2

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE
22 MAY 1997

3. REPORT TYPE AND DATES COVERED
MONOGRAPH

4. TITLE AND SUBTITLE
PROTECTING MECHANIZED FORCES FROM SMART WEAPON ATTACK

5. FUNDING NUMBERS

6. AUTHOR(S)
MAJ ROBERT A. BURNS

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
School of Advanced Military Studies
Command and General Staff College
Fort Leavenworth, Kansas 66027

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Command and General Staff College
Fort Leavenworth, Kansas 66027

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

SEE ATTACHED

19971106 157

14. SUBJECT TERMS
SMART WEAPONS

15. NUMBER OF PAGES

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UNLIMITED

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)

PROTECTING MECHANIZED FORCES FROM SMART WEAPON ATTACK

A MONOGRAPH
BY
Major Robert A. Burns
Armor

School of Advanced Military Studies
United States Army Command and General Staff College
Fort Leavenworth, Kansas

SECOND TERM AY 96-97

SCHOOL OF ADVANCED MILITARY STUDIES

MONOGRAPH APPROVAL

Major Robert A. Burns

Title of Monograph: *Protecting Mechanized Forces From Smart Weapon Attack*

Approved by:

LTC Jeffrey L. Shafer, MMAS — Monograph Director

COL Danny M. Davis, MA, MMAS — Director, School of Advanced Military Studies

Philip J. Brookes, Ph.D. — Director, Graduate Degree Program

Accepted this 22d Day of May 1997

Protecting Mechanized Forces From Smart Weapon Attack

by

Major Robert Burns
Armor

School of Advanced Military Studies
U.S. Army Command and General Staff College
Fort Leavenworth, Kansas

Term Two AY 96-97

ABSTRACT

PROTECTING MECHANIZED FORCES FROM SMART WEAPON ATTACK by Major Robert Burns, USA, 53 pages. In "Maneuver in the Information Age," BG Wass de Czege challenged his readers to think about future war in the age of information systems and smart weapons. In this article, BG Wass de Czege argued that the fundamentals of war would remain unchanged while the organization of U.S. Army forces and the manner in which they would maneuver and deliver fires would change dramatically. He postulates a vision of a future organization called the "Potential Force 2010." The Potential Force 2010 is best adapted to stand-off 45km to 200(+) km and annihilate the enemy with indirect, smart weapon fires.

If our mechanized forces fight upon tomorrow's battlefield, how will we protect them from the slaughter of the enemy's smart weapons? To answer this question, this paper considers the technology of smart weapons, countermeasures, specific smart weapons already in development and the worldwide state of smart weapon proliferation.

This paper concludes that smart weapons will be the dominate weapons on future battlefields, and that there are at least six methods available to protect our mechanized forces, including: denying enemy reconnaissance and HUMINT operations; obtaining air superiority; currently available and field expedient countermeasures; denying or disrupting the enemy's ability to mount many-on-many smart weapon fires; a host of technical countermeasures not yet fielded, and; operational and tactical deception. Most importantly, the paper calls for an aggressive program to develop technical countermeasure systems to protect moving vehicles and suggests renewed emphasis upon deception as a tactical and operational countermeasure from smart weapon attack.

PART I:

INTRODUCTION and the SMART WEAPON ENVIRONMENT

In "Maneuver in the Information Age,"[1] BG (ret.) Huba Wass de Czege challenged his readers to think about future war in the age of information systems and smart weapons (SW). In this article, Wass de Czege argued that the fundamentals of war would remain unchanged, while the organization of U.S. Army forces and the manner in which they would maneuver and deliver fires would change dramatically. There are two main components of Wass de Czege's theory. The first is the "Chess Analogy," the second is the "Potential Force."

The Chess Analogy addresses an obvious concern of the problem of war in the information age: What if friendly and enemy leaders both have equal and complete knowledge of the other's situation, as in a game of chess? Is winning a war still possible? Wass de Czege argues that it is, and further, that war will remain chaotic, unbalanced and that victory will go to the warfighter who plans ahead, anticipates and delivers fires from positions of advantage. [2]

The Potential Force 2010 is Wass de Czege's vision of a superior, future organization already within the Army's reach. Much like the Mobile Strike Force (MSF) in concept, the Potential Force is best adapted to stand-off from the enemy and deliver lethal fires 45 kilometers to 200(+) kilometers in depth.[3] This proposed future force uses a preponderance of indirect-fire smart weapons to accomplish its mission.

Wass de Czege's theory concludes that maneuver is still a relevant and key part of future war, and that future mechanized forces may even be similarly equipped as current heavy forces are with the exception that the slowest vehicles will be eliminated and there will be a preponderance of indirect-fire systems. Roles will also change, with tanks and other maneuver forces fighting to secure advantageous terrain from which SW systems can deliver their fires. Assuming Wass de Czege's theory is even partially correct then future mechanized forces, even though they might look different and perform different roles than today's Abrams- and Bradley-equipped forces, still have a role on the future battlefield.

If mechanized forces fight upon tomorrow's battlefield, how will we protect them from the slaughter of SW? Is it even possible? If Wass de Czege is wrong, then SW will dominate the battlefield, deny maneuver and lead to a stalemate as severe and costly as that which existed in World War I.

What is the environment of the future battlefield? To answer this question this paper will consider the technology of SW, SW countermeasures, specific SW in development and the state of SW proliferation worldwide. After determining the extent of the threat posed by SW to U.S. mechanized forces, this paper will explore practical methods through which the operational planner can protect mechanized forces deploying onto future SW battlefields.

The Technology of Smart Weapons

Categories of Smart Weapons. There is a dazzling array of smart weapon types and capabilities. Some of these weapons already exist while new technologies are still emerging. Other forms of smart and guided weapons are yet to be imagined. Importantly, the conceptual framework for understanding the categories of SW seems to be changing.

The reader of literature about guided, smart and brilliant munitions is bewildered by a range of confusing and intertwined definitions all determined by when the writer wrote, the context in which he wrote, the manner in which the author conceptualized weapons, the existing state of technology and the exactness the author imposed upon definitions.

In the simplest sense, all weapons are guided in some fashion. A rifle bullet or "dumb bomb" is first loosed by a shooter or pilot with at least some direction. A capricious weapon ignorant of any control would be as harmful to friendly troops as the enemy. Even a gas cloud dispersed from compressed gas cylinders in World War I was released with some expectation it would drift over the enemy and not harm friendly troops. The relevant question is not one of control, but of how control is provided.

Weapons firing projectiles flying a free flight, ballistic trajectory to their target without the capacity for further guidance are not guided or smart weapons. The previous examples of a rifle bullet or dumb bomb are forms of free flight munitions. In current vernacular, they are thought of as unguided weapons while that family of weapons receiving inflight guidance to a <u>specific</u> <u>target</u> (not just a target location) are considered to be "smart weapons." The difference among these weapons is how they are guided. All are smart weapons, of which there are three categories: Guided Munitions (GM), Smart Munitions (SM) and Brilliant munitions.[4] In simplest terms, a weapon given inflight guidance is guided either by a human or a machine. All weapons guided by human eye and hand are considered to be guided munitions. Weapons with an "eye" (sensor) of their own to guide them are considered smart. Lastly, weapons with a "brain" to decide which specific type of target to attack (a SCUD launcher in lieu of a tank, for instance) are considered "brilliant."

The TOW missile is a familiar example of a GM. Usually these weapons are guided one at a time by a soldier to a specific target. As such, they are referred to as "one-on-one," "man-in-the-loop" weapons. This is an important distinction. Guided munitions normally require Line of Sight (LOS) to the target, but unlike the TOW, are not necessarily direct-fire weapons.

COPPERHEAD is an example of an indirect-fire GM. In this case, a human eye with LOS to the target illuminates the target with a laser and the shell tracks to the laser spot. Of itself, the COPPERHEAD munition has no capacity to identify a target. A human hand controls the laser spot and impact point of the shell. As a "system," COPPERHEAD requires LOS. Laser guided bombs (LGB) guided by a third party also use the LOS method.[5]

An important limitation of GM is their requirement, from detection through launch to impact, for individual one-on-one guidance involving one human, one weapon and one target. Time, manpower and equipment are important limiting factors. Even rifles and tank cannon have the advantage of "fire-and-forget" within their limits of accuracy and range. Because of this fault, GM alone do not have the high rates of fire needed by Wass de Czege's 2010 Potential Force. Smart and brilliant munitions address this problem and also permit Non-Line Of Sight (NLOS) engagement.

Smart munitions have the "self-contained ability to search, detect, acquire, and engage targets but have minimal capability to discriminate among target classes or target types."(underline mine)[6] Significantly, depending upon type, smart weapons may be employed when the shooter has LOS or NLOS. JAVELIN is an example of a LOS technology, "fire and forget" antitank munition. The most important feature of SW is their suitability for use in the NLOS "many-on-many" scenario, where many munitions are fired into an area of many targets.[7] Armor vehicles stationary or moving in close formation are prey for this type of smart munition.

Unlike mere smart munitions, brilliant munitions have the additional capacity to selectively identify and engage specific classes of targets. Brilliant munitions can, in theory, differentiate between a tank, an armored personnel carrier and a SCUD missile launcher.

