High Power Lasers—Directed Energy Weapons
Impact on Defence and Security

Amitav Mallik

Defence Research & Development Organisation
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Metcalf House, Delhi

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HIGH POWER LASERS–DIRECTED ENERGY WEAPONS: IMPACT ON DEFENCE AND SECURITY

AMITAV MALLIK

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‘There is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success than to take the lead in the introduction of a new order of things.’

- *Niccolo Machiavelli*, Italian Political Philosopher, 1527.

‘HPL–DEW is a new class of weapon that has faced many problems through the development years, but has prevailed to establish its unique position in the new order of defence and security.’

- *Amitav Mallik*, 2012
I would like to dedicate this monograph in memory of my scientist father Shri Akshoy Kumar Mallik, who motivated me to take up research in Laser Technology in 1968.
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Preface

Laser technology has been one of most fascinating discoveries of the 20th century. The laser device is unique in many ways, the most striking aspect being its extraordinary brightness. This has caught the imagination of mankind towards realisation of the ultimate ‘death ray’ weapon that could outmatch all other weapons. Directed energy weapons (DEW) using high power lasers (HPL) have indeed arrived and are about to make a major impact on the strategies for future wars and on the ways technological deterrence will play an important role in avoiding future wars.

Directed energy weapons using HPL are a new generation of weapons that travel at the speed of light with unprecedented accuracy. This has opened up very interesting applications hitherto not possible with conventional technologies. Worldwide R&D in HPL–DEW has demonstrated many successful tests to establish the technology with its promising potential for the future of defence and security.

The aim of this monograph is to present an overview of this fascinating technology in all its dimensions in simple language, so that this serves as an easy reference for the highly complex subject that combines several disciplines to bring the science fiction like concepts into real-life applications. The other focus of the monograph is to present an analysis of the strategic impact of HPL–DEW in the context of strategic missile defence and space security that may significantly affect the perceptions of deterrence in the world power balance equations.

The narrative is divided into seven chapters; the first four chapters giving an introduction to the subject and the HPL–DEW technology, and the fifth chapter discussing defence applications. The last two chapters present the strategic implication and a quick recap of HPL–DEW technology including Indian perspective.

Much of the matter in this monograph is from the author’s own notes and his long experience in HPL technology. This monograph is not intended as a reference textbook but is oriented to add to the understanding of HPL–DEW as a weapon and bring out its impact on defence and security.

August 2012

Amitav Mallik
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I must in particular thank Ms Alka Bansal and Ms Anita A, Head, Monograph Division of DESIDOC for the excellent support in every possible manner. I must thank the library staff of DESIDOC for help with reference search and library support.

My special thanks go to my friend and associate Dr BS Patel, for agreeing to review the manuscript and give valuable suggestions.

I write this monograph with many warm memories of all my colleagues and friends in the high power laser technology field, without whom the success achieved a decade ago at Laser Science and Technology Centre, Delhi would not have been possible.

Amitav Mallik
Chapter 1

Directed Energy Weapons: An Introduction

1.1 DIRECTED ENERGY WEAPONS FOR DEFENCE AND SECURITY

The progress of science and technology has been closely linked to man’s pursuit of electromagnetic spectrum towards higher frequencies as this has opened up new application potentials and enabled new capabilities for defence and security. After the early days use of radio frequency for communication, radar and microwaves have opened up new avenues related to defence applications. Today, the decisive impact of technology on war and peace is much more pronounced than ever before. As we commence the 21st century, the perceptions of military might and defence preparedness are changing significantly as compared to the last century which was dominated by cold war.

The cold war era was dominated by nuclear weapons and missile technology. More recently, satellite surveillance, information communication technologies (ICT), and precision strike capabilities have transformed the strategic doctrines for defence and security around the world. Thus, 21st century is likely to be influenced by technologies that can either complement these capabilities or create new capabilities that can out-match the winner technologies of the 20th century.

While information technology and space technology are proving to be major enablers for modern network centric warfare, another new technology emerging clearly as critical for 21st century is directed energy weapons (DEW). Sustained R&D over past three to four decades and successful tests after overcoming many hurdles and problems, have led the technology to a state of maturity that is likely to enable deployment of new generation beam weapon systems. While high power lasers (HPL) and high power microwaves (HPM) have emerged as the two main options for the DEW technology, HPL technology has progressed rapidly and has a clear advantage for long-range military applications. Directed energy weapons are revolutionary in nature and thus have the potential to significantly influence the international power balance in the 21st century.

Electromagnetic energy is known to travel at the speed of light to reach long distances in a split second, and this aspect has always fascinated human mind over the ages. One of the first uses of such energy against enemy was the use of mirrors by Greek warriors to reflect sun rays into the eyes of the enemy to blind them before attacking them.
One is of course familiar with the mythological tales of the third eye of ‘Lord Shiva’ (Indian deity) that could send a scorching beam of light to burn and destroy the evil. All such perceptions and early adaptations of the use of visible light energy were indeed precursors to DEW. Ever since the discovery of laser (light amplification by stimulated emission of radiation) in 1960, the real world has come very close to the science fiction images of bright light beams as the new generation weapon. HPL—DEW, today is recognised as unique speed of light energy beam weapons using high power lasers that can be precisely aimed to target over long strategic distances. Other DEW options include HPM and particle beams, but they are yet to mature to the level of HPL, which is ready for direct use as a weapon system in modern warfare.

