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Fighting Smarter: Leveraging Information Age Technology

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and

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FIGHTING SMARTER:

LEVERAGING INFORMATION AGE TECHNOLOGY

by

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The Institute of Land Warfare

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Fighting Smarter:
Leveraging Information Age Technology

by E. H. Josephson and R. M. Macedonia

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FOREWORD

The Army, in many respects, is leading the way in adapting to the realities of the information age. This paper presents the thesis that a further shift in thinking is needed to take full advantage of 21st century technology.

The essence of the needed shift in thinking is described as focusing on interdependence as opposed to independence. The application of systems thinking is postulated as a way to make the total force greater than the sum of its parts by leveraging information technology with modern capabilities evolving from different technology bases. With a shift in thinking, it will be possible to replace battlefield systems that simply magnify physical power with new information age systems capable of performing functions not previously contemplated. This paper indicates that with a shift in thinking, it will be possible to increase the effectiveness of other systems by changing relationships, developing synergy, and changing time and space relationships of combat.

An example is developed to demonstrate the potential capabilities obtainable by combining information age technology with other modern technologies and an appropriate shift in thinking. In addressing the potential benefits smart autonomous mines can bring to the future battlefield, the paper shows that the benefits far exceed any previously envisioned. Undoubtedly, there will be ample opportunities in the future to exploit information age technology leveraged with other modern technologies.

JACK N. MERRITT
General, U.S. Army Retired
President

August 1994

GLOSSARY

AHM	Anti-Helicopter Mine
ARPA	Advanced Research Projects Agency
CONUS	Continental United States
DSB	Defense Science Board
ERAM	Extended Range Antiarmor Munition
FM	Field Manual
GPS	Global Positioning System
IDA	Institute for Defense Analyses
IMF	Intelligent Minefield
RISTA	Reconnaissance, Intelligence, Surveillance, Target Acquisition
SFW	Sensor Fuzed Weapon
SINCGARS	Single Channel Ground and Airborne Radio System
SWARM	Smart Wide Area Robotic Munition
WAM	Wide Area Mine

FIGHTING SMARTER:
LEVERAGING INFORMATION AGE TECHNOLOGY

INTRODUCTION

This paper suggests a means to enhance significantly the capabilities of the Army in supporting the ambitious goals of our national security strategy. The approach exploits the Army's concept of digitizing the battlefield. It leverages the technologies of the information age and a class of robotic systems now being developed to provide a seamless meld of manned and autonomous systems on an intelligent battlefield. The requisite technologies exist. Successful exploitation requires a basic shift in thinking about the applications of those technologies.

There is a strong sense that we have entered a new technological age. Dr. Russell L. Ackoff, in a lecture at the Wharton School of Finance and Commerce, called it *the second industrial revolution,* while Army Chief of Staff General Gordon R. Sullivan uses the term *information age*.[1] The attributes of this new age include the ability to collect, store, observe, manipulate and communicate information faster and with higher quality than was thought possible even a few years ago. The result is a *dynamic complexity*[2] that must be understood to be successful.

In business, success means establishing and sustaining a strategic competitive advantage. In war, success or failure has more dire implications. To be successful in combat requires quality soldiers and leaders provided with the right equipment (technologies) at the right time (acquisition system) used the right way (doctrine/tactics). There are many examples of failure to bring these three ingredients together either quickly or efficiently, but there has always been time to work things out. In the information age there may not be sufficient time. The good news is that the ingredients of the information age that create dynamic complexity also provide the means to cope with it. This paper provides one example of how the Army might better adapt to change to exploit the information age technologies.

On September 1, 1993, in describing the results of the recently completed Bottom-Up Review, Secretary of Defense Les Aspin and Chairman of the Joint Chiefs of Staff General Colin L. Powell explained the national military strategy for the United States.[3] The concept presented consists of two parts. The first part focuses on deterring potential regional aggressors. The second part addresses those situations where deterrence fails and conflict occurs. Successful combat operations evolve through four main phases: Phase I– halting the invasion to minimize the territory and facilities that the invader can capture; Phase II– enabling buildup of U.S. combat power in the theater (in most cases in conjunction with allies) *while reducing the enemy's combat power*; Phase III– decisively defeating the enemy; Phase IV– providing for postwar stability to protect withdrawing forces and ensure that conditions which led to the conflict do not recur. In announcing his approach for carrying out this new strategy, Secretary Aspin stated, "We'll have a force based on tomorrow's requirements, a lean, mobile, high-tech force ready to protect Americans against the real dangers they face in this new era."[4]

THE CHALLENGE FOR THE ARMY

In the midst of rapidly changing geopolitical conditions, changes in the way warfare is conducted, severe reductions in the force structure of the Army, and reduced forward basing of Army forces outside the continental United States (CONUS), the new strategy presents some major challenges, including a need to rationalize the roles and capabilities for each of the services, especially the Army. One of the key lessons emerging from Operation Desert Storm was an appreciation for the impact that overwhelming combat power can have on winning swiftly and keeping friendly casualties to a minimum.[5]

The concepts of decisive victory, decisive force and overwhelming combat power were fully integrated into the June 1993 edition of Field Manual (FM) 100-5, *Operations*.[6] Unfortunately, the importance of these concepts has also been learned by potential adversaries of the United States. They have learned that to deny decisive victory to the United States in a future conflict, they must have the capability to prevent the United States from rapidly building up its forces and obtaining information and, above all, they must rapidly generate as many American casualties as possible and drag out the conflict as long as possible. To that end, many regional powers are acquiring increasingly lethal and sophisticated weapons and establishing their own production capabilities for manufacturing advanced systems.

