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Nonlethal Weapons: Considerations for Decision Makers

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Abstract

The rapid changes in the political and technological arenas occurring today are fostering significant reexaminations of the role of military forces in the future. The success of high technology weaponry in the Gulf War, the increasingly intense media scrutiny of military operations, and the wide range of missions to which the military must now respond have combined to raise expectations that future wars may be fought with much less destruction and far fewer casualties. In support of such a vision, significant resources are being spent to develop nonlethal weapons that will disable and disrupt an enemy causing them to accede to our will and terminate the conflict. Ideally these weapons would not kill and their effects would be temporary and reversible, although in practice that may not always be true.

This paper examines several key issues surrounding nonlethal weapons. A variety of the proposed nonlethal weapons are discussed in the context of their technological maturity and support required, their operational utility, and the potential for countermeasures to reduce their impact. More general considerations are also analyzed including important underlying assumptions about future conflicts and the reactions of leaders, the legal ramifications of using certain of the proposed nonlethal weapons, and the potential for increased risk to friendly forces by their employment.

The conclusions drawn from this effort are that nonlethal weapons may offer some additional tools for use in crisis situations. However, the technology for several concepts is unproved and plausible countermeasures exist for some as well. The operational employment schemes for many of them are very preliminary and incomplete. Serious legal questions exist for many of the concepts. The impact of the media on the use of these weapons has also not been well explored.

Several recommendations are offered for critical reviews of the above issues including a Defense Science Board analysis of the technologies, an operational utility study using soldiers and commanders in the field, and strategic level war games with senior government officials.

About the Author

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Introduction

The pace of technological and political change in the current age is mind-numbing. In the military arena, technology has spawned incredible new weapon systems with capabilities only dreamed of just two decades ago. Political upheaval around the globe is producing a growing number of diverse situations in which to employ these wonder machines. Thus despite the tremendous advances in hardware and software, the precise political or technological tool required to resolve a particular situation is sometimes unavailable.

In attempting to meet the changing needs of the political and military leadership, there has arisen a chorus of voices advocating the development of what are termed, nonlethal weapons. Nonlethal weapons are, ". . . 'weapons that are designed to disable personnel, weapons, supplies, or equipment in such a way that death and severe permanent disability to personnel are unlikely'"(Cook, 78). A considerable amount of literature exists that extols the virtues and potential capabilities of such weapons. However, little of it delves into the various concepts in detail.

This paper examines a variety of proposed nonlethal weapons concepts and provides an assessment of their technological maturity and operational utility. In addition it discusses a range of the philosophical, political, and practical aspects of nonlethal weapons. In summary we will show that while nonlethal weapons have potential for addressing delicate situations, there are also very serious questions and unknowns that must be answered before a major development effort could proceed.

These topics will be addressed by first providing a short walk through history and the development of weapons, both lethal and nonlethal, leading to the call for nonlethal weapons. The crux of the paper will follow as a review of several of the major nonlethal weapons concepts focusing on the technological maturity, operational issues, and the probability of countermeasures. Then some of the key arguments in favor of nonlethal weapons will be examined. Next will come a discussion of certain overriding considerations such as the legal aspects of nonlethals, their likelihood of increasing risks to U.S. forces and interests in crisis situations, and the seduction of gradualism in their use. Finally some general conclusions will be drawn and recommendations will be offered for proceeding with nonlethal weapon development.

Technological Sketch of the History of Warfare

The history of warfare can be traced down many intertwining paths including the rise and fall of great leaders, the rise and fall of different political and governmental forms, as well as the development of technology and the weapons of war. The latter is the concern of this paper, for significant changes in the means of waging war are now occurring on the technological front. The meteoric rise of the microchip has enabled the acquisition and analysis of quantities of data that would likely have boggled General Douglas MacArthur's mind in Korea. The emergence of stealth has provided at least a temporary cover of electronic invisibility for aircraft. Precision-guided munitions (PGMs) permit us to drop bombs down air shafts and shoot missiles through specific doors rather than leveling entire city blocks. And the list goes on.

War is usually the last resort used to resolve a dispute. The costs of war in blood and treasure are always high. Thus only matters of the gravest national concern or interest merit such expenditures. The overriding motivation of military action in war is to achieve the political goals of the national leadership.

Subservient only to the above is the desire to preserve the lives of one's troops. It is the combination of these two goals that has driven the development of the strategy, the tactics, and the weapons of war.

Lethal Approaches

Among the most basic capabilities required in war, is the ability to exert force against the adversary in order to coerce him to relinquish his position in the dispute. The earliest men, no doubt, used their hands and feet to bend an opponent to their will. While effective, these "weapons" had limited range requiring the adversaries to be in close contact. Thus there was a high probability that both parties would suffer some damage in the exchange of blows. Further, a smaller, weaker opponent was at a distinct disadvantage, although maneuver and speed could sometimes compensate.

To overcome these limitations of the most basic weapons of war, man sought tools that would extend the range of effect and increase his survivability (as long as his opponent did not have a similar tool). Further, he looked for tools that would perhaps offset any size disadvantage. The club was a natural extension of the arm. It proved useful, but readily available to all parties, so the search continued.

Spears and bows and arrows projected force over much greater range than clubs and with impressive lethality. They could be produced fairly readily and made personal attributes such as steady hands, keen eyesight, good muscle control almost the equal of brute strength. They enabled previously "weak" individuals to not only survive, but to defeat physically larger opponents. However, soon this technology proliferated widely and the desired increased survivability was lost against similarly equipped foes. So ideas were explored to find weapons that acted over still longer ranges with even greater lethality. Enter the gun.

The invention of the gun and its evolution to include rifled barrels, mortars, and cannon caused dramatic shifts in tactics. Early firearms in massed formations were more useful for shock because of their very limited range and accuracy. They were used to stun an opponent with noise and uncertainty of being hit, thereby creating the precious seconds needed to set up and execute the decisive bayonet charge. These were classic Napoleonic maneuvers. The U.S. Civil War was one of the first conflicts to demonstrate that improved firearms permitted devastating attacks for more than a hundred yards with rifles and machine guns and farther with artillery. The days of the massed frontal assault were over as the enemy could be mowed down well before he reached his opponent's line.

Unfortunately for the dead and wounded of that war and World War I, doctrine and strategy were slow to adapt to the new battlefield reality. However, the common soldiers knew that a new level of lethality had arrived and, thus the period of trench came to pass. Gas attacks sought to break the stalemates of World War I, but proved so horrible by even the standards of war that they were subsequently outlawed— for those who respect such rules. The tank returned mobility and survivability to the battlefield vis-à-vis the infantry. However, in the game of move and countermove, tanks begot antitank weapons, so that they too became vulnerable.

The droning of aircraft in World War I and II brought war to the skies and, more importantly beyond the front lines. From then on no place was safe from attack. Air power advocates claimed that appropriate attacks against a nation's or enemy's centers of gravity (for example, leadership, communications, transportation nodes, power, and so forth) could induce surrender without having to meet and annihilate his army in the field as in the past. Coupled with an atomic weapon, a single bomber could wreak unimaginable destruction in minutes on an enemy's homeland.

Still there was hope of countering bombers with fighters, missiles, and the deterrence effect of one's own bomber fleet. Enter the ICBM. Now one could possess a weapon of incredible destructive power, able to strike anywhere on the globe within about 30 minutes, with virtually no means of countering it except deterrence. Fortunately, however, such systems are so sophisticated and expensive that only a few states have had the resources to build and operate them—to date. Thus at the major state level, a "Cold War"

was waged wherein means other than direct military confrontation were employed to promote and protect national interests.

Thus over the centuries, man has progressed from fisticuffs to thermonuclear war, from the ability to kill one at a time to killing millions in seconds. To many it may not appear to have been progress, but it was one flow of technology as men sought the twin goals of political resolution and personal survival.

Nonlethal Approaches

Paralleling the growth of lethal capability came developments in nonlethal means of military coercion in an attempt to minimize bloodshed. Methods were developed to put pressure on an enemy while keeping friendly forces and peoples at a safe distance. No doubt one of the earliest nonlethal techniques was maneuver. If one could put his adversary at a positional disadvantage, for example, backed up against a wall, or the sea, or trapped on all sides by opposing forces, there was some hope that the adversary would surrender without actual fighting. Sometimes it worked when the futility of the situation brought a logical response from the disadvantaged party. Sometimes it did not, when the emotion reigned more than reason. In the latter case the enemy still may have lost due his predicament, but a fight nonetheless ensued with losses on both sides.

Deception was employed to try and confuse the opposing leadership and convince them that they were outnumbered, outflanked, or otherwise in an untenable position. Again this may have worked a few times, but at other times, a fight and losses still resulted.

In some cases, an enemy could be isolated within the castle walls, in a Vietnamese valley, or in a modern city of the Olympics, Sarajevo. Rather than crash the gates and fight door-to-door, a siege was laid. (Note that an embargo is simply the economic analog of a military siege.) Without help or a valiant counterattack, the enemy chooses either to die slowly from deprivation and continuing weapons attacks or he agrees to terms of surrender. However, sieges tend to be long affairs that tax even the superior side. While sieges may not be strictly nonlethal, especially for the besieged, they potentially obviate direct fighting depending primarily on the reaction of the besieged.

Psychological operations (psyops) were developed to attempt to reach the rational and instinctive motivations of people and convince them that they would be better off to stop resisting. Common psyops techniques are dropping leaflets and transmitting radio and TV broadcasts explaining the advantages of "surrender" and the futility of one's prospects. By sowing the seeds of doubt about one's leadership, about one's relative capabilities, and about one's chance of survival, psyops hope to motivate the troops of an adversary to give up the fight saving himself and, no doubt, a few of the winners as well.

On a theater-wide geographic scale, interdiction and strategic attacks could be considered attempts to forestall the direct fighting of surface forces. Interdiction attacks destroy, delay, and disrupt the flow of supplies and troops to a battle area. On a somewhat broader scale, strategic attacks target the ability of the enemy to conduct operations, normal and wartime, by severing the leadership from the masses and disrupting key networks such as communications, power, and transportation. Strategic attacks could also range in severity from impeding up to destroying vital production capability such as nuclear, biological, or chemical weapons. The intent of such attacks is to create conditions under which the leadership cannot function effectively and realizes that they have no hope of successfully prosecute the conflict. In such a circumstance, the rational leader would sue for peace and avert further destruction and disgrace. While not strictly nonlethal, such attacks could be targeted against key facilities only, thus minimizing losses on both sides.

The latter stages of the Vietnam War and, most dramatically, the Gulf War saw the use of precision-guided munitions (PGMs). Laser-guided bombs and Tomahawk cruise missiles demonstrated the ability to hit vital targets with devastating effect, but minimal collateral damage. Vice the mass bombings of World War II, PGMs offered the opportunity to carry out strategic attacks without leveling entire cities and

causing enormous civilian casualties. Again PGMs are not strictly nonlethal, but they dramatically reduce the level of destruction needed to achieve a desired result.

Police forces have over the last few decades sought to develop nonlethal means to subdue criminals and control crowds. The civil disturbances of the 1960s saw the introduction of water cannons to disperse unruly demonstrators. Tear gas has been used in such roles as well as to dislodge barricaded suspects. More recently police have tried rubber bullets to stun and knock down offenders. Pepper spray and Mace have become popular for disabling an assailant in close quarters. Somewhat more high tech devices include the laser and stun gun that project high voltage electricity into a person via attached electrodes or darts with trailing wires back to the gun. All of these have met with varying degrees of success. However, some, like rubber bullets, have a higher degree of danger than desired. Others, like the Laser and stun gun, have very limited range and their effects negated by heavy clothes. Still, they continue to be used and modified to increase their utility. Some of these devices have been considered for military applications as well.

