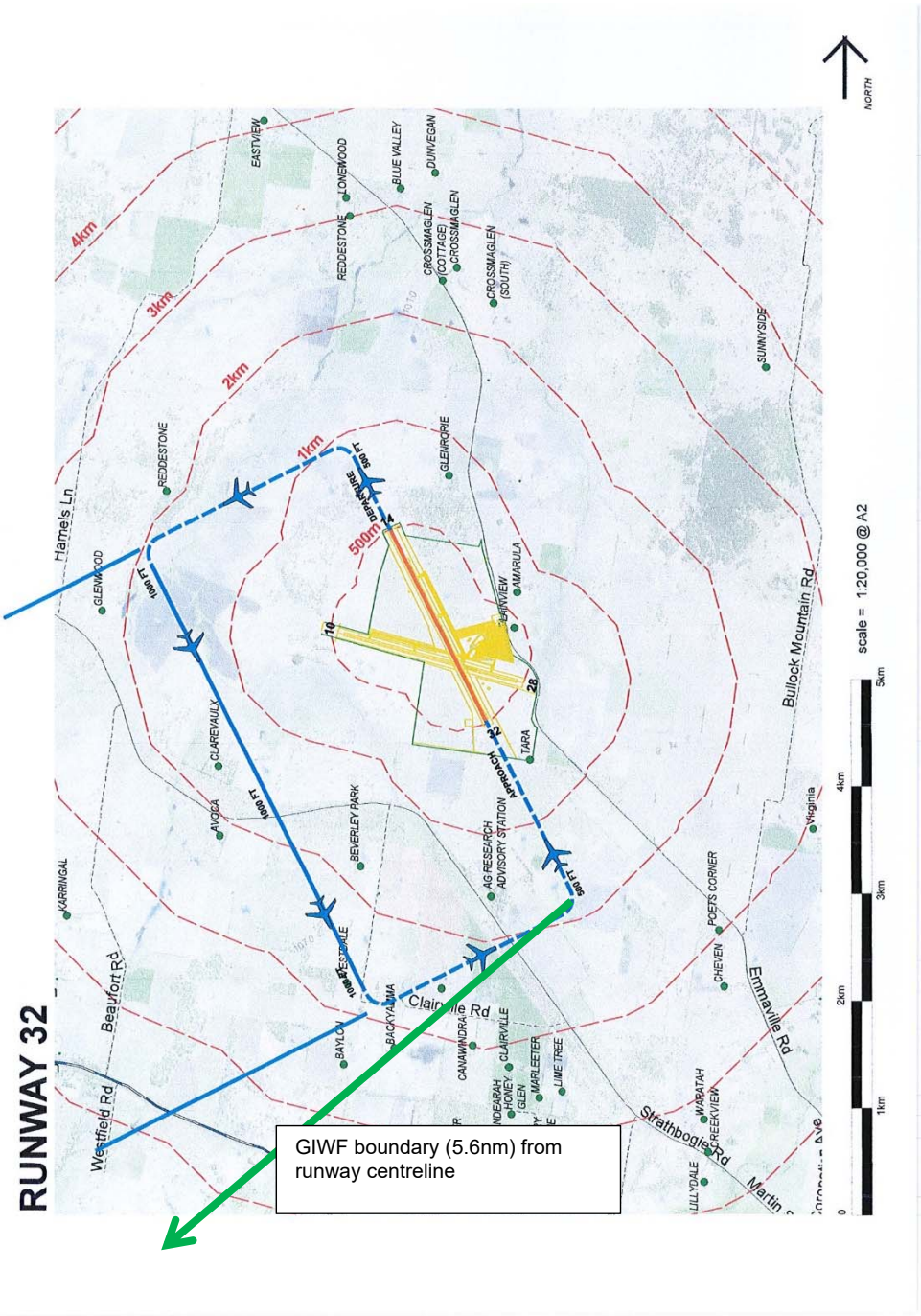
The proponent should ensure details of all wind monitoring towers on the Project site are communicated to Airservices Australia, and local and regional aerodrome and aircraft operators before, during and following construction.

APPENDIX A. GLEN INNES CIRCUIT PATTERNS

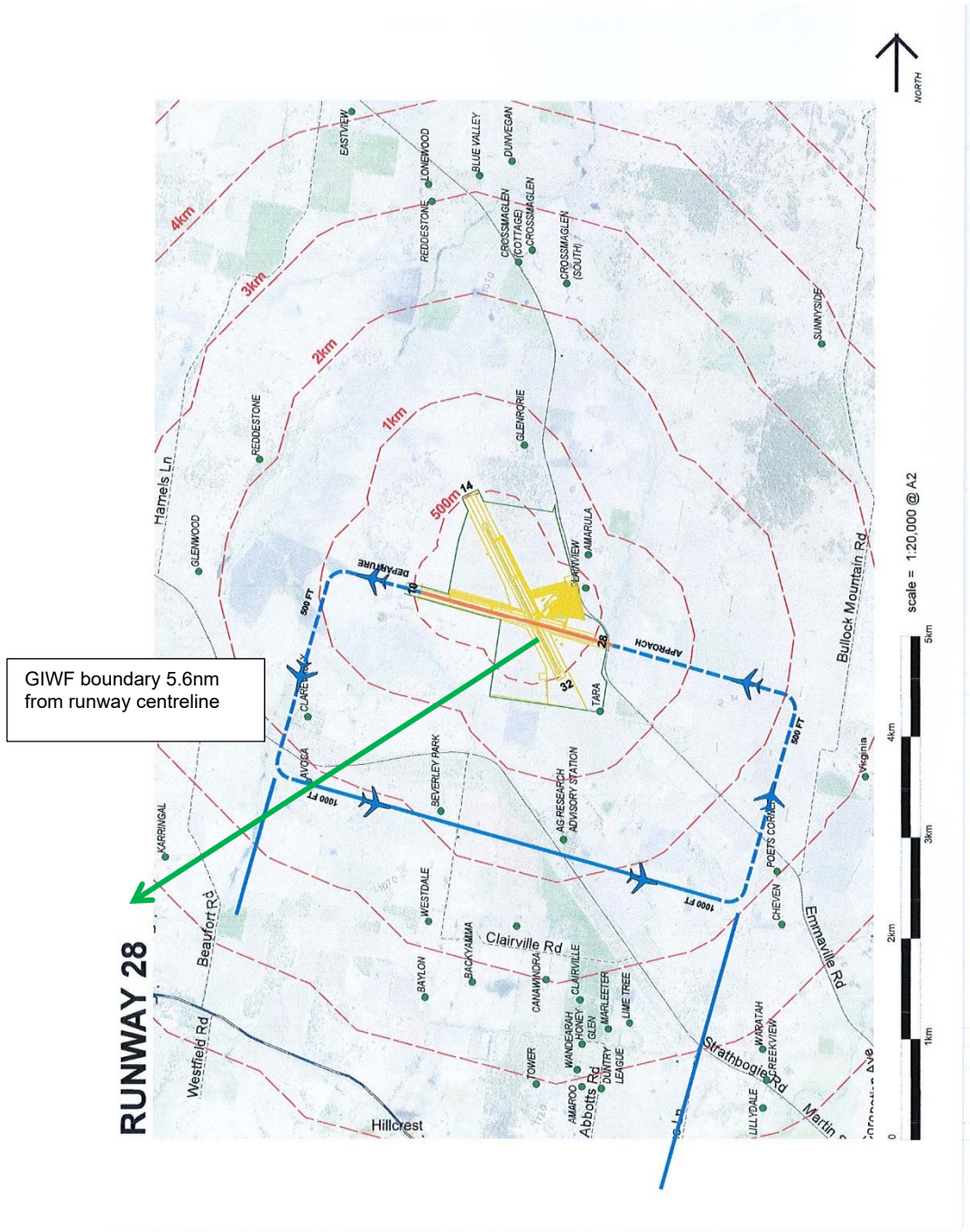
Runway 14



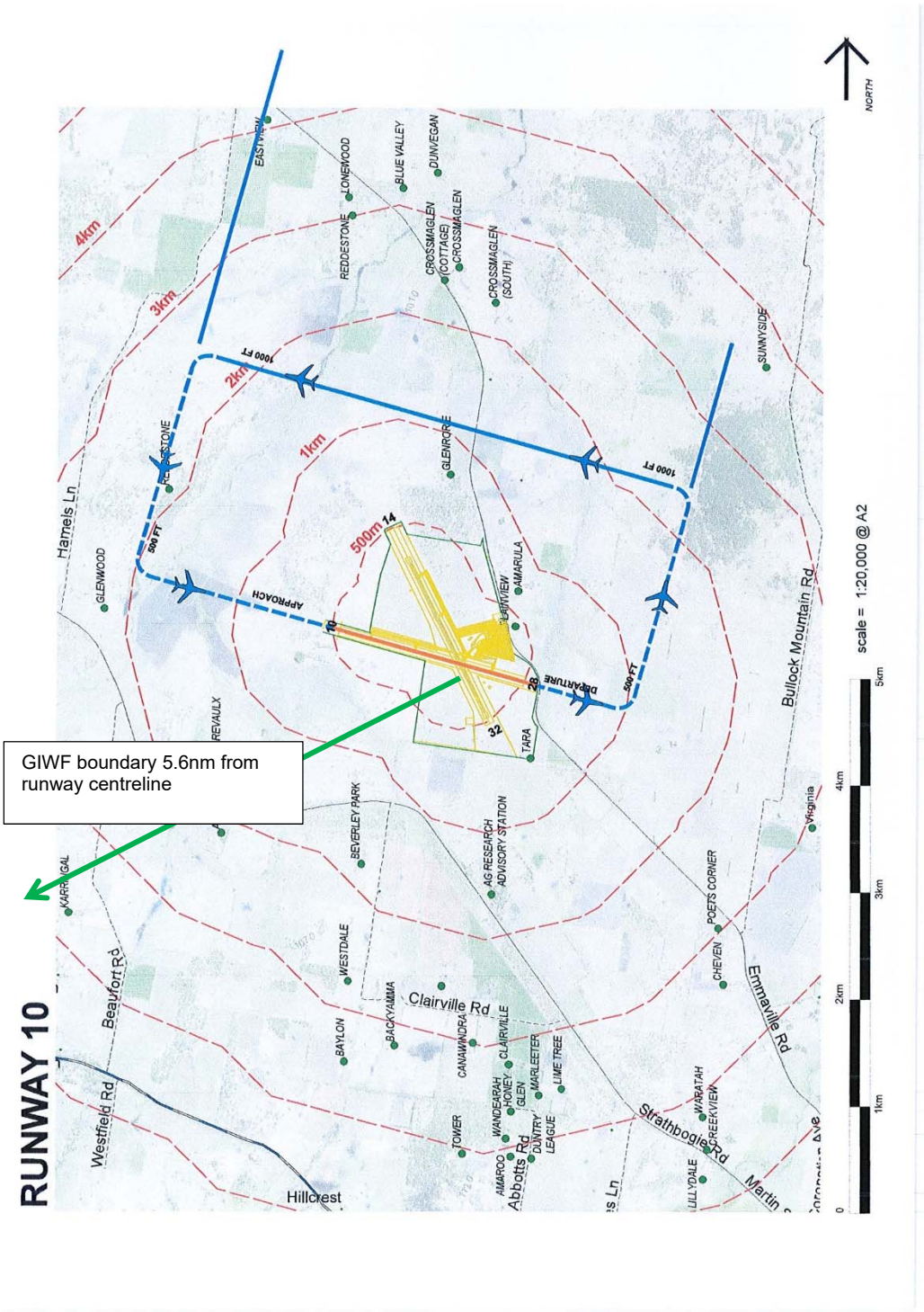
Runway 32


RUNWAY 32
GIWF boundary (5.6nm) from runway centreline
4km
3km
2km
1km
500m
NORTH
scale = 1:20,000 @ A2
Hamels Ln
Beaufort Rd
Westfield Rd
Bullock Mountain Rd
Emmaville Rd
Strathbogie Rd
Clairville Rd
EASTVIEW
LONEWOOD
BLUE VALLEY
DUNVEGAN
REDDESTONE
CROSSMAGLEN (COTTAGE)
CROSSMAGLEN
CROSSMAGLEN (SOUTH)
SUNNYSIDE
GLENROBBIE
GLENWOOD
AMARULA
BAYVIEW
TARA
CLAREVAULX
AVOCA
BEVERLEY PARK
AG RESEARCH ADVISORY STATION
KARRINGAL
BACKYARMA
BAYLOL
CANAWINDRA
CLAIRVILLE
INDEARAH
HONEY GLEN
MARLEETER
LIME TREE
POETS CORNER
CHEVEN
Yhagnia
WARATAH
CREEKVIEW
LILLYDALE
10
28
1000 FT
500 FT

Runway 28


GIWF boundary 5.6nm from runway centreline
RUNWAY 28
NORTH
scale = 1:20,000 @ A2
4km
3km
2km
1km
500m
500 FT
1000 FT
14
32
DEPARTURE
APPROACH
Hamels Ln
Bullock Mountain Rd
Beaufort Rd
Westfield Rd
Clairville Rd
Emmaville Rd
Strathbogie Rd
Abbotts Rd
Martin
Hillcrest
REDDESTONE
GLENROBIE
SUNNYSIDE
CROSSMAGLEN
CROSSMAGLEN (COTTAGE)
CROSSMAGLEN (SOUTH)
LONEWOOD
BLUE VALLEY
DUNVEGAN
EASTVIEW
GLENWOOD
KARRINGAL
WESTDALE
BEVERLEY PARK
AG.RESEARCH ADVISORY STATION
POETS CORNER
CHEVEN
BAYLON
BACKYARMA
CANAWINDRA
CLAIRVILLE
MARLEETER
LIME TREE
WANDERAH
HONEY GLEN
TOWER
AMAROO
COUNTRY LEAGUE
WARATAH
CREEKVIEW
LILLYDALE
AMAROLA
TARA
CLAREVIEW
WYOGA
Virginia

Runway 10


GIWF boundary 5.6nm from runway centreline
RUNWAY 10
4km
3km
2km
1km
500m
1000 FT
500 FT
APPROACH
DEPARTURE
14
32
NORTH
scale = 1:20,000 @ A2
Hamels Ln
Bullock Mountain Rd
Beaufort Rd
Westfield Rd
Clairville Rd
Abbotts Rd
Strathbogie Rd
Emmaville Rd
Hillcrest
GLENWOOD
REDDESTONE
LONEWOOD
BLUE VALLEY
DUNVEGAN
CROSSMAGLEN (COTTAGE)
CROSSMAGLEN
CROSSMAGLEN (SOUTH)
SUNNYSIDE
GLENROSE
AMARULA
TARA
BEVERLEY PARK
AG RESEARCH ADVISORY STATION
WESTDALE
BAYLON
BACKYAMMA
CANAWINDRA
CLAIRVILLE
MARLEETER
LIME TREE
WANDEARAH
HONEY GLEN
TOWER
AMAROO
DUNTRY LEAGUE
POETS CORNER
CHEVEN
WARATAH
CREEKVIEW
Virginia

APPENDIX B. RECORD OF STAKEHOLDER CONSULTATION

The following table provides a record of the discussions held between Ambidji and identified key stakeholders when undertaking the risk assessment for the increase from 150m to 180m tip height turbines.

Date	Organisation / Contact	Discussion Points / Comments	Hazard Identification (HAZID) items
7/7/2017	CASA / Matthew Windebank. Telecon.	Matt presented the following view in regard to windfarm risk assessments and lighting requirements: CASA take the view that they must consider their liability in any recommendations regarding lighting of wind turbines. This means that even though a risk assessment might indicate no lighting requirement, CASA may still recommend that lighting be installed. There are a couple of wind farms in remote areas (e.g. Broken Hill & Dubbo – 180m turbines) where CASA have recommended that no lighting is required. For the neighbouring Sapphire wind farm, Matthew understood that Medium Intensity lighting had been recommended. Ambidji pointed out that this approach undermines one of the purposes of the risk assessment. Matthew indicated that CASA consider that a “cookie cutter” approach to many aviation risk assessments is taken and therefore do not have great confidence in their findings / recommendations. The potential effectiveness of lighting as a last line of defence as collision mitigation was discussed and Ambidji presented that this needs to be presented in comparison to other controls that may be more effective in preventing pilots descending to a low level in the vicinity of the wind farms. This includes the clear identification of key accident scenarios and the relevant preventative / mitigative controls so that a logical and well-founded outcome could be presented. Ambidji suggested that the Bowtie risk assessment methodology would be well suited and arranged to follow up with a face to face meeting on the 11th July in Canberra to discuss further. Matthew was unavailable on the day.	Traffic Density Cumulative Effect of multiple wind farms.

Date	Organisation / Contact	Discussion Points / Comments	Hazard Identification (HAZID) items
		The cumulative risk from multiple wind farms and the potential additional hazard that could be introduced if a non-standard approach re: lighting is taken (false negative) was also discussed, with Matthew in agreement that the cumulative risk should be considered.	
19/7/2017	SuperAir – David Boundy telecon	SuperAir are the key aerial application contractor who operate in the area (bases at Armidale, Scone & Tamworth) and have been involved in previous consultation for wind farms and also specifically in the Land and Environment Case for GIWF. When asked about the effect on their operation that the turbine height increase would have, David was clear that it will make little difference to them. David considers that the existing approved wind turbines will already prohibit aerial application in many situations. David will only be able to assess whether aerial application is feasible for particular locations, once the turbines have been constructed and all aspects can be viewed (i.e. a case by case assessment taking into account wind direction, terrain, turbulence, visibility, sun glare etc). David has no view on the need for lighting as they do not operate in low visibility conditions. David was of the opinion that all WMT should be marked and lit (day time) – irrespective of whether they were marginally under the required height for lighting. David stated that he has already expressed this view on many occasions with the multiple planning stages that have occurred in the region and feels that the wind farm developers and planning authorities simply ignore the impact that these wind farms will have on the aerial application business, which are already operating on low margins (profit). The cumulative effect of the number of wind farms in the region means that the need to operate at a higher level or with a large lateral margin from the turbines will make aerial application unviable – not safe or economic. When asked about operations at the Aeroplane Landing Areas (ALA's) in the vicinity of the wind farm, David expressed a view that these should not be	Collision with WMT – need for marking / lighting Collision with wind turbine – case by case detailed risk assessment undertaken. Loss of Control due to Turbine turbulence – assessed in task risk assessment.

Date	Organisation / Contact	Discussion Points / Comments	Hazard Identification (HAZID) items
		considered as ALA's as they are only suitable as "Ag strips" requiring a high level of skill to operate safely from them. As far as he was aware there were no "private" operations from any of these Ag strips. David stated that as far as he was aware, SuperAir were the only Aerial Application operator routinely working in the area.	
3/8/2017	Glen Innes Regional Airport / Neil Hansford Director telecon & e-mail	Glen Innes Regional Airport Pty Ltd have approved Development Approvals to construct a commercial flight academy on the airport where it has a 30+30 year lease with a first right option to purchase. Construction is due to commence in November 2017. The capacity is to have 35 aircraft on-line, up to 600 international ab-initio students which will equate to an aircraft movement every 6 minutes when completed at Stage 4. When asked about the impact of the increased turbine height on operations at Glen Innes Airport, Neil was satisfied that as long as the impact assessment indicates no impact on the obstacle free surfaces, that the wind farm is far enough away that it will not affect their operations. Neil provided the recently approved RNAV procedures for the airport and the fact that these will move to the west with future runway changes (200m extension at each end). The flight academy will ensure that their training areas and flight paths / to & from are clear of the wind farm locations. Neil confirmed that the NSW Ambulance Service contractors, Royal Flying Doctor Service perform all night operations on instruments utilising the R-Nav approach and therefore he has no concern for their operations so long as the R-Nav approach isn't compromised by the Glen Innes Wind farm development and the development has perimeter lighting consistent with the requirement placed on the Sapphire Wind Farm development. Neil is mostly concerned for the itinerant recreational VFR pilots (e.g. RAA), whom are not licensed to fly at night and are most likely to "continue on" to try to get to the airport in deteriorating visibility and marginal daylight operations. Neil is concerned that it is inevitable that a collision will occur in such conditions and that	Day VFR Collision with Turbine - Pilot descending in low visibility conditions. Day VFR collision - students Night VFR Collision with Turbine – false negative due to lack of or failed lights. Night VFR – Westpac rescue helicopters performing medical rescue. Loss of Control – Turbulence from wind turbines (vertical & horizontal).

