AEROSPACE RECOMMENDED PRACTICE

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Unauthorized Laser Illuminations: Pilot Operational Procedures

RATIONALE

The G-10 Operational Laser committee has agreed to stabilize this document as the content has been determined to be basic and stable information not dynamic in nature.

STABILIZED NOTICE

This document has been declared "Stabilized" by the SAE G10-OL Operational Laser Committee and will no longer be subjected to periodic reviews for currency. Users are responsible for verifying references and continued suitability of technical requirements. Newer technology may exist.

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INTRODUCTION

The SAE G-10T, the Laser Safety Hazards Subcommittee, was established in 1994 in response to a request from the FAA Administrator, David Henson. The SAE G-10 was tasked to provide input for the revision of the FAA's 7400.2 Procedures for Handling Airspace Matters, and to produce new guidance in the form of an Advisory Circulars (AC) and other technical material for the aviation industry.

As part of our efforts to improve operational safety, the SAE G-10 Committee has worked with 17 different agencies to identify the issues, technologies, and operational considerations of outdoor laser illuminations in navigable airspace. Products of the SAE G-10T subcommittee have been used for major revisions to FAA Order 7400.2 and the more recently issued FAA Advisory Circulars 70-1. "Laser Operations in the National Airspace System" and 70-2, "Reporting of Laser Illumination of Aircraft." Together, these three documents, along with ANZI Z 136.6, "Standards for the Safe Use of Lasers Outdoors," interface with AS4970, "Human Factors Consideration for Laser Operations in Navigable Airspace" to provide in-depth reference materials for outdoor laser operations.

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1. SCOPE

This document addresses the operational safety and human factors aspects of unauthorized laser illumination events in navigable airspace. The topics addressed include operational procedures, training, and protocols that flight crew members should follow in the event of a laser exposure. Of particular emphasis, this document outlines coping strategies for use during critical phases of flight. Although lasers are capable of causing retinal damage, most laser cockpit illuminations, to date, has been relatively low in irradiance causing primarily startle reactions, visual glare, flashblindness and afterimages. Permanent eye injuries from unauthorized laser exposures have been extremely rare. This document describes pilot operational procedures in response to the visual disruptions associated with low to moderate laser exposures that pilots are most likely to encounter during flight operations. With education and training, pilots can take actions that safeguard both their vision and the safety of their passengers.

2. REFERENCES

2.1 The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of the other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.FAA Publications

Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591, Tel: 866-835-5322, www.faa.gov.FAA Order 7400.2EProcedures for Handling Airspace Matters

AC No: 70-1 Outdoor laser operations. December 30, 2004

AC No: 70-2 Reporting of laser illumination of aircraft. January 11, 2005

2.2 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

AS4970 Human Factors Considerations for Outdoor Laser Operations in the Navigable Airspace

ARP5535 Observers for Laser Safety in the Navigable Airspace

ARP5572 Control Measures for Laser Safety in the Navigable Airspace

2.3 ANSI Publications

Available from American National Standards Institute, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ANSI Z136.1 American National Standard for the Safe Use of Lasers (June 2000)

ANSI Z136.6 American National Standard for the Safe Use of Lasers Outdoors (August 2000)

3. DEFINITIONS

The terms defined in this section are limited to those actually used in this standard and its appendices and are not intended to constitute a dictionary of terms used in the laser field as a whole.

AFTERIMAGE: A reverse contrast shadow image left in the visual field after an exposure to a bright light, similar to the effects of a camera flash.

BEAM: A directed stream of optical energy emitted from a source that may be parallel, convergent, or divergent.

CONTINUOUS WAVE (CW): The output of a laser that is operated in a continuous rather than a pulsed mode. In this standard, a laser operating with a continuous output for a period >0.25 s is regarded as a CW laser.

CORNEA: The transparent outer coating of the human eye that covers the iris and the crystalline lens. The cornea is the main refracting element of the eye.

DISORIENTATION: Losing perspective in the spatial relationship between the direction of travel and surroundings.

DISRUPTION: Interference or interruption of critical tasks.