Recent conflicts have seen the rise of the media as a vital tool, if not a weapon, of conflict. Used effectively by the Somali gangs, the television images of a dead American soldier being dragged through the streets aroused strong sentiment among the American public to withdraw. The Iraqis attempted to use it to promote sympathy by showing selected pictures of bombed buildings. Early on they also used it as a threat by showing pictures of American "guests" who were not allowed to leave the country. The clear implication being that they were being held as hostages against an attack. Indeed, the pervasiveness of television and radio demand that a party's actions be able to meet the scrutiny of the media. The humanistic bias of most media representatives means that any action that seems unjust or extreme (by their own definition) will be trumpeted loudly and used to excoriate the perpetrator—especially if it is the United States. Thus any destruction or loss of life will require the leadership to justify to the news anchors why it had to be. This microscopic examination of each detail of the conflict has put intense pressure on the military to minimize loss of life and property. A clever adversary will thus use the media to argue his case on the world stage trying to sway world opinion in his favor.

This abbreviated jaunt through history has shown that man has sought to develop effective means to defend himself and his interests while putting himself at minimal personal risk. This has resulted in parallel technology and strategy paths. On the one hand the capability to deliver lethal power has escalated from punches from the hip to hydrogen bombs from the other side of the globe. On the other hand nonlethal means of inducing compliance have progressed from maneuver to media sound bites. In an increasingly humanist society with instant access to distant places and events, the loss of life and property is viewed by the developed countries with increasing distaste. The American people want to be protected, but they want everyone else protected, too. Could this desire to minimize loss result in putting U.S. lives and property at risk solely to preserve that of the enemy's? A review of recent U.S. experience in conflicts of various sorts may provide a background to examine the above question.

Results of Recent Conflicts Set Expectations

Civilization provides a framework of rules for living together and sharing resources among competing interests—read, people. As a civilized society Americans would like to foster our traditions of life, liberty and happiness around the globe. We dislike aggression, but will use it if it serves our supreme national interests. We were repulsed by the bloodshed in Vietnam on both sides. We were motivated to support the Gulf War, although the debate was considerable, by our distaste for Saddam Hussein's wanton rape of Kuwait. Yet there was much agonizing before the actual shooting war began over the potential conflict and loss of life. The American public and the world were pleasantly surprised.

American losses in the Gulf War were extraordinarily small—just 390 killed (Mann, 123). While prewar predictions set our losses in the many thousands, the final result was a relief, but may also be a curse. Indeed the campaign plan that the coalition executed achieved the objective of expelling Iraq from Kuwait with minimal losses and seemed to function so smoothly that an expectation has been established in the mind of the media and the American public that all future wars will be like the last one. Such a

sentiment is one of the cardinal sins in military history and planning, that is, to expect the next war to be just like the last war.

The Gulf War had some unique aspects that played strongly into our hands, but may not be, in fact were not, there in subsequent conflicts. For example the Iraqis made their move into Kuwait and then dug in. They gave us six months to move in troops and supplies without interference, thus allowing us to take full advantage of the considerable infrastructure of bases, roads, ports, and so forth that existed in Saudi Arabia. Had they kept on moving into Saudi Arabia and the neighboring states after taking Kuwait, no one could have stopped them. They would then have controlled the majority of the world's oil reserves and been able to unilaterally conduct an oil embargo that would have seriously impacted the coalition nations. They also would have controlled all of the facilities, such as air bases, ports, roads, and so forth, and land in the theater. We would have had to stage an amphibious assault, which we have not done since Korea, and bomb from who knows where—Europe or even the Continental United States (CONUS). Having to fight our way in would have radically altered the strategy. The luxury of a 40-day strategic air campaign and the resulting dismemberment of the Iraqi infrastructure and fielded forces would likely have been sacrificed in favor of close air support, air superiority, and close interdiction missions.

The Gulf geography was ideal for our operations. The flat featureless terrain permitted our optical systems unobstructed views of targets over long distances. While some will claim the weather was poor, the weather anywhere can be poor. Our tanks could rumble across the open sands with their infrared sights picking out enemy tanks and trucks easily and firing on the run with no fear of interference from trees or rocks or buildings. One can not help but wonder how well things would have worked in the triple canopy jungles of Vietnam.

It should also be noted that this was the first conflict after the "end of the Cold War". And, while the Soviets were not enamored with the coalition approach toward their former client state, it was clear that a superpower confrontation would not result from our actions. One could suggest that this allowed the coalition to do things they may not have under earlier circumstances, such as violating Iraqi sovereignty by invasion and bombing. It is dangerous to think we will have such free rein in all future operations.

Yet elsewhere we have seen that in the 1990s, mankind is still quite capable of mass slaughter. The wars in Somalia and Rwanda have left hundreds of thousands dead, starving, and diseased. And lest we think it only happens in "underdeveloped, uncultured" nations, the spectacle in Bosnia is a chilling reminder that we all can succumb to such emotional arguments as nationalism and ethnic preservation.

In the above cases our vaunted weapons and military prowess had debatable impact. In Somalia, we came as "angels of mercy" to protect the relief workers and end the starvation. These admirable goals were not appreciated by those who derived power their control of the food supply. However, when we attempted to halt the aggression by trying to directly suppress the warring factions, we were portrayed as the enemy by the warlords and the media. By employing low-tech guerrilla tactics, the "technicals" were able to frustrate our effort at control and produce a seemingly moral victory over the best our Army has to offer. The resulting outcry from the media, the Somalis, and the American citizens over the deaths of U.S. troops forced our withdrawal.

In Bosnia our military efforts and those of our allies had arguable effect on the conduct of the war prior to the Dayton Peace Agreement. The dubious results stemmed from a lack of resolve to take decisive action against all parties in the fighting. Part of that reservation derived directly from the Western view that the Serbs were the primary culprits, but the Russians favored the Serbs based on historical alliances. Thus the lurking shadow of the old superpower stand-off hovered over all deliberations. The warring parties saw the confusion and hesitation in the response of the European and American governments so they pressed on with their attempts to divide the country. Even the presence of UN peacekeepers did little to quell the violence. Knowing the restrictive rules of engagement the peacekeepers operate under, the factions avoided directly attacking the peacekeepers "en masse" and dared the United Nations to stop them otherwise. Only after a significant military turnaround brought on by the Croatian–Muslim offensive did the Serbs see that it was time to negotiate and preserve what territorial gains they still had.

With the peace agreement came a massive influx of peace enforcers with much more liberal rules of engagement, but also with a specified time limit. To date, there has been little resistance to meeting the terms of the agreement. However, despite the aggressive mandate the peace forces have under the treaty, the level of paranoia about being seen as too mean or unfair is graphically illustrated by the fact that in the several clashes with recalcitrant parties, the allied troops have actually had to count and report how many bullets they shot.

It is an interesting confluence of views on such disparate situations as the grand success of high technology weapons in the Gulf War and the frustration of the unconventional circumstances faced in Somalia that has brought forth a call from some quarters for more and better options for dealing with crises—nonlethal options.

Call for Nonlethal Weapons

In a rapidly changing world one needs to have many tools to respond to new predicaments. In the arena of international affairs, the standard resources of diplomacy, economic inducement, military power, and media exposure continue to be the principal means by which states and transnational organizations deal with each other. However, some claim that this increasingly nuanced world requires more options, more means to preserve the peace and protect our interests. In particular they are concerned with the tremendous leap that occurs when diplomacy is insufficient and military force—lethal military force—is applied (Black, 3). They ask if there are not some ways to apply force, but in such a way as to gain the adversary's compliance without suffering the world's recrimination for having used it. Enter nonlethal weapons.

The term nonlethal weapons refers to ". . . weapons systems that are explicitly designed and primarily employed so as to incapacitate personnel and materiel, while minimizing fatalities, permanent injury to personnel, and undesired damage to property and environment" (Swett, 1). Nonlethal weapons can be broadly classed as either antimateriel or antipersonnel. Some technologies can be both.

Among the goals of nonlethal weapons is to provide national leadership and field commanders those additional options mentioned above to apply force that is nominally below the lethal threshold. As a leading advocate, Janet Morris, has stated:

> Nonlethality's allure is simple: between the moment when diplomacy fails and conventional military force is considered, the United States needs more options to either sending in a totally lethal force or accepting the status quo (Morris, 58).

Hopefully such actions will convince the opponent to accept our terms before either side incurs significant losses because of the employment of lethal force.

The draft DOD policy for nonlethal weapons further specifies desirable features they should possess:

> a. They have relatively reversible effects on personnel and materiel. The targets either return to their pre-attack state without extrinsic assistance, or in the case of some materiel targets, it is cost effective to render them fully functional again rather than replacing them.

> b. They affect objects differently within their area of impact. Unlike lethal weapons which by their nature are damaging to virtually al physical objects with which they come in contact, non-lethal weapons may leave different objects within their radius of effect totally or partially disabled, or altogether unharmed (Swett, 1).

As such nonlethal weapons may degrade the target nation's infrastructure during a conflict, but permit its rapid reconstitution afterward, thus reducing reconstruction costs. Some make the argument that the level of destruction contributes to the stability of the resulting peace. Pointing to Sherman's campaign in the Civil War and the resulting debacle of Reconstruction, the punitive provisions of the Versailles Treaty that contributed to the rise of Hitler, and the counterexample of the Marshall Plan after World War II,

Bouchard, and others, suggest that nonlethal weapons could enhance peaceful settlements by reducing the difficulty and costs of returning to normal (Bouchard, 21–23).

There exists much debate about the term "nonlethal weapons". Most parties acknowledge that no system is absolutely nonlethal under all circumstances (Alexander 1995, 2; Swett, 3). As Eliot Cohen writes:

> In many cases, so-called nonlethal weapons will prove just the reverse. The occupants of a helicopter crashing to earth after its flight controls have fallen prey to a high-power microwave weapon would take little solace from the knowledge that a nonlethal weapon had sealed their doom. Some of these weapons (blinding lasers for example) may not kill, but have exceedingly nasty consequences for their victims (Cohen, 121–122).

A variety of other terms are sometimes used including "soft-kill," "disabling," and "less-than-lethal". However, as John Alexander, the most visible advocate has said, "I have chosen to use 'nonlethal' because it has an emotional hook" (Alexander 1995, 3). And elsewhere he suggests that:

> It is postulated that major political benefit can be accrued by being the first nation to announce a policy advocating projection of force in a manner that does not result in killing people. Having been through a number of names, I can say that nothing has had the impact of "Non-Lethal" (Alexander 1992, 5). (Emphasis is original author's.)

Nonlethal weapons advocates are also fond of quoting Sun Tzu, the ancient Chinese military thinker who wrote:

> To fight and conquer in all your battles is not supreme excellence; supreme excellence consists in breaking the enemy's resistance without fighting. In the practical art of war, the best thing of all is to take the enemy's country whole and intact; to shatter and destroy it is not so good. So, too, it is better to capture an army entire than to destroy it, to capture a regiment, a detachment, or a company entire than to destroy them (Tzu Sun, 9).

The nonlethal advocates suggest that winning, that is, achieving the military and political goals, is not sufficient any longer. One must do it with minimal, preferably no, dead and wounded.

However, the nonlethal advocates do not forsake completely the use of lethal force. Alexander responds to his critics' objections saying:

> A second argument goes that "Non-Lethal" would infer a position of weakness. Nothing is further from the truth and recent Persian Gulf activities have adequately demonstrated our lethal capabilities. We are advocating an integrated approach including lethal force when necessary. The focus is on expanding options for the commander, not in reducing capabilities (Alexander 1992, 5).

Indeed the draft DOD policy further states:

> The availability of non-lethal weapons will not limit a commander's inherent authority and obligation to use all necessary means available and to take all appropriate action in self-defense of the commander's unit and other US forces in the vicinity (Swett, 2).

> Non-lethal weapons may be used in conjunction with lethal weapon systems to enhance the effectiveness and efficiency of military operations. This shall apply across the range of operations to include those situations where overwhelming force is judged the best means of minimizing fatalities and collateral damage by ensuring that the conflict comes to a rapid and uncontested conclusion (Swett, 3).