Studies conducted by the Army clearly indicate that outnumbered forces must generate massive loss exchange ratios in order to keep their casualties to a minimum. For example, forces beginning a fight outnumbered by 3 to 1 require an attrition ratio of 15 to 1 in order to sustain casualties of less than 10 percent.[7] For the smaller U.S. Army, and with the increased spread of sophisticated weapons, the question becomes one of how to generate these high exchange ratios, especially in the early period of the conflict. History indicates that the solution to this critical need centers on providing the right overmatching technology to high-quality, well-trained and well-led troops employing proper doctrine and tactics. The challenge is not only to find the right technology, but also to find the right tactics, doctrine and training methods that will enable the full potential of the technology to be fully utilized. One element in meeting the challenge independent of other choices of technology will be ensuring U.S. forces will always have the information advantage–the ability to gather information rapidly on the enemy, terrain and situation, and to get it to the right people at the right time and place.

Coping with the new realities is further complicated by the impact of technology on the conduct of warfare. General Gordon R. Sullivan and Lieutenant Colonel James M. Dubik described some of these changes in their paper titled *Land Warfare in the 21st Century*.[8] Among the most important, weaponry has increased in lethality to such a degree that it has compelled a major reduction in density of forces on the battlefield and greatly increased the tempo of operations. With reduced density of forces operating at higher tempo, soldiers must now control and influence greater areas and must operate at unprecedented speed. In World War I, a corps was responsible for a front of approximately 14 kilometers. In Desert Storm, a corps was responsible for controlling a front of approximately 400 kilometers.

THE NEW ARMY

It is not too difficult to hypothesize what type of fighting machine the Army might have to become to meet its new challenges. The following is an examination of the capabilities needed by the Army to compensate for the reduction in the number of available soldiers, especially in the early phases of a conflict or crisis.

Providing Deterrence

The first task of the strategy is deterrence, recognizing that the danger could be both regional and economic.[9] For the Army to contribute to deterrence it must compensate for reductions in strength and forward basing to ensure retention of essential attributes.[10] The transition from a forward-based Army to one that is primarily based in the United States places a premium on strategic and tactical lift and the prepositioning of equipment. Rapid and timely introduction of properly equipped troops will depend on maintaining adequate available lift and significant reductions in both tonnage and volume of supplies and equipment.

The Army should be able to deter but not be provocative in a crisis. While this suggests that introduction of Army units in a crisis should be perceived as defensive in nature, it also suggests that the mere presence of ground forces neither provides new incentives for politically motivated aggressive acts nor inhibits the use of other military options. Introduction of Marines into Lebanon as a peacekeeping force in 1983 was, perhaps somewhat arrogantly, apparently perceived to be sufficient. Rather than deterring aggressive action, however, the Marines became a target of opportunity for a militarily meaningless but politically valuable low-risk attack. The result was the loss of 241 American lives.[11] In Somalia, the initial humanitarian objectives were rather quickly accomplished due, it is argued, to the introduction of a massive force clearly capable of quickly and decisively accomplishing its objectives against any possible opposition. Once the surprise and shock of the initial deployment wore off, U.S. forces were reduced, the warlords adjusted, and the presence of United Nations forces became more of an incentive for hostile action than a stabilizing influence for peace. One paradox of peacekeeping operations is that peacekeepers often become the targets of retaliation. A force deployed in a peacekeeping operation must somehow have the capability to avoid being provocative while possessing the strength to deter aggression and, if necessary, counter any retaliation.

The attributes needed by the Army to provide deterrence are similar to those needed to fight, but the emphasis is as much on perceived capabilities as on real combat power. The Army of deterrence must be clearly perceived as having the unquestioned capability to accomplish its task when and where employed. In the mind of a potential opponent, there should be no doubt as to the capacity of the Army, once employed, to achieve decisive victory while limiting its own casualties. Given that perception, opposition leadership is likely to go to great lengths to avoid provoking a situation where the Army will be used.

The prerequisite is that Army forces, no matter how small in number, must be able to protect themselves against any likely opposition. It is not enough to rely on the belief that a rational enemy will not attack for fear of overwhelming retaliation. If the deployed units do not have the organic capability to protect themselves, they become high-value targets. While specific defensive requirements are scenario dependent, it is possible to suggest some broad features. Since potential threats can range from well-planned terrorist attacks to conventional force engagements, the deployed units must be trained and equipped to respond to virtually any challenge. In the past it was possible to employ specialized units to deal with specific mission requirements. This will not suffice in the future. The first soldiers employed in a deterrence role will have to be a well-trained and well-equipped force of exceptional versatility.

If the opposition has armor, the deterrence force must have the firepower to cope with a determined armor probe. The force must be capable of providing intelligence and equipped with affordable and appropriate technologies to offset numerical deficiencies. It must be able to function in ways compatible with our coalition allies. The force must be easily and rapidly deployable, and it must be ready for combat without the need for intense training.