DISTRACTION: Momentary attention shift from primary tasks.

FLASHBLINDNESS: A loss of visual sensitivity from a bright light exposure, which persists after the source of illumination has been removed.

GLARE: Obscuration of an object in a person's field of vision due to a bright light source located near the object.

ILLUMINANCE: A measure of the irradiance on a surface multiplied by a factor to adjust for human visual sensitivity. Measurement units are foot-candle (lumens per square foot) or lux (lumens per square meter).

INCAPACITATION: Loss of spatial orientation and loss of spatial awareness in reference to the outside world. Incapacitated flight crew members should immediately transfer control of the aircraft because they can no longer reliably sense the attitude, altitude, or direction of the aircraft.

IRRADIANCE: Radiant power incident per unit area upon a surface. Unit: watt per square centimeter ($W \cdot cm^{-2}$).

LASER: A device that produces an intense, coherent, directional beam of light, either visible or invisible, by stimulating electronic or molecular transitions to lower energy levels. LASER is an acronym for "Light Amplification by Stimulated Emission of Radiation."

LASER LIGHT SHOW SYSTEM: A demonstration laser product for producing and redirecting laser beams to create a visual effect.

MAXIMUM PERMISSIBLE EXPOSURE (MPE): The level of laser radiation to which a person may be exposed without hazardous effect or adverse biological changes in the eye or skin. In general, MPE is expressed as mW/cm^2 or mJ/cm^2. Selected MPEs for the eye are listed in Tables A1, A2, and A3.

NOMINAL OCULAR HAZARD DISTANCE (NOHD): The distance from the laser system beyond which the beam irradiance of the laser does not exceed the MPE for that laser.

PILOT FLYING: (PF) The PF will monitor/control the aircraft, regardless of the level of automation employed.

PILOT MONITORING (PM): The PM will monitor the aircraft and actions of the PF.

POWER. The rate at which energy is emitted, transferred, or received. Unit: watts (joules per second).

PULSED LASER: A laser that delivers its energy in individual pulses, lasting less than 0.25 s. See repetitively pulsed laser.

SOURCE: A point of origin of laser light or a surface that reflects laser illumination.

STARTLE: Startle is the involuntary reaction to an unexpected event that alters mental, physical, and visual activities and diverts selected attention away from the normal primary tasks of the flight crew.

TRANSMITTANCE: The ratio of total transmitted radiant power through a medium to total incident radiant power.

VISIBLE LASER: For the purposes of this standard, a laser producing light in the wavelength range between 380 and 780 nanometers—that capable of detection by the human eye

WAVELENGTH: Term commonly used to provide a numeric description of the perceived color of visible laser radiation. ANSI Z136.1-2000 states that wavelength is the distance between two successive points on a periodic wave which have the same phase.

4. BACKGROUND:

Starting in the summer of 2004, there was a marked increase in the number of laser illumination incidents across the country not associated with any specific known laser installations or approved entertainment venues. These illuminations of flight crew personnel occurred while conducting flight operations in terminal areas, and many sightings appeared to originate from elevated structures. In January 2005, the FBI stated that none of these illuminations were known to be a part of an organized air safety threat. Such laser activities, whether intentional or unintentional, potentially pose a real safety hazard to flight operations in navigable airspace. Flight crew members are more susceptible to laser effects during night operations.

Because lasers have become more compact, cheaper, and more powerful due to technological advances, the number of lasers in use by the general public has increased dramatically in recent years. Green laser pointers are now available for very low cost (less than $100) and are already in the hands of thousands of consumers unaware of the associated safety risk to flight operations in navigable airspace.

Lasers are available in a variety of wavelengths, both visible and non-visible. The color of a visible laser depends on the wavelength (Figure 1). The human eye is many times more sensitive to green than red. Lasers may be single pulsed, repetitively pulsed or continuous wave (CW). This document primarily addresses procedures and issues in response to the recent unauthorized illumination events of visible lasers in navigable airspace.

