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Higher-Dimensional Warfighting

Robert J. Bunker

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MODERN AMERICAN military perceptions articulated in *Joint Vision 2010* and *Concept for Future Joint Operations: Expanding Joint Vision 2010* are designed to achieve the required capabilities for the challenges that our nation faces in the 21st century.¹ These visions increasingly speak more to the present era than to the emerging one. Qualitative advances in human civilization periodically redefine the military arts and sciences. The introduction of the stirrup and gunpowder into the European system represents two such seminal events. They helped define land warfare in terms of animal energy in the three-dimensional medieval era and mechanical energy in a four-dimensional modern world.²

The military arts and sciences are again being redefined—this time without supporting bureaucracies. The sheer magnitude of the change is beyond our national experience. Instead of looking to the 1920s and 1930s for indicators of coming change, our leaders should look to the Dark Ages and the European Renaissance. That notion, however, seems a bit too farfetched for today's global vision. Scientific sectors of society are well aware of the current changes. Research increasingly focuses on emerging sciences—bioengineering, advanced biometrics, cloning, chaos and complexity theory, non-linearity, post-mechanical energy and even psi-based research. In theoretical physics:

Many of the world's leading physicists now believe that dimensions beyond the usual four of space and time might exist. This idea, in fact, has become the focal point of intense scientific investigation. Indeed, many theoretical physicists now believe that higher dimensions may be the decisive step in creating a comprehensive theory that unites the laws of nature—a theory of hyperspace. . . . This seminal concept has sparked an avalanche of scientific research: several thousand papers written by theo-

Military logic remains literally within the "box" of the three dimensions of space and the fourth dimension of time. . . . Information operations and warfare, while increasingly discussed and recognized for their importance, lack any real form of dimensional residence. They are relegated to the electromagnetic spectrum, an uneasy addition to modern battlespace perceptions.

retical physicists in the major research laboratories around the world have been devoted to exploring the properties of hyperspace. The pages of *Nuclear Physics* and *Physica*, two leading scientific journals, have been flooded with articles analyzing the theory. More than 200 international physics conferences have been sponsored to explore the consequences of higher dimensions.³

Fifth-dimension research, referred to as "hyper" when describing higher-dimensional geometric objects and "cyber" when referring to the higher-dimensional qualities of information, does not influence the majority of our military scholars. US military journals and publications almost completely omit research, speculation or even debate concerning higher-dimensional space and its potential impact upon future warfighting. Military logic remains literally within the "box" of the three dimensions of space {x,y,z} and the fourth dimension of time {t}. Information operations and warfare, while increasingly discussed and recognized for their importance,

Reformist thinkers increasingly recognize a fifth-dimensional battlespace attribute. In addition to space and time, they include another characteristic, commonly referred to as cyberspace. This attribute is required to account for both the impact of the Internet and a stealth-masked terrorist on the advanced battlefield.

lack any real form of dimensional residence. They are relegated to the electromagnetic spectrum, an uneasy addition to modern battlespace perceptions.

This article will build upon earlier battlespace research by discussing higher dimensional warfighting and its potential impact upon future operations.⁴ Further, it will cover linear and nonlinear projections of the future battlefield, highlight recent research concerning five-dimensional {cyber} battlespace, analyze concepts and technologies underlying bond-relationship targeting and cybershielding and explore warfighting implications of redefined battlespace.

A Linear or Nonlinear Dimensional Future?

Future warfare projections have crystallized in DOD initiatives based upon the revolution in military affairs.⁵ This traditionalist school of thought predicts rapid advances in the information sciences will revolutionize modern warfare. This logic principally derives from early military technical revolution writings of Soviet authors; studies and research promoted by the Pentagon-based Office of Net Assessment; and Alvin and Heidi Tofflers' popularized view of an emergent Information Age, "The Third Wave."⁶ Joseph Nye and William Owens envision the United States with a qualitative change in its "system-of-systems" permitting "dominant battlespace knowledge."⁷ George and Meredith Friedman repeat the siren's call in their writing on future war—a future based on precision-guided munitions and America's undisputed military domination of war.⁸

The traditionalist school of thought has gone on to dominate future US joint force perceptions of

war. In *Concept for Future Joint Operations*, new warfighting techniques derive from US information superiority and technological innovation. These operational concepts—dominant maneuver, precision engagement, full-dimensional protection and focused logistics—are considered the epitome of modern US military thinking that is greatly influenced by its stunning coalition battlefield successes in the 1991 Gulf War. Embedded in these operational concepts are precision targeting, informational superiority, a systems-of-systems approach to warfighting and, most significant, a linear spatial projection of the future battlefield.

