RECOMMENDED PRACTICE

LASERS: USE AND GENERAL SAFETY

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1. Outline

1.1 This Recommended Practice (**RP**) aims to provide the aviation industry with information on how to use Laser devices safely for the purpose of wildlife hazard management.

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 It is intended that the practices outlined in this document will be utilised by industry representatives to:

- Use Lasers safely to manage wildlife in order to ensure aviation safety; and
- Use Lasers in accordance with any applicable regulations.

1.4 It is recommended that this document should be read in conjunction with:

- RP 3.2.1 : Firearms: Use and General Safety
- RP 3.2.2 : Effective Use of Firearms *(Reserved)*

1.5 This document will be subject to regular review through the AAWHG. Should you wish to provide comment or would like to contribute to the content of this document, please contact the group at its email address: info@aawhg.org

2. Nature of Hazard - General

2.1 Lasers are capable of producing intense beams of collimated radiation in the optical/visible, UV and infra-red spectrums. While lasers vary greatly in power output, wavelength and purpose, the hazard potential can be significant due to the concentrated energy density. Laser radiation can be extremely hazardous to the eyes and the skin and a number of cases of serious injury, including loss of sight, have been documented. Additionally, the extreme distances at which Laser emissions can be visible pose a significant threat to aviation through the possibility of startling, dazzling or distracting pilots.

NOTE: The hazard posed by a given Laser cannot be determined by simple checking of the output power, wavelength or beam-size. For example, a 5mW with a 3mm beam at 600nm may be more hazardous than a 30mW device with a 30mm beam at 600nm, given other variable parameters.

2.2 As a result, a number of international and Australian standards which set out requirements for laser safety have been published or revised in recent years. This Recommended Practice provides advice on the administrative measures needed to implement these standards on an airfield/aerodrome.

2.3 While lasers vary greatly in power output, wavelength and purpose, the current Australian Standard is AS/NZS IEC 60825:2011 *Safety of Lasers Products*; and is the principal document that should be used for laser safety in this country.

3. Definitions

3.1 The following terms are commonly used when refering to Lasers and some are used within this Recommended Practice:

Blink Reflex	Also known as the corneal reflex; is an involuntary reflex of the eyelids (or blinking) caused by stimulation of the cornea (such as by touching or by a foreign body), or in this case a bright light. The reflex is rapid; generally taken as <0.1sec.
Beam Size/Diameter	This is one of several elements used to describe a given laser beam; generally expressed in millimeters (mm). Due to divergence, the beam diameter may not correlate to the actual spot size seen on the ground.
Diffuse Reflection	The component of a reflection from a surface which is incapable of producing a virtual image such as is commonly found with flat finish paints or rough surfaces. A matt surface will reflect the laser beam in many directions. Viewing a diffuse reflection from a matt surface may produce either a small or a large retinal image, depending on the viewer distance and the size of the illuminated surface.
Divergence (ϕ)	For the purpose of this document, the divergence is the increase in the diameter of the laser beam with distance from the exit

	aperture, based on the full angle at the point where the irradiance (or radiant exposure for pulsed lasers) is 1/e times the maximum value.
Intrabeam Viewing	All viewing conditions whereby the eye is exposed to the direct or specularly reflected laser beam, in contrast to, for example, to viewing of diffuse reflections.
Laser	1) An acronym for light amplification by stimulated emission of radiation. 2) A device that produces an intense, coherent, directional beam of optical radiation by stimulating emission of photons by electronic or molecular transitions to lower energy levels.
Nominal Ocular Hazard Distance (NOHD)	The distance along the axis of the laser beam beyond which the appropriate maximum permissible exposure (MPE) is not exceeded (i.e. an indication of the "safe viewing" distance). An equivalent term for skin exposure is "Nominal Skin Hazard Distance (NSHD)".
Nominal Skin Hazard Distance (NSHD)	The distance along the axis of the laser beam beyond which the appropriate maximum permissible exposure (MPE) is not exceeded (i.e. an indication of the "safe skin exposure" distance). An equivalent term for eye exposure is "Nominal Ocular Hazard Distance (NOHD)".
Power	The rate at which energy is emitted, transferred or received. Unit: Watts (W) (eqv. joules per second).
Specular Reflection	A mirror-like reflection that usually maintains the directional characteristics of a laser beam.
Wavelength (λ)	The distance between two successive points on a periodic wave that have the same phase. It is commonly used to provide a numeric description of the colour of visible laser radiation. Unit: nano-metres (nm).

