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Lasers Aimed at Aircraft Cockpits: Background and Possible Options to Address the Threat to Aviation Safety and Security

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Summary

A recent rash of incidents involving lasers aimed at aircraft cockpits has raised concerns over the potential threat to aviation safety and security. While none of these incidents has been linked to terrorism, security officials have expressed concern that terrorists may seek to acquire and use higher powered lasers to, among other things, incapacitate pilots. There is also growing concern among aviation safety experts that the ubiquity and low cost of handheld laser devices could increase the number of incidents where pilots are distracted or temporarily incapacitated during critical phases of flight. Possible options to mitigate the threat of lasers include restricting the sale or use of certain laser devices; amending criminal statutes associated with interfering with flight operations; providing pilots with laser eye protection; expanding and enforcing laser free zones around airports; and educating the public regarding the risks of lasers to aviation safety. This report will be updated as needed.

Flight Safety Hazards of Lasers

Lasers, an acronym for light amplification by stimulated emission of radiation, pose a safety hazard to flight operations. Brief exposure – sometimes just a fraction of a second – to even a relatively low-powered laser beam can cause discomfort and temporary visual impairments such as glare, flashblinding, and afterimages.¹ To a pilot, these visual distractions can produce spatial disorientation or loss of situational awareness. Retinal injury could result from exposure to these devices, although long-term damage to a pilot's eye is unlikely due to the viewing distance and the low power of most laser pointing devices available to the general public. However, unlike the brightness of a lightbulb that drops off considerably with increasing distance, the focused beams of a laser light remain

¹ Van B. Nakagawara and Ronald W. Montgomery. *Laser Pointers: Their Potential Affects on Vision and Aviation Safety*. Federal Aviation Administration, Office of Aerospace Medicine. Report Number DOT/FAA/AM-01/7. April 2001.

quite powerful at extended viewing distances. Because lasers remain powerful over large distances, a laser pointer can expose pilots to radiation levels above those considered to be flight safe for takeoffs and landings when seen from distances of up to two miles.² More powerful lasers, sometimes used in outdoor light shows, can distract pilots and affect vision from considerable distances. For example, one flight crew reported seeing afterimages after being hit by a green laser from a laser light show in Las Vegas, NV. At the time they were flying at 31,000 feet about 90 miles south of the laser source.³

These higher powered laser devices can incapacitate pilots and inflict eye injuries when viewed at closer ranges. The National Transportation Safety Board (NTSB) documented two such cases in which pilots sustained eye injuries and were incapacitated during critical phases of flight.⁴ In one of these events, the pilot experienced a burning sensation and tearing. A subsequent eye examination revealed "multiple flash burns" in the pilot's cornea.⁵ In a few other documented incidents, pilots provided safety reports indicating that injuries were sustained from exposure to laser lights. In one case, a copilot received burns on the outer coating of the eye and broken blood vessels.⁶ In another incident, a pilot was struck several times by a laser beam and was diagnosed as having a "burned retina."⁷ In about a dozen other cases, pilots reported short term visual impairment that did not require further medical attention.

FAA researchers have compiled a database of more than 400 incidents since 1990 in which pilots have been startled, distracted, temporarily blinded, or disoriented by laser exposure.⁸ To date no aviation accidents have been attributed to laser lights, although there have been crashes caused by similarly debilitating glare and flashblinding from natural sunlight.⁹ Flight simulator studies conducted by the FAA found that exposure to bright lasers can result in unacceptable levels of visual and operational problems, but

² Van B. Nakagawara, Ronald W. Montgomery, Archie Dillard, Leon McLin, and C. William Connor. *The Effects of Laser Illumination on Operational and Visual Performance of Pilots During Final Approach*. Federal Aviation Administration, Office of Aerospace Medicine. Report Number DOT/FAA/AM-04/09. June 2004.

³ National Aeronautics and Space Administration, Aviation Safety Reporting System (NASA/ASRS). *Report Numbers 285090 and 290037*. Moffett Field, CA.

⁴ National Transportation Safety Board. *Safety Recommendation Letter – Safety Recommendations A-97-13 through -15*. Washington, DC.