The difference in capability between a smart and a brilliant munition to discriminate and choose a target is likely to become a subject of future debate and confusion. Importantly, both weapons have the autonomous capability to identify and engage a target after a human being has detected a target(s) and begun the attack. The difference in "intelligence" between a SM and a brilliant munition is its ability to discriminate between targets of specific types (SCUD launchers versus tanks). Increasing refinements in sensor technology will likely erase this difference.[8] Arguably, the future definition of a "brilliant munition" might be that of a weapon that passively waits, identifies and attacks a target by itself. The key difference being whether a human or machine initiates the engagement. Some existing air defense systems already have or imitate this capability.[9]

Many-On-Many Scenarios. This paper is most interested in the many-on-many SW scenario and will further explore this form of attack in Part II. For now it is sufficient to say that the many-on-many scenario involves the firing of a large number of SM into an area known to contain many vehicle targets. Within minutes, many vehicles are attacked and destroyed. This is the root of Wass de Czege's vision of the 2010 Potential Force.

Specific Smart Weapon Capabilities. A wide variety of SW exist on the market today. These weapons include relatively short range, direct-fire weapons, and intermediate and long-range indirect-fire systems. Countries other than the U.S. have also developed their own systems. This paper is especially concerned with surface-to-surface, cannon and missile launched, medium- and long range- indirect-fire systems. These are high technology systems and only a few nations are working on them. Presently, there are only four such systems under serious development: SADARM, BAT, SMArt and Bonus.

SADARM (Sense And Destroy Armor Munition) was the first indirect-fire SW. The concept originated in the early 1960s, but the required technologies were not yet mature.[10] In 1979, both Honeywell and Aerojet Electronic Systems demonstrated a successful test of their submunition. By 1985, both firms had successfully demonstrated the firing of a 155mm projectile with two submunitions.

SADARM submunitions are carried to the target area in a 155mm artillery projectile. At a preset altitude, the submunitions are ejected from the back of the shell by a small explosive charge and stabilized nose-down by a small parachute. A dual mode, MMW (millimeter wave radar) and IR (infrared) seeker searches beneath the falling submunition, detects a vehicle target, aims itself and detonates an Explosively Formed Penetrator (EFP) capable of penetrating a tank's upper surfaces.

The U.S. Army chose Aerojet as the sole contractor in 1991, while some components remain subcontracted to Honeywell. In 1993, the U.S. Army temporarily halted the development program because of three problems: [11]

> a. The SADARM submunitions were malfunctioning because they collided with each other after ejection from the 155mm carrier.
>
> b. After ejection from the carrier, the stabilizing parachute designed to slow and pitch the submunition nose-down sometimes failed causing the submunition to malfunction.
>
> c. Due to hardware failure, the submunition sometimes malfunctioned because of failed electrical power supply.

At present, the U.S. Army is continuing to develop SADARM and plans to field it in the near future.[12]

Northrop-Grumman Corporation began secretly developing the BAT (Brilliant Anti-Armor Submunition) in 1984.[13] The program became publicly known in 1991. Like SADARM, BAT uses common SW attack profiles and methods, but functions differently than SADARM.

BAT is intended to be delivered by the ATACMS missile (Army Tactical Missile System), giving the U.S. Army an especially long-range SW. ATACMS Block II missile carries 13 BATs to 140 km. The extended range Block II ATACMS missile can deliver a reduced payload of six BATs to even greater range.[14]

Unlike SADARM, BAT uses a different combination of sensor technologies. The earliest BAT design of 1991 used dual acoustic and IR sensors. In 1995, the IR sensor was redesigned as a now familiar dual-mode IR and MMW sensor and tailored for use against stationary and specific targets. BAT also has acoustic sensors. The 1995-version

BAT, for instance, is designed to identify and attack specific HVT (High Value Targets), such as SCUD launchers.[15]

The U.S. is not the only nation interested in indirect-fire SW. France and Sweden are collaborating on the "Bonus" SW.[16] The Swedish Bofors company and Giat Industries of France began the program in 1991. In concept it is very similar to the U.S. SADARM. "Bonus" is a 155mm delivered SW composed of two antitank submunitions guided by a dual mode IR/MMW nose mounted sensor. It has a planned range of 34 km. Perhaps learning a lesson from SADARM, Bonus carries only two submunitions in each 155mm projectile. Sweden and France plan to begin Bonus production in the year 2000 or shortly thereafter.[17]

SMArt is a German designed SW that is identical in concept and form to Bonus. Development began in 1989 and a complete successful demonstration, from firing to target detection and warhead detonation, was performed in 1994.[18] The GIWIS company is continuing development and preparing to begin production.

Smart Weapon Proliferation. Clearly the U.S. is the unmistakable leader in SW development (SADARM and BAT). Only three other countries, all friendly to the U.S., are pursuing specific indirect-fire SM programs: Germany (SMArt), and; France and Sweden (Bonus). Despite the high lethality of SW and the threat they pose to U.S. Force's heavy operations, it appears to some people that SW technology will remain safely in friendly hands.

Unfortunately, this is not the case. Although no nation hostile to the U.S. is developing SM, there is an unmistakable trend in SW proliferation.[19] Arms sales, technology exports and the shifting balance of power will spread SW technology and weapons. The Russians are currently offering laser-guided artillery and mortar systems for sale. There have been no known purchases.[20]

It is inconceivable the U.S. would place SADARM on the market tomorrow. Ultimately, however, the U.S. and other nations will sell SW as commonly as we sell machine-guns and fighter airplanes today. There is no reason to believe otherwise. Excepting nuclear weapons technology, the U.S. has eventually exported all of its other weapons and technology.

Other than future arms sales, SW technology will still proliferate in the near term. Today, major arms purchases seldom involve the mere transfer of hardware, software and maintenance contracts. Developing nations seek "offset agreements" for all major purchases. South Korea, for instance, decided that the McDonnell-Douglas F-18 was the fighter airplane best suited for its needs. However, South Korea instead bought a contract for Lockheed-Martin F-16s when McDonnell refused to transfer technologies associated with the F-18 and license South Korean F-18 production. Only the first 12 F-16s will be built in the U.S. The next 36 aircraft will be assembled in South Korea from kits of U.S. provided parts. The remaining 72 aircraft will be built entirely in South Korea with many South Korean parts.[21] More than just buying fighter airplanes, South Korea is purchasing advanced and transferable technologies.

While the U.S. is today the world's only superpower, there is an increasing tilt toward the Pacific Ocean. Asia's "Big Eight" represent the only region in the world with increasing military expenditures.[22] Michael Klare reported in, "East Asia's Militaries

Muscle Up," that Asian countries are actively purchasing the best, highest technology weapons available. Some countries, like Japan, clearly have the technical capability to pursue SW projects even if they have none currently under development. From 1990-94, North Korea, with little else to export, sold $693 million of SCUD missiles and other Russian weapons. China sold $6.1 billion in the same period.[23]

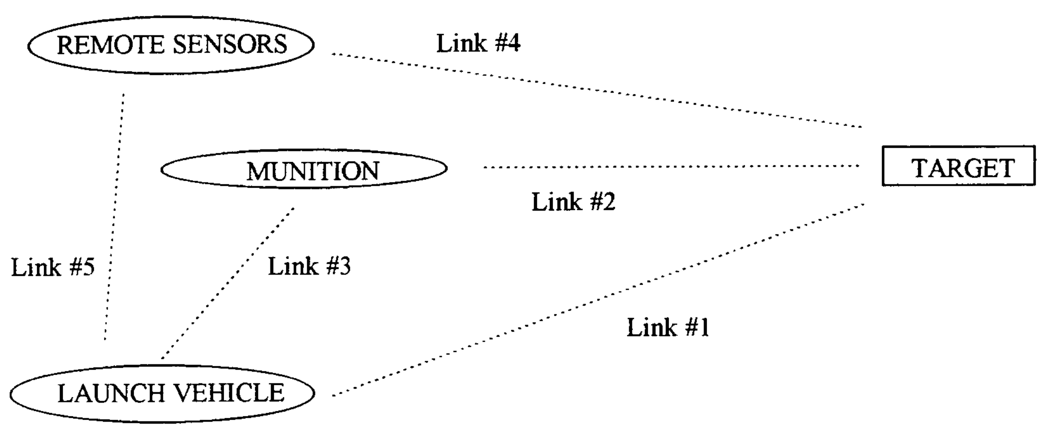
It appears that the arms market, through direct sales, technology transfers, and the shifting power balance will provide the increasingly capable Pacific Rim militaries with the best weapons in the world. Why would other wealthy nations, the Arabs for instance, not also participate in this trend? The eventual transfer of SW technology worldwide is inevitable. Someday, these weapons will be used against U.S. Forces. A fictitious scenario could look like this:

> The platoon sergeant, standing in the TC's position of his tank, leaned against the open commander's hatch and drank a cup of cold coffee. It was just after dawn on a February day in 20XX. The gently undulating desert floor stretched out all around him. Funny, he thought, how things go-around in circles. Another "Gulf War."
>
> The desert was cold. The air calm. The company had just finished stand-to and the last turbine engine had just whined to a stop. The hot exhaust had felt good on the back of his neck, and he missed its warmth.
>
> The first one went off like a gunshot just above the CO's tank. There was a brilliant, pyrophoric splash and double report as the penetrator hit the tank's back deck above the hot engine. The submunitions rippled in. They were loud and came quick, like firecrackers in a school hallway. Each submunition's IR seeker aimed for the tank's hot engine deck that sharply contrasted against the cold desert floor.
>
> Exploding ammunition from an M-1's turret bustle shot spectacularly across the desert. Huge columns of smoke stood in the sky. A few tanks, their fire suppression systems unable to put-out the fire, had enormous fuel-fires burning in their rear fuel cells. A few tanks smouldered ominously from turret hits. The sergeant looked in the direction of A Company, and saw similar columns of smoke. Pyres of smoke marked other companies, too. The whole battalion was hit.

