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ADVANCE VERSION OF LASER IN DEFENCE SECURITY

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ABSTRACT

The field of laser has witnessed tremendous scientific and technical developments in the recent past, enabling its deployments for a variety of biological, industrial, commercial and scientific applications. The key applications of laser technology can be divided into the domains of health sciences, engineering, and technology and security and defense. One of the rapidly progressing fields in the defense sector is the offensive use of laser for airborne military applications. Laser weapons have many advantages over traditional weapons. First, the transmission at the speed of light allows laser-based weapons to engage distant targets immediately after detection. Second, the directed laser energy provides less collateral damage and low-profile and covert operations capabilities [1]. Laser is a surgical weapon of choice, offering precise target-point selection. Initial installation costs are high but after deployment, laser weapons provide cost-effective engagements. Finally, the laser deployments can be flexibly tuned to deliver a gradient effect to tailor the range of results to non-fatal, destructive and disruptive outcomes [2].

KEYWORDS-defence, laser, security, weapons, surgical, deployments

INTRODUCTION

Today many types of lasers are available having different power ranges, wavelengths, operating efficacies, spectral bandwidths, and other features. The increase in the maturity of compact optical and laser devices have improved their abilities for military purposes. Consequently, laser technologies have changed the paradigm of modern warfare, by serving in diverse roles, such as indicators & target designators, sensing devices, data relays, active lighting, rangefinders, weather regulators, and directed energy weapons [3]. The laser systems deployed as Directed Energy (DE) weapons have the potentials to leave devastating effects on a very large scale. A high energy laser beam can be utilized to destroy moving targets over a thousand miles with optimal accuracy and precision. Huge investment and research are being done in the domain of high energy laser weapons [4]. According to United States Department of Defense (DOD) "DE is a general term for technologies that cover the production of concerted electromagnetic (EM) energy and nuclear or atomic particles. DE weapons are those systems that use DE for incapacitating, damaging, disabling, or destroying enemy targets."[1,2] Directed Energy Warfare (DEW) is a military operation, which includes the utilization of DE weapons, installation of such weapons, and defensive approach to damage or destruct enemy's equipment, amenities, or personnel, to identify, reduce, exploit, or avoid hostilities using Electromagnetic Spectrum (EMS); through destruction, disruption, and damage. It also includes acts to protect friendly equipment, amenities or personnel, and to maintain friendly use of EMS. With the maturity of DE technology, weaponized DE systems have become more and more powerful, and have become an important subcategory of the electronic warfare (EW) operational area. Examples of DE include radio frequency (RF) weapons, lasers, active denial technology and DE anti-satellite and High-Power Microwave (HPM) weapon systems [5].

From the history of military warfare, almost all weapons rely on the rapid transfer of calamitous energy to targets [6]. Technological advances then allow the transfer mechanism to shift from direct hits to impulsion-driven flight and ballistic orbital. The kinetic energy delivered on the target is enhanced by the biochemical energy induced by the explosive nuclear warhead. The basic physical phenomena remain the same. Even the complexity of modern military missiles platform does not rule out the fact that neutral potential mechanisms are still based on physical projectiles to achieve their goals.

This paper reviews and analyzes the applications of laser technology in its earlier and ongoing scientific advancements. The scope of this paper is confined to the offensive use of lasers for airborne military applications, which have revolutionized today's battlefields. The paper presents a comprehensive taxonomy of such applications while correlating them with historical perspectives as well as recent advancements in the form of government-funded projects.

A laser weapon is a Directed Energy Weapon (DEW) based on lasers. Laser weapons are being researched and developed by many nations; including addressing atmospheric thermal blooming on account of rain, snow, smog, dust obscurant and chemicals obscurant, since a lasergenerates a beam of light which needs clear air, or a vacuum. Many types of laser can potentially be used as incapacitating weapons, through their ability to produce temporary or permanent vision loss of humans.

