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DIRECTED ENERGY WEAPONS AND THEIR EMPLOYMENT IN FUTURE WARFARE

BY

PROF VIRBHADRA SINGH RAWAT

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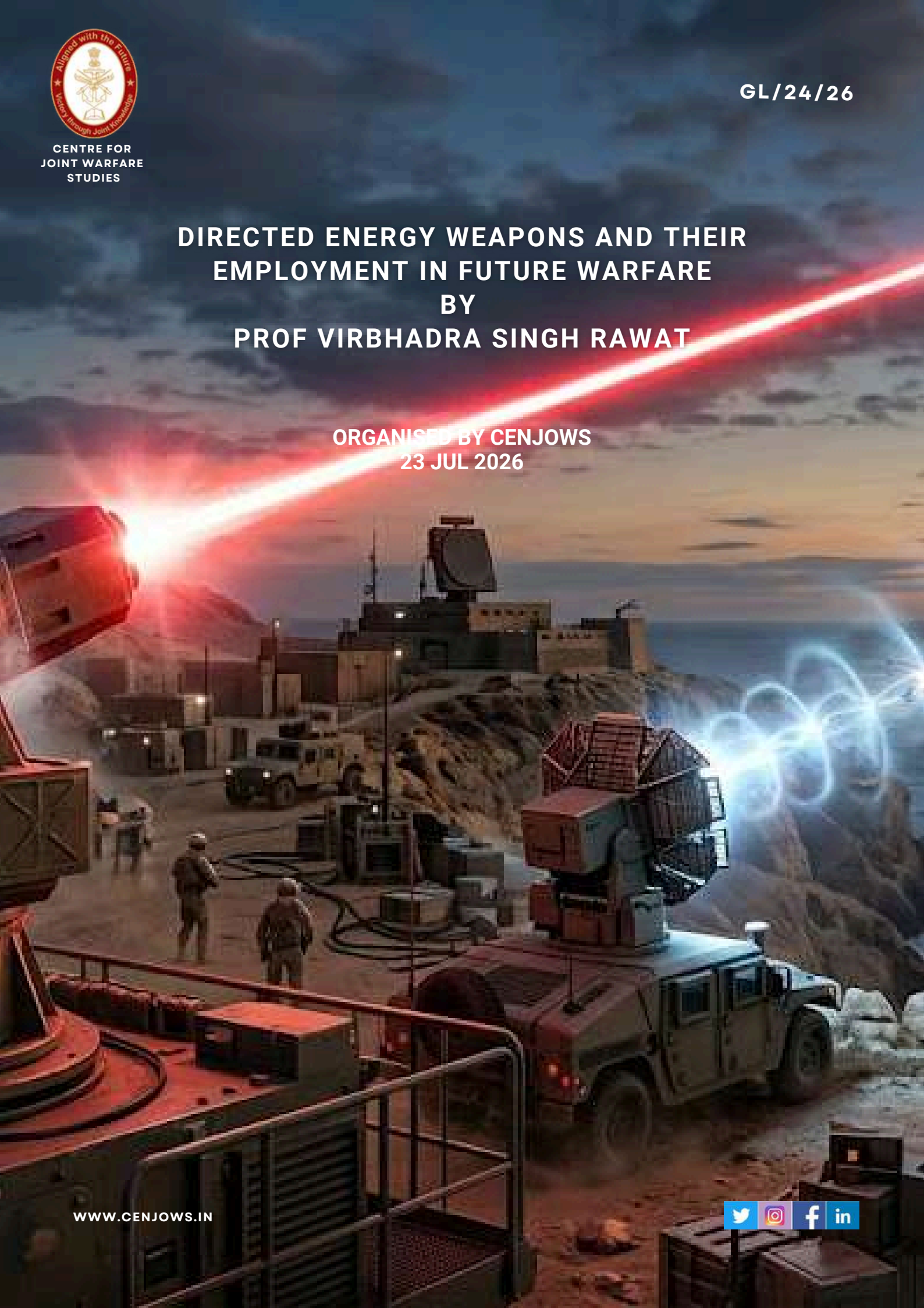

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DIRECTED ENERGY WEAPONS AND THEIR EMPLOYMENT IN FUTURE WARFARE

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The lecture focuses on the growing importance of Directed Energy Weapons (DEWs), particularly laser-based systems, in modern warfare. The speaker, professor Virbhadra Singh Rawat from IIT Ropar, explains why these weapons have become strategically significant, especially in response to the rapid rise of drone warfare. He also discusses India's efforts to develop indigenous DEW technology, the challenges involved, and the future role of these systems in national defence.