Countermeasures. Countermeasures (CM) are one method of interfering with a SM's target acquisition and guidance. Both separate target acquisition systems and SM rely upon one or more "links" to execute a successful engagement. First the target must be detected by the shooter or, depending upon the system, a ground or airborne sensor. After launch, the SM must also acquire a target and guide itself to a successful attack.

CM can break or interfere with these linkages and prevent or degrade a SM's ability to conduct a successful attack. The illustration and table below show the five links identified by the Guidance And Control Information Analysis Center (GACIAC).[24]

Smart Weapons Systems Data Links



Link #1	Target Acquisition, Designation and Tracking
Link #2:	Homing Guidance
Link #3:	Missile Command and Tracking
Link #4:	Target Acquisition and Track
Link #5:	Data Link

Each specific SW has one or more of these links, but do not usually function with or depend upon all of them. Link #3, for instance, is not part of the HELLFIRE system.[25] Successful CM must interfere or break specific links used by specific systems.

Different systems, obviously, rely upon different means to communicate across their links. Some use IR seekers, visual images, lasers, radar or a combination of sensors to guide the munition. These sensors might operate alone or in combination on any of links #1-4.

A broad range of sensor types likely requires a broad range of CM tailored to counter each specific SW. A weapon using a combination of links and a combination of sensors will probably be more difficult to successfully employ CM against. Clearly there are practical limits to this approach. If the munition functions autonomously, than it must carry its own suite of expensive sensors to destruction at the point of impact or detonation. Added autonomous capability also means added weight that must be flown or shot downrange to the target.

In many cases, it will be easier to prevent a munition from being launched rather than attempting to disrupt or destroy it in flight. Active CM may also include destruction of target acquisition systems communicating to launch platforms via Link #5 in order to deny the enemy's ability to detect targets for their SM. If feasible, launch platforms might also be destroyed before launching their weapons, or while munitions are inflight if they depend upon Link #3 for guidance. The latter is a familiar method for disrupting wire-guided antitank missiles. At the operational and tactical level of war, target acquisition systems and launch systems are good candidates for HVT analysis.

The most obvious method of countering a SM is a technical CM interfering with the SM's ability to acquire or guide itself to the target. With regard to SM, there are four classes (or methods) of EW (Electronic Warfare) CM: signature alteration; decoys and deception; obscurants, and; DEW (Directed-Energy Weapons) and jammers.[26] Each of these methods is a technical CM aimed to defeat or destroy one or more of the five links upon which SW depend. As will be seen, these methods overlap to some degree. The future will likely realize new technical EW CM that can be added to these generic classes. For that reason, this list should not be regarded as complete.

The purpose of signature alteration is to make the target (a vehicle, for instance) indistinguishable from the background.[27] If achieved, a SW weapon system will neither detect nor, if launched, successfully guide itself to the target. Signature alteration includes the use of foliage, camouflage and low emmissivity nets and paints, redirecting engine exhaust, and masking of hot spots. Foliage and camouflage are already familiar methods of concealing vehicles in their natural surroundings and recognized methods of avoiding detection. An exception to the general purpose of signature alteration is not to make the vehicle blend with its natural surroundings, but to alter the way in which the SW sees the target. Examples of this are flares and chaff as used by aircraft to deny SW acquisition systems and decoy launched SM away from the real target. Heated smoke from vehicle exhaust and smoke pots can also decoy away SM. Fires (such as a campfire or fire-pot) can also perform this function, causing the SM to attack the heat source rather than the vehicle. Heated and unheated corner reflectors (also known as "corner cubes") can also deceive acquisition systems and alter the vehicles appearance to fool SM sensors or cause the SM to attack the corner cube instead of the vehicle's center of mass. Redirecting the engine's exhaust alters the way a heat sensitive SM sensor sees the target vehicle, and may cause the SM to fail to identify the target or attack the new heat source.

As a class, obscurants are simply intended to hide vehicle targets from acquisition or prevent penetration of SW laser guiding systems.[28] Obscurant CM techniques include smoke and chaff systems, but are primarily concerned with the concept of hiding vehicle targets from SW sensors or degrading the image received by launched SM. Like corner cubes and low emissivity paints, chaff and smoke can be optimized to function from the visible through millimeter wave spectrum.

As a class, decoys and deception tend to overlap with the classes of signature alteration and obscurants. Though similar in function they are different in purpose. The concept is simply to use decoy vehicles, heated plates, fires, corner cubes and other measures to create an entirely new set of targets.[29] Decoys, dust and smoke are currently accepted methods of deceiving the enemy and can also work against SW sensors. The goal is not to deceive enemy machines, but to deceive human enemy leaders to misread the battlefield and waste time and expend resources against a decoy set.

Jammers and DEW are active systems emitting radio, laser or microwave energy.[30] Low intensity CM emissions, such as jammers and low intensity lasers or radio emitters, are tailored against a specific SW sensor and can cause a launched SM to fail because it loses target lock. These systems can even be vehicle-mounted to protect the host vehicle from incoming GM and SM.[31] A high intensity CM emission, such as a High-Powered

Microwave) HPM or high-energy laser, is intended to physically damage a SM inflight and cause it to malfunction.

There is yet another method of stopping an inflight SM. "Projectile-based CM" detect and attack incoming SM by destroying them with explosive warheads or kinetic impact. Rockwell's Missile Systems Division began developmental research of vehicle-mounted smart CM missiles to detect and destroy inbound SM in the early 1990's. The program is ongoing.[32] Detecting and tracking an incoming SW, and launching a SW CM munition to destroy it, is clearly the most technically complicated SW CM. Are there other ways of stopping SW?

This paper has so far considered CM only from the western point of view. Operation DESERT STORM had a significant effect upon other armies of the world. The U.S. impressed the world's nations with our target acquisition systems, lethal and accurate indirect-fire systems and imposing GM capability. During the war, television media captivated worldwide audiences with incredible images of GM flying down laser beams through windows and ventilator shafts. What methods have other nations devised to counter SW?

Lester Grau, author of Desert Defense and Surviving PGMs: The New Russian View, observed that the Russian Army is especially interested in methods for fighting on SW-dominated desert battlefields.[33] In response to Operation DESERT STORM, the Russians devised methods to protect mechanized forces from SW.

Emerging Russian TTP (Tactics, Techniques and Procedures) includes a range of methods to protect against SW attack. These methods include signature alteration, decoys, deception and obscurants. The Russians also developed operational doctrine for fighting an enemy with highly capable SW.

Signature alteration is the primary technique the Russians devised to both avoid detection and successful targeting by SW. The most employed means through which they accomplish this is by digging-in. All vehicles, fighting positions, communication trenches and command posts are dug-in and carefully concealed from overhead observation. The purpose of digging-in is to simply make specific targets within a defensive position invisible.

The most innovative Russian technique is their construction and use of plastic covers to hide vehicles from overhead detection and SW attack.[34] These covers are constructed in the field. After the vehicle's fighting position is dug to proper depth, the spoil (dirt or sand) is heaped into a mound. Next, the plastic cover is constructed over this mold of mounded earth. The mound is shaped into the cover's desired shape and size and then covered with plastic film. The soldiers then spray polyurethane foam over the mold. When dry, the rigid cover is lifted from the mold and placed over the vehicle's fighting position. Lastly, soldiers scatter dirt and foliage over the polyurethane cover to naturally camouflage it, blending it with surrounding terrain. Soldiers cover foxholes, other small positions and trenches with ponchos and canvas and then camouflage them also.[35] If carefully constructed, the cover still permits a vehicle to fight from its camouflaged position, or the vehicle can displace to an alternate position.

Borrowing a technique from the Russian oil industry, the Russian Army learned a way to prevent erosion of carefully prepared fighting positions and trenches. Russian oil workers use a chemical called "Nerosin" to stabilize soil around oil pipelines and other structures. Soldiers discovered that spraying a 4-5mm-thick layer of Nerosin on and around their fighting positions deters erosion and increases the soil's durability against wind and rain.[36]

The Soviets successfully used high quantities of flares and chaff to protect their aircraft in Afghanistan from IR-guided antiaircraft missiles. Since the early-1980s, the Russians also employed these techniques to protect ground forces.[37] Each company-sized position includes flare and chaff dispensers to obscure and decoy incoming SW.

Russian ground forces will also employ radar reflectors, corner cubes, dummy positions and dummy systems to decoy incoming SW and minimize the number of SW attacking real targets. Dummy positions include heat sources and radar reflectors.

The Russians believe that the Iraqi Army constructed many decoys and dummy positions during the Gulf War[38], and that many American SW were targeted against these positions. The Russians believe inflatable and fiberglass Iraqi decoys were painted with metallic paint and heated to ensure they were seen by target acquisition systems and targeted by SW systems.[39] Based upon this observation, Grau believes future Russian defenses will employ numerous dummies and decoys in and around their defensive positions.

The Russians studied the employment of smoke and dust to impair laser-guided SW performance. They noted that it takes 30-70 minutes for the dust to settle after an artillery attack before laser-guided SW can be successfully employed against the position.[40] Smoke is also useful and can be tailored against specific laser frequencies.

