



EAC

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LASER EMISSIONS WHICH MAY ENDANGER THE SAFETY OF AIRCRAFT

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1. References:

- ECAR 139, Item 139 (a) (2).
- ICAO Doc 9815, Manual on Laser Emitters and Flight Safety.
- Australian Civil Aviation Safety Authority AC 139-23 (0), Laser emissions which may endanger the Safety of aircraft.
- Civil Aviation Safety Authority of New Zealand AC91-17, Laser Illumination of Aircraft

2. Purpose:

2.1 This Guidance Material provides general information and advice on measures to protect pilots of civil aircraft from accidental laser beam strikes, on or in the vicinity of an aerodrome.

2.2 It should be of interest to aerodrome operators, and to the operators of laser shows. It may also be of interest to Air Traffic Controllers.

2.3 This guidance should be used in the planning and control of advertising, entertainment, and similar visual displays using visible laser light.

2.4 This Guidance Material is unlikely to prevent willful or malicious laser attacks against aircraft.

3. Status of this Guidance Material:

3.1 This is the first guidance material to be issued on this subject.

4. Glossary:

4.1 Irradiance (E). The power per unit area expressed in watts per square centimeter (W/cm²) or watts per square meter (W/m²). Small values may be expressed as micro watts per square centimeter (μ W/cm²) or nano watts per square centimeter (nW/cm²), 10⁻⁶ and 10⁻⁹ respectively.

4.2 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 transition to lower energy levels.

4.3 Maximum Permissible Exposure (MPE). The internationally accepted maximum level of laser radiation to which human beings may be exposed without risk of biological damage to the eye or skin.

4.4 Protected Flight Zones. Airspace specifically designated to mitigate the hazardous effects of laser radiation.

- (a) **Laser-beam critical flight zone (LCFZ).** Airspace in the proximity of an aerodrome but beyond the laser-beam free flight zone (LFFZ) where the irradiance is restricted to a level unlikely to cause glare effects.

- (b) **Laser-beam free flight zone (LFFZ).** Airspace in the immediate proximity to the aerodrome where the irradiance is restricted to a level unlikely to cause any visual disruption.
- (c) **Laser-beam sensitive flight zone (LSFZ).** Airspace outside, and not necessarily contiguous with, the LFFZ and LCFZ where the irradiance is restricted to a level unlikely to cause flash blindness or after-image effects.
- (d) **Normal flight zone (NFZ).** Airspace not defined as LFFZ, LCFZ or LSFZ but which must be protected from laser radiation capable of causing biological damage to the eye.

5. General:

5.1 Lasers can produce a beam of light of such intensity that permanent damage to human tissue, in particular the retina of the eye, can be caused instantaneously, even at distances of over 10 km. At lower intensities, laser beams can seriously affect visual performance without causing physical damage to the eyes.

5.2 Protection of pilots against accidental laser beam strike has become a serious factor in aviation safety with the advent of the laser light display for entertainment or commercial purposes.

5.3 To protect the safety of aircraft against the hazardous effects of laser emitters, the following protected zones should be established around aerodromes:

- (a) A laser-beam free flight zone (LFFZ),
- (b) A laser-beam critical flight zone (LCFZ), and
- (c) A laser-beam sensitive flight zone (LSFZ).

5.4 ECAR139 figures 5-10, 5-11 and 5-12 may be used to determine the exposure levels and distances that adequately protect flight operations.

5.5 The restrictions on the use of laser beams in the three protected flight zones, LFFZ, LCFZ, and LSFZ, refer to visible laser beams only.

5.6 Laser emitters operated by authorities in a manner compatible with flight safety are excluded from these restrictions. Typical examples of lasers used to support aviation include some cloud base or visibility measurement equipment, some bird harassing devices, and some aircraft docking guidance systems. Aerodrome authorities are to ensure that these lasers have the beam aimed in such a direction, and/or that the times of operation are controlled, to ensure no hazard is posed to aircraft operations.

5.7 In all navigable air space, the irradiance level of any laser beam, visible or invisible, is expected to be less than or equal to the maximum permissible exposure (MPE) unless such emission has been notified to the authority and permission obtained.

5.8 The protected flight zones are established in order to mitigate the risk of operating laser emitters in the vicinity of aerodromes.

5.9 The dimensions indicated for the various zones are given as guidance, but ICAO Doc 9815 advises that they have been found to provide for the safe operation of aircraft in the vicinity of aerodromes.

