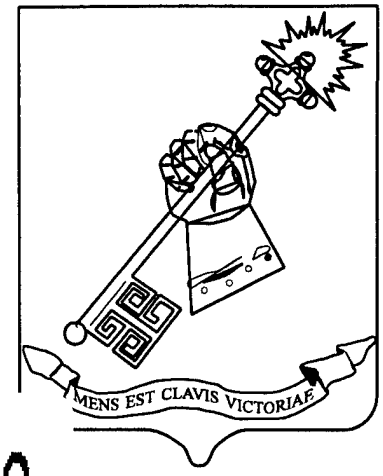
POTENTIAL INTO POWER:
The King of Battle's Transformation into the 21st Century

A Monograph
By
Major David C. Fowles
Artillery



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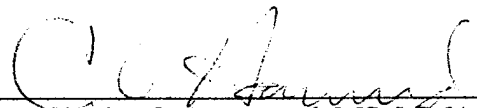

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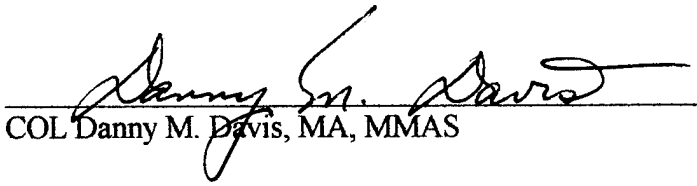

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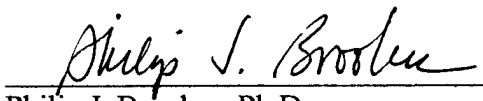

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ABSTRACT

POTENTIAL INTO POWER: THE KING OF BATTLE'S TRANSFORMATION INTO THE 21ST CENTURY by MAJ David C. Fowles, USA, 57 pages.

This monograph discusses the impact of emerging artillery technologies on the development of combat power. The technologies specifically focused on are those associated with the artillery's future weapon system, the Crusader, and the munitions that it will likely employ. Using the elements of combat power, as described in Brigadier General Huba Wass de Czege's paper, "Understanding and Developing Combat Power," (1984), the monograph identifies both contributions and some unidentified outcomes of these technologies in achieving maximum combat power.

The monograph first examines the contributions of emerging technologies and clearly shows the significant effects that technology will have on increasing combat power. The firepower effects that the Crusader will contribute are especially noteworthy. Following the discussion of technological contributions, the challenges to maximizing combat power that result from emerging technology are discussed. Key among these challenges are: costs of technological advancements; difficulties of command, control, and communications; and issues of terrain management.

The primary conclusion is that the real ability to leverage technology and increase combat power lies with the ability to develop what FM 100-5 states is "the most essential dynamic of combat power," the leadership element. However, technology tends to focus on the firepower element, and to a lesser extent, the maneuver and protection elements. Emerging artillery technologies will challenge the abilities of junior leaders to maintain technical proficiency and lead centralized organizations with decentralized methods across a widely dispersed battlefield. The army must remember that technology merely provides a better tool. The key is to provide a doctrine that will allow soldiers to use those tools to maximize combat power.

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CHAPTER 1
PROBLEM STATEMENT AND INTRODUCTION

The impact of technology on the development of combat power is as dramatic today as it was a hundred years ago. Future artillery weapon systems reflect significant improvements resulting from new technologies. These future automated systems will use liquid propellants, have increased rates of fire, and greater ranges and accuracy. The artillery has not experienced this type of technological change since the industrial revolution. This period saw the development of rifled barrels and breech-loading steel guns, among other significant improvements.

New technologies, however, don't guarantee a military's ability to develop combat power. Equally important as the technological improvements are the doctrine, tactics and organizational changes that must accompany significant technological advancements. The deadly consequences of this lesson were particularly vivid in the mid 1800's when battlefield tactics failed to develop at the same rate as rifled barrels. Applicable and effective tactics and doctrine must accompany new technologies to maximize combat power.

As an example, the M109A6, Paladin, is an evolutionary improvement to the decades old M109 family of howitzers. It has capabilities that allow it to operate much differently than previous generations of howitzers. While the Paladin is using some of its

capabilities, the development of the doctrine and tactics that will capitalize on its full potential hasn't occurred.

Emerging technologies should dramatically improve the artillery's ability to provide indirect fires. The artillery's future weapon system, the Crusader, represents far more than the evolutionary changes of the previous century. However, the army has thus far focused on its technical capabilities, expounding the near incomprehensible abilities of its future systems. Discussions of doctrine, tactics, and training that will turn this potential into combat power has been sadly lacking.