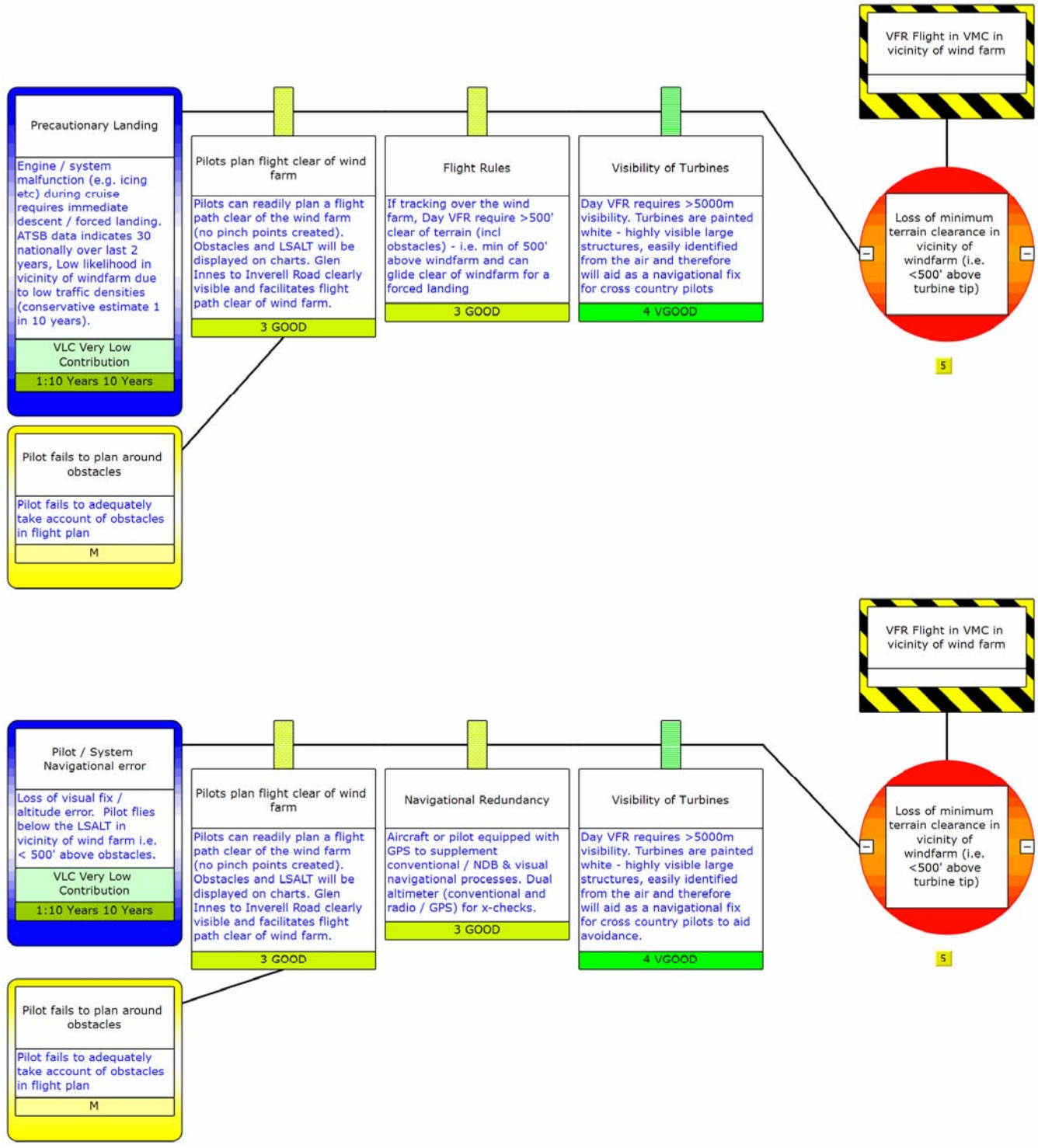
Date	Organisation / Contact	Discussion Points / Comments	Hazard Identification (HAZID) items
		this would also have a detrimental reputational impact on the Glen Inness Airport and flight academy and the reputation overseas of Glen Innes/Inverell being a unique safe training environment for student pilots. It must be noted that overseas students come with zero flying experience. Neil is therefore firmly of the opinion that obstacle collision lighting is required and believes it should follow the same lighting plan as the neighbouring Sapphire Wind Farm whose DA was modified in this regard by NSW Department of Planning. Neil agreed that preventative controls to reduce the likelihood of a pilot descending into a wind farm area in low visibility conditions would be a high priority, but felt that this was almost impossible to achieve in a self-regulating environment (i.e. RAA). Neil agreed that there is the possibility that a false negative could be created if neighbouring wind farms (near) do not follow the same lighting standard – i.e. if planning approval is given for lighting at one wind farm, then night VFR pilots will use them as a navigational aid and that, the absence of lights on another wind farm might falsely indicate to a pilot that they were clear of all turbines. Though obstacles like turbines are shown on the Navigation charts there is no guarantee recreational pilots will consult their charts before flying in the area. It is also imperative that consideration is made of rotary operations at night in medical roles i.e. Westpac Rescue on behalf of NSW Ambulance Service. Similarly, Neil spoke of the importance in having constant monitoring of lighting to ensure that they are working, as a failed light could lead a pilot into a false sense of security (i.e. believe they are clear of obstacles). Neil gave the example of the TV antennae lights on Carpenters Hill (in proximity to Glen Innes airport), which an airport employee checks on a daily basis as part of the Airport Daily Operations Check and is constantly reporting failed lights.	

Date	Organisation / Contact	Discussion Points / Comments	Hazard Identification (HAZID) items
		On the subject of wake turbulence generated by wind turbines, Neil was concerned that there was not significant scientific evidence available to indicate the potential vertical rise of wakes and that this needed to be considered in terms of separation requirements. It is accepted that horizontal wake turbulence is out to 600 metres but there is no empirical evidence of vertical wake turbulence where pilots flying under visual flight rules may descend under the 1,000 ft ceiling to get below cloud to land at Glen Innes or Inverell Airports or to transit the area	
Multiple Dates	Glen Innes Council / Graham Price. Telecon & e-mail	Contact with Glen Innes council has been attempted via telephone and e-mail, leaving messages for Graham Price. On 3/8/2017, Greg Doman picked up the call and suggested that an incoming member of staff Malcolm Donally would be well placed for consultation. Greg offered to forward the e-mail previously sent to Graham Price on to Malcolm. To date no response has been received.	
3/8/2017	RAA / Safety	RAA receptionist suggesting e-mailing their safety department for the attention of Janelle. No response received to date.	
3/8/2017	Inverell Aviation	Left a message for Chief Pilot to call back – not yet received. Suggested also talking to Daryl who operates a daily freight run between Inverell and Glen Innes (message left, no response).	
2/8/2017	NSW RFS / Luke Wallace	Luke Wallace in the aviation operations group stated that the RFS would treat the wind turbines as per any other obstacle and perform a detailed risk assessment on a case by case basis. Luke has forwarded questions in general regarding any available RFS policy on fire fighting in proximity to wind farms. No response received in this respect to date.	
3/8/2017	NSW Ambulance Service	After speaking with Stephen Flannagan in the New England regional office, he has forwarded questions via e-mail to relevant persons in the Air ambulance division. No response received to date.	
3/8/2017	RAAA	RAAA main office phone rang out. E-mail enquiry sent via the RAAA website “contact us” form. Automated response only received.	

APPENDIX C. BASELINE FULL BOWTIE CUT-OUTS

VFR Flight in VMC

Threats



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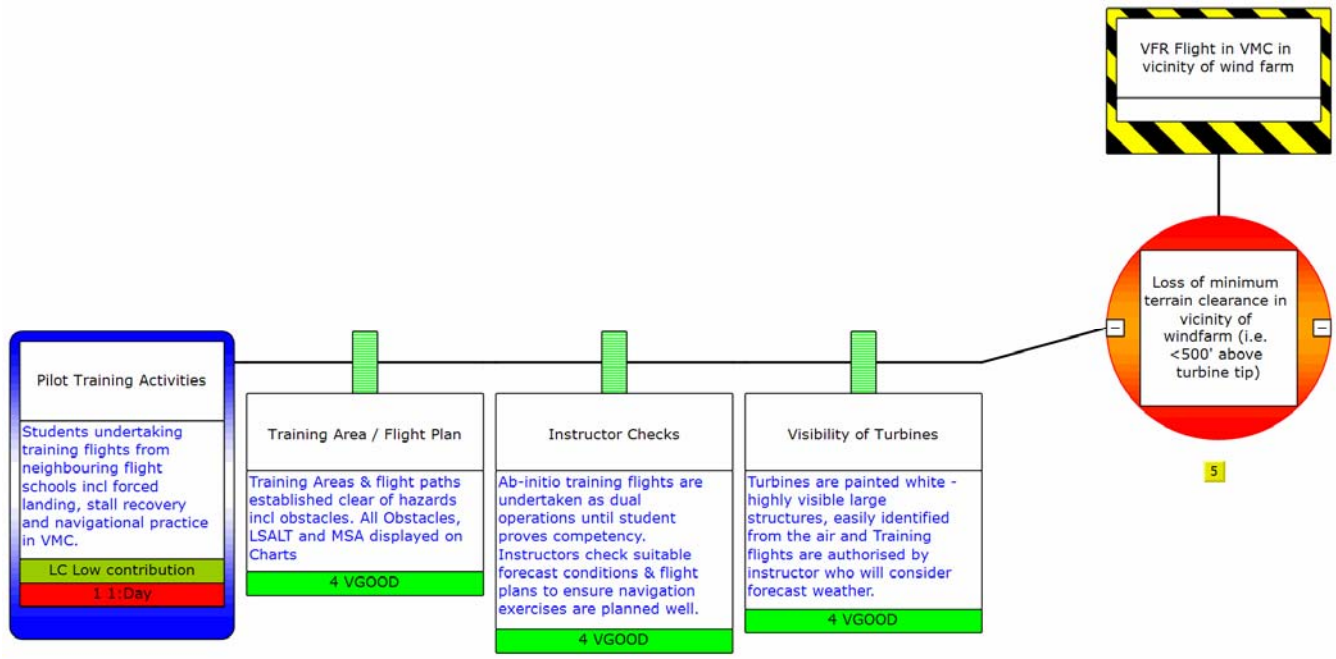
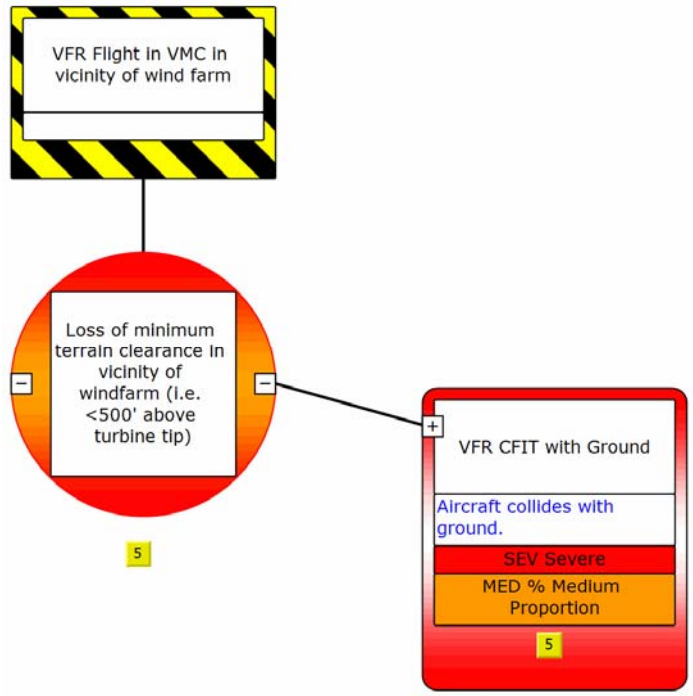
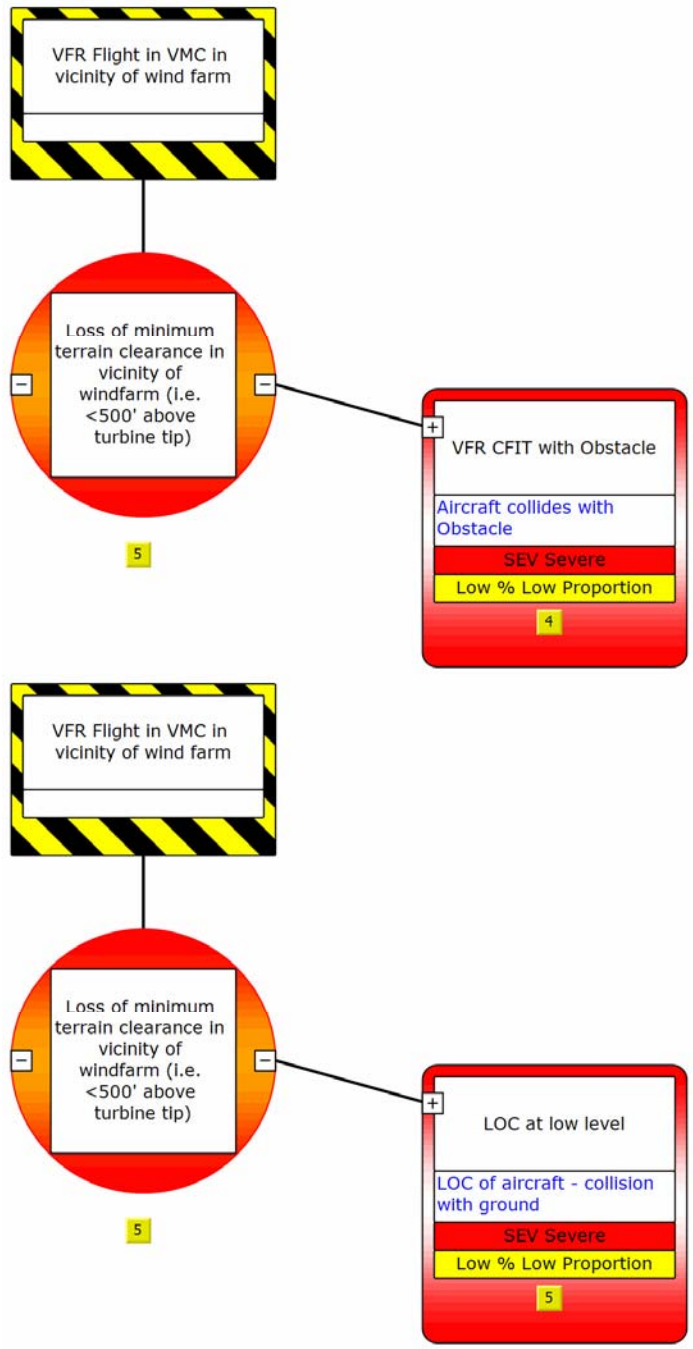
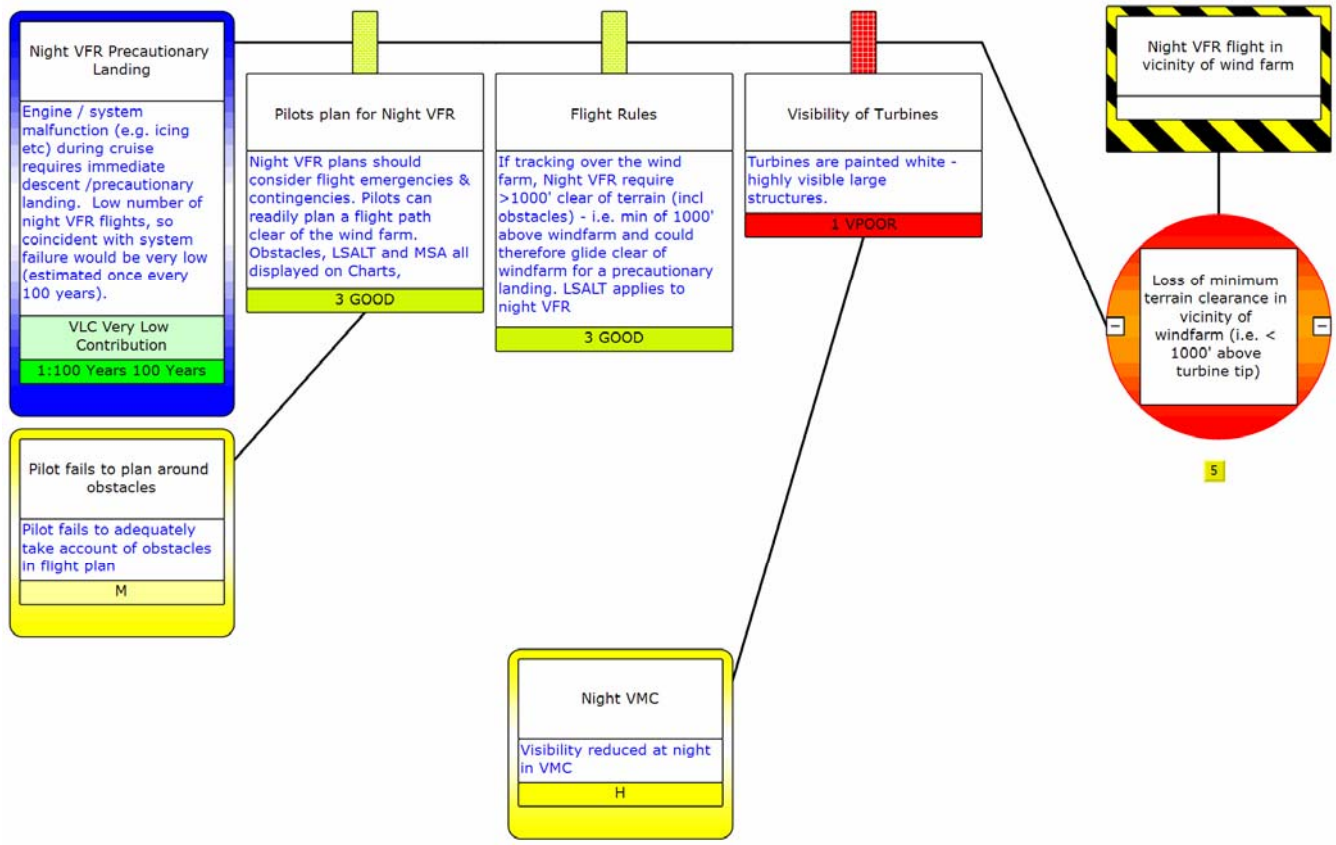