The United States has seen in recent years an increase in the number of military operations that are conducted below the threshold of full-scale, theater-level war. Consider our recent deployments into Panama, Grenada, Haiti, Somalia, and Bosnia. One could also argue that our efforts protecting the Kurds in northern Iraq and maintaining air cover for the minority Shiite Muslims in southern Iraq are in the same category although they derived directly from the Gulf War. Such activities are becoming a major focus of

military life and have spawned a new term to describe them—Operations Other Than War (OOTW). While we have always conducted humanitarian missions, they have usually involved airlift and maybe some civil engineers. Now we find combat troops on the ground and in the air keeping peace, trying to establish infrastructure, and rebuild states.

In many of these cases, the military functions as a police force. In so doing they face the same challenges of "real" police in deciding when to use and when to refrain from using lethal force. Crowd control can be especially difficult when instigators use civilians, women and children, as shields for looting and sniping at the troops. Indeed in many situations the bad guys look just like everyone else. How is the soldier to sort them out? Could nonlethal weapons permit a greater ability to handle such nebulous situations?

Even beyond the police role, many argue that nonlethal weapons can play a role, perhaps a decisive role, in the conduct of conventional, theater war (Bouchard; Klarren). They point to the use of carbon fibers on Tomahawk cruise missiles that shorted out power substations in the early hours of the Gulf War as evidence of their utility (Aftergood, 42; Fulghum 1992, 62; Fulghum 1994, 26). They envision entire communications networks taken off the air, power grids shut down, aircraft and vehicles immobilized, financial systems gone haywire, all without human casualties and able to be undone quickly and easily when the offending entity capitulates to our demands.

The next section will address some of the emerging nonlethal weapons concepts. In so doing, the concepts will be measured against the above attributes and analyzed for their potential operational contributions and limitations.

Review of Concepts

The breadth of potential nonlethal weapons is quite broad as it should be if their utility is to span the range of conflict from humanitarian assistance to full-scale conventional war. Unfortunately few of the articles written on nonlethal weapons discuss the concepts in much depth. Usually they simply give a simple description of the technology and a superficial sketch of how it might be employed. The present article seeks to distill from the unclassified literature a more thoughtful examination of these concepts. Each technology will be described and an assessment of the existing or required technology support to bring it to fruition will be discussed. The operational utility of the technology will be addressed including its possible uses and difficulties therewith. The operational utility discussion will also seek to differentiate between OOTW applications and full-scale theater war applications. Certainly nonlethal weapons might be used throughout the force application continuum, but examining the end points of that range may be enlightening. A "Red Team"-type analysis is also included to assess the feasibility of countermeasures including direct and indirect responses. The subsequent section of the paper will address some broader considerations of countermeasures that may apply across the board for these technologies.

The nonlethal concepts discussed below will not include the existing systems mentioned in the previous section. The limitations of those techniques (Tasers, pepper spray, rubber bullets, and so forth) make them less useful for the wide-ranging applications facing the military. Nonetheless in OOTW situations, some of these more "traditional" means may be employed for police-type actions. Thus the following concepts are those advanced ideas that may have broader applications for military missions.

Stick-ums

Of the variety of possible nonlethal weapons, perhaps the most popular, near-term, and visible are affectionately known as "stick-ums". The purpose of these devices or substances is to impede, hopefully deny, the mobility of vehicles and personnel.

The stick-ums come in two forms. In one a condensed polymer is shot from a gun reminiscent of a child's Super-Soaker, reacts with air to physically expand, and form a highly sticky foam. Used against an individual, the person can be virtually glued to a surface or turned into an immobile "tar-baby". A second type, similar to super glue might be sprayed as a mist from aircraft or aerial munitions to foul air-breathing engines or cooling systems for vehicles or facilities, perhaps even lock up aiming and firing mechanisms in guns and artillery (Evancoe June 1994, 70; Scott, 50).

The technology for some of these has been demonstrated. Sandia Laboratory has produced a polymer foam and sprayer that can propel the foam up to 35 feet (Valenti, 87). Sandia has also tested the foam on aircraft landing gear to show its effectiveness (Scott, 50). In fact, the Marines covering the withdrawal of U.S. troops from Somalia in 1994 were equipped with some of Sandia's sticky foam sprayers (Scott, 50). While nontoxic, the foam is exceedingly difficult to remove requiring additional research into possible solvents. The foam can also present a serious danger to victims if it is ingested into the mouth or lungs.

Operational Utility

OOTW Application. An obvious use of sticky foam would be in a police-type action such as crowd control or a hostage crisis where one or a few localized villains need to be selectively subdued. If the offender can be identified and approached, the foam may be a better alternative to a gun even in a crowd. It may be

better to risk having several innocents sprayed with sticky foam rather than sprayed with bullets. Further, one can envision "barricades" of foam that would restrict movement of the crowd and keep them out of sensitive areas. Similarly if a vehicle could be sprayed, it may be possible to gum up the wheels so it could not move or only move slowly.

Theater War Application. On a grander scale of shutting down an air base or denying access to a road or bridge, the key factor would be delivery of the foam. Larger areas will require much greater quantities of foam. On site delivery via truck would be the simplest for a road. Long distance delivery via bomb or shell or missile warhead would require some degree of precision although that should not be difficult. However, many bombs or shells may be needed to cover the area desired with a sufficient quantity of stick-um to deny transport. The bombs and shells may also require special designs to minimize the collateral damage simply from the kinetic energy of their impact and their fragments.

The super-glue aerosol might be a better choice for area coverage because it might only require a thin film and thus much less quantity than the foam (Garwin, 111). However, the effects on people caught in a super-glue mist could be quite lethal.

Possible Countermeasures

Potential responses to the stick-ums depend on the circumstances. For example, the most direct counter to the sticky foam sprayer in a one-on-one encounter is a gun. Consider the relative ranges of an AK-47, Uzi or Saturday Night Special to the 35–50 foot range of the sprayer.

For area denial, one can imagine several possibilities. Noted defense technology consultant, Dr. Richard Garwin offers:

> The use of "stick-um" provides an interesting example of countermeasures. If some such contact adhesive were sprayed on the pavement, it could very well inhibit foot traffic and even passage by certain vehicles. Bare feet would soon be bloody because of the removal of a layer of skin with each step. However, sand spread on the stickum-coated surface would presumably stick (what else?) and provide a "sandpaper" surface on which one could walk or drive (Garwin, 116).

Alternatively, if the area is clear enough, setting fire to the surface by spreading gasoline or such might burn the stick-um off relatively quickly. Of course, going around the area may also be possible. Such countermeasures are clearly within the capability of any adversary.

Summary

Adhesive technology may be useful for surprise situations to apprehend a subject or to delay use of a road, bridge or runway. The technology exists, although delivery mechanisms are limited by range, quantity required versus quantity delivered per carrier, and the potential for collateral damage. Several simple countermeasures are available that could significantly limit the impact of stick-ums.

Slick-ums

The slick-ums, or anti-traction technology, derive from work on superlubricants like Teflon. Surfaces coated with a slick-um become almost impossible to walk or drive across. Such compounds exist for a variety of uses, but are not currently used for anti-traction applications (Evancoe 1993, 28). A recent example of this type of technology is the introduction of automobile engine oil additives that coat the internal engine parts and reduce the wear on these parts especially during a cold start when oil is not present. For maximum effect, it may be necessary to combine several lubricating substances into a single solution (Evancoe 1993, 28).

The slick-um material might be applied by spraying from an aircraft or, if the desired location is accessible, another vehicle. Alternatively, it might be dispersed by a munition, be it a bomb, missile, or even artillery shell (Evancoe June 1994, 69–70).

Operational Utility

OOTW and Theater War Application. The obvious uses for slick-ums are to deny an enemy use of key transportation features and other surfaces. Likely examples of such surfaces are railways, roads, bridges, and runways (Evancoe 1993, 28). Like the stick-ums, a major concern is the amount of material required to achieve the desired result. The effectiveness will clearly depend on the particular nature or condition of the target surface. A smooth surface such as a concrete runway will be easier to deny than a gravel road. The larger the area or the thicker the coating required, the greater the quantity of slick-um that will be needed. Thus the delivery schemes might get rather complex or large. The advantage of using the slick-um vice an explosive device (bomb, missile warhead, cannon shell) that craters the site will have to be weighed against the relative number of munitions and vehicles needed and the risks to the accompanying air crews or artillery crews associated with delivering the two alternatives (Evancoe 1993, 28).

Further, slick-ums may be temperature and weather-dependent. If so, each application may have to be carefully blended for the conditions expected. This may add complexity to field deployments by requiring complex mixing facilities and a range of compounds to be on hand. Depending on the sensitivity of the compound to weather conditions, the delay imposed may only last as long as the weather. It may also lead to effective countermeasures.

A key issue is whether the delay imposed by the slick-um is sufficient to permit achievement of a particular objective. Persistence is a vital attribute that slick-ums must possess. The time factor involved may be relevant for close battle situations where short periods of minutes or hours are needed to allow maneuvers to a position of advantage. This could apply to both OOTW and theater war situations. However, for "strategic" or deep interdiction targets, the surface must be unavailable for a considerable period (days or more) to impact the larger campaign or the functioning of the state. If the slick-um cleans up relatively easily or loses its properties with weather changes, then the target must be hit again and again to keep it unavailable. This can make the whole process very costly and very risky.

Possible Countermeasures

A number of potential countermeasures can be envisioned. First, using a flamethrower or covering the surface with gasoline and trying to burn it off may be quick and easy. It may be possible to use some type of acid to eat away the coating. This would likely take longer than burning, but may be more surreptitious. Such reactions would be available to both an industrialized opponent like Iraq and the "technicals" in Somalia.

A more sinister approach would be to recognize that nonlethals are being used largely in response to the media coverage of warfare and the repulsion of the general public, Western society especially, to the realities and brutalities of war. How much would the aura of nonlethals suffer if CNN were handed a videotape of a bus full of children that slid off a bridge or tumbled down from a mountain pass that had be "slicked" the night before? If this sounds far-fetched, recall that the communications bunker in Baghdad was being used as a shelter. Did Saddam hope to dissuade an attack by using human shields? Dismissing such possibilities as unlikely or ridiculous stems directly from assuming the opposition holds the same values and respect for human rights as we do. This can be a dangerous assumption.

Summary

Slick-ums may have some limited utility for specific situations to channel or limit enemy movement for short periods, especially in urban areas. Should there be key nodes such as limited numbers of bridges or mountain passes, the use of slick-ums may be able to impact the theater-level battle. The vital quality

in question is the persistence of the material. It is likely that even an unsophisticated enemy would be able to quickly respond and limit the impact of the slick-um on their operations.

Lasers

Lasers are often touted as likely nonlethal weapons. Very large lasers have been under development for many years to destroy targets at great distances, but remain unwieldy for widespread applications. For example, the Air Force has a program to demonstrate an airborne laser to destroy ballistic missiles in their boost phase. However, the device requires a Boeing 747 to carry it.

Smaller, lower power lasers have a variety of potential applications. Well known among these are the use of laser range-finders on Army tanks to accurately gauge enemy targets while the tank is on the move. Also lasers were introduced in Vietnam to designate targets for guided bombs. The accuracy of such systems has continued to evolve, so that in Desert Storm, we saw laser-guided bombs directed into the front doors of aircraft shelters and down the ventilation shaft of the Iraqi Air Force Headquarters. While the laser itself was not lethal in these cases, its use was part of an overall lethal weapon system.

The Army has investigated using lasers to blind optical sensors such as missile seekers, forward-looking infrared sensors (FLIRs), low-light-level television cameras, and night-vision goggles (O'Connor, 339). The proliferation of these sensors on helicopters, tanks, and throughout the battlefield makes their incapacitation a high priority.