It is critical for the army to address more than just the technical aspects of developing combat power. The army must also examine how these technologies apply to the firepower, maneuver, protection, and leadership elements of combat power. A key component of this monograph is the understanding of the elements of combat power. BG Huba Wass de Czege presents his Combat Power Model in "Understanding and Developing Combat Power," dated 10 February 1984. He establishes an analytical framework by defining four elements of combat power as functions of many variables.[1] Chapter 3 will discuss these elements in greater detail. (Also, see Appendix A through Appendix D.) The army's ability to synchronize the firepower, maneuver, protection, and leadership elements will decide its future combat power capabilities.

The key to victory on future battlefields lies in our commanders' abilities to apply overwhelming combat power. Critical elements are superior equipment, doctrine, training, leadership, and the courage and skills of the American soldier.[2] Emerging technologies will provide us with superior equipment. However, winning our future

battles will depend upon our ability to understand the dynamics of combat power as they relate to these technologies.

The purpose of this study is to examine the impact of emerging artillery technologies on the development of combat power. It will especially focus on the artillery's weapon system of the future, the Crusader, and the associated munitions that it will employ. Using elements of combat power, this monograph will identify both contributions and some unidentified outcomes of these technologies in achieving maximum combat power. This examination will contribute to the concurrent development of doctrine and tactics to transform future technological potential into real combat power.

CHAPTER 2

DESCRIPTIONS OF SELECTED ARTILLERY WEAPONS

This paper will focus on emerging artillery technologies, especially those associated with the Crusader. However, a basic description and comparison of current and future weapons systems will provide an initial understanding of the significant capabilities provided by emerging technology. Specific capabilities of the following three weapon systems are shown in Table 1.

M109A2/A3. The M109 self-propelled howitzer was originally fielded in the 1960's. The versions currently in use by most heavy artillery units are the M109A2/A3. The M109 has received many improvements and remains the "workhorse" of the artillery.

M109A6 PALADIN. The Paladin is a product-improved version of the M109 howitzer. It came about as a result of several studies conducted during the late 1970's and early 1980's. These studies determined that the M109 had several major deficiencies, to include responsiveness, survivability, and reliability. Developing a complete new weapon system was too expensive, so in 1984 the decision was made to upgrade the M109 once again, using the most current technology.[3] The improvements included

> an onboard ballistic computer and navigation system, secure radio communications, an improved cannon and gun mount, automatic gun positioning, automotive improvements, improved ballistic and nuclear-biological-chemical protection, driver's night vision capability, and built-in test equipment.[4]

The 2d Battalion, 17th Field Artillery, Fort Sill, Oklahoma became the first Paladin fielded battalion in the summer of 1993.[5] Other battalions have since received the Paladin, to include the 24th Infantry Division (Mechanized), the 3d Armored Calvary Regiment, and the 1st Calvary Division. The Paladin will replace all other versions of the M109 in active duty units by fiscal year 1997. Several National Guard artillery units will receive the Paladin in fiscal year 1999.[6]

Crusader. Crusader is the army's first major weapon system designed for 21st century warfare. It will serve as the prototype for future land combat vehicles fighting on a digitized battlefield. The Crusader provides the artillery the mobility to maneuver alongside the Bradley Fighting Vehicle and the Abrams.

> That mobility, along with ballistic protection, smart countermeasures and automated situational awareness will increase Crusader's survivability. Crusader will be able to move constantly while firing on more targets than ever before. Crusader's increased range and high rate of fire will put fires on targets simultaneously throughout the battlespace,. . .[7]

The Crusader is "currently in the demonstration and validation stage of development."[8] Units should begin receiving the Crusader in 2006.[9]

TABLE 1

COMPARISON OF ARTILLERY WEAPON CAPABILITIES[10]

Capability	M109A2/A3	Paladin	Crusader
Maximum Range(meters)			
without RAP	18,100	24,000	40,000
with RAP	23,500	30,000	50,000
Sustained Rate of Fire	1 rd min	1 rd min	3-6 rds min
Multiple-Round Simultaneous Impact	0	0	4-8 rds
Horsepower	405	440	1,500
Cross-country Speed	27 kph	27 kph	48 kph

CHAPTER 3

COMBAT POWER

"Winning in battle depends on an understanding of the dynamics of combat power and putting them together to ensure the defeat of the enemy."[11] As such, the goal of any army should be a better understanding and an increased ability to apply combat power. Field Manual 100-5, Operations, describes combat power as the combination of the elements of maneuver, firepower, protection, and leadership.[12] BG Huba Wass de Czege in Understanding and Developing Combat Power, Dated 10 February 1984, discusses at length the issue of combat power. He defines combat power as

> that property of combat action which influences the outcome of battle. . . . Prior to battle there exists only capability. Leaders . . . transform this capability into combat power. . . . The appropriate combination of maneuver, firepower, and protection by a skillful leader . . . will turn combat potential into actual combat power. Superior combat power applied at the decisive place and time decides the battle.[13]

These four primary elements require a closer examination to understand their role in the development of combat power.

