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Visionary doctrine is needed to capitalize on the decisive combat capabilities that DEWs offer. The author contends strong leadership by the USAF and joint experimentation emphasizing spiral development will enable force transformation by facilitating assimilation of maturing DEWs. Failure to adapt may result in ceding the high ground to enemies bent on reducing U.S. military advantages.
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NAVAL WAR COLLEGE

Newport, Rhode Island

TWENTY FIRST CENTURY WARFARE – THEATER OPERATIONS AT THE SPEED OF LIGHT

by Sean Jersey ,Major, United States Air Force

A paper submitted to the Faculty of the Naval War College in

partial satisfaction of the requirements of the Department of Joint Military Operations.

The contents of this paper reflect my personal views and are not

necessarily endorsed by the Naval War College, the Department of

the Navy, or the Department of the Air Force.

Signature:

03 February 2003

PREFACE

I wrote this study to stimulate debate on the promising role of directed energy weapons in twenty-first century joint warfare. The work is an outgrowth of my experience with missile defense, space, directed energy, and national security programs. I was fortunate to participate in development of the Airborne Laser and other directed energy weapon applications. Like many, I went to Kirtland Air Force Base a skeptic and came out a firm believer in these new weapons. Soon, high energy laser and high power radio frequency directed energy weapons will yield capabilities that U.S. war fighters can use to revolutionize the way we fight future wars in the same way aviation, missile, and stealth technologies did in the twentieth century. Too often, I have seen promising weapon concepts fail because we lacked the necessary vision. This experience and the sense of history provided by pioneers of modern airpower lead me to contend that the war fighters in the U.S. Air Force must continue to lead the rest of the Services and our Nation in developing the significant combat potential of directed energy weapons. I hope this paper “stirs the pot” while providing a few helpful lessons for those who continue the effort to deliver on that promise.

I wish to thank Col Edward Duff (USAF, Retired), Col Douglas Beason (USAF, Retired), Lt Col Brent Richert (USAF), Mr. Michael Sheehan, and the crew of “laser huggers” at Kirtland Air Force Base who showed this skeptic the future of modern warfare. Most importantly, I owe a great debt to my wife Tracey and our two children, Shelley and Bryce, who collectively make the future worth fighting for.

ABSTRACT

Today’s commanders should begin integrating directed energy weapons into combat operations. Directed energy technology is beginning to deliver on its promised potential. Existing and planned laser and radio frequency weapons offer the ability to deliver precise doses of lethal power to distant targets at nearly instantaneous speeds, thereby enabling revolutionary new combat capabilities. However, operational fires delivered by directed energy weapons represent a significant departure from employment of current weapons. As such, their use will require considerable out-of-theater planning and coordination for effective command and control—issues we have only begun to address.

Joint forces lack a coherent vision of how to fight with directed energy weapons. Existing doctrine on planning, commanding, and executing operations is insufficient to exploit the full combat potential of speed-of-light weapons. While strong focus by war fighting commanders on missile defense has nurtured Airborne Laser development, the author contends that it is time to vigorously pursue lethal offensive applications. Continued focus on missile defense is unintentionally constraining development of U.S. combat capabilities by limiting examination of potential offensive capabilities for directed energy weapon systems such as the Airborne Laser.

Visionary doctrine is needed to capitalize on the decisive combat capabilities that directed energy weapons offer. The author contends that strong leadership by the Air Force and a joint experimentation architecture emphasizing spiral development will enable the transformation of today's forces by facilitating assimilation of maturing directed energy technologies. Failure to adapt may result in ceding the technological high ground to enemies bent on reducing the wide advantage in capabilities enjoyed by U.S. military forces.

INTRODUCTION

Why should today's military commanders begin integrating directed energy weapons (DEWs) into future combat operations?1 This paper seeks

to answer this question by examining how precision operational fires using DEWs could provide valuable options to U.S. military forces. It discusses operational level command and control issues that the Services must consider for the effective use of high energy laser (HEL) and high power radio frequency (RF) weapons, which can be fielded in the early twenty-first century. Finally, this paper addresses the vital role of doctrine in transforming future military operations.

Fig. 1 – Artist's Conception of Airborne Laser Operation
(Photo Courtesy of the Air Force Research Laboratory)

"We have seen the miracles associated with things like the Airborne Laser. Who could possibly imagine being able to shoot a laser hundreds of kilometers through the atmosphere and hit a target only a meter or so in diameter? I know I didn't believe it. No, I was the biggest skeptic in the world, and I took my leather jacket and my white scarf right out to Kirtland [Air Force Base, New Mexico], sat my butt down, and said 'You guys are going to have to prove this to me.' I left there saying, 'Amen, brother,' because it is going to work."2

–General John P. Jumper, USAF (2001)

Directed energy weapons will provide revolutionary combat capabilities to U.S. Armed Forces in the early twenty-first century. Operational fires delivered by DEWs represent a dramatic departure from employment of current weapons. Laser and RF weapons offer the ability to precisely deliver lethal power to points across the globe at

instantaneous speeds—deeply altering our conception of operational factors time, space, and force. Skeptics note that we heard this promise under the Strategic Defense Initiative of the 1980's. Then, the siren promise of technology outpaced our ability to engineer the weapons. Today, the situation is reversed with DEW development outpacing changes in doctrine needed to exploit the fighting capabilities of these revolutionary arms.

