Directed Energy Weapons for the Indian Armed Forces

Bishwajit Bose*

Military planners believe that the 'blast and fragmentation' type conventional weapons cannot advance much further technologically. The next chapter in weapons technology development is expected to be realized from Directed Energy weapons (DEWs). It can be assumed that by 2035, DEWs consisting of laser, microwave and millimeter waves can reach current performance levels of the existing kinetic energy weapons (KEWs) and conventional weapons. While these will co-exist with KEWs, a non-DEW option would have a debilitating effect on the defence preparedness of any nation. Its numerous advantages has made DEWs a preferred project of choice for development by Russia, France, US and China. India too should consider the potential advantages of developing DEW technology. This article aims to highlight the importance of DEWs in the Indian context and urge thinkers and policymakers to make a road map for development of DEWs.

Introduction

If there is a single dominant factor that has changed the course of warfare in human history, it is technology. Technological advances in weaponry, intelligence gathering, guidance system, propulsion systems, and more, have helped evolve new war strategies and doctrines which have revolutionized the conduct of warfare at various stages in history. The most significant and pervasive influence of technology on warfare is being witnessed in the current evolution of new systems. Unfortunately, in the

* Group Captain Bishwajit Bose is a Senior Research Fellow with the Centre for Air Power Studies (CAPS), New Delhi.

ISSN 0976-1004 print

Journal of Defence Studies, Vol. 8, No. 1, January–March 2014, pp. 95–108

Indian case, the experiences with the Defence Research and Development Organization (DRDO) have prompted the services to look for only foreign purchases whenever it wants to upgrade any technology. Due to this, there will perhaps always be a quantum of difference between the technologies which are specifically required and that which are finally made available.

Within a decade or so, the Indian Air Force (IAF) will replace its legacy aircraft, the erstwhile MiG-21.The replacement will be a variety of superior fourth-generation aircrafts. Most of these will be multi-role, hence frequent changing of configuration will become a thing of the past. However, it must be noted that no matter how advanced an aircraft is, its basic role is still that of a platform to carry weapons. The effective punch of any generation of aircrafts is the weapon it wields. Hence, the induction of improved weapons to match the advanced platform should be the focus to enhance effectiveness. It should not be forgotten that the lethality of the enemy air defence system has also improved simultaneously. Therefore, exposing a sophisticated platform without utilitarian weaponry will not prove to be cost effective. There is a need to have a precision and stand-off capability in any air weapon of today. Such systems may not be readily available or, if available, may not be parted with by the concerned country of origin. In any case, there are only two options to remain ahead in the arms race: either have a cooperative foreign partner whose interests match yours or develop your own potential to produce weapons.

As per current estimates, we will have 270 Su-30MKI, 126 medium multi-role combat aircraft (MMRCA) and 40 Tejas by 2020. Yet, these superior aircraft would continue to function with weapons many generations behind. As the IAF is slowly shedding its old skin and taking on a new garb, it is also time to add a new set of teeth which will give a lethal force to its bite. The need of the hour is a weapon which can take on multiple targets from a stand-off distance, one with a magazine that lasts longer than the endurance of the aircraft and which has the capability to take on missiles launched at supersonic or hypersonic speeds. Such a weapon needs to be developed in-house so that it can form a part of our force expansion process for a longer period with many modification in its entire life cycle.

The lifespan of a modern weapon system is in the region of 30 years which is normally extendable by another 10–15 years after a mid-life upgrade. New equipment procured for the IAF over the next decade will remain operational up to 2050, possibly up to 2060 at most. As the

nature of warfare itself is undergoing transformation, it is necessary to make a comprehensive reassessment of the contours of the operational scenario that the IAF will have to contend with and reconfigure its inventory accordingly. To do this at this point in time, the IAF needs to take note of India's regional power status in the emerging world order and assess its possible role and responsibility in the new geopolitical and geostrategic environment. The IAF's sister services are also faced with a similar dilemma.

DEW—The Sharper Cutting Edge

Development of directed energy weapons (DEWs) and creation of weapons on electromagnetic pulse effects without a nuclear blast are likely to change the course of future warfare. A DEW emits energy in an aimed direction without the means of a projectile. It transfers energy to a target and introduces uneven heat stresses, leading to failure of structural integration of the target and causing its destruction. This weapons effect on humans may be changed from lethal to non-lethal. The DEWs broadly encompass two fields which are: high-energy lasers (HELs); and high-power microwaves (HPMs)—millimeter waves and microwaves.