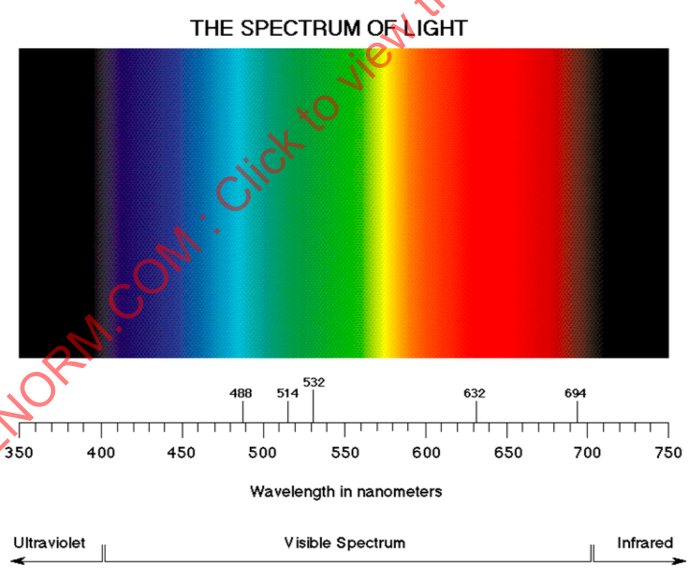

FIGURE 1. THE SPECTRUM OF VISIBLE LIGHT (380-780 NANOMETERS) REPRESENTS VIOLET, INDIGO, BLUE, GREEN, YELLOW, ORANGE, AND RED TO HUMANS WITH NORMAL COLOR VISION. BY DEFINITION, *VISIBLE* LASERS HAVE OUTPUT LIGHT ENERGY WITHIN THIS RANGE OF WAVELENGTHS. VISIBLE WAVELENGTHS OF 488, 514, 532, 632, 694 NANOMETERS ARE COMMONLY PRODUCED BY LASERS AVAILABLE ON THE MARKET TODAY.

Laser threats to flight operations vary from temporary visual deficits, such as glare and flashblindness, to permanent eye injuries. Even when irradiance levels are relatively low and visual disruption is minimal, pilots often experience a startle response to laser exposure. The potential of startle, stress, and anxiety to laser exposure may increase the risk to safe flight operations. The possibility of retinal damage is low from the lasers used in typical illuminations. Interestingly, evidence from US military studies suggests that the startle response to eye-safe laser irradiance levels can be minimized in pilots who undergo specialized procedural training for recognition and response to laser exposures.

Glare has been defined as a hindrance to vision by too much light. It has also been defined as a relatively bright light that degrades vision and may cause discomfort as long as the light is present. Glare amplitude varies greatly from a mild localized area of obscuration immediately around a light source to an extended obscuration affecting much of the visual field. Common cultural lighting sources, such as stadium lights, produce some degree of visual glare but do not significantly impair flight safety. Assuming equal exposure distance and power output, lasers are more likely to produce visual disturbances at greater range than other types of lights because of their low beam divergence and efficient propagation over great distances.

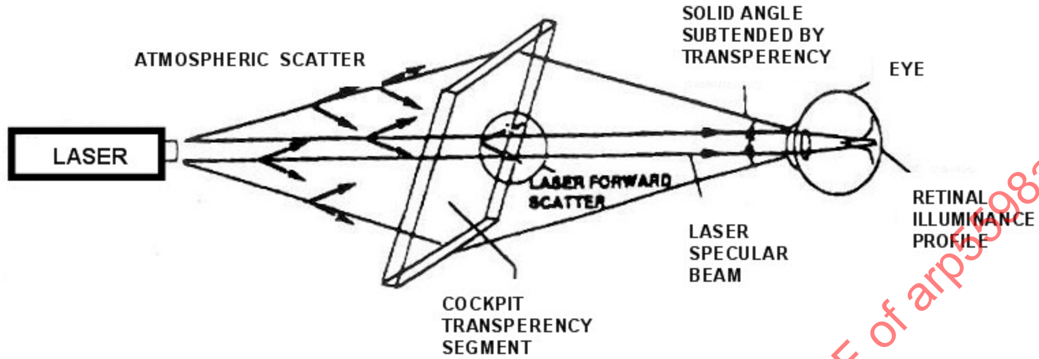

FIGURE 2. SOURCES OF SCATTER FOR THE LASER LIGHT ARE ALL SHOWN IN THIS DIAGRAM. THE ATMOSPHERE, WINDSCREEN, AND INTRAOCULAR SCATTER ALL CONTRIBUTE TO OBSCURATION OF VISION BY LASER LIGHT.