Revolutions are tricky affairs. The term "revolution" implies momentous and rapid change. For some, change wrought by revolution poses a threat. For others, revolution spells opportunity. So how do self-proclaimed skeptics like General Jumper commit to buying an expensive and unproven weapon like the Airborne Laser (ABL; see Figure 1) at a time when the Air Force is struggling to buy next-generation fighter aircraft? Doubters laughed off Jumper's quip as a sop for the "laser huggers" who nurture dreams of zapping targets with lasers and "deludium Q-36" particles. Well, the skeptics got it wrong. A revolution is taking place in the Armed Forces—but it's not hiding in the labs. The revolution is occurring in the minds of fighting men who have a vision of how they want to win future wars and have learned how to harness the capabilities of modern technology needed to transform their vision into reality.

Joint Vision 2020 lays out the strategic vision for developing capabilities in today's Armed Forces needed to meet U.S. national

security needs in the twenty-first century. Modern technologies such as directed energy will provide the means by which our fighting forces can attain full spectrum dominance through core capabilities of dominant maneuver, precision engagement, focused logistics, and full dimensional protection.3 The Services have complementary visions describing how

each plans to use its core competencies and emerging technologies to achieve the shared goal of full spectrum dominance. The question then becomes how commanders can use DEW technology to support these strategic visions.

To answer this question, the Air Force initiated two studies that examined potential combat applications for DEWs. In 1998, the Directed Energy Applications for Tactical Airborne Command Study identified promising tactical applications for DEWs.4 In 2000, the Congress and DoD capitalized on this initiative by developing a High Energy Laser Master Plan to focus investment on emerging national security needs. Both studies asserted that DEW systems are ready for many of today's most challenging weapons applications and their use would maintain an asymmetric technological edge over our adversaries.5

WHY DIRECTED ENERGY?

Military fascination with directed energy technology is understandable when one considers the unique operational capabilities

DEWs bring to the fight. First, they deliver lethal energy at the speed of light.6 This enables instant reaction to fast, highly maneuverable targets by eliminating many problems with arming, aiming, and reloading.

Second, DEWs can deliver discriminate firepower with precise accuracy.

This enables commanders to choose both the level (nonlethal to complete destruction) and area (pinpoint to wide area) of damage desired.7 Third, DEWs cost less to operate compared to conventional missiles or guns. Like all weapons, DEWs require investments in technology and support. However, since each “round” is pure energy, firing the DEW costs relatively little. More, the use of electrically powered devices (e.g., solid-state lasers and RF payloads) simplifies logistics.

Fourth, DEWs can rapidly engage multiple targets simultaneously.8 With the advantages noted above, DEWs have a deep magazine that enables constant and persistent attacks. Fifth, the transmission characteristics of electromagnetic energy permit attacks on previously untouchable targets. For example, laser energy is best suited for transmission in space, enabling global reach for operational fires. RF energy, on the other hand, is unaffected by weather and can penetrate deep into the earth, enabling attacks on buried bunkers. Together, these advantages offer compelling reasons to pursue operational DEW applications.

DoD laser weapon research and development focuses on improving laser devices, beam control systems, and advanced optics along with understanding lethality mechanisms for damage effects.9 Chemical lasers such as the ABL's chemical oxygen/iodine laser are used today because they have the power and beam quality needed to project lethal energy over long distances. Operational and strategic missions are feasible for these lasers (e.g., missile defense, global power projection, etc.) but current systems are too large for most tactical applications. In contrast, solid-state lasers are compact and run on electricity, a ready power source on aircraft, ships, and armored vehicles. Scientists expect solid-state lasers will deliver the lightweight, compact devices needed for battlefield applications in the coming decade. Beam control technology is a critical enabler since all lasers require the means to concentrate lethal power on the target.10 Finally, lethality analysis is vital because attacking targets with laser energy entails fundamentally new kill mechanisms compared to the kinetic effects we have known for centuries. RF weapons research follows a similar path.

RF weapon research and development focuses on improving antennas, pulsed power devices, and microwave sources along with understanding the effects of RF emissions on target electronics. Over the past two decades, Air Force scientists and engineers have significantly reduced the size, weight, and volume of microwave sources and antennae while simultaneously increasing power levels.11 These efforts are bearing fruit with several weapons concepts being tested and developed.12

Together, HEL and RF technologies are mature enough to address a variety of operational missions, both offensive and defensive.

Maturation of directed energy technology is providing combatant commanders with weapon systems that address critical missions such as missile defense and force protection. The Air Force-led development of the ABL as a shield against ballistic missiles is the most ambitious, but other programs are equally exciting. Together with Israel, the Army is developing the Tactical High Energy Laser for defense against short range rockets. The Marine Corps is leading joint development of a vehicle-mounted area denial system with the Air Force.13 (See Figure 2.) The Navy also is considering DEWs for fleet defense.14 Offensive applications include the Advanced Tactical Laser system for attacking ground targets from tactical aircraft and RF weapon payloads for unmanned combat air vehicles (UCAVs) that can be used for command and control warfare.15 All of these programs fill vital needs for the combatant commander. Still, the future offers much greater possibilities.