⁵ *Ibid.*; NASA/ASRS. *Report Number 354327*.

⁶ NASA/ASRS. *Report Numbers 285091 and 290036*.

⁷ NASA/ASRS. *Report Number 322991*.

⁸ Van B. Nakagawara, et al.. *The Effects of Laser Illumination on Operational and Visual Performance of Pilots During Final Approach*; Department of Transportation. "U.S. Secretary of Transportation Norman Y. Mineta Announces New Laser Warning and Reporting System for Pilots, Measures to Safeguard Pilots and Passengers, Support Timely Enforcement." Press Release DOT 08-05.

⁹ Van B. Nakagawara, et al.. *The Effects of Laser Illumination on Operational and Visual Performance of Pilots During Final Approach*.

concluded that enforcing already established limits to protect pilots from laser exposure when operating near airports provides an adequate margin of safety.¹⁰

Lasers as Possible Terrorist Weapons

While none of the more than 400 incidents involving flight crew exposure to lasers over the past fifteen years has been linked to terrorism, the Department of Homeland Security and the FBI issued a memo in December 2004, warning that terrorists have explored using lasers as weapons. The memo indicated that, while lasers are not proven methods of attack, like explosives and hijackings, terrorist groups overseas have expressed an interest in using these devices against human sight.¹¹ The memo went on to state that, if laser weapons adversely affected the vision of both pilots during a visual approach to landing, there is a potential risk of a airliner crash.

The likelihood of such a scenario has since been the topic of considerable speculation and debate. While most would agree that incapacitating both pilots and downing an airliner by aiming a handheld laser pointer into the cockpit is highly unlikely, there is concern that a military laser, such as the Chinese-made ZM-87 laser blinder, or a high powered industrial laser in the hands of terrorists could pose a more significant threat. There is also concern that terrorists may improvise an intense laser blinder by bundling several higher powered handheld laser devices.¹² While these types of lasers may not be particularly appealing to terrorists because their effectiveness is highly uncertain, they are relatively small and easy to conceal. An FAA report noted that a "laser attack could be quickly deployed and withdrawn, leaving no obvious collateral damage or projectile residue, and would be difficult to detect and defend against. The possible visual impairment, startle, distraction, and the loss of spatial orientation created by such an attack could make landing an aircraft difficult at best."¹³ While protecting aircraft against such attacks is a daunting challenge, several possible options are available to mitigate the risks posed by lasers.

Possible Options to Mitigate Flight Crew Exposure to Lasers

Policymakers may consider a variety of available options to mitigate the potential dangers of flight crew exposure to lasers. Options that may be considered include restricting the sale or use of certain laser devices; amending criminal statutes associated with interfering with flight operations; providing pilots with laser eye protection;

¹⁰ Van B. Nakagawara, *et al.*. *The Effects of Laser Illumination on Operational and Visual Performance of Pilots During Final Approach*; Van B. Nakagawara, *et al.*. *The Effects of Laser Illumination on Operational and Visual Performance of Pilots Conducting Terminal Operations*. Federal Aviation Administration, Office of Aerospace Medicine. Report Number DOT/FAA/AM-03/12. August 2003.

¹¹ Curt Anderson. "Government says terrorists could use lasers to blind pilots." *Associated Press Newswires*, December 9, 2004.

¹² "Analysis: Whether laser beams could be used to bring down an airplane." *Day to Day*. National Public Radio, December 15, 2004.

¹³ Van B. Nakagawara, *et al.*. *The Effects of Laser Illumination on Operational and Visual Performance of Pilots During Final Approach*.

expanding and enforcing laser free zones around airports; and educating the public regarding the risks of lasers to aviation safety.

