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Backgrounder

JANUARY 2009

NEAR-TERM PROSPECTS FOR BATTLEFIELD DIRECTED-ENERGY WEAPONS

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For more than a decade, the Center for Strategic and Budgetary Assessments (CSBA) has closely followed emerging technologies that, integrated with new operational concepts and organizational structures, offer the potential to fundamentally change how advanced militaries fight. Such changes in the conduct of war constitute what has come to be called a "revolution in military affairs," or RMA. The German military's development of Blitzkrieg in the years between the two World Wars (1918-1939) constitutes one of the more familiar examples of an RMA. Visionary officers integrated tanks, radio communications, and tactical aircraft with opportunistic deep-penetration tactics and the flexible, combined-arms structure of the Panzer division in ways that still influence how we conduct combined-arms warfare.

Directed-Energy Weapons: More than "Interesting Toys?"[1]

Lasers have long been considered a technology that could give rise to a new RMA. As a December 2007 Defense Science Board on directed-energy weapons (DEW) observed, lasers promise to be a transformational "game changer" in military operations. To date, though, the only high-energy laser program of record, the Airborne Laser (ABL) for boost-phase missile defense, continues to experience delays. ABL is a large chemical laser on a modified 747 platform. Although offering megawatt-class power, chemical lasers are too unwieldy and logistically fragile for "tactical" applications on fighter aircraft, ground combat vehicles, or even most naval combatants.

Recent advances in solid-state laser (SSL) technologies suggest, however, that directed-energy weapons in the 100-kilowatt (kW) range with power sources dense enough to provide "deep" magazines could be fielded in the near future. In early 2008, these advances led CSBA to examine the likelihood that the US military might achieve initial operational capability (IOC) with one or more "battlefield" laser weapon systems by 2018 despite an array of fiscal, operational, and institutional constraints. The basic question CSBA investigated was: Has SSL technology matured sufficiently to be employed in tactical

1 The term "interesting toys" was used by a former US secretary of defense to describe directed-energy weapons.

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environments to perform such tasks as defending friendly forces and areas against guided or unguided rockets, artillery rounds, mortars, and missiles?

The G-RAMM Challenge

The motivation for focusing on battlefield laser systems that could deal with guided rockets, artillery, mortars, and missiles (G-RAMM) stems from Hezbollah's use of unguided rockets during its summer 2006 conflict with Israel. Over the course of thirty-three days, approximately 4,000 Hezbollah rockets hit Israel. Since the rockets were unguided and predominately short-range, Hezbollah fighters were reduced to aiming at area targets: settlements, towns, and cities in northern Israel, much as the Germans had done in attacking London with V-1s and V-2s in 1944 and 1945. Hezbollah managed to survive the Israeli military's best efforts to destroy it, and little imagination is needed to realize how much more effective Hezbollah's rocket campaign would have been with guided weapons able to achieve 10- or even 20-meter accuracy.

Moreover, the ongoing proliferation of cheap terminal guidance technologies such as solid-state inertial navigation, infrared, radio frequency, millimeter-wave, and Global Positioning System (GPS) argues that it is simply a matter of time before US forces are confronted by adversaries armed with precision-guided rockets, artillery, mortars, and missiles. From the 1991 Persian Gulf War to ongoing operations in Iraq and Afghanistan, the US military has enjoyed a virtual monopoly on precision munitions. This situation, however, will not last forever; CSBA research has indicated that even terrorist organizations like Hezbollah have the sponsors, resources, and capability to acquire and employ G-RAMM weapons in the near term.

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Laser systems' unique ability to destroy artillery and mortar shells, rockets and missiles in flight makes them the primary means of defending against G-RAMM threats. It therefore seems imperative that the United States move aggressively to achieve IOC with battle laser systems to defend against these threats. Achieving an IOC within a decade—before the proliferation of G-RAMM—appears to be a prudent goal.

A Shift from Chemical to Solid-State Lasers?

Where do electrically-based solid-state and fiber laser technologies currently stand? Are they mature enough to enable the US military to field one or more battlefield laser systems capable of dealing with the imminent G-RAMM threat by 2018? In September 2008, two 15-kW SSL modules were combined in a chain to produce a record 30 kW with excellent beam quality (crucial to concentrating laser energy), thereby passing the third phase of the Joint High Power Solid State Laser (JHPSSL) program. The main purpose of this test was to demonstrate the scalability of SSL chains to achieve 100 kW, single-beam lasers with high brightness, good beam quality, and reasonable power efficiency. This achievement alone suggests that the basic technology for battlefield laser systems appears to be sufficiently mature to permit the fielding of battlefield laser systems by 2018. Demonstrations planned for early 2009 aim for the 100 kW goal. Assuming adequate prioritization and timely decisions on development, the technical and engineering barriers to effective battlefield laser systems now appear surmountable.

Yet, even if developers overcome technical and temporal barriers, it is unclear whether the US military will field such systems within a decade. CSBA's analysis of the prospects for achieving a 2018 IOC has ascertained that a significant number of perceptual, fiscal, operational and institutional obstacles would have to be addressed before fielding is likely to take place. To begin with, there is a history of unfulfilled promises regarding high-energy laser (HEL) technologies from the directed energy community that extends back to the 1970s. The danger, of course, is that this poor past performance could lead decision-makers to downplay or ignore recent advances in laser technologies that, if pursued, could finally yield battlefield applications.

Laser weapons' history of premature promises and excessive optimism must be overcome, particularly in the eyes of the US military Services.

Congress has already moved to stimulate laser development. In September 2008 the Senate included additional funds in the 2009 defense authorization bill for laser programs and directed the Pentagon to accelerate efforts to make DEW operational in the near future.[2] Nonetheless, the legislators also noted that despite years of investment in DEW, an operational HEL system has yet to be produced. Thus, laser weapons' history of premature promises and excessive optimism must be overcome, particularly in the eyes of the US military Services.

