Growing laser threats to airline pilots and soldiers require new protection technologies

“Lasers are a source of collimated, monochromatic, coherent light that can travel long distances with very little loss of intensity. This coherent property is what allows a laser to maintain a narrow, high-powered beam over long distances. This is also the cause of lasers being able to do damage to sensors, facilities, and personnel at a long range.

The military and security agencies are using Handheld Lasers to temporarily blind terrorists and at check points for crowd control. Lasers have been used en masse against riot police in demonstrations in regions as diverse as Canada, the U.S., Ireland, Thailand, Greece, Egypt, and Italy, among others.

In Seattle, WA, protesters at a WTO summit directed pointers in the field of vision of crowd-control police. In Cairo in 2013, dozens of green lasers were seen striking Egyptian military helicopters circling over Tahrir Square during large-scale gatherings, as well as directed against governmental buildings, police, and, at times, opposing protestors.

Until recently, the expense of lasers had limited their use to professional shows, but lower prices on handheld laser pointers have made this type of device widely available. They have also become easier to buy on the internet. However, these laser pointers have been cause of many aircraft accidents. According to the US-based Federal Aviation

Authority, more than 2000 laser incidents were recorded in the US alone during the first four months of 2017, while in 2015 more than 10,000 laser incidents were reported to the FAA, and the UK’s Civil Aviation Authority and Transport Canada.

Laser attacks targeting pilots and air crews are a major concern across the world with most attacks reported to take place during take-off and landing. They are typically caused by cheap, high-powered hand held devices that are readily available on the internet. Results of these attacks include distraction, obscuring of instruments and dials, a high probability for short-lived “flash” blindness and even permanent eye damage.

Therefore research is increasingly looking for laser protection technologies. Last year, the aircraft manufacturer Airbus announced that it was joining with Lamda Guard, a Canadian company, to test a metamaterial-based coating for cockpit windows to protect pilots in commercial aircraft from being blinded by laser pointers.

Effects of Laser attacks on Pilots

The FBI has warned released public information films to warn about the effects of laser pointers, explaining how beams can blind pilots at night, with their effects intensified as light is dispersed by the cockpit windows. A laser illumination incident begins quite suddenly as the flight deck is filled with a bright light. The glare makes it difficult to concentrate on the flight instruments and can remove the crew’s visual references with the runway environment, making pilots unsure of their position relative to the runway and the

ground. Green lasers, which have become increasingly more affordable, have been reported in more than 90 percent of the documented laser incidents," says Boeing.

"Even weaker lasers could have serious consequences if pilots were distracted by the beams when landing planes: "It's a critical point in flight, you have to have complete concentration. When it comes into the flight deck, it bounces around the walls of the cockpit," said British Airline Pilots' Association's (Balpa) general secretary, Jim McAuslan.

Half of all pilots targeted in past year involved laser used in weaponry, says pilots' association. Since 2004, more than 3,200 laser incidents have been reported within the United States, along with hundreds more internationally. Incidents are occurring not only in the United States but internationally as well. Reports of laser incidents have come from Australia, Canada, England, Germany, and Ireland. According to figures compiled by the Civil Aviation Authority (CAA), the number of reports of laser incidents in the UK has remained relatively constant at about four to five a day on average over the last four years.

Growing threat of powerful Military lasers

The Chinese military has begun equipping its soldiers with handheld laser guns, in direct contravention of international treaties banning the use of blinding laser weapons. The official PLA Daily December 9th 2015 edition announced that Chinese soldiers are now in possession of laser guns. The PY132A laser gun, revealed during the Chinese Police Expo in December, is designed to blind enemy sensors and cameras and intended for use against enemy vehicles and drones. International conventions like the 1998 Protocol on Blinding Laser Weapons ban the use of lasers and blinding weapons used

against people.

Military forces worldwide are increasingly using lasers for many purposes including, range finding, anti-missile systems, target designation, ranging of guided munitions and the neutralizing of enemy weapon systems. Laser directed energy weapons are being developed to neutralize rockets, UAVs and missiles.