While the technology today is still far from providing the ultimate death-ray gun in the hands of a foot soldier, DEW as a platform-based weapon system is being pursued by many advanced countries, albeit at varying levels of technology maturity. Invisible infrared (IR) lasers have been in use for IR countermeasures (IRCM) through much of the cold war period. These devices are aimed at blinding or disabling enemy sensors in the visible or IR band to deny enemy the early advantage of accurate observation. More modern versions of IRCM capability include causing dazzle effects to weapon system operators or damaging the guidance sensors onboard on enemy missiles or unmanned air vehicles (UAVs) to render them ineffective. As threats become complex, the need to respond rapidly and accurately with minimum collateral damage will be very essential, and most defence and security planners envisage increasing use of DEW to meet this future challenge across the full spectrum of modern warfare.

The major boost to DEW came in 1983 from the strategic defense initiative (SDI) of the Regan era, when ‘Star War’ technologies were promoted with the promise of making nuclear weapons obsolete. Billions of dollars have been spent for R&D in DEW, driven by the logic that advanced DEW capability should provide a paradigm shift in the perception of ‘strategic deterrence’ that need no longer depend so heavily on nuclear-tipped missiles. While HPL technology made impressive progress and remained in the news, significant technological advances were also achieved in the areas of HPM as well as in particle beam technologies.

Extensive research into DEW sources and the concurrent advances in beam directing technology have pushed technology envelop to the level where fully configured DEW systems are now being designed and tested for imminent deployment. Advances in material technology, information technology, and space-based capabilities of the 21st century are also providing the right environment for growing demand for DEW systems. The US Air Force project on airborne laser (ABL) is a classic example of how DEW technology is transforming into a formidable weapon system with hitherto unthinkable military capabilities.

Although some of the space-based laser weapon concepts, as espoused by the US President in the SDI–Star War initiative have remained unrealised, the potential of laser-based DEW for tactical air defence, anti-ballistic missile defence, and anti-satellite (A-SAT) applications is now beyond doubt, as proven by several successful HPL tests in the past two decades. While more advanced nations like USA and Russia in this field are already busy solving the final engineering issues for effective deployment of such energy weapons, the technology levels needed for such
systems do not appear to be out-of-reach of several other progressive nations, such as China, Israel, Japan, Germany, France, and India. However, India being one of the late entrants in this field, it has only managed to establish the core competence and the facilities needed to demonstrate the basic concept of HPL–DEW to its Armed Forces and strategic planners so that further system development could be as per the specific requirements of India’s strategic plans in this area. Given the imminent deployment of DEW systems by advanced nations in the near future, particularly in the context of missile defence and space security, India will need to quickly consolidate all efforts to narrow the technology gap in this critical area to be at par with leading nations in this very promising futuristic technology.

As threats become more complex in the dynamic environment of the 21st century, the need to respond rapidly with high precision is becoming very critical for military superiority. Defence analysts and military officials now recognise DEW as a potential technology that can effectively leverage the integrated capabilities of high situational awareness of today, thanks to advances in satellite surveillance and ICT. The attention is thus turning to DEW for accuracy and innovation. In the United States, defence planners are constantly looking for new and improved capabilities in both strategic and tactical missile defence, as well as for satellite defence and space superiority. They recognise that laser and optical system technology offers the potential for a paradigm shift in weapon systems for the 21st century.

Directed energy weapons continue to offer the promise of a transformational game changer for the strategic planners in the US and other advanced countries as they encounter new asymmetric and disruptive threats while facing increasingly sophisticated traditional challenges. They believe that DEW will fundamentally change warfare as we know it and only the most technologically advanced nations will have these weapons for some time in the future, providing the decisive techno-military edge in future conflicts. Anybody waging war against nations armed with these new generation energy weapons could be defenceless against DEW which can strike enemy targets with lightening speed and unprecedented precision.

HPL–DEW is well recognised as a sensitive critical technology for the future of defence and security. Hence, much of the detailed information has remained in the classified domain. However, many of the scientific achievements and technological developments are often reported in open source literature. It shall be the endeavour of this monograph to provide the reader a comprehensive review of this fascinating technology, and present some analytical insight based on the strategic consequences of this technology based on the personal experience of the author as a laser scientist as well as a strategic analyst.

1.2 TECHNOLOGY DEVELOPMENT: HISTORY AND STATUS

The major milestones in the long history of military technology perhaps could be recognised as gun powder, air power, nuclear weapons, missiles, and space power. These could be identified as revolutionary and transformational milestones, and now the advent of DEW is poised to make an impact of the same magnitude for the 21st century defence and security. These are proving to be a new class of weapons that are not only well suited for modern warfare, but are also usable from any platform in all dimensions of defence and security.