During the Gulf War, the Army deployed two units of a prototype system called Stingray, which were designed to blind optical sensors. The Stingray was designed to mount on a vehicle. The systems were never used because sufficient training and tactics had not yet been devised to allow them to be integrated into an existing operating force (Callen, 1).

Unfortunately, such devices can have sufficient power to cause temporary and, under certain circumstances, permanent blindness in personnel. The Army and others had been testing laser rifles to blind optics and provide a more portable device than the Stingray. Some were sent to Somalia, but the local commander banned their use probably because of concern for the possible political ramifications of an accidental blinding (Arkin, 63). It had been the position of Army lawyers that such devices fell within the limits of the Law of Armed Conflict (LOAC). The Army had awarded a full-scale production contract in the fall of 1995, but canceled the contract shortly thereafter when the Administration changed its position on blinding lasers and sought to demonstrate positive initiative in this arena (Arkin, 62).

Operational Utility

OOTW Applications. An anti-materiel laser is useful only against a sophisticated enemy who possesses optical devices. Many of these devices are likely to be found in a theater-level conflict as they are sold by most major developed nations. It is also likely that some equipment, like night-vision goggles and low-light television systems, are used by well-heeled drug dealers and terrorists. To that extent an optics-blinding laser may cause great disruption of an adversary's operation if he suddenly can no longer where he is going. Further, the reflection of the laser beam off the optics should allow the enemy to be located across significant distances and in obstructed settings such as a jungle or an urban area.

Theater War Applications. A key consideration is the desired result of using the laser. In the ideal nonlethal mode, only the opponent's optics would be attacked and damaged. If the intent is not to shoot the opponent with explosive ammunition, is it reasonable to expect that he will surrender or run just because his optical system is blinded? Most military systems have back-up modes of operation just in case the primary mode fails. While not optimum, the back-up system still allows the soldier, sailor, or airman to complete his or her mission with some degree of confidence or effectiveness. From a parochial viewpoint, I doubt that a U.S. crew of an M1A2 Abrams tank would surrender just because their thermal sight stopped functioning. They would find another way to get the job done. Therefore the laser may be

effective in disabling the enemy's primary detection and tracking device, but is that sufficient to render him harmless?

Which leads to the logical issue that if one is going to shoot the opponent with an armor-piercing shell anyway, why worry about his optical sight? What is the purpose, much less advantage, of blinding his optical sight, but leaving the tank or artillery piece otherwise intact to face you with a back-up targeting system now or on another day with a new optical sight? Further, how "nonlethal" is the laser if it simply causes the opponent to hesitate so he can be destroyed more easily. The DOD draft policy certainly allows for such integrated use of lethal and nonlethal weapons. Still, one must ask what is the marginal benefit over going strictly lethal versus the cost in money and complexity of adding the nonlethal component.

Beyond tanks, another similar use of a laser is to knock out the tracking sensor of an infrared or optically-guided surface-to-air missile (SAM). Such missiles are becoming increasingly sophisticated, available and lethal. Most of the aircraft lost by the coalition in the Gulf War went down to shoulder-fired, infrared SAMs. Imagine the political and media impact of shooting down a cargo plane full of troops or orphans just after take-off or before landing. Large transports are extremely vulnerable because of their size, slow speed, and limited maneuverability. Using a laser to sweep an area and disable any and all optical instruments seems like a good idea. However, unless the system is very smart or discriminating, one may take out the eyes of a child with binoculars, who just came out to see the planes, as well as the SAM. While sounding far-fetched, consider that a SAMs range can be several kilometers so that the sweep pattern must likewise extend several kilometers in diameter along the flight path. To reach these distances will require lasers of considerable power that would be capable of permanently blinding people who looked at it.

Possible Countermeasures

Which raises the issue that canceled the Army program. The LOAC bans certain weapons that are intended to maim and cause unnecessary physical suffering, but not necessarily kill (Cook, 80). There has been an on-going national and international debate as to whether low power lasers intended for blinding people fall under this category (Arkin; Cook, 84-85; Anderberg). The United States had long maintained that blinding lasers were not covered by the above restrictions. However, because of much international pressure and the different viewpoint of the current Administration, the United States agreed to a ban on ". . . laser weapons specifically designed, as their sole combat function or as one of their combat functions, to cause permanent blindness to unenhanced vision . . ." (Arkin, 62).

The above protocol has some obvious loopholes that will no doubt permit use of lasers on the battlefield for designation, ranging and, possibly, damaging optical equipment. However, the United States seems to have taken a more proactive position. In canceling the Army program, the Department of Defense sought to ". . . take a lead role . . . by swearing off the development and use of lasers intentionally designed to blind people" (Arkin, 62).

Clearly, then the most effective countermeasure may be to parade some blinded soldiers in front of some CNN cameras to show how brutal the United States and her allies are. Cries of war crimes would certainly be heard. It is probable that the nonlethal property of the system would be lost in the furor.

As a practical matter, optical filters can also be used to protect many systems. The difficulty is knowing what the wavelength of the laser is so that the correct filter is used. Obviously a filter restricts some of what the sensor can see. If the filters need to protect against a wide range of laser wavelengths, the effectiveness of the sensor is seriously degraded. However, if only a couple of wavelengths are threats, it is possible that cheap, effective filters could be produced quickly. Conversely, the complexity and expense of a nonlethal laser system increases if it must work at multiple wavelengths or several systems are needed to cover a wide enough range to beat the filters. The resulting "cat and mouse game" should be examined from a cost-benefit standpoint to determine the value of pursuing it.

Summary

Low power lasers for damaging optical systems are or soon will be available. They will likely have utility against a sophisticated enemy who is employing optics as we do. However, their effectiveness may be limited by battlefield conditions and the use of filters. Current U.S. policy and recent LOAC conventions forbid lasers whose primary purpose is to blind personnel. The United States has no programs developing such devices. Despite our efforts and policy pronouncements, use of anti-materiel lasers could result in collateral blindings with attendant outcries from the opposition (Garwin, 121). The key question is whether just disabling an optical system is sufficient to stop an attacker or induce conciliatory action on their part. If not and we have to shoot them with lethal rounds anyway, it would seem that the nonlethal laser has limited relevance for such scenarios.

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Electromagnetic Pulse

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Electromagnetic pulse (EMP) systems deliver electromagnetic energy at radio-frequency wavelengths, which are much longer than lasers. EMP could be used to disrupt or damage electronic components in computers, communications systems, radar sets, and so forth (Evancoe June 1994, 69). It offers some potential advantages in that EMP is much less affected by the weather or other optical obstructions. EMP suffers from being much less directional and immature in its development.

   EMP devices are derived from phenomena observed during high-altitude nuclear weapons effects tests wherein very large pulses of broadband electromagnetic energy were generated in the blast (Alexander 1989, 38). In particular, it was found that at high altitudes, this energy could propagate great distances and cause significant disruptions of communications and power distribution systems.

   The proposed EMP devices would be non-nuclear driven using a conventional explosive to drive a pulse generator (Fulghum 1994; Kiernan; Fulghum May 24, 1993, 61; Fulghum Feb. 22, 1993, 20). A much-discussed delivery mode is aboard a modified air-launched cruise missile (ALCM). The ALCM would approach the target at a relatively low altitude, but rather than diving into the target and blowing it up, the missile would explode above the target and direct its EMP pulse at the target (Fulghum Feb. 22, 1993, 20; Fulghum May 24, 1993, 61). The Army is looking at alternative approaches including EMP artillery shells ("Army Prepares," 62).

   The vital issue for EMP devices is whether sufficient energy can be generated in a package sufficiently small to be delivered. A conventional explosive produces orders of magnitude less energy than a comparable-sized nuclear device. Further, the proposed EMP generator requires a capacitor bank to provide an initial current and field that is "amplified" in the explosion (Fulghum May 24, 1993, 61). Capacitors are notoriously heavy, although continuing development is slowly reducing their size (Evancoe 1993, 27). Thus to achieve the desired energy on target in an acceptable size package, the EMP source must be reasonably close.

   A second issue is directing the energy. Clearly, if the energy can be "focused" on the target, less total energy is needed than if it is allowed to spread everywhere. Indeed this is the real advantage of the laser over an ordinary very bright light. However, at the longer wavelengths and across the broad band of wavelengths EMP devices produce, focusing of the beam is difficult. One design discussed in the literature professes to have a thirty degree beam spread, which is still wide as will be discussed below (Fulghum May 24, 1993, 61).

   And overshadowing all of the above is a significant level of uncertainty regarding the vulnerability, or level of energy required to produce a desired effect, of the systems being attacked. The vulnerability uncertainty must then be multiplied by the uncertainty of the fraction of energy that penetrates into the device after having to pass through building or bunker walls, interior enclosures, and, finally, the device's case. As a result, the energy required in the EMP pulse to be effective can vary over a wide range. System designers must either build very powerful, thus large, devices to account of the worst case or accept some level of risk of failure by designing to some lower level.

Operational Utility

OOTW Applications. Operationally, EMP looks like a strong nonlethal contender. If it can deliver sufficient energy, it could disrupt communications systems, cause computers to lock up or distort data, and may disturb other electronic components such as vehicle ignition systems ("Army Prepares," 62; Evancoe 1993, 27). Further, it could do this without actual contact with the target and with very little collateral damage. Ideally, EMP would actually cause physical damage by inducing very strong stray currents in components causing them to fail catastrophically. Disabling an adversary's communication system would clearly make him less effective and disrupt his coordination of movement. The level of sophistication of the opponent in an OOTW context would ultimately determine the usefulness of EMP. Further, should the battleground be an urban area, the use of EMP may produce serious collateral damage to the electronics of the noncombatant population. Thus locating and isolating the adversary would be very important to effective employment of and EMP weapon.

Theater War Applications. The effects of an EMP device could take air defense systems off-line, disable tanks and vehicles, and shut down command and control networks. In the case of disruption, the effect may last seconds to minutes, while systems are reset. In the case of damage, the time factor may be hours to days since the failures would be randomly located in the devices and thus perhaps, very difficult to isolate and repair.

Another serious concern with using EMP is battle damage assessment. Because there is no smoldering hulk of a command bunker or radar van or communications building, how does one know that the desired results were achieved? Certainly, monitoring the sight for signals would give a good indication. If there are none, or significantly fewer than before the attack, one may reasonably assume that some level of effect was produced. However, the adversary could also be playing possum, waiting for a better time to reactivate his systems. In no case would the attacker know how long the effect(s) will last. If lucky and actual damage was produced, the time could be long. If not so lucky, it may be only a short period. This will only be known if and when the target starts operating again. In the case of a SAM site, this situation would not give the subsequent attacking flights much confidence that the site is really down and will not come up just as they come in range. Depending on the target, it may be necessary to hit it repeatedly to keep it off the air with the associated costs and risks of doing so.

Possible Countermeasures

The most straight-forward approach to protecting against EMP is to harden vital electronics. This includes using grounded, closed cases that act as Faraday cages and prevent penetration by electromagnetic fields. Indeed, most U.S. and Soviet military equipment is hardened for EMP resistance. During the Cold War both sides planned for the possibility of having to operate in a nuclear environment. As a result they had EMP hardening specifications on most of their electronic equipment. Because this equipment has proliferated and continues to do so as both sides draw down their forces, many potential adversaries may already possess fairly hard systems. Newer equipment is also somewhat hardened simply to be able to operate without interference from other nearby equipment. Further, placing the equipment in a hardened facility would help.

Landlines and fiberoptics are also viable alternatives. A system without antennas is much harder to couple energy into. Because they emit only weak or, in the case of fiberoptics, no, signals that can be picked up by outside sensors, wire and fiber networks are also very difficult to monitor for damage or upset.

