AAWHG
AUSTRALIAN AVIATION WILDLIFE HAZARD GROUP

RECOMMENDED PRACTICE

WILDLIFE RISK ASSESSMENT AND ANALYSIS

Release Date: October 2014

Document: AAWHG RP 1.3(0)

1. Outline

1.1 This Recommended Practice (**RP**) aims to provide the aviation industry and supporting authorities with information on how to assess the risk that wildlife pose to operating aircraft.

1.2 This document has been developed through the Australian Aviation Wildlife Hazard Group (**AAWHG**). It has drawn upon information available from the AAWHG membership, local industry representatives and also from international sources.

1.3 The practices outlined in this document should be considered by industry representatives when:

- Assessing the risk that wildlife pose to aircraft operations if they do not already do so; or
- Modifying their existing wildlife risk assessment and analysis process to support a common industry approach.

1.4 This document should be read in conjunction with:

- RP 1.1 Wildlife Monitoring and identification (Reserved)
- RP 1.3 Database Management (Reserved)

1.5 This document will be subject to regular review through the AAWHG. Comment or feedback on the content of this document can be provided to the group at its email address: rp@aawhg.org

2. The need to assess risk of wildlife to operating aircraft

2.1 Risk management is an essential and fundamental element for good management practice. Wildlife hazards are a known and proven risk to aviation safety and need to be effectively managed. The wildlife risk assessment and analysis process links the available data on the wildlife hazard and then provides a risk profile. This profile is then analysed so a plan for mitigation and/or control can be developed.

2.2 Any risk should be reduced to an 'As Low as Reasonably Practicable' (ALARP) level. ALARP is an officially recognised term by the Australian Government and is referenced by the Civil Aviation Safety Authority guidance material and Safe Work Australia (amongst others). Please refer to section 7 for more information.

2.3 Organisations who do not manage their wildlife risk expose their operation to the increased likelihood of an incident or accident occurring. This Recommended Practice aims to provide organisations with strategies for identifying and controlling the associated risks for which they are responsible.

2.4 International experience has shown that many organisations have been exposed to legal proceedings following their involvement in a wildlife strike event, incident or accident. In comparison, organisations with an effective wildlife risk management process, supported by clear and complete record based evidence, have typically been able to mount an adequate legal defence.

3. Who should conduct a wildlife risk assessment

3.1 It is recommended that a wildlife risk assessment is conducted by any organisation if:

- their activities could contribute to the occurrence of a wildlife strike; or
- they could be involved in the occurrence of a wildlife strike event, incident or accident event.

3.2 These organisations could include but are not limited to:

- Aerodrome/Airport operators
- Aircraft operators;
- Air Traffic Service providers;
- Aircraft, maintenance and parts manufacturers (Australian based);
- Defence organisations;
- Insurers;
- Land use planning authorities; and
- Policy makers/Regulators.

3.3 Those organisations which are not directly involved in aviation but may contribute to the risk of a wildlife strike or incident should consider these type of consequence 'events' in their risk assessments. This process will assist such organisations to understand how their activities contribute to the risk.

4. Australian regulatory context

4.1 *Aerodrome Operators*

4.1.1 For Certified Aerodromes with a confirmed wildlife hazard, the Manual of Standards - Part 139 Aerodromes, section 10.14 requires a Wildlife Hazard Management Plan to be developed. This plan must address the assessment of wildlife hazards including monitoring actions and analysis.

4.1.2 Advisory Circular (**AC**) 139-26 recommends that Certified Aerodromes integrate their Wildlife Hazard Management Plan (**WHMP**) with their Safety Management System (**SMS**).

4.1.3 AC 139-26 also recommends that Registered and other aerodromes conduct an analysis of their wildlife hazard and to manage the resultant risk.

4.2 *Aircraft Operators*

4.2.1 Holders of an Air Operators Certificate under Civil Aviation Orders 82.3 and 82.5 are required to implement an SMS which is applicable to their level of operation. This SMS is required to contain a safety risk management plan including documented details of the hazard identification and risk management process.

4.2.2 Civil Aviation Advisory Publication SMS – 1(0) describes the required process to identify hazards associated with the organisation's operations and to analyse and assess the risk.

4.3 *Land Use Planning and Approval Authorities*

4.3.1 Following the Aviation White Paper, the Department of Infrastructure and Transport has developed the National Airport Safeguarding Framework (**NASF**). Guideline C from this framework addresses the assessment of both existing and proposed developments/land uses based on their potential impact to the wildlife risk to any nearby aerodrome.

4.3.2 Planning regulations, systems and controls vary between the states and territories. Please refer to your applicable authority for more information.

4.3.3 The NASF guidelines can be accessed via the Department of Infrastructure and Transport website: www.infrastructure.gov.au

5. Wildlife Risk Assessment Process

5.1 General

5.1.1 The following approach is consistent with the principles of International Standard 31000 — "Risk Management – Principles and Guidelines." This approach can be successfully applied to any wildlife hazard context – not just those hazards present on or in proximity to an aerodrome.