Windscreen glare is a special type of glare caused by internal reflection of light within the windscreen optical medium. Windscreens that are scratched, pitted, or dirty are particularly prone to producing this type of glare. This same type of glare is experienced by car drivers with dirty windshields facing oncoming headlights. Figure 2 shows a possible laser exposure beam geometry as well as windscreen glare induced by a 532 nanometer laser (green) in a flight simulator.

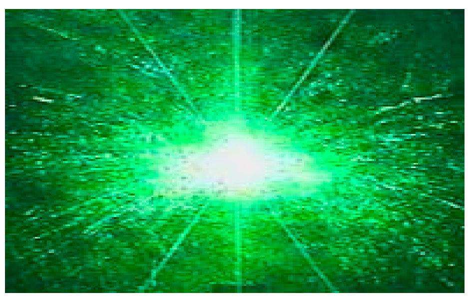

FIGURE 3. LASER EXPOSURES OFTEN ORIGINATE BELOW AIRCRAFT (LEFT PICTURE) AND DO NOT ALWAYS ENTER THE COCKPIT FROM A FORWARD ANGLE, THEREFORE WINDSCREEN SCATTER MAY BE THE FIRST SIGN OF UNAUTHORIZED ILLUMINATION. WINDSCREEN SCATTER (RIGHT PICTURE) IS CAUSED BY INTERNAL REFLECTION OF LIGHT WITHIN THE WINDSCREEN MATERIAL ITSELF. THE INTERNAL REFLECTION CAUSES THE WINDSCREEN TO LIGHT UP AND BLOCKS THE OUTSIDE VIEW.

Flashblindness is a period of visual desensitization of varying strength and duration that persists after exposure to a bright light. A common example of flashblindness is the flashbulb afterimage effect in photography. Flashblindness occurs as the eye adapts back to lower illumination levels after exposure to a bright light. The depth of flashblindness is dependent on ambient illumination, brightness of the light, length of exposure and several other variables.

Eye injury occurs when the amount of light incident on the eye reaches a level which causes tissue damage such that long lasting or even permanent vision loss results. This requires a more intense laser exposure than is required for the temporary effects of glare and flashblindness.

It should be noted that not all lasers aimed toward cockpits pose risks to aircrew flight operations. In fact, NORAD, together with the US Air Force, has developed a visual warning signal that uses a laser system to alert pilots when they breach controlled airspace. The irradiance level of the visual warning system is very low, and its signal has been specifically designed to draw attention to itself but not create significant visual glare. The degree of ocular effects expected from lasers depends upon the output power of the laser, the laser beam's divergence, the viewer's distance from the laser source, the ambient lighting conditions, and the duration of the exposure.

There is a recommended practice summary at the end of this document, based upon input from airline industry and government experts. Further flight simulator research should be accomplished, however, to verify the effectiveness of these recommended practices.

5. RECOMMENDATIONS

5.1 Operational Air Safety Considerations

The flight crewmembers should maintain situational awareness to assess the potential for an unauthorized illumination event. Certain flight configurations present a higher risk of exposure. For example, fixed wing aircraft may be at particular risk during departures and arrivals, especially during steady turns. Further, low altitude flight operations and slow, stable airspeed may make an aircraft an easier target for unauthorized cockpit laser illuminations.

5.2 Procedure Considerations

Flight crewmembers should be familiar with the characteristics of a laser illumination and its symptoms when one member of the flight crew has been exposed. Procedures should be developed to take into account the significant variation of aircraft, crew configuration and aircraft operation. Crew configuration refers to single or dual pilot control, and type of aircraft refers to fixed or rotary wing platforms. The flight deck design incorporates head-up or head-down display technologies.