HEL has gained more emphasis at present due to ease in deployability and low operational cost as compared to other options. It is also a very popular choice due its varied use against different targets. This article is an attempt to justify undertaking its development in context of inducting it into the Indian armed forces.

Why DEW?

According to military planners, the conventional 'blast and fragmentation' weapons have reached their pinnacle as far as further technological developments are concerned (see Figure 1).

The inherent characteristics of the DEWs give it some distinct advantage over today's existing kinetic energy weapons (KEWs). Pursuing development of a DEW is attributed to the following unique properties:

- Travels at the speed of light (greater than all the future, present and past conventional weapons) and no complicated calculation for target movement necessary.
- Not affected by gravity (no trajectory calculations required).
- Can be invisible and silent; attacker remains concealed.
- Duration for deployment—a few seconds to a minute—reduces exposure of launcher to enemy position.

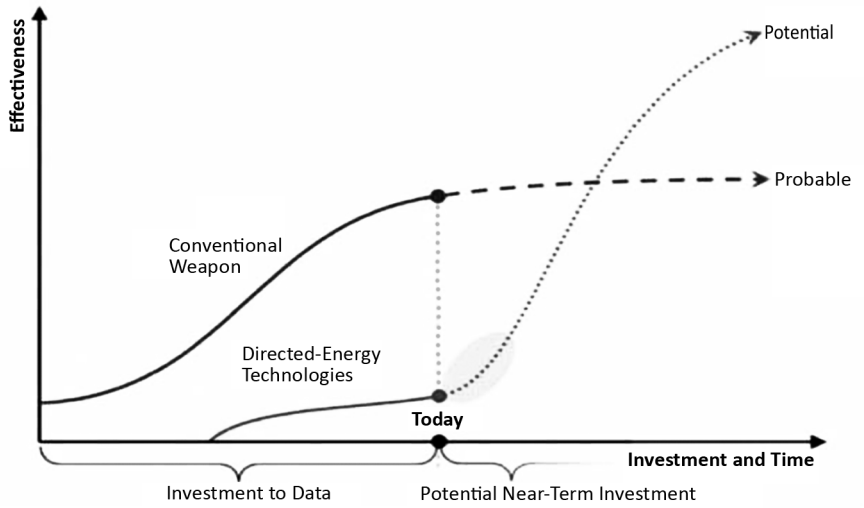

Figure 1 Scope of Development of DEW

Source: Dietrich Schroeer, 'Directed-Energy Weapons and Strategic Defence: A Primer', Adelphi Papers 221, Summer 1987, p. 33.

- Recharging of magazine non-existent, only source of energy required.
- No recoil as there is no momentum, so equipment mountings need not be large.
- Operation range larger than conventional weapons.

All is Not Well

However, the above-mentioned properties are not all-encompassing; there are some restrictions which can make DEWs non-effective, and they can be used as measures to counter a DEW attack.

- The target has to be in the line of sight of the laser.
- Due to divergence, an inherent property of a beam of light, the range gets restricted to a few 100 km and not beyond. Technological advances are being worked out to increase range.
- Presently, the requirement of energy source is large, but with advancement in superconductivity and nanotechnology, this problem is being worked upon.
- The beam can be scattered by creating a smoke screen over the target, placing reflective surfaces, spraying water, etc.

Is it a Weapon of the Future?

Not exactly, because it cannot be the only weapon. It will have to co-exist and complement the KEWs considerably. But over the long run the non-DEW option would have a detrimental effect for any nation. The rapid advancement in the information and communications technology (ICT) and nuclear technology will pose a major challenge for any defence force in the future. The only weapon capable to disable, deny, damage or destroy a nuclear weapon as well as an ICT equipment is the DEW. This makes it a viable choice for the future.