4. Laser Classification

4.1 Lasers are grouped into seven classes according to accessible emission limits. Note, modifications can increase the class and subsequent hazard of a laser.

4.2 **Class 1.** Lasers are safe under most circumstances and are incapable of damaging the eyes or skin because of either engineered design or inherently low power output.

4.3 **Class 1M.** Lasers emit in the wavelength range 302.5–4000nm and may be hazardous if optics[1] are used in the beam.

4.4 **Class 2.** Lasers emit in the visible wavelength range 400–700nm and have sufficient power output to cause damage to the eyes if viewed continuously. The 'blink reflex' generally affords suffiecient eye protection given the low output of these devices. Additional hazard control measures take the form of cautionary signs or labels.

4.5 **Class 2M.** Lasers are similar to Class 2 however viewing may be more hazardous if the user employs optics within the beam.

4.6 **Class 3R.** Lasers emit in the wavelength range 302.5–1060nm and have the potential to cause damage to the eyes from intra-beam viewing but the risk is lower than for Class 3B lasers. Precautions are required to prevent both direct viewing and viewing with optical instruments.

4.7 **Class 3B.** Lasers are more hazardous because of either higher output or operation outside visible wavelengths. In addition, specular reflections may also be hazardous. In general, more stringent controls are needed to prevent exposure.

4.8 **Class 4.** Lasers are high power devices capable of producing eye damage even from diffuse reflection. They may cause skin injuries and could also constitute a fire hazard. Examples of class 4 lasers include surgical lasers and those used in the plastic, wood and metal fabrication industries.

5. Hazards: Health and Bioeffects of Laser Exposure

5.1 The hazards associated with the operation of a Laser can be generally broken down to:

- Environmental – fire hazard
- Environmental – wildlife
- Operator – skin hazard
- Operator – ocular hazard
- Other airfield users – ocular hazard
- Overflying aircraft – ocular hazard

5.2 **Fire Hazard.** The laser emission from high-power (Class 4) lasers can readily ignite sensitive materials in their path. Laser emission from even lower-class lasers, especially when concentrated over very small areas, can cause explosions in combustible liquids and gases or in high concentrations of airborne dust. Laser

[1] Optics when referred to in Laser Classification, refers to the use of any magnifying viewing instrument. Such instruments includes binoculars, telescopes or magnifying lenses such as those used in telescopic sights on weapons.

equipment can also present a fire hazard by virtue of the flammable components, plastic parts etc. contained within it, which can overheat or catch fire in the event of a fault within the equipment.

5.3 **Skin Hazard.** Skin is less at risk from damage caused by lasers, but exposure to lasers still need to be managed appropriately to minimise the potential for skin burns.

5.4 **Ocular (Eye) Hazard (Operator and Wildlife[2]).** Eyes are the most susceptible to damage from lasers. Different parts of the eyes are susceptible to different wavelengths. Damage can be in the form of retinal burns, retinal haemorrhage, corneal damage or global rupture. Appropriate controls are essential to prevent eye damage. Other ocular hazards associated with Laser exposure includes:

- Distraction (may occur at distances of tens of kilometres from the aerodrome),
- Glare (often referred to as Dazzle; may occur at distances of up to 10–15km),
- Flash-blindness (can persist from several seconds to several minutes),
- After-images (can persist from several minutes up to many days),
- Scotomas (may be a temporary or permanent ocular defect); or
- Other (including psychological).

5.5 **Other hazards.** In addition to laser radiation, there are additional hazards such as collateral radiation, electrical shock, fire, thermal shock, mechanical hazards, vapours and chemicals. All these hazards need to be considered when completing a risk assessment associated with Laser employment.

6. Hazard control and safe practice

6.1 Laser hazards may be controlled by the use of engineered controls, administrative controls and personal protective equipment, either used singularly or in combination. As a general principle, engineered controls are preferred where appreciable hazards exist, although these may need to be supplemented by the use of appropriate eye protection.

6.2 The control measures and the associated requirements of all laser classifications are listed in detail in Australian/New Zealand Standard AS/NZS IEC 60825.14:2011 *Safety of Laser Products–Part 14 A User's Guide*.

[2] Glahn et al (2001) reported laboratory findings of no ocular damage to cormorants after direct exposure to a Class-III B Laser at distances as small as one metre. However, Lustick (1973) suggested that birds with higher concentrations of rhodopsin pigment are more sensitive to light intensity. Therefore, avian species that are active at night (e.g. owls, waterfowl, wading birds) may be more likely to be adversely impacted by high intensity lasers.