The session begins with an introduction highlighting the increasing uncertainty in global security and the growing relevance of directed energy technologies. IIT Ropar has emerged as a major research hub in this field, supported by a government-funded project worth approximately ₹75 crore. The institute is also establishing a large defence research park in collaboration with the Indian Army, demonstrating India's commitment to advancing indigenous defence technologies and fostering collaboration between academia, the armed forces, and industry.

Professor Rawat limits his discussion primarily to laser-based directed energy weapons, although he acknowledges that other forms, such as high-power microwave systems, also exist. Directed energy weapons work by concentrating energy onto a specific target rather than launching a physical projectile. While microwaves mainly disrupt electronic systems, lasers destroy targets through intense heat, making them particularly effective against drones and other aerial threats.

A major reason for the renewed interest in directed energy weapons is the changing nature of warfare. Traditional air defence systems were designed to intercept incoming aircraft and missiles using other missiles. However, recent conflicts, including the Russia–Ukraine war and India's military operations, have demonstrated that inexpensive drones have become one of the greatest threats on the battlefield. Using costly missiles to destroy low-cost drones is economically unsustainable. For example, a drone costing around ₹25 lakh may require an interceptor missile costing over ₹2.5

crore. In contrast, firing a laser costs only a few dollars per shot. This dramatic reduction in operational cost changes the economics of warfare, making laser weapons an attractive alternative for counter-drone operations.

Beyond cost, laser weapons offer several operational advantages. Since laser beams travel at the speed of light, they engage targets almost instantly. Unlike conventional weapons that rely on ammunition, laser systems only require a reliable power source, giving them what the speaker calls a virtually unlimited magazine. They also provide exceptional precision, allowing operators to engage specific targets while minimizing collateral damage. These characteristics make laser weapons particularly suitable for protecting military installations, airports, and other critical infrastructure.

The lecture distinguishes between thermal kill and electronic kill systems. Thermal kill weapons use concentrated laser beams to physically damage or destroy targets, while electronic kill systems rely on high-power microwaves to disable or interfere with electronic equipment. India has made greater progress in laser technology, whereas microwave-based systems remain under development. Thermal lasers are currently viewed as the more practical solution for countering drones, rockets, and loitering munitions.

Despite their advantages, directed energy weapons face several technical challenges. Laser beams require a clear line of sight and are significantly affected by environmental conditions such as fog, dust, smoke, rain, and clouds, all of which reduce beam concentration and effective range. Another major challenge is generating sufficient electrical power and managing the heat produced during operation. High-energy lasers require advanced power generation systems and highly efficient cooling technologies to maintain continuous operation. The speaker notes that reducing the "dwell time"—the interval between successive laser shots—to three to five seconds is one of the Indian Army’s key technological goals.

The lecture emphasizes that the rise of drone warfare is the primary driver behind the accelerated development of directed energy weapons. Although research into laser weapons dates back to the 1960s, the widespread use of inexpensive drones capable of destroying highly valuable military assets has fundamentally altered defence priorities. Directed energy weapons are increasingly viewed as the most cost-effective

solution for neutralizing quadcopters, first-person-view (FPV) drones, loitering munitions, rockets, and other aerial threats.

Several countries have already made significant progress in this field. Israel's Iron Beam, Australia's Apollo, South Korea's laser defence programs, and the United Kingdom's DragonFire are among the leading examples. Some of these systems have already been deployed operationally. However, due to export restrictions and technology transfer limitations, India cannot rely on foreign suppliers for cutting-edge laser capabilities. As a result, the country is focusing on developing indigenous systems.

Within India, organizations such as DRDO are collaborating with private companies to accelerate development. Emerging firms, including Paras Defence, Adani Defence, and some others, are working on various laser weapon projects. Some systems have already undergone limited deployment or testing with the Indian Air Force, while others remain under development. Current Indian laser systems are primarily designed for point defence with engagement ranges of approximately 3–5 kilometres.

In conclusion, Professor Rawat argues that directed energy weapons are no longer futuristic concepts but practical military technologies whose importance will continue to grow. Although current systems have limited range and must operate alongside conventional air defence weapons in a layered defence strategy, advances in laser power, cooling technologies, and energy storage are expected to significantly enhance their capabilities. For India, developing indigenous directed energy weapons is essential not only for reducing defence costs but also for achieving technological self-reliance and strengthening national security against evolving aerial threats.