This linear spatial projection, however, is never mentioned. It is implicitly assumed by traditionalist thinkers that battlespace is historically defined by three spatial dimensions {x,y,z} and one temporal dimension {t} just as it is implicitly assumed by the thinkers that our most dangerous future opponents will be peer-competitor nation-states rather than emergent warmaking entities which defy our perceptions of crime and war. Such global visions and images of reality portray a modern hubris that expects other peoples and cultures to blindly follow Western military and ethical norms derived from the Treaty of Westphalia in 1648. However, Nye and Owens argue that "because the United States will be able to dominate in battle, it has to be prepared for efforts to test or undermine its resolve off the battlefield with terror and propaganda."¹¹

Reformists argue that what traditionalist thinkers consider "off the battlefield," is the future battlefield. Reformist thinkers increasingly recognize a fifth-dimensional battlespace attribute. In addition to space and time, they include another characteristic, commonly referred to as cyberspace {c}. This attribute is required to account for both the impact of the Internet and a stealth-masked terrorist on the advanced battlefield. The National Defense Panel's report *Transforming Defense* defines cyberspace as both benign and potentially dangerous: "The Global Information Infrastructure; That aspect of the area of conflict composed of the electromagnetic spectrum and nonhuman sensing dimension in which stealth-masked forces either stage attacks or seek refuge from them."¹²

Such a nonlinear projection of the future battlefield is at odds with *Joint Vision 2010* perceptions. It incorporates both the traditional humanspace found in modern definitions {x,y,z}+{t} along with the higher dimension of cyberspace {c} derived from post-mechanical energy sources. On this fu-



The pilot of a hijacked TWA airliner is threatened not to talk to reporters at Beirut International Airport, June 1985.

Rather than envisioning revolution in only military affairs, reformist scholars argue that fundamental social and political changes are also taking place; together these shifts are transforming the very nature of war. . . . Individuals thousands of kilometers away can be brought right to the battlefield for either virtual support or psychological warfare purposes as in the case of American citizens sitting in their living rooms watching world events unfold on CNN.

ture battlefield, the United States will be unable to achieve anything even remotely near “dominant battlespace knowledge” because stealth-masked forces are able to seek higher-dimensional battlespace for defensive purposes. Reformist thinkers hold that the future principal threat to Western nation states will be non-state (criminal) forces who exploit advanced battlespace—both upper-tier cyberspace (such as the Internet and electromagnetic spectrum) and lower-tier cyberspace (such as the stealth-masking of physical forces). Rather than envisioning revolution in only military affairs, reformist scholars argue that fundamental social and political changes are also taking place; together these shifts are transforming the very nature of war.

Five-Dimensional (Cyber) Battlespace

As noted earlier, to recognize that we have entered the information age is now cliché in most US military circles. The perceived primacy of information is an illusion, however, analogous to the peak of an iceberg visible above the waterline.

Inherently linked to it, yet unseen, is a foundation derived from nonlinear, post-mechanical, chaotic and complex technologies and sciences. Hence, information does not independently drive change as proponents of the revolution in military affairs suggest, any more than industrialization before it. Instead, information is an outcome of underlying strata. This being the case, five-dimensional battlespace will allow us to overcome the limitations

Rather than matter, electromagnetic energy is employed as a weapon. Such weaponry, be it infrasound or high-power millimeter waves, bypasses such physical armor and defenses by being out of phase with them. In a worst-case scenario, criminal forces using such weaponry in a failed state's sprawling slum would be able to overcome US armored vehicles and incapacitate or injure their crews with little effort.

inherent in four-dimensional, or modern, battlespace for advanced warfighting purposes.

To better understand the new potentials that cyberspace offers, three limitations of modern battlespace must be addressed. The first limitation is that of physical distance and orientation. In modern warfighting an object at $\{x,y,z\}_1$ resides at a measurable distance from another object at $\{x,y,z\}_2$. The distance between the objects and their orientation to each other is fundamentally important. Terms such as *frontal*, *flank*, *rear*, *stand-off* and *close-in* describe this mutual relationship. Cyberspace warps that mutual relationship through spatial expansion and contraction as demonstrated in Figure 1. Spatial expansion takes two military objects that are close to each other and makes them far away from each other. Stealth fighters were able to fly over Baghdad at night because, to the unaware, they did not exist. If they had, they would have been targeted by severe air defense fires. The same process works for terrorists. A terrorist standing five meters from a US soldier may as well be thousands of kilometers away because stealth-masking protects him.¹³ Spatial contraction takes two military objects that are far away from one another and brings them close together. The use of the Internet, telemedicine and even real-time media broadcasts for military purposes are all examples of spatial contraction. Individuals thousands of kilometers away can be brought right to the battlefield for either virtual support or psychological warfare purposes as in the case of American citizens sitting in their liv-

ing rooms watching world events unfold on CNN.

The second limitation is that of the time $\{t\}$ it takes to travel between two military objects. If one object is at $\{x,y,z\}_1$ and the other at $\{x,y,z\}_2$, a time window exists between them. In the case of a fired projectile, this would be its time of flight from shooter to target. Cyberspace can either compress this window or make it totally nonexistent. A directed-energy weapon, such as a laser, for all practical purposes has no time of flight; firing the weapon and impact are virtually simultaneous. No warning of attack will exist because no defensive mechanism can approach the absolute speed of light. As a result, based upon *any* warning, four-dimensional limitations have been overcome.