Dispersing facilities so it is difficult to impact more than one site per weapon adds redundancy to the overall network and increases the cost of taking it down. Along these lines the advent of the cellular phone will make communications very resilient. While today one might envision being able to strike the existing ground nodes of the cellular network, soon, thanks satellite constellations like Motorola's Iridium and Teledesic's planned system, worldwide, continuous cellular access will be available. These nets will carry

voice and data permitting computer networking via cellular phones anywhere, anytime. Absent taking out the satellite network, how one suppresses its use over a large area for a long period is a serious challenge.

EMP might be able to disrupt or damage phone sets over a localized area. Further, as the cellular phone capability expands, the price of phones will drop precipitously, so the adversary can simply throw the dead one away and grab another.

Summary

EMP weapons may be able to disrupt electronic systems over localized areas with varying degrees of effectiveness depending on the specifics of the situation. While probably most applicable to a relatively sophisticated adversary like Iraq, the rapid dispersion of electronics throughout the world may make EMP useful in OOTW circumstances as well. The technology required to produce the power levels and package sizes necessary to make viable EMP systems is very challenging. The physics of the interaction of the EMP energy with the target makes it extremely difficult to predict how much a target will be effected by an EMP pulse. Significant unknowns about energy coupling into buildings, device housings, singular and connected electronic components all multiply together to yield a high level of uncertainty of impact. There are several effective countermeasures that can be employed. Hardening already exists in much U.S. and Soviet equipment and can be added with some moderate degree of difficulty depending on the device in question. Use of alternative transmission schemes like landline and fiberoptics are very effective although perhaps less mobile. The future proliferation of communication sites using cellular phones will make it very difficult to shut off communications for an extended period of time and will be available to both high- and low-technology opponents soon.

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Infrasound

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There is quite a bit of interest in using acoustic energy to repel adversaries. Most of this work centers on the use of infrasound. Infrasound is very low frequency sound energy, less than 50 Hz and well below the threshold for human hearing, that is used to disturb parts of the human body and cause temporary distress. When tuned to around 16 Hz and projected at sufficiently high intensity levels, investigators claim that a person can be made nauseous and disoriented (Evancoe June 1994, 69). They also claim that these effects are temporary and stop when the victim is moved away from the source of the sound or the sound is turned off (Kiernan, 14).

Open source literature is limited and principally deals with naturally occurring infrasound and man-made "environmental" infrasound sources. In the 1960s and '70s, some work was done to assess the impact of infrasound on people from things like railroads, electric generators, rocket launches, and the like. The results of those studies indicate that a variety of effects are possible, including those espoused by nonlethal advocates, but that the intensities required are extremely high (greater than 150dB) (Tempest, 125). Producing such low frequencies at such high intensities is a significant technological challenge.

To conduct the human tests years ago, the researchers had to build very specialized equipment and chambers to produce the infrasound (Tempest, 119-123). That equipment is not scalable for use in an open environment over a large area. Consider that the size of a speaker is proportional to the volume or intensity desired of it and it is inversely proportional to the frequency of the sound it is to produce. Thus loudspeakers, such as used at rock concerts are very large. Also, one may note that the high frequency sounds come from speakers called tweeters, which are relatively small, while the low frequency sounds come from speakers called woofers, which are very large. Today many sound systems come with even lower frequency speakers called sub-woofers, which are larger still and are used to amplify the bass or very low sounds and actually vibrate the listener. Because infrasound is much lower than human hearing and the intensity needed to produce the desired effects is so very high, the infrasound speakers would have to be enormous and demand similarly enormous amount of energy to drive them. Such systems do not exist, but could be developed with sufficient expenditure of money and time (Evancoe June 1994, 69).

Another consideration in using infrasound is the impact it may have on surrounding structures and people. Anyone who has recently heard a car go by with the stereo blasting likely felt the sub-woofer also for a considerable distance. Indeed, the low frequency sound waves propagate much farther than high frequency waves such that the listener probably sensed the sub-woofer long before and after the rest of the music was out of earshot. This long range of effect would be magnified for infrasound. It will easily transmit through walls and vehicles (Evancoe June 1994, 69). This deep-penetrating capability gives infrasound an indiscriminate nature that has the potential to produce serious collateral damage thus impacting how it might be used.

Operational Utility

OOTW Applications. The obvious use of infrasound is for crowd control to stem a riot or prevent the overrun of an embassy or other facility (Evancoe June 1994, 69). A colorful scenario is painted by some advocates:

> As thousands of rioters approach the walled U.S. compound, their leaders fall to the ground vomiting and defecating. Hundreds of protesters double over and appear disoriented. None comes closer to the wall than half a city block away. As the number of nauseated and diarrhea-disabled protesters grows, the crowd breaks and gradually departs, some of its members crying out that Allah is punishing them (Toffler, 129).

Infrasound might also be used for hostage situations or to drive out invaders from a facility. The situation faced by the FBI in Waco, Texas, was such a case.

However, there are concerns with using infrasound. Because it can propagate long distances and into most structures, how would it impact the non-rioting public standing on the sidelines or just in the vicinity? More importantly how does one "protect" one's own troops or embassy occupants, in the example above, from the deleterious effects of the device designed to help them? Indeed the "friendlies" may be closer to the speakers than the bad guys. Also consider an urban environment such as the embassy case, the sound bouncing around among the buildings could set up standing waves that would amplify energy such that serious, permanent damage may result to the unfortunates who happen to be there at the time. The nonlethal nature may be lost in these particular cases. Similarly the structural integrity of the surrounding buildings may be affected, which could have disastrous consequences (Williams, 25).

Theater War Applications. From a deployment standpoint, infrasound poses some serious challenges. The very large size and power requirements of an infrasound generator precludes its portability. Thus its use is likely restricted to protecting fixed sites such as embassies and bases. Using it in the battlefield or jungle would require an enormous logistical effort. It would also require a stationary enemy who would wait patiently while the speakers and power system are transported in and set up. Further, how does one's own soldiers operate in an infrasound environment to surround and disarm the enemy?

Possible Countermeasures

The simplest countermeasure is to sabotage the system. Alternatively, one could fire a rifle-launched grenade into the bank of speakers. Certainly the speakers have to be somewhat, if not completely exposed, in order to project the infrasound thus leaving them vulnerable to attack. Cutting off power to the facility is another possibility. For most large sites alternative power supplies would be available, but they could be attacked as well.

Using the media may also be an effective counter. Showing graphic videos of "peaceful protesters," including women and children, doubled over vomiting and defecating in the streets would no doubt draw a response from folks watching the evening news over dinner. Claims of brutality and long-term illnesses would likely follow requiring detailed explanations from high government officials. No one may have been killed, but visions of civil right protests and police with water cannons will certainly dance in the public's head.

Summary

Infrasound has some potential for useful application in OOTW situations and police work. Its indiscriminate effect and large area of coverage make it attractive for crowd-control, facility access control, and hostage stand-offs. However, these very properties are also problems because they could also affect one's own troops or the people one is trying to protect. The enormous size of the speakers and amplifiers to drive them as well as the necessity for the speakers to be exposed make the system vulnerable to sabotage or direct attack. Infrasound's utility may also be seriously limited by the prospect of video clips of vomiting and defecating protesters providing the adversary with prime propaganda material.

Computer Viruses

The advances in computer and information technology have permeated every aspect of our lives. Indeed, they have spawned many of the changes in military systems over the past thirty years. So-called "smart" weapons are smart because they contain miniaturized computing systems that give them on-board capabilities previously reserved to room-sized computers. The exceptional command and control demonstrated by the Coalition during Desert Storm stemmed directly from the use of small computers, advanced communications satellites, and information software able to handle enormous quantities of data. On the civilian side computers handle our phone calls, transmit faxes and data over the Internet, track business inventory, account for monetary transactions for banks and other financial institutions, and even check us out at the grocery store. The world, especially the industrialized world, has become very dependent on computers to maintain the pace of business and living today.

Thus the implications of corrupting computer systems with software viruses could be severe. A computer virus is a computer program, usually small in size, that is designed to attach itself to a computer's main operating program and then perform some action. They are also usually designed to be spread by copying themselves and attaching to other programs that people copy onto disks or download from a network and use in another computer. Thus they can spread rapidly, quietly, and be hard to detect until they act. The actions can be as mild as writing a message on the computer screen. Viruses can also erase data and programs in the computer's memory, cause computer hardware to fail by making it operate in modes it should not, or they simply change data so that erroneous answers are generated.

The capability to create a virus is well known and widespread. Numerous instances of worldwide contamination by viruses have occurred. Some of these have been pranks, some have been malicious. Among nonlethal advocates, some suggest that specialized computer viruses should be developed that we can use to infiltrate an adversary's command and control network and shut it down at a time of our choosing (Stix, 95; Gunther, 64).

Operational Utility

OOTW Applications. Computers and their use are becoming more widespread around the world. The Internet is providing outlaw groups a quick, easy way to communicate and coordinate actions all over the globe. It is likely that narco-traffickers use them to track shipments, financial deals, and intelligence on law enforcement activities. Infiltrating their computer system would may prove difficult. However, if successful, one can conceive of scrambling their financial data, or distorting their movement schedules to one's advantage.

On the other side, many OOTW scenarios involve parties without computers, who do things by word-of-mouth and courier. In such cases, computer viruses would have little impact.

Theater War Applications. Large scale, fast paced warfare as the Coalition conducted in the Gulf War can not be conducted today without the aid of computers. Clearly an adversary with advanced technical capabilities would be more susceptible to viruses than a less developed opponent. On the other hand a sophisticated entity may also be more capable of preventing or minimizing the impact of a virus. Nonetheless being able to disrupt or destroy an adversary's computer network without firing shot or

dropping a bomb has a great deal of attraction. Disconnected from the leadership, the troops in the field would lack direction. The loss of intelligence information would hamper their movement and preparation for battle since they would have no idea what to expect or when. Losing connectivity with other units would impede their combined effectiveness and coordination of action. Simply consider what would have happen to the Coalition's operations had our computers not worked.

However, to be effective, the virus has to be able to infiltrate an enemy's network. The advent of viruses has motivated the development of virus checkers that the would have to be circumvented. The virus would have to be controllable so it could be activated and deactivated at our discretion. Ideally the virus would somehow be put in place prior to or at the beginning of a crisis. Then when situations warranted, it could be turned on. A virus simply set to turn on at a preset time would be less than ideal since the crisis may have changed or been resolved and we would no longer want the virus to act.

The virus might also be controllable in the magnitude of effect it has on its host system. For example, in the early stages of a confrontation, it might be possible, optimistically, to persuade an adversary to accept our position simply by "demonstrating" that we could disrupt his network with an harassment event of limited scale and duration. Of course once demonstrated, the adversary will quickly try to eradicate the virus or seek alternative operating modes.

Possible Countermeasures

Well established computer security practices can certainly help reduce the risk of interference by viruses. Screening all software and data that flows into the network can help prevent infiltration. Alternatively, developing all the programs in-house in a secure environment would help, but would be expensive.

Playing the media card again could prove beneficial. For example, videotapes of a plane crash or train wreck blamed on the failure of the air traffic control system or train switching network because of attack by a virus planted by the United States could easily dispel the nonlethal aura of our actions and rob us of the "moral high ground" we sought to gain.

Alternatively, initiating a massive propaganda campaign claiming that the United States is trying to take control of the world by seizing mastery of everyone's computer networks would likely raise some heated discussion in the United Nations and elsewhere. Painting a picture of entire nations laid bare and vulnerable by the insidious invasion of their vital systems would play well with those who believe the United States still has imperial aspirations.

In particular, consider that some advocates of nonlethal strategic attacks suggest that contaminating a nation's (or non-state entity's) financial records or network would be an effective means of hampering their activities (Stix, 95). Changing the account balances or denying access to accounts would certainly interfere with external supply lines. One can imagine even disturbing the payrolls of "innocent" civilians in an attempt to incite them to overthrow their leadership.