Phase I — Halting Invasions

Where deterrence fails, the need to achieve decisive victory with minimum casualties becomes paramount. An idealized Army intervention force must be deployed with the versatility to operate in many environments. It should be capable of operating independently, as part of a coalition, and in combined arms teams. It needs the capacity to delay, disrupt and destroy enemy ground forces in the first phase of the operation (halting the enemy) and conduct increasingly offensive operations in the subsequent phases. It must be capable of controlling the scale and tempo of operations by conducting countermobility actions (against ground vehicles and helicopters) and counterreconnaissance actions. Ideally, early-arriving forces should also be capable of desynchronizing enemy operations. Providing all this capability in an intervention force deployable from the United States is a tall order. Even when the full force capabilities of the Navy and Air Force, as well as possible support of allied partners, are added to the mix, the early-entry forces are likely to have their hands full. We are suggesting that a small, highly professional force be capable of dealing with a numerically superior enemy, even when that enemy has heavy armor. Obviously there are limits to this proposition, but the early-entry forces may not have much choice. They must be able to defend themselves and to ensure adequate conditions for arrival of the follow-on forces.

To do so, an idealized force in this phase must also be able to conduct reconnaissance, intelligence, surveillance and target acquisition (RISTA) functions for other members of the combined arms team. These units need to be highly lethal, capable of operating independently around the clock and in all kinds of weather, and, because of the expanding battlefield, capable of controlling large areas.

Phase II — Enabling Buildup of Combat Power

Establishing sufficient control of the situation to enable buildup of U.S. combat power in the theater, while preventing the enemy from effectively employing his numerically superior force, could be the most demanding task facing an early-entry force. Once the enemy attack has been stopped and the situation stabilized, the early-arrival forces would provide protection for critical locations such as airfields and ports and to the newly arriving forces. They may also be required to engage in limited offensive operations to deny the enemy any opportunity to exploit the situation.

Phase III — Decisively Defeating the Enemy

In the third phase, Army doctrine calls for providing commanders with the capability to synchronize ground, air, sea, space, and special operations forces to strike the enemy simultaneously throughout his tactical and operational depths. It is a capability that needs to be designed and developed that ensures that commanders are provided with options to defeat the enemy quickly and decisively at least cost while desynchronizing the enemy's operations to a point that the enemy has no options.

Phase IV — Providing Postwar Stability

The idealized future force should have the capability to disengage and depart a theater as effectively and efficiently as it enters. This means possessing the capability to protect departing troops and provide intelligence to help prevent future conflicts.

CAPITALIZING ON CHIP TECHNOLOGY

As the Army seeks to build for land warfare in the 21st century,[12] it is faced with the realization that it cannot simply replicate prior successes. The Army finds itself facing severe budget pressures that have already caused devastation to the investment accounts and raised havoc with modernization plans. Nevertheless, the Army must create a machine capable of performing the functions required by the phases of the National Military Strategy: a force ready to deploy anywhere in the world, capable of decisive victory with minimum casualties against any opponent, yet affordable in a constrained budget. Quite a challenge to say the least. But in fact, the Army has already developed most of the foundation for such a warrior force.[13]

For most of this century, the Army focused its modernization efforts on taking advantage of the industrial revolution to develop machines and weapons that store, manipulate and control energy to help it fight. The focus was on the weapon on making it as effective and as powerful as possible. The effectiveness of the total force was perceived as the aggregation of the performance of individual weapon systems. The philosophy underlying this perception is known as *reductionism*, which means taking a system apart, understanding and explaining its individual elements, and viewing the system as a collection of those parts.[14] In many respects, the Army, in exploiting the industrial revolution, had found ways to use energy to multiply the warrior's muscle power. Adding up the strength of many individual weapons provides a useful approximation of the strength of the total force. Similarly, the strength of a combined arms force is essentially estimated by adding the elements contributed by each service. Little, if any, attention is placed on the interactions between services or between weapon systems, or on quantifying the *process elements* of combat.

Now the opportunity to multiply the power of the senses and the brain itself has become reality. For the past two decades, the Army has moved toward a new combat dimension by placing greater emphasis on taking advantage of advancements in the microchip, communications and miniaturization in new types of machines. These machines generate, collect, store, observe, manipulate and communicate symbols — in effect, operate as the brain and, potentially, multiply the power of the brain. Now rather than merely increasing the power of individual weapons in the hope of increasing the effective combat power of a force, it is possible to visualize using machines to effectively integrate other machines and force elements to maximize the collective performance of the force as a whole.

The philosophy underlying this new possibility is *expansionism* — putting things together so the performance of the whole is not simply the addition of individual elements, but rather a consequence of relationships between and among the elements. The Army is beginning to exploit machines that actually harness both muscle *and* brain power. Just as nuclear energy can be a deadly battlefield determinant, so too can the energy unleashed by the possession of superior information. Collection, manipulation, interpretation and dissemination provide equally deadly, and more usable, power to the modern Army. Just as similar information machines are providing the catalyst for accelerating changes in almost every aspect of society, they are having a similar effect in the military. **These new machines are helping the Army to recruit smarter, train smarter, work smarter, and buy smarter. Most importantly, they are also capable of helping the Army fight smarter**.