The last limitation of modern battlespace is dimensionality, the physical structure of an object $\{x,y,z\}$. Historically, defensive matter has been an impediment to military forces—it must be defeated in some manner. For example, the armor protecting a tank is designed to withstand an antitank projectile. The post-mechanical nature of fifth-dimensional battlespace overcomes this offensive limitation. Rather than matter, electromagnetic energy is employed as a weapon. Such weaponry, be it infrasound or high-power millimeter waves (HPMMW), bypasses such physical armor and defenses by being out of phase with them. In a worst-case scenario, criminal forces using such weaponry in a failed state's sprawling slum would be able to overcome US armored vehicles and incapacitate or injure their crews with little effort.

All of these examples suggest that cyberspace will offer new warfighting capabilities that are cur-

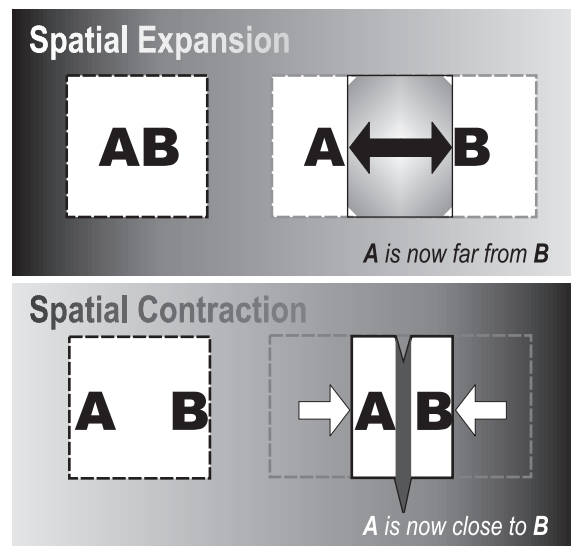


Figure 1. Spatial Warping of Modern Battlespace

rently little understood or even discussed. We do know that the battlefield advantages of higher-dimensional space must be fully exploited by US forces and denied to their opponents. Earlier research on this new form of battlespace has focused on its basic spatial constructs: humanspace and cyberspace, which define its parameters, and data fusion and stealth that allow for dimensional transcendence.

Research also developed basic defensive concepts of stealth—"The application of sensory defeating procedures and technologies which allow military forces to enter cyberspace"—and cybermaneuver—safely moving military forces outside four-dimensional humanspace.¹⁴ Notably, this cybermaneuver concept conflicts with the *Joint Vision 2010* concept of full-dimensional protection. While full-dimensional protection concerns itself with protecting US forces that reside in the kill zones of modern battlespace, cybermaneuver is meant to protect them from danger in the first place.

To these advanced operational concepts can now be added bond-relationship targeting and cybershielding.¹⁵ While historical precedents exist, their potential can only now be fully recognized because of technological advances. Bond-relationship targeting represents the principal offensive component of cyberwarfighting, while cybershielding offers a secondary form of defense for military forces who have had their stealth-masking compromised. Bond-relationship targeting is at odds with the *Joint Vision 2010* concept of precision engagement, which is viewed as simply a precise form of attrition warfare; cybershielding appears to have no *Joint Vision 2010* corollary operational concept. These concepts and the various technologies that support their emergence will be discussed in the following two sections.

Bond-Relationship Targeting

In modern four-dimensional warfighting, the US Army is renowned for its ability to seize ground, destroy enemy armored fighting vehicles and aircraft and kill opposing forces. This type of warfare focuses on personnel, material and terrain using operational styles of attrition, precision strikes and maneuver. Conventional wisdom suggests that as an opposing force is worn down by a meat grinder effect, surgical-like strikes or physically cut off, it will lose its effectiveness in combat and at some point cease to be militarily viable. This logic works well when facing opposing armies fielded by other nation-states but breaks down when applied to non-state opponents. An immense disparity between US and Vietcong casualty figures suggests

[Bond-relationship] targeting functions along a continuum from the micro to macro level—from subatomic particles to states and their coalitions to the environments in which they exist. Rather than gross physical destruction or injury, the desired end state is a tailored disruption within a thing, between it and other things or between it and its environment by degrading, severing or altering the bonds and relationships which define its existence.

that we physically won the Vietnam War. We cannot overlook that the Tet Offensive physically broke the back of the communist insurgency. Using this logic, the rescue attempt in Somalia also indicates we were physical victors with 18 Rangers killed versus perhaps up to 6,000 to 10,000 Somali casualties.¹⁶ However, both the conflicts in Vietnam and Somalia are considered failures because they did not achieve our political goals and eventually resulted in US military withdrawal.

