Federal Aviation Administration

Laser Hazards In Navigable Airspace

Laser Targeting of Aircraft

An American Airlines 757 is on final approach to Boston Logan Airport's Runway 4 R after flying for nearly three hours in nighttime conditions, when the captain is suddenly hit with a dazzling green laser light that obliterates his vision! The laser beam had hit the captain's left eye with such intensity that he feels as if he has been "punched in the eye." He ducks down, closes his eyes, and tells the first officer he has been hit by a laser beam and not to look at the light. The pilot experiences pain, spasms, and spots in his vision. The flash was so bright that he believes the aircraft may be the target of a terrorist attack! So distraught by the event that occurred and visibly shaken, he gives up control of the aircraft to the first officer, who, fortunately, has not been hit by the laser beam and is able to land the plane successfully.

The captain's symptoms persist in the hotel that night. Upon waking in the morning, he perceives that the vision in his left eye is noticeably more blurred with or without his glasses, and his "eye hurts and feels strained." The pilot goes to an eye doctor that afternoon and is diagnosed with accommodative spasm, sluggish pupil responses, and increased light sensitivity, which continue on for several days before finally clearing up. For a while, though, the pilot thinks that his flying days may be over.

This laser incident is fictitious but is based on actual events and personal interviews with pilots that have been exposed to laser beams while flying here in the United States.

Although lasers have many legitimate outdoor uses, such as in astronomical research, deep-space communications, orbital satellite imaging, and outdoor displays to attract and entertain the public, the misuse of laser devices poses a serious threat to aviation safety. Aviators are particularly vulnerable to laser illuminations when conducting low-level flight operations at night. The irresponsible or malicious use of laser devices can threaten the lives of flight crews and passengers.

Why Should I Be Concerned?

Federal Aviation Administration researchers have compiled a database containing more than 3,000 reports of aircraft laser illumination events over a 20-year period. These reports describe the illumination of military and civilian aircraft by lasers, including law enforcement and medical evacuation flights. No accidents have been attributed to the illumination of crewmembers by lasers, but given the sizeable number of reports and debilitating effects that can accompany such events, the potential does exist.

Sudden exposure to laser radiation during a critical phase of flight, such as on approach to landing or departure, can distract or disorient a pilot and cause temporary visual impairment. Permanent ocular damage is unlikely since the majority of incidents are brief and the eye's blink response further limits exposure. In addition, considerable distances are often involved, and atmospheric attenuation dissipates much of the radiant energy.

FAA flight simulator studies, however, have shown the adverse visual effects from laser exposure are especially debilitating when the eyes are adapted to the low-light level of a cockpit at night. Similar to a camera flash at close proximity or the high-beam headlights of an oncoming

car, recovering optimal visual performance after exposure to laser light may take from a few seconds to several minutes.

Besides startle and distraction, the three most commonly reported physiological effects associated with laser exposures are:

Glare – Obscuration of an object in a person's field of vision due to a bright light source located near the same line of sight.

Flashblindness – A visual interference effect that persists after the source of illumination has been removed.

Afterimage – A transient image left in the visual field after an exposure to a bright light.

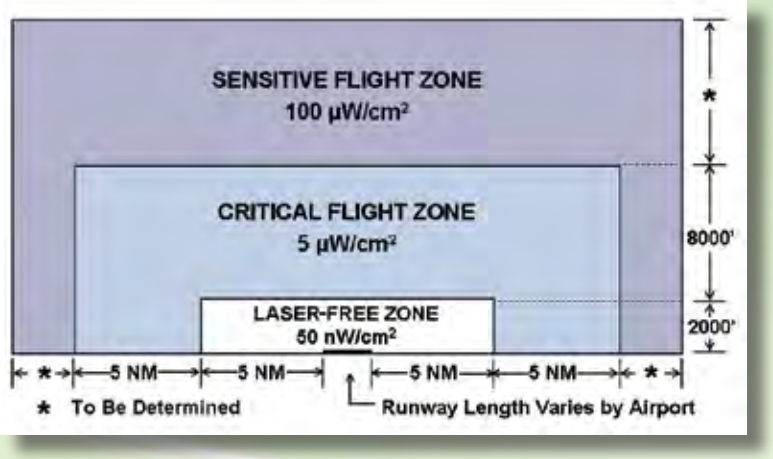

Figure 1:
Protected Flight Zones for a Single-Runway Airport

Is Anything Being Done?