Emerging from the application of information age technology to war is a requirement to find ways to measure the contributions of these new systems to achieving total force objectives. It is no longer adequate to sum up values attributed to individual weapon systems or elements. The essence of the rationale for digitizing the battlefield is that it will provide operational benefits that magnify the strength of any given force. Traditional weapon effectiveness techniques have been developed with a one-on-one focus on capabilities and with cost effectiveness as a key discriminator. The introduction of information age systems — those that magnify the strength of the brain as well as the muscles — will require new techniques and metrics in addition to those traditionally employed. It is going to be critically important to evaluate interactions among systems and the impact of each system on the *process* of war.[15]

The Germans have a great word for it: *Weltanschauung*. It means, literally translated, a view of the world. It's much more than just a view, it's a conception and appreciation of the interdependent relationships; an understanding of what is going on. The complexity of the information age makes *Weltanschauung* a major challenge.[16]

The Army is embedding these new machines that harness brain power into selected systems. The Wide Area Mine (WAM) is a premier example of these new kinds of weapon systems.[17] WAM has the capability to detect, identify, track and defeat a target. It has the sensors and computer power to emulate many functions of the warrior in the most dangerous tasks and, when linked through its internal communications to other force elements on a digitized battlefield, to become part of integrated defensive and offensive operations. These new weapons do not look very much like Buck Rogers-types of robotic soldiers, but they are highly lethal and effective in providing smaller units with the capability to create decisive effects. They are also more affordable than the science fiction versions. At this point such weapons are generally thought of as evolutionary extensions of earlier weapons. WAM is seen by many as simply a new type of mine, but the technologies on which it depends are totally new and entirely different. In reality, WAM has little in common with previous mines except the name. Currently the tactics for employment are somewhat new but are fully consistent with traditional mine employment concepts. A breakthrough in thinking is needed before the full potential of these new systems is realized. The realization that systems like WAM are not simple evolutionary growth models of well-understood weapons, but in fact represent totally new technologies with far-reaching doctrine and tactical implications, is not yet a reality.

TRANSFORMATION OF SMART MINES INTO WARRIOR WEAPONS

The sensor fuzed warhead of WAM comes from the Air Force's Sensor Fuzed Weapon Program (SFW), an air-to-ground smart munition now in production. In an early-1980s development program, the Air Force integrated a sensor fuzed warhead, acoustic and seismic sensors, a microprocessing control system and a launching system to create the first smart mine, called the Extended Range Antiarmor Munition (ERAM). At a testing facility in China Lake, California in early 1986, the ERAM successfully completed a system demonstration test by autonomously detecting, classifying and tracking a moving tank and launching a live smart warhead that traveled about 50 yards and destroyed the tank. However, for fiscal reasons, the Air Force suspended ERAM development.[18]

In the summer of 1986, the Defense Science Board (DSB) conducted a study on mines and countermines.[19] The DSB recommended transfer of ERAM technology to the Army for development as a low-risk, high-payoff means of increasing conventional capabilities. In addition to countering armor threats, the DSB identified this technology as a means to counter the mobility and combat effectiveness of enemy helicopters. Because the technology for sensing and destroying helicopters was not as mature as that developed to counter armor threats, the DSB recommended the Defense Advanced Research Projects Agency — now known as the Advanced Research Projects Agency, or ARPA — be tasked to develop the Anti-Helicopter Mine (AHM). Both DSB recommendations were implemented. The Army named its smart mine program Wide Area Mine (WAM).

WAM is in engineering and manufacturing development. It provides the first order advantage of smart mines — a major redefinition of engagement geometry — that prompted the DSB recommendations. While a conventional mine is effective against the track or, at best, the width of a tank, the WAM provides 360-degree engagement to a range of more than 100 meters. That means more than 300,000 square feet of lethal coverage with an autonomous weapon system. The second generation member of the family, the Anti-Helicopter Mine, provides full three-dimensional coverage — vertically as well as horizontally — to give unmanned air defense capabilities to complement conventional air defenses, fill gaps and deny areas to enemy helicopter operations. Combining the capabilities of WAM and AHM with two-way command, control and communications systems establishes the potential for a totally new role for advanced technology to meet the needs of the future Army. In fact, the Army is developing the first generation technologies needed to provide WAM and AHM with just such two-way command, control and communications capabilities in a program called the Intelligent Minefield (IMF). The IMF envisions use of a unit called a Gateway to provide the communications link and to control clusters of WAM or AHM.

Additional research is underway to investigate integration of the Global Positioning System (GPS) into WAM and AHM to provide self-mapping. Expert systems are also under development to provide this family of new autonomous weapons with the capability to synthesize and optimize targeting and tactics.[20] Such capabilities, when combined with the integral communications systems, create the potential for smart mines to assist in developing situational awareness and to provide both RISTA and counter-RISTA in support of the information battle.