The two previous examples imply that crude "body counts" short of genocide poorly measure future operational success against the non-state (criminal) soldier and the new warmaking entities within which he or she will be organized.¹⁷ Bond-relationship targeting overcomes these limitations by attacking the linkages between things rather than things themselves. This targeting capability would extend to the concept of embedded information proposed by John Arquilla and David Ronfeldt's *In Athena's Camp*.¹⁸ This form of targeting functions along a continuum from the micro to macro level—from subatomic particles to states and their coalitions to the environments in which they exist. Rather than gross physical destruction or injury, the desired end state is a tailored disruption within a thing, between it and other things or between it and its environment by degrading, severing or altering the bonds and relationships which define its existence.¹⁹

This operationalized end state greatly broadens Richard Harknett's *cyberwar*, which he refers to as "conducting and preparing to conduct military

An assault upon the Internet-based communication infrastructure of a country would also be considered a bond-relationship attack. While clearly violating our modern rules of warfare, these methods point ominously toward some non-state groups posing a threat in the future.

operations against or in defense of military connectivity.²⁰ The operationalization also highlights those unique properties of nonlethal weapons, means other than gross physical destruction that prevent a target from functioning.²¹

Bond-relationship targeting at a micro level can affect inorganic materials like metal and ceramic tank armor and the rubber tires of jet aircraft or ground vehicles. Liquid metal embrittlement (LME) agents alter the molecular structure of base metals or alloys and biodegrading microbes and can produce enzymes that break down rubber products.²² Timothy Thomas has discussed the disruptive effects using strobe lights, VHF generators, noiseless cassettes and other forms of psychotronic weapons against organic forms such as human beings. Such weapons, according to a Russian source, are “used against the human mind to induce hallucinations, sickness, mutations in human cells, ‘zombification’ or even death.”²⁴ Many such effects may violate current arms control treaties and international norms, but as components of bond-relationship targeting, they must be openly recognized and debated for ethical and operational implications.

Against military systems such as tanks, this form of targeting can not only degrade tank armor but also cause engines to fail by means altering combustion via vapor ingested through air intakes, disrupt crew vision with rapid-hardening agents applied against vision ports and optics and disable onboard fire control computers using an energized pulse.²⁵ Other target sets, such as aircraft and naval vessels, can also have their functioning disrupted and degraded in a similar manner. When applied against armies and criminal-military fighting structures, bond-relationship targeting will focus on their military connectivity as currently proposed by cyberwar theorists. This dis-

ruption will require manipulating the electromagnetic spectrum that channels waves and Internet messages, isolating and overwhelming key nodes in these networks, thus creating cascading failures.²⁶

Societal and political groups such as traditional and emergent state forms are vulnerable at the bonds which hold them together. Among Westphalian nation-states, the linkages within the Clausewitzian trinity represented by the government, the people and the military can be targeted as illustrated in Figure 2.²⁷ Rather than seeking victory on the traditional battlefield, the Vietcong engaged us on a higher dimension, eroding the bonds between our people and the government and military that served them. Terrorism also operates at this level, undermining societal security. A government that fails to stop terrorist attacks or overly infringes upon personal liberties while doing so alienates its people. We currently know very little about the bonds and relationships which hold warmaking entities, such as drug cartels, together, but this target set scheme appears to offer great possibilities over current methodologies such as “bale count” and “bag count.” Whether its structure looks like the Clausewitzian trinity conception or something else is unknown.²⁸

Using bond-relationship targeting and environmental warfare appears to be effective against state forms and their physical surroundings. Iraqi forces employed a crude form of this concept, setting countless oil well fires, causing environmental damage to Kuwait. Weather modification and the use of biological agents to disrupt crop yields or dairy milk production represent more sophisticated attacks, as does the detonation of radio frequency weapons that can “pollute” a nation’s electromagnetic spectrum.²⁹ An assault upon the Internet-based communication infrastructure of a country would also be considered a bond-relationship attack. While

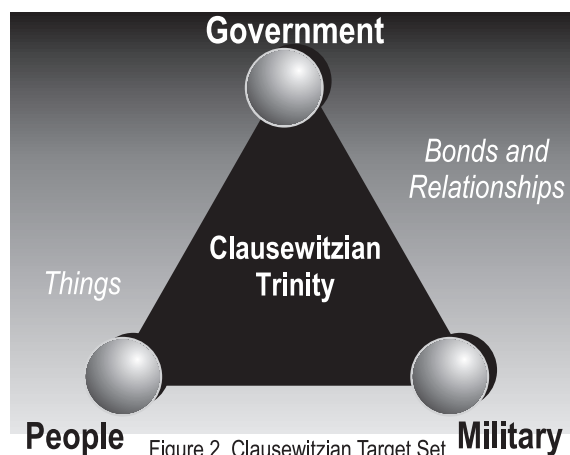


Figure 2. Clausewitzian Target Set



A political warfare team made up of US and South Vietnamese soldiers tries to convince Vietcong guerrillas to surrender during the Tet Offensive, Saigon, February 1968.