The Russians are also interested in DEW and jammer technology. They pioneered this technology with early vehicle-mounted jammers to decoy flare-tracked ATGM (AntiTank Guided Missiles) such as TOW.[41] Multi-mode IR, MMW and acoustic sensors are inherently more difficult to decoy and may be able to disregard a sensor mode if it is jammed or degraded.

The technology, TTP and operational CM described by Grau are not revolutionary, but are adaptations to the SW threat. It will likely be very useful at fixed sites such as airfields. Digging-in is extremely time and resource intensive. Some situations will not permit digging-in. It is impractical in offensive operations. In the whole, digging-in as the primary CM against SW attack severely limits tactical employment of mechanized forces.

An Operational Solution? In an effort to solve this tactical stalemate, the Russians conceptualize future SW warfare in two phases. The first is a "defensive, counter-SW" phase. This phase is characterized by SW-imposed tactical stalemate. There is little maneuver. Both sides attempt to use SW fires to attrit the enemy, weaken their combat power and destroy HVTs. Opponents slowly expend their limited, irreplaceable SW stocks. Eventually, one side or the other exhausts their stock of SW and a more or less conventional war of mechanized maneuver ensues (Phase Two counteroffensive).

Nations other than Russia are also looking for ways to defeat SW. China, for example, studies SW technology and tactics with acute interest.[42] Importantly, the battle against SW does not end with technical, tactical and operational CM.

Counter-countermeasures. What will the enemy (and the U.S.) do with a SM after a CM successfully defeats or degrades it? The obvious method is to redesign the SW's hardware and software. From a warfighter's perspective, this appears to be the most desirable fix. In the long-term, redesigning and upgrading SW is certainly the ideal method to defeat existing or envisioned enemy CM. In the short term, however, the warfighter can help himself.

There is a tendency, especially from the combat arms perspective, to view a SM defeated or degraded by an enemy CM as an inadequate, faulty weapon requiring replacement or an upgrade of its hardware or software. The Guidance And Control Information Analysis Center's *Countermeasures Study* found that this is not the case and that hardware fixes are usually the most expensive method of countering an enemy CM.[43] Hardware and software changes also take the most time to implement and will do the warfighter no good in the heat of battle.

This process, that of countering a CM, is known as counter-countermeasures (CCM). CCM are not limited to hardware and software changes, but may also include changes in doctrine, tactics and training to alter the method whereby friendly forces employ a SM to counter a previously successful enemy CM. In later parts, this paper will specifically focus on means by which friendly forces can employ operational and tactical CM to prevent and degrade enemy SW attack.

It is possible to construct a nearly perfect SM, given enough money, time and intelligence on enemy CM.[44] The reality is that new CM and CCM will competitively co-evolve with both sometimes being superior to the other. A realistic solution is the combination of field expedient measures and software and hardware redesign to both extend the life of fielded SW and protect friendly forces.

CCM are an example of looking at the battlefield through the eyes of the enemy and through the sensors that guide his SW. This is not just an exercise in theory. The enemy will slaughter our soldiers, destroy our expensive and irreplaceable mechanized forces, and cause our mission to fail if we do not successfully combat his target acquisition and SW systems. It is better for us to think now about what we will do then. Ninety-two years ago, The Defence of Duffer's Drift challenged us to do the same.

Thinking About SW and Future War.

> "Between you and me, I was really relieved to be able to put off my defensive measures til the morrow, because I was a wee bit puzzled as to what to do. In fact, the more I thought, the more puzzled I grew. The only "measure of defence" I could recall for the moment were, how to tie "a thumb or overhand knot," and how long it takes to cut down an apple tree of six inches in diameter. Unluckily neither of these useful facts seemed quite to apply. Now, if they had given me a job like fighting the battle of Waterloo, or Sedan, or Bull Run, I knew all about that, as I had crammed it up and been examined in it too. I also knew how to take up a position for a division, or even an army corps, but the stupid little subaltern's game of the defense of a drift with a small detachment was, curiously enough, most perplexing. I had never really considered such a thing. However, in the light of my habitual dealings with an army corps, it would, no doubt, be child's-play after a little thought."

So begins the odyssey of Lieutenant Backsight Forethought and his attempts to defend "Duffer's Drift." Then Captain Swinton, later Major General Sir Ernest Swinton, K.B.E., C.B., D.S.O., published the whimsical and instructive tale, The Defence of Duffer's Drift,[45] in 1905 after returning from service in the Boer War.

Swinton's purpose in writing was to teach basic and practical tactics to officers bored by countless lectures and examinations on grand strategy and the dull theories of war in army service schools and colleges. Swinton's advice was practical and smelled of gunpowder and sweat. He challenged the reader to compete against the enemy and build the best possible defense of a ford across a shallow river. Through a series of "dreams" Swinton leads the reader through a compelling saga of six iterations of the defense. Only in the last dream does the hapless hero, Lieutenant Backsight Forethought, "get it right," successfully defending the crossing and defeating the enemy unit attempting to cross.

Swinton's tale of Backsight Forethought's tactical education is very engaging. Unfortunately, five of the six dreams are in reality nightmares ending in defeat and the loss of his soldier's lives. Wass de Czege's image of future war is even more horrific than Forethought's nightmares.

Wass de Czege's vision of the Potential Force is one of a unit with tremendous, nightmarish firepower. He predicts a Potential Force brigade could use precision fires to completely destroy an enemy division in less than ten minutes.[46] Forethought's process of iterative learning would be too costly, and too bloody, to contemplate. We cannot afford such expensive education. We owe better to our fellow Americans, and should expect them to withdraw support for our operations if we suffer undue casualties.

Let's now consider techniques of protecting mechanized forces from SW attack. The purpose is to consider today what solutions might work tomorrow. Swinton confronted the reader with a "model," and challenged his readers to solve the tactical riddle of Duffer's Drift. His model was composed of the crossing site and surrounding terrain, a clever enemy, available friendly forces and Lieutenant Forethought's mission.

To consider how best to protect U.S. mechanized forces from SW attack, we must also consider a realistic model.

A SW MODEL. Our model is set in in the year 20XX. The circumstances are not unlike Operation DESERT STORM and should be familiar to all contemporary readers. "The War of 20XX" is much like the Gulf War of 1991, except modernized U.S. Forces fight SW-armed enemy forces. Opponents have and use comparable SW already under development, including BAT and Bonus/SADARM and SMArt.

As in Operation DESERT STORM, U.S. Forces accomplish the mission per the operational phasing of FM-100-7:[47]

Phase IIA: Deployment
Phase IIB: Defense and Force Build-up
Phase IIC: Offensive Operations

The conditions for the "War of 20XX" are much the same as SWA in late-August 1990. U.S. Forces enter the theater unopposed through a friendly nation to oppose an enemy's hostile action. U.S. Forces conduct an unopposed deployment, defensive operations, and prepare for and conduct offensive operations. Like Operation DESERT STORM, U.S. Forces are still vastly superior to enemy forces. The biggest difference, of course, is the existence of enemy SW on the battlefield.

PART II: A SW MODEL

Phase IIA: Deployment

Operational Countermeasures Against Smart Weapon Attack During Deployment Operations. During deployment operations friendly forces deploy into the theater of operations. Friendly forces deploy along Air Lines Of Communication (ALOC) and Sea Lines Of Communication (SLOC) to their respective Air Ports Of Debarkation (APOD) and Sea Ports Of Debarkation (SPOD). From the Ports Of Debarkation (POD), mechanized forces debark, trans-load, organize and deploy via air, rail and road to their Assembly Areas (AA). When deploying by road, mechanized forces frequently prefer to roadmarch most wheeled vehicles and transport tracked vehicles on HETT (Heavy Equipment Transporter-Trucks).

Projection and entry of friendly units into a theater of operations is the first operational phase that could possibly bring mechanized forces within range of enemy SW. Methods through which enemy forces might interdict deploying friendly forces enroute are outside the scope of this monograph. Upon arrival in the theater of operations, however, enemy forces can target mechanized forces at the SPOD, APOD, Lines Of Communication (LOC) and AA. Planners will likely attempt to conduct most deployment operations before the outbreak of hostilities, therefore, planners should assume the integrity of enemy command and control , Link #5 systems (the data link between remote sensors and launch platforms) and the full capability (if not the will) to mount very-long-range SW attacks.

However, ports and urban areas make poor engagement areas for many-on-many SW attacks. Neither the terrain or target array is suitable for employment of many-on-many SW. More importantly, shipping, aircraft and fixed-facilities will likely be more profitable targets then individual vehicles at ports and airfields. If vehicles at a port or airfield are "warehoused" by closely parking them fender-to-fender, then traditional large-caliber, guided or unguided, high explosive or NBC (Nuclear, Biological and Chemical) weapons can economically destroy them or deny their use. There is no reason to use many-on-many SW in this situation. The enemy is unlikely to employ BAT-like indirect-fire SW for these attacks.

Vehicles dispersed into assembly areas near ports and airfields are still susceptible to large-caliber high explosive or NBC attack. The enemy might also attack them with many-on-many SW. Which will they prefer?

This is a specific technological question also beyond the range of this paper. It is probable that SW will forever improve in their ability to attack increasingly dispersed target sets. Dispersal, however, will still remain one of the best ways of deterring SW attack. Available SW technology, terrain, dispersion of vehicles and other factors[48] will determine which weapon the enemy might use. Assuming that SW are the weapons of choice, how are mechanized forces dispersed into AA near ports and airfields best protected from them?