Hypothetical Scenarios

Consider a hypothetical scenario in which two countries are in conflict. Well aware of the value of asymmetric weapons, one country begins investing in DEWs and equips its armed forces with these weapons. In the event of an unwanted war, for defensive protection, they intend to use HPM sources to disrupt the other country's stealth aircraft, which are potentially more susceptible due to their wave-absorbing nature. Moreover, they plan to protect their own fighter aircrafts with free electron laser (FEL) cannons against incoming missiles and shoot down the other's rockets and artillery fire with tactical high-energy laser (THEL) from the arsenal of a multi-platform, multi-mission defence system. For offensive applications, this directed energy-conscious nation suppresses the other's air defence and command, control, communications, computer and intelligence (C4I) facilities with unmanned air vehicles (UAVs) loaded with radio frequency (RF) weapon payloads. Using a modularized sealed exhaust chemical oxygen iodine laser (COIL), they can disable the other's critical domestic infrastructure, transportation and communications systems with advanced tactical laser (ATL). In addition, agents use transient electromagnetic devices (TEDs) to cause detrimental effects on infrastructure such as financial institutions (that is, banks, ATMs and stores), airport facilities and other critical entities.

The second country underestimates DEW attacks by prioritizing conventional fighters and cruise missiles against their enemy's defences. With the unique role of DEWs' combination of rapid reaction times, long ranges and speed-of-light engagement, unlimited magazine and precision, this second nation is susceptible to DEW attacks that can destroy its aircraft and missile systems. The HPM signals from the directed energy-equipped adversary's installations cause over 90 per cent of cruise missiles to fail en route to their targets. Following a directed energy-equipped

nation's attack with an E-bomb, airborne laser (ABL) and/or advanced tactical lasers, there is little left of this second country's ground facilities and airborne defence systems, with the added condition that minimal collateral damage resulted from the directed energy-equipped country's attack.

So, which country do we want to be is a question we need to ask ourselves.

DEW as a Tri-Service Weapon

Recent advances in technologies have made the development of DEWs technically feasible. After the third quarter of the last century, scientists offered many logical and convincing explanations about why DEWs will be a dominant force in the coming years. Although early documents categorize particle beams as DEWs, later studies just examine laser and HPMs under the directed energy umbrella and do not include particle beams in the discussion. All the sources found in academic journals highlight the importance of DEWs and how they will change the battlespace perspective of future wars. While some sources present these weapons simply as reflections of technological improvements, other researchers offer more complicated and technical discussions. Most current scientific studies discuss just one type of DEW and, at this point in time, do not include military applications in the discussion. Military writings mostly view these weapons with just one service branch's point of view—army, navy or air force. Envisaging the role played by our defence services in the future, DEWs can be broadly described as per the specific service.

Air Force

The goal of the IAF is to become a force with a 'strategic reach', both in peace and war. A major responsibility of the IAF in the future would be in the area of strategic power projection. Given its emerging regional power status and the newly formed strategic partnership with the US, if not abrogated by the incoming administration, India may be called upon to project power in the region. This may involve highly sophisticated technology or low but effective technology. In either case, it should possess a weapon which, in any scenario, can give the IAF superiority once it has undertaken a policing role. Strategic weapons other than those for mass destruction need to be developed and used. In-house expertise with the involvement of the IAF would, therefore, need to be built up practically

from scratch, as no such technology currently exists within the country to develop this kind of weapon.

This weapon will, in turn, enhance the effective potency of the IAFs force multipliers already on its inventory. At the strategic level, it will provide the nation with credible nuclear deterrence against its adversaries. It will also increase the capability of power projection in perceived areas of national security and in interest of our allies in regions beyond national borders. For strategic strike deep into enemy territory, the IAF needs to have a combination of satellite-based and long-endurance, airborne platform-based DEW—the latter with powerful electronic warfare equipment to suppress and defeat enemy air defence systems. Tactical roles may be transferred to unmanned combat aerial vehicles (UCAVs) and helicopters at later stage when the equipment size can be reduced (with nanotechnology and superconductivity).

