European Laser Safety: Laser Emitters and Flight Safety

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ILRS Technical Workshop, October 2019, Stuttgart

European Laser Safety: Laser Emitters and Flight Safety

- Classes of lasers.
- Laser bioeffects and hazards.
- Laser hazard evaluation.
  - Maximum Permissible Exposure (MPE).
  - Nominal Ocular Hazard Distance (NOHD).
- Lasers and flight safety.

Classes of Lasers

- Class 1: No risk to eyes.
- Class 2: No risk to eyes for short time exposure.
- Class3: Medium to high risk to eyes, low risk to skin.
- Class 4: High risk to eyes and skin.

Class 4 lasers

- Appoint a Laser Safety Officer (person responsible).
- Undertake a risk assessment.
- Ensure that users act responsibility, and are adequately aware and appropriately trained.
- Establish a system of key security.
- Use in an interlock-protected enclosed controlled aera.
- Use an interlock connector and beam attenuator as necessary.
- Keep open beam paths to a minimum, using guards, screens, etc.
- Use appropriate eye protection.
- Follow the manufacturer’s instructions.
- Develop and use adequate procedural control measures.

Biological tissue damage mechanism

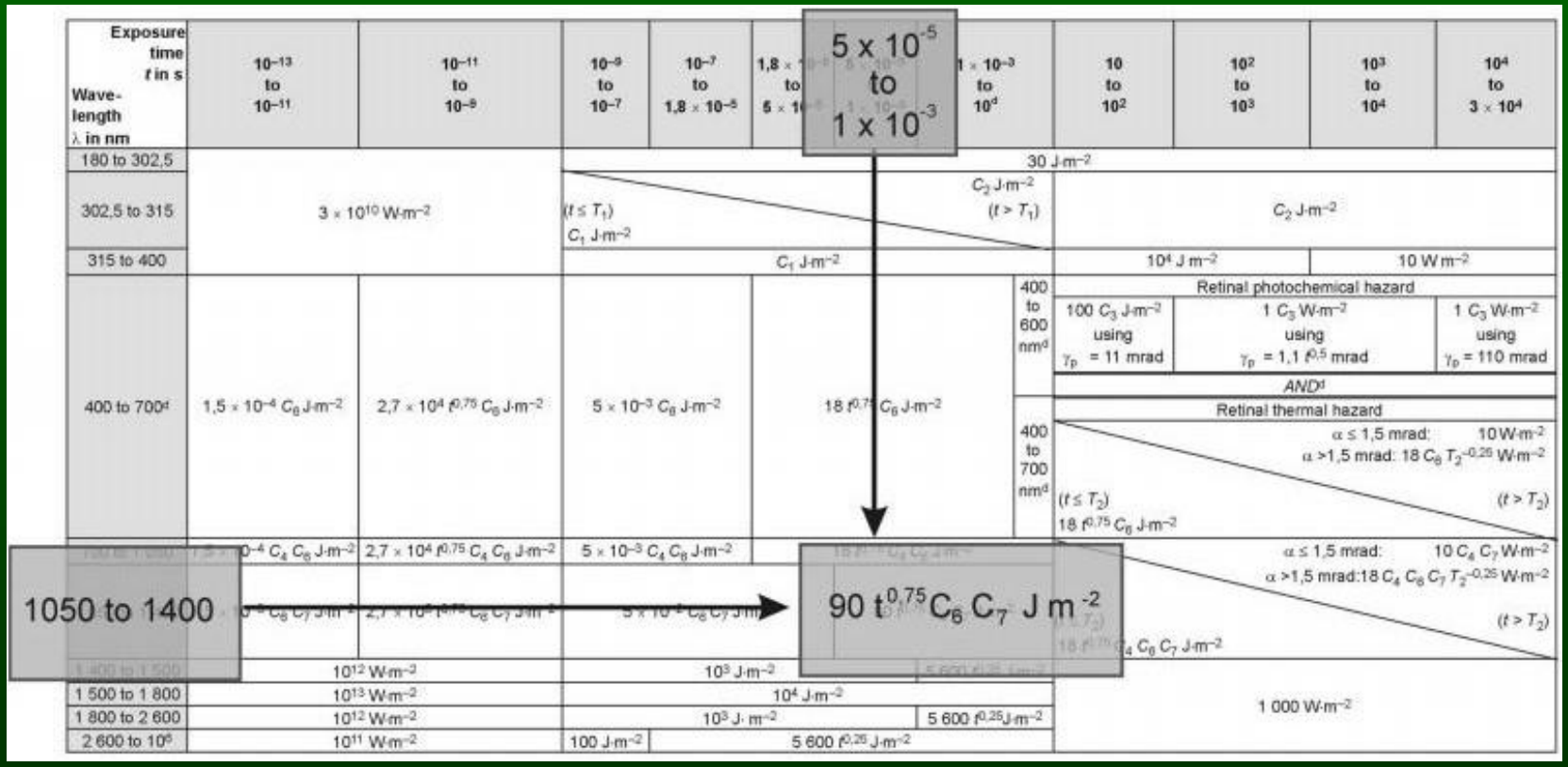
- Photochemical damage: occurs when the energy of an incoming photon is high enough to break existing chemical bonds within individual molecules (cataracts, macular degeneration…).
- Thermal damage: when organic molecule absorbs a photon, this additionally new energy drives the molecule into several types of unstable excited states. The heat can damage surrounding proteinsand other tissues (retinal lesions much larger than expected).
- Acoustico-mechanical damage: occurs as a consequence of high energy, short-duration exposures. Ultra-fast elevations of tissue temperature generate bubbles in the tissue. Aera affected 220 times larger than the thermal damage.