Firepower. FM 100-5 states that "firepower provides destructive force; it is essential in defeating the enemy's ability and will to fight."[14] Firepower can come from direct or indirect fire systems and is most effective when synchronized with maneuver. Maximum

firepower requires the integration of all lethal and non-lethal fire systems and procedures that contribute to accurate targeting and allocation of firepower assets.[15]

BG Wass de Czege states that the effectiveness of fires against an enemy depends upon the following variables: "The volume of munitions [fire], the lethality of each munition, the accuracy of delivery means, target acquisition capability, and the flexibility of employment of delivery systems."[16] He further states that these variables are functions of additional subordinate variables as shown in Appendix A.

Maneuver. FM 100-5 defines maneuver as

> the movement of combat forces to gain positional advantage, usually in order to deliver--or threaten delivery of--direct and indirect fires. Maneuver is the means of positioning forces at decisive points to achieve surprise, psychological shock, physical momentum, massed effects, and moral dominance. Successful maneuver requires anticipation and mental agility.[17]

BG Wass de Czege states that the purpose of maneuver is to maximize the effects of friendly firepower and reduce the effects of enemy firepower. Positioning to engage the enemy or to prevent him from engaging you accomplishes the purpose of maneuver. In some cases, the threat alone of firepower resulting from effective maneuver may be enough to deter an enemy. Maneuver then is a function of "unit mobility, effective tactical analysis, effective management of resources, and effective command, control, [and] communications."[18] These major variables are similarly the functions of additional subordinate variables as shown in Appendix B.

Protection. "Protection conserves the fighting potential of a force so that commanders can apply it at the decisive time and place."[19] It has four components.

operations security and deception are the first component with the purpose of preventing the enemy from locating friendly units. The second component of protection concerns the general well-being of the soldier and his morale. This includes all measures of caring for basic soldier needs and providing adequate equipment and supplies. The third component of protection is safety. Safety is a critical part of all training and combat operations. The last component is the avoidance of fratricide. Avoiding fratricide preserves combat power and increases unit morale.[20]

According to BG Wass de Czege, the purpose of the protection element of combat power is to minimize attrition on the battlefield. Protection is a function of avoiding detection on the battlefield, limiting your exposure to the enemy once detected, and reducing damage when fired upon and hit by the enemy.[21] Appendix C shows the sub-elements of these three variables.

Leadership: "The most essential [element] of combat power is competent and confident officer and noncommissioned officer leadership. Leaders inspire soldiers with the will to win. They provide purpose, direction, and motivation in combat."[22] Leaders must be tactically and technically proficient. They must understand battlefield dynamics and human relationships. Effective leaders are moral and ethical, providing an example of dedication, honor, and duty. They are the unquantifiable combat multipliers. Effective leadership is the key to synchronizing all of the elements of combat power.[23]

BG Wass de Czege states that "leadership is the element, which when combined with the effects of firepower, maneuver, and protection, becomes combat power."[24] The

leader, however, must possess certain characteristics to effectively apply combat power. First, the leader must be tactically proficient. He must possess certain job skills and understand basic doctrinal procedures and have the ability to apply them. Effective leaders must also know the capabilities of their units and understand how to best apply them. They must possess good military judgment, analytical skills, and communication skills. They are dedicated and committed professionals. Lastly, the leader must be able to anticipate battlefield events and reduce confusion and uncertainty.[25]

The leadership effect is the key to effectively integrating and applying the other elements of combat power against the enemy. Because of the nature of the combat power elements, the leadership effect has a much greater impact upon the development of combat power. The other elements of combat power, (firepower, maneuver, and protection,) consist in great part of specific capabilities. Either they exist or they don't. However, it is through the leadership effect that the commander has the opportunities to maximize those capabilities. From training or experience, the effective leader must possess the abilities and qualities that comprise the leadership effect of combat power. Appendix D contains the sub-elements of these variables.

CHAPTER 4

CONTRIBUTIONS OF EMERGING ARTILLERY TECHNOLOGIES TO THE DEVELOPMENT OF COMBAT POWER

Firepower Effects

The contributions of emerging artillery technologies to the development of combat power are particularly evident as they apply to the firepower effects provided by future artillery systems. These dramatic contributions go far beyond previous evolutionary changes.

As stated in Chapter 3, firepower provides the destructive effects on the enemy. The effects of firepower are functions of volume of fire, lethality of munitions, accuracy of fires, target acquisition capabilities, and employment flexibility of the weapon systems.[26]

Volume of Fire.