Fig. 2 – Existing DEW Programs (Left, Vehicle-Mounted Area Denial System;
Right, THEL Concept; Photos Courtesy of AFRL and Army SMDC, respectively.)

Creative minds have examined different architectures for conducting DEW fires. Two methods often cited are RF weapons delivered by UCAVs

and lasers directed by relay mirrors.16 The RF weapon concepts (Figure 3) offer the ability to attack buried bunkers or heavily defended air defense sites, and is viable in the near-term. For lasers, analysts agree the most operationally effective and politically viable configuration is a combination of space-, air-, and ground-based lasers operating with relay mirrors.17 Such systems could accomplish missile defense, counterair, counterspace, and land attack from platforms that never leave the friendly confines of the United States.18 Both options pose challenges for planning, commanding, and executing fires. Thus, aggressive efforts to integrate doctrine for DEW fires into the joint force are a crucial step towards providing commanders with more lethal power projection capabilities in the timeframe for Joint Vision 2020 and beyond.

Fig. 3 – Future Concept of UCAV Attack Using RF Weapons
(Photo Courtesy of The Boeing Company)

Our failure to vigorously pursue doctrine envisioning lethal offensive DEW applications unnecessarily constrains U.S. combat capabilities. As we learned during the past decade with information systems, existing technology enables significantly greater combat power than our Service cultures and doctrine allow us to assimilate and employ.19 Defensive applications envisioned for the early twenty first century provide a good base for establishing the combat viability of DEWs. However, it is time to accelerate development of visionary doctrine in order to capitalize on the decisive combat capabilities that

DEWs can provide to future U.S. military forces.

TICAL IMPLICATIONS FOR THEATER OPERATIONS

DEW technology offers far greater combat capability than present doctrine allows us to employ. Operational fires by DEW systems will differ significantly from conventional fires in their effects and methods of execution.20 Thus, integrating DEW fires into joint campaigns and major operations requires modification of existing doctrine for planning, commanding, and executing these attacks. Establishing command and control doctrine is a vital step leading to integration of new combat systems with joint forces because how we command and control often determines how we organize, plan, and execute missions. In the interest of brevity, this paper examines three basic command and control issues that must be resolved in order to integrate DEWs in joint forces; command relationships, coordination of operational fires in a theater, and integration of DEW fires in the joint targeting process.

New weapon systems raise basic questions about command relationships. Combatant command (COCOM) is the authority of a combatant commander that provides full authority to organize and employ forces needed to accomplish assigned missions. OPCON is inherent in COCOM and gives the commander authority to direct all aspects of military operations and training needed to accomplish assigned missions.

Unlike COCOM, OPCON may be delegated and exercised through subordinate commanders.21 The Services have well-established command relationships for their respective forces and weapon systems. Thus, command and control of operational fires using RF warhead-equipped UCAVs appears straightforward since the weapon platforms fall under existing Navy and Air Force operating structures. Command relationships for new multi role DEW systems will be more problematic, especially for those that have strategic capabilities.

Command relationships for multi-role military assets that are capable of executing strategic, operational, and/or tactical fires have always been controversial.22 Still, we have developed workable solutions at the strategic and operational levels for air and naval assets. Consider the example of strategic bombers. Under current doctrine, U.S. Strategic Command (USSTRATCOM) retains COCOM over strategic assets such as B-2 bombers but transfers OPCON to the Joint Force Air Component Commander (JFACC) when the bombers depart the continental United States.23 Once the bombers leave the area of responsibility (AOR), the JFACC returns OPCON to the original commander.

This arrangement provides a starting point for developing command relationships for future DEW assets like the ABL, but delegating OPCON will not always be feasible or desirable.24

Due to their global nature and strategic missions, USSTRATCOM (or a similar joint command with a global mission) should retain OPCON of high value DEW assets.25 Transferring OPCON of such assets is ill-advised for two reasons. First, certain DEW assets can provide operational fires from outside the AOR. For example, fixed GBL sites located in the United States or mobile ABL systems stationed out of theater may deliver operational fires in the AOR through relay mirrors. This “reachback” arrangement is advantageous because it obviates the need for specialized planning skills and communication capacity in theater. Force protection is also easier because planning and support takes place in friendly areas. Second, as with strategic lift and space forces, some DEW systems can support multiple theaters. In this case, the responsible commander allocates effects rather than specific forces. The Joint

Force Commander retains the ability to control effects by using staff coordination and liaison processes, but will not “own” the shooters. While this idea still makes some uncomfortable, the trend toward shared assets is undeniable.26 Operationally, the arrangement is viable if we train and exercise accordingly since many space assets and strategic airlift assets are controlled in a similar fashion. Coordinating DEW operational fires in a theater may prove more troublesome.