Consequences

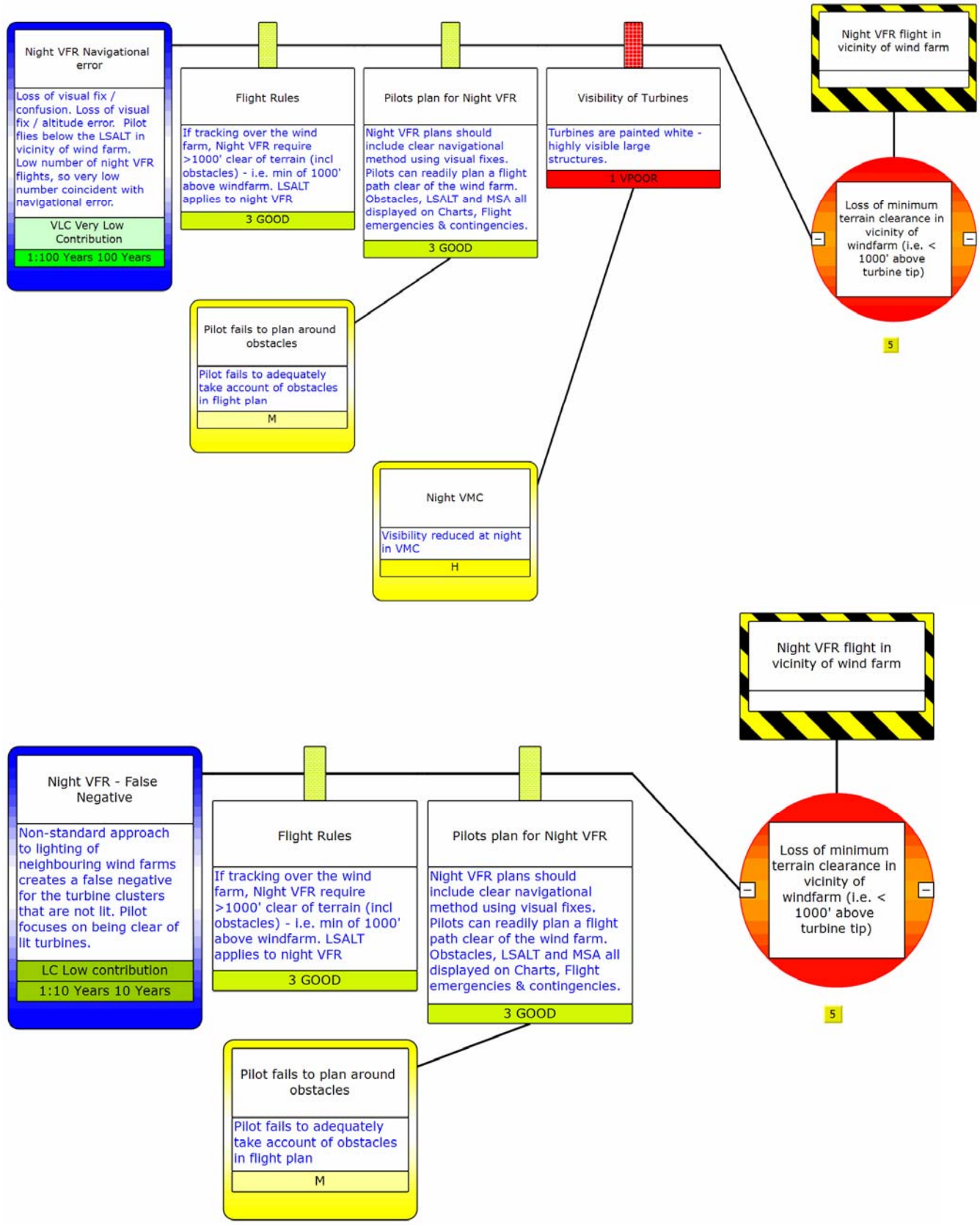



VFR Flight in VMC in vicinity of wind farm
Loss of minimum terrain clearance in vicinity of windfarm (i.e. <500' above turbine tip)
5
VFR CFIT with Obstacle
Aircraft collides with Obstacle
SEV Severe
Low % Low Proportion
4
VFR Flight in VMC in vicinity of wind farm
Loss of minimum terrain clearance in vicinity of windfarm (i.e. <500' above turbine tip)
5
LOC at low level
LOC of aircraft - collision with ground
SEV Severe
Low % Low Proportion
5

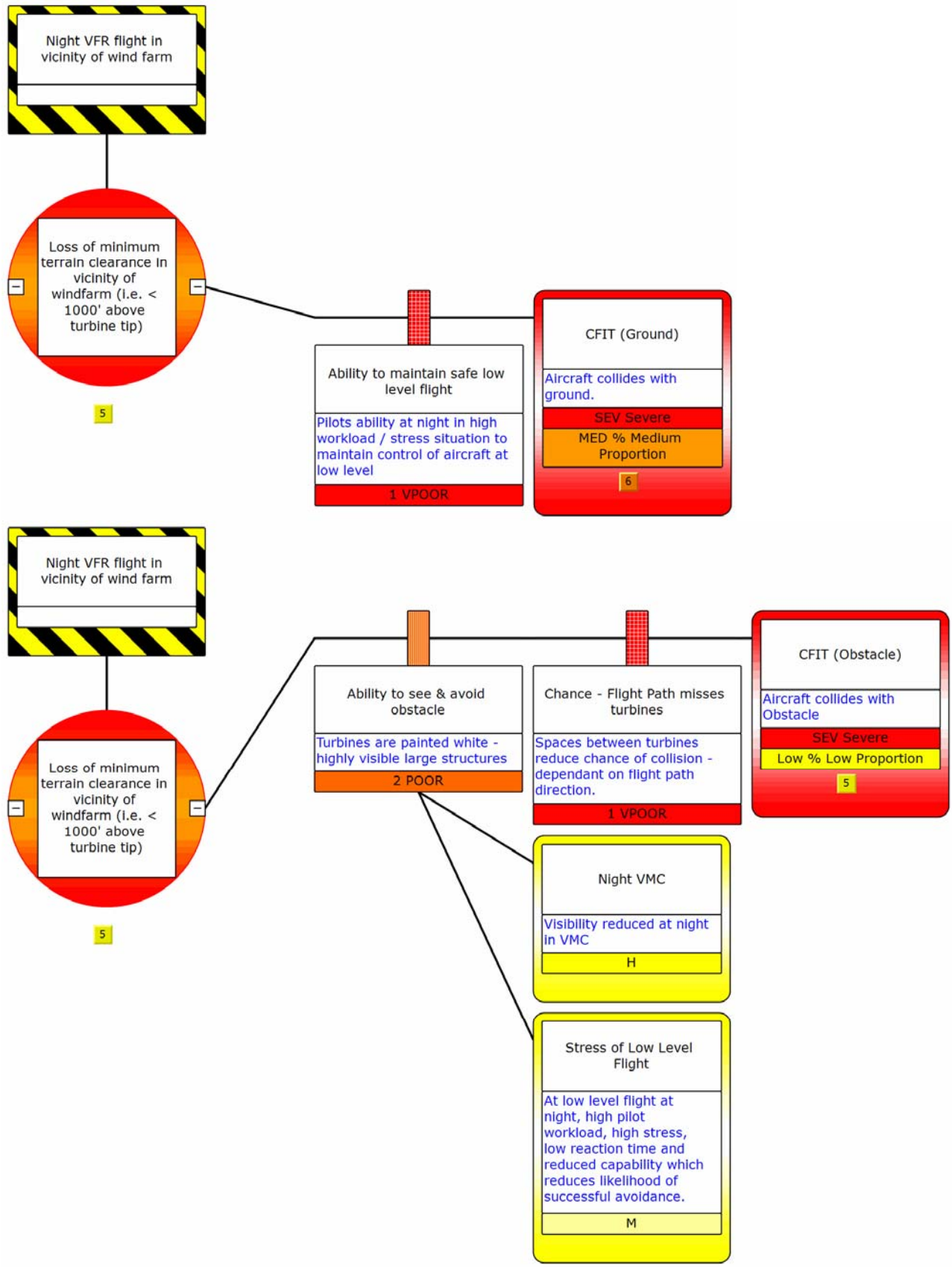
Night VFR flight
Threats

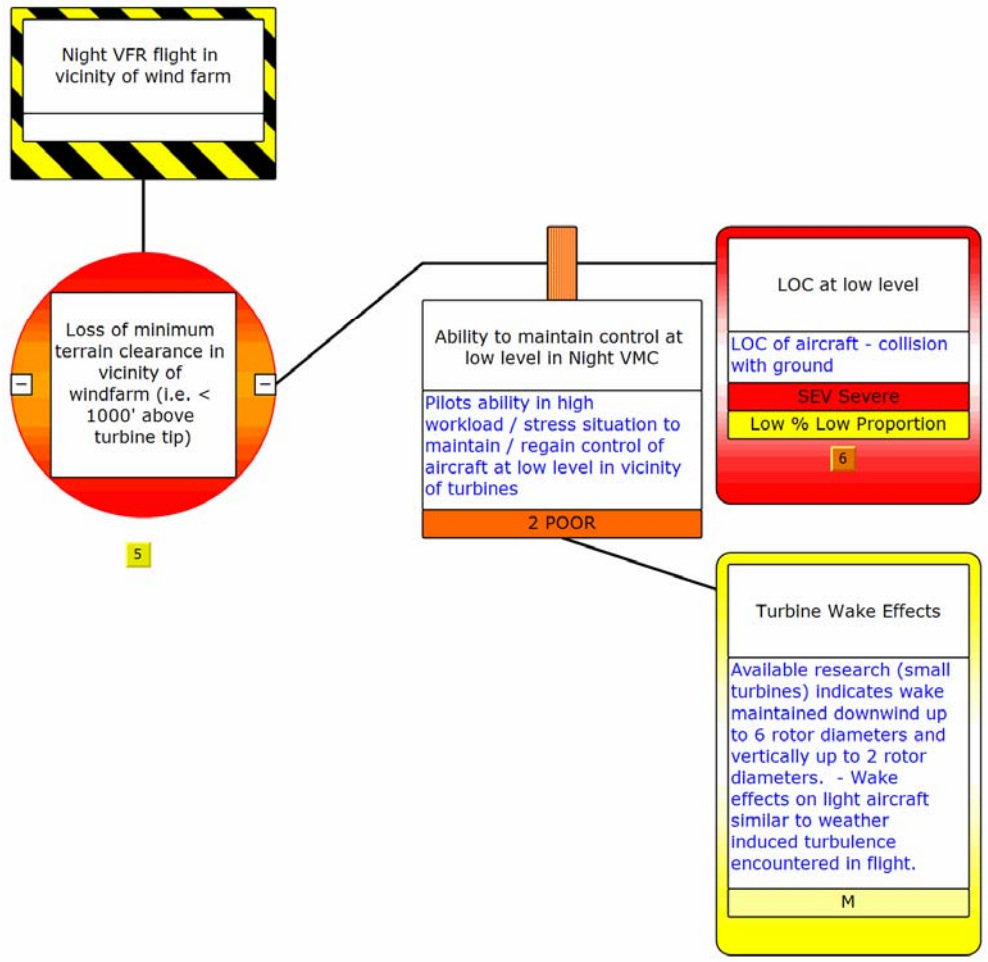


THE AMBIDJI GROUP



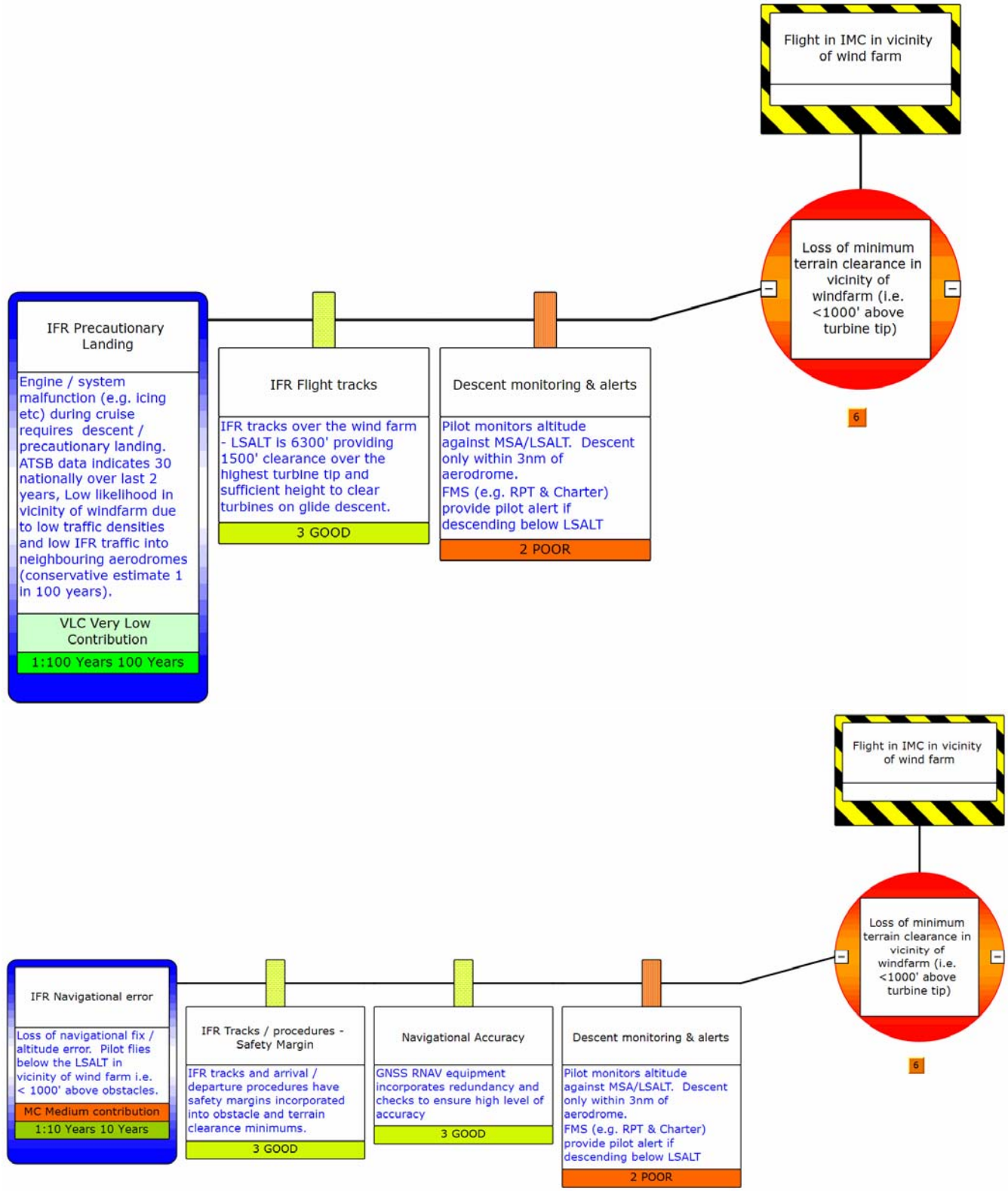
Consequences


Night VFR flight in vicinity of wind farm
Loss of minimum terrain clearance in vicinity of windfarm (i.e. < 1000' above turbine tip)
5
Ability to maintain safe low level flight
Pilots ability at night in high workload / stress situation to maintain control of aircraft at low level
1 VPOOR
CFIT (Ground)
Aircraft collides with ground.
SEV Severe
MED % Medium Proportion
6
Night VFR flight in vicinity of wind farm
Loss of minimum terrain clearance in vicinity of windfarm (i.e. < 1000' above turbine tip)
5
Ability to see & avoid obstacle
Turbines are painted white - highly visible large structures
2 POOR
Chance - Flight Path misses turbines
Spaces between turbines reduce chance of collision - dependant on flight path direction.
1 VPOOR
CFIT (Obstacle)
Aircraft collides with Obstacle
SEV Severe
Low % Low Proportion
5
Night VMC
Visibility reduced at night in VMC
H
Stress of Low Level Flight
At low level flight at night, high pilot workload, high stress, low reaction time and reduced capability which reduces likelihood of successful avoidance.
M


Night VFR flight in vicinity of wind farm
Loss of minimum terrain clearance in vicinity of windfarm (i.e. < 1000' above turbine tip)
5
Ability to maintain control at low level in Night VMC
Pilots ability in high workload / stress situation to maintain / regain control of aircraft at low level in vicinity of turbines
2 POOR
LOC at low level
LOC of aircraft - collision with ground
SEV Severe
Low % Low Proportion
6
Turbine Wake Effects
Available research (small turbines) indicates wake maintained downwind up to 6 rotor diameters and vertically up to 2 rotor diameters. - Wake effects on light aircraft similar to weather induced turbulence encountered in flight.
M

Flight in IMC

Threats



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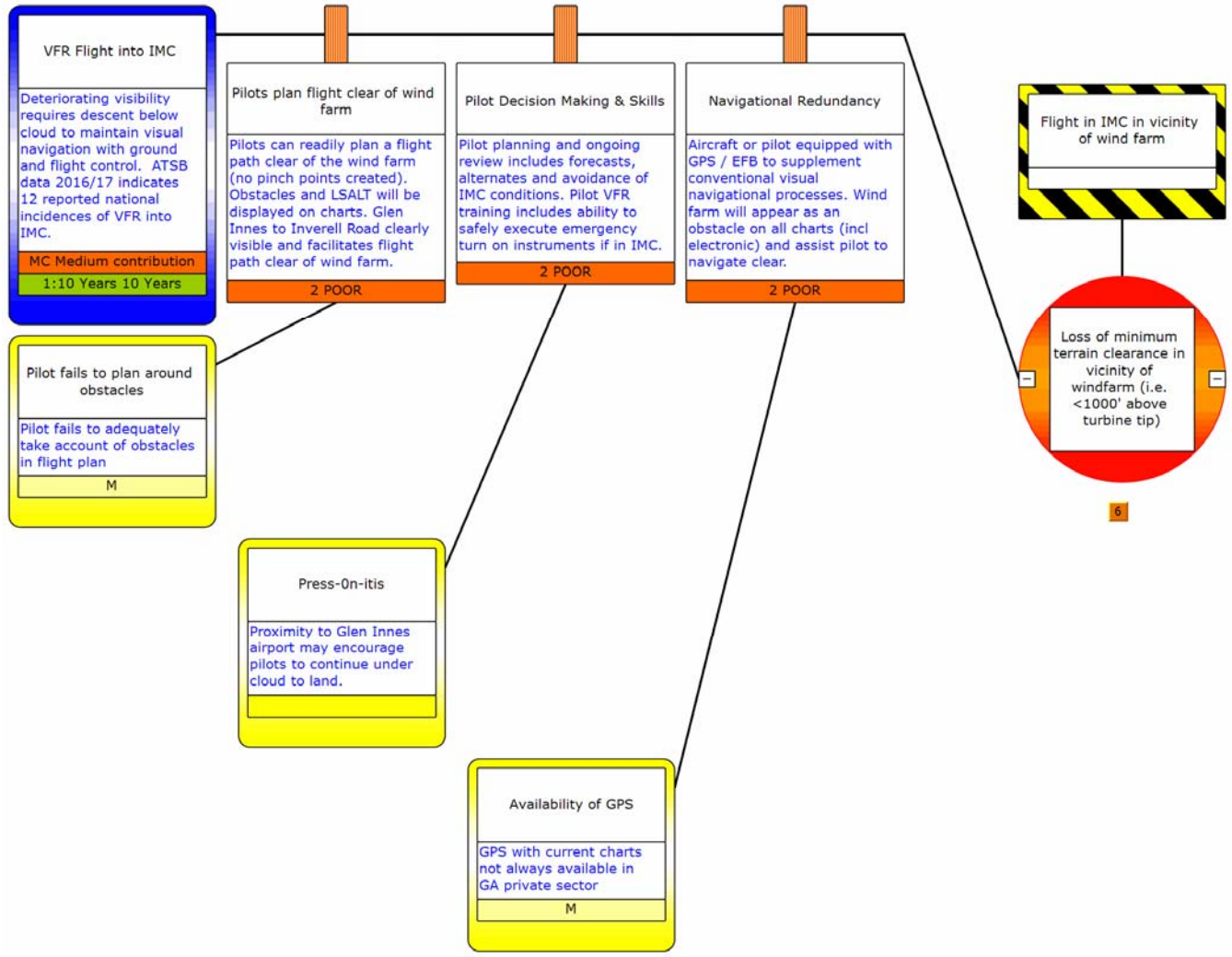
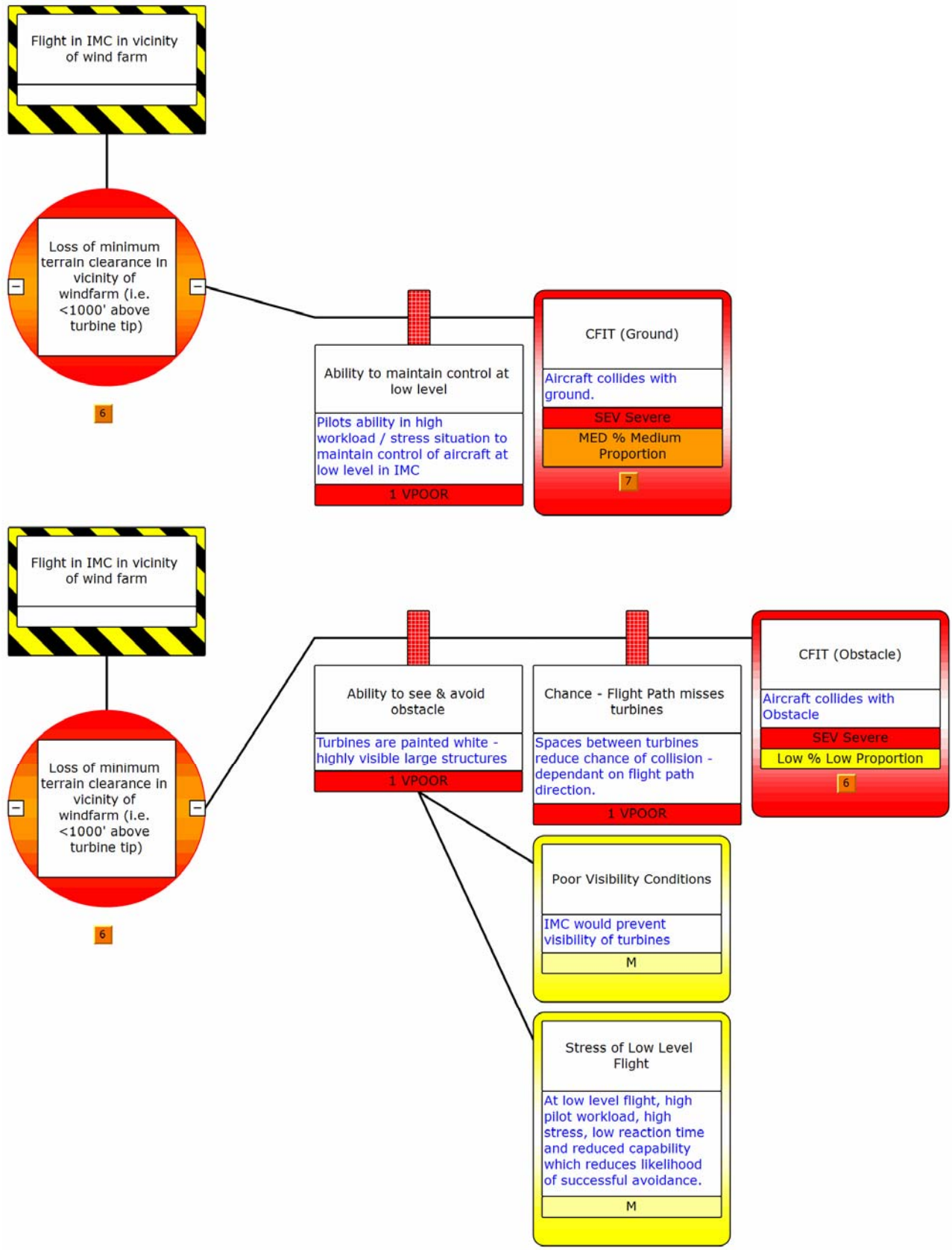
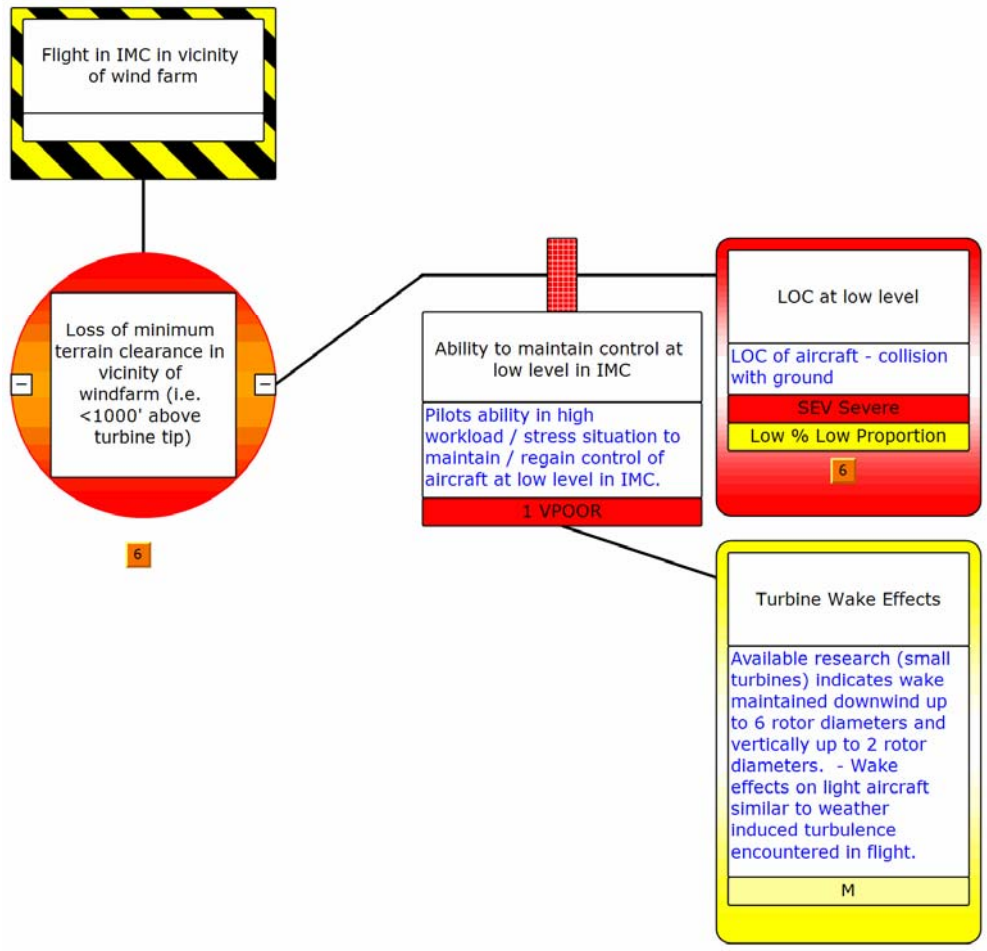