Regulation of Laser Devices. The regulation of laser devices is under the purview of the Food and Drug Administration, which establishes and enforces regulations for commercially available laser devices based on safe exposure criteria derived from current medical knowledge.¹⁴ Lasers fall into five general categories: Class I, Class II, Class IIIa, Class IIIb, and Class IV. Class I includes devices, such as laser printers and DVD players, that have enclosed lasers designed to prevent the escape of any harmful radiation. Class II lasers emit visible light and are considered too bright to view for extended periods, but momentary viewing is not considered hazardous. Class IIIa devices are hazardous if the beam is viewed directly, but cannot produce a reflected beam hazard unless viewed for extended periods at close range. Most commonly available laser devices, such as laser pointers and laser levels, are either Class II or Class IIIa devices. While FDA regulations specify that lasers specifically manufactured for demonstration purposes such as entertainment, artistic, or advertising displays not exceed Class IIIa specifications, this does not preclude more powerful lasers from being used in such activities. Furthermore, although not manufactured for use as “legal” laser pointers, some Class IIIb lasers packaged as laser pointers can be purchased over the Internet.¹⁵ Momentary exposure to a Class IIIb laser can cause eye damage. More powerful Class IV lasers used in research, medical, industrial, and military applications can pose fire hazards, damage skin, and can cause significant eye damage even when viewed indirectly. Various safety precautions, including eye protection, are needed when working around these devices. While not widely available, these powerful lasers could potentially be used as a terrorist weapon to attempt to incapacitate a flight crew.

While no official conclusions have been drawn, the recent rash of laser incidents may be attributable, in part, to the increasing availability and reduced cost of green laser pointers. Green lasers pose particular hazards to pilots because they are perceived to be about 35 times brighter than equivalently powered red lasers due to the fact that humans are so much more sensitive to green light.¹⁶ One policy option that may be considered, is whether to apply different standards for laser output based on the color (wavelength) emitted by the device. Current standards treat the output uniformly across the visible spectrum despite the fact that humans are much more sensitive to green light.

Another option is to restrict the sale or establish tighter controls on the use of certain laser devices. The United Kingdom restricted sales of Class IIIa laser pointer devices in response to several incidents involving lasers directed at aircraft.¹⁷ Imposing a similar ban or even more limited restrictions in the United States could pose significant challenges because these devices are widely available at low cost and are used in a variety of applications such as laser pointers, laser levels, and laser gun sights.

¹⁴ See *Title 21 Code of Federal Regulations*, §1040.10 and §1040.11.

¹⁵ Van B. Nakagawara, *et al.*. *The Effects of Laser Illumination on Operational and Visual Performance of Pilots During Final Approach*.

¹⁶ Van B. Nakagawara and Ronald W. Montgomery. *Laser Pointers*.

¹⁷ Van B. Nakagawara, *et al.*. *The Effects of Laser Illumination on Operational and Visual Performance of Pilots During Final Approach*.

Relevant Criminal Statutes. Besides regulating the availability and use of laser devices, criminal statutes pertaining to the interference with flight crews may serve to deter malicious use of laser devices against flight crews. Malicious use of a laser device that interferes with a flight crew can be prosecuted under criminal statutes pertaining to destruction or attempted destruction of aircraft¹⁸ or provisions enacted under the USA PATRIOT Act (P.L. 107-56) regarding acts of violence against mass transportation systems. In the first known case of its kind, the federal government charged a New Jersey man in December 2004, alleging that he shined a green laser pointer at a charter jet and a law enforcement helicopter.¹⁹ While existing federal statutes could be applied to cases involving lasers aimed at aircraft, lawmakers may consider whether more explicit statutes regarding malicious use of laser devices are needed or whether language is needed to establish prohibitions against certain outdoor uses of lasers.

Laser Eye Protection. The use of protective eye wear is strongly recommended to prevent eye injuries whenever there is a probable risk of exposure to laser light.²⁰ However, applying this recommendation to pilots may not be practical. Because lasers are available in a variety of colors, it may be difficult to find a single solution that can provide eye protection against all laser threats without significantly impeding vision, including the ability to view cockpit displays and see certain aviation-specific lighting colors, such as red obstruction lights. An alternative approach is to equip aircraft with protective glare shields capable of significantly reducing the brightness of a laser shined into the cockpit. However, identifying an optical filter for use as a glare shield that can protect against laser threats across multiple colors without sacrificing some capability to view the outside visual scene, particularly at night, may prove difficult. While laser-protective glare shields could be mounted on roll up shades or pull down visors and relatively easily installed, they may be more costly than protective eye wear. However, they would not block the pilots view of cockpit displays and therefore, may have significant advantages over protective eye wear. The military is researching the use of special visors whose light-blocking filters would only activate when a laser threat is detected. For the moment, the DOT has indicated that given the relatively small number of laser light incidents, there is no specific need to require protective eye equipment for pilots at this time.²¹ However, Congress may consider whether further study to identify effective laser eye protection is warranted and under what circumstances pilots may require laser eye protection.