6. Laser-Beam Free Flight Zone:

6.1 Within this zone, the intensity of laser light should be restricted to a level that is unlikely to cause any visual disruption. The irradiance should not exceed 50 nW/cm² unless some form of mitigation is applied. The level of brightness thus produced is indistinguishable from background ambient light.

7. Laser-Beam Critical Flight Zone:

7.1 While the suggested extent of this zone is shown in the Figures, this zone may have to be adjusted to meet air traffic requirements.

7.2 Within this zone the irradiance should not exceed 5 UW/cm² unless some form of mitigation is applied. Although capable of causing glare effects, this irradiance will not produce a level of brightness sufficient to cause flash-blindness or after-image effects.

8. Laser-Beam Sensitive Flight Zone:

8.1 The extent of this zone should be determined by the operations at the particular aerodrome. The LSFZ need not necessarily be contiguous with the other flight zones.

8.2 Within this zone the irradiance should not exceed 100 μW/cm² unless some form of mitigation is applied. The level of brightness thus produced may begin to produce flash-

blindness or after-image effects of short duration; however, this limit will provide protection from serious effects.

9. Normal Flight Zone:

9.1 The NFZ is any navigable airspace not defined as LFFZ, LCFZ or LSFZ. The NFZ should be protected from laser radiation capable of causing biological damage to the eye.

9.2 The maximum irradiance level (MIL), should be equal to or less than the maximum permissible exposure (MPE).

10. Hazards:

10.1 The red laser pointer commonly seen in classrooms and conference venues are low-powered devices of less than one milliwatt (mW). These are normally a 'Class 2' laser device (the higher the class number, the greater the hazard), with insufficient power to cause actual physical harm, although they still require care in their operation and use.

10.2 Green laser pointers are readily available with a maximum power rating of 5 mW, and are classified as a 'Class 3R laser device' (more hazardous than Class 2). The eye's maximum sensitivity to visible light is around the wavelength of a green laser, and the eye will interpret a green laser light of a given power as being up to 30 times brighter than a red laser of the same power. Direct eye exposure to a Class 3R laser beam can result in temporary visual impairment.

10.3 Some effort would be required to inflict actual eye damage with a 5 mW green laser pointer as both the low power and the eye's natural defense (blinking reflex) would combine to limit potential damage. However, some vendors are now advertising higher-powered (from 10 to 400 mW) green laser pointers which are definitely harmful, and can cause permanent eye damage.

10.4 The severity and duration of the vision impairment varies significantly, depending on the intensity and wavelength of the light, the individual's current state of light (or dark) adaptation, and even the person's skin pigmentation (eye colour). The effects of exposure to a laser beam include:

- Distraction: The dazzling effect on the eye can be a major distraction, particularly in situations of high workload (e.g. take-off, approach, and landing).
- Temporary Visual Impairment: Adverse visual effects that include: glare (a temporary disruption in vision caused by bright light within an individual's field of vision); flash-blindness (the inability to see, caused by bright light entering the eye) that persists after the illumination has ceased; and after-image (an image that remains in the visual field after exposure to a bright light).
- Eye Injury: Temporary or permanent damage to the eye caused by exposure to laser light. Normally: the result of direct exposure to prolonged or high power laser light.

10.5 Laser illumination of aircraft can cause distraction, disorientation, and discomfort for pilots resulting in a potentially hazardous situation during critical phases of flight.

11. Role of Air Traffic Service:

11.1 As soon as possible following laser illumination occurrence, the flight crew should report the incident by radio to the appropriate ATC unit. Expedient reporting will allow ATC to alert other pilots to the hazard and will assist the Police in locating the source of the laser transmission(s).

11.2 The initial radio report to ATC should include the following:

- Aircraft call sign
- Nature of report (laser illumination)
- Aircraft position at time of occurrence
- Aircraft altitude at time of occurrence
- Colour of laser
- Location of origin of light source or relative direction and estimated distance from aircraft
- Any other information that might assist law enforcement Pilots should avoid looking directly at the source (priority is to minimize exposure effects).

11.3 All ATC Units advised of a laser illumination occurrence will provide relevant information to any following aircraft. The ATC Unit involved will also contact Local Police as soon as possible and provide them with a detailed report to assist in locating the source of the laser.

12. Role of Air Carrier:

12.1 The time and place of an unauthorized illumination of an aircraft by a laser is difficult to predict, although there is evidence that aircraft operating in certain locations, particularly around airports, are increasingly likely to be subject to unauthorized illumination. Whenever practicable, flights within areas of recently reported laser or bright light activity should be avoided. Pilots operating in controlled airspace should obtain an ATC clearance before deviating from their cleared flight path, having first dealt with their immediate safety concerns.