Lasers of even a fraction of a watt-power can produce immediate, permanent vision loss under certain conditions. Using lasers or 'Tasers' as non-lethal weapons is controversial. Weapons designed to cause permanent blindness, are banned by the Protocol on Blinding Laser Weapons. But protocols/laws/conventions matter little to rogue nations like China. In 2017, China claimed it had developed a laser rifle 'ZKZM-500' capable of burning a hole in the human body from a distance of 800 metres. Such a weapon would be a boon to terrorist.[3,4]

America's Lockheed Martin recently showcased the beam from its Advanced Test High Energy Asset (ATHENA) which is a 30KW high-power laser weapon - believed to be most powerful ever documented in a laser weapon. In the case of Russia, President Vladimir Putin had unveiled the 'Peresvet', Russian laser weapon on March 1, 2017, as part of six new strategic weapons. The weapon is named after Alexander Peresvet – a Russian Orthodox monk who fought in a single combat with the Tatar champion Temir-murza at the opening of the Battle of Kulikovo. Peresvet also means supra-light. In 2017, an article in Chinese media described a Chinese laser weapon called 'Silent Hunter'; a fiber-optic laser air-defence system that could burn through two 5-millimeter steel plates from a range of 1,000 meters. In November 2017, China demonstrated its new LW-30 laser defence weapon system that uses a directional-emission high-energy laser to quickly intercept many kinds of aerial targets, such as photoelectric guidance equipment, drones, guided bombs and mortars.

The LW-30 features sustainable-combat, high-energy focused launch, efficient thermal management and is reportedly also capable of long-range detection and imaging. The system can complete independent operations or multiple network strikes, and can be integrated into traditional air defence weapon systems including close-in weapon system and air-defence missiles. It can detect drones and contain enemies' tactical reconnaissance and strike aerial terror attacks.

DISCUSSION

China has been very focused on both laser as well as hypersonic systems. It is widely acknowledged to be the leader in the field of hypersonic systems, having already fielded such weapons in the form of the DF-17 hypersonic glide vehicle. The DF-41 ICBM is the most powerful weapon of the bunch with the DF-17 hypersonic boost glide missile in second place. American nuclear strategists will have to take these missiles into account as they ponder Chinese first or second-strike capabilities and intentions to use. In February 2016, Israeli Prime Minister Naftali Bennett announced that a new laser defence system 'Iron Beam' will be deployed within a year to intercept incoming missile attacks; highlighting the increasing pace of development and utility of using high-energy lasers for missile defence. Israel already deploys the 'Iron Dome' (co-developed with the US) missile system that fires interceptors to destroy incoming missiles. Israel has also successfully tested an air-based laser system that can intercept drones. But use of 'Iron Dome' system has high costs especially in wake of increasing Hamas rocket attacks; to intercept each incoming Hamas rocket (costing $300-800), Israel has to spend at least $40,000 which is not cost-effective. Therefore, the urgency for 'Iron Beam'; use much less costly laser to destroy an incoming target rather than using kinetic energy.[5,6]

India has developed the KALI (Kilo Ampere Linear Injector) to destroy enemy missiles and aircraft. The project was initiated in 1985 by Dr R.K. Chidambaram, the then Director of the Bhabha Atomic Research Centre (BARC).

Work on the project began in 1989 to develop industrial applications but its various abilities helped in making it a powerful weapon. The KALI series (KALI 80, KALI 200, KALI 1000, KALI 5000 and KALI 10000) are described as 'Single Shot Pulsed Gigawatt Electron Accelerators'. The single shot devices use water filled capacitors to build the charge energy. The beams from the weapon can shatter any satellite, aircraft, missile or UAV instantly.

KALI's ability to emit powerful pulses of electrons and the conversion of electron energy into electromagnetic radiation pulse fuelled hopes that KALI could be used as a High-Power Microwave (HPM) gun. The X-Rays emitted by it are being used as an illuminator for ultrahigh speed photography Electronic components currently used in project can withstand fields of approximately 300 volt per centimeter. The Relativistic Electron Beams (REB) can be used for the generation of High Power Microwaves (HPM) and Flash X Rays (FXR).
News reports of February 19, 2016, state that Professor Ramesh Kumar Singh, from the Indian Institute of Technology, Bombay, has developed laser-based technology that autonomously repairs and restores high-value components such as moulds, turbine blades and other aerospace components with minimal human intervention. The technology has immense scope in the defence and aviation sectors. This technology has already undergone validation and testing.