The Tet Offensive physically broke the back of the communist insurgency. Applying this logic to the rescue attempt in Somalia also indicates we were physical victors with 18 Rangers killed versus perhaps 6,000 to 10,000 Somali casualties. However, both the conflicts in Vietnam and Somalia are considered failures because they did not achieve our political goals and eventually resulted in US military withdrawal. . . . Crude “body counts” short of genocide poorly measure future operational success against the non-state (criminal) soldier and the new warmaking entities.

clearly violating our modern rules of warfare, these methods point ominously toward some non-state groups posing a threat in the future.

Both intrastate and interstate bond-relationship targeting raise important concerns. Perhaps future strategic-level warfare will evolve from weapons of mass destruction that target things to weapons of mass disruption which target linkages between those things. Recent demographic trends and Army war games suggest that opponents of the United States will defend in complex terrain such as massive urban zones. Instead of solely developing a capability to fight in such “urban death traps,” our forces should be able to send a city into chaos instead of physically invading it at all. Abstracting this possibility to a higher level suggests future US defense policy option—sending a belligerent state, society or city into chaos, rather than physically invading or destroying it, by using a fifth-dimensional attack.

Cybershielding

The initial operationalization of the term *cybershielding* was as a defensive contingency operation (CONOP) against a BlueFor *Joint Vision 2010* legacy force:

“The capability of defeating a precision strike by means of generating an invisible shield around a force which has been stripped of its stealthing and acquired in time and space. The shield could either prematurely detonate a precision-guided munition via electronic impulses, or potentially project a semisolid ‘phase state’ as a physical barrier. This secondary form of defense is derived from advanced nonlethal weaponry with dimensional-shifting capability.”³⁰

However, against a more advanced opposing force with bond-relationship targeting capabilities, this operationalization proves insufficient. While the capability of disrupting or neutralizing a physically based precision strike is critical and should be

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retained, a defense against bond-relationship targeting is also required. Further, generating defensive nonphysical barriers to protect our soldiers also appears to fall within the purview of this operational concept. None of these capabilities appears in the *Joint Vision 2010* concept of full-dimensional protection.³¹ Cybershielding has more in common with the concepts of antilethal weapons and weapons of mass protection suggested by Chris and Janet Morris and Thomas Baines.³² Primarily, cybershielding protects bonds—relationships within a thing, between it and other things or between it and the environment. Secondly, it defends against a precision strike from a less technologically advanced opponent.

The desired primary end state concerns shielding against bond-relationship targeting.³³ At the lowest level of shielding, some sort of cyberbarrier could be developed for the individual soldier. Such a barrier would complement the personal battle armor of the Land Warrior modular fighting systems. These systems’ “basic components are a helmet-mounted display, an improved image intensification (I²) modular weapon, improved protective clothing to include improved modular body armor, a computer and radio setup and special software for battlefield communications.”³⁴ Additional shielding would offer protection against advanced nonlethal weaponry. The power source to generate this shield, which would be projected immediately over the battle armor and visor, would already be organic to the soldier system for other component power needs.³⁵ Aircraft and ground vehicles could also be considered for cybershielding, protecting systems, crews and passengers from radio frequency (RF) and high-powered microwave (HPM) weaponry or barriers.

With regard to military connectivity, Martin Libicki of the National Defense University suggests that the true dangers from hacker attacks are corrupt information and the decisions that depend on it.³⁶ To counter this warping of data, he suggests a number of defensive measures:

“cryptographic methods to hide information, regulate external access to a system or tag internal changes to its data; filters that permit only a limited number of set messages to be transferred among machines; unerasable media to archive information and protect against viruses; air-gapping for a few systems [removing outside access to a nuclear power plant] as well as more quotidian defenses [such as firewalls, anomaly detection, heightened awareness].”³⁷

Once a network has been penetrated, antiviral programs represent another form of cybershield. This digital struggle pits virus and antivirus software programs against one another. Possibly the immune system metaphor is useful when discussing defensive measures against bond-relationship attacks targeting our information systems.³⁸

The shielding of social and political groups also potentially benefits from fifth-dimensional thinking. This approach would likely center on how the psychic effects of a terrorist incident, such as the bombing of American servicemen in Lebanon and Saudi Arabia, could be degraded or mitigated. It would require a better understanding of the Clausewitzian trinity and the bonds-relationships among the government, military and people. Currently, our knowledge is very limited in this regard. Additionally, regardless of whether the United States seeks the capability to send a belligerent state or entity into chaos by using weapons of mass disruption, it would be prudent to develop shielding countermeasures against such attacks. Preventing a “digital or radio frequency Pearl Harbor” is common sense.