But that is still only part of the story. It is possible to replace the lethal smart warhead in WAM with nonlethal components to create autonomous sentries or to exploit other nonlethal technologies. It is also possible to provide limited movement capabilities (similar to the soldier in combat) to adjust firing positions, seek cover or adapt to the local environment, such as adjusting to uneven terrain. These systems can also be used to paint the dynamic battlefield. At the corps and division levels, they can be used in the communications mode (lethal mechanism off) for real-time augmentation of the primary systems used to track changes in demarcation of the battlefield. This can be accomplished by using the mines to establish boundaries such as phase lines, axes of advance, engagement areas, and fire support coordination lines. Such capabilities will be of the utmost importance on the dynamically changing battlefield to reduce fratricide incidents by providing an additional means of ensuring that friendly units stay within their assigned sectors and that other ground and air forces know their location. An additional benefit of smart mine technology is that the high degree of positive control provided by its internal communications link drastically reduces the threat to innocent civilians. These systems are lethal when they are supposed to be lethal and present little danger at other times.

What we have been discussing are systems that can "see" (using infrared or millimeter wave portions of the electromagnetic spectrum), "hear" (with their acoustic sensors), "feel" (seismic energy), "interpret" the information they collect, "decide" if they are sensing a target (based on preestablished criteria), and "engage" (using high-speed miniaturized computers). Once the decision is made to engage, the system launches a smart projectile that has the capability to make the final corrections and fire the warhead to kill the selected target. Future technologies can make it possible for these systems to know where they are as well as enabling them to move limited distances — for example, to move from a hide position to a firing position either on command or at a predetermined clock time. They would be able to report their location, what they "see," the actions they take, and the results of those actions. They can be networked to perform in concert. They can be given new instructions, and they can respond to those new instructions. These capabilities have profound implications for the warrior army. The potential for a family of smart weapons with these current and future capabilities can be realized through an overarching employment concept that we call SWARM (Smart Wide Area Robotic Munition).

A SHIFT IN THINKING IS NECESSARY

As indicated earlier, it is not enough to have the right technology to fully reap the benefits from technology advancements. It is also critical to have the right employment concepts, tactics, training, commander's vision and quality soldiers. Richard Simpkin's extensive research of breakthroughs in military technology, described in his book *Race to the Swift*,[21] indicates that it takes approximately 50 years for most nations to obtain the full potential of a new weapon system technology, especially when the new system is derived from an entirely different technology base than the system it is replacing, and/or when the new technology radically changes the time and distance relationships on the battlefield. Simpkin used many examples to support his findings, including the classical example of the airplane.

The airplane was envisioned, in the eyes of the early military users, as a follow-on to the hot air balloon, useful only for observation of the enemy. That paradigm resulted in its assignment to the Signal Corps. But the internal combustion engine, the key technology for the airplane, was an entirely new technology base that had no relationship to the hot air balloon. The airplane could perform observation like the hot air balloon, but it could do so much more. This fact, obvious in hindsight, took 15 years to be appreciated. It would take the stalemate of World War I trench warfare to force the necessary shift in thinking to begin exploitation of the full potential of the airplane, a process that continued into World War II and, some may argue, continues today. First, the airplane was armed in an *ad hoc* response to combat, then employed individually, and eventually evolved into systems that could be formed into units. Initially the airplane was viewed as a unique weapon system of limited military value. It took almost 40 years of employment doctrine evolution before the airplane was integrated into the combined arms team. The world first saw the dramatic effects of this evolution when Germany demonstrated the integrated use of the tank and the airplane in an effective shock force called the *Blitzkrieg*.

From the beginning the inherent attributes of airplane technology captured the imagination of airpower visionaries, but it took decades before the necessary shift in thinking permitted development of the full military potential of that technology. Today the pace of technological change is accelerating at an increasing rate. Thinking must adapt far more rapidly to properly exploit appropriate technologies to meet the needs of the future Army. With a shift of thinking that would expand the utility of smart mines beyond the simple extension of traditional mines to new operational concepts and tactics, WAM (including derivative systems such as the AHM) could provide much of the solution to the needs of the future warrior force. This shift in thinking is gathered under the term SWARM. The image of the SWARM is a large number of individual attack elements working collectively through communications and control to achieve a common goal.

Smart WAM and AHM will be integrated to operate in concert under the Intelligent Minefield program, which is now under contract. The Intelligent Minefield — and therefore WAM and AHM — can then become part of the digitized battlefield to work in concert with the human warrior in both offensive and defensive operations. With a new paradigm, smart wide area mines are not just mines anymore, but a totally new combat capability designed to capture the potential of the computer chip — including sensors, communications, control, lethality and networking as units — to magnify the mental and physical powers of the warrior to meet the needs of the future Army. The challenge now is to find ways to accelerate the shift in thinking to allow the reaping of the full promise of the systems upon which the SWARM concept is based and the full utilization of all of the potential benefits of SWARM, especially on the digitized battlefield.

Studies conducted by the DSB have indicated that past experiences with the use of conventional mines have created a mind-set and an expectation that mines will be effective primarily in defensive operations and that their use imposes high logistic and manpower costs.[22] Some experts consider the greatest impact of mines to be psychological; also, once employed, mines are as great a hazard to friendly forces as they are to the enemy. The DSB studies indicate modern scatterable mines have had some impact on modifying such views because they can be delivered quickly and remotely, and they self-destruct at specified times. But the change is slow. The Air Force employed scatterable mines to create killing zones during Desert Storm, but apparently the Army did not use them at all.[23] This suggests that, for the ground forces, the disadvantages outweighed the advantages in that fast-paced war. The logistics burden and lack of full control of scatterable mines might limit their value to the future Army. SWARM systems, such as WAM and AHM, provide totally new capabilities and economies of scale to satisfy the voids and deficiencies of current systems.