Beyond Technical Barriers

Mention of the military Services raises a potentially even more daunting barrier to near-term fielding of battlefield directed-energy weapons: historically, the US military has often been slow to identify, adequately prioritize, and respond effectively to the emerging challenges likely to impose the greatest stresses on our forces in future contingencies. A current case in point is the growing anti-access/area-denial capabilities (AA/AD) of the People's Republic of China (PRC). The Chinese appear to be progressing toward fielding a capability to attack US surface combatants, including aircraft carriers, and main operating bases more than 1,500 kilometers into the Western Pacific, with a long-term goal of extending their AA/AD reach to Guam.[3] The emergence of such a capability would certainly be disruptive to current US concepts for air and maritime operations.

There are also instances in which US military Services failed to exploit the full potential of new weaponry even after their efficacy had been demonstrated in combat. One example is the US Navy and Air Force's neglect of laser-guided bombs (LGBs). Despite their spectacular performance in Vietnam during 1972–1973, not until after the 1991 Persian Gulf War, nearly two decades later, did the Air Force and Navy fully embrace LGBs.

Based on the history of a number of past RMAs, armies, navies and air forces have been most likely to embrace new systems or capabilities when they satisfied three criteria. First,

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2 Walter Pincus, "Senate Boosts Funding for Laser Weapons," *The Washington Post,* September 22, 2008, p. A13.

3 Office of the Secretary of Defense Department of Defense, "Annual Report to Congress: Military Power of the People's Republic of China 2008," pp. 2, 22–24, 25.

the new system or capability solved an important problem at the operational level of war; second, it sustained a way of fighting already integral to that Service; third, it preserved the Service's dominant sub-cultures. Operationally, Blitzkrieg (literally "lightning war") restored mobility to the battlefield and offered Germany a way of coping with a two-front war by adding mechanization and armor to the infiltration tactics the Germans had developed at the end of World War I; it also relied upon the kind of bold, daring leadership from the front called for in the German Army's 1933 manual *Truppenführung [Troop Leadership].*

By contrast, LGBs did not address any pressing operational problem for the US Navy and Air Force fighter communities during the 1970s and 1980s. Instead, these weapons, with their high per-round costs compared to unguided ordnance, promised to devalue the individual dive bombing skills on which most fighter pilots prided themselves. At the same time, the improved bombing computers in the F-16 and A-7 appeared to offer a cheaper way of achieving "pickle-barrel" bombing accuracy without disrupting the fighter culture that increasingly dominated both the Air Force and Navy.

The implications of these two contrasting historical cases for battlefield lasers are not difficult to discern. Insofar as directed-energy weapons do not address current operational problems such as combating insurgents and terrorists in Iraq or Afghanistan, and to the extent that they promise to disrupt ways of fighting with which the US military Services are comfortable or to threaten dominant subcultures within these institutions, there may be considerable resistance to this new class of weaponry from the warfighters. As a December 2007 Defense Science Board task force on DEW noted, a concerted education effort needs to be undertaken in the Defense Department to inculcate in the military Services a more comprehensive understanding of the potential benefits and limitations of directed energy systems.

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Fiscal constraints constitute another barrier: the direct costs of the war on terror will easily exceed $1 trillion; costly programs such as the Joint Strike Fighter and the Army's Future Combat Systems remain on the Pentagon's books; critical systems like the Air Force KC-X air-refueling tanker languish; the Navy's shipbuilding account is underfunded; and the Department of Defense is currently expanding the Army and Marine Corps by 92,000 troops. Given the wide-spread economic problems that emerged in 2008, it is far from obvious that DEW programs will get the focused funding needed to field battlefield systems before key threats emerge.

Laser systems are not a panacea, however. There are at least two operational barriers that might inhibit fielding battlefield lasers by 2018. One is the vulnerability of these systems—especially if they are not mobile—to being overwhelmed by saturation attacks. Guided artillery and mortar rounds are cheap enough for small nations and even insurgents to procure in huge quantities. Adding inertial/GPS guidance to rockets is also fairly inexpensive. At best, kinetic solutions to saturation G-RAMM attacks would impose unsupportable costs on the US military. Speed-of-light laser weapons promise a more effective and less costly solution, even if they can be saturated in some circumstances. So while saturation attacks are likely to remain a challenge, DEW systems with magazines deep enough for scores of shots offer the best hope for damage and casualty limitation, especially in the long run.

The other operational challenge is that of fast-moving, hardened targets, especially when battlefield laser systems have to engage them "head-on" or need long dwell times. Battlefield systems based on SSLs in the 100 kW range may have limited utility against incoming ballistic missile warheads with these characteristics. Thus, a sensible development strategy may be to concentrate initially on using movable lasers to defend fixed high-value areas and, later, deploy road-mobile systems that can be integrated into the maneuver elements of ground forces or fielded on tactical aircraft.

In sum, the technical challenges that have long delayed the fielding of directed-energy weapons for battlefield use finally appear to be giving way to technical and engineering progress. These hurdles include weather and atmospheric effects on beam quality, target acquisition and tracking; adequate power for deep magazines; the size and ruggedness of laser platforms; and heat dissipation. Furthermore, near-term threats such as G-RAMM proliferation require the unique defensive capabilities that laser systems offer. Nonetheless, there remain some major non-technical hurdles that still need to be overcome if battlefield lasers are to enter service in the US military in time to meet and deter those threats. Institutions inside and outside the Pentagon can play a critical role in overcoming those challenges by accelerating laser systems out of the laboratories and into the field.