With regard to its secondary end state, a cybershield would represent a nonphysical or semi-solid barrier which against a precision strike. Unlike three-dimensional based armor for individual vehicles and soldiers, this protective barrier would be projected out around a defending force. The best known example of this principle is the *Shortstop* system deployed in Bosnia. It generates an electronic barrier, prematurely detonating mortar rounds by sending false messages to their fuzing.³⁹ Radio frequency (RF) and high-powered microwave (HPM) devices are able to generate similar defensive barriers. Unshielded precision missiles and munitions entering their electromagnetic fields

would have their circuitry burned out or fused, rendering them inoperable. Such barriers could also be used against attacking aircraft. Several early crashes of Army UH-60 Black Hawk helicopters have been attributed to their flying too close to large microwave transmitters.⁴⁰

Cybershielding used to generate nonphysical defense falls within the parameters of the secondary end state. Likewise, this specific capability is conceptually problematic and might also be considered offensive. It does have immediate applicability in domestic riot control and foreign failed-states environments. One form of this shielding would be an "acoustic curtain" projected in front of soldiers protecting a contested facility, such as a radio station in Bosnia. Such curtains could also be generated across a bridge, at a road block or even at a choke point in a sewer system. The biophysical effects generated by these curtains could range from nausea and loss of bowel control at their edges to more severe effects closer to their centers.⁴¹ To mark these barriers, specially designed holograms could be projected within their confines with either wording or symbols to designate their danger levels.⁴²

Holograms, remarkably, make for another form of defensive shielding. They can create the illusion of solid walls, roadblock barriers and other terrain obstacles such as fences, and as a means to hide spike strips and caltrops. While the two above technologies with barrier capability are projected, a new state-of-the-art laser technology is currently being field tested. The *Laser Dazzler* is a handheld 532nm diode-pumped laser that resembles an oversized flashlight. This *eye-safe* laser-baton generates an "optical wall" out to over 500 meters that causes most individuals to turn away from the light source. In addition, a "strobe" effect is built into the laser's programmable power supply, increasing disorientation effects. Such an optical wall not only provides a time cushion to US soldiers but could potentially distract, disorient and temporarily immobilize an approaching group of rioters. Such a group would be unlikely to continue its advance or aggressive activities.⁴³ As a modification on this theme, variants of the *Laser Dazzler* placed on 360-degree mounts on a high mobility multipurpose wheeled vehicle (HMMWV) could provide a close-in-defense system to protect troop convoys against urban mobs.

Warfighting Implications

Many ideas in this article concerning the influence of five-dimensional (cyber) battlespace, bond-relationship targeting and cybershielding in future land warfare may range from mild inaccuracy to

The warfighting challenge we now face is maintaining the ability to fight and win the four-dimensional conflicts of the past, which take center stage in Joint Vision 2010, while simultaneously obtaining a growing capacity to fight the five-dimensional wars of the future. Victory in those new types of wars will likely not be obtainable quickly.

something much further off the mark. Such an attempt is in some ways analogous to the effort made by Mr. Square who lives in flatland $\{x,y\}$ to visualize the higher third dimension $\{x,y,z\}$ after an encounter with Lord Sphere in Edwin Abbott's celebrated 1884 work *Flatland*.⁴⁴ Such attempts to understand the implications of higher-dimensional space, even if they partially fail, go beyond thinking that overlooks cyberspace's impact on future warfare.

Joint Vision 2010 is probably the most advanced document ever written concerning four-dimensional $\{x,y,z\}+t$ warfighting, but the form of warfighting based on mechanical, linear, reductionist, synchronized and proportional concepts and technologies is becoming increasingly obsolete. Human civilization is qualitatively changing based on postmechanical and nonlinear sciences that generate cyberspace $\{c\}$. With this change comes the expectation that the military arts and sciences will be redefined. It is only a matter of time before seminal technology on the scale of the stirrup or gunpowder will emerge or become fully recognized after its successful demonstration on the battlefield—possibly some sort of electromagnetic energy-generating device of the Internet itself. Unfortunately, such a demonstration may be conducted by a hostile warmaking entity.

The warfighting challenge we now face is maintaining the ability to fight and win the four-dimensional conflicts of the past, which take center stage in *Joint Vision 2010*, while simultaneously obtaining a growing capacity to fight the five-dimensional wars of the future. Victory in those new types of wars will likely not be obtainable quickly.⁴⁵ To face this challenge, military scholars and officers must ask

difficult questions concerning the dimensional parameters of the battlefield, its influence on future land warfare and how matter-energy and space-time analysis can develop future operational concepts suited

to higher-dimensional warfighting. Military thinkers have no choice—one of the greatest sins a professional force can commit is not understanding the parameters of its next battlefield. **MR**□

NOTES□

I would like to thank Dr. Steven Metz, CWO5 Sid Heal, USMCR, and Deputy John Sullivan, LASD, for their valuable insights and comments on an earlier draft of this article.

1. *Joint Vision 2010*, Chairman Joint Chiefs of Staff (Fort Monroe, VA: Joint Warfighting Center, July 1996); and *Concept for Future Joint Operations: Expanding Joint Vision 2010*, Chairman Joint Chiefs of Staff (Fort Monroe, VA: Joint Warfighting Center, May 1997).