Volume of fire is a function of the number of weapons employed and positioned to bring fire upon the enemy, the effectiveness of the supply system to make munitions available for the weapon systems, and the rate of fire of the weapon system.[27]

Number of Weapons. The number of weapons that contribute to the firepower effect is essentially a matter of two variables: Tables of Organization and Equipment (TOE) and the ability to concentrate or mass the effects of the weapon.[28]

Currently there are no published plans to change artillery TOEs. The Directorate of Combat Developments at Fort Sill has stated that the Crusader will replace the Paladin in Force Package 1 units. The initial issue quantity (IIQ) has been set at 824 Crusaders,[29] enough to equip over 34 field artillery battalions.

Future technology will greatly enhance the ability to mass effects. A single Crusader will be able to fire multiple rounds that will impact simultaneously. This ability to fire from four to eight rounds that will impact simultaneously from each Crusader will give a four-gun platoon the first round massing effects currently only achieved by an entire battalion. The Crusader will also fire standard projectiles 30 to 40 kilometers. Rocket assisted projectiles will reach 50 kilometers.[30] These extended ranges will double the ranges of current munitions. This capability will dramatically increase the artillery's ability to mass their effects while the actual delivery systems remain dispersed. The ability of future weapon systems to mass from positions throughout the battlespace will provide significantly enhanced combat power.

Supply Capability. The capability of the supply system to provide the proper and adequate numbers of munitions to weapon systems is a function of: (1) basic loads and fire discipline of the user; and (2) production and delivery by the supplier.[31]

Emerging technologies will have a dramatic impact on basic loads in the future. The Crusader and its accompanying Crusader Resupply Vehicle (RSV) will have increased ammunition carrying capability. The Crusader will carry up to 75 rounds[32] and the RSV up to 200 rounds.[33] The increased load carrying capacities of future systems will not be

the only variable to influence the size of basic loads in the future. Rates of fire and munitions costs will also have a significant impact upon the size and the makeup of basic loads.

A unit's fire discipline greatly influences the supply capability's contribution to volume of fire. Emerging technology will enhance unit fire discipline. Automated systems, improved targeting systems, and smart munitions will increase a unit's ability to get the greatest firepower effects from their munitions.

The automated systems of the Crusader and the RSV will allow the RSV to upload the Crusader with a complete load of ammunition in 12 minutes.[34] Technology will definitely improve the ease and quickness of resupply at the shooter level.

Rate of Fire. Rate of fire is a function of the sustained rate of fire of the weapon system, the time it takes the system to go from an out-of-action status to a firing status, and the proficiency of the crew.[35]

Emerging technology will increase the sustained rate of fire of the Crusader to 3-6 rounds a minute.[36] This is a dramatic improvement to the current sustained rate of fire of one round a minute by the M109 howitzer. This increased rate of fire will contribute significantly to the development of combat power.

The Crusader will also be able to fire within 15-20 seconds of receiving a mission when stationary and within 30-45 seconds when moving.[37] The Crusader's cross-country mobility and speed will also enhance its ability to get quickly into a firing position.

The automated firing systems of future weapon systems will require crews to become

very proficient in the use of automated technologies. Built in decision aids will be of great assistance. Currently, a significant hindrance to achieving increased rates of fire is the significant physical human endurance required. Future automated systems will no longer require massive physical effort, but instead will rely on the intellectual abilities and the proficiency of the crew in working computerized, automated systems.

Lethality of Munitions.

Technological improvements to munitions especially contribute to increased combat power. To accurately attack with indirect fires requires the coordination of an entire system. No matter how well the system works, little is accomplished if the munitions aren't effective against the attacked target.

The lethality of munitions is a function of the design characteristics of the munition, the explosive energy of the munition, and the proper selection and distribution of the munitions.[38]

Design Characteristics of Munitions. Emerging technology is increasing the lethality of munitions primarily through the development of "smart"[39] and "brilliant"[40] munitions that can identify and attack specific targets. Artillery submunitions are being developed that can be fired at the general vicinity of high payoff targets, be dispensed above the targets and then using various technologies can seek out and kill moving or stationary armored targets by top attack.[41]

Explosive Energy of Munitions. Revolutionary advancements in the explosive

energy of munitions will also occur through emerging technologies. BG Leo J. Baxter stated that

> Future systems will employ a variety of munitions including directed-energy weapons, such as non-nuclear electromagnetic pulse and high-powered microwave. Other munitions will deliver nonlethal agents that could cause engines to seize-up or blackout optical sights. We'll also have munitions with explosive and penetration characteristics that are so powerful, we'll be able to achieve the blast effect of a massed battalion without massing.[42]

Proper Selection and Distribution of the Munitions. Emerging technology will also contribute to combat power through the development of multi-function fuzes, rounds, and rockets. A multi-option fuze that will replace eight fuzes currently used will solve some of the challenges associated with munitions management.[43] The development of warhead submunitions capable of defeating soft or hard, stationary or moving, or accurately or inaccurately located targets[44]will resolve many of the other challenges associated with proper munition selection and distribution.

