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Space and Missile Defense Challenges:

The Potential of Directed Energy

(Fourth in a series of four 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. The test proved 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. As Lieutenant General John Costello, Commanding General, U.S. Army Space and Missile Defense Command, said shortly after this intercept, "We've just turned science fiction into reality."

The Potential of Directed Energy

The characteristics of the Objective Force, the ultimate result of the Army's Transformation initiative, are responsiveness, deployability, agility, versatility, lethality, survivability and sustainability. Directed energy (DE) weapons such as battlefield lasers may support all these characteristics by offering the advantages of near speed-of-light engagement, rapid response to multiple targets, greater (line-of-sight) ranges than missile and gun systems, smaller logistical requirements, low cost-per-kill, and high kill probability. The ability to conduct precision engagement of theater ballistic missiles, rockets, cruise missiles, tactical air-to-surface missiles, and unmanned aerial vehicles will have significant payoff on tomorrow's battlefields. DE has potential for other contributions as well, from high-capacity communications, to electronic warfare applications, to detection and detonation of buried mines and biological/chemical identification.

DE Weapons

Directed energy systems use concentrated beams of electromagnetic energy as their means of damaging or destroying materiel systems or subsystems. 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.

DE Applications

In addition to missile defense, several other areas are current or potential users of DE 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. The Army illustrated the vulnerability of satellites to DE when, on 20 October 1997, scientists at White Sands Missile Range, New Mexico, aimed the Mid-Infrared Advanced Chemical Laser (MIRACL) at an Air Force research satellite which was due to reenter the atmosphere and so provided an ideal "target of opportunity." Two bursts from the chemical laser struck a sensor array on the craft: an initial burst calibrated the laser's location on the satellite's body, then a second burst triggered on-board sensors to report back to ground tracking and monitoring stations that MIRACL had successfully tracked and illuminated the satellite.
- **Countersensor.** Lasers are also important in countering battlefield sensors, particularly electrooptical weapon sights and visual observation devices. They can inflict physical damage to lenses supporting electronics.
- **Countermine.** Laser-based systems for neutralization of mines may replace or augment explosive ordnance disposal (EOD) equipment currently available.
- **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; 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 weapons concepts and technology programs.

- **The Enhanced Area Air Defense (EAAD).** The EAAD concept is the notional requirement under development by USAADASCH that responds to the need for a cost-effective mechanism to protect troops and forward-area assets from attack by aircraft, rockets, mortars, artillery projectiles and unmanned aerial vehicles (UAVs) in the post-2000 time frame. The EAAD requirements will apply to 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, reducing the incidence and impact of single point failures and allowing for graceful defense degradation. 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 such as threat vulnerability, obscuration, weapon availability and ammunition supply. The commander may prefer 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).** The White House announced in April 1996, that the United States and Israel would undertake a joint effort to evaluate the effectiveness of a tactical high-energy laser to negate the threat posed by Katyusha rockets to populated areas in northern Israel. The THEL Advanced Concept Technology Demonstrator (ACTD) is a joint effort of SMDC and Israel 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 demonstrator has successfully destroyed single and multiple Katyusha rockets in tests conducted

during June, August and September 2000 at White Sands, and will undergo further testing before deployment to Israel. Follow-on efforts, if funded, may lead to a mobile THEL weapon system which could provide a solution to the problem of defending U.S. troops against "dumb munitions"—a primary concern because counterbattery artillery fire may not be feasible in densely populated areas. A mobile THEL will be able to move with the force it is protecting, set up quickly and fire with speed-of-light flyout for close-in engagements where time lines are very short, at costs of only a few thousand dollars or less per kill.

- **Solid State Heat Capacity Laser (SSHCL).** SMDC's Directed Energy Office 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 can be adjusted by trade-offs against size, weight and input power 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.
- **Solid State Fiber Optic Laser (SSFOL).** This conceptual weapon system is based on dual-clad, rare earth-doped optical fiber laser technology, under development for years for commercial applications such as long-haul communications and materials processing involving cutting and welding. The concept of a high average power SSFOL weapon is in essence the optical analog to a conventional phased array radar, i.e., the coherent combining of many small laser "beamlets" to form one large laser beam. The self-contained system would draw directly on the host vehicle power for recharging, thus the only consumables would be fuel for the vehicle itself, minimizing logistics requirements.
- **Electrochemical Chemical Oxygen Iodine Laser (EC-COIL).** COIL devices, under development for the U.S. Air Force's Airborne Laser (ABL), are 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.
- **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, governmental, academic and commercial researchers. HELSTF will be key in the assessment and development of directed energy technologies, to include ongoing testing of the THEL, creation of a Solid State Laser (SSL) test bed, upgrades to existing facility control systems, and assessment of COIL technology. HELSTF is currently performing a detailed assessment of required test and evaluation (T&E) infrastructure requirements to best support Army and Department of Defense (DoD) T&E objectives for DE weapon system development.

Conclusion

There is high potential for DE systems to provide significant technological opportunities to the warfighter to achieve new and improved capabilities across a broad spectrum of missions that support the Army Transformation Strategy. DE technologies offer the potential for a dramatic leap forward of capabilities in the future, ideally supporting many of the joint and Army visions and warfighting concepts of the 21st century. The jointly funded U.S./Israeli THEL program, as well as the Army's SSL and supporting technology development program, will be leveraged to develop and exploit DE technologies to fulfill the warfighting needs of the future.