5.1.2 **Note:** *Most of the wildlife risk assessment tools currently available are designed for use in the aerodrome context. In itself, this can limit a complete risk assessment and analysis being undertaken for wildlife hazards. As the understanding of wildlife hazard management matures further, it is expected that the application of risk assessment to the wider wildlife hazard context will become more common. Future editions of this RP will follow this progression and any new tools that become available.*

5.1.3 The 31000 process is shown below in the following diagram:

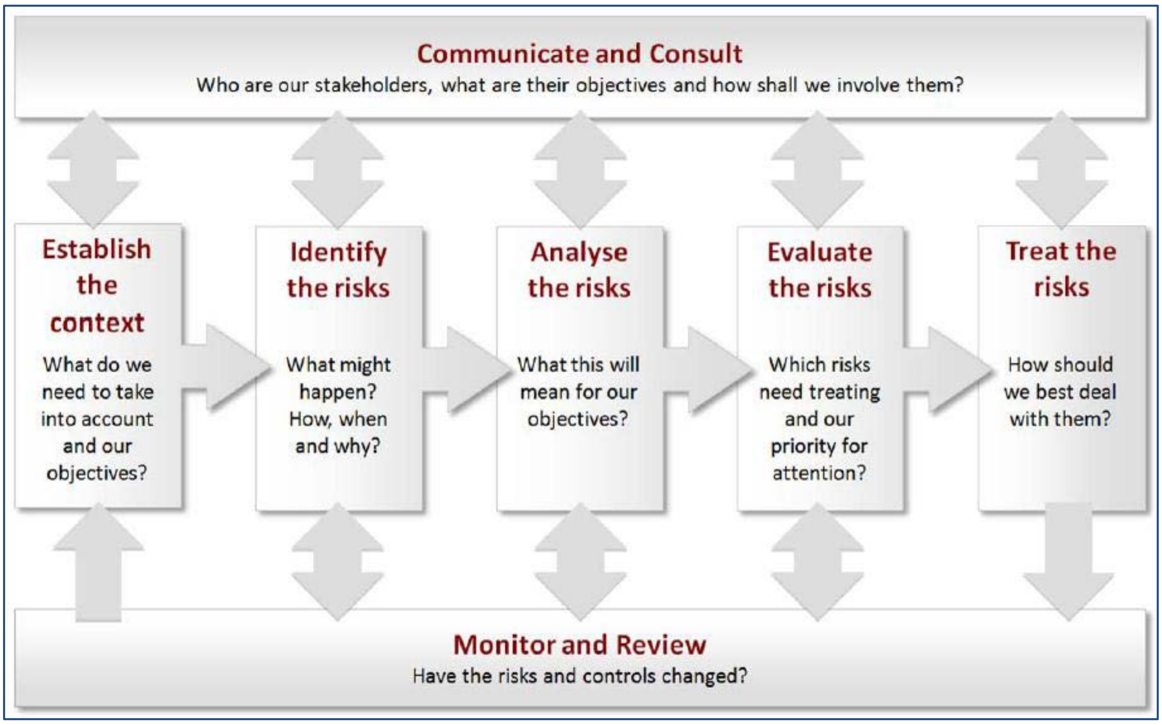

Figure 1.1: Risk assessment process (AS/NZ 31000:2009)

5.1.4 The **context** of the risk assessment should be first established to clearly identify the responsibility hazard the individual or organisation has over the hazard. In this case, the context could be the operational safety management of wildlife hazards. Once the context is established, the objective and scope of the risk assessment can be developed.

5.1.5 To identify the risk(s), the **likelihood** of the hazard event should be considered based on the best and most complete data available. This assessment should consider, but not be limited to, the following sources of information:

- Previous strike events;
- Previous strike events resulting in damage to an aircraft;
- Previous wildlife incidents or near misses;
- Results from wildlife monitoring activities, population studies, observations, etc;
- The proximity of known wildlife activity to aircraft manoeuvring areas and flight paths;
- Wildlife migratory information;
- Wildlife behavioural characteristics (hunting and feeding practices, roosting and nesting, reproduction, socialisation etc.);
- Wildlife agility, speed, manoeuvrability and their ability to avoid aircraft;
- Wildlife grouping or flocking tendencies
- Wildlife response to management actions;
- Aircraft type, schedules, operating times and flight paths.

5.1.6 When assessing the possible **consequence** of a wildlife strike event or incident, consideration should be given to, but not be limited to, the following:

- Aircraft type;
- Previous strikes causing adverse effects (damage or delay);
- The mass of the wildlife species (both observed and previously struck);
- that the strike or incident will involve multiple animals;
- The velocity of the aircraft involved, the resultant impact force(s) and the damage that could result; and
- If adequate control of the aircraft can be maintained following a strike event or wildlife incident.

5.1.7 The expression of the likelihood and consequence are then combined to determine the resultant level of risk. Where information is not available to fully categorise the likelihood and/or consequence, it is recommended that the worst case situation is considered for the assessment.

5.1.8 The process recommended by ISO 31000 is to then analyse, evaluate and treat the risk. These steps are described later in this recommended practice.

5.1.9 It is recommended that the risk assessment is conducted within a team environment involving all relevant stakeholders. The team should consist of personnel who are knowledgeable in:

- the wildlife hazard;
- any management/mitigation actions that are already in place; and
- the risk assessment process itself.

5.1.10 It is furthermore recommended that appropriate expertise is sought where required to ensure the risk assessment is complete and will provide a realistic outcome.

5.2 Assessing Bird risk

5.2.1 A 'Bird Risk Assessment Model for Airports and Aerodromes' has been developed between Adelaide Airport, The University of Adelaide and the AAWHG.