5.3 Protocol Issues

During critical phases of flight, disruptive laser illuminations should be treated as any other abnormal or emergency situation. Currently, some airlines have prepared company procedures to deal with lasing events, but there are no abnormal or emergency procedures developed for laser illuminations for the industry as a whole. These procedures should address the human factors issues associated with flight crewmember verification of flight display instruments during visual impairments and maintaining control of the aircraft.

5.4 Human Factors Issues

Anytime a flight crewmember experiences visual impairment with loss of spatial orientation (SO) and loss of situational awareness (SA), it becomes a priority issue for safety of flight. The flight crewmembers should communicate immediately as to their visual status and transfer control to the pilot that has not been affected by the laser illumination. If the pilot flying (PF) is executing a steady departure turn, the human balance system will revert to inner ear (vestibular sensing). This information is highly unreliable due to the visual/inner ear conflict known as sensory cross coupling. This cross coupling can influence the crewmember to make inappropriate decisions with respect to aircraft control.

Low altitude terminal operations below 10 000 feet require a sterile cockpit and there are limited visual cues. At this time, the crew's visual, mental, and physical workloads are at their highest and the effects of a laser illumination could elevate the visual workload and reduce the flight crew's ability to recognize and respond during critical phases of flight. The recovery time for vision impairment varies with the intensity of the laser at the pilot's eye position, how well the pilot is dark adapted, ambient flight deck illumination and other physiological factors such as age of the pilot. However, for low intensity single exposures, a majority of the visual function will be restored in less than 5 minutes. The after-effects may still affect the flight crewmembers ability to restore color and symbology contrast recognition.

Startle effects of distraction, disruption, disorientation, and incapacitation are major factors that determine the level of spatial orientation (SO) and situational awareness (SA) that has been impaired.

5.5 Communication

Communication procedures for the flight deck should be developed to determine transfer of control protocol. In addition, Air Traffic Control (ATC) procedures should be followed to report laser activity, laser illuminations, and ATC aircraft handling in the air or on the ground.

5.6 Education

To reduce threats to aircraft safety, the general public should be made aware of the hazards and applicable laws associated with unauthorized illumination of aircraft with laser devices in navigable airspace. Educational materials should be developed for this purpose. In addition, educational materials should be developed for flight crewmembers to better inform them of the effects of visual sensitivity to certain colors and how the eye restores vision after laser illumination.

5.7 Training, Simulation, and Recurrent Ground School

Training programs should be developed for recurrent ground schools. Development of training aids that include videos of simulated cockpit laser exposures and optional eye-safe laser exposure simulator guidelines may be useful. These guidelines would help mitigate the risk of the startle response for pilots and help define appropriate procedures to minimize distraction, and disruption. This training should be specific to aircraft type (fixed or rotary wing) and crew configuration.

5.8 Equipage

Laser eye protection (LEP) devices should be carefully considered for use by flight crews as a secondary protection since it has limitations. Selection of appropriate laser eye protection devices for flight crews will require significant analysis of laser threats and consideration of flight visual demands (e.g., visibility of cockpit controls and indicators). The goal of LEP for aircrews would be to minimize optical transmission of light wavelengths associated with known laser threats while maximizing transmission of the rest of the visual wavelength spectrum. This is important because ideal LEP allows pilots to see well in night conditions as well as see colors without significant chromatic shifts. There are many different types of laser filtering technologies and each technology has unique pros and cons. Virtually all currently available LEP creates visual artifacts that can affect visual performance. Obviously, flight compatibility studies should be conducted to verify LEP performance.