Enhancing and Enforcing Laser Free Zones Around Airports. In 1995, the FAA responded to growing concerns over laser light shows by defining flight safe exposure levels to lasers in specific zones around airports. The FAA based these standards on the potential for temporary visual impairment from laser exposure. Relying on historic safety data, scientific research, and consultation with laser and aviation safety

¹⁸ Title 18 U.S. Code, § 32.

¹⁹ Damien Cave. "U.S. Says Man Shined Laser at Aircraft." *The New York Times*, January 5, 2005.

²⁰ Van B. Nakagawara, et al.. *The Effects of Laser Illumination on Operational and Visual Performance of Pilots Conducting Terminal Operations*.

²¹ Department of Transportation. "U.S. Secretary of Transportation Norman Y. Mineta Announces New Laser Warning".

experts, the FAA established three airspace flight zones around airports for mitigating laser exposure: 1) sensitive flight zones; 2) critical flight zones; and 3) laser free zones.²² These zones were established as guidelines for evaluating the potential impact of outdoor laser usage, working with laser operators to mitigate potential interference with aviation operations, and notifying pilots regarding laser activity. The laser free zone extends out 2 miles from each runway in all directions and also includes 5000 foot-wide strips extending 3 miles from the approach and departure end of each runway. Exposure from laser activity in these areas is to be restricted to a level that would not cause any visual disruption. These standards preclude the use of Class IIIa laser pointers in laser free zones. However, the widespread availability of these devices poses significant challenges to enforcing compliance. Options to further protect flight crews during critical phases of flight might include the promulgation of specific regulations or laws prohibiting or restricting the outdoor use of lasers in designated laser free zones. Policymakers may also consider whether expanding the size of laser free zones around airports could further mitigate potential laser hazards.

In January 2005, responding to growing concerns over lasers shined at aircraft, the FAA issued an advisory to pilots urging them to immediately report suspected laser illumination of their aircraft.²³ The advisory provides pilots with specific notification and reporting instructions designed to aid law enforcement in investigating laser incidents and the FAA in issuing timely warnings to other pilots. From a homeland security perspective, airport perimeter security patrols and surveillance could help to deter and detect laser attacks. However, preempting a terrorist attack using lasers would likely be extremely difficult because a laser would be virtually undetectable until shined at an aircraft, and even then, may be difficult to spot from the ground. Also, given that takeoff and landing patterns extend for several miles beyond the airport perimeter, a rather large area would have to be patrolled. For this reason, neighborhood watch programs in areas underlying flight paths could be of potential benefit in spotting and reporting suspicious activities.

Public Education. Product warning labels and product information shipped with laser devices could be enhanced to specifically warn of the dangers these devices pose to aviation safety. While current product labeling on lasers inform operators of the eye hazards posed by lasers, there may be widely held misperceptions that lasers cannot affect a pilot's vision because of the large distances the beam travels before reaching the aircraft. The general public may also lack a full appreciation for the visual demands during critical phases of flight and the potential consequences of visual distractions in the cockpit. Besides conveying this information in materials shipped with laser products, such information could also be disseminated through public awareness campaigns. Additionally, public education materials could convey strong messages regarding available criminal penalties and potential legal consequences of using lasers to maliciously target aircraft.

²² Federal Aviation Administration. *FAA Order 7400.2E, Procedures for Handling Airspace Matters*, Ch. 29, "Outdoor Laser Operations.", June 3, 2004.

²³ Federal Aviation Administration. *Advisory Circular 70-2, Reporting of Laser Illumination of Aircraft*.