Accuracy of Fires.

Accuracy of fires is a function of weapon and munition design characteristics, crew proficiency, terrain effects, and visibility.[45] When discussing emerging artillery technologies, terrain effects and visibility have little impact on the accuracy of indirect fires. Therefore, I will only discuss the functions of weapon and munition design characteristics and crew proficiency.

Weapon and Munition Design Characteristics. Smart and brilliant munitions that can locate specific targets are at the heart of increased accuracy of fires. Their

capabilities to increase the firepower effect of combat power have already been discussed as part of the lethality of munitions effects. Emerging technology will make these types of munitions commonplace, but limited because of expense. The accuracy of indirect fires will increase through self-locating systems, such as the Global Positioning System (GPS). Already in selective use, these systems are an integral part of future munitions and weapon systems. Additionally, the Crusader will have a built-in velocimeter that will provide round by round muzzle velocities to the on board ballistic computer. Each crusader will also have a system called trajectory real-time analysis closed-loop (TRAC) that will infer meteorological data for the target area.[46]

Crew Proficiency. Automated, precise fire control systems will enhance accuracy where lack of crew proficiency on manual systems previously lead to inaccurate fire. The same technologies that will help crews to increase rates of fire will also enhance a crew's ability to achieve accurate fires.

Flexibility of Employment.

Flexibility of employment is a function of weapon ranges, weapon system mobility, weapon signature, fire control systems, variety of munitions, and doctrine.[47]

Most of the variables that contribute to the flexibility of weapon system employment are also related to other firepower variables and have already been discussed. These variables include increased weapon ranges, improved cross-country mobility and speed, quicker displacement and emplacement times, and self-locating positioning systems that all contribute to "shoot and scoot" tactics. Other flexibility contributing variables

previously discussed are the variety of munitions and automated fire control systems. The doctrine that will determine the employment methods of weapon systems hasn't been developed yet, and therefore can't be examined. As a result, I will only mention the function of weapon signature.

Weapon Signature. The development of liquid propellants is a revolutionary technological contribution. Liquid propellants reduce secondary muzzle blasts and do not produce a flash. Developed for use in the Crusader, liquid propellants will significantly reduce its weapon signature.[48]

Maneuver Effects

The purpose of maneuver is to position forces in relation to the enemy to concentrate the combined effects of your combat power upon the enemy. The effects of maneuver are functions of unit mobility, tactical and operational analysis, management of resources, and command, control and communications.[49] The previous section showed the profound effects that technology will have on firepower capabilities; this section will address the impact of emerging artillery technologies upon the development of the maneuver effects of combat power.

Unit Mobility.

Unit mobility is a function of physical fitness and health of individuals, unit teamwork and esprit, unit equipment capabilities, unit equipment maintenance, and unit mobility skills.[50]

Physical Fitness and Health of Individuals. The automation that will result from emerging technologies will likely result in fewer injuries. Machines, instead of soldiers, will perform many tasks, among them some of the most hazardous tasks. Current tasks of occupying firing positions, preparing ammunition for firing, and ammunition resupply, among other tasks, are labor intensive and potentially very dangerous. The injuries that result from doing these physically demanding tasks should decrease when they are no longer performed.

Unit Teamwork and Esprit. Emerging technologies will significantly affect the morale and cohesion of artillery units. The revolutionary capabilities of future systems will instill confidence in artillerymen as they apply and see the overwhelming effects of these systems.

Unit Equipment Capabilities. The mobility capabilities of future artillery systems are much improved and will enhance the maneuver effect of combat power. Not only will technologies allow weapons to move more rapidly on the battlefield and be ready to shoot sooner, but will also allow the same effects to be achieved using lighter platforms. These lighter weapon systems will be air deployable and will add immensely to the army's ability to project combat power worldwide.

Unit Equipment Maintenance. Unit equipment maintenance must be considered from both the preventive and the corrective perspective. Preventative maintenance will be enhanced by the development of technologically smart systems that can perform self-

diagnosis and make maintenance recommendations to vehicle operators. The use of modular "plug-in" components will simplify some corrective actions.

Unit Mobility Skills. Future systems will enhance mobility skills. While the need for these skills will increase, the use of navigational aids, such as the Global Positioning System, will be of great assistance. Current navigation aids have proven to be very effective and easy to use and will continue to improve.

Tactical and Operational Analysis.