2. Medieval battlespace is three-dimensional in nature. It is based upon $(x,y)+\{z, \{x,y\}$ = the two physical dimensions of depth and width and $\{t\}$ = time. The knight and the castle represent the dominant weapon system and fortification type of this epoch based upon an animal motive source. Modern battlespace is four-dimensional in nature based upon the incorporation of the physical dimension of height $\{z\}$. This was only made possible by the harnessing of mechanical motive sources that allowed for the development of the firearm, cannon and later aircraft and missile weaponry.

3. Michio Kaku, *Hyperspace: A Scientific Odyssey Through Parallel Universes, Time Warps, and the 10th Dimension* (New York: Anchor Books, 1994), 9.

4. Robert J. Bunker, "Advanced Battlespace and Cybermaneuver Concepts: Implications for Force XXI," *Parameters* (Autumn 1996), 108-120; and *Five-Dimensional (Cyber) Warfighting: Can the Army After Next be Defeated Through Complex Concepts and Technologies?* (Strategic Studies Institute [SSI], US Army War College [USAWC]: Carlisle, PA, March 10, 1998), 1-42.

5. For background information see Jeffery R. Cooper, *Another View of the Revolution in Military Affairs* (Carlisle, PA: SSI, USAWC, 15 July 1994), 1-46.

6. Mary C. FitzGerald, "The Soviet Image of Future War: Through the Prism of the Persian Gulf," *Comparative Strategy* (October-December 1991), 393-435; and "The Russian Image of Future War" *Comparative Strategy* (April-June 1994), 167-180. See MG Vladimir I. Slipchenko (Ret), "A Russian Analysis of Warfare Leading to the Sixth Generation," *Field Artillery* (October 1993), 38-41.

7. A.W. Marshall, "Some Thoughts on Military Revolutions," (Office of Net Assessment Memorandum, 27 July 1993); and Andrew Krepinovich, "Cavalry to Computer: The Pattern of Military Revolutions," *The National Interest* (Fall 1994), 30-42.

8. Alvin and Heidi Toffler, *War and Anti-War: Survival at the Dawn of the 21st Century* (Boston: Little, Brown and Company, 1993).

9. Joseph Nye and Williams Owens, "America's Information Edge," *Foreign Affairs* (March-April 1996), 20-36.

10. George and Meredith Friedman, *The Future of War: Power, Technology & American World Dominance in the 21st Century* (New York: Crown Publishers, 1998).

11. Nye and Owens, "America's Information Edge," 25.

12. Report of the National Defense Panel, *Transforming Defense: National Security in the 21st Century* (Arlington, VA, December 1997), 90.

13. Bunker, "Advanced Battlespace and Cybermaneuver Concepts: Implications for Force XXI," 116-117.

14. *Ibid.*, 111.

15. Bond-relationship targeting and cybershielding as operational concepts were first discussed in Robert J. Bunker, *Five-Dimensional (Cyber) Warfighting*. Prior to that paper, the concept of bond-relationship targeting being used by non-state forces was proposed in my article "Failed-State Operational Environment Concepts," *Military Review* Insights, September-October 1997), 91.

16. Malcolm H. Wiener, Chairman, *Non-Lethal Technologies: Military Options and Implications*, Report of an Independent Task Force (New York: Council on Foreign Relations, 1995), 4.

17. This form of warfighting also offers great potential against rogue nation-states willing to suffer massive human casualties to further their causes. Of concern is the great likelihood that the development of five-dimensional offensive operational concepts such as bond-relationship targeting has already been realized by non-state entities against the Western nation-state form. Such concepts would likely develop from a trial-and-error process rather than a focused research effort.

18. John Arquilla and David Ronfeldt, ed., *In Athena's Camp: Preparing for Conflict in the Information Age*, Chapter Six, "Information, Power, and Grand Strategy." In Athena's Camp-Section 1" (Santa Monica, CA: National Defense Research Institute, RAND, 1997), 148-149. Such targeting could be considered "hyper" rather than "cyber" based. Hyper targeting corresponds to novel technologies that attack, alter or influence embedded information as in the case of a genetic or chemical code. Cyber targeting attacks, alters or influences the higher-dimensional qualities of processing information within or outside the electromagnetic spectrum. I am indebted to Deputy John Sullivan for this observation.

19. Concepts of weapons of disruption and the employment of mass disruption as an operational concept first originated in discussions held by members of the Los Angeles County Terrorism Early Warning Group (TEWG) in 1996.

20. Richard J. Harknett, "Information Warfare and Deterrence," *Parameters* (Autumn 1996), 97. This term first developed by John Arquilla and David Ronfeldt when used by Harknett focused upon command and control warfare. See John Arquilla and David Ronfeldt, *Cyberwar is Coming!* (Santa Monica, CA:

RAND, P-7791, 1992).

21. Department of Defense, *Policy for Non-Lethal Weapons*, No. 3000.3, 9 July 1996.

22. Arthur Knoth, "Disabling Technologies: A Critical Assessment," *International Defense Review* (July 1994), 33-39.

23. Timothy L. Thomas, "The Mind Has No Firewall," *Parameters* (Spring 1998), 84-92. For other publications by this author on this theme go to the Foreign Military Studies Office website located at <<http://leav-www.army.mil/fmsol/fmsopubs/fmsopubs.htm>>.