The question over who controls DEW fires in theater may prove nettlesome due to the very attribute that makes the systems valuable – their flexibility. Mission flexibility enables one DEW platform to

accomplish several tasks. Hence, command and control issues are likely to arise over coordination and allocation of DEW operational fires. For example, a commander may elect to use the same GBL weapon to conduct a counterspace mission in the morning, a counterair strike in the afternoon, followed by an ISR mission in the evening, with on-call support for missile defense. Different component commanders on the joint staff may plan each operation, but all must go to the same Service component for execution. Which component commander should coordinate the tasks so operations are synchronized? Under current doctrine, the JFACC is responsible for coordinating theater-wide attacks but, in truth, the Joint Force Commander may assign this responsibility to himself or any component commander. The salient point is that integration of operational fires should be conducted through a single joint component commander in order to maintain unity of effort and centralized command.27 Another type of conflict is likely to arise with the ABL.

When the ABL demonstrates that it can shoot down a theater ballistic missile in flight, it will be obvious that the same laser beam can kill other targets. For now, missile defense is the sole mission for ABL. In a deliberately crafted effort to sustain a long-term development program, Air Force leaders chose to concentrate on proving the ABL's primary mission while laying the groundwork for future "adjunct missions" such as offensive counterair, self-defense, and intelligence, surveillance, and reconnaissance (ISR).28 Thus, when the

ABL flies, commanders will have a potent weapon capable of offensive operations that is constrained by a doctrine envisioning only defensive operations. Conflict will ensue over opposing needs to conduct offensive strikes while maintaining a missile shield, but the missile shield will win because that is how we are currently training to fight.

Unless we develop operating procedures to synchronize and allocate fires between different missions, doctrine will preclude utilization of the full combat potential of the ABL in theater operations. Given the trend toward smaller forces, squandering combat capability is wasteful when we can devise doctrinal remedies relatively easily through war games and exercises. A similar issue will arise for DEW systems during targeting.

Unlike conventional thinking, integrating and synchronizing operational fires from DEW weapons into the joint targeting process will differ from conventional fires.29 Most analysts rightly claim that DEW systems should utilize the standard joint targeting cycle. Differences in details of intelligence analysis, weaponeering, and damage assessment for DEWs will arise as part of the normal learning curve for new weapons.30 Coordinating the process will be difficult. From an overall perspective though, the process for planning and executing effects-based operations remains the same, whether the weapon used is a guided bomb or a laser beam. The critical difference between directed energy and

conventional kinetic weapons lies in their ability to deliver discriminate firepower.

DEW systems can deliver operational fires with a degree of discrimination and accuracy that is orders of magnitude more precise than conventional weapons. By varying factors such as power and engagement geometry, laser and RF weapon systems provide commanders with the capability to achieve a full spectrum of negation effects (deny, disrupt, degrade, deceive, and destroy) using a single weapon platform.

This is a capability which we can achieve today in a far less precise manner only by using a variety of different weapon systems and munitions. Achieving precise effects requires precise intelligence and, fortunately, current efforts to improve ISR and targeting for precision guided munitions will make it easier to assimilate DEW systems within the existing joint force structure. However, the technology by itself is insufficient; we must also evolve our doctrine and war fighting procedures to realize the full capabilities of new directed energy weapons.

OPPOSING VIEWS

"Airplanes are interesting toys but of no military value."31

– Marshal Ferdinand Foch (1911)

All new weapons have skeptics, and directed energy is no exception. Many still regard DEW systems as speculative, particularly the notion of discriminate effects. Further, the assertion that we must aggressively pursue more visionary doctrine for future DEW applications is at odds with conventional wisdom and prevailing Air Force opinion.

The argument over how fast to integrate DEW systems into military operations seems too fine a point for many skeptics. After all, for the average citizen, laser rays in space and beams of electronic energy are

the stuff of science fiction. However, supposedly learned people put forth similar arguments about U.S. high technology weapons such as cruise missiles prior to Operation DESERT STORM. Like all weapons, lasers and RF weapons have their limitations. Nevertheless, DEWs are facts of science and are now mature enough to merit significant investment in their development as combat weapons. We have demonstrated in our labs and over the skies of New Mexico technologies to generate lethal beams of energy and direct them over many miles to destroy military targets. This systematic approach has successfully led the United States to where we are with the Airborne Laser and other DEWs today.

Many are quick to point out that the ABL is worth buying for missile defense alone. This assertion is true and, regrettably, that is exactly what we are buying. Evolving doctrine for combat employment of

the ABL portrays it as an orbiting air platform for intercepting theater ballistic missiles.32 Our focus on making the program work has unintentionally fostered a narrow mindset among many who view the ABL as a single mission aircraft—we forget those "adjunct missions" of offensive counterair, self-defense, ISR, and (in the future) interdiction.33 Unfortunately, that precedence is encouraging a similar approach to other DEW concepts, such as RF weapons and GBL/relay mirror systems.

