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# DIRECT ENERGY WEAPONS

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**Abstract** — A Directed Energy Weapon (DEW) is a weapon system, capable of discrete target selection, which produces a beam or field of electromagnetic energy, acoustic energy or atomic/subatomic particles as the primary means to cause disruptive or damaging effects to equipment, facilities or personnel. The full potential of this technology is still being realized and if deployed extensively will have a significant effect on a wide range of military operations. The potential electronic warfare uses for DEWs include improvised explosive device clearance, disruption to electronic systems, and crowd-control. The industrial use of high power laser technology, primarily for cutting purposes, has developed sufficiently for potential game changing military applications. So, the investigations about DEWs present news possibilities for developing defense systems and industrial equipments.

## I. BACKGROUND

The first conceptual building block of the laser was Albert Einstein's 1916 proposal that photons could stimulate emission of identical photons from excited atoms. Rudolf Ladenburg reported indirect evidence of stimulated emission in 1928. However, physicists of the time called the effect "negative absorption," and considered it of little practical importance because they expected Boltzmann population distributions to be the norm, with higher energy states inevitably less populated than lower levels. In 1954, Charles H. Townes and several of his students at Columbia University fabricated and successfully demonstrated a device called a "MASER" (Microwave Amplification by Stimulated Emission of Radiation). This device produced electromagnetic amplification and operated at microwave frequencies. Soon afterwards, in 1960, T. H. Maiman of the Hughes Research Laboratories was the first to demonstrate the "optical maser," or electronic amplification at optical frequencies, which has come to be known as the "LASER" (Light Amplification by Stimulated Emission of Radiation). These devices validated the basic physical principles of laser energy generation which had been previously postulated in the early days of quantum theory. Simultaneously, as a spinoff of 1950 's research focused on applying "particle beam" concepts as a means of breeding fissionable material for military applications, the possibilities of eventually developing particle beams into effective weapon systems generated considerable interest. [1]

The possible military applications of both of these infant technologies were immediately recognized. If matured technology could succeed in increasing the power output of these devices to sufficient levels, the revolutionary prospect of generating an extremely intense and controllable "energy beam" weapon could become reality.

With this opportunity, weapons with these skills, collectively designated "DIRECTED ENERGY WEAPONS" or "DEW", offer the following attractive features [2]:

- 1) The ability to deliver lethal energy at the speed of light over long distances;
- 2) The achievement of surgical targeting accuracy;
- 3) The realization of vastly improved retargeting slew rates. The "massless" and therefore "inertia-less" quality of the energy beam would reduce the retargeting problem to the simple movement of a mirror. This could markedly increase engagement frequencies in a high-target density environment;
- 4) The virtual liberation from the conventional projectile limitations of gravity effects, aerodynamic forces, and requirements for extensive lead-angle information in fire control solutions.

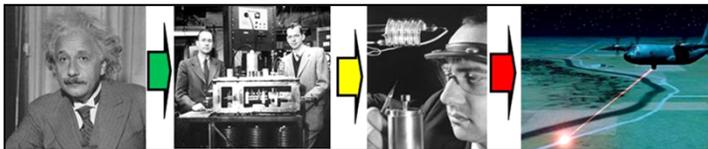


Fig. 1. FROM CONCEPT TO PRACTICE. [adapted by author]

These qualities, might dramatically revolutionize the art of warfare, projecting near-term employment possibilities primarily in tactical nature. Communications, anti-air warfare (both anti-aircraft and anti-ship missile), anti-submarine warfare, minesweeping, laser guided projectiles, laser radar, missile guidance systems, fire control pointing and tracking systems, meteorology, and environmental modification (such as burning through or away fog), are all possible tactical applications of direct interest to the Armed Forces. Space-based or strategic employment concepts, such as Ballistic Missile Defense (BMD) and Anti-Satellite (ASAT) weapons are possible.

## II. GENERAL EMPLOYMENT

Initial investigations of DEWs technologies, however, at least as far as major weapons applications were concerned, exposed serious technological and engineering questions regarding the fundamental soundness of the concepts themselves. Furthermore, even assuming the eventual solution of all major technological and engineering problems, it became increasingly apparent that the production and deployment of high-power, viable DEW systems would be very expensive. On the other hand, DEW is a controllable weapon system, capable of discrete target selection, which produces a beam or field of electromagnetic energy, acoustic energy or atomic/subatomic particles as the primary means to cause disruptive or damaging effects to equipment, facilities or personnel.