A statement issued by the Ministry of Science and Technology reads, "It is expected that this technology will leap-frog the restoration and repair industry to the next level and help in nucleation of a viable cutting-edge laser manufacturing ecosystem." The defective component that needs to be repaired is examined autonomously for damage with a laser scanner and special algorithms are used for determining the deposition path. Laser-directed energy deposition (LDED) technique is then used to deposit the required material followed by finishing and automated post-restoration inspection.

Professor Ramesh Kumar has said in a statement, "The repair and restoration system is robotic and capable of functioning autonomously for all key activities such as scanning, path planning, damage assessment, material deposition, finishing and inspection.In addition, the process parameters will be obtained from physics-based models to induce favourable residual stress, which is one of the key limitations in restoration. This paves the way for the development of 'science enabled technology' solutions, which are not available for restoration of high-value components. The developed technology is very impactful, and a game-changer for the restoration and repair segment of the manufacturing industry and has huge market potential. The components which can be reconditioned via this technology are very high-value. The level of accuracy and precision, which is possible through this technology, is phenomenal and is far ahead of the current state-of-the-art methods."

RESULTS

Directed energy laser weapons has been derived from science fiction movies which is now being applied to the real war world, ever since H.G. Well, the famous fiction writer wrote "The war of world". This uses conception producing a deadly ray which can effectively destroy the enemy target causing blisters & holes in their body. Now, it has been a century, since Well's put forth the "deadly ray", & now in this highly agile & sophisticated era, laser technology is maturing to point of soon becoming deployable. It was not just a development of a laser weapon, but its discovery was marked by several scientific breakthroughs & important engineering millstones. There is variety of weapons in the Directed Energy Technologies: High Energy Lasers (HEL) Weapons, High Power Microwave (HPM) Weapons, Particle beam weapons, Laser induced plasma channel (LIPC). The first two are common Directed Energy weapons while Particle weapons use atomic or subatomic particles as projectiles accelerated to relativistic speeds. LIPC is a hybrid which induces laser to ionize a channel of molecules to the target which carries high electric field which can purge the electronic equipment & devices. There is deep connection between lasers & Masers (Mission of Radiation). Both Lasers & Maser act as amplifiers of electromagnetic radiation, if somehow we reflect these radiations through mirrors we can create an oscillator which can act as producer of Electromagnetic radiation. In practical terms the energy used to excite the atoms & molecules is given out in the form of high intensity light of a particular color & wavelength. The process of exciting the device is called pumping. Early High Energy system made use of rapid heating & cooling of gases, further research showed that cooling can be obtained by expansion of heated gases. This concept was used to make the first Gas Device Laser (GDL) using mixture of & , which delivered 400KW for 4 millisecond. The ambiguity was cleared that now High Energy Laser are feasible. The