WHAT A SHIFT IN THINKING COULD DO

In contrast to war, which provided the catalyst for creating a shift in thinking for the airplane, peace might very well be the catalyst for making a shift in thinking for the SWARM employment concepts. The major reductions in the force levels of the military — as a result of the end of the Cold War and the cost of the warfare itself — are creating the environment for accepting changes in thinking. For example, a number of publications have already created the structure for making a shift in thinking in the Army. Sullivan and Dubik discuss in their paper, *Land Warfare in the 21st Century*, the major technological innovations (including integrated technology that is employed in the SWARM operational concept) that promise to have a dramatic effect on the conduct of land warfare.[24]

The June 1993 edition of FM 100-5 — with its emphasis on versatility and force projection and its requirement for quick and decisive victory with minimum casualties — provides the clear requirements for systems that will protect and reduce casualties for early entry forces.[25] General William E. DePuy in his seminal article on dynamic synchronization, *Concepts of Operation: The Heart of Command, the Tool of Doctrine*, provides the intellectual structure not only for dramatically reducing the complexities of the modern battlefield for commanders, but also for providing a systems view of the battlefield toward recognition of how autonomous weapons could be synchronized and integrated into the combined arms team.[26] *The Army Modernization Plan*, dated January 1993, provides the criteria for making the shift in thinking. In a joint statement in the foreword, Secretary of the Army Michael P.W. Stone and Army Chief of Staff General Gordon R. Sullivan state the following:

> The Army of the 1990's and the 21st Century will be significantly different from the Army of the Cold War period. As we reshape to a smaller, contingency oriented, power projection Army, the imperative to maintain a viable modernization program has never been more important. We must ensure our Army retains overmatching fielded technological capabilities as we modernize. The path to attainment of that goal is promulgated in our Modernization Vision.
>
> Our Modernization Vision flows from the confluence of many global and national political and military factors. Today's world security environment is unpredictable, unstable and volatile. The battlefield of the future will be characterized by increased lethality, speed and depth. Resources have diminished, resulting in a smaller Army. Moreover, the criterion for success is to win swiftly with minimum casualties.
>
> The soldier is still the key to American victory in war. Quick, decisive victory requires land force dominance. To achieve **Land Force Dominance**, the Army must continually field high payoff technologies that support the five objectives of our modernization vision: quickly project and sustain forces; protect those forces; win the battlefield information war; conduct precision strikes; and dominate the maneuver battle.[27]

Relationship to a Power Projection Strategy

Under a National Military Strategy that envisions dependence on power projection from the United States, and with most combat capability scheduled to be domestically based, it is critical that weapon system attributes be consistent with the need for strategic and tactical mobility, including prepositioning.[31] The SWARM system's high productivity, low logistic burden, and synergism with other systems make these highly deployable systems preferred for early-entry forces. The persistency of SWARM systems, positive control, and nonescalatory attributes (even potentially to diffuse a crisis) permit introduction into a crisis region for use by coalition forces even before hostilities begin. Because all SWARM weapon systems are "wooden rounds" requiring little or no maintenance in storage, they are ideal candidates for prepositioning ashore or afloat. In other words, the synergy and versatility of SWARM systems provide an ideal match with the National Military Strategy.

Protect the Early-entry Forces

There is probably no better illustration of the utility of SWARM systems, when integrated in a new employment concept, than in protecting early-entry forces. When the decision is made to project military power into a hostile, or potentially hostile, environment, the first troops on the scene are at their gravest risk. One of the lessons of Desert

Shield/Storm that any potential enemy is sure to learn is to not give the United States time to build combat power. Unfortunately, this lesson has been reinforced by numerous expert (and not so expert) opinions that the American public will not tolerate casualties unless there is clear public support for the mission being undertaken. Often it takes time to develop public support, so an aggressor might reasonably conclude that giving the U.S. forces a quick bloody nose can swing public opinion for withdrawal before the national leadership can make the case with the American people. Clearly a potential aggressor has strong incentives to strike early-entry forces before they are established. The future early-entry force must be able to cope with such attacks and still limit friendly casualties. This can be done by substituting technology for manpower.

With their acoustic and seismic sensors and microprocessors, SWARM systems can independently detect, classify and track targets hundreds of meters away and kill them a football field away. SWARM systems can autonomously destroy vehicle (WAM) and helicopter (AHM) targets without exposing the troops, even when the targets are hidden from other weapon systems. Under one set of scenarios and tactics, they can provide protective complex barriers and obstacles around air fields, beachheads and key facilities. Under another set of conditions, SWARM systems can be used in concert with maneuver forces on offense or defense to present a continuous gauntlet to forces moving to contact; to deny operating locations; and to stop and fix forces in killing zones for other systems. In other words, the SWARM concept provide unexcelled versatility for systems employment throughout the battlefield under a broad range of combat conditions from Phase I — halting the invasion to minimize loss of territory and facilities — through Phase IV — providing for postwar stability and protecting withdrawing forces.[28]

Future variants of both WAM and AHM might be emplaced remotely using virtually any type of delivery system from trucks to helicopters to fixed-wing aircraft (both combat and transport) to missiles and rockets. Under the SWARM operational concept (starting with its first generation technology, represented by WAM, AHM and the IMF), commanders of early-entry forces will be able to dominate the movement of enemy vehicles without exposing forces. In many respects, SWARM systems can be operated in clusters and viewed as robotic killer teams. These "teams" are often remotely emplaced and remain alert and ready to kill on command around the clock in any weather. The communications and control capabilities inherent in SWARM operations can provide extended unmanned sensors on the digitized battlefield and limit the risk to friendly forces and civilians. No other technology provides the potential to protect and enhance early-entry forces by providing continuous coverage, adequate firepower, low manpower demands and very low risk.