For instance, the high-energy lasers have potential to provide an enhanced capability for air defense and possibility anti-satellite roles, while radio frequency weapons have the potential for persistent disruption or damage to electronics-rich equipment including Command and Control centers (C2). Radio-frequency weapon techniques have been used for many applications at Operational Theatre (TO), such as improvised explosive device neutralization. The full potential of this technology is still being realized and if deployed extensively will have a significant effect on a wide range of operations.

Although the effect of laser-induced plasma breakdown of air molecules (known as 'blooming') can cause lasers to lose energy, particularly in the presence of dust, fog or smoke, technologies such as carbon nanotubes and metamaterials allow the development of phased-arrays to overcome this. Certain DEWs utilize this blooming effect to send a powerful electric charge down the plasma track, such devices are termed 'electro lasers'. This technology is being investigated in the civilian field under the Franco-German TeraMobile project. Potential uses for this type of device include improvised explosive device clearance, disruption to electronic systems, and crowd-control. The industrial use of high power laser technology, primarily for cutting purposes, has developed sufficiently for potential game changing military applications. So, the investigations about DEWs present news possibilities for developing defense systems and industrial equipments.

## III. MILITARY INTEGRATION OF DEW

DEWs are being created and tested around the world, mainly in Armed Forces with notable weapons capabilities such as the United States, China, France and Russia, among others. The current example is the High Energy Laser Rockets and Mortars Artillery (HELRAM), which can be used to destroy multiple types of threats, including artillery rockets and light mortars as well as Tactical High Energy Laser (THEL), developed for use by U.S. Army against tactical missiles with short and medium range. On air and space theatres, may be exemplify by Anti-missile Airborne Laser (ABL) platform used by Boeing 747 U.S. Air Force (USAF) against intercontinental ballistic missiles as well as Space Base Laser (SBL), based on a 20 satellite constellation, operating at a 40° inclination, intended to provide the optimum threat missile negation capability. [3]

In a statement, the Department of Defense of U.S. (DoD), through the high power solid-state laser development program, announced in December 2004, it had already reached a 25 kW of power with Solid-state laser (SSL) in the laboratory, although so far from the power required to be tactically effective in accordance with the DoD should be greater than 100 kW. [3]

Another type of laser with potential applicability in DEWs systems is the Free Electron Laser (FEL) whose base of operation is in free motion of a relativistic electron beam through a fixed magnetic structure. Recently the North American National Laboratory Thomas Jefferson (2013) showed that it has reached the power of 14 kW. With emphasis on this expectation, on June 9, 2009, the office of the Research Department of the U.S.N., responsible for promoting science and technology programs of the U.S.N. and U.S. Marine Corps, announced the contract closing with Raytheon Company for the development of an experimental 100 kW FEL. [4]



FIG. 2. MILITARY DEWs. [adapted by author]

The major challenge in understanding the operational implications of the progress on DEW technology is the great variety of characteristics of such weaponry. The system's weight is a problem since it's been estimated about 11,000 Kg for a laser of 100 kW. On the other hand, the American defense industry estimates that the technological development of SSL can reduce this weight to less than 4,000 Kg [3], allowing the use of lighter and more agile platforms. However, power level is not the only feature to improve. For a system to be effective DEW, a strong integration between subsystems for acquiring and tracking targets must be made, as well as the system base should monitor and provide enough energy power in several engagements at combat.

## IV. CONCLUSIONS

The DEW technology presentation done on this poster is the first step to aware for operational and scientific community about evolution in this area, and intend to alert the authorities about military importance given on the nations with high technologies capabilities.

Initially, was done a background description from DEW concept to real practice of this technology, as well as the general equipments were showed on military and civil areas. Thereafter it was presented a military overview about equipments in use and its limitations.

A wide range of military actions can be conceived from the DEW technology. Offensive and defensive missions with greater accuracy and speed can be performed by lowering the collateral damage and the need of mass destruction.

Finally, the investment in such technology may generate industrial competences, adding scientific knowledge and expanding the national economy.

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