5.2.2 This model is freely available for use by the operators of airports and aerodromes when assessing their wildlife hazard risk involving birds. Copies can be accessed from the AAWHG website: www.aawhg.org

5.2.3 An alternative assessment model is available and is titled 'A protocol for bird strike risk assessment at airports.' This protocol was authored by Dr John Allan and is available through this link.

5.2.4 It is recommended that any bird risk assessment is conducted with the support of a qualified ornithologist who is familiar with the bird hazard and its alleviation (Allan. JR, 2000).

5.3 Assessing flying fox and micro bat risk

5.3.1 Flying foxes and Micro bats are a known threat (hazard) to aviation safety. Although their mass can be less than the most commonly struck species of birds, their nocturnal activity and group behaviour both increase the likelihood of a strike and also the chance of a multiple strike event occurring.

5.3.2 A dedicated risk assessment model for flying foxes is currently under development. Please contact info@aawhg.org for more information. The general procedures for assessment should be followed in the interim as outlined above in section 5.1.

5.3.3 It is recommended that such any flying fox and micro bat risk assessment is conducted with the support of a qualified person who is familiar with the hazard and its alleviation.

5.4 Assessing land animal risk

5.4.1 Land animals pose a known threat (hazard) to aviation safety. Although the likelihood of such strikes is typically lower when compared to birds and other flying animals (such as flying foxes and micro bats), the mass of land based animals can be more significant which increases the potential consequence and hence the risk.

5.4.2 At present there is no freely available risk assessment model available for land based animals. The general procedures for assessment can be followed however as outlined above in section 5.1.

5.4.3 It is recommended that such any land animal risk assessment is conducted with the support of a qualified person who is familiar with the hazard and its alleviation.

6. Analysis

6.1 Analysis follows the assessment process and is used to improve understanding of the risk. This process assists organisations to determine the priority of treatment and the most effective strategies available to mitigate/control. This approach is consistent with the International Civil Aviation Organisation (**ICAO**) Airport Services Manual Part 3 titled "Bird Control and Reduction."

6.2 There are in various and differing wildlife strike assessment methods/models. Generally speaking, there are no right or wrong approaches rather those which are effective versus those which are ineffective. Consideration of the following strategies is recommended

- Risk ranking analysis;
- Damaging strike analysis;

6.3 Also available are more advanced risk analysis methods. These are commonly used in other industry contexts and have been applied to wildlife hazards:

- Network theory/cause and effect ('bow-tie') analysis;
- Event/Outcome Analysis

6.4 Simple illustrative examples of these more advanced techniques can be referenced in Appendix 1 of this RP.

6.5 <u>Risk ranking analysis</u>

6.5.1 This method analyses the risk outputs produced from the ISO 31000 or a similar method. This type of analysis may be necessary due to the 'subjective' nature of the outputs (risk scores) using this method of assessment. More 'objective' methods are as outlined under headings 6.5, 6.6 and 6.7 below.

6.5.2 The first step is to rank all the risk scores from lowest to highest. Depending on how the original assessment was carried out, these may have been assessed for a particular species or an occurrence type. Care however should be taken as the risk outputs may not be easily sorted in a clean risk sequence.

Example: If two assessed wildlife species both result in the same risk score, consideration needs to be given as to why this was the case and what are supporting conditions for the hazard of each. A post assessment review of these conditions may eventually result in one species being ranked higher than the other.

6.5.3 When using this method, you should be aware of the possible limitation in the use of 'likelihood descriptors' and/or the subjective nature of their selection by the assessor or the assessment team. In other words, it can be a challenge to choose between two likelihood descriptors (i.e. Unlikely vs Possible) unless the descriptors you are using contain a numerical basis which can be matched with objective data.

Example: It may be harder to match a general observation of bird populations (possibly subjective) to a particular likelihood ranking versus an actual survey of wildlife populations or bird count data (objective and quantifiable) which can be more readily linked to a descriptor containing a numerical basis.

6.5.4 Using a subjective method like ISO 31000, it may be beneficial to ensure likelihood descriptors feature a numerical basis to make them more objective (resolving the ambiguity).

6.5.5 The same limitations can exist when using of 'consequence descriptors.' Again, the use of objective measures may resolve any ambiguity faced by the assessment team.

6.5.6 **A word of caution:** Sometimes there is an inclination to continuously 're run' risk assessments by selecting a different likelihood and/or consequence category until the expected risk score/result is achieved. The unexpected risk score may actually be the most accurate output based on the available information. If an error is detected and/or there is strong disagreement within the assessment team, then it may be appropriate to re-conduct the assessment.

6.5.7 Once the risk outcomes are scored and ranked, this provides a reference list to begin mitigation activities. Refer to section 7 for more information.