6. RESEARCH: VISUAL IMPAIRMENT DURING FLIGHT OPERATIONS

Research questions and considerations that should be addressed that relate to visual impairment of flight operations:

1. How do visual, physical, and mental demands vary by phase of flight, and how does transient visual degradation affect the ability of pilots to meet these demands?
2. What cockpit procedures ensure greatest flight safety? As an example, should one pilot always fly heads down during night operations with autopilot and coupler use?
3. How does pupil size vary among pilots of different ages, cockpit lighting conditions, and by the state of retinal light adaptation? Are current threat analysis computer models appropriate for civilian aircrews that may be older than the military pilots the computer models were designed to represent? (Pupils tend to become smaller with age, and older eyes may be more sensitive to glare due to natural changes within the crystalline lens of the eye.)
4. How does off-axis illumination which is bright enough to cause flashblindness, afterimage, and glare in a pilot's peripheral vision affect flight operations, even if the pilot's central vision is not significantly affected?
5. In cases of laser induced glare and flashblindness, how can the design and layout of flight control panels be optimized to promote safety? What effects do switchology design, shape, and location have on visual recognition and information transfer?
6. What symbols and colors are easiest for pilots to recognize through laser glare?
7. What symbols and colors are restored first during visual recovery from flashblindness? Which ones are the last to be restored?
8. Can the flight crewmembers identify information on the standby instruments by their shape (symbology) color or location?

9. How can simulation training and eye safe laser demonstrations in controlled environments reduce the startle response and temporary anxiety associated with unauthorized cockpit laser exposures? Can procedural training minimize selective attention shifts during and after laser exposures?
10. How do startle effects during critical phases of flight impact spatial orientation (SO) and situational awareness (SA)?

7. INFORMATIONAL VIDEO ON LASERS

The FAA, in cooperation with the US Air Force, has produced an informational video on cockpit laser illuminations that is (22) minutes in duration. The video includes footage of laser illuminations, a short technical description of lasers, and a discussion of how laser light can affect visual function. In addition, operational procedures such as approaches and landings, departures, landing rollouts, and taxi maneuvers to and from the gate, will be shown and demonstrated by crewmembers in a simulator. These operations will reflect recommended pilot responses to unauthorized cockpit illuminations. The video reviews the appropriate process to report a suspected laser illumination as described in FAA Advisory Circular AC70-2. A copy of the video can be available from the FAA when released.

Figure 4 depicts how visual impairment may vary as a function of viewer distance from the laser source. The Nominal Ocular Hazard Distance (NOHD) is the distance from the power source that corresponds to the Maximum Permissible Exposure (MPE). The NOHD is the closest “safe distance” one can get to a laser. Obviously, the NOHD is unique for every laser system and is a function of the power of the laser, wavelength, its beam divergence, beam homogeneity profile, duration of exposure and atmospheric conditions. Figure 3 shows the relative relationship of the effects. Actual hazard distances and ocular visual effects will vary with the strength, viewing distance and color of the laser.

