MILE STONES

Early Directed Energy Weapons programs

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DIRECTED ENERGY WEAPONS (DEW) ARE CURRENTLY ON THE THRESHOLD OF OPERATIONAL deployment, specifically in the form of High Energy Laser weapons. Less visible have been developments in High Power Microwave weapons, yet that technology is also rapidly approaching its operational debut.

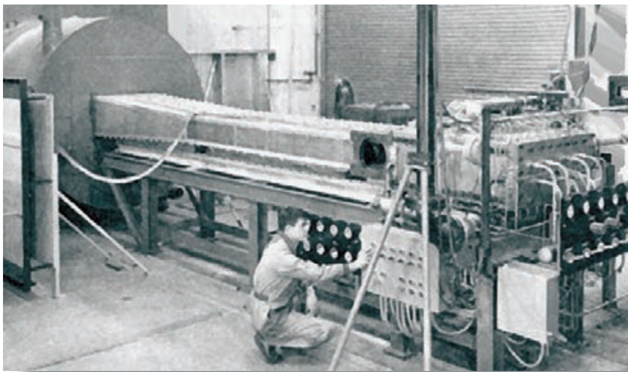
All Directed Energy Weapons are intended to destroy, damage or impair their targets by emitting a high power beam of electromagnetic radiation, sufficiently powerful to inflict damage upon a target. They are attractive to potential users for two reasons.

The first is the ability to hit a target at the speed of light, rather than at the time it takes for a projectile to travel the distance to the target. This has the potential to significantly reduce engagement cycle times, as sensors used to detect, track and assess damage on targets typically rely on speed of light radar or optical systems.

The second reason is the 'deep magazine effect'. Put simply, missile launch systems and automatic guns have a limited magazine size, and once emptied by sustained fire, especially in a saturation missile or bomb attack, must be reloaded. While reloading, the system is unable to fire, making it susceptible to attack. A Directed Energy Weapon, especially one which is electrically powered, is much less exposed in this respect. Another consideration in sustained conflicts is the rate of resupply. Guided missiles, smart bombs and smart ammunition take time and resources to manufacture, and no nation has yet mastered the art of mass producing complex munitions at a rate anywhere approaching the profligate rate of fire observed in recent conflicts.

These are good reasons for developing DEWs, sufficiently good to overlook the limitations of DEWs, which include a poor ability to penetrate cloud, rain, haze, dust and other obscurants in laser weapons, and collateral electrical damage in electromagnetic weapons.

Given the public relations and marketing barrage, which we have observed around DEWs in recent years, one could be forgiven for imagining that DEW technology and the underlying science is entirely new. The reality is much more mundane, in the sense that most of the key science and technologies involved date back to the 1960s, and some even the late 1940s. What has changed is that the science involved has matured into a usable rather than bench test technology, and the technology is being integrated into systems capable of use in real operational environments.



A pivotal milestone in the development of laser DEWs was the invention of the Gas Dynamic laser. Depicted the first demonstrator, built by Avco Everett and tested in 1966.

EARLY HISTORY OF LASER WEAPONS

Laser Weapons are likely to deploy in numbers before microwave weapons do, and likely due more to the popular appeal of the 'death ray / laser cannon / ray gun' rather than maturity of the underlying science.

The underlying theory dates back to the early 20th Century. The first experiment in this area that worked involved a MASER, which is a microwave analogue to the laser. The first MASER was successfully tested in 1954 by Charles Townes and Arthur Schawlow. Four years later they published the theory underpinning the laser.

The first laser was built by Gordon Gould in 1958, although it is usually credited to Theodore Maiman in 1960. Historical detail aside, the bottom line is that the laser came into existence about fifty years ago.

This is an interesting parallel to the assault rifle, first mass produced in 1944 but invented around 50 years earlier.

These early lasers could burn holes in metal plates in laboratory rigs, but were unable to produce the power levels needed for primary weapons applications. Lasers capable of causing eye damage to humans, or military electro-optical sensors, became feasible within several years and emerged as operational equipment during the 1970s and 1980s. Such laser weapons are known as '"Blinding Weapons' and have been justifiably criticised by human rights organisations as being inhumane weapons built to maim their victims permanently.

The first known combat use of a laser weapon was the British Laser Dazzle Sight used by the Royal Navy in the Falklands conflict to temporarily blind Argentinian pilots attempting to bomb British warships in shallow dive bombing attacks. This design was later emulated by the US, which developed a number of similar products oriented toward disabling an opponent's electro-optical equipment, and with a secondary anti-personnel role. The best known of the latter is the Dazer, which clips on to a rifle and is used by US Special Forces.

A far more sophisticated design was the US ALQ-179 Compass Hammer / Coronet Prince, developed late in the Cold War to defeat optically aimed Anti-Aircraft Artillery (AAA) systems. This podded electro-optical countermeasures system trialled on an F-4 Phantom fighter, used an electro-optical sensor to detect muzzle flashes produced by the AAA system. Once detected and tracked, a dual band infrared and green visible laser turret was pointed at the source of the ground fire and turned on to temporarily or permanently blind the attacker.

The idea has since evolved into the various Directed InfraRed CounterMeasures Systems (DIRCM) which are now available for fixed wing aircraft and helicopters, and are used to blind or jam the infrared homing seekers fitted to shoulder launched anti-aircraft missiles. While these systems currently lack the laser power and software functions to

The Soviets paralleled the US ALL program with the Beriev/Almaz A-60 program. Little has been disclosed to date on achievement.

double up as 'Compass Hammer' analogues, such an evolution is only a matter of a block upgrade to existing designs.