6.6 Damaging Strike Analysis

6.6.1 This methodology considers the likely consequence of aircraft damage based on a particular wildlife species and/or a particular strike scenario. Referring to the 'Energy damage model' (Viner. D, 1991), a hazard such as a wildlife strike will transfer energy through a mechanism to a recipient:

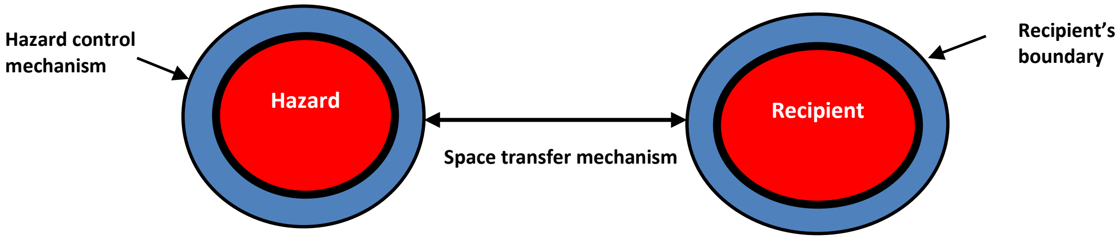

Figure 1.2: Energy damage model (Viner, 1991)

6.6.2 The initial energy type for wildlife strike events is Kinetic. The resultant energy will be transferred between the bird and aircraft at the moment of the strike. Kinetic Energy is calculated by multiplying the mass of an object by its velocity. One relevant equation is:

$$KE = 1/2mv^2$$

Where:	*KE*	*= Kinetic Energy*
	M	*= Mass*
	v	*= Velocity*

6.6.3 To a degree, the velocity of the aircraft can be controlled by the flight crew however there is a minimum speed that an aircraft must fly in order to generate lift and maintain controllability. The velocity of the animal involved in comparison is likely not to add significant energy when compared to the velocity of the aircraft striking it.

6.6.4 Any aircraft parts that rotate (i.e. propellers, rotors, fans, turbines etc) have their own velocity and therefore potential energy. When rotating parts strike wildlife, energy is again transferred following the collision. The resultant release in energy could result damage being sustained. This effect may be further compounded by the velocity of the aircraft itself at the time of the strike.

6.6.5 Like with velocity, the mass of the animal struck is significant. The larger the animal, the higher the resultant release of energy and the increased likelihood of critical aircraft damage being sustained. This risk is increased where multiple animals are struck such as a flock of birds, a swarm of insects or a group of land based animals (i.e herd, flock, pod, pack etc.)

6.6.6 The certification requirements of aircraft and their resultant susceptibility to wildlife strikes will vary depending on type, use and categorisation.

6.6.7 Whilst there is no set procedure for the conduct of damaging strike analysis, the following is recommended for consideration:

- The higher the mass of the animal struck, the higher the risk of significant damage being sustained by an aircraft;

- The higher the velocity of the aircraft when the strike occurred, the higher the likelihood of significant damage being sustained by the aircraft;
- The more animals struck during an single event, the higher the likelihood that the aircraft or a critical system will be compromised;
- Aircraft parts and components respond to strike energies in different ways. Engines, propellers, intakes, windscreens, control surfaces and sensors can be more susceptible to strike energy that other parts of an aircraft;
- Whilst at a lower velocity when compared to cruise speeds, aircraft at the point of rotation (take-off) or on final approach, are in their lowest energy state. In these configurations, aircraft are subject to increased drag, a limited manoeuvrability envelope and a lower opportunity to convert altitude to airspeed. Sustaining a damaging strike at this point presents a different risk to a strike sustained at cruise level.

6.6.8 It is recommended that any analysis of damaging strikes is conducted with the support of a qualified person who is familiar with the hazard and its affect on aircraft.

6.6.9 **Strike data and frequency rates alone does not give a complete picture of risk**. The history of damaging strikes and the likelihood of future strikes with the potential to cause aircraft damage needs to be considered. It would be folly to focus all mitigation resources on a species with a high incidence of strikes but with the low likelihood of aircraft damage being sustained to the exclusion of an animal with a low known strike rate but a high likelihood of catastrophic damage.

6.7 Network theory/cause and effect (‘bow-tie’) analysis - Introduction

6.7.1 Network theory/cause and effect, commonly known as 'bow-tie' analysis, is used trace a network of pathways. These originate from causal factors including but limited to human decisions, equipment, system performance etc. These then converge at the occurrence of a particular ‘event’ – in this context, a wildlife strike.

6.7.2 Following the event, another network of possibility pathways (known as nodes) will diverge outwards from the event and reflect a series of potential consequences/outcomes. Depending on the human perceptions, decisions, responses and the performance of systems and equipment *following* the event, a typically large number of consequences and outcomes are possible.

6.7.3 There are different methodologies available for network theory. These range from the relatively simple ‘bow-tie’ method based to the more complex ‘Fault tree analysis and Event/Outcome Analysis’ based on the research of

H.A Watson in 1962. There are also plenty of web based resources and risk management resources that provide guidance in the use of these methods.

6.7.4 It is up to the assessor to select which one technique is the most appropriate. It is recommended however that the advanced methods are only undertaken with the support of someone who is knowledgeable and competent in their use.

6.7.5 Please refer to Appendix 1 of this RP for further information.

7. Development of mitigation priority

7.1 Following the assessment and analysis process, the risks should be ranked in an order of severity. This priority list could be based on the species involved, the likely consequence event or another suitable method of categorisation.

7.2 The analysis should identify the causal factors and conditions which contribute to the hazard and the potential effectiveness of any applied mitigation.

7.3 The resultant output should be a 'prioritisation of mitigation.' This prioritisation should be based on the effectiveness of control and the resources available.

