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Space and Missile Defense Challenges:

The Potential of Directed Energy

(Second in a series of three Background Briefs based on information obtained from U.S. Army Space and Missile Defense Command)

Introduction

Ready or not, warfare is about to expand into yet another realm, bringing changes as inevitable as those following the invention of gunpowder and the unlocking of the atom. On 6 June 2000, scientists and technicians from the U.S. Army and Israel made history when they used a chemically fueled, high-powered laser to zap an incoming Russian-made Katyusha rocket with a live warhead on its nose. To date the system has successfully shot down an additional 24 Katyusha rockets in single and multiple engagement tests. The Army has proven it is practicable to use a beam of intense, highly focused light as an effective, dependable, inexpensive way of protecting our troops and allies from enemy rocket attacks.

The Potential of Directed Energy

Army Transformation, in order to support the ***Full-Spectrum Dominance*** focus of Joint Vision 2020, envisions an Objective Force possessing seven fundamental characteristics. Battlefield laser systems are the ideal leap-ahead technology for achieving these Transformation characteristics. Laser-based systems will be:

- ***Responsive.*** U.S. forces must be strategically responsive within hours to challenges to our national interests anywhere in the world. Responsiveness is enhanced by the ability of High Energy Laser (HEL) weapons and other systems to provide immediate operational capability for forward-deployed forces, or early-entry and follow-on forces projected from the Continental United States (CONUS).
- ***Deployable.*** Application of HEL and other Directed Energy (DE) technologies to multiple uses—weapons, sensors, communications, C^3ISR (Command, Control, Communications, Intelligence, Surveillance, Reconnaissance)—will simplify the Objective Force's airlift and logistic problems, particularly when a family of Future Combat System-compatible solid state lasers becomes available.
- ***Agile.*** The Objective Force's ability to move, mentally and physically, from stability and support operations to warfighting and back again without augmentation is enhanced by an HEL system's flexibility in lethal and nonlethal employment options, target types engaged, and selectable levels of damage desired.
- ***Versatile.*** HEL weapons will meet a wide range of missions, from deterrence to force protection to space control, and transition near-instantaneously from one mission to another. The technology itself is inherently versatile, lending itself to weapon, sensor and communications applications.

- ***Lethal.*** With high probability of kill at extended ranges with the speed of light, HEL systems will be devastatingly effective against aircraft, ballistic and cruise missiles, Katyusha-type rockets, artillery and mortar projectiles, lightly armored surface vehicles, communications systems and antennas, optical and electronic sensors and other targets. Attempts at "laser-proofing" with reflective, energy-absorbing or ablative materials will serve only to degrade a target's performance and stealth characteristics, rendering it more vulnerable to conventional weapons.
- ***Survivable.*** In addition to an HEL system's inherent self-defense capability, its ability to operate remotely and its reduced susceptibility to countermeasures enhance the survivability of an entire force by rapidly targeting and neutralizing the enemy's sensors, disrupting his communications, and attacking his weapons directly. And as the beams have no visible signature, science fiction movies notwithstanding, HEL systems are less vulnerable to detection and suppression than are conventional weapons, particularly when combined with no-emission passive sensors.
- ***Sustainable.*** The current generation of chemical lasers uses low-cost, readily available fuels as ammunition, giving HEL weapons deeper magazines and lower cost per kill than a traditional weapon. Future solid state ("electric") lasers will require only diesel, JP-8 (Jet Propellant 8, a standard kerosene jet fuel) or other fuels already common on the battlefield. This gives the system a virtually unlimited ammunition source and eliminates the resupply, storage and handling difficulties of chemicals. In combination with rapid and highly effective engagement capabilities, laser weapons will potentially reduce the fighting force's requirement for large caliber kinetic munitions—missiles, artillery rounds, antitank guided missiles, etc.—further simplifying logistic planning and supply problems.

DE Weapons

Directed Energy weapons—lasers, high-power microwaves, and charged or neutral particle beam systems—use focused or high-power electromagnetic energy to damage or destroy materiel systems or subsystems. The most mature DE technology is the laser. Lasers are highly directional, narrowly focused beams of coherent light. At low power they provide reliable communications; at higher powers they damage or destroy targets at long ranges.

Laser Applications

In addition to the air and missile defense potential of a laser system, several other mission areas are current or potential users of laser technology.

- ***Space Control.*** Maintaining access to space systems—communications satellites, imaging sensors, etc.—as well as a capability to selectively deny such access to an adversary, will be critical to the success of future military operations. DE applications hold the potential to provide the Army a capability to track, illuminate, and disrupt, degrade or destroy the functioning of our adversaries' space-based systems.
- ***Countersensor.*** Lasers are also important in countering battlefield sensors, particularly electro-optical weapon sights and visual observation devices. They can inflict physical damage on antennas, lenses and supporting electronics.
- ***Countermine.*** Laser-based systems for neutralization of mines may replace or augment explosive ordnance disposal (EOD) equipment currently available. The ZEUS program at Space and Missile Defense Command (SMDC) is developing and testing such a capability today.
- ***Precision Strike.*** Lasers may also be of interest to the Special Operations community and others for their potential in executing ultra-precise silent strike missions—attacks against single vehicles or buildings, for example—in urban terrain with minimal collateral damage.