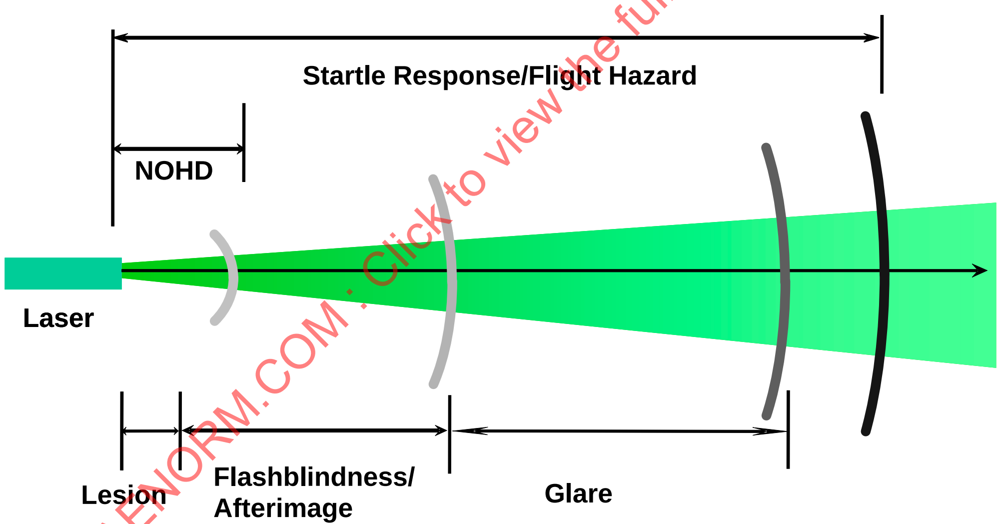

FIGURE 4. LASER OCULAR EFFECTS VS. RANGE-- ASSUMES THE LASER IS NOT EYE SAFE AT THE APERTURE AND THEREFORE, HAS AN ASSOCIATED NOMINAL OCULAR HAZARD DISTANCE (NOHD). IT SHOULD BE NOTED THAT LOWER POWERED LASERS MAY ACTUALLY BE EYE SAFE AT THE APERTURE AND NOT CAPABLE OF INDUCING PERMANENT EYE INJURY. STILL, EVEN LASERS CONSIDERED EYE SAFE AT THE APERTURE MAY BE BRIGHT ENOUGH TO CAUSE TRANSIENT VISUAL EFFECTS LIKE FLASHBLINDNESS, GLARE, AND STARTLE RESPONSES (NOT TO SCALE).

In addition to glare and flashblindness, non-injurious laser illuminations may induce reflexive tearing, light sensitivity, a feeling of dryness (especially in low humidity cockpits) and eye fatigue. All of these conditions contribute to ocular discomfort and visual impairment.

8. STARTLE RESPONSE CATEGORIES THAT AFFECT VISUAL PERFORMANCE DURING FLIGHT OPERATIONS

Startle is the involuntary reaction to an unexpected event that alters mental, physical, and visual activities and diverts selected attention away from the normal primary tasks of the flight crew. The startle response can be broken into four specific categories. These categories are:

Distraction: Momentary attention shift from primary tasks.

Disruption: Interference or interruption of critical tasks or task sequences that extend the shift of attention from primary tasks requiring selective attention.

Disorientation: Losing perspective in the relationship between the direction of travel and surroundings. Loss of spatial orientation (SO) and loss of situational awareness (SA). Disorientation can include both distraction and disruption startle. Transfer of aircraft control may be delayed as a result of disorientation.

Incapacitation: Loss of spatial orientation and loss of situational awareness in reference to the outside world. Incapacitated flight crew members should immediately transfer control of the aircraft because they can no longer reliably discern or control the attitude, altitude, or direction of the aircraft.

With startle, as with any operational environment, flight crews utilize normal, abnormal, and emergency procedures to operate in navigable airspace. During any abnormal or emergency event, the flight crew must recognize the event, and then respond with the appropriate checklist procedure to neutralize and restabilize the aircraft profile. The next section addresses the recommended aircrew operational procedures in response to the startle reaction from laser illuminations. These procedures utilize recognition and response (R&R) techniques that train flight crew's reaction away from startle and surprise by exposure reinforcement. These visual event rehearsals establish training behavioral objectives (TBO) for strategic memory that identifies event patterns with the appropriate procedure to return the flight crew and aircraft to a normal operating status.

9. AIRCREW OPERATIONAL PROCEDURES AFTER ENCOUNTERING LASERS

Pilots should be prepared to take appropriate practical actions following unauthorized laser illuminations. The following outlined procedures may reduce the recovery time from unauthorized laser illuminations and may minimize the effects of these events. Procedures and short checklists are given for different scenarios where laser activities are known to be in the area and for when aircrew are illuminated by lasers. The visual effects from laser illuminations will be most significant during approach and landings where visual, physical, and mental workloads are highest. Figure 5 illustrates the increase in the significance of visual effects as the workload increase, shortening the available recovery time for the pilot during approach and landing. During these critical stages of flight, visual function is crucial to flight safety.