More powerful laser beams, those that are commonly found on laser-guided munitions and long-range designators, require extreme protection against ocular injury. Other lasers require less protection due to their relatively low power. Depending on the specific laser threat, laser light absorption may range from 99.99% to 99.999% to provide the required protection, thus avoiding ocular injury.

Military Lasers can also causes damage to optical components like mirrors, fibers, nonlinear crystal materials, prisms, optical filters, optical modulators and saturable absorbers, photodetectors and SESAMs.

Therefore military forces involved in multinational operations are increasingly looking for technologies both for protection of eye as well as optical components from lasers used by both friendly and foe. Keeping pace with rapidly advancing and eminently available laser technology requires a sophisticated and pragmatic countervailing response.

Laser Protection Technologies

With the continuous development of military equipment including lasers, researchers are constantly seeking to improve laser eye protection technologies.

Laser lenses protect the eyes by blocking laser light either through an absorptive dye or reflective coating. The amount of

laser light that is blocked at a specific wavelength is referred to as the lens' Optical Density (OD). High OD numbers provide an order of magnitude higher protection.

Technologies of the future include tunable laser protection to counteract the threat of tunable lasers (lasers which can change their operational wavelength) and to protect against multiple laser threats simultaneously.

Also being explored are optical switches and limiters that activate only in the presence of specific laser wavelengths. This allows the protection to stay completely clear until laser protection is needed and allows for excellent visible light transmission.

Protective glasses.

A variety of safety glasses are available that can protect the wearer from green laser energy; however, airlines should consider the drawbacks that are associated with them. Filtering light reduces the total amount of light entering the eye, which can adversely affect normal viewing, especially at night when most laser incidents occur.

People working in hazardous environments and industries in India will soon have cost-effective goggles that can protect their eyes and improve efficiency. Bengaluru-based Hind High Vacuum (HHV) has developed a technology for high power laser safety goggles made of coated glass. There are just handful of companies with this technological capability globally, said Prasanth Sakhamuri, Managing Director.

By using these goggles, people involved in handling high precision laser equipment in research and production of hazardous material and workplaces can protect their eyes from harmful exposure.

Laser Safety Goggles are available in three varieties based on

the power of laser: low-power lasers need acrylic goggles, medium-power lasers need goggles made of treated glass and operating a high-power laser needs a goggle made of coated glass.

Dyes and dielectric coatings for laser protection

A laser protective dye is a pigment that is added to the lens material during the injection molding process. This dye neutralizes laser threats by absorbing laser light before it can reach the eye. Laser protective dyes are widely used due to their relative low cost and ability to retain high ballistic properties. While effective, there is a drawback: lenses that protect against multiple wavelengths require the use of two or more dyes which significantly reduces the light transmission of the lens. This makes it darker and therefore less suitable for low light applications.

The dielectric coatings are made of a fine stack of layers with different reflective properties. Currently, laser protective dielectric coatings are limited in their use due to their very high cost – a lens with dielectric coatings is roughly 10 to 20 times more expensive than a lens made using laser protective dye. Dielectric coatings are also easily scratched and generally require additional anti-abrasion protection.

BAE protection system

Utilising a novel technology, BAE Systems has developed a system to block laser attacks against aircraft and their crews. Engineers at the defense and aerospace giant have developed a low-cost, lightweight system that can block

dangerous laser light to protect pilots from hostile attacks.

Utilizing a novel film, the technique is selective in the way it prevents laser transmission, meaning a high level of natural light through can still pass though the canopy with minimal color distortion. As a result, pilots are protected from dangerous laser incidents with no deterioration in vision.

Dr Leslie Laycock, an executive scientist at BAE Systems commented, “A series of successful trials undertaken in a laboratory environment have proven that our method is effective against a wide variety of laser wavelengths. We have been able to achieve a visible light transmission in excess of 70%.

“Our system allows the majority of the light through the protective film, without the need for pilots to wear heavily tinted industrial goggles. This allows pilots to more effectively see instruments and their surroundings, whilst simultaneously blocking the dangerous laser light.”

As technology advances, the wavelength of proliferated lasers may change. Due to the adaptability of this technology, pilots will always be protected as the film can simply be upgraded and selectively tuned to combat new laser threats. The next phase of development will see experimentation and commercialisation within the public sector.