The flip side of this idea is that once someone has demonstrated the ability to infiltrate and disrupt the financial system of a nation, it can be easily generalized that the entire financial network of the world is now vulnerable. Who is to say that the United States has not been distorting things to our advantage for some time and will not do it in the future? Since most transactions come across a computer somewhere along the line, the basic trust between the individual and the financial establishments and businesses will be cracked, if not shattered. The worldwide political and economic ramifications are staggering, including runs on bank, termination of credit purchases, upheaval in the currency markets, stock market crashes, and reversion to cash-only purchases. These issues must be carefully weighed before, not after, employment of viruses.

Summary

The virtual explosion in the use of computers makes them an attractive target to influence an adversary. The more computers he has, the more susceptible he may be, although resistance may come with sophistication as well. Low tech opponents would be little impacted by this capability so it clearly is not applicable in all situations. Making viruses is a mature technology, that is, many people can do it. However, to be useful for political-military purposes the virus would need additional levels or means of control so they can be tailored to meet the circumstances. Countermeasures may range from good computer security practices to imploring sympathy for the "victims" of the network shutdowns. Finally the global ramifications of a state attacking another state or entity in this manner and the resulting breakdown in trust of financial systems, air traffic control networks, and so forth, need to be balanced against the anticipated benefits beforehand. Trying to put the pieces back after the fact will likely be exceedingly costly in monetary and political capital.

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Supercaustics

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Supercaustics are acids that are claimed to ". . . be millions of times more caustic than hydrofluoric acid" (Garwin, 108). Such compounds could obviously do serious damage to most anything with which they came in contact. While they exist in the laboratory, using them in a military or police situation would entail some particular challenges.

Principal among the difficulties in using supercaustics is the issue of how to deploy them. Some supporters contend that it may be possible to deploy them as binary compounds similar to modern chemical weapons (Evancoe June 1994, 69). In this way the two components of the supercaustic are kept in separate compartments such that each can be handled safely by itself. Once dropped as a bomb, or fired as an artillery shell or missile, or mixed in some spray system, the two components combine to create the highly potent supercaustic compound. Conceivably the substance could be formulated as a liquid for spraying, a gel, or even a powder (Evancoe June 1994, 69).

In addition to handling, the issue of precision delivery may arise. Such a substance would lose its nonlethal attraction if it ends up landing on troops or, worse, civilians. Certainly the technology for precision delivery exists, but if it requires the expense of a precision munition and it is intended to destroy the target anyway, why not use an explosive charge.

Operational Utility

OOTW and Theater War Applications. Supercaustics are anti-materiel weapons. It would seem almost impossible to use supercaustics in a one-on-one apprehension situation or in a crowd control mode. To be useful one would have to locate and isolate an adversary's supply depot or transportation choke point. Having done so supercaustics could be used to cloud optical systems, make goo of asphalt roads, weaken metal in weapons, bridges, aircraft, and buildings, erode tires on vehicles, and deteriorate power and communication lines. But they would take time to work. How much time they would require clearly depends on the target and the strength of the caustic substance.

The desired anti-materiel result of using the supercaustic may be very similar to that of an explosive charge. It is unlikely that the system attacked would be repairable. This characteristic runs counter to the desired capability to restore effected items to their original state with minimal effort as described in the DOD draft policy (Swett, 1). Thus the motivation for using supercaustics must lie primarily in the hope that their delivery would entail less collateral damage (materiel and human) than an explosive device.

Delivery via bomb or shell or missile may not be explosive, however, the casing would certainly fragment on impact producing shrapnel that could injure or kill nearby personnel. There would be no blast per se, but the splashing of the liquid or gel on impact would generate some footprint within which anything or anyone would be sprayed by the supercaustic. Actual spraying from an aircraft, be it manned or remote, would be even less precise and risk even higher levels of collateral contact. Thus in cases

where great precision is needed, it may be necessary to send in special operations teams to apply the substance in person. This latter case may be viable for covert situations, but it certainly puts our troops at great risk simply to "protect" the troops of the enemy. Is it worth the risk?

Possible Countermeasures

Among several conceivable countermeasures are such elementary actions like keeping valuable assets in shelters so they are not exposed to attack. If attacked it may be possible to wash the caustic off or neutralize it if rapid action is possible. Thus the time required for the supercaustic to produce its effect is critical.

No doubt an effective counter would be to parade the unfortunate troops and civilians "who just happened to be in the wrong place" when the supercaustic was delivered in front of TV cameras and accuse the United States of chemical warfare recalling visions of the gas attacks in World War I. Appeals to international tribunals on behalf of the poor disfigured victims would cause a political furor.

After calling for war crimes trials, the clever adversary would likely call Greenpeace and other ecology groups and claim that these supercaustics were destroying the environment, contaminating rivers and water supplies, and so forth. The time spent justifying their use and explaining their technology would be countered by eminent news commentators recalling pictures of Love Canal, Agent Orange, and other similar disasters.

Summary

Supercaustics could have significant impacts on exposed targets, especially if they are stationary and isolated. Delivery of the substance would require much precision to minimize collateral damage, particularly to nearby people. Supercaustics are a public relations land mine. The likely storm of protest over their environmental impact, not to mention any maimed or disfigured casualties, would be very costly.

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Liquid Metal Embrittlement

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Liquid metal embrittlement (LME) agents are chemicals that alter the molecular structure of metals and alloys making them weak and more susceptible to fracture (Evancoe June 1994, 69). As a clear liquid the LME agent leaves little perceptible residue making it ideal for covert use. LME solutions have been formulated to attack virtually any metal and can be sprayed, splashed, or brushed on the surface (Williams, 25). However, a solution formulated for one metal will not work on another (Evancoe May-June 1994, 29). Thus accurate intelligence about the makeup a given target is required. LME formulations can also be designed to be fast-acting or slow-acting permitting an additional degree of operational flexibility (Evancoe May-June 1994, 29). LME technology is widely available in the public domain and in college materials laboratories making it possible for both sides of a conflict to use it (Evancoe May-June 1994, 29).

The issue of delivery is not unlike that for the supercaustics with the exception that LMEs may not injure personnel as readily. Still a fair degree of precision is needed to ensure that the requisite amount of the LME compound contacts the target. The poorer the precision, the more LME agent required and the larger the platform to carry it.

A second issue harkens back to the slick-ums and stick-ums in that LMEs may be effected by climate and weather. Large temperature swings could result in reduced effectiveness of the LME agent (Evancoe May-June 1994, 29). Thus it may be necessary to have in-theater, the logistical capability to reformulate agents to adapt to changing weather conditions.

Operational Utility

OOTW and Theater War Applications. The utility of LMEs is similar to supercaustics, but without the immediate danger of collateral damage to personnel. As an anti-materiel weapon its use in both OOTW and theater war requires the location and identification of enemy weapons, supplies, equipment, and transport routes. Using LMEs to incapacitate artillery, bridges, rail lines, aircraft, power-line poles, trucks, tanks and metal shelters yields a very rich target set. A key consideration is how much is needed per target. Knowing this accurately will minimize the size of the bomb, or shell, or amount of spray that must be used. Similarly, how should the liquid be deployed through forested or jungle areas or into shelters? Spraying in a jungle might be difficult requiring massive amounts of agent. Penetrating a shelter to get to an aircraft or more specific target would necessitate penetrating the shelter with either a bomb or missile. Using a special operations team to infiltrate an area or shelter and apply the substance is possible, but the uncertainty of the LME working may make this scheme risk-prohibitive.

A difficult issue will be battle damage assessment (BDA). Unless the target collapses of its own weight, one may not know whether the LME worked until the target is used again. Further, should the enemy be informed that his equipment has been "attacked" with LME agents? If not, he may die trying to use the equipment thus ruining to some degree the nonlethality of the approach. If informed would he believe it?

Assuming there is no antidote to undo the molecular changes caused by the LME, then the target becomes worthless and is essentially destroyed as if it had been blown up. If the target were a bridge or railroad or other infrastructure facility, this fact defeats to some degree the DOD policy's desire for temporary effects and minimum rebuilding cost.

Possible Countermeasures

As with supercaustics, perhaps the best defense against LME is to keep potential targets sheltered or at least covered with fabric to prevent exposure. Rapid washing may be helpful if the LME is slow-acting.

What happens if a bridge or railroad is coated with LME and the next vehicle or train across by coincidence, or design, is full of civilians? As the cameras roll, the bus sinks or bodies are dragged from the wreckage. Then someone claims, true or not, that the United States used LME on the bridge or railroad. How do we respond? How can we claim that it was a nonlethal act just because nobody died when it was delivered? Will it be necessary to warn them when we have used it? Do we have an obligation to warn them that we have used LME on a target?

Summary

LME technology exists and may have a wide range of target applications. Key issues are the need for precision delivery and accurate intelligence so the proper amount of the correctly formulated solution gets to the target. The formulation must be able to be locally adjusted for changing weather conditions. If we use LME on infrastructure targets like bridges, should we inform the adversary that we have done so? Do we run a risk of civilians getting hurt by not telling them and thus lose the advantage we sought to gain?

Considerations

The preceding review of some of the principal nonlethal weapons concepts attempted to examine each in greater detail than most of the literature to date. In each case certain questions were raised that might impact the viability of the particular concept and its ultimate utility in helping meet the political and military goals of the confrontation. However, after reading through the above, the reader may sense some more overarching questions that nonlethal weapons raise. This section will address certain of these including the credibility of nondestructive attacks; the nature of warfare; the shape of future conflicts; the assumption of rational actors; the legal ramifications and treaty limitations on the use of nonlethal weapons; the potential for increased risk to U.S. soldiers; and the seduction of gradualism.

Nondestructive Attacks

Nonlethal weapons seek to disable materiel or incapacitate humans in a controlled, minimally destructive manner (Swett, 1). The idea is to "execute" a "soft kill" as opposed to the lethal, destructive "hard kill" resulting in twisted metal and dead bodies. Soft kill ideas have been around for a long time. The difficulty with soft kill is that there may be no way to tell if one's attack was successful.

For example, during the heyday of the Strategic Defense Initiative, there were some who argued that a space-based neutral particle beam system could effectively negate an ICBM reentry vehicle-warhead. They proposed that the beam would penetrate the warhead's surface and disable the fusing device causing the warhead to become a dud. This was a classic soft kill because there was no explosion, no wreckage, no deviation in trajectory, no burning metal. The difficulty with the concept was in determining that, in fact, the warhead was now a dud and that terminal defenses need not be used against it. Waiting until it hit the ground seemed a little late to find out. Thus while the proposal was technically elegant, it was precisely this lack of a signature of success that doomed the idea.

Consider that battle damage assessment (BDA) during the Gulf War was a highly contentious issue with the intelligence community claiming much lower levels of success than the operators (Cohen, 113, 118-120). This caused many targets to be hit multiple times thus risking crew lives and depleting available resources on potentially unnecessary sorties. If BDA was hard when two thousand pound bombs were being used, how will it be easier with nonlethal weapons? Could the enemy not just play possum, for example, turn off his radar, his communications, his vehicle, or himself-herself, until the attackers leave the area or until a more advantageous time comes? Playing dead when you know the other side is using nonlethal weapons entails little risk. He is not likely to shoot you, else why would he waste the time and effort to use a nonlethal device?

Thus systems that employ soft or low-signature "kill" techniques may be academically intriguing, but on the battlefield or in the air above it, warriors need to be sure. Taking chances with people and equipment that are trying to kill you is a dangerous gamble.

Ideally as proposed in the DOD draft policy, the effects of nonlethal weapons are temporary such that the targeted device or person can be relatively quickly returned to use (Swett, 1). This is clearly a two-edged sword. On the one hand being able to restore a defeated nation's power grid or civilian communications network quickly and inexpensively after a conflict is good for the "innocent" civilian population (Fulghum 1992, 62). Likewise a crowd control device that causes a riot to break up with no lasting effects on the "peaceful protesters" has political merit. But what of the tanks, trucks, airplanes, troops, terrorists, and thugs that are left behind, ready to fight another day (Sapolsky, 5)?