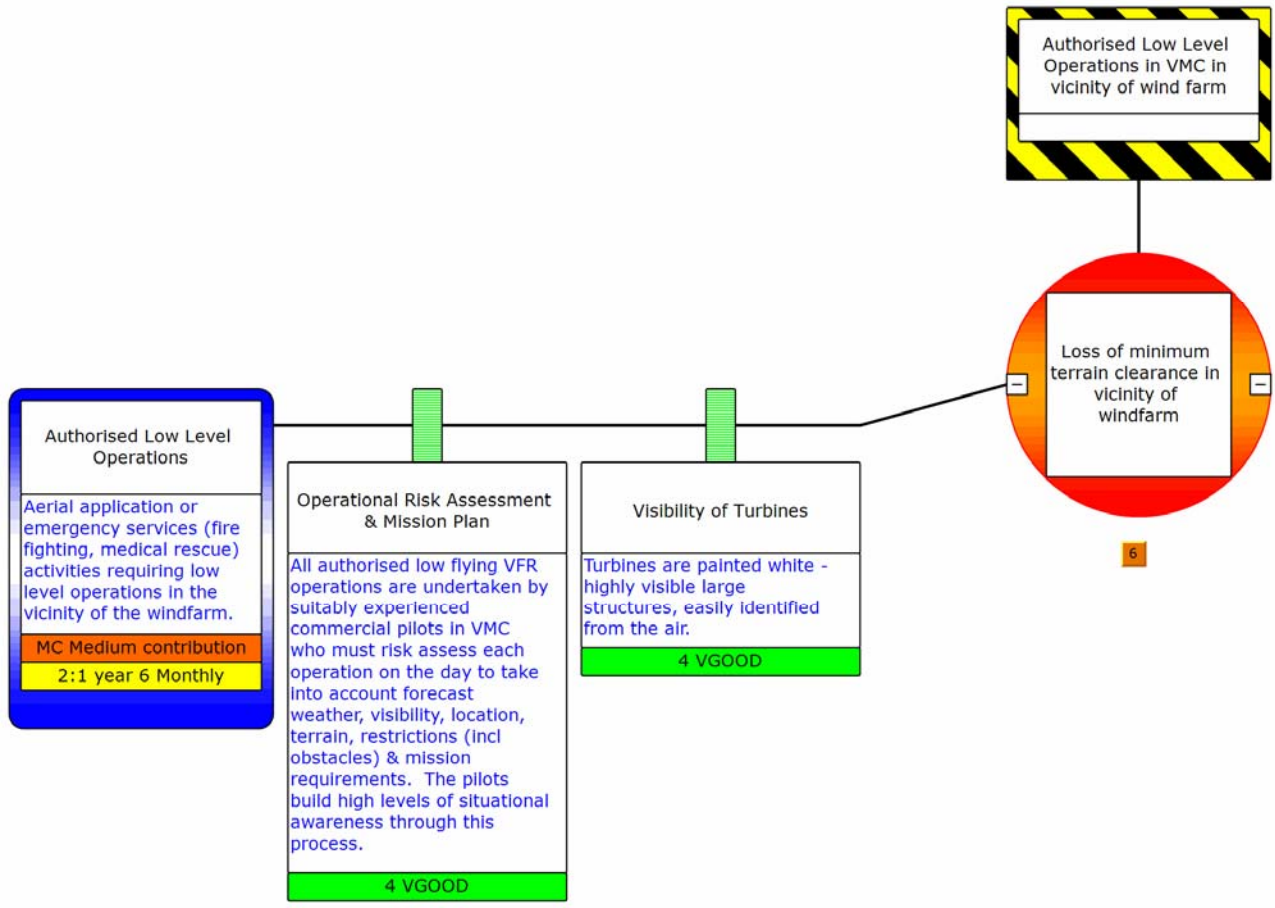
Consequences


Flight in IMC in vicinity of wind farm
Loss of minimum terrain clearance in vicinity of windfarm (i.e. <1000' above turbine tip)
6
Ability to maintain control at low level
Pilots ability in high workload / stress situation to maintain control of aircraft at low level in IMC
1 VPOOR
CFIT (Ground)
Aircraft collides with ground.
SEV Severe
MED % Medium Proportion
7
Flight in IMC in vicinity of wind farm
Loss of minimum terrain clearance in vicinity of windfarm (i.e. <1000' above turbine tip)
6
Ability to see & avoid obstacle
Turbines are painted white - highly visible large structures
1 VPOOR
Chance - Flight Path misses turbines
Spaces between turbines reduce chance of collision - dependant on flight path direction.
1 VPOOR
CFIT (Obstacle)
Aircraft collides with Obstacle
SEV Severe
Low % Low Proportion
6
Poor Visibility Conditions
IMC would prevent visibility of turbines
M
Stress of Low Level Flight
At low level flight, high pilot workload, high stress, low reaction time and reduced capability which reduces likelihood of successful avoidance.
M

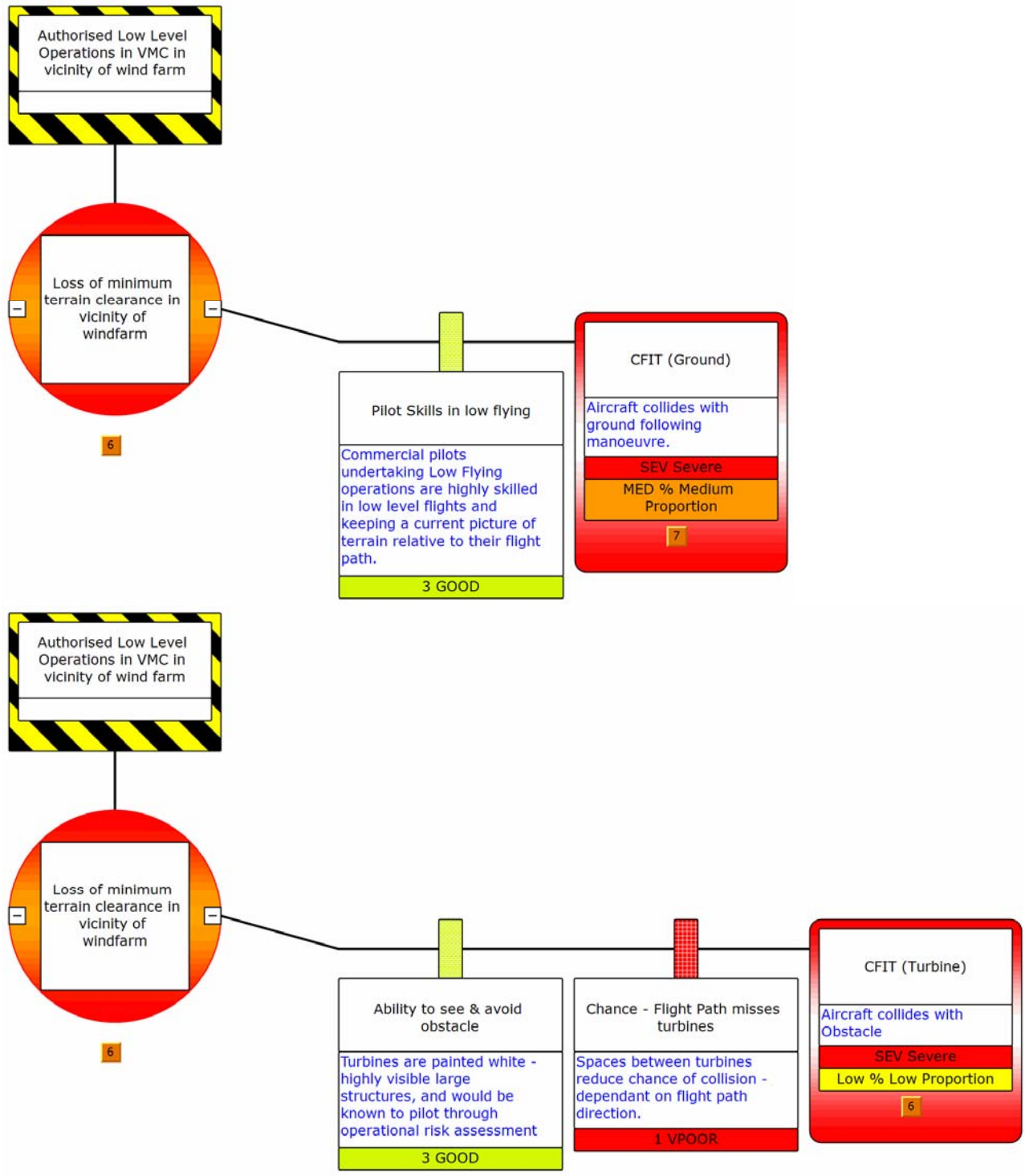

Flight in IMC in vicinity of wind farm
Loss of minimum terrain clearance in vicinity of windfarm (i.e. <1000' above turbine tip)
6
Ability to maintain control at low level in IMC
Pilots ability in high workload / stress situation to maintain / regain control of aircraft at low level in IMC.
1 VPOOR
LOC at low level
LOC of aircraft - collision with ground
SEV Severe
Low % Low Proportion
6
Turbine Wake Effects
Available research (small turbines) indicates wake maintained downwind up to 6 rotor diameters and vertically up to 2 rotor diameters. - Wake effects on light aircraft similar to weather induced turbulence encountered in flight.
M

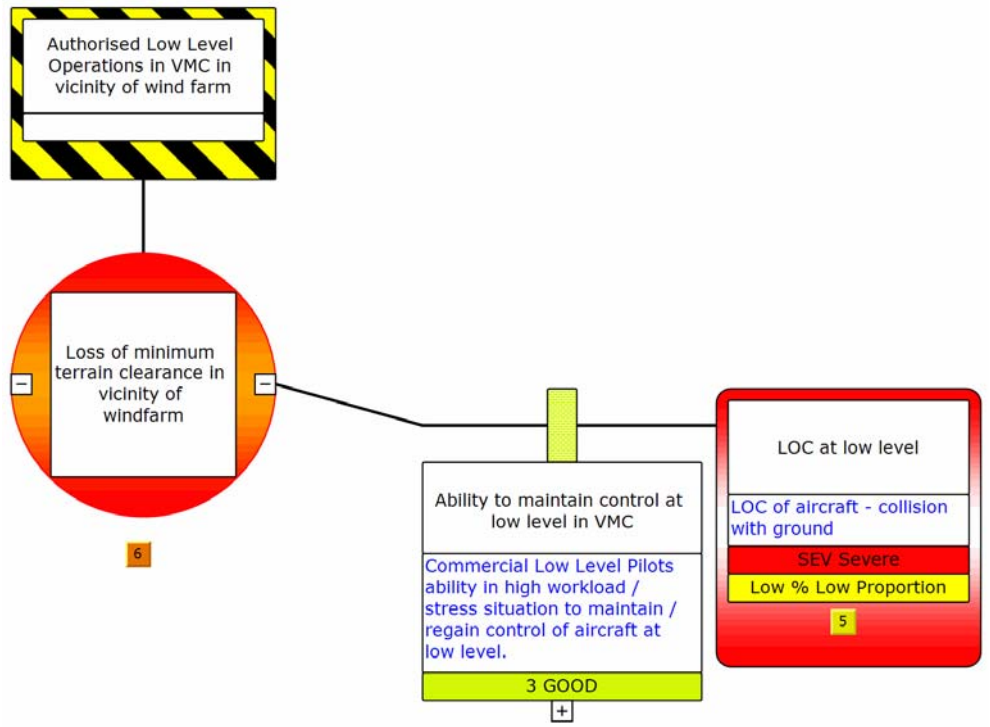
Authorised Low Level Operations

Threats



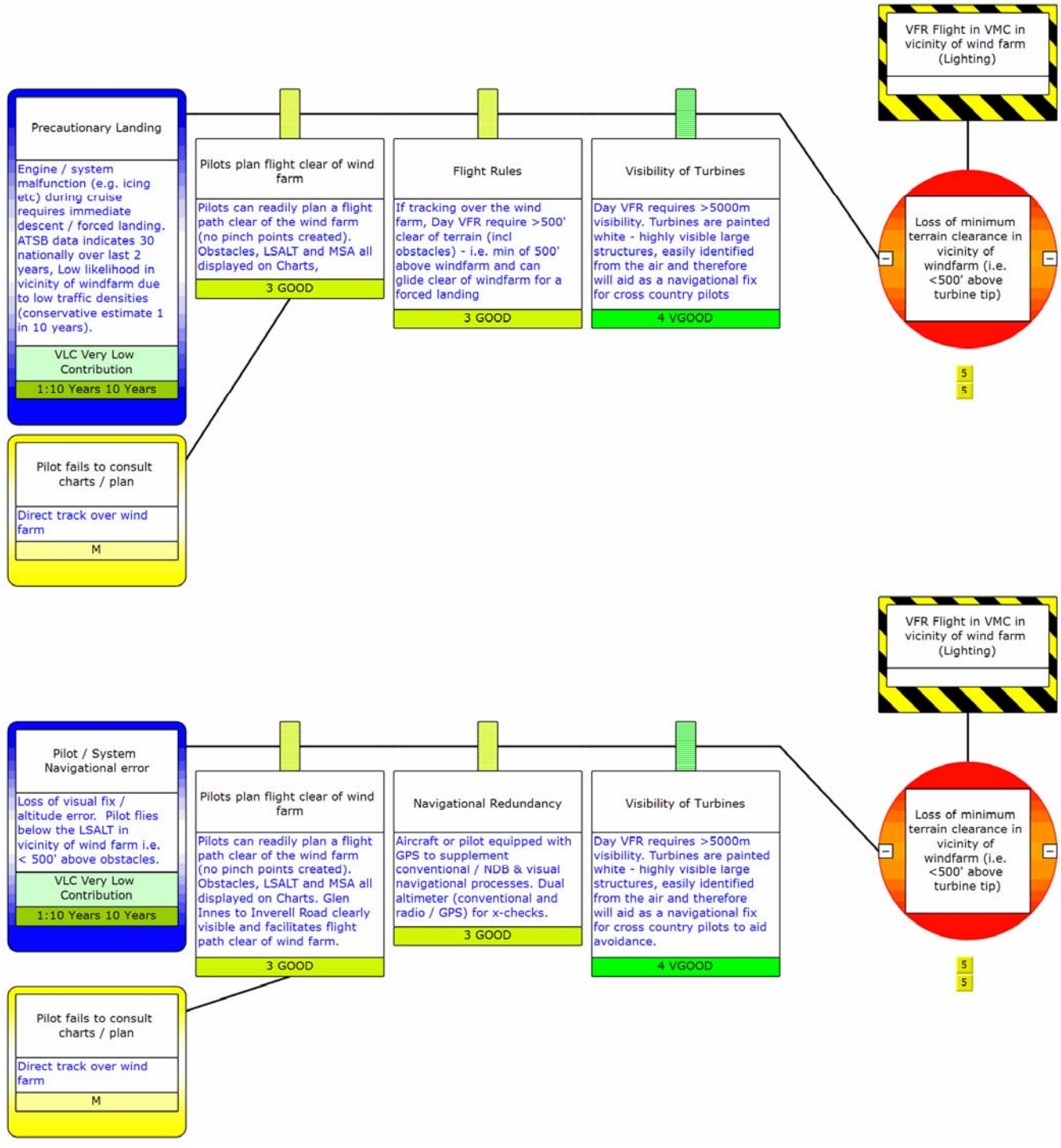
Consequences


Authorised Low Level Operations in VMC in vicinity of wind farm
Loss of minimum terrain clearance in vicinity of windfarm
6
Pilot Skills in low flying
Commercial pilots undertaking Low Flying operations are highly skilled in low level flights and keeping a current picture of terrain relative to their flight path.
3 GOOD
CFIT (Ground)
Aircraft collides with ground following manoeuvre.
SEV Severe
MED % Medium Proportion
7
Authorised Low Level Operations in VMC in vicinity of wind farm
Loss of minimum terrain clearance in vicinity of windfarm
6
Ability to see & avoid obstacle
Turbines are painted white - highly visible large structures, and would be known to pilot through operational risk assessment
3 GOOD
Chance - Flight Path misses turbines
Spaces between turbines reduce chance of collision - dependant on flight path direction.
1 VPOOR
CFIT (Turbine)
Aircraft collides with Obstacle
SEV Severe
Low % Low Proportion
6