12.2 In the event that a pilot encounters an unauthorized laser illumination of an aircraft, the following actions are recommended:

- Do not stare directly into the laser beam – avoid or shield the eyes if possible.
- If your vision is affected, hand over control (assuming a two-pilot crew, and that the other pilot has not been affected).
- Crews manually flying aircraft fitted with modern autopilots and Flight Management Systems (FMS) might need to consider autopilot re-engagement, and use of FMS to aid flight path control.
- Turning up cockpit lighting may assist in overcoming the ‘flash’ after-effects (peripheral vision may still be effective).
- Do not rub the eyes after exposure.
- If any lingering effect is experienced, seek medical attention after landing.
- Report the occurrence immediately to ATC, and as soon as possible through your normal reporting channel.

12.3 An unauthorized illumination of an aircraft by a laser constitutes an aircraft incident and therefore a pilot experiencing a laser illumination occurrence is required to submit details of the incident to ECAA.

12.4 All AOC holders should ensure that their exposition contains guidance information for crews on the immediate actions to be taken to mitigate the effects if their aircraft is targeted by a laser illumination.

The guidance should also include follow-up action including the need to report the incident. Crew members should be encouraged to seek medical attention if the eye exposure to a laser is of more than transient duration or if there are any lingering effects.

12.5 The information provided will assist the ECAA in identifying the key risk areas and determining appropriate mitigation and solutions in concert with other agencies.

13. Role of Airport management:

13.1 Aerodrome authorities are to ensure that any lasers have the beam aimed in such a direction, and/or that the times of operation are controlled, to ensure no hazard is posed to aircraft operations.

Laser emissions of which exceeds any of the limits or penetrates the protected zones described in ECAR 139.323(a)(2) shall be extinguished, screened or otherwise modified so as to eliminate the source of danger.

13.2 Airport should monitor the laser-beam free flight zone as part of airport serviceability inspections.

13.3 For any new light works in the vicinity of the airport, airport notify to ECAA which has the authority to take action in case of any potential deficiency.

13.4 If laser violation detected during inspections, it should be assessed and surveyed by as soon as possible to determine the extent of the infringements and changes to published information. If they exceed the limits specified in ECAR 139, the airport will raise a NOTAM and advise AIS.

14. Role of Light and Firework Display Organizers:

14.1 This section refers to procedures concerned with temporary laser light and firework displays.

14.2 For light and firework displays, Organizers should notify ECAA of their proposed activity. To allow time to de-conflict or co-ordinate the activity, as well as promulgate warnings to the aviation community and establish any control measures considered necessary, notification needs to be given at least 28 days in advance.

14.3 ECAA will examine the proposal based on the following guidelines. If no further information is required then appropriate warning action will be carried out. While the Display Organizer will not routinely receive written confirmation of this, if further

information or action is required from the Display Organizer, ECAA may contact the originator of the proposal to discuss suitable future courses of action.

Guidelines for Light and Firework Displays

14.4 It is of prime importance that light displays and fireworks are never directed at or towards aircraft or aerodromes. The Light Display organizer should also nominate a single point of contact, known as a Light Display Operator (LDO), who will be directly responsible for the conduct of the actual event. Display organizers should be aware of the following geographical zone, within which ECAA considers it necessary to impose restrictions in order to protect flight operations:

14.5 Within 18500m of an aerodrome's notified Aerodrome Reference Point (ARP) or similar, the following procedures should be adhered to:

- (a) Ideally, measures should be in place to prevent light escaping towards the aerodrome or along the extended runway centerline.
- (b) If this proves impractical, other precautions are to be taken to ensure that light displays do not impinge on safe flight operations, such as arranging for a direct telephone or radio communications link between the LDO and relevant aerodrome, through which the Light Display can be terminated immediately on request from either an aircraft or the affected aerodrome.

NOTE: If this is not possible, then the light display may represent a threat to flight safety and should not proceed.

14.7 Elsewhere, although the light display is unlikely to affect aerodrome flight operations, the Light Display organizer should notify ECAA to ascertain if there are any other aviation activities that may be affected by the display.

15. Further Information:

15.1 Further guidance on how to protect flight operations from the hazardous effects of laser emitters is contained in the ICAO publication "Manual on Laser Emitters and Flight Safety (Doc 9815)".