The best method, clearly, is to deny the opportunity to attack. POD and AA beyond the range of enemy surface-to-surface weapons are ideal. Normally this will deny enemy opportunity to attack while U.S. Forces continue to flow into theater and build combat power. If hostilities have not yet occurred, enemy forces may be politically restrained from initiating them at this critical phase in U.S. operations.

It may not be feasible to use APOD and SPOD entirely beyond the range of all enemy surface-to-surface weapons. Even if it is possible, enemy aircraft will still likely present a threat. During the Gulf War, Iraq successfully ranged SPOD used by U.S. Forces.[49]

Providing for air superiority is the single greatest contribution the operational planner can make during the deployment phase. If the enemy does attack, they must deliver their SW via aircraft, SCUD-like missiles or cruise-missiles. Although these weapons exceed the scope of this paper, the best means of defeating missile, cruise-missile and aircraft delivered SW attacks are to destroy the missiles or aircraft before they launch their SW submunitions. Air superiority is the best method of protecting ground forces from these very long-range weapons. The operational planner must allocate sufficient early-on transport to organizations, command and control systems and necessary logistical support structures to provide for early air superiority. Local air superiority is sufficient, but it must include coverage of POD, routes to AA and AA. Other than the obvious need for air superiority, there are other methods by which mechanized forces can protect themselves.

The choice of theater LOC may be crucial in denying the enemy optimal use of his SW. Flat terrain surrounding open, exposed roads creates an ideal SM EA (Engagement Areas) for slowly moving vehicle convoys. A better route moves through urban areas (background clutter), mountainous terrain (disrupted LOS) and terrain with thick overhead foliage (signature alteration). Along theater routes, the enemy will select EA associated with chokepoints to mass the effects of their SW. This is not a new technique: The U.S. Air Force identified chokepoints in Iraq and massed GM-laden aircraft into "kill-boxes" during Operation DESERT STORM.[50]

Theater movement from POD to AA during daylight hours may be a useful SM CM. Increased civilian traffic during daylight hours complicates the enemy's tracking of friendly vehicles. In the desert, movement during the heat of the day may minimize the IR contrast seen by an IR sensor between a target (vehicle) and the background.[51] Though not commonly thought of as an HVT, HETT and flat-bed transporters may be crucial to the successful inter-theater Phase IIA deployment of mechanized forces.

Tactical Countermeasures Against Smart Weapon Attack During Deployment Operations. During POD operations, tactical forces can do little to protect themselves from SW. Usually, mechanized forces at the POD are insufficiently organized and lack access to all their equipment. Further, they are normally unable to disperse, as the POD is usually crowded and space at a premium. Realistically, they are limited to the defensive framework established by reception-and-onward-movement forces at the POD. Fortunately, many-on-many SM are not well suited for attacks on POD.

During inter-theater movement, tactical units have little increased potential to provide for their own SW defense. Theater commands will dictate movement routes and timetables. Units will still not have ready access to all equipment and will probably not be fully organized, or capable, of conducting combat operations. Unlike at the POD, and despite the very-long-ranges, SW are well suited for attacks on friendly forces conducting onward-movement operations from the POD.

As at the operational level, air superiority is the best defense against very-long-range delivered SW attacks. At the tactical level, mechanized forces contribute to operational-level air superiority by active and passive measures protecting them against air attack. To the best of their ability, moving units should provide for their own air defense.

"Technical-CM" are necessary to protect moving units. Lacking fully automatic detection and defense CM, unmanned vehicles moving on HETT will be unable to defend themselves, but should still carry deployed corner cubes. Systems carried by other vehicles moving in the convoy must provide the bulk of the CM, to include chaff dispensers, flares, jammers, DEW and "projectile-based-SW-CM" systems. Vehicle-fired smoke grenades may be one of the best defenses available to convoys under SW attack.[52]

Friendly forces must conduct movements with extreme care. G-2 planners must accurately assess likely chokepoints, possible SW EA, and estimate diurnal and other environmental conditions (low ceilings, rain, fog, smoke, dust) when SM sensors will be most degraded.

There are two other operational and tactical techniques useful in minimizing SW attack: Deception and "Russian-style" CM. Successful deception might be executed at the operational or tactical level (or both). Mechanized forces may employ tactical "Russian-style" CM once inside their AA or in their battleposition. "Russian-style" CM are similar in application in both places. This paper will discuss operational and tactical deception under Phase IIC offensive operations. First, let's consider "Russian-style" CM techniques during defensive operations.

Phase IIB: Defense

Smart Weapon Operational Countermeasures During Phase IIB Defensive Operations. Deployment operations continue throughout Phase IIB as additional forces flow into theater to bolster minimal defenses already deployed and to provide for future Phase IIC offensive operations. Some units remain in their AA, others occuppy defensive positions. Friendly forces are usually within range of very-long-range SW, and may or not be within range of common, long-range missile and artillery delivered SW.

Air superiority, as before, remains an important SW CM in Phase IIB operations. Without air superiority, mechanized forces are prey to all long-range SW. Instead of denying the attack, friendly forces without air superiority must conceal themselves or decoy away each SW submunition. This is attrition warfare. Unless our CM are very good and the threat submunitions very poor, this strategy is likely to fail. At a minimum, it will permit the enemy to begin slowly eroding our mechanized forces and interfere with our all-important build-up of combat power. The Russian Army is placing increasing doctrinal emphasis upon SW attrition warfare.[53] Air superiority is, of course, only the first CM we must employ.

Tactical Smart Weapon Countermeasures During Phase IIB Defensive Operations. "Russian-style" CM are well suited for protecting stationary vehicles in AA and defensive positions. These measures, discussed in Part I of this paper, are relevant to all Phase IIB operations. Passive signature alteration, accomplished through digging-in all vehicles and covering them with camoflauged polyurethane covers, is one of the best ways of denying target identification by launched SM. These CM are very manpower and resource intensive, however.

Denying enemy HUMINT (Human Intelligence) will also remain an important component of protecting friendly forces deployed into defensive positions. Because friendly forces are well concealed and each vehicle is hidden in its fighting position, IR and radar signatures are reduced to an absolute minimum. This situation will encourage the enemy to use HUMINT and scouts to locate friendly forces.[54]

Just as during AA operations, technical-CM will be of lesser importance in protecting defensive positions. Vehicle crews will rely upon Russian-CM to best hide their vehicles from detection and protect them from incoming SW submunitions.

Decoys will also be an important method of minimizing successful SW attack upon defensive positions. With enhanced radar and IR signatures, decoys may draw-off a disproportionate share of incoming SM. A U.S. Army Development and Employment Agency JANUS wargame studied decoy placement in and around tank and infantry-fighting-vehicle positions. The simulation analyzed threat direct-fire engagements against friendly forces with varying ratios of decoys to real targets. The study also analyzed the possible synergistic effect of smoke. The study concluded[55] that decoys received an average of three shots before threat forces discovered them to be decoys. That a threshold ratio of one decoy to four real vehicles existed. Below this ratio, there was a marked increase in the number of friendly vehicles identified and struck by enemy fire. Predictively, decoy ratios above 1:4 ratio worked even better, but only slightly so. When decoys were placed immediately adjacent to a real target, it did not matter exactly where they were located. However, decoys were used to greatest effect when placed well to the front of real vehicles so as to ensure they were identified by enemy gunners before real friendly vehicles were seen. Importantly, smoke did not have a synergistic effect.

This relevant and potentially significant computer simulation may shed considerable light upon employment of SW decoys in and around battlepositions. Obviously, high decoy to friendly vehicle ratios are key to maximizing decoy effectiveness. Decoys should radiate enhanced IR and MMW images to ensure they are identified and attacked first by falling submunitions. Smoke, chaff and jammers may raise the background "noise" high enough to ensure real vehicles are "blended" with the background while enhanced-image decoys are easily detected and attacked.

When the attack comes, each SM submunition falls toward the ground searching for a target. Many submunitions will attack decoys having amplified IR and radar images. Vehicle crews will maximize their chances of survival by remaining hidden in their covered fighting positions.

Effective signature alteration requires altering the image perceived by the falling submunition. Some field expedient signature alteration techniques that might intuitively seem to work instead fail dramatically, actually enhancing a vehicle's probability of being hit by a SM. An example of this was a Guidance And Control Information Analysis Center test of a vehicle covered with a camouflage net. The covered vehicle was more often hit than an adacent fully exposed vehicle. Further testing determined that the camoflauge net trapped the vehicle's hot engine exhaust and increased the vehicle's IR signature.[56]

Chaff, smoke grenades and jammers will clutter the image received by falling SM, making it more difficult to sense (real) vehicle targets. Some submunitions will attack flares, fires and smokepots (thermal sources), although there will be little time to deploy any of these technical-CM except for flares. An important and needed innovation is a technical system automatically detecting a SW attack and triggering active-CM throughout the unit.

Phase IIC: Offensive Operations

Operational Smart Weapons Countermeasures During Phase IIC Offensive Operations. Mechanized forces will depart their AA and battlepositions to attack along an axis to an objective during Phase IIC offensive operations. Vehicles leave the safety of hidden positions, mass (to a greater or lesser degree) and begin moving toward the objective. Offensive action usually includes a deception operation to deceive the enemy of the friendly force's true location, timing and axis of attack.

This paper has emphasized the absolute importance of air superiority during Phase IIA and IIB operations, and air superiority is especially important during Phase IIC. As a combat multiplier, the enemy must not be able to bring their air assets to bear aginst vulnerable, massed and moving mechanized forces. At a minimum, air superiority removes the danger of massed aircraft and missile delivered SW attacks.