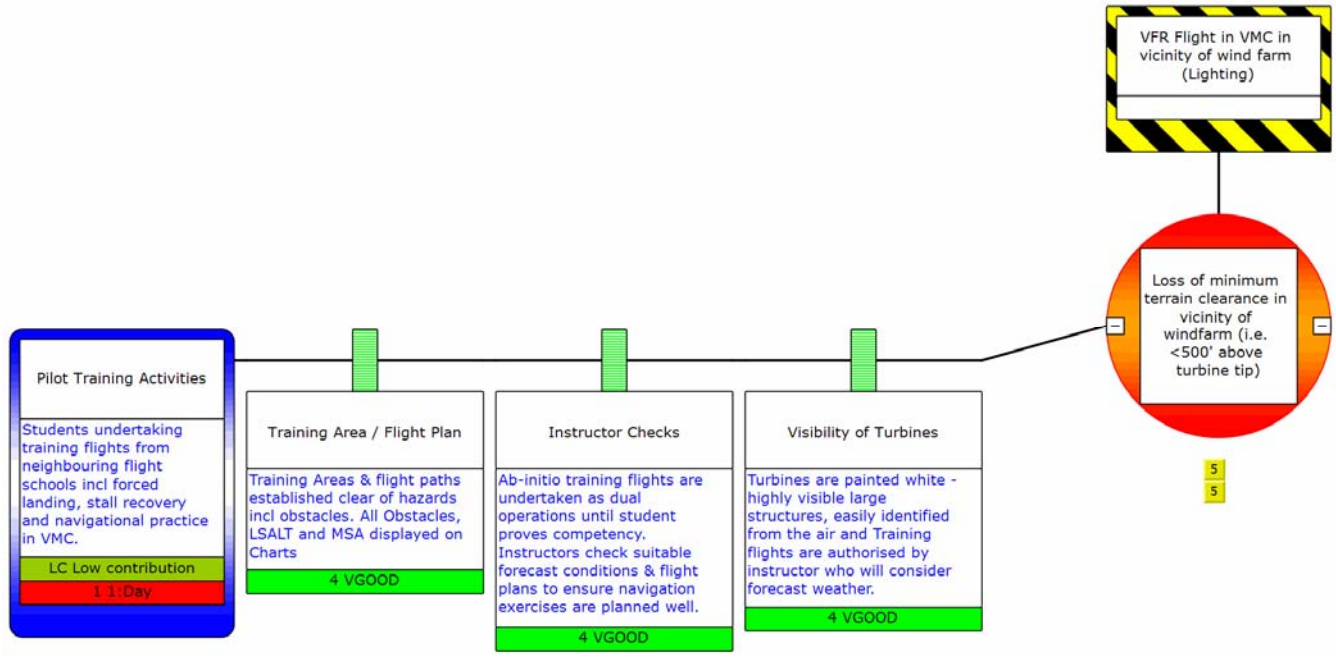

Authorised Low Level Operations in VMC in vicinity of wind farm
Loss of minimum terrain clearance in vicinity of windfarm
6
Ability to maintain control at low level in VMC
Commercial Low Level Pilots ability in high workload / stress situation to maintain / regain control of aircraft at low level.
3 GOOD
LOC at low level
LOC of aircraft - collision with ground
SEV Severe
Low % Low Proportion
5

APPENDIX D. OBSTACLE LIGHTING FULL BOWTIE CUT-OUTS

VFR Flight in VMC (Lighting)
Threats



THE AMBIDJI GROUP



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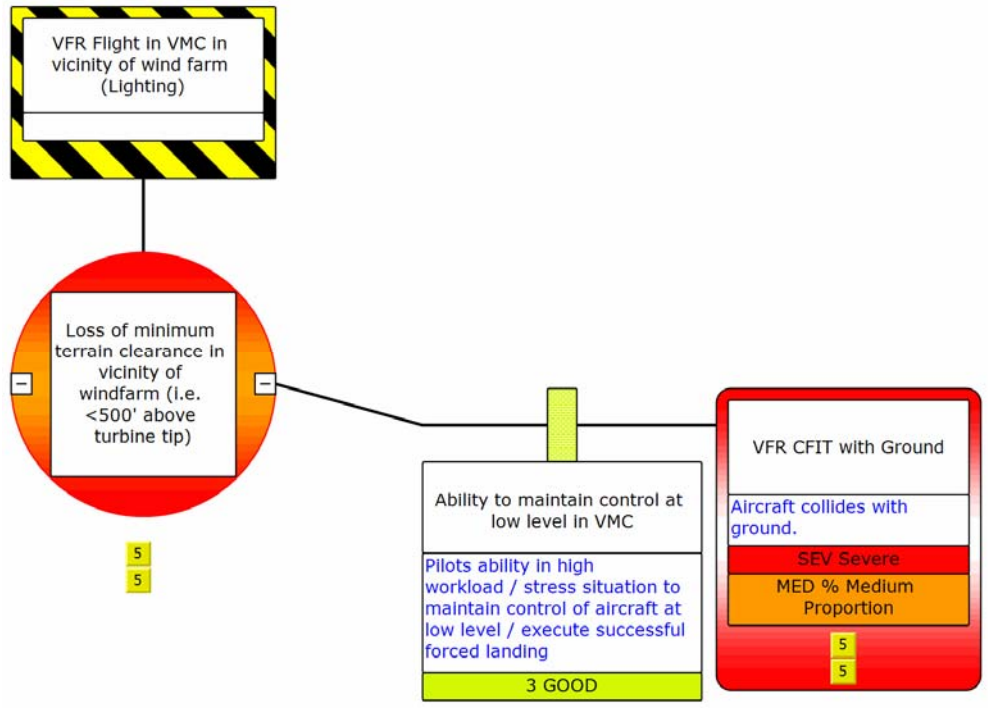
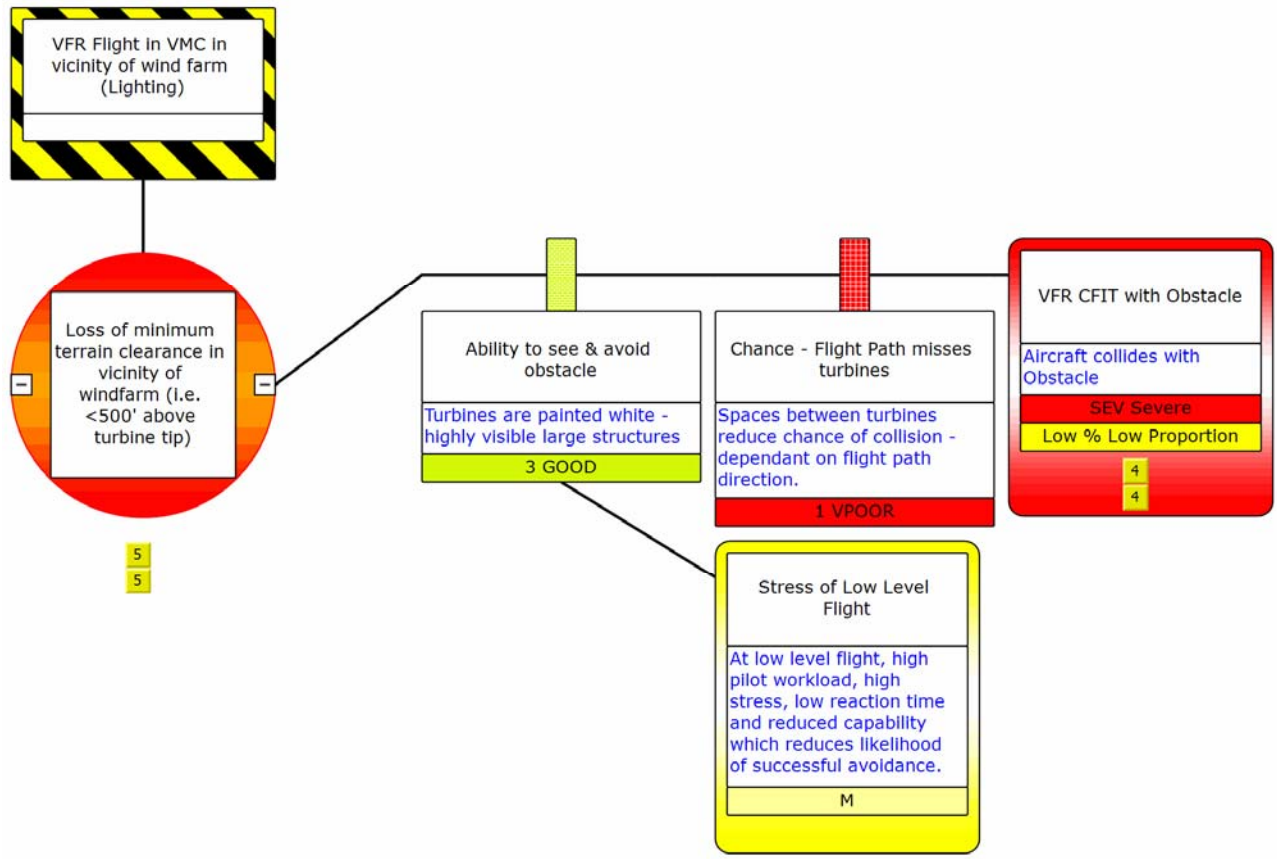
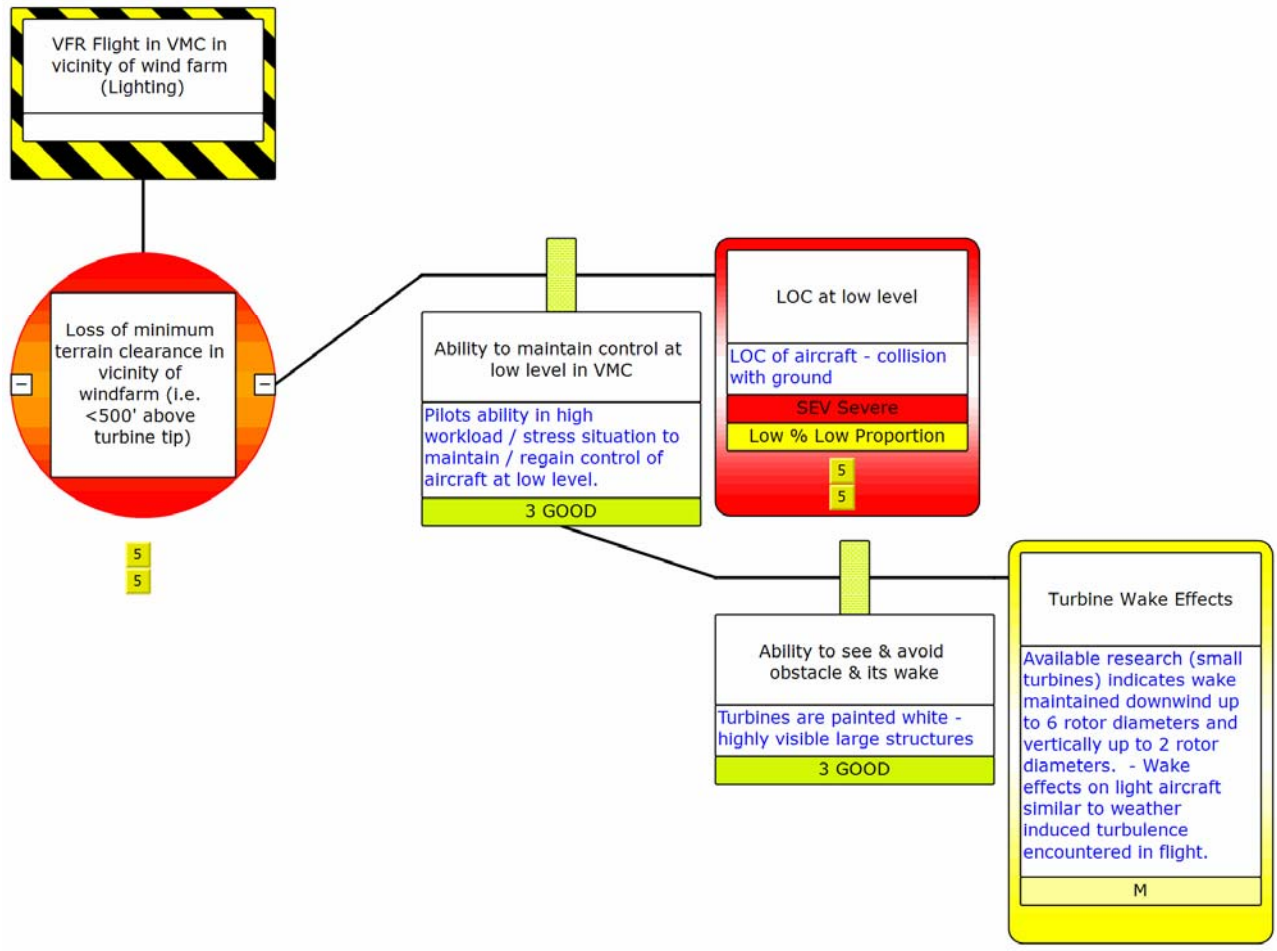
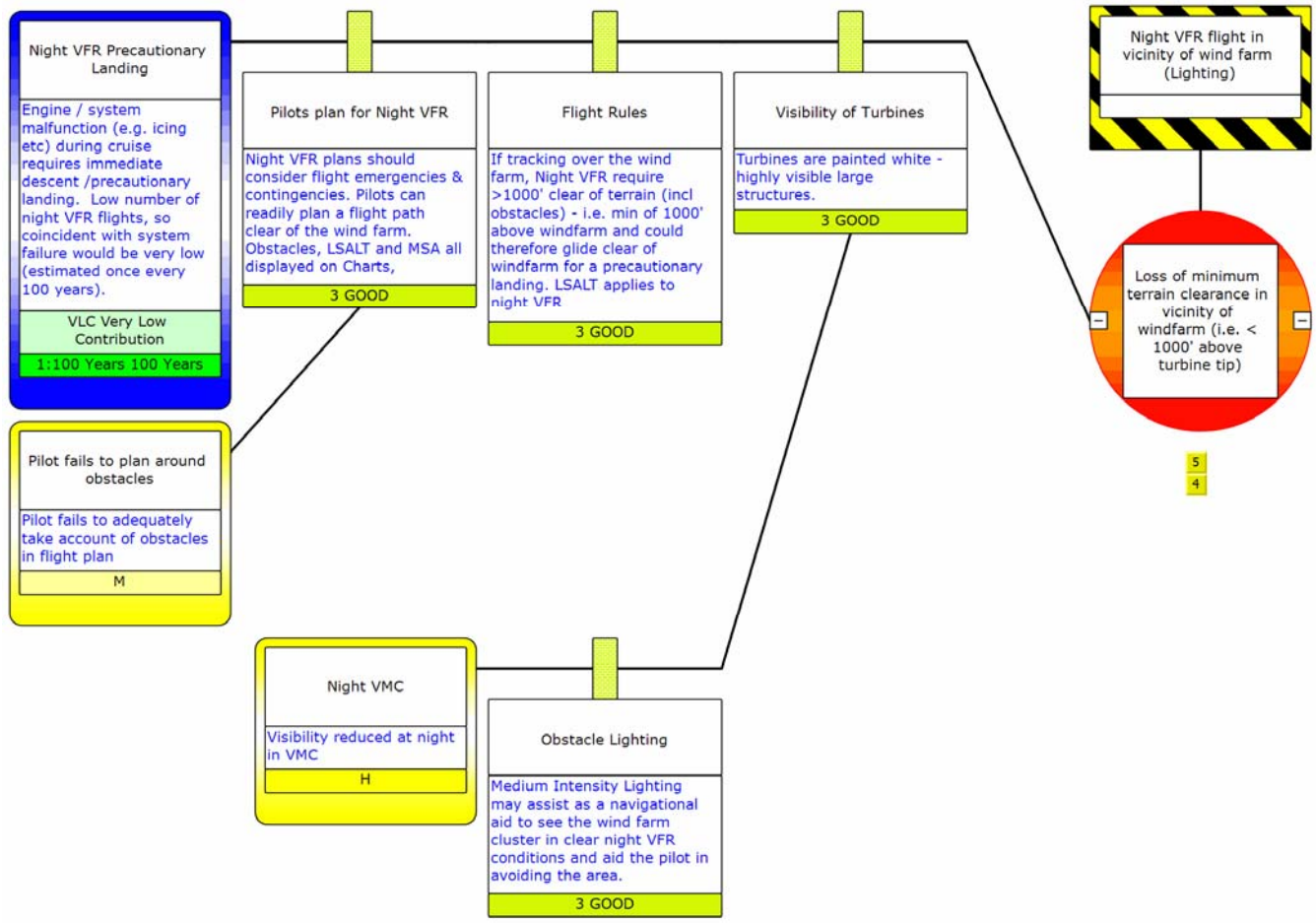
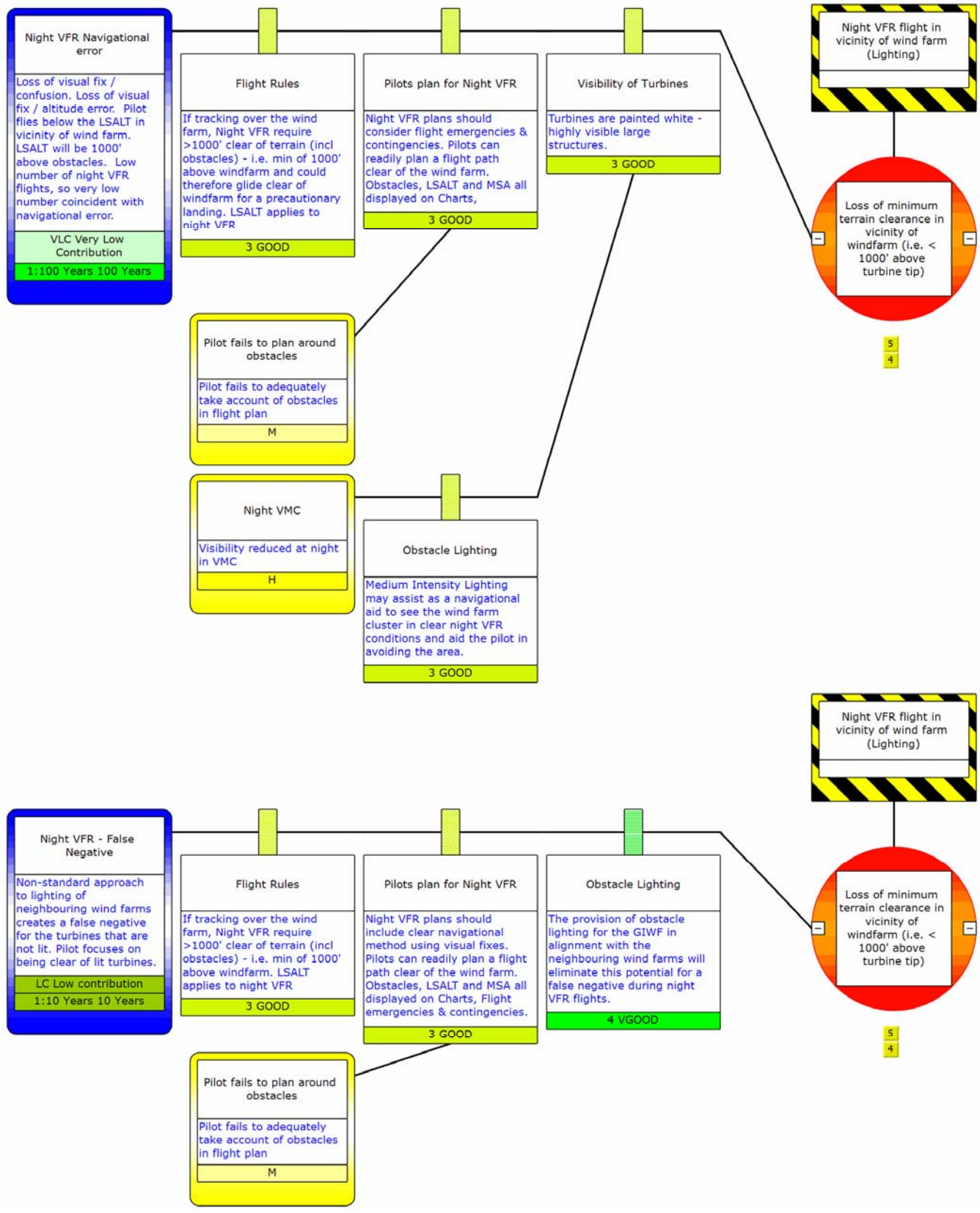