7. Engineering Controls

7.1 Lasers require certain built-in safety features dependent on their classification. These engineering control measures incorporated into the design of the laser system may include:

- protective housings
- remote interlocks
- access panels
- master switches
- spectrum filters
- enclosed, semi-enclosed or limited beam paths.

7.2 Lasers used in the vicinity of airfields should have an intergral system or interlock which disables the Laser at a pre-set angle reference the horizon. Such as system prevents unintended potential illumination of aircraft, particularly airborne.

8. Administration Controls

8.1 To aid in managing the risk associated with the use of lasers, the following controls are to be implemented where lasers are used:

- appointing a Laser Safety Officer
- safe working procedures
- user registration
- training
- record keeping
- correct labelling of device
- eye and skin examinations.

9. Personal Protective Equipment

9.1 The main form of PPE for Laser operators is protective eyewear, but in the case of class 4 lasers should also include protective clothing and footwear. Details on protective eyewear can be found in Australian/New Zealand Standard AS/NZS 1337.4 and AS/NZS 1337.5.

10. Laser Safety Officer

10.1 A Laser Safety Officer (LSO) is a designated operator who has received training to an appropriate level and is knowledgeable in the evaluation and control of laser hazards. The LSO would have responsibility for the suitable training of laser users and oversight of the control of laser hazards. A Laser Safety Officer must be appointed where Class 3 or 4 lasers are used.

LASERS: GENERAL SAFETY

11. Types of Lasers used in Wildlife Harassment & Dispersal

11.1 Lasers for use in wildlife harassment and/or dispersal generally fall into one of two groups; hand-held/portable and fixed/automated.

11.1.1 *Hand-held/Portable.* Hand-held/portable Lasers designed for use in wildlife harassment and/or dispersal generally appear like a 'pistol'. They have a main-body; housing the Laser itself, a pistol-grip type handle and an on/off trigger. Examples images of two available devices are shown below.

11.1.2 *Fixed/Automated.* Fixed/automated Lasers designed for use in wildlife harassment and/or dispersal are generally bulky, box-like devices. They will have some form of base or plate which is secured to the ground, they will often have a separate power-supply/control box and a gimbal-mounted Laser capable of movement through a number of axis. Examples images of two available devices are shown below.

11.2 **Advantages/Dis-advantages.** There are distinct advantages and dis-advantages with each of the groups of Lasers described above. These must be considered as part of the assessment prior to acquiring such technology and again when compiling the Risk Assessment for the operational employment of the Laser.

11.2.1 Hand-held/Portable. The advantages of a hand-held/portable Laser lies directly in their design. Being portable, they are able to be employed at any location airside or

landside considered appropriate and can be relocated as readily as the Wildlife Managent Officer can. These devices are relatively small and relatively cheap. The dis-advantages of a hand-held/portable Laser comes from the fact that the device requires an operator to utilise it. If there is a continuous threat from wildlife, then either multiple devices may be required (one for each operator) or the Wildlife Management Officer may need to be quite mobile, just as they are with conventional dispersal equipment.

11.2.2 Fixed/Automated. These Lasers do not require personnel to operate them; this is both advantage and dis-advantage. Extreme caution should be exercised in siting these devices and in the development of procedures for activating and deactivating them. While there is the same potential to startle and distract nearby aircraft operators and cause a significant safety concern as with hand-held devices, a fixed installation does not usually have an operator present at all times. Fixed/Automated Lasers are generally significantly more expensive than a portable device and may be best utilised during extended periods of airfield inactivity, preventing the influx of wildlife while a Wildlife Management Officer may be off-shift.

12. Use of Lasers - General

12.1 Lasers are increasingly forming a necessary and effective control measure within an integrated wildlife hazard management plan.

12.2 Lasers are generally used as a repellent measure for wildlife by using a 'spot' of Laser light in the vicinity of grounded wildlife, making them feel uneasy[3]. Normal response behaviour will generally result in the affected wildlife dissipating due to this feeling of restlessness. The use of directed beams of Laser light, onto the wildlife themselves and particularly the faces and eyes is STRONGLY DISCOURAGED from a humane and ethical perspective.

12.3 Any personnel operating a Laser or related equipment needs to be adequately trained in their safe and correct use. Adequate supervision needs to be maintained during the operation of Lasers. This applies equally to company personnel and/or any contracted (i.e. 3rd party) staff that are used for this purpose.

12.4 As with conventional weapons employed on an aerodrome, a register of approved Lasers should be maintained, including detailed information of the Risk Assessment of each different type of Laser approved for use.