Deception may become the most important operational SW CM in the future. In its opening pages this paper considered the significance of BG Wass de Czege's chess analogy. Wass de Czege's point was that even with complete situational awareness it was possible for a chess master to deceive his opponent as to the direction, timing and strength of attack. The campaign planner must perform the same sleight of hand to operationally protect mechanized forces in a SW environment.

The deception must seem real. To accomplish this, the deception effort will require significant resources, probably more than 50% of all resources available. Other than military elements of "D.I.M.E." (Diplomatic, Informational, Military and Economic) should be employed to enhance the deception effort. The enemy's tools for "seeing the battlefield" (electronic, HUMINT, media, satellites and soldier reporting) must be saturated to create the picture the enemy wants to believe.[57] Real maneuver units, decoys, artillery fires, helicopters, amphibious landing focres and aircraft sorties must batter the "front door" while the main attack quietly slips around to the "back window." The operational planner must make the chess master proud. The successful deception effort must draw the enemy's SW.

If the enemy uses "Link #5" (remote sensor to SW link), then the operational planner must plan to break or disrupt it prior to beginning offensive operations. With friendly forces on the move, Link #5 is critical to the enemy's ability to locate friendly forces and accurately time and fire SW and SM. Because of time-space considerations, denying this command, control, communications and intelligence link to the enemy during our offensive maneuver is more important than during any preceding phase of operations.

Tactical SW CM During Phase IIC Offensive Operations. Moving vehicles maximize their visible, IR, MMW and acoustic signature. During Operation DESERT STORM, Iraqi and coalition forces both massed into long, vulnerable lines during movement. Russian-style CM designed to conceal stationary vehicles in well-prepared positions are inappropriate for protecting moving vehicles. The enemy's target acquisition systems will readily detect moving mechanized forces. Worse yet, friendly vehicles are liable to mass (to a greater or lesser degree) as they execute offensive operations, making a target-rich environment for indirect-fire SM. Armored vehicles on-the-move are the ideal target array for indirect-fire, many-on-many SM. It is the target set these SM were designed to destroy in a barrage of falling submunitions. How can U.S. mechanized forces, maneuvering to impose the operational commander's will upon the enemy, protect themselves from SM slaughter?

Technical-CM will likely be the *primary* tactical SM CM used by moving vehicles. Simply put, moving vehicles are outstanding SM targets. Unlike signature alteration CM for stationary vehicles discussed in Phase IIB operations, increased background clutter does not significantly degrade MTI sensitive MMW sensors. Chaff and smoke are a less effective CM for the defense of moving vehicles. Moving vehicles attacked by MTI-sensitive SM should *stop* to reduce their MTI (and acoustic) signature. Therefore, it is essential for moving vehicles to decoy falling submunitions with flares and image-enhanced decoys. Jammers, DEW and projectile-based-SW CM probably have an important future in the defense of moving vehicles.

The Russians have devised an overhead, self-supporting screen mounted on top of their vehicles to conceal them from SM targeting. Vehicles are capable of unrestricted movement in open, desert-like terrain with these "geoforms" mounted above them. Geoforms are a follow-on development of, and similar in function to, polyurethane covers for defensive positions. Of course, geoforms cannot be used in restricted terrain.[58]

Deception will be an important tactical tool to protect moving vehicles.[59] With a finite number of indirect-fire systems, the enemy cannot simultaneously shoot everywhere on the battlefield. As BG Wass de Czege observed, sleight-of-hand will be more important than brute force. A tactical deception force could use corner cubes, radar reflectors and decoys to attract the enemy's attention. If portrayed in a realistic operational setting, the enemy will determine this force to be the main attack. The real main attack might proceed on concealed routes through urban, vegetated or broken terrain, complicating enemy detection. Smoke covering the attacking force, or thinly covering a second deception force might further confuse the enemy's targeting process. Of course, friendly counter-fires upon enemy indirect-fire systems will also limit the enemy's ability to launch effective many-on-many SM attacks. The selection of future High Pay-off Targets (HPT) will be critical. Current HPT matrices typically emphasize enemy command and control and Weapons of Mass Destruction (WMD) systems. As the enemy SM threat increases, future HPT matrices will place increasing importance upon destroying the enemy's many-on-many SM delivery and target acquisition systems.

PART III:

CONCLUSION

This paper, ultimately, is about fighting future war. Current trends suggest SW will be the dominant weapons on the future battlefield. These weapons are highly efficient, lethal and long-ranged. SW date at least as far back as World War II.[60] They were used in Vietnam. They played a highly visible role in Operation JUST CAUSE. They were used in unprecedented numbers in Operation DESERT STORM. SM are a logical and even more lethal extention of early GM technology.

Part I of this paper considered the significance of emerging SW technology, considered the four specific SM nearing production, evaluated the likelihood of SM technology spreading worldwide, looked at SW CM and the impact of CCM. Part II weighed SM technology against the tactics and operational sequencing currently practiced by U.S. mechanized forces. Part III will link SM technology (Part I) with counter-SW techniques, tactics and operational phasing (Part II) and attempt to draw practical conclusions for the protection of U.S. mechanized forces from SM attack.

Drawing Conclusions. The following chart summarizes this paper's description of SM CM during operational Phases IIa thru IIc. In this chart, CM are unconventionally grouped, and include other than doctrinal CM. One or two plus marks depict the relative positive value of each measure/CM.

Methods of Defeating and Degrading Enemy SW Attack.

Categories of CM	Phase IIA: Deployment	Phase IIB: Defense and Force Build-up	Phase IIC: Offensive Operations
Denying reconnaissance /HUMINT operations	+	+	
Air Superiority	+	+	+
"Russian-CM:"*		+	
Denying Link #5:		+	+ +
"Technical-CM:"			+***
Deception:	+	+	++

* "Russian-CM" refers to those signature alteration-based CM developed by the Russians and described by Lester Grau.

** "Technical-CM" refers to devices isssued to units and vehicles to protect them from SW. These include, but are not limited to, chaff dispensers, flare launchers, radar reflectors, corner cubes, thermal devices, jammers, DEW, and projectile-based anti-SW defensive weapons.

*** Per discussion in the section on tactical SW CM in the offense, increased background "noise" is not an effective CM against MTI operating on moving targets. Chaff, for instance, is relatively ineffective in this situation.

Counter-Reconnaissance Operations Remain Important. Lester Grau discussed the initial significance of Spetnatz and ground reconnaissance patrols. These are traditional forms of intelligence collection, and they will remain relevant on the future battlefield. Reconnaissance forces and HUMINT will attempt to locate friendly forces in the early phases (especially Phase IIa) of conflict. Deployment and POD operations are vulnerable to these forms of reconnaissance. Major General Sir Swinton also emphasized the importance of both enemy reconnaissance and HUMINT in his instructional tale 92-years ago.

The Importance of Air Superiority. In this by-phase analysis, air superiority consistently emerged as an essential CM to protect ground forces from very-long-range SM delivered by aircraft, cruise missile and surface-to-surface missile (such as SCUD).

Air superiority is especially important during Phase IIc offensive operations to protect vulnerable (moving and massed) mechanized forces.

Relying Solely Upon Russian-Style CM Is Not The Answer. Russian-style CM seem a successful signature alteration technique for stationary, defending forces. However, used alone, these CM greatly limit employment of mechanized forces. To simply accept a stalemate "SW Phase" followed by a phase of conventional maneuver lacks initiative and foresight. Deception and technical-CM can restore mobility to the SW battlefield. The Russians base their operational two-phase strategy on the premise that their enemy will "run-out" of SW. This may or may not be a correct assumption. Whether it is a correct assumption or not, this time-consuming game of hide and seek may result in significant attrition of friendly forces or allow SM to dominate battlefield maneuver without even being fired.

Link #5 Is A Vitally Important SM Link. Fully modernized enemy armies will exploit their complete situational awareness in order to target their many-on-many SM. Their reliance upon information and situation dominance emphasizes the importance of "Link #5." Therefore, enemy remote sensors and the C3I architecture supporting Link #5 will be lucrative HVT. U.S Forces can destroy or degrade the enemy's Link #5 in order to sieze the initiative or control operational tempo.

Technical-CM Are Essential To Protect Moving Vehicles. Many-on-many SM are most effective against moving vehicles. Moving vehicles have enhanced IR, acoustic and MMW signatures and are deprived of "Russian-style CM." U.S. Forces need fully automatic SW detection and CM systems to protect vehicles from attack.

Operational Deception Will Be More Important Than Ever In Protecting U.S. Forces During Offensive Operations. Mechanized forces are most vulnerable while conducting offensive operations. Enemy forces will use enormous numbers of SW (massing SW effects) to destroy attacking U.S. Forces. To succesfully defeat this SW attack, operational planners must deceive the enemy as to the strength, direction and timing of attack. Deception operations will also be important during deployment and defensive operations. Indeed, deception operations in these early phases may play a crucial role in successfully setting the conditions for the enemy to accept a Phase IIc deception story.

Lastly, this paper must consider a commonly heard SW theme: That opponents will "run-out" of SW. This assumption is the central premise for Russian two-phase operational SW CM. There is no reason to believe it.

Combatants will not "run-out" of SW. During the U.S. Civil War the Commandant of Springfield Arsenal opposed the introduction of breech-loading and repeating small arms. He doggedly produced muzzleloading muskets for the Union at Springfield Arsenal until war's end. He complained that breechloaders were unsuitable for a variety of reasons, not the least of which was that they were too expensive and that the troops would use too much ammunition. Regardless, both Union and Confederate armies procured increasing numbers of breechloading rifles.[61] The Civil War proved the advantages of breechloading rifles over muzzleloaders.