Currently, training and war gaming for DEW systems focuses largely on the practical details of integrated missile defense and other one-dimensional missions. One popular description of the ABL likes to say that it shoots "bullets of light."34 Though simplified, the description is telling, for that is exactly how most military planners conceptualize the operation of all DEW (lasers and RF) systems—one bullet, one kill, and on to the next target.35 The beauty of this approach is that it has kept expectations within Congress and the user community in line with the development community's ability to engineer the weapon. The problem with extending this approach to doctrine is that we artificially constrain examination of future combat capabilities by deliberately overlooking the ability of the ABL and other laser "shooters" to achieve discriminatory damage effects and instantaneous power projection—revolutionary capabilities which rival invention of the aircraft or tank. As such, we place our intellectual and cultural transformation one step behind our technological capabilities. In effect, we are

treating laser and RF weapons as nothing more than newfangled artillery pieces. Operating a DEW system on this principle ignores a significant source of inherent combat power and flexibility, a notion which is anathema to airmen.

RECOMMENDATIONS

"A hiatus exists between the inventor who knows what they [sic] could invent, if they only knew what was wanted, and the soldiers who know, or ought to know, what they want and would ask for it if they only knew how much science could do for them. You have never really bridged that gap yet."36

–Sir Winston S. Churchill

We must integrate DEW systems more quickly into existing U.S. force structure. Our current approach to developing systems and the doctrine needed for their use is measured in decades. Consequently, we deprive the forces of combat power and run the serious risk of yielding the technological high ground to adversaries who seek to counter our military strength.37 In order to realize the full potential of DEWs in combat operations, we must build toward a vision of how to employ these new capabilities in future wars. We build the vision through doctrine; we discover and confirm the vision through exercises and war games.

The Air Force must lead the other Services in developing initial war fighting doctrine for DEW systems. Doctrine starts by drawing

lessons from the past, serves our needs in the present, and leads us to the future. Thus, experience is critical, for there is no historical base of operational experience for directed energy systems. At this point, we must draw on other combat lessons and our technical knowledge.

We can expect airmen to contribute heavily to DEW doctrine since inherent strengths of directed energy mirror those of airpower—speed, range, flexibility, precision, and lethality. More importantly, the Air Force holds a vital edge in DEW research with over 40 years of experience and investment. Still, the global applicability of directed energy technology ensures that future systems must be joint in nature. Recognizing this, the Air Force was instrumental in creating a Joint Technology Office in 2002 to coordinate and focus DoD research and development in high energy lasers. This is encouraging from an

acquisition perspective, but similar efforts need to occur on the operational side to develop closer links with users.

In order to spur transformation of operational forces, the Air Force should create a DEW Battlelab, with an eye towards a joint initiative in the future. A DEW Battlelab would provide a critical conduit for proving operational concepts and driving revisions to doctrine. For DEW, that formal link between research laboratories and combatant commands is missing today. In 1996, when the Battlelab idea was conceived, DEW technology was not mature enough. Given the growth

of DEW technology since then, the Air Force's leading role in DEW development, and consolidation of joint research, a DEW Battlelab now seems to be a worthy investment. In its absence, the Air Force Research Laboratory (AFRL) has developed a limited number of demonstrations, such as the Advanced Tactical Laser program for US Special Operations Command.38 AFRL also initiated a laser fighter simulator for war gaming at the Theater Aerospace Command and Control Simulation Facility.39 However, a Battlelab would provide a more coordinated, focused link between all AFRL directorates and Air Force operators. Beyond that, the Air Force Battlelabs (and their Service equivalents) would provide direct linkage to the DoD exercise and war gaming architecture needed to spur development of joint doctrine and fighting concepts.

At the joint level, we must make greater use of rapid spiral transformation and other initiatives to spur evolution of DEW war fighting doctrine.40 A credibility issue remains with operators until DEWs are tested in combat. We can alleviate some of the angst by realistic testing during development and robust evaluation of operating concepts during joint exercises and war games. The ABL program is an excellent starting point. Already, the ABL program has worked closely

with Air Combat Command and joint missile defense organizations to develop joint operational concepts needed for missile defense. Admittedly, there is nothing new in this recommendation—the need for experimentation in transformation is widely understood. Rather, we need

to make greater room at the table for the future.

Most joint experiments and war games tend to fixate on the near term due to fiscal constraints and ongoing operations. While near-term operations clearly merit priority, over-emphasis slows force transformation by mortgaging our intellectual future. Returning to the ABL example, more could be done to evaluate the offensive potential of the ABL in joint operations. The ABL Program Office has conducted early lethality studies needed to evaluate the operational feasibility of ABL adjunct missions but such efforts receive scant attention outside the Air Force.41 Using such data in a spiral transformation process under

U.S. Joint Forces Command, the DoD could evaluate the theater-wide impact of the ABL in offensive counterair operations during a series of experiments. Such an approach serves two purposes. First, operators could anticipate and solve problems likely to arise during ABL operation, such as the command and control issues identified previously. Serving as a leading element for doctrine, this approach is much faster and preferable to waiting until the ABL is fielded. Second, the spiral experimentation process would naturally lead to exploration and evaluation of future DEW war fighting concepts, thereby generating a healthy tension between technological developments and operator needs. Because the combatant commanders are the principle advocates of joint capabilities, the process relies heavily upon joint force participation.