In 1995, an increase in the number of laser illuminations (mostly from laser light shows) resulting in the disruption of cockpit operations, prompted the FAA to revise FAA Order 7400.2 (Part 6. Miscellaneous Procedures: Outdoor Laser Operations). The revised Order established exposure limits to prevent temporary visual impairment in three new zones that become more restrictive at lower attitude and closer proximity to airport runways.

The new zones and exposure limits include:

Sensitive Flight Zone – 100 microwatt per square centimeter (µW/cm2),

Critical Flight Zone – 5 µW/cm2, and

Laser Free Zone – 50 nanowatts per square centimeter (nW/cm2).

While FAA Order 7400.2 has all but eliminated reports of incidents associated with legitimate laser operators,

such guidelines cannot prevent misuse due to ignorance or maliciousness. Inappropriate use of lasers has become more prevalent and dangerous as handheld lasers have become less expensive, more powerful, and increasingly available to the general public.

On January 12, 2005, in response to the rapid increase in laser illumination reports involving aircraft, the Department of Transportation published advisory circular AC 70-2 entitled, "Reporting of Laser Illumination of Aircraft." This document provides mitigation procedures and information on how to report laser illumination events. In addition to providing an official reporting mechanism, AC 70-2 also improved coordination between local and federal law enforcement agencies responsible for the apprehension and prosecution of violators. Frequently, prompt reporting has led to the capture of perpetrators.

Where Are We Now?

Laser activity in navigable airspace is continually monitored to better define the nature of the threat from outdoor lasers. Reports of illumination events have increased significantly since the issuance of AC 70-2. The number of laser events increased over 300% from 2005 to 2008. This increase may be due to heightened awareness of the problem by flight crewmembers, the introduction of an authorized reporting process, and the increased availability of high-output, handheld laser devices.

Once only marketed as "laser pointers" and used for pointing out topics of interest in slide presentations with output power from 1 to 5 mW, handheld laser devices can

now be purchased over the Internet with output power as high as 500 mW. While the Food and Drug Administration prohibits the sale of "laser pointers" that exceed 5 mW, it does not prohibit the sale of more powerful, handheld lasers, if they are equipped with the appropriate labels and safety mechanisms.

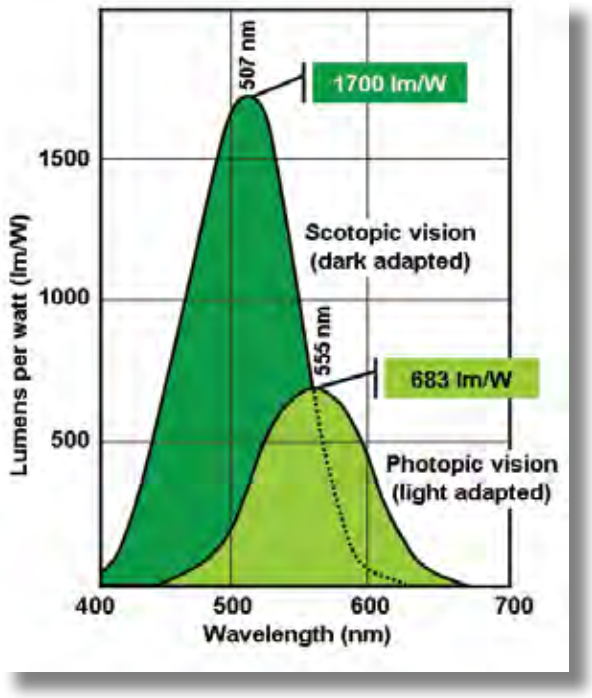

Figure 2:
Light and Dark Adapted Sensitivity by Wavelength of the Human Eye

Figure 3:
Example of a Powerful, Handheld Laser Device Available On-line

The latest reports indicate that aircraft illuminations by handheld lasers are primarily green (91%) in color, as opposed to red (6.3%), which was more common a few years ago. This is significant because the wavelength of most green lasers (532 nm) is close to the eye's peak sensitivity when they are dark-adapted. A green laser may appear as much as 35 times brighter than a red laser of equal power output. Due to this heightened visibility and increased likelihood of adverse visual effects, illumination by green lasers may result in more events being reported.