7.4 Any risk should then be reduced to an 'As Low as Reasonably Practicable' (ALARP) level:

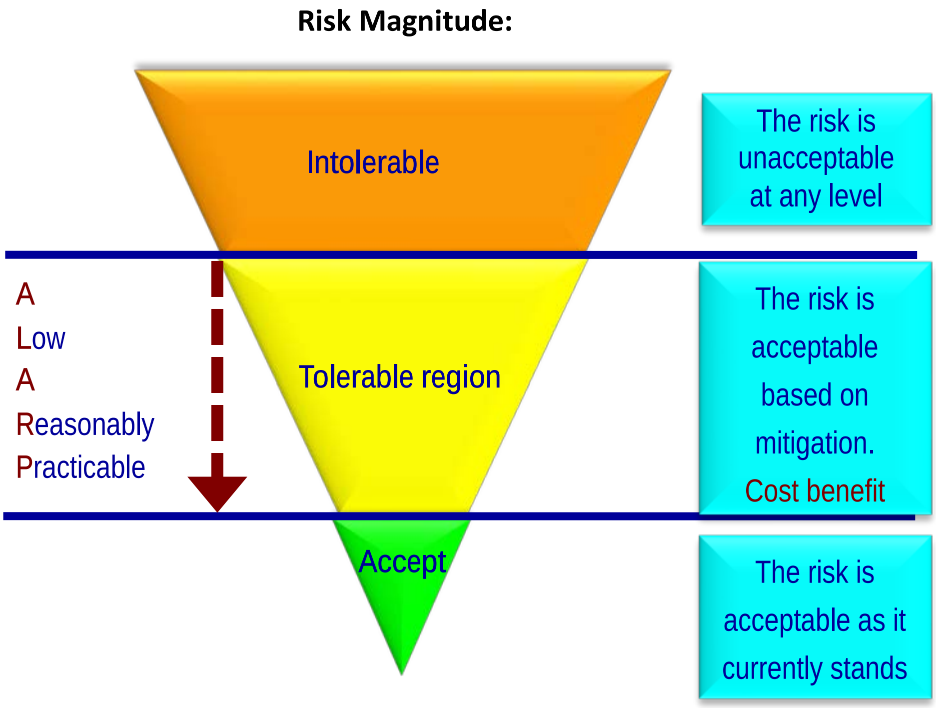

Figure 1.7: Example of the Risk Magnitude and ALARP (for illustrative purposes only)

7.5 Once it is believed that ALARP has been achieved for a particular risk, justification for this needs assessment to be clearly documented.

7.6 Even if ALARP is achieved, this level is unlikely to be maintained indefinitely. As the organisation itself develops, new technologies, techniques and methodologies will become available and the cost of mitigation changes, what is 'reasonably practical' will likely change.

8. Review

8.1 The process of wildlife risk assessment and analysis needs to be dynamic. Following any change in the wildlife hazard, the risk should be reassessed. This is also the case following any significant wildlife strike event, incident or accident.

8.2 Where no event formally triggers a review of the risk assessment, it is recommended that wildlife risk assessments and analysis are conducted on a regular basis.

9. Records management

9.1 The maintenance of records for wildlife risk assessment and analysis is vitally important to support the process. The maintenance of records will assist organisations in:

- Tracking the changes in risk over time;
- Indicating which risk items are to be given priority and why; and
- Providing a documented risk position ready for the next risk assessment cycle.

9.2 These records can also be used to substantiate an organisation's risk management process and the resultant decisions that are made for mitigation and/or management.

9.3 It is recommended that these records should be maintained for a minimum of **7 years** from the original date of their creation.

10. Training

10.1 It is recommended that at least one member of the assessment team has been formally trained in or is operationally familiar with International Standard 31000 or an alternate Risk Management methodology.

10.2 It is also recommended at least one member of the assessment team has undergone wildlife hazard management training or is operationally familiar with the process.

11. References

11.1 International Organization for Standardization, 2009, Geneva, *International Standard 31000:2009*

11.2 International Civil Aviation Organisation, 1991, *Airport Services Manual Bird Control and Reduction* (Doc 9137-AN/901 Part 3)

11.3 Paton, David C University of Adelaide & Adelaide Airport Pty. Ltd. & Australian Aviation Wildlife Hazard Group, 2010, Australia, *Bird Risk Assessment Model for Airports and Aerodromes*, <www.aawhg.org>

11.4 Civil Aviation Safety Authority, 1998, Australia, *Civil Aviation Safety Regulations 1998,* <www.comlaw.gov.au>

11.5 Civil Aviation Safety Authority, 2012, Australia, *Manual of Standards Part 139,* <www.comlaw.gov.au>

11.6 Civil Aviation Safety Authority, 2011, Australia, *Advisory Circular 139-26,* <www.casa.gov.au>

11.7 Civil Aviation Safety Authority, 1998, Australia, *Civil Aviation Regulations 1988 1988,* <www.comlaw.gov.au>

11.8 Civil Aviation Safety Authority, 2012, Australia, *Civil Aviation Orders,* <www.comlaw.gov.au>

11.9 Civil Aviation Safety Authority, 2009, Australia, *Civil Aviation Advisory Publication SMS-1,* <www.casa.gov.au>

11.10 International Bird Strike Committee, 2006, *Standards For Aerodrome Bird/Wildlife Control,* <http://www.int-birdstrike.org>

11.11 Allan, Dr John R, 2000, *A protocol for bird strike risk assessment at airports,* < http://onlinelibrary.wiley.com/doi/10.1111/j.1539-6924.2006.00776.x/abstract>

11.12 Viner, Derek. *Accident Analysis and Risk Control.* Derek Viner Pty. Ltd. First published in 1991. 4th Edition (2009).