- ***Countermunition.*** High-energy lasers can predetonate or interfere with the aerodynamic flight capability of munitions, causing them to fall short.
- ***Other DE applications.*** Other applications may include noncooperative target recognition; laser communications; nonlethal applications of lasers and high-power microwaves for crowd control and battlefield uses; advanced laser-based training devices; and medical applications.

Current Programs

The U.S. Army Space and Missile Defense Command (SMDC) and the Air Defense Artillery School (USAADASCH) at Fort Bliss, Texas, are pursuing several DE weapons concepts and technology programs.

- ***The Enhanced Area Air Defense (EAAD).*** The EAAD concept under development by USAADASCH responds to the need for a cost-effective mechanism to protect troops and forward-area assets from attack by aircraft, rockets, mortars, artillery and unmanned aerial vehicles (UAVs) in the post-2010 time frame. EAAD will support all types of operations ranging from war to stability and support operations. Weapon modules, mounted on a variety of Army common wheeled and tracked vehicles or airborne platforms, must be able to keep up with maneuver units and engage targets over a 360-degree field of fire while on the move. When deployed in a netted, distributed architecture, EAAD battle elements will merge into a single, seamless defense network, avoiding single point failures and allowing for "graceful degradation" of the defense should one or more nodes be damaged or destroyed. A mix of DE and kinetic energy (interceptor) technologies will probably be employed to achieve the EAAD requirements.

  The DE weapons may include a combination of lasers allowing a commander to select his weapons based on tactical considerations. The commander may prefer kinetic energy interceptors when rain, clouds, smoke or haze compromise the effectiveness of DE weapons or when DE weapon magazines are depleted.
- ***Tactical High Energy Laser (THEL).*** In April 1996, the United States and Israel began a combined effort to develop and evaluate the effectiveness of a tactical high-energy laser to negate the threat posed by Katyusha rockets to populated areas in northern Israel. The objective of the THEL Advanced Concept Technology Demonstration (ACTD) was to develop and conduct functional testing of a transportable THEL demonstrator, consisting of a laser; pointer-tracker; and command, control, communications and intelligence subsystems. The Office of the Secretary of Defense declared the THEL ACTD complete in October 2000. Since then, SMDC and Israel have been conducting a mobile THEL system engineering trade study that includes the determination of requirements for a mobile laser weapon. If the study concludes that a mobile THEL can be produced with available technology, such a system could begin development next year.
- ***Solid State Heat Capacity Laser (SSHCL).*** SMDC's Directed Energy Office, in coordination with the Department of Energy and Lawrence Livermore National Laboratory (LLNL), is developing compact, lightweight, agile pulsed laser technology suitable for a variety of short-range, time-critical missions. The SSHCL operates in a pulsed mode with the laser beam generated from rare earth-doped crystal slabs, which are pumped by monolithic, high-duty-cycle, diode arrays for improved efficiency and performance over flashlamp pumped lasers. The SSHCL achieves its compact size by separating the lasing phase from the heat rejection phase during operation. The maximum lasing phase can be sized to the threat the laser is designed to address, and adjusted by trade-offs against size, weight and input power requirements. The self-contained system draws directly on the host vehicle power for recharging, thus the only consumables are fuel for the vehicle itself, minimizing logistics requirements. Its pulsed mode of operation also presents possibilities for new lethality

mechanisms that could result in lighter-weight systems for deployment on a variety of ground and air platforms. In September 2001, LLNL's 10-kilowatt (10kW) solid state laser was moved to the High Energy Laser Systems Test Facility at White Sands, New Mexico to begin demonstration of the threat elimination capability this weapon can bring to the Future Combat System (FCS).

- ***Electrochemical Chemical Oxygen Iodine Laser (EC-COIL).*** COIL devices similar to those being developed for the U.S. Air Force's airborne laser (ABL), are also under consideration for shorter-range tactical applications with both air- and ground-based platforms. EC-COIL is a conceptual technology that would develop a compact COIL device requiring only electricity for continual operation.
- ***Advanced Tactical Laser (ATL).*** The ATL Advanced Concept Technology Demonstration (ACTD) is multiservice-sponsored to develop a laser weapon system for precision strikes against a variety of targets of primary interest to the Special Operations Command. It will be sized to roll on and off of aircraft such as the MV-22 (Osprey), the C-130, and the Chinook helicopter. As currently envisioned, the ATL ACTD will be based on the sealed exhaust COIL technology with the exhaust captured in a sealed container. This will allow ATL operations to be very quiet.
- ***High Energy Laser Systems Test Facility (HELSTF).*** Located at White Sands Missile Range, HELSTF—unique among the nation's facilities for laser experimentation—is used by military, government, academic and commercial researchers. HELSTF will be key in the assessment and development of directed energy technologies, to include ongoing testing of the THEL, SSL and assessment of COIL technology. HELSTF now has a 10kW SSHCL testbed, which became operational in September 2001. HELSTF is also performing a detailed assessment of other test and evaluation infrastructure requirements to best support Army and Department of Defense objectives for the development of DE weapon systems to support the war fighter.

Conclusion

Directed energy systems, particularly lasers, offer the warfighter a capability to maintain the asymmetric edge over our adversaries for the foreseeable future, with applications throughout the joint battlefield and across the entire spectrum of war. They represent a "leap-ahead technology" that will have tremendous impact on the development of future Army operational concepts and achievement of Objective Force characteristics. Investment in DE research and development now will have significant payoff on *tomorrow's* battlefield by enabling freedom of maneuver, thus enhancing the warfighter's ability to win decisively.