Win the Battlefield Information War

SWARM systems also provide powerful additional capabilities for winning the battlefield information war. SWARM sensors, information processors and communication modules can provide around-the-clock RISTA as well as lethal means to counter the

RISTA actions of the enemy — including RISTA by both enemy reconnaissance helicopters and scout ground vehicles. SWARM can be linked with the maneuver commander, other RISTA systems and other weapon systems in the combined arms team. They can be equipped with compatible communications modules to transmit real-time battlefield data automatically and receive commands from the maneuver force. Display screens of the digitized battlefield can be updated automatically to provide real-time location and status of the SWARM systems to reduce fratricide risk and significantly increase the ability of the maneuver commander to execute his concept of operations.[29]

Leveraging information age technology by integrating digital communications and smart mines into an Intelligent Minefield, and then developing appropriate employment concepts such as SWARM, provides the basis for a true Intelligent Battlefield where manned and unmanned systems operate in a seamless whole. SWARM systems will have the versatility and attributes to support other battlefield operating systems. Their autonomous firepower would be available on demand to protect friendly forces and desynchronize enemy operations. They can supplement RISTA systems by filling gaps and providing complementary capabilities to support the maneuver commander and to help synchronize friendly operations. They can provide true synergy with other systems by limiting the operational options available to the enemy (by limiting mobility), limiting enemy RISTA capability (by destroying reconnaissance platforms), increasing target densities (by creating complex obstacles), and by providing automatic target cueing information. In other words, and especially important for a power projection Army of the future, they increase firepower and enhance defense operations both directly and through synergistic effects on other systems to increase total force effectiveness to enhance deployability, sustainability and survivability of the entire force.

Conduct Precision Strikes

Two of the major trends in the conduct of warfare have been decreasing density of forces and increasing depth of operations.[30] The change in density of forces has been driven by increased accuracy, range and volume of fire provided by modern technology, as well as increased cross-country mobility of armored and helicopter forces. Reducing force density places a premium on maintaining the mobility advantage to enable commanders to concentrate their forces and fire at the critical time and place in sufficient strength to achieve victory.

At all times the objective is to control the dynamics of space and time on the battlefield — that is, to prevent the enemy from massing when he wants to, or force him to mass before he intends to, and fix him in place when he is a lucrative target. SWARM units can extend precision strike capabilities when remotely delivered through the depth of the battlefield. They can be delivered along lines of communications for delay, disruption and destruction. They can deny operations areas for helicopters, air defense units, surface-to-surface missiles, artillery and the like. They can be placed in front of and behind advancing forces to isolate the enemy and create killing zones. While employed in these tasks, they can provide continuous command, control, communications and intelligence as part of the digitized battlefield integrated targeting system. Because of this versatility, SWARM systems can become major aids to the battle commander in synchronizing all battlefield operating systems.

Dominate the Maneuver Battle

The development of digitized communications and networking technologies, along with technology to embed these capabilities into the SWARM employment concept, will greatly increase the capability to dominate the maneuver battle. For example, digitized SINCGARS-compatible communication modules in SWARM units will provide commanders with the information and control to respond rapidly to changing situations on the battlefield. With SWARM, the commander will be able to more easily seize/maintain the initiative, set terms of future battles, synthesize and share information and/or synchronize simultaneous attacks. In a Southwest Asia scenario, special operations forces or coalition forces could emplace SWARM systems, possibly even before hostilities begin, to halt maneuvering of advancing enemy forces and desynchronize his operations. It is even feasible to program these systems to attack specific types of command vehicles as a form of command and control countermeasures. When the buildup of combat power has reached sufficient levels for friendly forces to go on the offensive to seize the initiative, selected SWARM units could be ordered not to fire in order to allow the passage of friendly forces. Other SWARM units could be used to protect the flanks of the attacking friendly forces. With the capability to turn the lethal mechanisms in the SWARM units on and off remotely, commanders can maintain the mobility advantage by controlling where the enemy goes, when he goes, and how fast he can go. With the digitized communication link for battle command on the move, commanders can even allow enemy vehicles to move into a SWARM killing zone for a lethal and violent ambush. In the nonlethal mode, remotely delivered SWARM weapon systems can be used to fill communications gaps when setting or changing boundaries on the dynamically changing three-dimensional battlefield.

SIMULATIONS CAN STIMULATE THE NEEDED SHIFT IN THINKING

The potential combat payoffs of making a shift in thinking about the way emerging technologies, including smart mines, are employed can be investigated and, in fact, demonstrated using modern computer-assisted simulation techniques. Much good work has been done in this field, but in the opinion of the authors, operations research methodologies and metrics have not kept pace with the technology advances being evaluated. Modern interactive simulation techniques have high potential for rectifying this problem.