Maximum Permissible Exposure (MPE)

- MPE represents the maximum level to which a person can safely be exposed without incurring biological damage.

- MPE values are determined from biological studies:
  - the skin: 1 J/cm^2
  - the eyes: 50 µJ/cm^2

MPE table



MPE: 50mJ, 100ps, single pulse

- ANSI Z136.1-2000 (Table 5a):
  - 100ps: MPE = 2.7 $t^{0.75}$ J / cm^2
- $MPE_{100ps} = 2.7 (100 \times 10^{-12})^{0.75} = 0.1$ µJ / cm^2

Nominal Ocular Hazard Distance

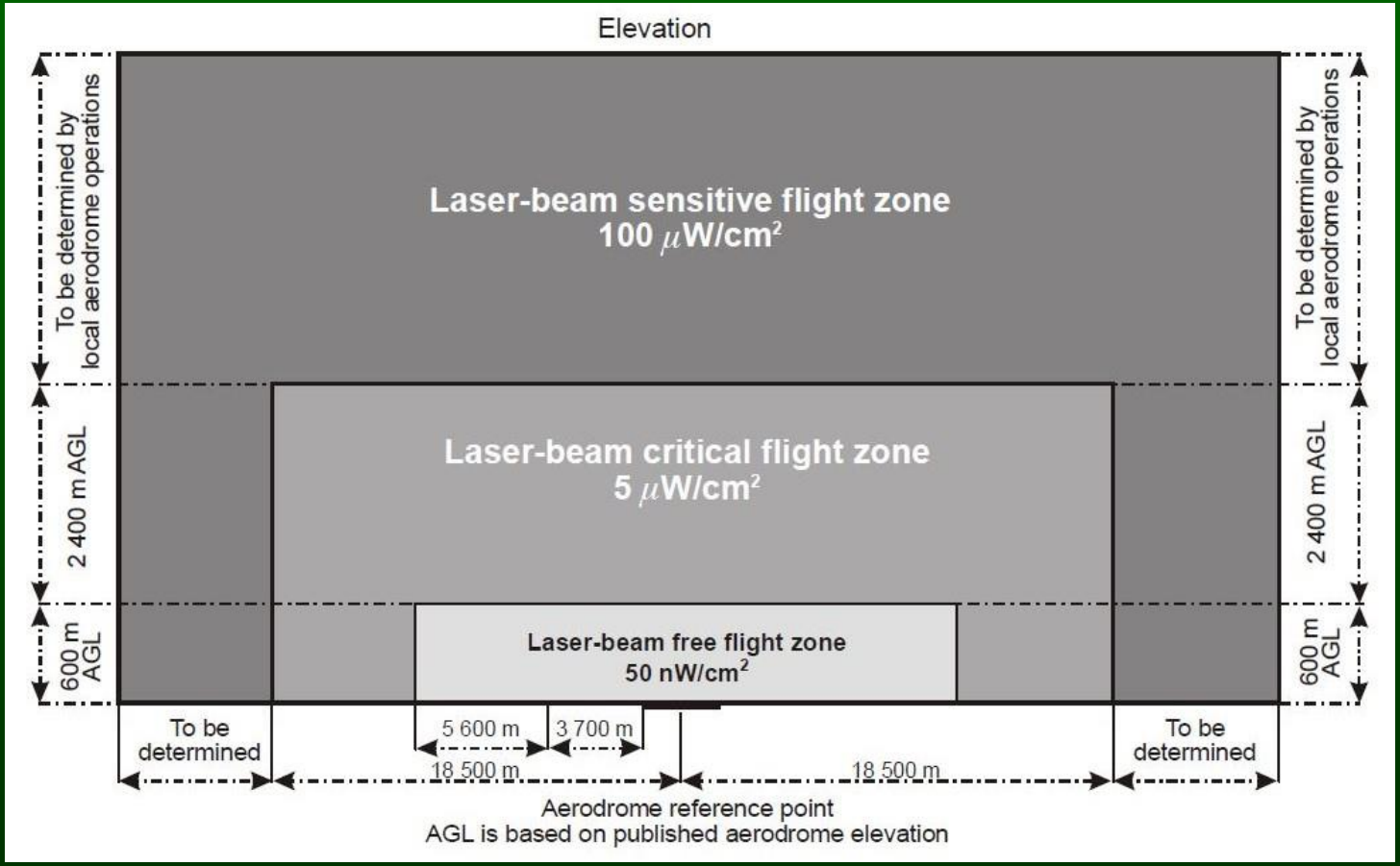
- NOHD is the distance, line of sight, from the emitting source beyond which an eye-safe laser hazard exists.