Illumination reports often describe several types of adverse effects. These include visual effects (8.2%), pain and/or possible injury (1.6%), and operational problems (3.2%). Operational problems include momentary distraction, disorientation resulting in another pilot assuming control, aborted landings, loss of depth perception, and shutting down of runways due to multiple laser strikes. While only 16.5% of all cockpit illuminations occurred below 2,000 feet (Laser-Free Zone), these incidents accounted for 31% of all visual effects, 42% of all pain or injuries, and 42% of all operational problems reported. Low-attitude illuminations, therefore, result in a greater risk to aviation safety.

Laser events can occur anywhere but have been noted most frequently in the Western Pacific and Southern regions of the United States. They are most frequently reported near airports and are often observed in clusters. Cluster laser attacks are multiple strikes on one or several aircraft that appear to originate from a specific location. These attacks may last a few minutes or be spread out over several days or weeks.

Studies have also shown that almost 70% of all incidents occurred between 2,000 and 10,000 feet AGL, 22% occurred in November and December, and 70% happened between the hours of 7 and 11 pm.

What Actions Can I Take?

Continuing research and interviews with pilots who were victims of lasing events have provided a list of recommended actions to minimize the effects of laser illumination:

Anticipate – When operating in a known or suspected laser environment, the non-flying pilot should be prepared to take control of the aircraft.

Aviate – Check aircraft configuration and (if available) consider engaging the autopilot to maintain the established flight path.

Navigate – Use the fuselage of the aircraft to block the laser beam by climbing or turning away.

Communicate – Inform Air Traffic Control of the situation. Include location/direction of the beam, your present location, altitude, etc. Once on the ground, request and complete a "Laser Beam Exposure Questionnaire" (i.e., AC 70-2).

Illuminate – Turn up the cockpit lights to minimize any further illumination effects.

Delegate – If another crewmember has avoided exposure, consider handing over control to the unexposed crewmember.

Attenuate – Shield your eyes when possible (hand, clipboard, visor, etc.). Do not look directly at the laser beam and avoid drawing other crewmembers' attention to the beam.

Do Not Exacerbate – Avoid rubbing of eyes and possibly inducing further injury.

Evaluate – If any visual symptoms persist after landing, get an examination by an eye doctor.

Can More Be Done To Protect Aviation Safety?

Continued monitoring of laser issues and effective reporting of illumination events provide data necessary to define the changing nature of the threat and develop better strategies for mitigating the problem. Strategies may include educating the public regarding the risks of lasers to aviation safety and encouraging the reporting of malicious behavior, restricting the sale of certain laser devices to the general public, encouraging manufacturers to attach warning labels on laser devices that address aviation concerns, performing studies on the use of laser eye protection as an option in the aviation environment, and investigating the value of deploying laser detection and recording systems on civilian aircraft. While no single strategy may completely end this threat, the FAA will continue to examine and recommend ways to best protect aviation from this serious hazard.

To request copies of this brochure and others listed below, contact

FAA Civil Aerospace Medical Institute
Shipping Clerk, AAM-400
P.O. Box 25082
Oklahoma City, OK 73125
(405) 954-4831

Other Pilot Safety Brochures Available

Number	Title
AM-400-94/2	Alcohol and Flying: A Deadly Combination
AM-400-03/2	Deep Vein Thrombosis and Travel
OK-06-148	Information for Pilots Considering Laser Eye Surgery
AM-400-98/2	Pilot Vision
AM-400-05/1	Sunglasses for Pilots: Beyond the Image
AM-400-01/2	When There are Questions About Your Medical Certification Application

To view these pilot and passenger safety brochures, visit the Federal Aviation Administration's Web Site

www.faa.gov/pilots/safety/pilotsafetybrochures/

Physiological Training Classes for Pilots

If you are interested in taking a one-day aviation physiological training course with altitude chamber and vertigo demonstrations or a one-day survival course, learn about how to sign up for these courses that are offered at locations across the U.S. by visiting this FAA Web site:

www.faa.gov/pilots/training/airman_ed

Medical Facts For Pilots

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