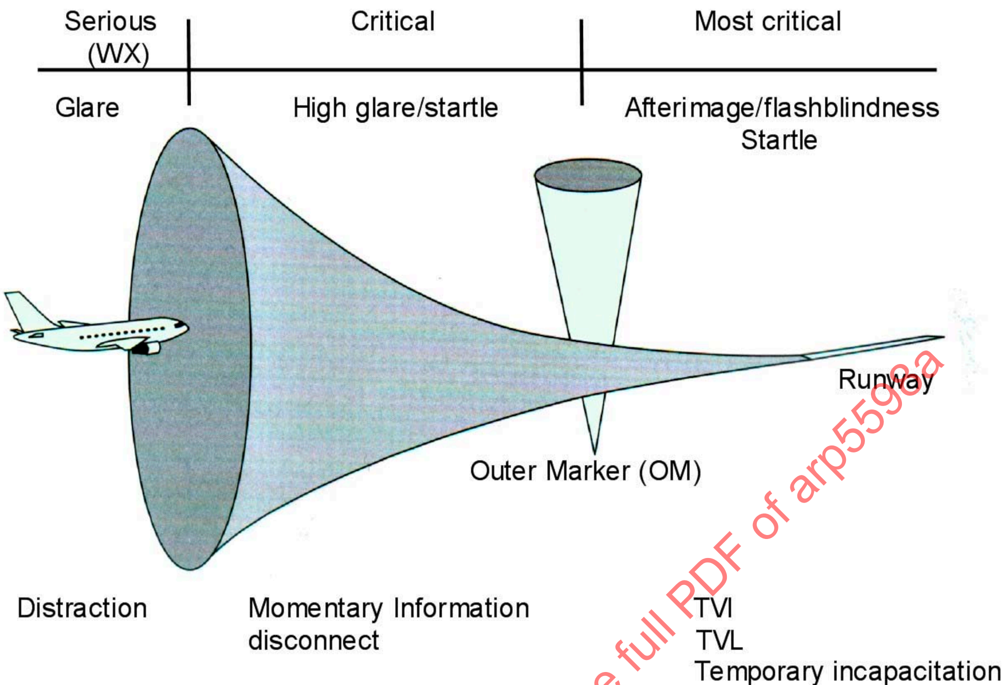

FIGURE 5. CONE REPRESENTS THE DECREASE IN TOLERANCE TO VISUAL DISRUPTION DURING THE FINAL PHASES OF AIRCRAFT FLIGHT. NOTE THAT VISUAL FUNCTION BECOMES MOST CRITICAL TO FLIGHT SAFETY IN THE FINAL MOMENTS BEFORE LANDING—A PERIOD THAT OVERLAPS THE PERIOD OF GREATEST VULNERABILITY TO UNAUTHORIZED LASER ILLUMINATIONS DUE TO THE AIRCRAFT'S LOW ALTITUDE (NOT TO SCALE). TVI IS TEMPORARY VISUAL IMPAIRMENT AND TVL IS TEMPORARY VISUAL LOSS.

NOTE: These recommended procedures will assist crewmembers to control their aircraft during temporary vision impairment from a laser exposure. A recommendation that the lights in the cockpit should be turned up to a bright level will minimize light level difference and enable the crewmembers to recognize and respond to flight instrument status while their eyes adapt back to normal visual function.

After any suspected laser illumination, crewmembers should remember to:

1. Not rub their eyes.
2. Avoid looking at the light source.
3. Report the incident as per FAA AC: 70-2.
4. Seek medical assistance, if necessary.

9.1 Procedures in areas of known authorized outdoor laser activity

1. NOTAMS – Reports the location of the laser source(s), schedule of activity, and hazard distance, relative power, and color.
2. At/ below 10,000 feet, crewmembers should use their outside lights (wing and landing lights)-- this will assist in aircraft identification and make the plane easier to visualize for other pilots.
3. AUTO PILOT on.
4. ONE crewmember heads down with his/her cockpit background lighting turned up, optional.
5. STANDBY instruments increase background cockpit lighting, turned up, optional.
6. ENGAGE coupler for aircraft capture of localizer and glideslope.
7. DISENGAGE auto pilot and coupler as per company policy.
8. PILOT who is heads up makes manual landing, if not illuminated.