Boeing patents a laser detection system to protect aircraft and pilots from hand held lasers

Military pilots are not only at risk of temporary blindness due to hand-held lasers, but are also subject to being “designated” by laser targeting. Generally in connection with

military aircraft, laser detection devices register laser radiation from laser rangefinders or laser designators and by a warning signal to make clear to the designated aircraft, i.e., pilot, that laser illumination has occurred or is continuing. Reliable detection and identification of laser radiation may be critical to mission success and accurate information related to the type of laser may provide for appropriate countermeasures.

“The present invention is a laser detection and warning system may include a detector configured to be mounted to an aircraft, the detector including an optical subsystem, a detector subsystem, and a processor subsystem to determine characteristics of incoming laser radiation and transmit a laser warning output signal, wherein the laser warning output signal includes wavelength characteristics of the laser radiation and corresponding protective eyewear type.

Soldier protection systems

Australian Army has introduced an enhanced ballistic laser ocular protection system (BLOPS) as part of the new soldier combat ensemble that provides ballistic, environmental and laser protection to soldiers. However they provide protection against limited spectrum of common lasers (laser lenses).

Protection against Multi wavelength Lasers

U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC), has developed a new optical system to protect soldiers using magnified direct-view optics, such as gunner’s primary sights on battle tanks, against eye-damaging Multi wavelength lasers.

The filters which are used to block single wavelength lasers

are ineffective against wavelength-diverse lasers, unless they block the entire visible spectrum. The new technology incorporates laser-protection cells at the focal planes, where a laser threat's energy is focused, that absorb and disperse the laser energy, weakening the light and distributing it over a larger area of the retina to minimize eyesight damage.

The system was tested against a multiple wavelength laser system developed by the U.S. Army Research Laboratory's Survivability/Lethality Analysis Directorate (SLAD) which simulated "a worst-case, visible laser threat" in terms of its energy, pulse width, beam size and divergence."

Optex Systems to deliver laser-protected periscopes to US Army

US-based optical sighting systems manufacturer Optex Systems has secured a contract to supply new periscopes for the US Army. Under the terms of the $841,000 deal, the company will supply an undisclosed number of periscopes to be installed aboard the army's Abrams tanks.

The periscopes will feature glass and plastic laser protection for soldiers' eyes. "We take pride in providing great optics solutions for our soldiers who are utilising and maintaining the current Abrams fleet."

Laser damage to eye

The visible and invisible wavelengths in a laser beam present a unique hazard to the human eye and can cause instantaneously vision disruption, distraction, disorientation, and even eye damage. The threat posed by lasers is often hidden – those in the invisible spectrum cannot be detected by the human eye and without proper protection the eyes can be severely damaged.

How a laser affects the eye depends on the wavelength of the laser, the power level, and the duration of the exposure.

The human eye sensitivity peaks in the green range and perceives green 30 times brighter than red. When comparing a green and a red laser of equal power output, the green one will appear much brighter than the red. The eye’s natural defense for bright visible light is the blink response, which can take effect within a quarter of a second.

Nonvisible light can be in the wavelength range of ultraviolet (200 to 380 nanometers), near infrared (750 to 1,400 nanometers), or mid to far infrared (1,400 nanometers to 1 millimeter). Nonvisible lasers also enter the optical system and affect the eye, but they are not visible and present a different challenge: the blink response only works with visible light, so there is no natural protection for the eye when outside the visible spectrum.

Laser Light can have very high optical intensities, because it is usually delivered in the form of a laser beam with small transverse dimensions, and in addition it is often generated in the form of short or even ultrashort laser pulses.

Exposure to a strong laser light source can result in flash blindness and afterimages. In flash blindness, exposure to a very bright light source can deprive pilots of vision for a period of time ranging from a few seconds to a few minutes. This can be followed by afterimages, such as the yellow and purple dots seen after a flash photo. Again, these afterimages will disappear in time.

In the most serious exposures to lasers, the lens of the eye concentrates the light energy on the retina and can actually burn the retinal tissue. The human eye can compensate for small area retinal burns by looking around them, but large area retinal burns can mean permanent loss of vision for the affected area.

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