12.5 The type of Laser used should be carefully selected to ensure it is appropriate and safe for the intended purpose.

12.6 When using a Laser, any wildlife that may be affected by its use should always be treated as humanely whenever possible.

[3] Note, the effectiveness of a Laser will generally be greater during low-light/dark conditions

12.7 All Lasers are potentially harmful in an airfield environment and need to be handled with care at all times. TREAT EVERY LASER AS IF IT IS A FIREARM.

12.8 The use of Lasers should be subject to an appropriate and complete risk assessment. Appropriate control measures need to be put in place prior to their use.

12.9 Any Laser, related equipment and their operating procedures should be managed by the relevant Safety Management System.

12.10 The use of a Laser and related equipment should also comply with any applicable Occupation Health and Safety legislation.

13. Operation of Lasers

13.1 *Recommended procedures for safe Laser use*

It is recommended the following procedures are followed to ensure safe Laser use:

13.1.1 ALWAYS treat Lasers as if they were a FIREARM – DO NOT ever point in a direction which is not safe.

13.1.2 When carrying a Laser ALWAYS ensure the aperture is pointed toward the ground or in a safe direction away from personnel, equipment and infrastructure.

13.1.3 Never operate a Laser from inside a moving vehicle.

13.1.4 Exercise caution when operating from a stationary vehicle due to restriction on all round visibility and scanning for conflicting people or aircraft.

13.1.5 Complete a thorough assessment of your surrounds before FIRING. Remember the HAZARD zone is not only the area between you and your target, but also the area around the target, in all directions. You need to consider the extreme range of the Laser, allowing for diffuse and specular reflections. If in doubt DO NOT FIRE or OPERATE THE LASER.

13.1.6 ALWAYS be ALERT to the DANGER of people, vehicles or aircraft (note helicopters could approach from any direction), moving into line of fire, both in-front of and behind the target area.

13.1.7 Always point Lasers in a safe direction. NEVER POINT OR AIM A LASER AT A PERSON. If in doubt DO NOT FIRE or OPERATE **THE LASER.**

13.1.8 NEVER point or aim a Laser at an object or at a target area UNLESS INTENDING TO FIRE.

13.1.9 NEVER shoot at a reflective surface or at the surface of water. Extreme caution should be exercised operating a Laser during or immediately after rainfall as the chances of specular reflections is great.

13.1.10 Certain Lasers can pose a FIRE HAZARD if operated very close to the ground/grass during dry conditions. After use, operators should monitor the site for signs of fire and respond accordingly.

13.1.11 REPORT all Laser faults or unserviceability to the responsible manager or accountable person. Refer Section 18 of this RP for more information.

13.1.12 Personnel using Lasers are strongly recommended to use appropriate Personal Protective Equipment. Refer Section 14.2 of this RP for more information.

13.2 *Personal Protective Equipment*

13.2.1 When using Lasers, it is strongly recommended that appropriate Personal Protective Equipment is used and/or worn. This should include but not be limited to:

- Eye Protection/Safety Glasses
- Sturdy/fully enclosed footwear

14. Regulatory requirements

14.1 *Aerodrome Operators*

14.1.1 For Certified Aerodromes with a confirmed wildlife hazard, the Manual of Standards Part 139, section 10.14 requires a Wildlife Hazard Management Plan to be developed. This plan must address an ongoing strategy for bird and animal hazard reduction and also suitable harassment methods.

14.1.2 Advisory Circular AC139-26 contains recommendations for regulated aerodromes to conduct wildlife hazard mitigation.

14.1.3 Under the *Aviation Transport Security Regulations 2005*, aerodromes which are bound by the *Airports Act 2004* must include in their Transport Security Programme (TSP):

- Procedures for using firearms and *other weapons*[4] in the airside area or landside security zones;
- Methods for ensuring that staff who have a need to know are aware of the restrictions on the possession and use of firearms, *other weapons* and prohibited items within the airport.
- Procedures to handle or transport firearms, *other weapons* and prohibited items (that) are consistent with relevant Commonwealth, State or Territory laws.

14.1.4 Under the *Aviation Transport Security Regulations 2005*, aerodromes which are bound by the *Airports Act 2004* are authorised to have personnel with firearms, weapons and other prohibited items within the airside area of an airport, if:

- with the consent of the airport operator, personnel are engaged in controlling wildlife or other animals on the airport;

[4] *Aviation Transport Security Regulations 2005 Table 1.09 row5 column2* states a weapon is – *[amongst other things]* Things designed to disable or incapacitate, or otherwise harm, a person or animal

- *(if required)* personnel hold and have in their position a firearms licence, validly issued under the law of the State or Territory in which the airport is located, for the firearm; and
- *(if required)* a licence or permission is required under the law of the State or Territory for the person to shoot wildlife or animals on the airport, the personnel hold and have in their position such a licence or permission.