VFR Flight in VMC in vicinity of wind farm (Lighting)
Loss of minimum terrain clearance in vicinity of windfarm (i.e. <500' above turbine tip)
5
5
Ability to see & avoid obstacle
Turbines are painted white - highly visible large structures
3 GOOD
Chance - Flight Path misses turbines
Spaces between turbines reduce chance of collision - dependant on flight path direction.
1 VPOOR
VFR CFIT with Obstacle
Aircraft collides with Obstacle
SEV Severe
Low % Low Proportion
4
4
Stress of Low Level Flight
At low level flight, high pilot workload, high stress, low reaction time and reduced capability which reduces likelihood of successful avoidance.
M

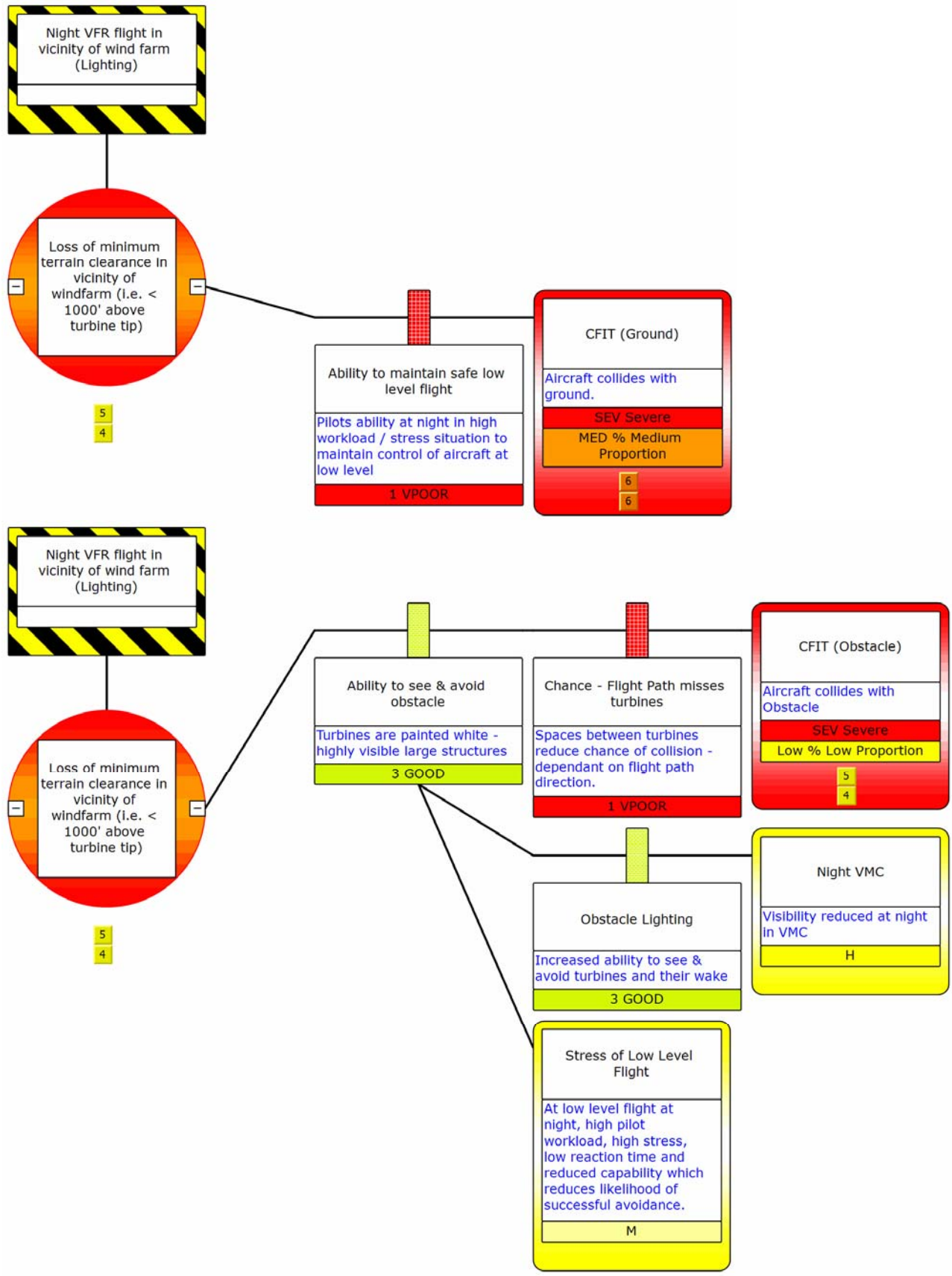

VFR Flight in VMC in vicinity of wind farm (Lighting)
Loss of minimum terrain clearance in vicinity of windfarm (i.e. <500' above turbine tip)
5
5
Ability to maintain control at low level in VMC
Pilots ability in high workload / stress situation to maintain / regain control of aircraft at low level.
3 GOOD
LOC at low level
LOC of aircraft - collision with ground
SEV Severe
Low % Low Proportion
5
5
Ability to see & avoid obstacle & its wake
Turbines are painted white - highly visible large structures
3 GOOD
Turbine Wake Effects
Available research (small turbines) indicates wake maintained downwind up to 6 rotor diameters and vertically up to 2 rotor diameters. - Wake effects on light aircraft similar to weather induced turbulence encountered in flight.
M

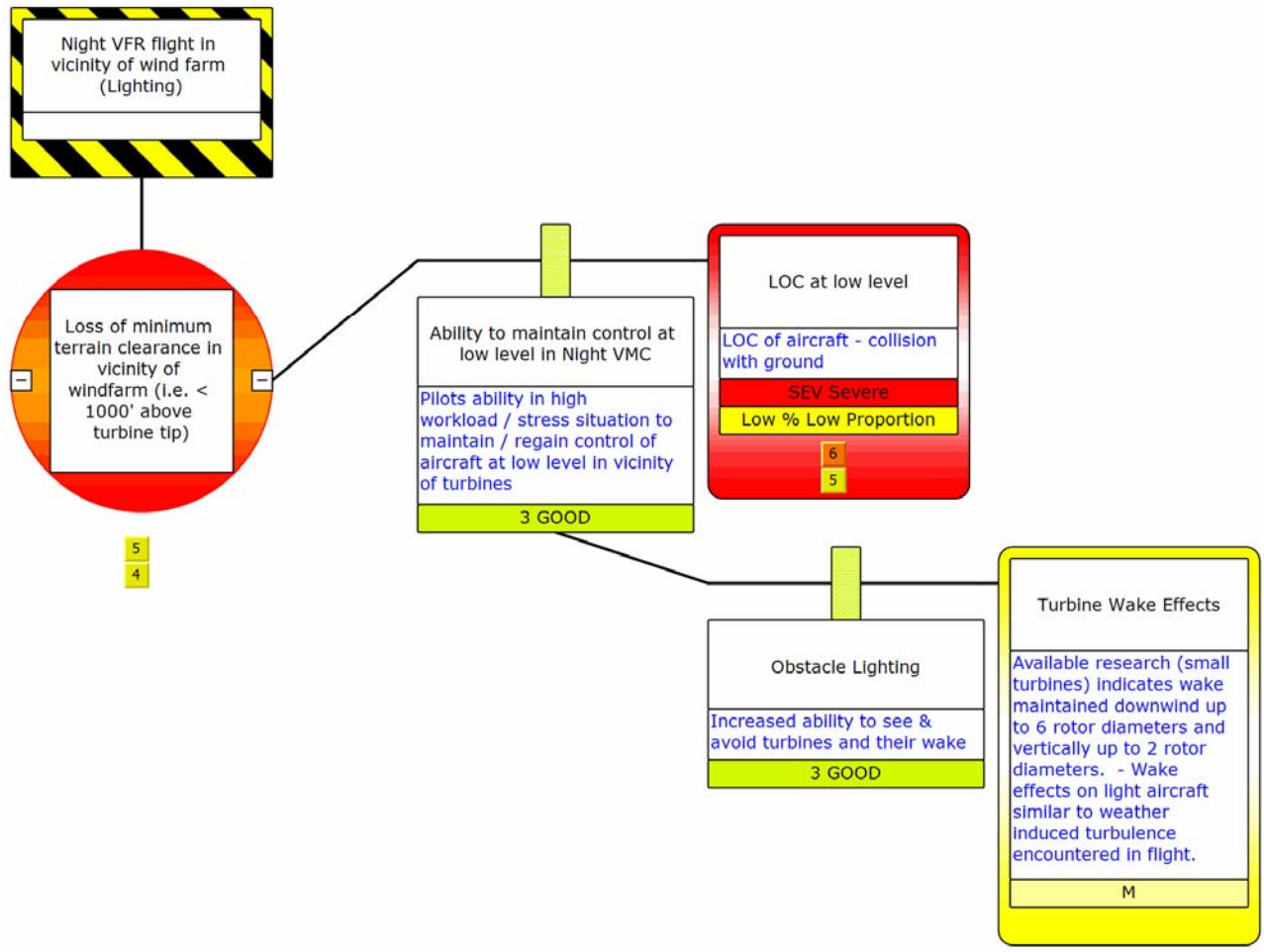
Night VFR flight (Lighting)
Threats



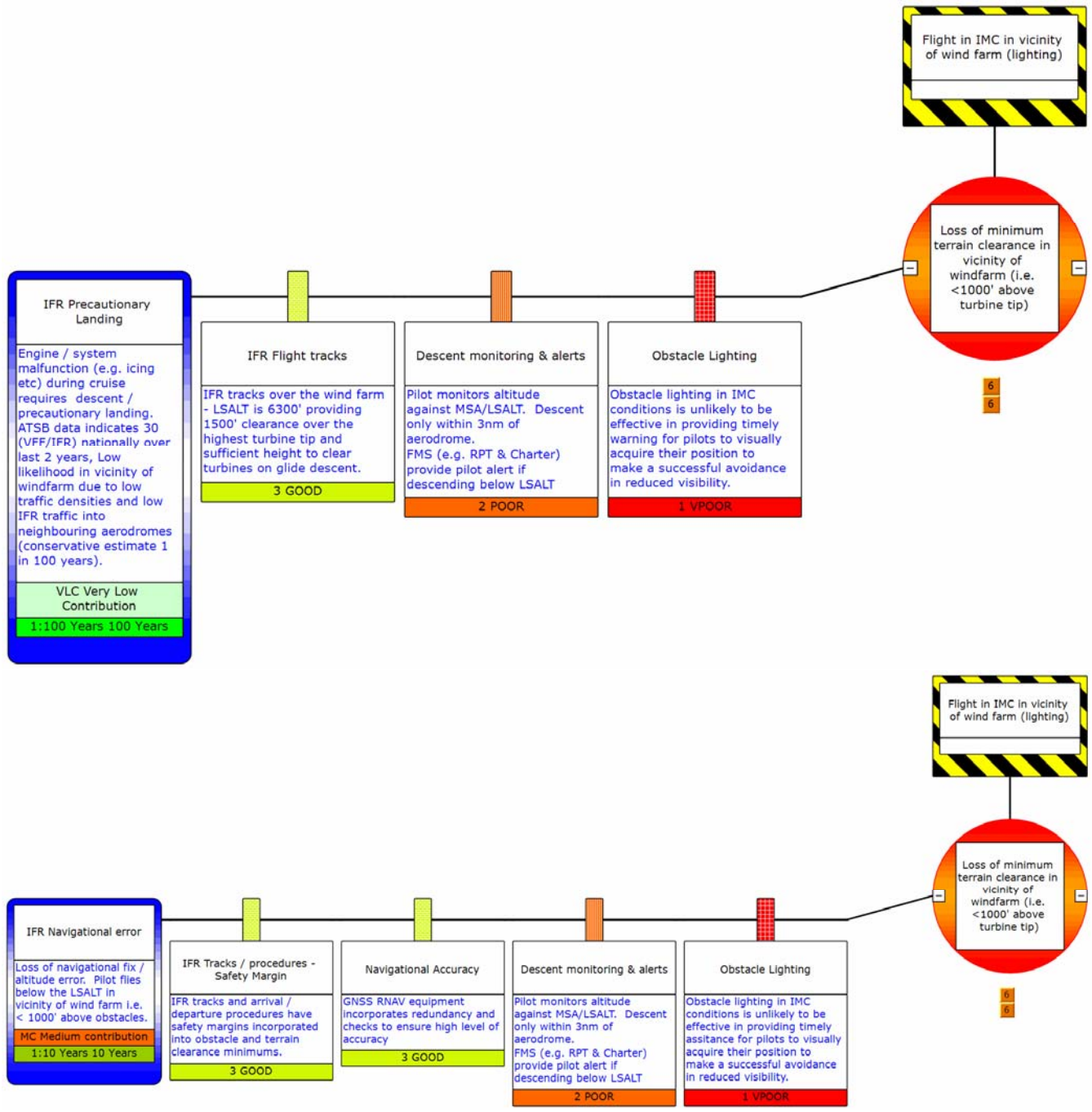


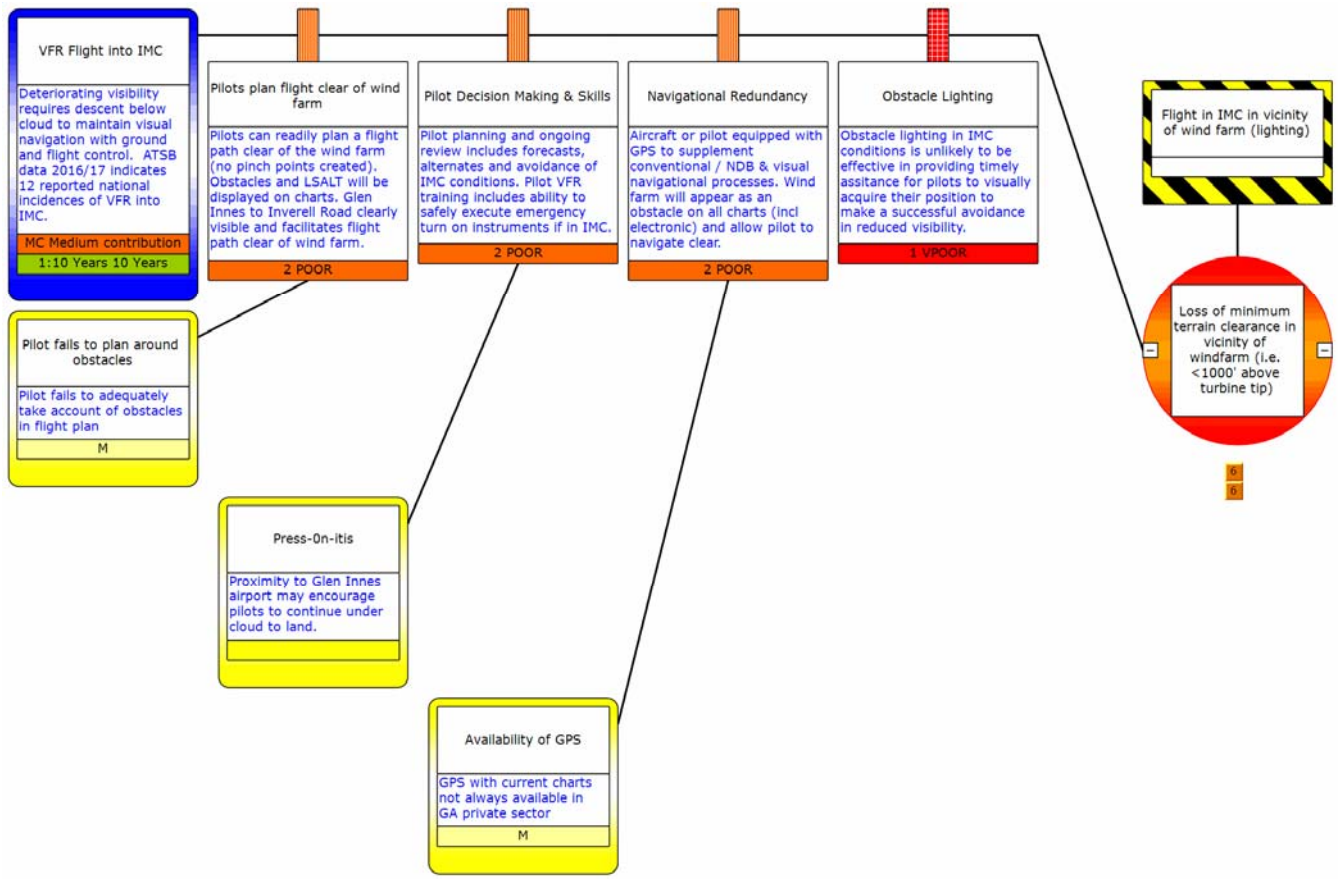
Consequences


Night VFR flight in vicinity of wind farm (Lighting)
Loss of minimum terrain clearance in vicinity of windfarm (i.e. < 1000' above turbine tip)
5
4
Ability to maintain safe low level flight
Pilots ability at night in high workload / stress situation to maintain control of aircraft at low level
1 VPOOR
CFIT (Ground)
Aircraft collides with ground.
SEV Severe
MED % Medium Proportion
6
6
Night VFR flight in vicinity of wind farm (Lighting)
Loss of minimum terrain clearance in vicinity of windfarm (i.e. < 1000' above turbine tip)
5
4
Ability to see & avoid obstacle
Turbines are painted white - highly visible large structures
3 GOOD
Chance - Flight Path misses turbines
Spaces between turbines reduce chance of collision - dependant on flight path direction.
1 VPOOR
CFIT (Obstacle)
Aircraft collides with Obstacle
SEV Severe
Low % Low Proportion
5
4
Obstacle Lighting
Increased ability to see & avoid turbines and their wake
3 GOOD
Night VMC
Visibility reduced at night in VMC
H
Stress of Low Level Flight
At low level flight at night, high pilot workload, high stress, low reaction time and reduced capability which reduces likelihood of successful avoidance.
M

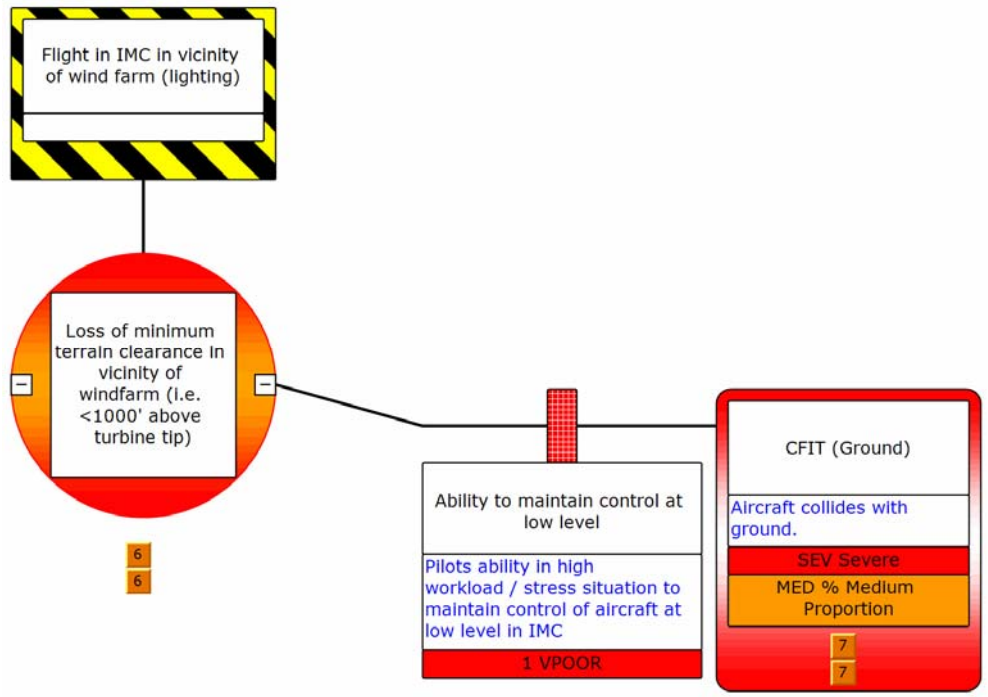

Night VFR flight in vicinity of wind farm (Lighting)
Loss of minimum terrain clearance in vicinity of windfarm (i.e. < 1000' above turbine tip)
5
4
Ability to maintain control at low level in Night VMC
Pilots ability in high workload / stress situation to maintain / regain control of aircraft at low level in vicinity of turbines
3 GOOD
LOC at low level
LOC of aircraft - collision with ground
SEV Severe
Low % Low Proportion
6
5
Obstacle Lighting
Increased ability to see & avoid turbines and their wake
3 GOOD
Turbine Wake Effects
Available research (small turbines) indicates wake maintained downwind up to 6 rotor diameters and vertically up to 2 rotor diameters. - Wake effects on light aircraft similar to weather induced turbulence encountered in flight.
M