APPENDIX 1

Bow-tie analysis

Bow-tie analysis is a method used to visually represent the causes, threats and conditions which cause result in a hazardous event and also the consequences that can follow from an event depending on the recovery preparation and actions.

The following is the basic structure for a bow-tie diagram:

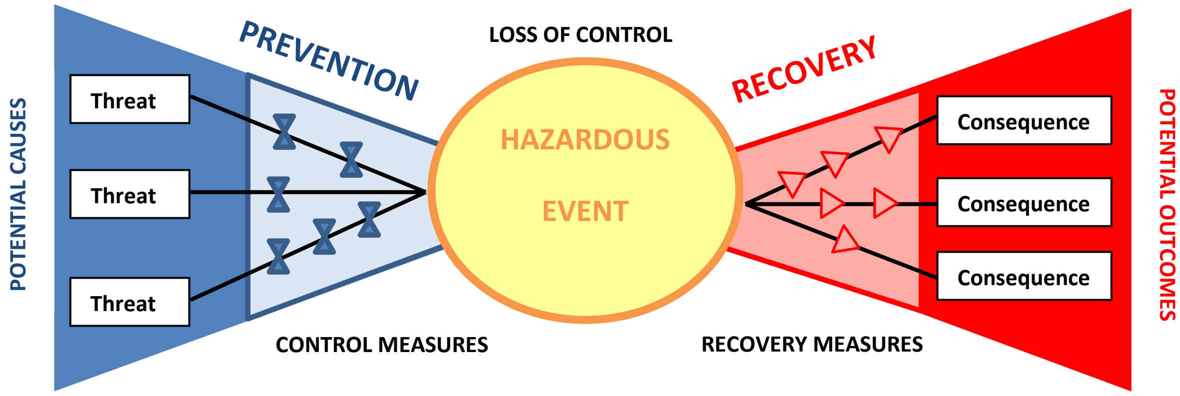

Figure 1.3: The basic structure of the bow-tie method

On the left side of the hazardous event are the causes/threats. By implementing control measures on this side of the model, the possibility for a loss of control of the hazard can be reduced or ideally prevented.

On the right side of the hazardous event are the recovery measures. The model assumes that the loss of control of the hazard has occurred at this point. The actions taken in recovery and any preparation can lead to different consequence outcomes. Some may be minimal however others could be catastrophic.

The following is a simple example of the bow-tie method as applied to a wildlife hazard context. No control measures nor recovery measures have been included to illustrate the relationship between the threats, the hazard and the possible consequences.

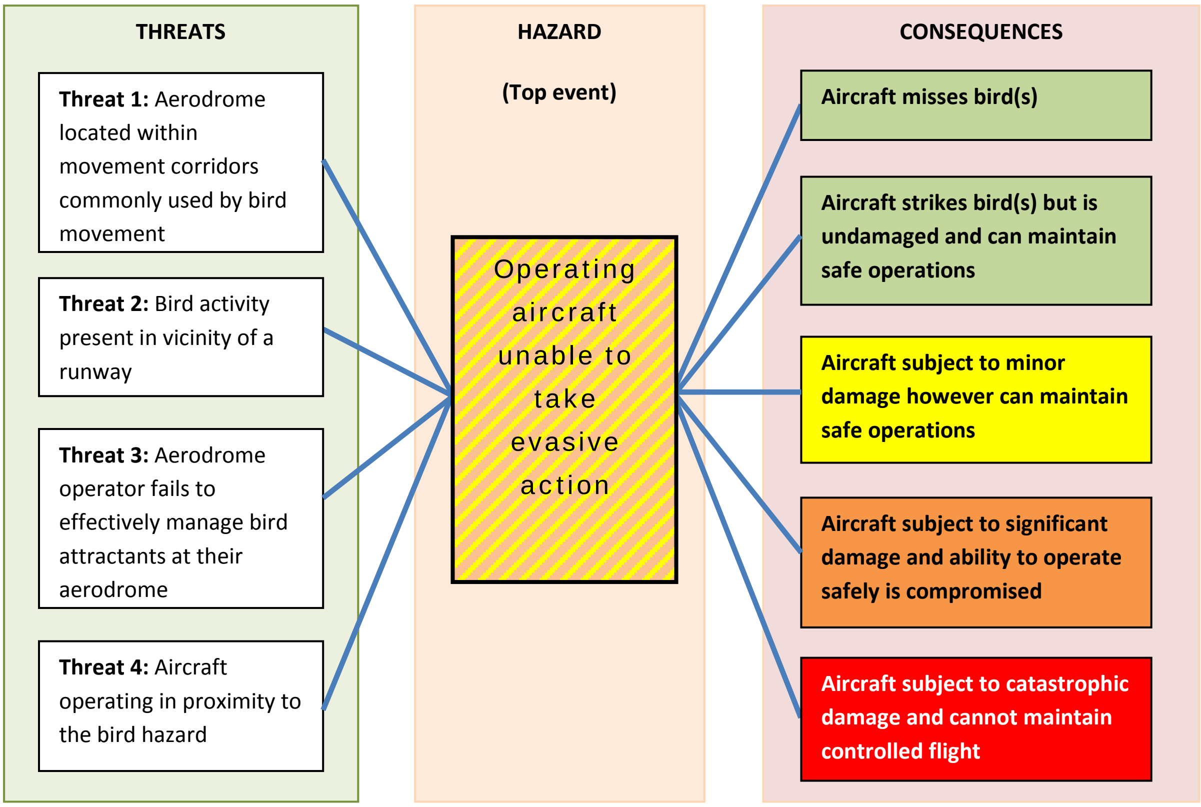

Figure 1.4: Simple example of the bow-tie method applied to a wildlife hazard context without controls (for illustrative purposes only)

With regard to mitigation, by addressing the latent conditions and/or active failures, a reduction in the likelihood and/or the severity of the top event may result. For example, threat 1 could be addressed by relocating the aerodrome and likewise threat 4 could be addressed by closing the aerodrome. Whilst effective, these control measure may not be a viable option due to financial, social or environmental factors. An improvement in the wildlife hazard management program however could address threats 2 and 3 which may reduce the potential of the top event occurring.