To provide effective air defence of the homeland, the IAF needs to acquire a fleet of Airborne Warning and Control Systems (AWACS) and Airborne Early Warning (AEW) aircraft, over and above the few already on order, to enhance surveillance capability at low level. These large-bodied aircrafts can be modified to incorporate the DEW system and act as search and destroy platforms. There is a need to introduce new-generation area and point-defence systems to replace the ageing and obsolete systems currently deployed. These new systems can also be incorporated with the newly developed DEW system which will prove to be more effective. The DEW is capable of being used as an area weapon by taking on multiple targets, one after another. Its capability as a precision weapon is, of course, flawless. For strategic and tactical intelligence, the IAF must have its own satellite systems which, if developed in-house, can be mounted with a DEW system to have effective coverage of potential targets from space (presuming that the stigma attached to weaponization of space is made more pragmatic by the time these weapons are developed).

Navy

Analysing the possibility of equipping the Indian Navy surface ships with DEWs in coming years raises a number of potential issues for the future naval planners. The Navy faces serious anti-ship cruise missile threats to surface fleet. The two aircraft carriers are our most expensive and valuable assets. They stand vulnerable to cruise missile threats from any nation who can afford or has access to buy them. Protection of the carriers and larger ships against SS-N-22 Sunburn (Russian origin) or its Chinese

equivalents would be a formidable task. This particular missile is capable of a 320 kg warhead, Mach 3 speed at high altitude and a sea skimming low-altitude Mach 2.2 speed with an effective range of 250 km. Reaction time at a distance of about 15–25 nm (28–45 km) or less to ship will be 25–60 seconds. In such a scenario, the use of DEW may certainly prove to be a viable possibility. The issues which the Navy needs to deliberate upon are:

- Whether the Navy should act now to adopt a programme for developing a production version of a shipboard DEW and/or make a road map that calls for developing DEWs for specific threats which its perceives in the future (as its plans till 2022 do not have any mention of such issues).
- What type of DEW may suit the existing power supply and other prerequisites required for generation of DEW on a ship, keeping in mind the available technology in shipbuilding in the Indian dockyards?
- The potential implications of ship-borne DEWs for maintaining sea control in the Indian waters.

In addition to decisions on whether or not to fund development of potential shipboard DEWs, the Navy or some other organization needs to perform an analysis of alternatives (AoA) comparing the cost effectiveness of DEWs and traditional kinetic weapons (such as missiles and guns) for countering surface, air and missile threats from 'Sunburn' and its equivalent class of missiles.

Army

India is not likely to face a military threat from the US or China because of its strength, both military and economic. A medium-level military threat may arise from Pakistan if it fails to make adequate economic and political progress, or its leadership passes to radical elements or the country, as such, fails and lapses into a state of anarchy. Such engagements may have the following characteristics. They will be of short duration, say, a week or less. Penetration in depth is unlikely to be attempted by either side. 'Cold Start' will be attempted whenever possible to achieve surprise and maximize gains. The entire border is likely to be activated with shallow thrusts, very heavy firepower and short-span manoeuvres. Nuclear weapons may not be used; their use may, however, be threatened. Special Forces and coup-de-main forces will play a major role. Integrated action by all three

services will be crucial for the enhancement of our combat power vis-à-vis that of the adversary. Levels of technology employed in the wars will be higher than at present. Wars will end in stalemate, with little or no gain, and military as well as civilian targets will face heavy losses. However, in the skirmishes, the danger of unarmed civilian casualties will be great and will need to be handled with firmness and imagination.

The cost involved and the casualty are the two factors which need to be paid attention to in case of the Army. Huge loss of trained manpower and expensive equipment requires greater effort to replace. The introduction of DEWs can play a major role in reducing both drastically. Avoiding the exposure of our own troops to the ranges of enemy fire and inflicting considerable damage to the enemy from stand-off distance of close to 100 km will indeed prove to be much more cost effective.

The Fourth Front

Operation Desert Storm in 1991 gave rise to the use of space as a military asset. This success prompted the US to use space more effectively in Operation Iraqi Freedom in 2003. More than 100 satellites were used in various roles to give an added advantage to the allied forces as far as collection and dissemination of information was concerned. These two operations gave rise to the era of space weaponization. Today, the global positioning system (GPS) and other information-providing assets are all space-based. Space-based assets enhance the capabilities of sea-, air- and land-based forces. The use of space is gradually shifting from force enhancement to force application, which is applying force directly onto targets.