- $NOHD = \frac{1}{\theta}\sqrt{\frac{4\,Q}{\pi\,.\,MPE} - d^2}$ cm

Q = Pulse energy in Joule	0.06 J at 532 nm
θ = Beam Divergence in radian	1 arcsec
d = Output beam diameter in cm	154 cm

- NOHD = 1 800 km

Protected flight zones



Air Space restrictions

- Laser beam free flight zone (LFFZ): 50nW/cm^2
- Laser beam critical flight zone (LCFZ): 5µW/cm^2
- Laser beam sensitive flight zone (LSFZ): 100µW/cm^2
- Normal flight zone (NFZ): equal or less than MPE

Laser beam bioeffects and air operations

- Distraction: natural reaction is to look at it.
- Glare: temporary disruptions in visual acquisition.
- Flash-blindness: interference effect that persists after the light is terminated.
- After-images: light dark or colored spots following the exposure.
- Scotomas: after-effect which is either temporary or permanent.
- Retinal burns: significant and permanent damage.
- Retinal haemorrhages: blood vessel disrupted somewhere in the eye.
- Globe rupture: tear in the tissue.
- Other: mechanical trauma to the cornea and conjunctiva.

Manuals, and Standards

- NF EN 60825: Security of laser products, Association Française de Normalisation (AFNOR), European Norm.
- ANSI Z136.1: American National Standard for Use of Lasers, (ANSI).
- Doc 9815: Manual on Laser Emitters and Flight Safety, International Civil Aviation Organization.
- SAND2004-1111: Laser Selection Based On Maximum Permissible Exposure Limits for Visible and Middle-Near Infrared Repetitively Pulsed Lasers, Sandia National Laboratories.
- Laser Safety: Roy Henderson (Bioptica, Cambridge, UK) and Karl Schulmeister (ARC Seibersdorf Research, Austria).

Safety

- Active safety:
  - Radars.
  - ADSB transponder: Commercial flights.
  - FLARM transponder: Private flights.
  - Infrared camera: Hot objects.
  - Visible camera: Recognition of objects.

- Passive safety:
  - Free aircraft zone in a cone at the vertical of the station.

Conclusion

- If in the past you had the excuse not to, or would not want to, know the risks that you should incur or you should make to someone (even for birds!), it is no longer the case!
- So use all your skills and ingenuity to avoid hazards.
- With one eye, it will be difficult for you to appreciate distances…