Flight in IMC (lighting)
Threats

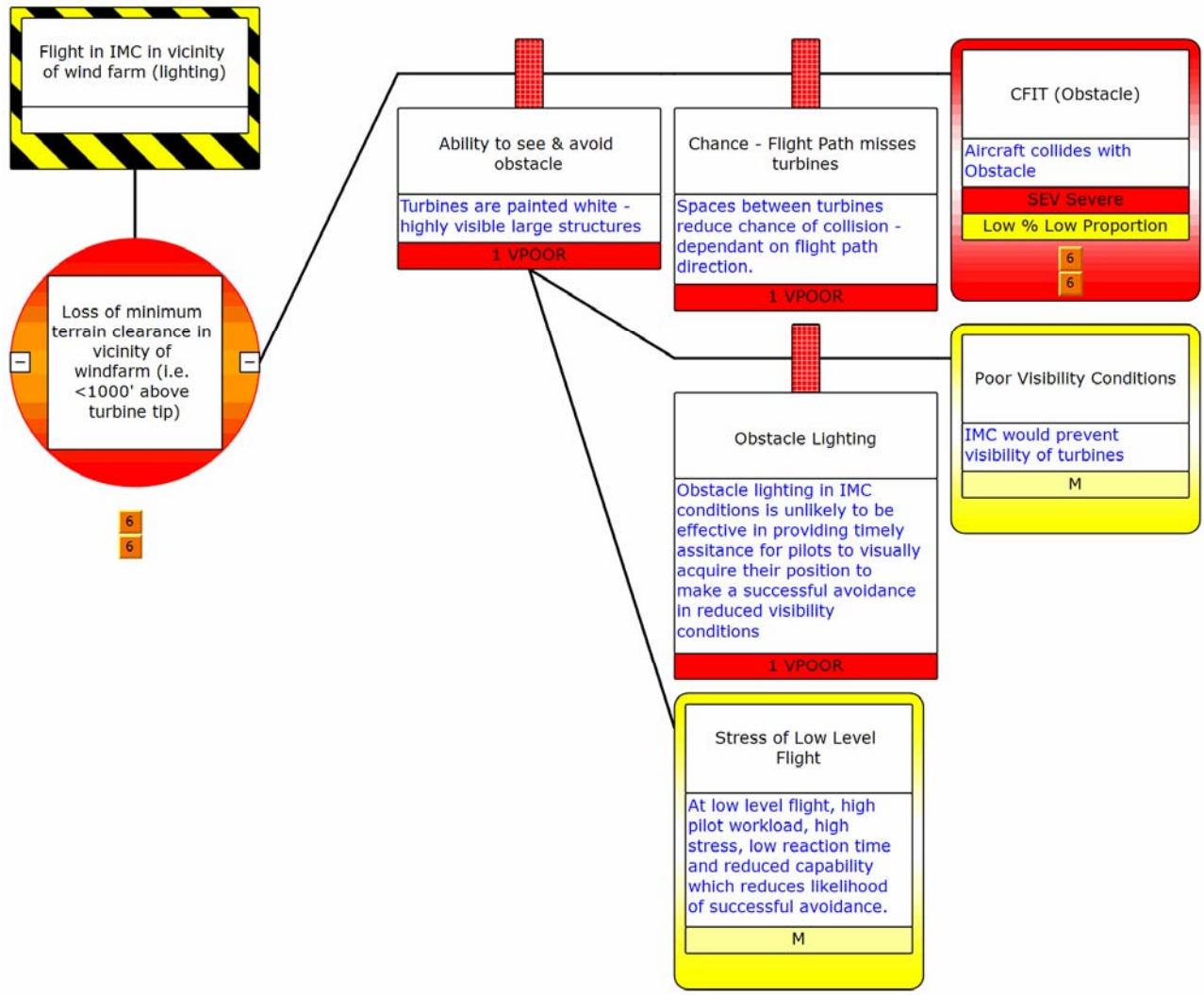


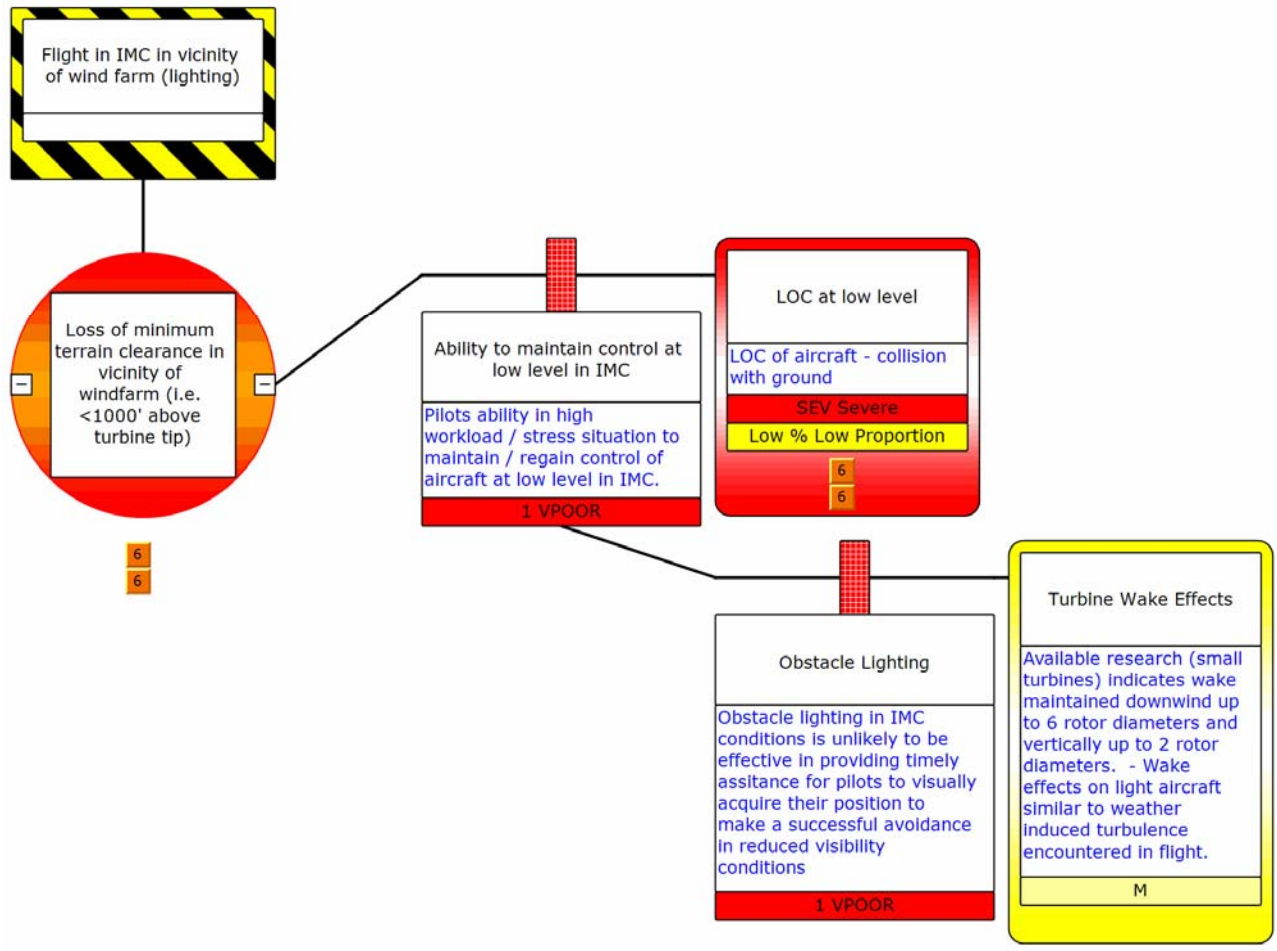


Consequences



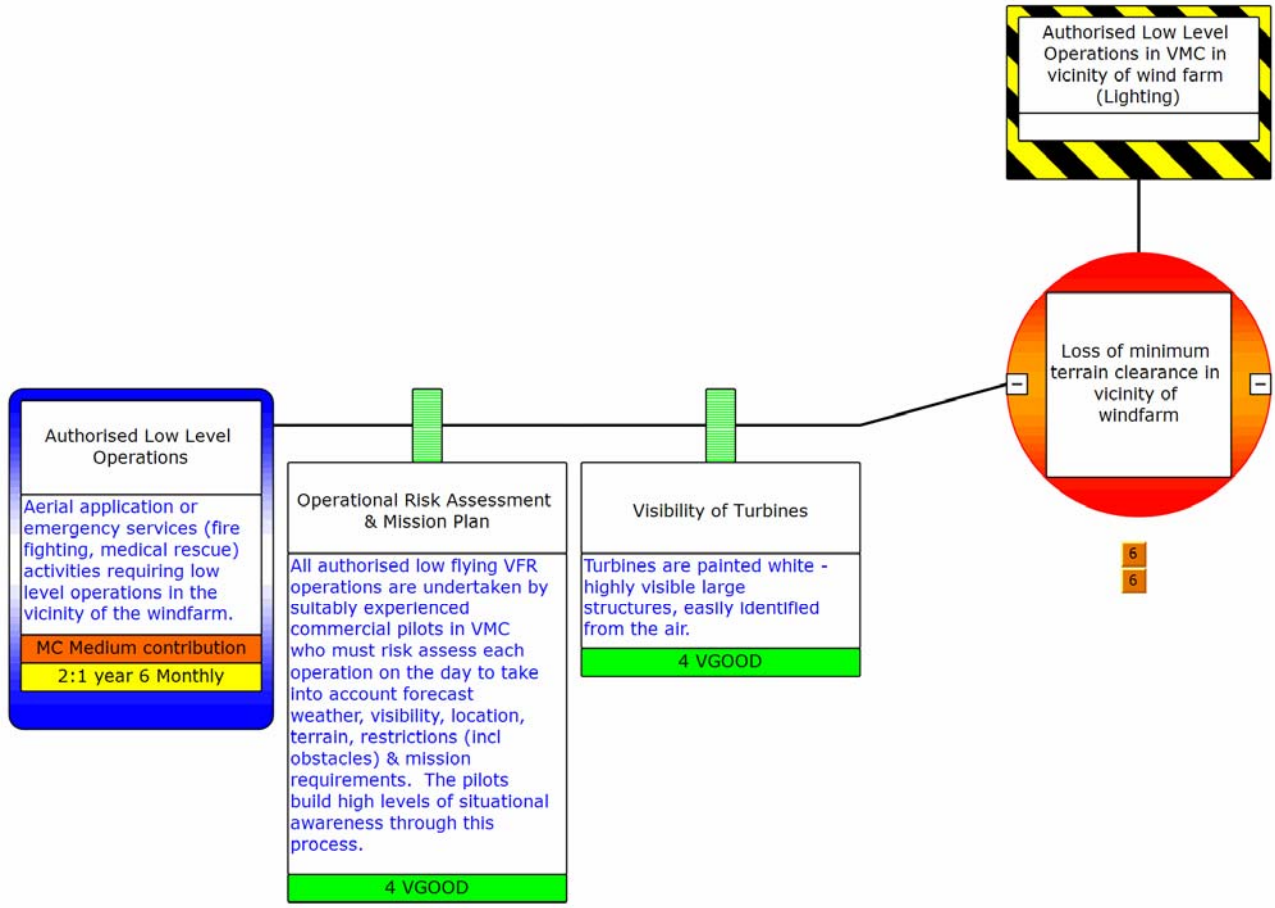
THE AMBIDJI GROUP



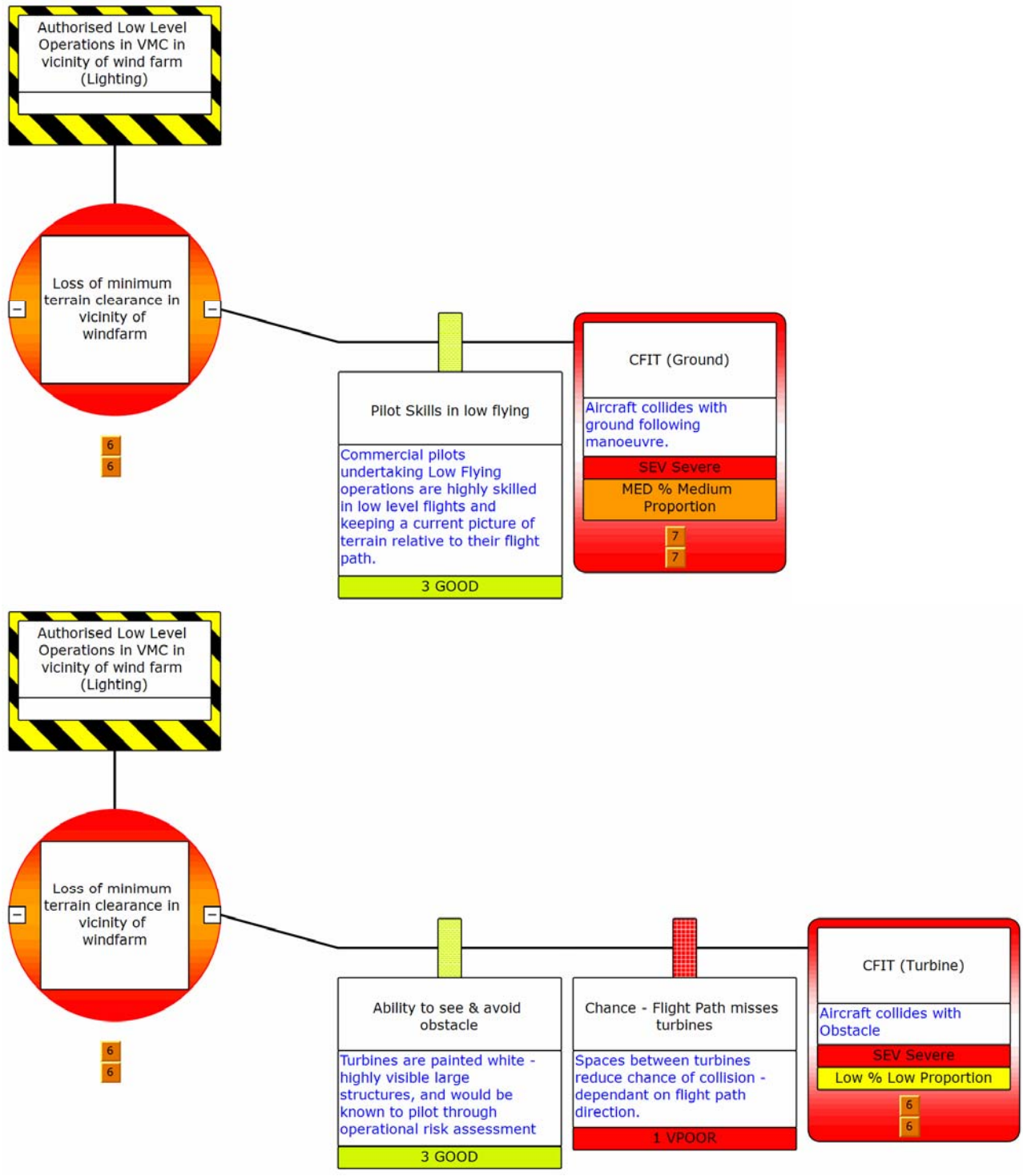

Flight in IMC in vicinity of wind farm (lighting)
Loss of minimum terrain clearance in vicinity of windfarm (i.e. <1000' above turbine tip)
6
6
Ability to maintain control at low level in IMC
Pilots ability in high workload / stress situation to maintain / regain control of aircraft at low level in IMC.
1 VPOOR
LOC at low level
LOC of aircraft - collision with ground
SEV Severe
Low % Low Proportion
6
6
Obstacle Lighting
Obstacle lighting in IMC conditions is unlikely to be effective in providing timely assitance for pilots to visually acquire their position to make a successful avoidance in reduced visibility conditions
1 VPOOR
Turbine Wake Effects
Available research (small turbines) indicates wake maintained downwind up to 6 rotor diameters and vertically up to 2 rotor diameters. - Wake effects on light aircraft similar to weather induced turbulence encountered in flight.
M

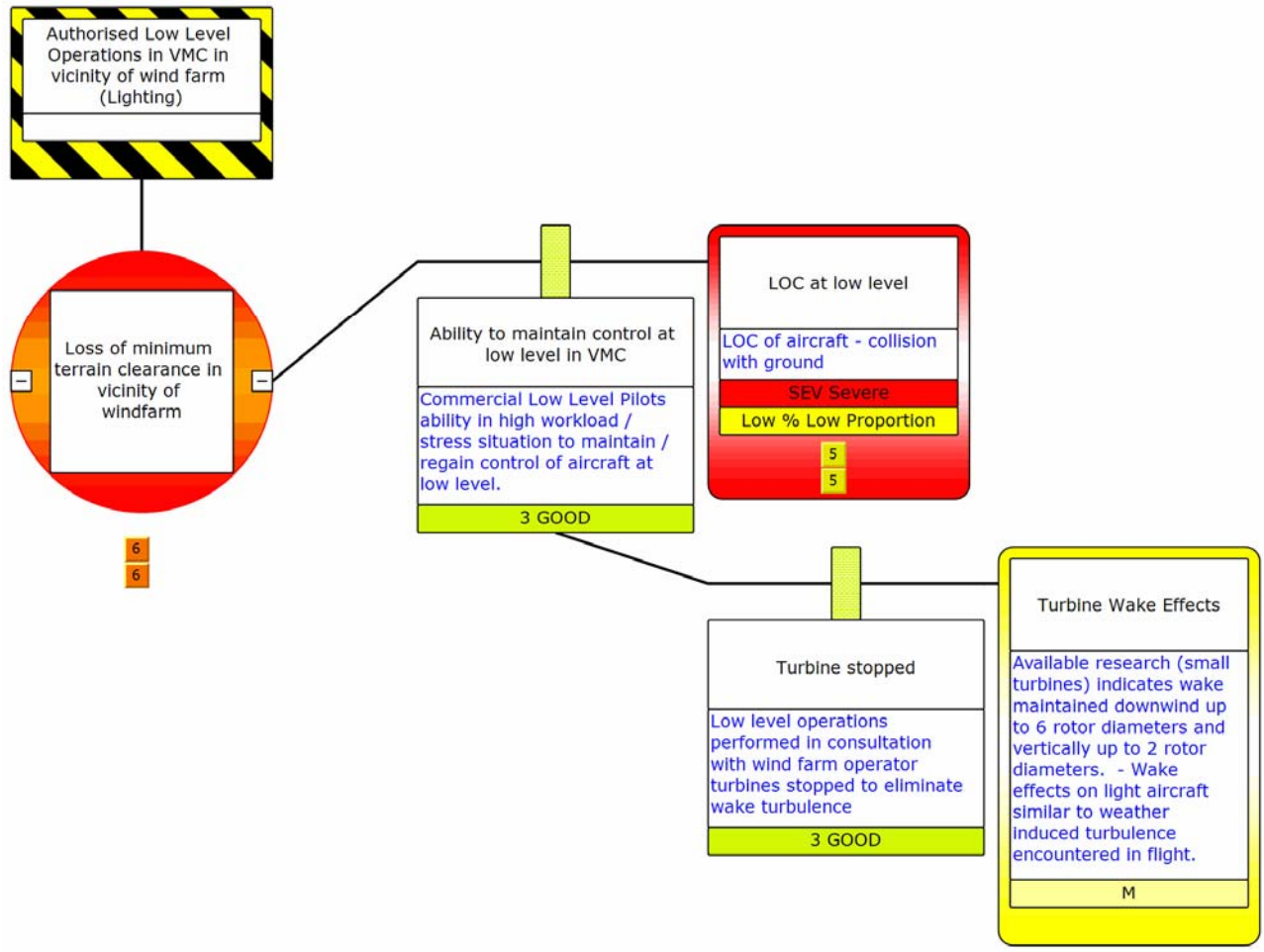
Authorised Low Level Operations in VMC (Lighting)

Threats



Consequences


Authorised Low Level Operations in VMC in vicinity of wind farm (Lighting)
Loss of minimum terrain clearance in vicinity of windfarm
6
6
Pilot Skills in low flying
Commercial pilots undertaking Low Flying operations are highly skilled in low level flights and keeping a current picture of terrain relative to their flight path.
3 GOOD
CFIT (Ground)
Aircraft collides with ground following manoeuvre.
SEV Severe
MED % Medium Proportion
7
7
Authorised Low Level Operations in VMC in vicinity of wind farm (Lighting)
Loss of minimum terrain clearance in vicinity of windfarm
6
6
Ability to see & avoid obstacle
Turbines are painted white - highly visible large structures, and would be known to pilot through operational risk assessment
3 GOOD
Chance - Flight Path misses turbines
Spaces between turbines reduce chance of collision - dependant on flight path direction.
1 VPOOR
CFIT (Turbine)
Aircraft collides with Obstacle
SEV Severe
Low % Low Proportion
6
6


Authorised Low Level Operations in VMC in vicinity of wind farm (Lighting)
Loss of minimum terrain clearance in vicinity of windfarm
6
6
Ability to maintain control at low level in VMC
Commercial Low Level Pilots ability in high workload / stress situation to maintain / regain control of aircraft at low level.
3 GOOD
LOC at low level
LOC of aircraft - collision with ground
SEV Severe
Low % Low Proportion
5
5
Turbine stopped
Low level operations performed in consultation with wind farm operator turbines stopped to eliminate wake turbulence
3 GOOD
Turbine Wake Effects
Available research (small turbines) indicates wake maintained downwind up to 6 rotor diameters and vertically up to 2 rotor diameters. - Wake effects on light aircraft similar to weather induced turbulence encountered in flight.
M

APPENDIX E. EXCERPTS FROM RELEVANT RULES & REGULATIONS

VISUAL FLIGHT RULES

The following information regarding Visual Flight Rules is provided to inform the readers of this report who may not be trained pilots.