24. *Ibid.*, 89.

25. Roland K. Mar, "Bang-Less Tank Killer," *U.S. Naval Institute Proceedings* (September 1986), 112-113; Stephen Budiansky, "All stuck up, no way to go," *U.S. News & World Report* (20 July 1987), 62; and Knoth, "Disabling Technologies: A Critical Assessment," 33-39.

26. Steven M. Rinaldi, "Chapter 10: Complexity Theory and Airpower: A New Paradigm for Airpower in the 21st Century," in David S. Alberts and Thomas J. Czerwinski, ed., *Complexity, Global Politics and National Security* (Washington: DC: The Center for Advanced Concepts and Technology, Institute for National Strategic Studies, National Defense University, June 1997), 247-302.

27. The actual Clausewitzian trinity is chance, rationality and passion. This trinity is loosely associated and has been promoted by modern military scholars such as Harry Summers, Jr., Martin van Creveld and David Jablonsky. For more on this controversy see Edward J. Villacres and Christopher Bassford, "Reclaiming the Clausewitzian Trinity," *Parameters* (Autumn 1995). To access this article within the Clausewitz homepage go to [<http://www.mnsinc.com/cbassfrd/CVZHOME/Trinity/TRININTR.htm>]. I am indebted to Dr. Steven Metz for this observation.

28. Mark T. Clark, "The Continuing Relevance of Clausewitz," *Strategic Review* (Winter 1998), 60.

29. Numerous documents and articles address the dangers that RF weapons pose to modern infrastructure. A number of these can be accessed at infowar.com. This threat is increasingly coming to the attention of the US government. See "GAO Launches Review of How DoD Handles the Radio Frequency Threat," *Inside the Pentagon*, 30 April 1998, 12.

30. Bunker, *Five-Dimensional (Cyber) Warfighting*, 24.

31. Joint Chiefs of Staff, *Concept for Future Joint Operations: Expanding Joint Vision 2010*, 52-54.

32. Chris and Janet Morris and Thomas Baines, "Weapons of Mass Protection: Nonlethality, Information Warfare, and Airpower in the Age of Chaos," *Airpower Journal* (Spring 1995), 15-29.

33. This proposed capability has not been discussed within the Department of Defense nonlethal weapons program. Instead, that program supports the *Joint Vision 2010* operational concept of full-dimensional protection. See Department of Defense Non-Lethal Weapons Programs, "A Joint Concept for Non-Lethal Weapons," *Marine Corps Gazette* (March 1998), A-1 to A-13.

34. Barbara A. Jezior, "Chapter 2: The Revolutionized Warfighter Circa 2025," in Douglas V. Johnson II, ed., *AY 97 Compendium Army After Next Report* (Carlisle, PA: Strategic SSI, USAWC, 6 April 1998), 41.

35. The battery issue is one of the major hurdles facing the Land Warrior system. See John G. Roos, "Power to Spare: Revolutionary Fuel Cell Could Be The Cure For The Army's 'Battery Blues,'" *Armed Forces Journal International* (May 1998), 17.

36. Martin C. Libicki, "Information War, Information Peace," *Journal of International Affairs* (Spring 1998), 419.

37. *Ibid.*

38. See Martin C. Libicki, *Defending Cyberspace and Other Metaphors* (Washington, DC: The Center for Advanced Concepts and Technology, Institute for National Strategic Studies, National Defense University, February 1997).

39. Pat Cooper and Jeff Erlich, "U.S. Troops to Field Shortstop Against Shells in Bosnia," *Defense News* (February 1996), 22.

40. Glenn W. Goodman Jr., "US Electronic Systems Highly Vulnerable to Radio-Frequency Beam Weapons," *Armed Forces Journal International* (May 1988), 20.

41. See Barbara Starr, "Non-lethal weapon puzzle for US Army" *International Defense Review* (April 1993), 319-320; and Sid Heal and Paul Evancoe, "Nonlethal Disabling Technology: A Future Reality," *Police and Security News* (September-October 1996), 3-16.

42. For recent Army work, see "Army Researchers Work on Realistic Holograms," *News Briefs, Army RD&A* (March-April 1998).

43. Jack Kehoe, "Laser Dazzler for Non-Lethal Force Applications," LE Systems Inc., Glattonbury, CT. Presented at Non-Lethal Defense III, National Defense Industrial Association, Johns Hopkins University, Laurel, MD, 25-26 February 1998.

44. Michio Kaku and Jennifer Thompson, *Beyond Einstein: The Cosmic Quest for the Theory of the Universe*, revised and updated (New York: Anchor Books, 1995), 165-167.

45. Earlier recognized by Ralph Peters. See his "The Culture of Future Conflict," *Parameters* (Winter 1995-96), 25.

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