Should control of the hazard (top event) be lost, preparation for the possible consequences could involve improvements to pilot training in wildlife strike recovery, the robustness of aircraft design and the reliability of critical systems. This preparation may assist of the flight crew dealing with the hazard where their successful actions may minimise the consequence.

The bow-tie method is sufficiently flexible to be applied to any ‘top event’ and also at any point in the event sequence. The careful identification of the top event however will result in a more beneficial analysis.

Fault Tree Analysis (Advanced)

The more complex ‘Fault Tree Analysis and Event/Outcome Analysis’ method uses formal logic gates which are assigned along the causal pathways. These logic gates generally come in the form of ‘AND’ or ‘OR’ and have their basis in Boolean Algebra.

Events and pathways leading from the logic gates link sub events and systems that in turn lead to subsidiary gates and a narrowing of conditions. Eventually these converge to the occurrence of the ‘top event’ which is being assessed. Events which do not contribute to the top event can also be excluded mathematically using this method.

It is recommended that such a method is used with the support of a Risk engineer or someone who is familiar with and is competent in this method. There are numerous online resources available that further explain the Fault Tree Analysis method and the laws of Boolean Algebra.

The following is a simple figurative example of the Fault Tree Analysis method:

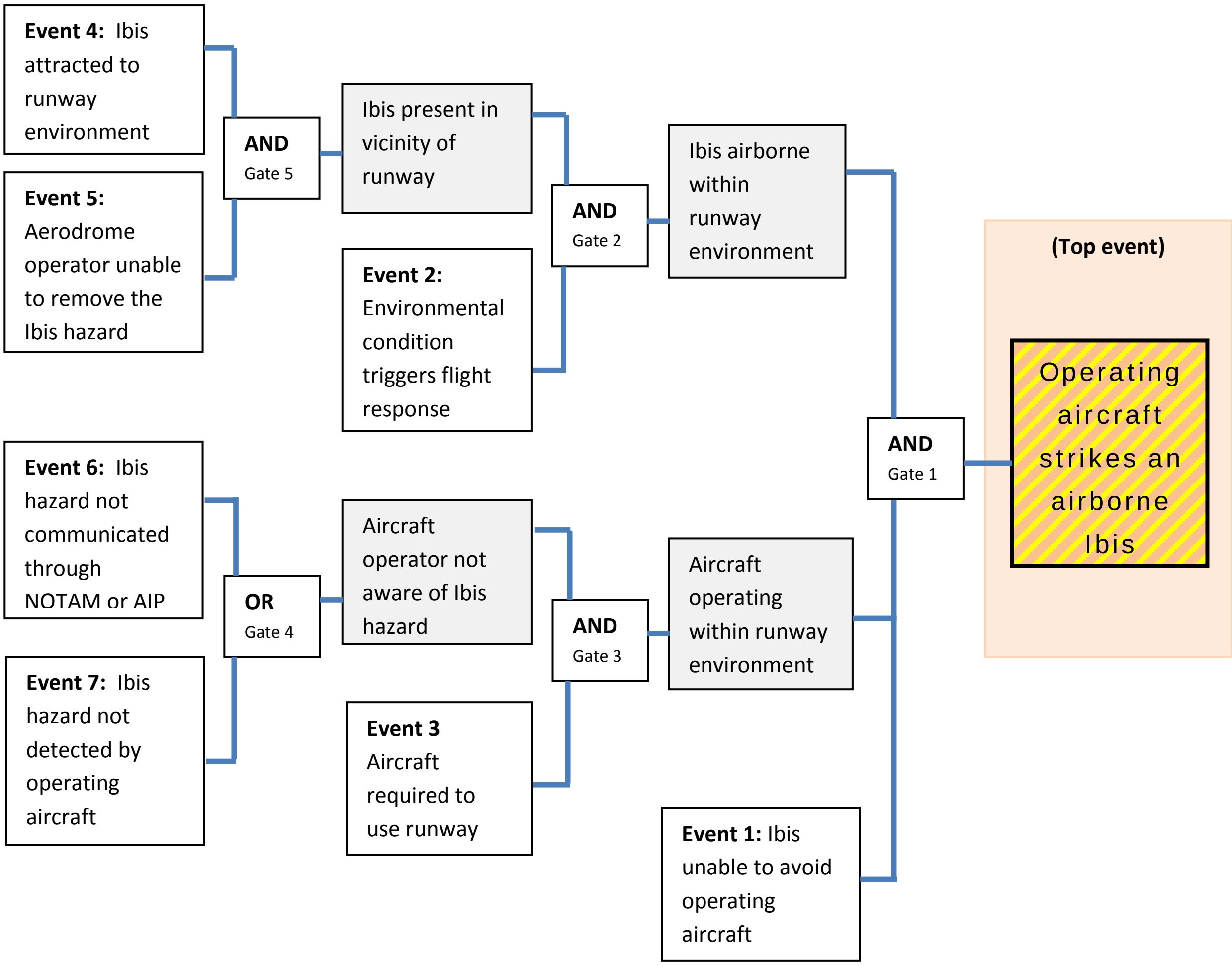

Figure 1.5: Simple example of a Fault Tree Analysis method (for illustrative purposes only)