A great boost was given in this direction by the ambitious plan initiated by US President Ronald Reagan in 1983 known as the 'Strategic Missile Defence'. The proposal was to use space-based lasers and particle beams to intercept and destroy incoming missiles. The project could not be sustained for long and was finally abandoned in 1993, but the technology developed during this time is now being used to give better and more effective results. This has given the US a three-decade head start, but many nations like Russia, China and France are slowly catching up in development of this technology. Our own Indian Space Research Organization (ISRO) has also not done badly—it has developed one of the largest constellations of satellites, the cheapest launch capability, and has made India one of the few nations to have sent an unmanned moon mission. The problems lies in it following a 'not-so-objective-driven' path

in development in space. One way to look at this is that no national aim or goal has been given to them, so, in turn, they are working to satisfy their scholastic needs. We have the capability but we need to define our national objective more clearly. Missions such as the unmanned moon mission should give some strategic advantage to the nation.

The US, of course, has been in the forefront in the use of space as a future arena. They have an ambitious plan to attain space superiority. They have gone ahead in identifying what are called 'liberation points' (L4 and L5), which are essential to gain control in space. As per the doctrine, 'Whosoever rules space commands planet earth; whosoever rules the moon commands space, and who rules L4 and L5 commands the earth–moon system'.[1] The L4 and L5 are points in orbit where the gravitational forces of the earth and the moon are equal, thereby providing a parking slot for spacecraft with minimal use of power. With such aggressive postures taken towards space weaponization, the control of orbital space and with it, control of space and thus, the domination of earth will become an operational necessity in the coming years.

The various operations in space can largely be qualified as space safeguard operations: protection of space-based assets; counter space operations, that is, denial of space to an adversary; and space attack operations—using space-based weapons on terrestrial or space-based targets, and also from land on to space targets. Space-based assets comprise mainly of various kinds of satellites. As per latest estimates, there are about 3,000 of these presently orbiting the earth. Among them, some may be for the GPS system, some for spying and the higher-orbit ones are for geostationary purposes like communication, information and other allied purpose. The low-orbit satellites do not pose a problem as far as their destruction is concerned. This aspect has been proved by the recent successful attempts made by the US and China in destroying their own life-expired satellites with ground-based aircraft with a high-range precision air-to-air missile. The problem lies in taking on the higher-orbiting satellites. These are the ones which create the main hub of information dissemination and provide steady flow of data in real time. Information will impact the wars of the future much more than they ever did in the past. If the source of information can be targeted, then achieving dominance in information warfare will prove to be easier.

As mankind starts thinking of waging war even in space, there are calls for preserving the sanctity of space. The present treaty, commonly called 'Outer Space Treaty', does specify the so-called restrictions on using

weapon other than the nukes. It limits the use of the moon and other celestial bodies to only peaceful purposes. It, however, does not prevent the use of a technology which can have a dual use: one which is peaceful upfront but can be turned into a weapon when selected to do so. This treaty thus allows nations to deploy weapons other than nuclear weapons in space. The development of any new weapon which is non-nuclear in nature can be pursued.

The DEW, being a laser-oriented weapon without any nuclear connection, can be developed and deployed in space. It will prove to be very effective when used against either low-orbiting or high-orbiting satellites. This kind of weapon will definitely provide dominance of space with its use for all the three space operations, namely, space safeguard, counter space operations as well as space attack operations.

Up till the last century, dominance of air was the key to dominate land. Today, the envelope has moved to the fourth dimension—space. The future war's fate will be decided by whosoever dominates this dimension. The DEW provides an incomparable advantage in this dimension of warfare.

Plan of Action for Indian Defence Forces

The next 10 years may see the emergence of DEWs as an operational capability in the US defence services. These weapons may have the unique capability of attacking targets at the speed of light and are likely to significantly impair the effectiveness of many weapon types, especially ballistic weapons.