SUMMARY AND CONCLUSIONS

"We must never fall into the trap of thinking that simply by fielding new and better systems we will maintain our lead. History has taught us…that technology alone is not the answer. The quality of our people, the caliber of our leaders, and the operational concepts and doctrine we use to employ technology on the battlefield—they are the decisive factors."43

–General Henry H. Shelton, USA (1998)

Directed energy technology is beginning to deliver on its promised potential. Existing and planned laser and radio frequency weapons offer the ability to deliver precise doses of lethal power to distant targets at nearly instantaneous speeds, thereby opening the possibility for revolutionary advances in combat capabilities. However, operational fires delivered by DEW systems represent a significant departure from employment of current weapons. As such, their use will require significant out-of-theater planning and coordination for effective command and control—issues we have only begun to address.

Joint forces lack a coherent vision of how to fight with directed energy weapons. Existing doctrine on planning, commanding, and executing operations is insufficient to exploit the full combat potential of speed-of-light weapons. While strong focus by war fighting commanders on missile defense has nurtured Airborne Laser development,

it is now time to vigorously pursue doctrine envisioning lethal offensive applications. The current focus on missile defense is unintentionally constraining development of U.S. combat capabilities by limiting examination of potential offensive missions for such existing systems as the Airborne Laser as well as future DEW concepts.

Visionary doctrine is needed to capitalize on the decisive combat capabilities that directed energy weapons offer. Strong leadership by the Air Force and a joint experimentation architecture emphasizing spiral development will enable the transformation of today's forces by facilitating assimilation of maturing directed energy technologies. Operator involvement is critical because, absent some compelling emergency, our combatant commands provide the mission focus and the sense of urgency needed to sustain development of weapons and war fighting procedures.

We like to say that there are no limits to our sky (Figure 4), an allusion to remind ourselves of the limitless possibilities of the human mind. In practice however, limits do exist, particularly when it comes to transforming the United States military. At times we face problems too complex for existing technology. At other times, we face problems of culture and mindset such as those we confront today with integrating radical new combat capabilities provided by directed energy, space, and information technologies. The latter are within our power to resolve. Creating weapon systems and doctrine that provide a decisive advantage

in combat is in the best interests of our Armed Services and the Nation.

Failure to adapt may result in ceding the technological high ground to enemies bent on reducing the wide advantage in capabilities enjoyed by

U.S. military forces.

Fig. 4 – Starfire Optical Range Illuminating a Space Object Over New Mexico

(Photo Courtesy of the Air Force Research Laboratory)

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2003.

Notes

1 See Department of Defense, Joint Chiefs of Staff, DoD Dictionary of Military Terms and Associated Terms (Washington, DC: DTIC,

1997), http://www.dtic.mil/doctrine/jel/doddict/, accessed 20 Dec 02. Directed energy weapons are devices that produce a beam of

concentrated electromagnetic energy, atomic particles, or subatomic particles to damage or destroy enemy equipment, facilities, or

personnel. This paper confines discussion to high energy lasers and high power radio frequency weapons due to the relative

immaturity of particle beam research.

2 General John P. Jumper, former commander of Air Combat Command and current Chief of Staff of the Air Force in remarks to Air Force

Association (15 Feb 01), Orlando, Florida; quoted in Robert S. Dudney, ed., “Verbatim,” Air Force Magazine 84, no. 4 (Apr 2001): 1.

3 Department of Defense, Joint Chiefs of Staff, Joint Vision 2020 (Washington, DC: GPO, June 2000), 1-3.

4 Department of the Air Force, Air Force Research Laboratory, Office of Public Affairs, Directed Energy Study Kicks Off, (Kirtland Air

Force Base, NM: 26 June 98), DE Release 98-32, http://www.de.afrl.af.mil/News/, accessed 20 Dec 02. The author supported this study

and the subsequent HEL Review during his assignment to the Air Force Research Laboratory between 1996 and 2000.

5 Department of Defense, High Energy Laser Executive Review Panel, Department of Defense Laser Master Plan (Washington, DC:

DTIC, 24 Mar 2000), ii. Significantly, the DE ATAC Study and HEL Executive Review Panel included substantial war fighter input and

direction. For example, former Chief of Staff of the Air Force General Ron Fogleman (retired) headed the DE ATAC study. This

partnership was instrumental in focusing both communities on critical areas where directed energy technology could impact near-term

missions.

6 Electromagnetic energy and atomic particles travel at the speed of light. While the speed of light is finite, bullets fired from guns are

much slower by comparison so directed energy effects are virtually instantaneous where human senses are concerned.

7 DEW systems can regulate the amount of energy deposited on a target by varying factors such as the power, dwell time, and

engagement geometry. By doing so, commanders can choose how much damage they want to cause. For instance, a short burst of

laser or RF energy may be enough to temporarily shut down the computer system for a surface-to-air missile command site, denying

use of the system to the enemy for a short time. This might be a desirable effect if we wished to avoid detection or raising alarm. A

longer burst could be used to permanently damage “softer” components on up to destroying the entire system.

8 For a succinct non-technical discussion of some of the operational capabilities of DEWs, see Loren B. Thompson, The Emerging

Promise (and Danger) of Directed-Energy Weapons, in remarks to the Lexington Institute Capitol Hill Forum on Directed Energy,

Washington, DC, 11 July 2002.
http://www.lexingtoninstitute.org/defense/energyforum_thompson.htm, accessed 11 Jan 2003.