Using this method, probability values can be assigned to each 'event' along the path. At each gate, the laws of Boolean Algebra can be applied which allows the calculation of probability at each junction point. These probability values are then traced to the top event where a final event probability can be calculated.

The calculation of a final event probability is one of the key benefits from using this method of objective analysis. In addition, the control of each 'event' and 'gate' can be analysed individually based on its impact on the probability of the top event.

Event/Outcome Analysis (Advanced)

The following is a simple figurative example of a simple Event/Outcome Analysis and Event/Outcome Analysis method:

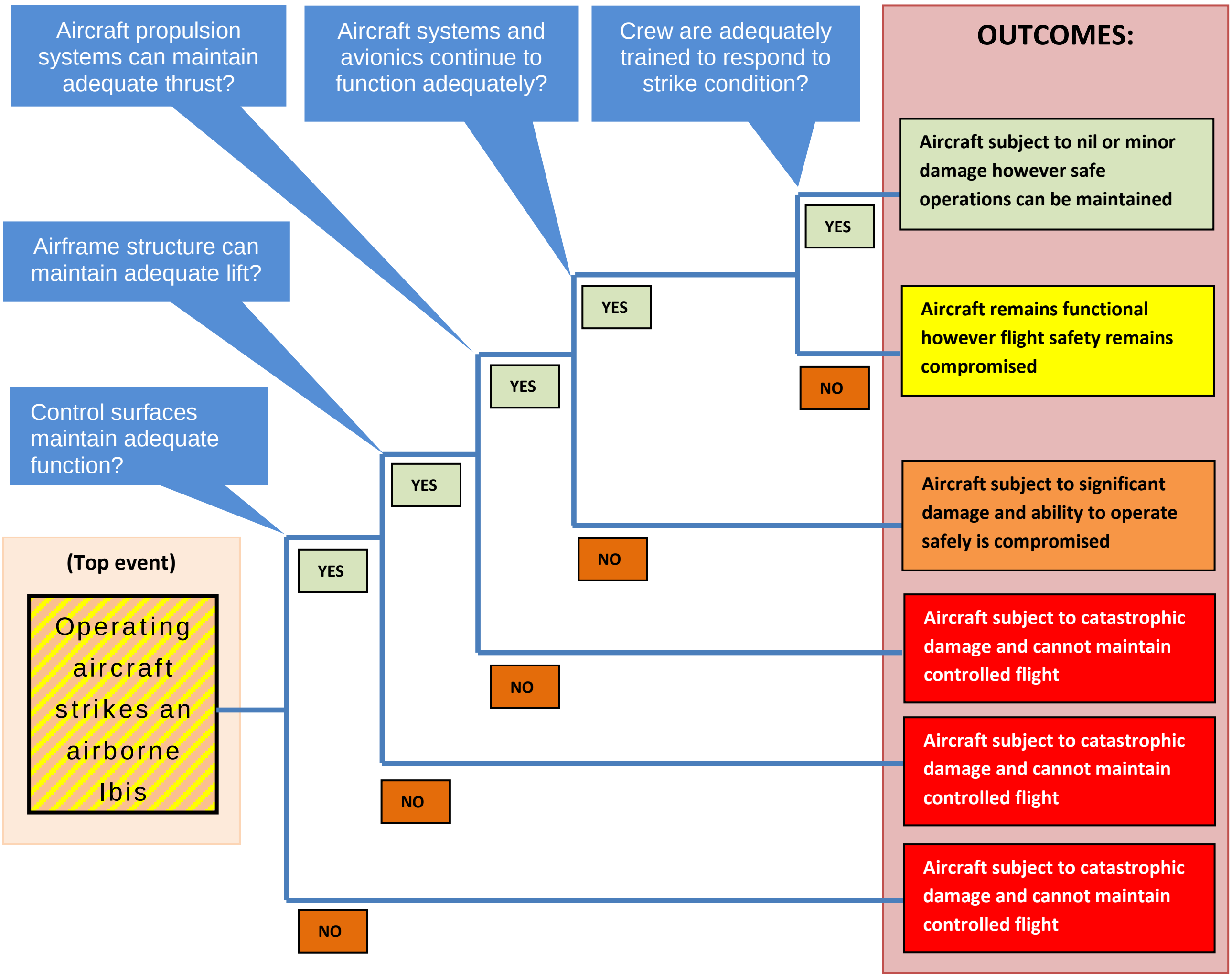

Figure 1.6: Simple example of Event/Outcome Analysis method (for illustrative purposes only)

Similar to the Fault Tree Analysis method, the probabilities of subsequent decisions and the performance of equipment and systems leading *from* the top event can be calculated. This can be assessed at each branch point until they are analysed to their logical conclusion.

This then allows the probability of all the considered outcomes (consequences) to be objectively considered.