Institutional Approach

What this actually highlights is that India (and in turn, the Indian defence forces) cannot waste 40 years in research and development (R&D) as the major concepts as well as prototypes have already been developed and are available in other parts of the world. What needs to be studied instead is an institutionalized approach to develop DEWs technology by taking advantage of the already developed principles and concepts. This effort may have to involve DRDO, the services (it can, for example, can be driven by them), academicians (universities, Indian Institutes of Technology [IITs] and other engineering colleges), private industry (could involve an external consultation agency like KPMG, Associated Chambers of Commerce and Industry of India [ASSOCHAM] and Confederation of Indian Industry [CII]) which act as a single integrator, ordnance

factories, etc. The Modular Open Systems Approach (MOSA), presently known as the Open Systems Architecture (OSA) system, can be an option adopted to ensure that no delay takes place like in the other research works undertaken by DRDO. The OSA can ensure coordination of multiple vendors who may supply subsystems that may connect to the main assembly through combinations of military and open industry standard hardware and software. Therefore, subsystems can be developed, in parallel, by multiple contractors and be interchangeable between the prototypes as they are tested to avoid delay in major assembly production. This may ensure a faster route to production than what is being followed in our present defence production units.

A probable phase-wise distribution of the project can be as follows:

- Phase I, which can include four lines (as per the required hardware for producing a DEW, that is, lasing medium, energy source, mirrors and lens) prefixed with firm price contract, with a designated time of completion (this can specifically be defined after discussion with all the stakeholders). This phase may be focussed on conceptual designs.
- Phase II may provide for more detailed design and development work in a predetermined time period after the first phase is over. This phase should have at least two systems going forward to the prototype stage.
- Phase III, running between two to three years from the end of phase II, may involve manufacturing, assembly and testing of the DEW(s).
- Phase IV may see deployment in the IAF, Indian Navy or the Indian Army, as the case may be, for testing and field trials.

The funding and coordination agency can be the service headquarters which monitors the progress through an autonomous body like Aeronautical Development Agency (ADA) (Air Force), and similar agencies in the other two services.

This research work can be carried out by any designated agency after laying the broad guidelines and defining the responsibility of various agencies which may implement the project for the Indian defence forces. The broad framework in which the research may take place is as follows:

- Evolving the requirement based on the threat perceived.
- Feasibility of transition from science and technology into acquisition and deployment.

- Facilitating systems integration.
- Leveraging commercial investments.
- Suggesting ideas to reduce the development cycle time and total life cycle cost.
- Giving recommendations to ensure that the system may be fully interoperable with all the systems which it must interface, without major modifications of existing components.
- Suggesting areas where commonality and reuse of components among systems can take place.
- Suggesting a road map to enhance access to cutting-edge technologies and products from multiple suppliers.
- Suggesting methods to mitigate the risk of technology obsolescence and single source of supply over the life of the system.

Conclusion

Warfare is largely unwanted, but often unavoidable. Under the shadow of this reality, innovations in technology and the application of that technology to military operations combine to provide an opportunity to gain military advantage. The rate of technological change in communications, computers, sensors, lasers and RF weaponry is influencing and increasing the complexity of modern warfare. Military communities have known of the detrimental effects of RF energy on electronics since World War I. As electronics devices are making modern weapons more accurate and deadlier than ever, the directed energy weaponry approach appears to be the most promising counter to this in the next 20 years or so. Although the subject is highly technical and requires a scientific approach, I have tried here to explain the necessity as well as the demands of DEW as a paramount requirement for national security in the future. The advantages far outweigh the disadvantages of DEWs. Being a new concept, it will not be easily accepted without criticism against its cost and long gestation. The need of the hour, however, is a visionary approach to our future security requirements and keeping in mind the changing weapon scenario; it will be a crucial decision either way. Today's decision will pay dividends after 30 years.

In this article, I have tried to address some critical issues which may enable Indian military planners to ponder on the capability of DEWs. The time is right, and the focus needs to change to allow the nation to retain the deterrence capability which it enjoys now. The neighbourhood is already launching a massive technological drive for bringing about

improvement in its arsenal. The power equation in the next 20–30 years may tilt in India's favour depending on today's decision. Our defence forces are the best as far as human qualities are concerned; however, we need to give them the best weapons to take them to the pinnacle of force standards. The success of this article would lie in triggering the minds of the change makers to start implementing the process to catch up with the advancement in weapon technology. The concept of service–private sector–academicians is a new aspect which needs to be developed to generate better project management techniques, especially in a country plagued with project/cost overruns. The OSA concept has benefitted other countries and the induction of this technology may prove beneficial for India and may set a standard path to avoid project overruns in other national projects.

Note

1. Collins, John, *Military Space Forces: The Next 50 Years*, 2004.