Tactical and operational analysis is a function of intelligence and knowledge of the enemy, understanding the effects of terrain, and understanding the full capabilities of one's own unit.[51]

Intelligence and Knowledge of the Enemy. The ability to "read" the battlefield and know the enemy situation will continue to improve. The Crusader will be equipped with the most current computers that will not only display friendly technical and tactical information, but will also provide enemy intelligence.[52] This will be a critical need when many of them will be operating throughout the battlefield outside secure defensive perimeters.

Understanding Terrain Effects. The ability of future weapons systems to occupy individually will allow artillery units to use terrain previously deemed unsuitable because it would not accommodate a platoon or battery of howitzers.

Understanding of Own Unit Capabilities. The enhanced and automated capabilities of the Crusader will provide a common knowledge of battlefield systems to commanders and subordinates alike. Leaders will know the situations of adjacent and higher units. They will know the status of their personnel, weapons, and ammunition, allowing them to better contribute their available combat power at the proper place and time.[53]

Management of Resources.

Maneuvering a unit on the battlefield requires the proper management of resources at all levels. This is a function of managing equipment, supplies, personnel, time, and the energies of subordinates.[54] I will address these functions as a whole, rather than each separately, because no one specific resource stands out from the others requiring specific discussion.

Future artillery technologies will provide significantly enhanced firepower capabilities that commanders at all levels will compete for. Establishing the priorities for use of these limited resources is the most critical aspect of resource management that will maximize the maneuver effect of combat power. Commanders will need to be very clear in their intent for indirect fires and the assignment of specific tasks for artillery units.

Command, Control, and Communications.

Successful maneuver is very dependent upon effective C3. The functions of C3 that contribute to the maneuver effect of combat power include the span of control, SOPs and doctrine, staff organization and efficiency, and the communications that hold the

previous functions together.[55]

Span of Control. Span of control normally means the number of subordinate elements an individual has under their control. However, as it applies to combat power, span of control refers to anything and everything that requires the attention of a commander or a leader.[56]

While the tasks and responsibilities of artillerymen at the supervisory level will not dramatically increase with future technologies, the focus of these tasks will change dramatically. Increased combat power will result. Artillery firing units will become increasingly flatter as technology assumes or makes obsolete many duties of senior NCOs and junior officers. The decentralization and dispersion of the autonomous Crusader will significantly change the duties of the individual howitzer crew chief. Rather than supervising the actions of many crew members and being directly supervised himself, he will monitor the computerized functions of the gun and be indirectly supervised. The Crusader's ability to compute its own firing data will result in the disappearance of fire direction centers. The direct human interface in determining firing data, positioning the howitzer, ensuring safe firing, and other essential tasks will no longer exist.[57] Leaders will be able to expand their control over more systems as a result of concentrating on fewer individual tasks.

SOPs and Doctrine. The ability to maximize combat power through the effective application of command, control, and communication is a direct result of sound doctrine and quality SOPs. The purpose of this paper is to get the army thinking about the

doctrine that will employ future artillery technologies. The impact of that doctrine on leveraging technology to maximize combat power can 't be determined until it is established.

Protection Effect

The purpose of the protection effect of combat power is to maximize the survivability of forces so that their potential can be applied at the right place and time on the battlefield. While non-combat actions can significantly reduce combat power, the Combat Power Model focuses on those actions and effects directly related to combat. The key components of conserving combat power through protection are "concealment to avoid being detected, exposure limitation to avoid being hit after detection, and damage limitation to minimize the effects of enemy 'hits'."[58]

Concealment.

Concealment is essentially a function of camouflage, stealth, equipment design, and the ability to counter enemy intelligence acquisition.[59] Emerging artillery technologies will affect the concealment function in several ways. Electronic protection measures will have the potential to control and reduce the signature effects of howitzers.

> Signature *control*, not just reduction, will be designed into the [Crusader]. Technology will provide the ability for the cannon to alter the way it "looks" (signature) to an enemy sensor/seeker. It'll be able to "alter" its sounds; skin materials that absorb, reflect or alter radar emissions (imaging); or its heat dissipation or projection. Active sensor countermeasures, such as jammers, will be standard on-board equipment. False signature generators will be standard equipment.[60]

Electronic protection measures, increased rates of fire, shorter times to prepare to fire

and to move after firing, and the ability to move and occupy individually,[61] will make detection of future artillery weapon systems more difficult. However, camouflage and stealth will continue to be a training and discipline issue in order to capitalize on these technological capabilities.

Exposure Limitation.

Exposure limitation is the ability to limit your exposure to the enemy once you've been detected, or to make yourself a more difficult target for him. This is a function of making "the target as small as possible, by minimizing exposure time, and by making a target difficult to track."[62]

The ability of future artillery weapon systems to shoot, move, and communicate rapidly and independently of other systems provides benefits for exposure limitation similar to those discussed for concealment. Future technology not only allows reducing target size by having individual guns fire from dispersed locations, but also allows minimizing the exposure time. Increased rates of fire and the ability to move quickly upon the completion of firing will decrease the attack exposure time for the Crusader. The Crusader will also have the potential to decide through warning sensors when it is under attack and be able to jam and disable selected threat fuzes.[63]

Damage Limitation.