Nature of Warfare

Many arguments in favor of nonlethal weapons appeal to the humanistic view of liberal, democratic society. But the real topic is war or the use of force, more specifically, it is a matter of life and death for soldiers and civilians alike. The employment of weapons, lethal or otherwise, should come only after discussion, argument, diplomacy, and other economic and political options are exhausted. When weapons are employed they should be used to achieve the political objectives as quickly and as decisively as possible. In this way, the fewest lives are lost and the least treasure is expended on both sides. Gradual approaches to the use of force, such as that used in Vietnam, rarely prove successful or less costly.

From an historical vantage point, the conduct of war tends to follow certain patterns driven as much by human nature as by the technology employed. As a response to the previous quote from Sun Tzu, one can invoke Clausewitz:

> Now philanthropic souls might easily imagine that there was an artistic way of disarming or overthrowing our adversary without too much bloodshed and that this was what the war should seek to achieve. However agreeable this may sound, it is a false idea which must be demolished. In affairs so dangerous as war, false ideas proceeding from kindness of heart are precisely the worst. As the most extensive use of physical force by no means excludes the cooperation of the intelligence, he who uses this force ruthlessly, shrinking from no amount of bloodshed, must gain an advantage if his adversary does not do the same. Thereby he forces his adversary's hand, and thus each pushes the other to extremities to which the only limitation is the strength of resistance on the other side (Von Clausewitz, 30).

We therefore have two oft-quoted military scholars at seeming odds over the value of lethal force and the possibility of restraining it. Certainly examples can be cited of instances of maneuver or siege when victory was achieved with little or no direct combat. However, it seems that many more can be cited showing that, despite a seemingly untenable situation, the trapped forces or nation chose to "fight to the last man" sometimes succeeding, sometimes not. The desperation of those battles gave rise to levels of violence well beyond the norm. Names like Vicksburg, Iwo Jima, Guadalcanal, Bastogne, Chosin Reservoir, and Khe Sanh come to mind. Which is it then? Can war be well-controlled and made more humane by one side using nonlethal weapons?

Future Conflicts

What are future conflicts likely to look like? Frequently discussed are cases of terrorism, drug trafficking, civil wars, ethnic clashes, as well as the ubiquitous "major regional conflict" around which much of the U.S. military posture is built. The first two are enhanced police actions usually dealing with individuals or small groups. Further, these groups tend to be heavily armed and fanatically driven either by religion, ethnicity, or money. Diplomatic appeals based on human rights and the rule of law are signs of weakness in their eyes. They are usually quite willing to die for their cause because either that fulfills their mission in life or they know the price of failure is death at our hands or their employer's. Surrender is rarely an option. Perhaps an incapacitating nonlethal system could subdue such an offender, but he would it be sufficient to cause him to renounce his cause?

The world has seen over and over again the passion and unremitting violence spawned in civil and ethnic wars. To this day the capacity to kill one's countryman is unfathomable. The situations in Bosnia, Rwanda, Somalia, Liberia, Chechnya, and Sudan demonstrate that, despite our enlightened age, mankind will not accept actual or perceived subjugation no matter the benevolence of the ruling party. How would nonlethal systems play in these cases? A report by the Council on Foreign Relations suggests that in Somalia and Bosnia, perhaps nonlethal means could control crowds and key transportation nodes (Council on Foreign Relations, viii). In Rwanda they suggest that jamming or overriding of radio broadcasts calling for genocidal killings might have helped (Council on Foreign Relations, viii). Would such measures have stopped the belligerents from further fighting simply because they were nonlethally inconvenienced?

As for the major regional conflict, there seems an implicit assumption on the part of some that the next war will be like the last. The world watched the Gulf War very carefully. Potential adversaries of the

United States will not likely repeat Iraq's mistakes. They will not likely take a bit of land and then "hunker down" waiting for our response. No, they will move fast, taking land and facilities so as to deprive us of any nearby support bases from which to launch a counteroffensive. Should we mount a response, they will make us fight our way in, attacking us in the field with conventional or guerrilla tactics.

In so doing, they will draw our vaunted air power away from strategic attacks on their infrastructure and force us into the immediate close-air support and interdiction fight where their shoulder-fired surface-to-air missiles will take their toll. It is to such widely-proliferated weapons that most of the aircraft that we lost in the Gulf War fell. They will also expand the theater of battle with terrorist attacks against our interests around the globe, including here at home, to immediately make us pay a significant price and question the value of continuing. The World Trade Center attack tolled the end of the United States' geographic immunity from terrorists. They very well may use chemical or biological weapons to magnify the shock of the conflict. Within the theater they will employ modern and widely available technology such as cellular phones over commercial networks to maintain command and control. They will navigate and target with exceptional accuracy with the aid of our Global Positioning System (Air Force News Service; Cohen, 112). They will fulfill Clausewitz's prediction. Where do nonlethal systems play when American blood is being spilled?

Move and Countermove

We should not forget the resourcefulness of the underdog. Should we have nonlethal weapons, is our opponent incapable of devising countermeasures? The military technology game of move and countermove does not end just because the United States has a new system. The concept review above addressed several possible countermeasures. But further, what of the potential side-effects or unintended consequences of using nonlethal weapons? Will an adversary not exploit those? Edward Bruner, a defense specialist for the Congressional Research Service comments that:

> First is the fact that we have to be able to protect our own troops against them. A lot of the types of weapons we're talking about are nondiscriminatory, unlike a rifle bullet which is aimed. And if it is easy enough to protect our own troops against, then the enemy might just as easily come up with countermeasures. Another problem is that many of these are weather-dependent, as opposed to a bullet or a bomb, which will have an effect no matter what the weather (Morrison, 759).

Rational Actors

The nonlethal proponents implicitly assume that the world is governed by rational actors who hold dear the same values of freedom, human rights, and respect for law that we do. In large part they argue that once an adversary is placed in a position of weakness, he will surrender, give up his cause, and walk off peacefully. History shows that this is not the case. For example referring to Saddam Hussein's reaction to the coalition's strategic air attacks in *Thunder and Lightning,* Col. Edward Mann writes:

> Reeling defensively, the nation-state under attack has only two options—stay on the mat or take a beating to end all beatings. It seems as though any rational leader would admit defeat and sue for peace. But Hussein and the Baath party—rational or not—did not appear to understand what was going to happen next and did not embrace the hopelessness that their situation warranted. Otherwise, they could have saved many lives, a considerable amount of military equipment, and the national infrastructure simply by announcing (and executing) unconditional compliance with UN demands any time in late January or early February 1991" (Mann, 101-102).

War is a horrible breakdown in the functioning of civilization. The killing and destruction can quickly cause logical thought to give way to passionate emotions of revenge and self-preservation. It is dangerous to attribute to other people, indeed other cultures, the same values and mores that we hold. Just because we might surrender to a nonlethal weapon, does not necessarily imply that someone else will also.

Legal issues

The wide range of potential nonlethal systems and applications may pose some new legal issues under the Law of Armed Conflict (LOAC). Cook, and others, provide a concise examination of this area (Cook). Under LOAC, weapons and their applications must meet certain tests to be considered legal. The key tests are military necessity, humanity and proportionality (Cook, 80).

Military necessity demands that all targets be military in nature. Thus military bases, runways, troops, radar sites and the like are clearly military targets and subject to attack. Other targets such as ports, railroads, bridges, and such likely have dual purposes for both military and civilian uses and may be attacked if they can be shown to be actually contributing to the war effort. Military necessity also permits the use of ". . . any amount and kind of force . . .", but, "There must be some reasonable connection between the destruction of property and the overcoming of the enemy"(Cook, 80) The latter phrase tempers the wanton application of force by any side. It would seem that nonlethal weapons would be welcomed under this concept as their intent is to limit damage. However, consider the calls by some to use computer viruses to ruin the financial network of an opponent. Can the banking system and the stock market of a country really be called a military target?

The principle of humanity seeks to minimize suffering because of war. Weapons, which cause horrific wounds, but do not kill, violate this principle. Of course some suffering is an unavoidable part of war. Some weapons, while not intended to cause suffering, may still produce it under specific situations. For example, a rifle is intended to cleanly wound or kill an opponent, but if the shot happens to sever the spinal cord it can leave the victim a quadriplegic, but alive. Is this unnecessary suffering? Perhaps but it was certainly unintentional. As a result, rifles are legal weapons. It was under this rubric that the United States terminated its laser blinding weapons programs discussed earlier. However, other laser systems designed to damage optical systems are still under development. These systems could certainly blind if a soldier were looking at the beam through binoculars (Arkin, 64). But in this case, the soldier contributed to his own vulnerability by enhancing his vision with an optical device—the binoculars. Or again, what happens when soldiers or civilians are splashed with supercaustics? It certainly was not intentional, but the injuries could produce incredible suffering.

The third principle is proportionality, which derives from combining military necessity and humanity in requiring that a reasonable balance exist between the amount of damage caused and the military significance of a target (Cook, 80). The advent of PGMs has raised the standard of proportionality in the sense that rather than having to level entire city blocks to take out one building, we can now take out that building and leave everything around it untouched. Clearly, the goal of nonlethals is to continue to advance this principle.

These ideas have been codified in international law through various conventions and court rulings and have given rise to more specific principles such as indiscriminate effects (Cook, 80). Extending the concern for unnecessary damage and injury beyond the airmen, soldiers, and sailors, to include noncombatant civilians, it is illegal to employ weapons that cannot discriminate between combatants and noncombatants. Nor can attacks be made, even against legitimate military targets, if the attack would result in disproportionate noncombatant casualties (Cook, 80).

It is this area of discriminate effects where some nonlethals may run into difficulty. Consider the use of infrasound for crowd control. On the one hand it can be argued that crowd control is a police action, not a military operation, so it is not governed by LOAC. Yet if it is being performed by military forces in a foreign state, is this really the case? Certainly infrasound with its great range and ability to penetrate buildings and vehicles has the potential to effect many noncombatants in an urban setting. Of course, infrasound is not a nuclear weapon or napalm such that the result of the exposure may just be embarrassment and discomfort, but it may be worse if a victim is close by. Does the limited suffering caused by the infrasound balance off against its indiscriminate impact?

What of the slick-ums and stick-ums used to deny use of facilities such as bridges or roads, and so forth? Certainly the application of the substance poses no difficulty. However, the surface cannot

discriminate between a bus of soldiers and a bus of school children. Should the bus of soldiers slide off into the river, this was a valid use and no worse, legally, than shooting it with a Maverick missile. But, what of the bus of children that slides off into the river?

An EMP system poses a dilemma depending on how it is used. In an open battlefield to disrupt communications between units or damage the ignition systems of tanks, EMP seems appropriate. Similarly in attacking an isolated command center to cut it off from its field units, EMP systems would meet the terms of LOAC. But what if the command center were in an urban area as was the case with several in Baghdad? Can the EMP be kept sufficiently confined that it does not effect surrounding civilian electronics? If the EMP device takes out the monitoring devices or power system in a nearby hospital with an attendant loss of life, has that use violated the principles above?

Clearly one can concoct untenable situations for nonlethal and any other weapon system. Still if nonlethals are to provide the moral high ground, their compliance with LOAC is vital. But, the legal considerations do not stop there.

The United States is party to numerous treaties and conventions related to weapons and warfare. Among these are the restrictions on biological weapons and chemical weapons. There are some who argue that many of the proposed nonlethal weapons may violate these treaties (Rothstein, 7; Rosenberg, 44-45). For example there is speculation that biological agents are being investigated to eat tires or jellify gasoline and diesel fuel (Kiernan, 14). Indeed microbes are now used to help clean up oil spills which justifies their development and production. However, their use against an enemy's fuel supply, while not lethal, could constitute a violation of the biological weapons treaty (Cook, 82).