It is often stated that aircraft flown in accordance with the VFR can legally fly at 500 feet above the ground. This "fact" is taken from Civil Aviation Regulations 1988 (CAR) Part 11, Division 2 Flight Rules, Regulation 157 – Low Flying.

This regulation is often selectively quoted to indicate that an aircraft can fly at 500ft above the ground, when in fact it is 500ft above the highest point of the ground **and any object on it**. If the wind turbine tip is 625ft above the ground an aircraft must be 500ft above the tip, which is 625 + 500 = 1125ft above the ground. The highest turbine tip in the Glen Innes wind farm is 4745 ft. AHD. For a VFR aircraft to comply with CAR 157 it would need to be at a height of 4745 + 500 = 5245ft AHD. For aviation purposes height above AHD is known as altitude. Consequently, a VFR aircraft would need to be flying at an altitude of 500ft over the wind turbines to comply with this regulation.

The primary regulation for Visual Flight Rules is CAR 171 – VFR Flight, which at sub regulation 2) states "Where an aircraft cannot be flown in accordance with the Visual Flight Rules, the pilot in command shall comply with the Instrument Flight Rules contained in Division 4 of this Part, or land at the nearest suitable aerodrome."

CAR 172 FLIGHT VISIBILITY AND DISTANCE FROM CLOUD

1) The pilot in command of an aircraft must not conduct a VFR flight at a height of, or less than 2000ft above ground or water if:

   a. The pilot is not able to navigate by reference to the ground or water; and

   b. CASA has not directed that the flight may be conducted at a height of 2000ft or less.

   Penalty 50 penalty points.

2) Subject to sub regulation 4), the pilot in command must not conduct a VFR flight if:

   a. The flight visibility during that flight is not equal to or greater than the applicable distance determined by CASA; and

   b. The vertical and horizontal distances from cloud are not equal to or greater than the applicable distances determined by CASA

   Penalty 50 penalty points.

   2AA) An offence against sub regulation 1) or 2) is an offence of strict liability.

   2A) CASA may determine applicable distances for the purpose of sub regulation 2)

   2B) CASA must notify the distances determined under sub regulation 2A) in AIP or NOTAMS

3) When determining applicable distances, CASA may do so by reference to class of airspace

4) In spite of sub regulation 2) the pilot in command of an aircraft may conduct a special VFR flight if:

   a. Air traffic control gives permission for the flight; and

   b. The flight is conducted in accordance with any special conditions to which the permission is subject,

5) In this regulation: *special VFR flight* means a VFR flight:

   a. Conducted in a control zone; or

   b. Conducted in a control area next to a control zone for the purpose of entering or leaving the zone;

   When the flight visibility or distances from cloud are less that the applicable distances determined under sub regulation 2).

174B VFR FLIGHTS AT NIGHT

1) The pilot in command of an aircraft must not fly the aircraft at night under the VFR at a height of less than 1000ft above the highest obstacle located within 10nm of the aircraft in flight if it is not necessary for take-off or landing.

   Penalty 25 penalty points

2) The pilot in command of a single engine aircraft must not fly the aircraft at night under the VFR if the flight is not one of the following operations:

   a. Private operations;

   b. Aerial work operations;

   c. Charter operations that do not involve the carrying of passengers for hire or reward;

   d. Charter operations that involve the carrying of passengers for hire or reward if:

      i. The operator is approved in writing by CASA to conduct he operations; and

      ii. The operations are conducted in a turbine powered aeroplane approved in writing by CASA for the operations.

   Penalty 25 penalty points

3) An offence against sub regulation 1) or 2) is an offence of strict liability

4) It is a defence to a prosecution under sub regulation 1) if CASA gave permission for the flight.

CAR 157 LOW FLYING7

1) The pilot in command of an aircraft must not fly the aircraft over:

   a. Any city, town or populous area at a height lower than 1000ft; or

   b. Any other area at a height lower than 500ft.

   Penalty 50 penalty units

[7] https://www.legislation.gov.au/Details/F2015C00993/Html/Volume_3#_Toc438213033 last accessed 1 April 2016.

2) An offence against sub regulation 1) is an offence of strict liability

3) A height specified in sub regulation 1) is the height above the highest point of the terrain and any object on it, within a radius of:

   a. In the case of an aircraft other than a helicopter – 600 metres; or

   b. In the case of a helicopter – 300 metres;

   from a point on the terrain vertically below the aircraft.

   3A) Paragraph 1) a) does not apply in respect of a helicopter flying at a designated altitude with an access lane details of which have been published in the AIP or NOTAMs for use by helicopters arriving or departing from a specified place.

4) Sub regulation 1) does not apply if:

   a. Through the stress of weather or any other unavoidable cause it is essential that a lower height be maintained; or

   b. The aircraft is engaged in private operations or aerial work operations, being operations that require low flying, and the owner or operator of the aircraft has received from CASA either a general permit for all flights or a specific permit for the particular flight to be made at a lower height while engaged in such operations; or

   c. The pilot of the aircraft is receiving flight training in low-level operations or aerial applications operations within the meaning of Part 61 of CASR; or

   d. The pilot of the aircraft is engaged in a baulked approach procedure, or the practice of such procedure under the supervision of a flight instructor or a check pilot; or

   e. The aircraft is flying in the course of actually taking off or landing at an aerodrome; or

   f. The pilot of the aircraft is engaged in:

      i. A search; or

      ii. A rescue; or

      iii. Dropping supplies;

      In a search and rescue operation; or

   g. The aircraft is a helicopter:

      i. Operated by, of for the purposes of the Australian Federal Police or the police force of a State or Territory; and

      ii. Engaged in law enforcement operations; or

   h. The pilot of the aircraft is engaged in an operation which requires the dropping of packages or other articles or substances in accordance with directions issued by CASA.

Sub regulation 4) a) provides for the pilot, who through poor airmanship has ‘pressed on’ into marginal VMC, to extricate themselves from an unsafe situation. Refer to CAR 171 sub regulation 2) below for what a pilot is required to do if they cannot proceed in accordance with the VFR.

The Visual Flight Rules are shown in Civil Aviation Regulations 1988 (CAR) Part 12

Division 3[8].

CAR 171 VFR FLIGHT

1) A flight conducted in accordance with the provisions of this Division is classed as a flight under the Visual Flight Rules.

2) Where an aircraft cannot be flown in accordance with the Visual Flight Rules, the pilot in command shall comply with the Instrument Flight Rules contained in Division 4 of this Part, or land at the nearest suitable aerodrome.

   Penalty 25 penalty points

3) An offence against sub regulation 2) is an offence of strict liability.

[8] https://www.legislation.gov.au/Details/F2015C00993/Html/Volume_3#_Toc438213061 last accessed 1 April 2016.

APPENDIX F. OBSTACLE LIGHTING CHARACTERISTICS

Aeronautical obstacle lighting is required to meet specified operational and performance characteristics as defined in the following documents:

- CASA Manual of Standards (MoS) Part 139 – Aerodromes; and
- NASF Guideline D) – "Managing the Risk to Aviation Safety of Wind Turbine Installations (Wind Farms)/Wind Monitoring Towers"

A summary of these requirements is provided below.[9]

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

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

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

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

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

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

CASA Advisory Circular AC139-18(0)

Although this Advisory Circular has been withdrawn by CASA it has been advised that the technical recommendations still apply. In the case of Wind Farms, AC139-18(0) defined the required obstacle lighting characteristics as follows:

- Two flashing red medium intensity obstacle lights should be provided;
- Light fixtures to be mounted sufficiently above the surface of the nacelle so that the lights are not obscured by the rotor hub, and at a horizontal separation to

[9] This summary is considered to provide a comprehensive overview of obstacle lighting requirements. However, it is recommended that the proponents of Sapphire Wind Farm fully familiarize themselves with the requirements when conducting their detailed obstruction lighting and system design.

ensure an unobstructed view of at least one of the lights by a pilot approaching from any direction;
- Both lights should flash simultaneously;
- Characteristics of the obstacle lights should be in accordance with MoS Pt 139;
- All obstacle lights on a wind farm are to be synchronised so that they flash simultaneously; and
- An appropriate monitoring, reporting and maintenance procedure is to be established to ensure outages are detected, reported and rectified.

The requirements of AC139-18(0) have been superseded by the NASF Guidelines

Visual Impact Minimisation

It may be necessary to allow for minimisation of the visual impact on the environment. Some shielding may be installed provided it does not compromise the operational effectiveness of the obstruction lighting.

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

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

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

Obstacle light fittings are commercially available that minimise visual impact and accord with CASA performance and operating requirements.

Obstacle Lighting Operating Requirements

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

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

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

APPENDIX G. GLOSSARY

To facilitate the understanding of aviation terminology used in this report, the following is a glossary of terms and acronyms that are commonly used in aeronautical impact assessments and similar aeronautical studies. A full list of terms and abbreviations used in this report is included in this Appendix. It should be noted that, within aviation, the International standard unit for altitude is feet (ft.) and distance is nautical mile (nm).

AC (Advisory Circulars) are issued by CASA and are intended to provide recommendations and guidance to illustrate a means, but not necessarily the only means, of complying with the *Regulations*.

Aeronautical study is a tool used to review aerodrome and airspace processes and procedures to ensure that safety criteria are appropriate.

AHD (Australian Height Datum) is the datum to which all vertical control for mapping is to be referred. The datum surface is that which passes through mean sea level at the 30 tide gauges and through points at zero AHD height vertically below the other basic junction points.

AIP (Aeronautical Information Publication) is a publication promulgated to provide operators with aeronautical information of a lasting character essential to air navigation. It contains details of regulations, procedures and other information pertinent to flying and operation of aircraft. In Australia, the AIP may be issued by CASA or Airservices Australia.

Air routes exist between navigation aid equipped aerodromes or waypoints to facilitate the regular and safe flow of aircraft operating under Instrument Flight Rules (IFR).

Airservices Australia is the Australian government-owned corporation providing safe and environmentally sound air traffic management and related airside services to the aviation industry.

Altitude is the vertical distance of a level, a point or an object, considered as a point, measured from mean sea level.

AMSL (Above Mean Sea Level) is the elevation (on the ground) or altitude (in the air) of any object, relative to the average sea level datum. In aviation, the ellipsoid known as World Geodetic System 84 (WGS 84) is the datum used to define mean sea level.

ATC (Air Traffic Control) service is a service provided for the purpose of:

a. preventing collisions:
   1. between aircraft; and
   2. on the maneuvering area between aircraft, vehicles and obstructions; and
b. expediting and maintaining an orderly flow of air traffic.

CASA (Civil Aviation Safety Authority) is the Australian government authority responsible under the *Civil Aviation Act 1988* for developing and promulgating appropriate, clear and concise aviation safety standards. As Australia is a signatory to the ICAO *Chicago Convention,* CASA adopts the standards and recommended practices established by ICAO, except where a difference has been notified.

CASR (Civil Aviation Safety Regulations) are promulgated by CASA and establish the regulatory framework *(Regulations)* within which all service providers must operate.

Civil Aviation Act 1988 (the Act) establishes the CASA with functions relating to civil aviation, in particular the safety of civil aviation and for related purposes.

ICAO (International Civil Aviation Organization) is an agency of the United Nations which codifies the principles and techniques of international air navigation and fosters the planning and development of international air transport to ensure safe and orderly growth. The ICAO Council adopts standards and recommended practices concerning air navigation, its infrastructure, flight inspection, prevention of unlawful interference, and facilitation of border-crossing procedures for international civil aviation. In addition, the ICAO defines the protocols for air accident investigation followed by transport safety authorities in countries signatory to the Convention on International Civil Aviation, commonly known as the *Chicago Convention*. Australia is a signatory to the *Chicago Convention.*

IFR (Instrument Flight Rules) are rules applicable to the conduct of flight under IMC. IFR is established to govern flight under conditions in which flight by outside visual reference is not safe. IFR flight depends upon flying by reference to instruments in the flight deck, and navigation is accomplished by reference to electronic signals. It is also referred to as, "a term used by pilots and controllers to indicate the type of flight plan an aircraft is flying," such as an IFR or VFR flight plan.

IMC (Instrument Meteorological Conditions) are meteorological conditions expressed in terms of visibility, distance from cloud and ceiling, less than the minimum specified for visual meteorological conditions.

LSALT (Lowest Safe Altitudes) are published for each low-level air route segment. Their purpose is to allow pilots of aircraft that suffer a system failure to descend to the LSALT to ensure terrain or obstacle clearance in IMC where the pilot cannot see the terrain or obstacles due to cloud or poor visibility conditions. It is an altitude that is at least 1,000 feet above any obstacle or terrain within a defined safety buffer region around a particular route that a pilot might fly.

MOS (Manual of Standards) comprises specifications *(Standards)* prescribed by CASA, of uniform application, determined to be necessary for the safety of air navigation.

NASAG (National Airports Safeguarding Advisory Group) set up in May 2010 to implement the Australian Government's National Aviation Policy White Paper, *Flight Path to the Future* initiatives relating to safeguarding airports and surrounding communities from inappropriate development. NASAG comprises representatives from state and territory planning and transport departments, the Civil Aviation Safety Authority (CASA), Airservices Australia, the Department of Defence and the Australian Local Government Association (ALGA) and is chaired by the Department of Infrastructure and Regional Development (DIRD).

NASF (National Airports Safeguarding Framework) is the set of guidelines, adopted in July 2012, developed by NASAG to safeguard airports and surrounding communities.

NOTAMs (Notices to Airmen) are notices issued by the NOTAM office containing information or instruction concerning the establishment, condition or change in any aeronautical facility, service, procedure or hazard, the timely knowledge of which is essential to persons concerned with flight operations.

Obstacles - 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.

OLS (Obstacle Limitation Surfaces) are a series of planes associated with each runway at an aerodrome that defines the desirable limits to which objects may project into the airspace around the aerodrome so that aircraft operations may be conducted safely.

PANS-OPS (Procedures for Air Navigation Services - Aircraft Operations) is an Air Traffic Control term denominating rules for designing instrument approach and departure procedures. Such procedures are used to allow aircraft to land and take off under Instrument Meteorological Conditions (IMC) or Instrument Flight Rules (IFR). ICAO document 8168-

OPS/611 (volumes 1 and 2) outlines the principles for airspace protection and procedure design which all ICAO signatory states must adhere to. The regulatory material surrounding PANS-OPS may vary from country to country.

PANS-OPS Surfaces - Similar to an Obstacle Limitation Surface, the PANS-OPS protection surfaces are imaginary surfaces in space which guarantee the aircraft a certain minimum obstacle clearance. These surfaces may be used as a tool for local governments in assessing building development. Where buildings may (under certain circumstances) be permitted to penetrate the OLS, they cannot be permitted to penetrate any PANS-OPS surface, because the purpose of these surfaces is to guarantee pilots operating under IMC an obstacle free descent path for a given approach.

Prescribed airspace is an airspace specified in, or ascertained in accordance with, the Regulations, where it is in the interests of the safety, efficiency or regularity of existing or future air transport operations into or out of an airport for the airspace to be protected. The prescribed airspace for an airport is the airspace above any part of either an OLS or a PANS OPS surface for the airport and airspace declared in a declaration relating to the airport.

Regulations (Civil Aviation Safety Regulations)

VFR (Visual Flight Rules) are rules applicable to the conduct of flight under VMC. VFR allow a pilot to operate an aircraft in weather conditions generally clear enough to allow the pilot to maintain visual contact with the terrain and to see where the aircraft is going. Specifically, the weather must be better than basic VFR weather minima. If the weather is worse than VFR minima, pilots are required to use instrument flight rules.

VMC (Visual Meteorological Conditions) are meteorological conditions expressed in terms of visibility, distance from cloud and ceiling, equal or better than specified minima

APPENDIX H. ABBREVIATIONS

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

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

Abbreviation	Meaning
FAP	Final Approach Point
ft.	feet
GA	General Aviation
GNSS	Global Navigation Satellite System
GP	Glide Path
IAS	Indicated Airspeed
ICAO	International Civil Aviation Organisation
IFR	Instrument Flight Rules
IHS	Inner Horizontal Surface, an Obstacle Limitation Surface
ILS	Instrument Landing System
ISA	International Standard Atmosphere
km	kilometres
kt	Knot (one nautical mile per hour)
LAT	Latitude
LLZ	Localizer
LONG	Longitude
LSALT	Lowest Safe Altitude
m	metres
MAPt	Missed Approach Point
MDA	Minimum Descent Altitude
MGA94	Map Grid Australia 1994
MOC	Minimum Obstacle Clearance
MOS	Manual of Standards, published by CASA
MSA	Minimum Sector Altitude
SSR	Monopulse Secondary Surveillance Radar
MVA	Minimum Vector Altitude
NASAG	National Airports Safeguarding Advisory Group
NASF	National Airports Safeguarding Framework
NDB	Non Directional Beacon
NE	North East
NM or nm	Nautical Mile (= 1.852 km)
nnDME	Distance from the DME (in nautical miles)
NNE	North North East
NOTAM	NOtice To AirMen
OAS	Obstacle Assessment Surface
OCA	Obstacle Clearance Altitude
OCH	Obstacle Clearance Height
OHS	Outer Horizontal Surface
OIS	Obstacle Identification Surface
OLS	Obstacle Limitation Surface
PANS-OPS	Procedures for Air Navigation Services – Aircraft Operations, ICAO Doc 8168
PRM	Precision Runway Monitor
PROC	Procedure
PSR	Primary Surveillance Radar

Abbreviation	Meaning
QNH	An altimeter setting relative to height above mean sea level
Rnnn	Restricted Airspace – promulgated in AIP as R with 3 numbers
REF	Reference
RL	Relative Level
RNAV	aRea NAVigation
RNP	Required Navigation Performance
RPA	Rules and Practices for Aerodromes — replaced by the MOS Part 139 — Aerodromes
RPT	Regular Public Transport
RWY	Runway
SFC	Surface
SID	Standard Instrument Departure
SOC	Start Of Climb
SSR	Secondary Surveillance Radar
STAR	Standard ARrival
TAR	Terminal Area Radar
TAS	True Air Speed
THR	Threshold (Runway)
TNA	Turn Altitude
TODA	Take-Off Distance Available
VFR	Visual Flight Rules
V_n	aircraft critical Velocity reference
VOR	Very high frequency Omni directional Range