In terms of the much sought after 'death ray', capable of burning holes into targets from distances of multiple kilometres, the key breakthrough occurred during the 1960s, with the invention of a new type of laser, known as a Gas Dynamic Laser (GDL) or more recently Chemical Laser (CL). These lasers produce energized gas as a laser medium, usually in a supersonic expansion nozzle.

The problem from a weapons designer's perspective with most laser types is their poor conversion efficiency, which is a measure of how many kiloWatts of power the laser produces per kilowatt of power used to drive it. If a laser weapon is to produce a useful 100+ kilowatt beam, an efficiency of at least 20 per cent or better is needed else cooling becomes an insurmountable problem. Early crystal and gas lasers achieved a few per cent of efficiency, simply not good enough for weapons applications.

The theory underpinning the GDL/CL idea was produced in 1962, and the first 135 kilowatt rated Carbon Dioxide GDL was tested by Avco Everett Research in the US, in 1966.

The promise of this laser technology led soon to intensive research effort by the US and the Soviets to create an operationally useful design.

The US Air Force launched the Airborne Laser Lab (ALL) effort in 1976, to investigate the problems involved in carrying such lasers on aircraft, and to further develop the various supporting technologies such as tracking and pointing systems, steerable optical turrets and mirrors.

The ALL laser produced a raw output of 456 kiloWatts of optical power in an 8 second sustained burn, before propellant was exhausted, and an output from the optical aiming system of 380 kiloWatts, reported in 1979 literature. The ALL project ran for 11 years, culminating in a series of trials during which five AIM-9 missiles were shot down, and a single BQM-34A Firebee drone destroyed.

Initiated by the Soviets as a parallel program to the US Air Force Airborne Laser Laboratory, the Almaz/Beriev A-60 program aimed to demonstrate an airborne laser DEW capability, and provide the knowledge needed for the development of an operational weapon.

Two A-60 demonstrators were built, the first flying in 1981, the second in 1991. Much of what is available from Russian open sources does not detail actual progress or achievements in this program. All open source imagery of the A-60 shows a dummy optical beam director turret installation in the nose, quite different from the dorsal turret on the USAF NKC-135A ALL demonstrator. There have been no disclosures on the type of laser intended for the A-60, although given the concurrent effort by Almaz on the CO2 GDL for the ground based mobile point defence weapon, it is reasonable to assume the same design. The large exhaust port in the aft fuselage is consistent with a GDL or chemical laser.

The USAF effort was paralleled by the US Navy, which sought a laser DEW to kill anti-ship cruise missiles. The Navy favoured the Deuterium Fluoride laser over the Air Force Carbon Dioxide laser. The MIRACL laser and Sealite Optical Beam Director turret were built and trialled to demonstrate the technology. One well publicized experiment involved a sheetmetal pressurized cylindrical target, stressed under compression to emulate a ballistic missile fuselage under boost. When the laser burnt through the skin of the target it exploded.

Less well known was the successful very late Cold War Soviet effort to develop an analogous weapon, intended to defend Soviet ground forces and airfields against NATO strike aircraft. Led by Almaz and centred on a Carbon Dioxide GDL similar to the US ALL design, this project matured to the point that it was listed in the last edition of the US DoD 'Soviet Military Power' annual report.

Almaz have released imagery of the demonstrator on their website. It was to be carried by the 8 x 8 MAZ-7910 'Kashalot', better known as a 'Scud launch vehicle'. It is interesting to observe that one of the recent rounds of public relations promotion by US defence contractors, extolling the virtues of US laser DEWs, produced an angry outburst by a former Soviet researcher in the Russian press, who complained that the Soviet effort achieved much the same results 20 years ago.

The US Air Force Airborne Laser Lab was a key milestone, proving the viability of laser DEWs in an airborne environment.

The US Army led THEL program proved the viability of the Soviet Almaz concept of a highly mobile land based point defence laser DEW in a series of trials, between 2000 and 2004. Unfortunately, with a large and cumbersome toxic fuel driven Deuterium Fuoride laser, the containerised static THEL became an evolutionary dead end, overtaken by newer electrically driven solid state lasers, and derivatives of the US Air Force Chemical Oxygen Iodine Laser (COIL), itself invented by the US Air Force Weapons Laboratory in 1977, and now used in the YAL-1A airborne Anti Ballistic Laser (ABL) system.

The laser Directed Energy Weapon makes for a good case study of the time it takes to evolve a viable idea supported by solid science into a mature and operationally viable weapons capability. The case study of the assault rifle was cited earlier but combat aircraft are no different, in the sense that it took a half century of aircraft evolution from the Wright brothers, to build the B-52, which remains in use today. Air launched guided missiles were first developed by the Germans during the 1940s, yet it has taken nearly a half century for these to mature to the point where they have viable kill probability and reliability – and this still remains a hotly disputed issue in professional military analysis circles. Smart bombs emerged during the 1940s but did not mature until the 1990s.

The deeper reality is that all these military technologies rely upon other supporting technologies to work properly, and until all of the technologies in a system are mature and work well, the system itself cannot be mature and work well. This reality seems to be more than often forgotten, or not understood, in contemporary Western defence bureaucracies. The last decade has seen far too many failed development programs precisely for this reason, insofar as unrealistic expectations are produced that a design can achieve a given capability, by using some new and immature technology. Yet the actual design ends up needing several new and immature technologies to work, and then simply doesn't work. A not uncommon problem seems to be a bureaucratic expectation that a weapon system can be made to work even if the basic science to make it work is incomplete, or even absent.

As the history of the science and technology underpinning laser DEWs shows very clearly, the path from scientific idea to operational reality can take entire decades.