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next class of laser which was invented involved Hydrogen Fluorine (HF) Laser & Oxygen Iodine Laser. Tactical High Energy Laser (THEL) is a Military based laser system also known Nautical Laser system. This Powerful laser Demonstrator was jointly constructed by US Navy & Israel, starting this program in 1996. The design of THEL system aimed to provide point defense weapon by engaging & destroying the rockets, artillery shells & small distant aircraft. The THEL demonstrator was trailed successively between 2000 & 2004 hampering Katyusha rockets, multiple artillery shells & motor rounds including salvo attack by motor. It makes use of Deuterium Fluoride chemical laser working at wavelength of 3.8microns. Ethylene is burnt in the atmosphere of toxic Nitrogen Trifluoride to produce excited Deuterium Fluoride Lasing Medium [7,8] which is mixed in deuterium & helium & fed into expansion nozzles as same as laser in GDL. Now it might be fatal if the exhaust components of deuterium fluoride is released in atmosphere. To avoid this problem, diffusion & pressure equalization technologies must be used, including a neutralization stage to soak up the highly corrosive & toxic deuterium fluoride exhaust efflux gas. The first DF laser was tested by the US Navy's MIRACL (Mid Infrared Advanced Chemical Laser) & it was a great success in producing a directed energy weapon. Its test was done extensively since 1983 in White Sands Missile Range in New Mexico. This device produced output in order of megawatts. The radar used was phased array radar which locates the coordinates of incoming targets & accordingly the beam was directed. THEL is short range weapon used to defend local area unlike ABL (Air Borne Laser), SAM (-----), AAA (-----). Its disadvantage can be looked through weather conditions & propagation limitations. This type of device cannot be used in humid tropical environments or northern temperate environment where moist, fog & low level clouds & similar propagation obstruction are common. The expenditure in fuel is about several thousand dollars per shot hence it becomes problematic to use the DF in large quantity. The impact is still to be determined in strategic terms unlike ABL which changes the game completely. The present MTHEL technology is prominent to become the feature of ground to air defense in the upcoming decades. But the physicists are shifting in making a new laser technology i.e. electrically pumped Solid State Laser Technology. 5. LOC The border between India & Pakistan is about 3000 kilometers long. About which 182 kilometers of border is unguarded due to Hilly area, Marshy land, etc. So, The infiltration of Pakistan is more in these sites. So, BSF had taken a decision of installing laser walls across these odd kilometers of border. KVI-101s system is used for these laser walls. The system KVI-101S requires very little human intervention, has advanced detection capabilities & the encryption are hack proof. The new technology uses next generation IR optics to provide all weather & harsh terrain early detection capabilities. With the help of infra-red rays & laser beam, the laser walls cannot just detect when there is a breach but can also tell differentiate between man & beast. Hence using this virtual border India will able to solve the issues of terrorism in those areas & also will able to stop infiltration of Pakistan. A further integration of laser wall with a system called miCRON, has enabled encrypted communication for five layer fencing, complete automation of border holding, is being designed & manufactured in India. The walls will be fully upgraded in western (Indo-Pak) border in Feb. or Mar. 2017. Furthermore India is also planning to install these laser walls in eastern border as well.[6,7]

CONCLUSION

6. Laser Guided Bomb A Laser Guided Bomb was first developed by United States during Vietnam War. This LGB is a guided bomb that they uses semi-active laser path to strikes a accurate target with high accuracy than any other unguided bomb. They have quickly proved their aim in precision strikes of difficult point targets. These weapons uses an electronic board to track the targets by designated laser. The laser guided bombs achieved directly hits approximately 50% of time v/s just 5.5% for undesignated bomb, that is shown from Vietnam data laser guided ammunitions carry less explosive & cause less collateral damage than unguided ammunitions. Nowadays, these bombs are one of the most common & widespread guide bombs. These are used by the large number of World's Air Forces. These weapons, first developed in United States & United Kingdom in early 1960s, where United States Air Force issued the first development contract in 1964. With the support of IRDE a lab of DRDO India built its first Sudarshan laser guided bomb in October 2010. This is the part of ongoing research to achieve self-dependency in defense area. 7. Anti-Ballistic Missile The thought of destroying rockets prior they can hit their targets was first made by Germans in their V1 & V2 program of worldwar-2, which provoked the idea of AntiBallistic Missile. It is a surface to air Missile which is designated to destroy Ballistic missile. A Ballistic missile is kind of a missile that follows ballistic trajectory. Basically these missiles are used to deliver nuclear, chemical & biological or conventional war heads in a ballistic flight trajectory. The "Anti-Ballistic Missile" is layman term depicting a system devised to intercept & destroy any type of ballistic threat. The Indian Ballistic Missile Defense Program is an