Operation DESERT STORM proved SW technology. Coalition aircraft expended nearly 16,000 GM against ground targets during the war.[62] Planners had anticipated even greater expenditures of SW. Importantly, at the beginning of operations, planners intended to employ nearly all GM on precision attacks against specific HVT. They did not intend to use GM on generalized attacks against tactical vehicles, yet this is exactly what happened, and represents a significant change in the conduct of war. "Tank plinking" was a direct result of not quickly enough producing the desired attrition of Iraqi armor with common munitions. There is a strong connection, then, between weapon accuracy and our confidence that a weapon will produce results.

F-111F and F-15E aircraft began a dedicated campaign against Iraqi armor on 6 February.[63] Aircraft with laser self-designating capability became extremely valuable, and both the Americans and British rushed more aircraft to the theater with this important capability. The effect of aircraft delivered GM in stopping the Iraqi attack on Kafji and later during their retreat on the Basra Road is well known. Until the end of the war, aircraft continued to expended large numbers of GM against Iraqi armor. U.S. Forces' employment of GM in Operation DESERT STORM contradicts Russian two-phase SW doctrine. Coalition Forces employed SW not just at the beginning of the war, but throughout the war. Routed Iraqi forces were especially vulnerable to coalition SW. As the Civil War proved the lethality of repeating rifles, ODS proved the lethality of SW.[64]

There has been a revolution, marked by Operation DESERT STORM, in the conduct of conventional, mechanized warfare. SW are a characteristic of that revolution. SW, and SM in particular, are the repeating rifles of the future. SW are expensive, but this will not deter their high volume use.[65] Indeed, it is the stated goal of the U.S. Army's Armament Research and Engineering Center (ARDEC) to make "smart munitions a major part of the basic munition load."[66] SW answered our need in the Gulf War and will likely answer our need again in the next war.

SW, and SM in particular, are here to stay. They have a deadly future on the next battlefield. We will continue to develop and field these weapons. Other nations, including our future enemies, are also interested in obtaining them. Someday, an enemy will use them against us. We should heed Swinton's warning, and prepare now for tomorrow. On a future battlefield, perhaps soon, the ultimate question for America's heavy forces will be, "How do we protect ourselves against smart weapons?"

Technical and Military Acronyms

AA	When referring to aircraft: Anti-Aircraft
AA	When referring to mechanized forces: Assembly Area
ADA	Air Defense Artillery
ALOC	Air Line Of Communication
APOD	Air Port Of Debarkation
BAT	Brilliant AntiTank (submunition) is an ATACMS delivered brilliant submunition.
Bonus	Not an acronym. Bonus is the name of a Swedish and French collaborative effort to develop a 155mm SM.
BP	Battle Position
CCM	Counter- Counter Measures
CM	Counter Measures
COPPERHEAD	Not an acronym. COPPERHEAD is the name of a U.S. developed 155mm laser-guided SW.
C2	Command andControl
C3I	Command, Control, Communications and Intelligence
DCA	Defensive Counter-Air
DEW	Directed Energy Weapons
EA	Engagement Area
EFP	Explosively Formed Penetrator
EW	Electronic Warfare
GM	Guided Munitions
HETT	Heavy Equipment Transporter, Truck

HPM	High Power(ed) Microwave
HUMINT	Human Intelligence
HVT	High Value Target
IR	InfraRed
LGB	Laser Guided Bomb
LOC	Line Of Communication
LOS	Line Of Sight
MMW	MilliMeter Wave (radar)
MSF	Mobile Strike Force
MTI	Moving Target Indiator
NLOS	Non-Line Of Sight
PGM	Precision Guided Munitions
SADARM	Sense And Destroy Armor Munition. SADARM is the name of a U.S. developed 155mm SM.
SCUD	Not an acronym. NATO Codeword for a family of intermediate-range, surface-to-surface missile.
SLOC	Sea Line Of Communication
SM	Smart Munition
SMArt	Not an acronym. SMArt is the name of a German developed 155mm SM.
SPOTREP	Spot Report
SW	Smart Weapons
TOW	Tube-launched Optically-tracked Wire-guided missile

Endnotes

---

[1] Wass de Czege, Huba, BG (ret.), "Maneuver in the Information Age," (unpublished, undated).

[2] Ibid., p. 2.

[3] Ibid., p. 5.

[4] U.S. Army Visual Information Center, Smart Weapons, Smart Targets: Army Target Sensing Systems, (Tobyhanna: U.S. Army Visual Information Center, undated), Videotape.

[5] For a description of COPPERHEAD and its method of operation see:

Foss, Christopher F., Jane's Armour and Artillery, Sixteenth Edition, 1995-96, (Alexandria: Jane's Information Group, Inc., 1995), p. 726.

[6] GACIAC, Guide to How Countermeasures Affect Smart Weapons, Volume 1, (Chicago: IIT Research Institute, June 1993), p. 2-1.

[7] U.S. Army Visual Information Center, Smart Weapons, Smart Targets: Army Target Sensing Systems.

[8] This is my opinion. The current difference between SM and brilliant munitions appears to be linked to the BAT and the advantage it offered over SADARM in targeting certain types of vehicles. That the definition appears linked to a specific technology indicates to me that it will not last as all sensors become more capable, more resistant to CM and better able to discern vehicle types.

[9] PATRIOT and AEGIS represent two air defense systems replicating this capability. The reader with a bent toward science fiction can imagine a machine able to independently detect and autonomously initiate defensive fires against a ground or surface attack.

[10] Cullen, Tony and Foss, Christopher F., Jane's Armour and Artillery Upgrades, Eighth Edition, 1995-1996, (Alexandria: Jane's Information Group, Inc., 1995), p. 165.

[11] Ibid., p. 165.

[12] Rigby, Randall L., MG, "Mapping the Future: FA State of the Branch, 1996," (Field Artillery: November-December 1996), p. 1.

[13] Foss, Christopher F., Jane's Armour and Artillery, Eighth Edition, 1995-1996, (Alexandria: Jane's Information Group, 1995), p. 728.

[14] Cullen, Tony and Foss, Christopher F., Jane's Armour and Artillery Upgrades, Eighth Edition, 1995-1996, p. 127.

[15] Foss, Christopher F., Jane's Armour and Artillery, Eighth Edition, 1995-1996, p. 728.

[16] Cullen, Tony and Foss, Christopher F., Jane's Armour and Artillery Upgrades, Eighth Edition, 1995-1996, p.127.

[17] Ibid., p. 127.

[18] Ibid., p. 124.

[19] This is consistent with the proliferation of weapons technology as described in:

TRADOC, TRADOC Pamphlet 525-5: Force XXI Operations, p. 2-5.

[20] Cullen, Tony and Foss, Christopher F., Jane's Armour and Artillery Upgrades, Eighth Edition, 1995-1996, p. iii.

[21] Klare, Michael, "East Asia's Militaries Muscle Up," (The Bulletin of the Atomic Scientists: January-February 1997), p. 59.

[22] Ibid., p. 56.

[23] Ibid., p. 58.

[24] GACIAC, Guide to How Countermeasures Affect Smart Weapons, Volume 1, p. 2-5.

[25] Ibid., p. 2-2.

[26] Ibid., p. 3-2.

[27] Ibid., p. 4-1.

[28] Ibid., p. 4-13.

[29] Ibid., p. 4-9.

[30] Ibid., p. 3-6.

[31] Walters, Brian, "Defensive Aids-Systems For Armoured Vehicles," (Asian Defence Journal, January 1997), p. 33.

[32] Ibid., p. 31.

[33] Grau, Lester, Desert Defense and Surviving PGMs: The New Russian View, (Fort Leavenworth: Foreign Miltary Studies Office, December 1994), p. 1.

[34] Ibid., p. 6. Grau noted that a 5m x 3.5m polyurethane cover weighed approximately 150 kg and required four men to lift and place over the fighting position.

[35] The Iraqi 26th Infantry Division also constructed elaborate, concealed positions below the desert surface to conceal their soldiers from overhead observation. These soldiers dug pits into the ground, erected canvas tents inside the pits, and carefully covered them with a thin layer of sand. From above, they were flush with the desert floor and invisible. Author's observation.

[36] Grau, Lester, Desert Defense and Surviving PGMs: The New Russian View, p. 8.

[37] Ibid., p. 4.

[38] The Iraqi use of decoys has been confirmed. After the war, UN Observers oversaw the destruction of mobile SCUD-launchers and very realistic decoys. Decoys of lesser fidelity were also seen. See:

Keaney, Thomas A. and Cohen, Eliot A., Gulf War Air Power Survey Summary Report, (United States: Department of the Air Force, 1993), p. 86.

[39] Grau, Lester, Desert Defense and Surviving PGMs: The New Russian View, p. 4.

[40] Ibid., p. 8.

[41] Walters, Brian, "Defensive Aids-Systems For Armoured Vehicles," p. 33.

[42] As an example, see QIAO, "Antitank Weapon Systems For The Year 2000," (Charlottesville: Army Foreign Science and Technology Center, February 21, 1989).

[43] GACIAC, Guide to How Countermeasures Affect Smart Weapons, Volume 1, p. 2-10.

[44] Ibid., p. 2-10 to 2-11.