9 Delores M. Etter, former Deputy Undersecretary of Defense for Science and Technology, Science and Technology for Directed

Energy Weapons, in remarks to the Lexington Institute Capitol Hill Forum on Directed Energy, Washington, DC, 11 July 2002.

http://www.lexingtoninstitute.org/defense/energyforum_etter.htm, accessed 11 Jan 03.

10 Department of Defense, High Energy Laser Executive Review Panel, Department of Defense Laser Master Plan (Washington, DC:

DTIC, 24 Mar 2000), 2-4.

11 Department of the Air Force, Air Force Research Laboratory, Office of Public Affairs, Electrical Power and Thermal Management for

Airborne Directed Energy Weapons, (Wright-Patterson Air Force Base, OH: Sep 01), PR-01-01,

http://www.afrlhorizons.com/Briefs/Sept01/PR0101.html, accessed 20 Dec 2002.

12 Eileen Walling, High Power Microwaves—Strategic and Operational Implications for Warfare, (Center for Strategy and Policy, Air

War College, Air University, May 2000), 3, Occasional Paper No. 11. Colonel Walling is a former Director of the Air Force Research

Laboratory High Power Microwave Program and one of the program directors the author supported during his assignment at the

laboratory. Her paper provides an excellent non-technical summary of the state of the art in high power radio frequency weapons,

including plain language descriptions of the terminology associated with these weapons.

13 Department of the Air Force, Air Force Research Laboratory, Office of Public Affairs, Active Denial Technology—Directed Energy

Non-Lethal Demonstration, (Kirtland Air Force Base, NM: Mar 01),
http://www.de.afrl.af.mil/factsheets/activedenial.html, accessed 20

Dec 2002.

14 William McCarthy, Directed Energy and Fleet Defense—Implications for Naval Warfare (Center for Strategy and Technology, Air

War College, Air University, May 2000), 4, Occasional Paper No. 10.

15 David A. Fulghum, "USAF Acknowledges Beam Weapon Readiness," Aviation Week and Space Technology, 7 Oct 2002, 27-28.

16 A Strategic Defense Initiative program called the Relay Mirror Experiment proved the basic concept in 1990. In 2002, the U.S. Air

Force initiated a joint program with the National Reconnaissance Office and U.S. Navy to demonstrate orbiting mirrors in space that

could be used to direct high energy laser beams to targets anywhere on the globe. The current demonstration is more practical in

nature and aims to validate the engineering methods for employing adaptive optics on a space-based platform.

17 See for example William Possel, Lasers and Missile Defense – New Concepts for Space-Based and Ground-Based Laser Weapons

(Center for Strategy and Policy, Air War College, Air University, Jul 1998), 24-25, Occasional Paper No. 5. See also Steven Leonard,

Laser Options for National Missile Defense (Air War College, Air University, Apr 1998): 42, AU/ACSC/165/1998-04.

18 Though it is less likely that laser powers will approach levels necessary to attack ground targets before 2020, such fires are

technically feasible in the long term. Nevertheless, the capability to attack airborne and space-based targets anywhere in the world,

and without warning, constitutes a significant strategic and operational capability. For example, consider the implications for our

enforcement of no-fly zones over the skies of Iraq if the United States had the ability to monitor and attack Iraqi flights without having

to forward base large numbers of our fighter aircraft in the area of operation.

19 Consider a relatively straightforward process such as distributing an Air Tasking Order (ATO). Despite the considerable information

and communication systems in use during Operation DESERT STORM in 1991, people had to hand-carry copies of the ATO to Navy

ships in the Persian Gulf. The process took days to accomplish and received considerable criticism. Air Force and Navy information

and communication systems, as one example, were simply not integrated. Today ATO distribution is largely automated and

distribution takes place in a matter of minutes thanks to considerable integration efforts by the Services.

20 See Milan N. Vego, Operational Warfare (Newport: Naval War College, 2003), 239-243. Operational fires are the application of

firepower to achieve a decisive impact on the outcome of a campaign or major operation. As such, these fires represent an inherently

joint function. They are distinguished from other types of fires primarily by their ultimate purpose. Operational fires can be lethal or

non-lethal.

21 For expanded definitions of command relationships, see CJCS, Joint Doctrine Capstone and Keystone Primer (Washington, DC:

DTIC, 10 Sep 2001), II 6-11.

22 Consider the stormy history behind creation of the U.S. Air Force. Battles rage today over command and control of close air support,

air defense, intelligence, and space assets to name a few modern examples.

23 United States Strategic Command, U.S. Strategic Command Public Affairs, U.S. Strategic Command Overview and Organization Fact

Sheet, (Offutt Air Force Base, NE: Jan 03), http://www.stratcom.af.mil/, accessed 30 Jan 03.

24 The author is indebted to Major Timothy Lea, USAF, for a great deal of the background on employment and organization of joint air

and space forces used in this section. See Timothy J. Lea, Integrating Space-Based Fires Into the Joint Force After Next (Air War

College, Air University, April 2000): 11-13, AU/ACSC/103/2000-04

25 Command relationships for National Missile Defense are still evolving and may result in the creation of a new combatant command or

reallocation of missions to existing commands.