A good example of the insights that can be developed using simulations is illustrated by a series of simulations conducted in 1989 by the Institute for Defense Analyses (IDA) for the Office of the Deputy Under Secretary of Defense and the Defense Advanced

Research Projects Agency (now the Advanced Research Projects Agency).[32] The results clearly demonstrated the massive potential of the synergy of embedded digitized communications in autonomous weapons when integrated and synchronized into the fire control net. In these studies, networks of autonomous smart weapons provided both major lethality increases and dramatic decreases in casualties to friendly forces.

In one case, IDA used a scenario in which an armored cavalry squadron reinforced with artillery was performing a covering force mission against an attacking enemy division. The mission of the covering force was to delay and attrit the enemy, force him to reveal his strength, and determine where he was making his major attack. The covering force was not to become decisively engaged with the enemy. IDA used the Janus simulation model, an interactive combat model with excellent graphics to facilitate employment of tactics. The simulated combat period was 40 minutes of battle. In the base case, when no WAMs were used, few enemy vehicles were destroyed and high losses were suffered by friendly forces. When 99 autonomous WAMs were added to the covering force (employed in groups of three to form gauntlets of ambushes along the most likely avenues of approach), there was a major increase in kills of enemy vehicles and a corresponding major reduction in friendly casualties.

In another case, the 99 WAMs employed in ambush attacks were provided with embedded digitized communications and integrated into the fire control net. The kill and survival rates increased dramatically, primarily because WAM provided higher target density and cued the artillery for quick response to capitalize on the killing zone WAM established. The most dramatic results, however, were obtained in the case where the covering force troops were removed and only the 99 WAMs with digitized communications integrated and synchronized into the artillery fire control net were used. Naturally, the kills were not as high as when troops were also used, but the kills were significantly higher than the base case without loss of any of the covering force. While these results are important indicators of potential, much more work, including field tests, needs to be done to verify the results. **The important point here is not the results *per se*, but rather that the shift in thinking — removing a covering force from the initial contact with an enemy possessing both superior firepower and numbers and instead relying on autonomous mines integrated with artillery through a communications net — enabled technology to damage the enemy more than the covering force could achieve, and to do so with zero risk to the troops**. This shows the importance of developing new approaches to employing smart weapons and mines — which can only be fully examined after adoption of new ways of viewing the battlefield — to exploit emerging technologies for the future Army.

SUMMARY

The marriage of information technology, smart munitions and robotics with emerging target acquisition, surveillance and stealthy delivery systems provides an opportunity for the future Army to control time and space relationships on the battlefield in ways as dramatic in its impact as the marriage of the tank and the airplane in the *Blitzkrieg* early in World War II.

As was the case with the airplane, however, it will take a shift in thinking to realize the full potential of these new technologies. Richard Simpkin, in his book *Race to the Swift*, warns us that, if technology advancements are left to the normal weapon development process, history indicates it takes at least 50 years for the new thinking about doctrine and tactics to fully reap the benefits of battlefield technology breakthroughs.[33] The arrival of the information age and the accelerating rate of change of technology means no nation can afford such a leisurely process. The major reductions in force levels and forward deployed forces — in spite of an uncertain and unstable world — should provide sufficient incentive for breaking the mold of history by grasping the opportunity of these new technologies now. The lesson for the United States from Desert Storm is that the capability to apply overwhelming force ensures both decisive victory and minimum casualties.[34] Under the National Military Strategy, however, it is not entirely clear that fewer forces can generate the desired level of overwhelming force, especially during the early stages of power projection missions. Certainly it cannot be done without major shifts in thinking about how some of these new technologies might be employed.

One example of where new thinking would produce great benefits for the future Army warrior is the integration of the emerging technologies of the digitized battlefield. The Wide Area Mine (WAM), Anti-Helicopter Mine (AHM) and Intelligent Minefield (IMF), all under development, and future variants, when employed with other systems in an employment concept like SWARM, establish a seamless intelligent battlefield. The shift in thinking required is the realization that these new devices we now call mines are based on totally new emerging technologies that provide such significant inherent capability advances that they **are not just mines anymore**. The major reason for this increase in capability is that SWARM technology integrates emerging sensor fuzed munition technology (muscle power) with the microprocessor (brain power) and integral communications (information power). Depending on the commander's concept of operations and how individual systems are employed, SWARM systems provide a maneuver commander with the area fire, many-on-many attributes of indirect fire artillery or air-delivered cluster munitions plus the aimed accuracy and lethality of direct fire weapons and missiles. At the same time, the commander gets the persistency and autonomous operation of mines and the enhanced capability of computers to use SWARM sensors to collect, store, observe, manipulate and communicate information. These capabilities can be integrated into a fire support network as part of a maneuver plan. For certain missions, these capabilities make it possible to use networks of SWARM systems talking to each other and to other weapon systems to augment and multiply the capability of a smaller force and actually substitute for the soldier in the most hazardous tasks. Exploitation of SWARM technology provides early-entry forces with the capabilities to hold and win when outnumbered by a hostile force possessing superior firepower— **in other words, a means of fighting smarter by harnessing new technologies in an integrated way to achieve the goals of the National Military Strategy**.

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