The ability to limit the amount of damage once targeted by the enemy can have a significant impact upon a unit's combat power. The Combat Power Model lists numerous variables that affect damage limitation.[64] However, the only variable

significantly affected by emerging artillery technologies is combat vehicle design. The Crusader will consist of many separate compartments that will limit potential damage. It will also have increased armor protection on the top.[65]

Leadership Effects

Leadership is the most important element of combat power. Effective leadership integrates the other elements of combat power and applies it against the enemy. From training and experience, the effective leader must possess the following abilities and qualities: technical proficiency, an understanding of unit capabilities, judgment and analytical skills, communication skills, dedication, commitment, and moral force, and an understanding of battlefield effects.[66]

While technology does influence all aspects of the military and combat, emerging artillery technologies don't directly contribute to the development of the leadership effect in the same way that they contribute to the development of the other elements of combat power. Emerging technologies will have a significant impact upon the training of future leaders. However, leaders don't develop analytical or communication skills, or dedication, commitment, or moral force through the application of emerging technologies.

Technical Proficiency.

Emerging technology will transform the way we train and improve the technical proficiency of tomorrow's artillerymen. Major General John A. Dubia, recently the Chief of Field Artillery stated:

> As TRADOC's primary test bed for learning technology, the Field Artillery School is spearheading the exploration of distance training and education. . . . Our emphasis on leveraging technology for training also is reflected in increased reliance on simulators and simulations to train fire support.[67]

Current technologies will continue to improve and, as they do, the methods and abilities to train and develop technically proficient leaders will dramatically increase.

Understanding of Unit Capabilities.

The Crusader's computer systems will greatly enhance leaders' understanding of their capabilities at any point in time. The situational awareness available to leaders will increase their ability to control and understand the status of many variables, thus improving their ability to develop and apply combat power. Decision aids will also assist leaders in managing and understanding how they can best apply the available capabilities.

CHAPTER 5

CHALLENGES OF EMERGING ARTILLERY TECHNOLOGIES TO THE DEVELOPMENT OF COMBAT POWER

Firepower Effects

The technologies that will allow the field artillery to increase the firepower effects of combat power as described in the previous chapter also bring with them several challenges. The army must address these challenges if it is to get the most benefit from these technologies. Key among these issues are the costs associated with technologically advanced systems and the desired effects on the battlefield from indirect fires. This section will address those factors, along with others, within the Combat Power Model framework.

Volume of Fire.

Number of Delivery Means. The Crusader program is one of the few fully funded, major equipment development and acquisition programs for the army as it enters the 21st Century. The number of weapon systems procured will have a significant impact upon the potential volume of fire. Many would argue that the significant capabilities of the system justify an increase in total weapon systems over what is currently in the structure. However, those in position to influence the actual quantity procured could make the

opposite assumption: the number of weapon systems should decrease because of their cost, a lack of a dominate threat, and because the capabilities of advanced technologies allow a system to do more requiring less total systems. Reducing TOEs because of these arguments will definitely reduce the volume of fire that can be placed upon the enemy.

Supply Capability. Delivery of munitions to weapons is a significant issue that the army must address if it is to maximize the firepower effects of future artillery technology. The ability of future weapon systems to fire greatly increased quantities of munitions will place additional burdens upon logistical resupply operations. Brilliant munitions of the future will provide more destructive effects than dumb bombs, requiring fewer munitions fired per target. While a particular target will require fewer munitions, it doesn't mean that a weapon will fire fewer rounds. Limiting the overall quantity of munitions might occur because of the arguments used in the previous paragraph to limit the quantities of delivery systems. However, the quantities of munitions fired by individual howitzers will increase.

Two additional factors will complicate the supply capability: the various types of munitions available and the dispersion of firing units on the battlefield. The types of munitions already in use and the development of new munitions, greatly increases the difficulty of having the proper ammunition at the right place at the right time. The challenge will only increase as individual delivery systems spread throughout the battlefield. While the Crusader Resupply Vehicle (RSV) will facilitate resupply operations within Crusader batteries, these vehicles will still be operating autonomously

over extended distances. The inability to deliver sufficient quantities of the proper munitions in a timely manner to the right units will negate many technological contributions to the development of combat power.

Lethality of Munitions.

As described in the previous chapter, future munitions will be extremely lethal. This lethality, combined with extreme accuracy, will destroy systems and kill personnel with precision. The capability to kill soldiers by indirect fires in quantities never before experienced will exist. In contrast, the artillery, as an area weapon, has traditionally wounded more soldiers than it has killed. Wounded soldiers are a much greater drain on a unit's resources than are dead soldiers.[68] While an increased ability to kill the enemy has a direct correlation with combat power, wounding enemy soldiers, rather than killing them, might be more effective.