26 The Airborne Laser is simply the latest in a long line of critical high-value assets such as aircraft carriers, AWACS, the U-2, many

satellites, and UAVs.

27 See CJCS, Command and Control For Joint Air Operations (Washington, DC: DTIC, 14 Nov 1994), II 2-3, Joint Publication 3-56.1.

Integration at the operational level will not be affected by the identity of the force provider—the force provider could be any of the

Services. If current doctrine is followed, the JFACC is responsible for coordinating the JFC's theater-wide attacks (including strategic

attack and interdiction).

28 See for example, Simon P. Worden and Robert Luzzi, Why We Need the Airborne Laser (George C. Marshall Institute, 1 Dec 1998), 2,

http://marshall.pjdoland.com/article.php/80.html, accessed 11 Jan 03. See also remarks by Col Ellen Pawlikowski, ABL Program

Manager, in John A. Tirpak, "Attack at the Speed of Light," Air Force Magazine, Dec 2002, 5.

29 See Lea, Integrating Space-Based Fires, 17 and Worden, Why We Need the ABL, 8.

30 These are critical issues involving capabilities along with significant changes in Service cultures and well-entrenched bureaucracies

in the Defense Intelligence Community. The author does not minimize their importance, but must leave detailed treatment to other

researchers.

31 Marshal Ferdinand Foch, French military strategist and future WWI Commander, as quoted on ABL website,

http://www.airbornelaser.com.

32 Adapted from briefing material provided by Edward Duff and the Airborne Laser Systems Program Office, Directed Energy

Directorate, Phillips Research Site, Kirtland Air Force Base, NM, Airborne Laser Program – ABL Overview Briefing, 1998. Also, see

the ABL web site at http://www.airbornelaser.com.

33 Adapted from Airborne Laser Program – ABL Overview Briefing. Interdiction is a mission that becomes possible in the long term

with development of higher power lasers and beam control techniques that allow deeper penetration into the earth's atmosphere. For

the near term, it is possible using the existing ABL technologies to attack other targets in the air and, conceivably, in space. Arguably,

the business of acquiring, tracking, and destroying a boosting ballistic missile is more difficult than for other target sets.

34 The allegory "bullets of light" arises naturally as a way for scientists to explain laser system concepts in plain terms and has become

a ubiquitous reference. However, it also happens to form part of the title for an excellent historical account of Air Force laser

technology programs that led to the ABL. See Robert Duffner, Airborne Laser—Bullets of Light, (New York: Plenum Press, 1997), title

page.

35 Even some prominent airpower visionaries soft peddle the ABL, downplaying its significance as "just another shooter" (albeit a very

fast and deadly one) for established operational counterair missions. See Worden and Robert Luzzi, Why We Need the Airborne Laser,

2.

36 Sir Winston S. Churchill as quoted in Douglas Beason, "The Need for Technical Warriors," Aerospace Power Journal (Spring 2000):

1.

37 While the United States leads in overall development of DEWs, that lead is neither complete nor overly large. Practically every major

nation is conducting significant research and development in directed energy weapons, including many of our potential adversaries.

China in particular has attached significant priority to DEWs, believing such weapons will provide an asymmetric advantage against

dominant U.S. conventional forces and space systems. For a detailed unclassified examination of Chinese high technology research

and development see Mark Stokes, China's Strategic Modernization: Implications for the United States (Strategic Studies Institute,

U.S. Army War College, Sep 1999), 109-123. The author is a former Assistant Air Attaché to China and a current defense expert on the

Chinese military.

38 David A. Fulghum, "Lasers, HPM Weapons near Operational Status," Aviation Week and Space Technology, 22 Jul 2002, 3.

39 Department of the Air Force, Air Force Research Laboratory, Directed Energy Directorate, F-16 Simulation Goes High Energy,

(Wright-Patterson Air Force Base, OH: Jan 2003), http://www.afmc-pub.wpafb.af.mil/HQAFMC/

PA/centennial/archive/news/story24.htm, accessed 11 Jan 2003.

40 See Under Secretary of Defense for Acquisition, Technology and Logistics memorandum dated 12 April 2002, "Evolutionary

Acquisition and Spiral Development." Evolutionary acquisition is a strategy that defines, develops, produces or acquires, and fields an

initial hardware or software increment (or block) of operational capability. Spiral development implements evolutionary acquisition

through an iterative process for developing a defined set of capabilities within one increment. Each increment may involve a number of

spirals and the process relies heavily upon collaboration between user, tester, and developer. Together, these approaches provide the

best means of getting advanced technologies to war fighters quickly while providing for follow-on improvements in capability.

41 The author participated in early lethality studies for the ABL between 1996 and 2000.

42 See John Hanley, "Rapid Spiral Transformation," Transformation Trends (3 Feb 2003), 6-7. The paper makes a cogent case for

extending an acquisition process to encompass the wider issue of force transformation, and includes a rationale for combatant

commander involvement.

43 Henry Shelton, “Operationalizing Joint Vision 2010,” Aerospace Power Journal (Fall 1998): 2.