Besides the slick-ums, stick-ums, and supercaustics described above, some work may also be underway to develop chemical relaxants or calmatives (Cook, 83; Kiernan, 14). The Chemical Weapons Convention, which has been signed by the United States, but not yet ratified by the Senate, prohibits the use, development, production, acquisition, and stockpiling of chemical weapons as well as prohibiting the use of riot control agents in war (Cook, 83). While not on a par with mustard and nerve gas in their effects, would sleep-inducing agents be covered by the convention? Further, although supercaustics are designed for antimateriel purposes and would likely be used as such, would casualties suffered by collateral exposure constitute a violation of the convention (Rosenberg, 44)? Clearly, the legal aspects of nonlethal weapons will need to be examined carefully to ensure compliance with existing treaties.

Increased Risk

The purpose of war is to achieve a political goal at minimum cost in blood and treasure not attainable by other less violent and expensive means. There are some things, such as national survival, where a "victory at all costs" may be appropriate and even necessary. However, with the exception of the Russian nuclear arsenal, there do not appear to be any threats of such magnitude to the United States in the foreseeable future. Thus our likely military conflicts will be limited in scope and therefore, a key measure of success will be the cost in lives and money expended to achieve the goal.

Clearly the cost of re-establishing a functioning state of Somalia was not, in the eyes of the American public and their decision-makers, worth the price of a couple dozen soldiers. Prior to Desert Storm, there were arguments at the highest and lowest levels of American society about whether we should trade blood for oil. Some were quite willing to let Saddam get away with his aggression rather than risk any American lives.

For nonlethal weapons to make a significant contribution to the U.S. arsenal, they must provide viable options to lethal force and other means of influence. They must also reduce the risk of loss of American lives and resources relative to other means of coercion. They should also reduce the loss of life and level of damage to an opponent. But will they do so in actual practice?

The nonlethal weapons are proposed as a means of providing more options to decision makers facing a crisis. Nonlethals are viewed as another step up the escalation ladder between diplomacy and death. Their

existence and the investment made in them may "force" future leaders to use them as a mandatory step before employing lethal weapons. In so doing U.S. soldiers could be put at risk no matter the probability of success of their nonlethal weapons.

The draft DOD policy addresses this issue as noted in the introduction above by saying that a commander has full discretion when and if to use nonlethals. The policy specifically states that a commander is not obligated to use nonlethals (Swett, 2). Unfortunately what a policy paper states and what evolves in practice in response to pressure from the media, politicians, and elsewhere can sometimes disagree.

Consider the situation where U.S. troops have nonlethal weapons available to put down an uprising or intervene in a civil conflict. There are three overall scenarios. First, the commander uses the nonlethals and succeeds in his mission. The media declare the commander a hero and a genius. Second, the commander employs lethal force without the nonlethals. Will not the media grill that commander about why they were not used? Will they not ask how many lives could have been saved or injuries avoided had the nonlethals been used? Will they not question the money spent to develop them only to have them sit idle? Third, the commander employs them, but because of limited success, the commander calls on lethal force to complete the task. Will they not question why the nonlethals were ineffective and why we spent so much money on such weapons? Will they not ask how many lives and injuries could have been saved had the lethal force been used from the start? It is clearly an uncomfortable position for the commander. But it is pressure just as this that sometimes undermines plans and policies.

The foregoing discussion of various nonlethal weapons concepts makes clear that serious uncertainties are likely to arise from their use, principally the BDA issue and the fact that many threats will live to fight another day. Uncertainties increase risk. Risk is a natural, unavoidable part of conflict, but decreasing risk, not increasing it, is the desirable direction to proceed, because in war risk manifests itself as dead and wounded.

What is the likely reaction of a state to an attack by lethal force? In most cases they would retaliate for the damage and violation of their sovereignty. Is it reasonable to expect that an attack with nonlethal weapons will be viewed with much less contempt and passion?

Consider the earlier discussion of the assumption of a rational actor for an adversary. Using nonlethals is analogous to punching someone in the stomach. They are hurt, but not seriously and can recover quickly. Do most people simply surrender to such an assault as the nonlethal advocates suggest any rational actor would? No, most people react by striking back with greater force if possible to preclude a repeat attack. As one nonlethal critic put it, "An enemy discomfited and temporarily defeated by the use of non-lethal weapons will be only too anxious to avenge the affront" (Hogg, 35).

It is certainly unreasonable to expect that an adversary will play the game by the same rules we are, that is, since we are using nonlethals then they will only use nonlethals. As the above vignette implies, Clausewitz's maxim about the violence in a conflict escalating will likely hold true. Besides, it is well known that the United States puts great value on life and is averse to casualities and body bags. The entire effort in nonlethals derives from this sensibility. Thus to maximize one's chance for success against the United States, an enemy is likely to attempt to inflict as many casualties as possible to induce the Americans to pull out. Iraq planned to do this, but was stupid about it. The Somali warlords were more successful as were the North Vietnamese. The question is, how many soldiers do we have to lose while we play "nice guy" and use nonlethals before we resort to real guns and bullets?

And what of the political consequences of having lost the nonlethal war? There will be many who will characterize us as failures and incompetents for not having succeeded with nonlethal systems and thus having to resort to lethal force. If we are still in the fight, we will likely respond with overwhelming firepower as is our legacy. Then we will be portrayed as bullies who had our nose bloodied by a little kid and sought unmitigated revenge. The political cost will be high.

Seduction of Gradualism

The perception of additional options presented by nonlethal weapons may also lead to a potentially dangerous sense that we can get involved in more situations than we would otherwise. Terms such as "coercive force" and "enhanced sanctions" appear in numerous nonlethal papers (Andrews, 23). In the area of nuclear proliferation, some people are anxious to employ nonlethals in situations that are clearly acts of war, but are somehow excused since they were conducted with nonlethal weapons.

> Power projection is critical in this environment, and more options to project power are required, especially for contingencies short of open warfare, including crisis management, peacekeeping operations, hostage-rescue operations, and such operations as counterdrugs, counterterrorism, and counterproliferation. The use of nonlethal capabilities, perhaps along with precision-guided and other smart munitions, would help to minimize the negative consequences of military actions and thus avoid a potentially negative international backlash against the cause for which the United States is fighting (Pilat, 286).

Continuing this line of thought carries some to promote preemptive strikes against other nations to disable or recover nuclear material, disable weapon storage or launch sites during a crisis, disable or destroy facilities for producing or storing weapons of mass destruction (Pilat, 286-287). Others point to the counterdrug arena and claim that sending U.S. troops armed with lethal weapons into a state to help stop drug producers would be tantamount to an invasion and a violation of their sovereignty. But if we give the soldiers sticky-foam sprayers instead of M-16s, then it's OK.

The concept of gradualism is pleasing to the intellect, but has rarely succeeded to accomplish the goal. Vietnam stands as a classic example of the failure of gradualism because the U.S. leadership failed to grasp the intensity of the North's desire to win. When issues escalate to the point of being willing to die for a cause, gradual means seldom carry the impact necessary to induce compliance. If the Somalis were willing to fight us and succeed in throwing us out when we were using lethal means, why should they surrender to nonlethal means?

Conclusions and Recommendations

The world is a rapidly changing, but still hostile place. As alliances and allegiances change, desires and animosities arise giving birth to new conflicts. An increasingly global, interdependent economy gives us interests in many new places, unstable places. Worldwide media coverage places aggression and suffering in our living rooms every night crying out for a response. The United States finds itself unshackled from the Cold War bonds of facing off with the Soviet Union all over the globe. At the same time fiscal and political limitations restrict our power projection capabilities. New ways are sought to respond to crises and many look to technology for answers.

Nonlethal weapons have the potential to help solve many such dilemmas. In attempting to limit damage to personnel and materiel, they suggest alternative means to coerce an adversary to respond in a desirable way without the bloodshed and financial expense of lethal means. However, by offering a wider array of options, they may also increase the likelihood of our involvement in many more situations than perhaps we should. Each involvement risks political capital, financial resources, and military lives and resources.

Many concepts for nonlethal weapons are under study. The unclassified literature contains little detailed consideration of these concepts from the technical and operational viewpoints. The technology for some of the concepts is in hand although perhaps not yet integrated into a complete system. The technology for others has many hurdles to climb. Some concepts seem to be easily countered, while others may be more robust.

The operational utility of some nonlethal weapons concepts is questionable either because the nature and impact of their effects are not well understood, the delivery schemes are imprecise, the battle damage assessment process is very uncertain, or the time to produce or maintain the desired effect is inappropriate. There is also the concern that the required tactics of employment for some nonlethal weapons put friendly soldiers at greater risk while trying to protect an opponent's soldiers or civilians from harm. Each nonlethal concept must be examined in light of legal restrictions from LOAC and international treaties. Several of the concepts raise serious legal issues and are subject to a broad range of interpretations thus weakening their moral attraction.

It is a curious dilemma for nonlethals that they were partially driven by the desire to satisfy media scrutiny and criticism by showing themselves as more humane alternatives to guns. Yet one can envision numerous scenarios where it is precisely that media scrutiny that could be the undoing of the concept. The media will no doubt hold these systems and their users accountable for meeting the goals set for them by the advocates.

The marriage of nonlethal concepts and advanced technology to support them is new. Visionaries see great hope for them to make the world a more humane place. Skeptics see problems and dangers that may risk lives. Interestingly, both sides want the same ultimate goal—peace and safety for soldiers and civilians alike, but approach that goal from different perspectives.

What is required is a frank, open dialogue between the advocates and the skeptics moderated by the soldiers, airmen, sailors, and marines that will have to use the weapons. First, a serious technical review of the nonlethal area needs to be held using a reasonably unbiased group such as the Defense Science Board. Their task will be to perform a technical sanity check on the results, claims, and predictions for the various technologies and present a critical assessment of which concepts are technically feasible and worthy of pursuit.

Second, an operational analysis should be conducted. This study could include some modeling and simulation. However, it should primarily be a gathering of the operators, who will have to employ these systems, to review the proposed technologies and develop tactics and scenarios in which to use them. Such an exercise at this point is certainly preliminary and will not be intended to generate employment handbooks. Rather it will be a chance to view these weapons concepts through the glasses of solid operational experience well beyond what the literature to date, including this paper, has done. In so doing new issues and new possibilities will likely arise that can form another filter in sorting out the worthwhile concepts.

Third, as part of the operational analysis or separately, a public affairs review should be held. Nonlethal weapons have the potential for high media interest and as well as many plausible misunderstandings and distortions that could be associated with them. A solid media plan should be devised beginning in the development phase and including "How do I answer the question of . . ." exercises for future commanders in various scenarios.

Fourth, a concerted legal review must be performed in the early stages of development to identify and resolve treaty and LOAC concerns. The paper by Cook, and others, is a solid beginning, but more formal policy development needs to occur (Cook).

Finally, the results of the above efforts should be rolled into some war games where real commanders are faced with reasonable scenarios with the filtered set of nonlethal weapons as part of their arsenal. Such games will again identify those technologies, concepts, and employment schemes that would likely be used. At an even higher level, some strategic games could be conducted using senior officials with nonlethal weapons as part of the force structure. The results of such games could address the question of whether national leadership would take greater risks or become more involved in crises because of the availability of nonlethal weapons.

The ability of nonlethal weapons to provide significant intermediate options between diplomacy and lethal means must be examined in detail. This paper has endeavored to raise a number of issues for consideration. Some of these issues, if substantiated by further study, may be significant enough to halt the development of a particular concept. Others such as media reaction, do not negate the potential utility and value of nonlethal weapons, but should cause decision-makers to ponder how they will address the question. The goal of nonlethal weapons is admirable and worthy of pursuit and the ultimate measure of their viability must be how much they contribute to securing U.S. and allied lives and interests in a difficult world.

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