14.2 *State and Territory regulations affecting Laser owners and operators*

14.2.1 Regulations for the possession and use of certain restricted items including Lasers, vary between the states and territories. Please refer to your applicable State authority for more information.

14.3 *State and Territory regulations affecting workplace health and safety*

14.3.1 Regulations and policy related to Workplace Health and Safety can vary between the states and territories. Please refer to your applicable State authority for more information.

15. Authorisation and licencing

15.1 All personnel who handle and operate Lasers should have received appropriate training and be deemed competent by the applicable authority.

15.2 All Lasers used for wildlife hazard management should be approved and registered under the relevant regulations of the applicable state or territory (if required).

15.3 Any modifications to the Laser should be approved in accordance with the relevant regulations of the applicable state or territory. Any such modifications should be made by a properly qualified and experienced person.

15.4 Officers who are tasked to handle and operate Lasers should be properly authorised by their organisation.

15.5 Any relevant permits to control and/or harass wildlife should be obtained from the relevant authority(s) prior to commencing wildlife management.

16. Training

16.1 It is strongly recommended that all operators of a Laser are appropriately trained and are assessed as being competent in their use. This training should include but not be limited to:

- Completion of a Laser safety course,
- Company based safety training,
- Dedicated wildlife hazard management training,
- Completion of a Aerodrome Reporting Officer course (or are supervised by an Aerodrome Reporting Officer who is trained),
- Specialised Laser training as required (i.e. on the specific device); and/or

- Humane treatment of wildlife.

17. Review

17.1 The procedures for the use of Lasers should be subject to regular review and should be conducted annually at a minimum.

18. Records management

18.1 The maintenance of records for the use of Lasers is vitally important to support the process. The maintenance of records will assist organisations in:

- Tracking when Lasers are used;
- Tracking what species were controlled/deterred by using a Laser;
- Tracking the effectiveness of Laser use in controlling the wildlife hazard.

18.2 These records can also be used to substantiate an organisation's mitigation strategy.

18.3 In the absence of an overriding legislative requirement, it is recommended that these records are maintained for a minimum of 2 years from the original date of their creation.

19. References

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

19.2 International Civil Aviation Organisation, Annex 14—Aerodromes, Volume 1—Aerodrome Design and Operations, ICAO, Montreal, Quebec, Canada, Fifth Edition, 2008.

19.3 International Civil Aviation Organisation, 2012, *Airport Services Manual – Wildlife Control and Reduction* (Doc 9137-AN/898 Part 3)

19.4 *International Civil Aviation Organisation, 2003, Manual on Laser Emitters and Flight Safety (Doc 9815-AN/447)*

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

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

19.7 Civil Aviation Safety Authority, 2007, Australia, Advisory Circular 139-23*, Laser Emissions which may Endanger the Safety of Aircraft,* <www.casa.gov.au>

19.8 Civil Aviation Safety Authority, 2011, Australia, Advisory Circular 139-26, *Wildlife Hazard Management at Aerodromes*, <www.casa.gov.au>

19.9 Infrastructure and Transport, 2005, Australia, *Aviation Transport Security Regulations 2005,* <www.comlaw.gov.au>

19.10 Australian/New Zealand Standard AS/NZS IEC 60825.14:2011 *Safety of Laser Products–Part 14 A User's Guide*.

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

20. Other reading

20.1 Blackwell, Bradley F.; Bernhardt, Glen E.; Cepek, Jon D.; and Dolbeer, Richard A., *"Lasers As Non-Lethal Avian Repellents: Potential Applications In The Airport Environment"* (2002). USDA National Wildlife Research Center - Staff Publications. Paper 147. http://digitalcommons.unl.edu/icwdm_usdanwrc/147

20.2 Glahn, J. F., G. Ellis, P. Fiornelli, and B. Dorr. 2001. *"Evaluation of moderate- and low- power lasers for dispersing double-crested cormorants from their night roosts."* Proceedings of the Eastern Wildlife Damage Management Conference 9:34- 45.

20.3 Lustick, S. 1973. *"The effect of intense light on bird behavior and physiology."* Bird Control Seminar Proceedings 6:171- 186.