[45] Swinton, Ernest, Major General, Sir, The Defence of Duffer' Drift, (reprinted at Fort Leavenworth: U.S. Army Command and General Staff College, originally published in Infantry Journal, 1905).

[46] Ibid, p. 3.

[47] Department of the Army, FM 100-7, Decisive Force: The Army in Theater Operations, (Washington D.C.: Department of the Army, May 1995), p. C-6.

[48] Collateral damage may restrict the enemy's ability to use WMD or very large HE munitions.

[49] For a discussion of Iraqi SCUD employment, and U.S. air attacks against them, see: Keaney, Thomas A., and Cohen, Eliot A., Gulf War Air Power Survey Summary Report, p. 82 - 90.

[50] Ibid., p. 25, Figure 8.

[51] SW engineers are intensely concerned about the test environment of their weapons. Rain and "shade from a passing cloud may change the IR signature of a target and the background enough to significantly affect the test results." See:

GACIAC, Countermeasures Study, Volume 4, p. 2-48.

[52] As discussed in this paper and supported with test evidence, background clutter does not significantly degrade MTI radar performance. Raising the level of background clutter does degrade IR sensors. Frequency-matched smoke can, however, present an opaque surface to specific radar transmitters. The difficulty is maintaining an effective smoke blanket or cloud for more than a few seconds. See the GACIAC studies noted elsewhere in this paper.

[53] For a discussion of SW and their implications in attrition warfare see:

Grau, Lester W., LTC, "Continuity and Change," (Fort Leavenworth: Military Review, December 1991, p. 20.

[54] This observation is consistent with Russian Counter-PGM Phase I operations. See:

Grau, Lester W., and Thomas, Timothy L., "A Russian View of Future War," The Journal of Slavic Military Studies, Vol 9, Number 3, (London: Frank Cass, September 1996).

[55] Kramer, J., Battlefield Deception, (Fort Lewis: U.S. Army Development and Employment Agency, February 29, 1988), p. 42.

[56] GACIAC, Guide to How Countermeasures Affect Smart Weapons, Volume IV, (Chicago: IIT Research Institute, June 1993), p. 2-33.

[57] For a compelling, fictitious example of the importance of worldwide news media, see: Dunlap, Charles H., LTC, "How We Lost the High-Tech War of 2007," (The Weekly Standard, January 29, 1996).

[58] Per conversation on March 12, 1997 with Mr. Lester Grau of the Foreign Military Studies Office, Fort Leavenworth.

[59] This is the author's opinion. The importance of deception, and our ability to successfully deceive the enemy, can only be experimentally tested in computer simulations or tried operationally. Many-on-many SM fires will likely be triggered by long-range sensors and target acquisition systems. This technological revolution can be exploited, and may reemphasize the age-old importance of deception to conceal the true purpose, speed and direction of our attack while simultaneously triggering a barrage of enemy SM submunitions upon a decoy set realistically presented to the enemy.

[60] Operation APHRODITE during World War II was one of the first operational GM efforts. U.S. Army B-17 and U.S. Navy B-24 bombers were fitted with radio control equipment and loaded with TORPEX (the best explosive of the era). In retaliation for German V-1 and V-2 attacks on London (and as a demonstartion of what the Allies might do against German cities) the bombers conducted several attacks against heavily-fortified German submarine pens in Holland. Some pens were struck, but the program was not an overall success.

[61] For a discussion of the struggle to adopt repeating rifles, and the bureaucratic stonewalling of General Ripley, see Chapter 11 of:

Hallahan, William H., Misfire, (New York: Charles Scribner's Sons, 1994).

[62] Keaney, Thomas A., and Cohen, Eliot A., Gulf War Air Power Survey Summary Report, p. 203

[63] Ibid., p. 105.

[64] Ibid., p. 226-227.

[65] This is the author's opinion. SW are, today, the most lethal weapons on the battlefield. Nations that possess them will use them to quickly establish their initiative and sustain a high OPTEMPO to overwhelm their opponent. This is a key part of

BG Wass de Czege's 2010 Potential Force. There is no evidence that we or any other nation will suffer a severe limitation in our ability to procure and use SW.

[66] Gourley, Scott R., "Smart Munitions," (Army, July 1995), p. 41.

BIBLIOGRAPHY

BOOKS

Cullen, Tony and Foss, Christopher F. Jane's Armour and Artillery Upgrades, Eighth Edition, 1995-1996. Alexabdria: Jane's Information Group, Inc., 1995

Hallahan, William H. Misfire. New York: Charles Scribner's Sons, 1994.

Keaney, Thomas A. and Cohen, Eliot A. Gulf War Air Power Survey Summary Report. 1993.

Kromer, Robert A. New Weapons and NATO: Solutions or Irritants? New York: Greenwood Press, 1987.

Kromer, Robert A. Precision Guided Weapons. London: Adelphi, 1975.

Foss, Christopher S. Jane's Armour and Artillery, Sixteenth Edition, 1995-96. Alexandria: Jane's Information Group, Inc., 1995.

Grau, Lester. Desert Defense and Surviving PGMs: The New Russian View. Fort Leavenworth: Foreign Military Studies Office, December 1994.

Swinton, Ernest, Major General, Sir. The Defence of Duffer's Drift. Reprinted at Fort Leavenworth: U.S. Army Command and General Staff College, oringinally published in Infantry Journal, 1905.

MANUALS

TRADOC Pamphlet 525-5: Force XXI Operations, A Concept of Full Dimensional Operations for the Strategic Army of the Early Twenty-First Century, 1 August 1994.

FM 100-7, Decisive Force: The Army in Theater Operations, May 1995.

PERIODICALS

Dunlap, Charles H. "How We Lost the High-Tech War of 2007." The Weekly Standard. January 29, 1996.

Gourley, Scott R. "Smart Munitions." Army. July 1995.

Grau, Lester W. and Thomas, Timothy L. "A Russian View of Future War." The Journal of Slavic Military Studies, Volume 9, Number 3. September 1996.

Klare, Michael. "East Asia's Militaries Muscle Up." The Bulletin of the Atomic Scientists. January-February 1997.

MH. "German air-launched anti-tank technology on offer." Jane's International Defense Review. November 1996.

Rigby, Randall L., Major General. "Mapping the Future: FA State of the Branch 1996." Field Artillery, November-December 1996.

Walters, Brian. "Defensive Aids-Systems For Armoured Vehicles." Asian Defence Journal. January 1997.

REPORTS

Kramer, J. Battlefield Deception. Fort Lewis: Army Development And Employment Agency. February 29, 1988.

Army Missile Command. Description And Operation Of The Combined Arms Multi-Purpose Missile System Beam Projector Unit. Redstone Arsenal: Army Missile Command. September 1992.

Army Training And Doctrine Command. Army Target Sensing Systems Handbook. Fort Monroe: Army Training And Doctrine Command. March 1994.

Cold Regions Research And Engineering Lab. Smart Weapons Operability Enhancement In Proceedings. Hanover: Cold Regions Research And Engineering Lab. November 14, 1991.

Department Of The Air Force. Project Management Directive For Project Chicken Little. Washington DC: Department Of The Air Force. August 1, 1995.

Dynetics Inc. The Effects Of Signature Reduction On Smart Weapons Performance. Executive Overview. Huntsville: Dynetics Inc. August 1992.

Dynetics Inc. AMC-SWMO Countermeasures Study. Volume 1. Guide To How Countermeasures Affect Smart Weapons. Huntsville: Dynetics Inc. June 1991.

Honeywell Inc. Dual-Mode Seeker Producibility Study. Minnetonka: Honeywell Inc. December 1985.

National Air Intelligence Center. Review Of Development Of IR Guidance Techniques. Wright Patterson AFB: National Air Intelligence Center. April 1, 1996.

New Mexico State University. Developing A Methodology To Improve The Performance Of Smart Weapon Systems In Countermeasure Environments. Las Cruces: New Mexico State University. November 30, 1990.

Guidance and Control Information Analysis Center. Proceedings Of Smart Weapons Conference. Chicago: Tactical Weapons Guidance and Control Information Analysis Center. October 1990.

Guidance and Control Information Analysis Center. Guide to How Countermeasures Affect Smart Weapons. Volume 1. Chicago: Tactical Weapons Guidance and Control Information Analysis Center. June 1993.

Guidance and Control Information Analysis Center. AMC-SWMO Countermeasures Study. Volume 4. Chicago: Tactical Weapons Guidance and Control Information Analysis Center. June 1993.

Guidance and Control Information Analysis Center. Proceedings Of The PGW 1990 Annual Symposium On Precision Guided Weapons International Programs. Chicago: Tactical Weapons Guidance and Control Information Analysis Center. June 1993.

QIAO. Antitank Weapon Systems For The Year 2000. Charlottesville: Army Foreign Science And Technology Center. February 21, 1989.

THESIS

Berry, Reginald R. "Future Utility Of The Heavy Tank On The Twenty First Century Battlefield In Mid- To -High Intensity Conflict," Carlisle Barracks: U.S. Army War College, February 1996.

Kolditz, Thomas A. "Modern Tactics In The Moral Domain: Smart Weapons And The Production Of The Combat Stress Reaction." Fort Leavenworth: Advanced Military Studies Program, December 19, 1992.

Wass de Czege, Huba, Brigadier General (ret.) "Maneuver in the Information Age," unpublished.

BRIEFINGS

U.S. Army Visual Information Center. Smart Weapons, Smart Targets: Army Target Sensing Systems. Tobyhanna Depot: Army Visual Information Center. May 1994.