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initiative to develop & deploy a multi-layered ballistic missile defense system to protect from ballistic missile attacks. Prithvi Air Defense (PAD) belonging to the class of missile is a high altitude interceptor & The Advanced Air Defense (AAD) used for low altitude interceptor. The first test of PAD was carried out in November 2006, followed by AAD in 2007. The positive results of PAD made India the fourth country in making an anti-ballistic missile defense system after United States, Russia & Israel. It is yet to be officially commissioned although it has undergone several tests 8. LiDAR LiDAR known as the light detection & ranging system which adopts remote sensing method, that transmit light energy in the form of a pulsed laser to measure the distance of the target or variable distances on the earth. It sends a beam of laser which illuminates the target & by measuring the time interval of the reflected laser, the distance of the target is calculated. It can be also called as laser scanning or 3-D scanning. It has many uses in the field of Geology, Geodesy, archaeology, geometrics, atmospheric physics, etc. It has a very interesting history, LiDAR came into applications in early 1960s just after laser was invented. It is a combination of laser & focused imaging with an ability to calculate the distances by measuring the time for a signal to return using appropriate sensors & data acquisition electronics. Most importantly it was used in Applo-15 Mission when the astronauts used the laser altimeter to map the landscape of the moon. Examples of military application of LiDAR are Air Borne Laser Mine Detection System. Airborne multi laser LiDAR is used to map the territory of the enemy i.e. to locate their tanks & warheads. 9. Space Defence Project De-Star, a project given by scientist to destroy asteroids which are aiming towards Earth. This project is important as asteroids / space debris especially rocks are a few kilometers big but the destruction made by them on earth is deadly for all human as well as animal species. Example of asteroid destruction are 1: destruction or end of whole dinosaur species. & 2: The Vredefort Dome, the Vredefort crater has an estimated radius of 118 miles (190 kilometers), making it the world's largest known impact structure. One asteroid, if few km big falls on earth creates destruction more than Hiroshima Nagasaki attack or even more than energetic weapon on earth.

De Star stands for Directed Energy System for Targeting of Asteroids & exploration system to deflect asteroids, comets, & other near-Earth objects that pose a credible risk of impact. As we see above the object that cross the earth's orbits even a tiny one, has a very destroying effect on Earth. So NASA has introduced orbital planetary defense system which is capable of melting or vaporizing the object by heat produced by laser. Laser will just vaporize or cut down it into fine pieces. DE-STAR is a modular phased array of kilowatt class lasers powered by photovoltaic .We consider two classes of systems, Large "stand-off" DE-STAR arrays, which remain in Earth orbit & deflect the target from a far. Much smaller "stand-on" DE-STARLITE systems which travel to & deflect from alongside the target. The modular design allows for incremental development & test, lowering cost, minimizing risk, & allowing for technological codevelopment. DE-STAR is designed as stand-off that can accomplish task from far. While comparing DE-STAR & DE-STARLITE, DE-STARLITE is small & it can be deployed on a single launcher but still powerful i.e. capable of diverting large asteroids in given sufficient warning time. In both the systems a highly focused laser light beam is targeted on an asteroid at a spot, the temperature at that spot rises up to ~3000K which will instantly vaporize the material in that spot & material gets ejected which alters the direction of asteroids or comet's orbit. Ideal DE-STAR systems can simultaneously engage multiple targets. Project DEEP-IN As we know that we don't have such a technology that can go up to 2-3% the speed of light. But NASA have studied & invented an idea that make us travel at approx. or greater than 25% speed of light & that project is named DEEP-IN. As we know, we humans have sent a voyager space satellite in 1977 & now it has crossed our solar system. It weighs half the space shuttle load or even more. So this system takes very less fuel & also less costly. But it can carry fewer loads. So we can send "wafer sats", waferscale systems weighing no more than a gram. The wafer sats would include integrated optical communications, optical systems& sensors. As these weigh less they can travel as fast as possible.[7,8] So, with the help of this propulsion we can reach our closest star in few years. DEEP-IN (Directed Energy Propulsion for Interstellar Exploration) is a NASA program to use massive directed energy to thrust small spacecraft to relativistic speeds to enable humanity's first interstellar missions. This program was started in 2009 with initial funding from UC Santa Barbara & the NASA Space grant Consortium with funding from the NASA Innovative Advanced Concepts (NIAC) program from a 2014 proposal. NIAC Phase I funding began in April 2015 with Phase II funding started in May 2016. 10. Conclusion & Future Scope Due to the properties of laser like high intensity high coherency its use for military & defense application makes it a perfect choice. It has made huge impact on Law Enforcement sector due to its various ranging application of laser technology like LiDAR, ABL, THEL, etc. Many major threats can be averted in the future. Because of the invention of the PHaSR Rifle, there will be improvement in the Law Enforcement, as it will be bullet free & the damage effects would be

temporary. Scientists are still trying to improve the prototypes design of weapons & defense system which will reduce the cost & increase the efficiency. The Applications of laser technology are also been studied in India at various institutions & they are being researched for improvements. [8]

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