Accuracy of Fires.

The increased accuracy and firepower capabilities of artillery systems like the Crusader and the development of brilliant munitions raise the important issue of the desired effects of indirect fires. There is no question that among the many capabilities of future munitions the ability of the artillery to attack and kill armored vehicles is significant. However, precise munitions will not achieve the same effects in the future that artillery has been known and feared for.

For centuries, massed artillery, while wounding more than it has killed, has crushed morale, numbed the senses and paralyzed movement.[69] J.B.A. Bailey in Field Artillery

and Firepower described four major effects of the artillery on the enemy: (1) the effect of neutralizing the enemy, preventing movement, observation, and the manning of equipment; (2) the material effect of destroying equipment; (3) the lethal effect of destroying enemy troops; and (4) the moral effect of shock and demoralization of personnel under indirect fire.[70]

Precision munitions will achieve some of these effects. However, the costs of these munitions will prevent the use of the vast quantities required to "numb the senses" and neutralize enemy actions. The army must address the effects desired from the artillery before it concludes that future technology can provide all the answers.

Target Acquisition.

Location and Functioning of Observers and Sensors. The field artillery community must address the role of the artillery observer on the future battlefield. Almost every other system on the battlefield will possess the target acquisition capabilities and communications abilities that he will have. Battlefield digitization that will allow situational awareness will allow other individuals in other locations to perform the duties currently associated with the field artillery observer. The sensor, whether an unmanned aerial vehicle or an M1 tank, will locate the target, describe it, clear and request the fires, and provide the battlefield damage assessment. Organizational structures not requiring specific individuals as artillery observers will contribute to the development of combat power, but only after the development of techniques and procedures that will allow others to perform the duties of artillery observers.

Maneuver Effects

Unit Mobility.

Physical Fitness and Health of Individuals. The automation that will result from emerging technologies could very well affect physical fitness. The current tasks of ammunition resupply, preparing and loading ammunition for firing, and occupying firing positions, among other tasks, are labor intensive. Not only is physical fitness enhanced when soldiers perform these tasks, but soldiers also perceive a need to maintain a proper level of physical fitness. Emerging technologies will either automate these tasks or make them obsolete, directly decreasing the current strength and fitness requirements. Leaders will have the challenge of maintaining proper physical fitness in light of automation to leverage technology to increase combat power rather than diminishing it.

Unit Teamwork and Mobility. The emerging technologies that will allow future artillery systems to disperse on the battlefield will separate units and crews like never before. The characteristics and strengths of mutual support and teamwork that have existed in units that previously occupied the same firing position will no longer be possible. Small teams, of perhaps as few as three, will man individual weapon systems. Artillerymen will still have comrades present with them on the battlefield, but the morale and esprit that comes from being surrounded by your unit will not exist.

S.L.A. Marshall said "I hold it to be one of the simplest truths of war that the thing which enables an infantry soldier to keep going with his weapons is the near presence or the presumed presence of a comrade."[71] He specifically wrote of the combat infantryman

during World War II, comparing the strength and morale of the individual with that of the team. However, it is possible that the same principle might apply to an individual howitzer section on the battlefield working and firing independently of other sections.

While the overwhelming firepower effects discussed in the previous chapter will contribute to positive morale, the lack of unit togetherness and support might outweigh the benefits of technology. The technology serves no purpose if soldiers are incapable of using it, whether it results from incompetence or from lacking the will to fight. The army can't allow technology to blind itself from the fact that fighting soldiers are sustained primarily by each other and secondarily by their weapons.[72]

Unit Equipment Maintenance. Automated, computerized subsystems will make field expedient repairs very difficult, if not impossible. Corrective maintenance procedures could become more difficult, not only because of the dispersion of systems throughout the battlefield, but also because of the wide range of maintenance requirements. "Hi-tech" automation and computer systems will require "hi-tech" repairs while engine and transmission repairs will require "grease monkey" skills and knowledge.

Tactical Analysis.

Terrain Effects. The technologies that will allow artillery weapon systems to occupy rapidly and autonomously require not only an understanding of the effects of terrain, but more important, require the understanding of the effects of these delivery systems on the use of the terrain. Terrain management becomes a significant issue as the artillery disperses throughout the battlefield.

The M109A6 Paladin is currently giving artillerymen a taste of what the future will be like with the Crusader. The Paladin is an evolutionary system and lacks many of the capabilities that the Crusader will possess. However, the Paladin is a semiautonomous, computerized weapon system that can function separated from the platoon. These capabilities now require section chiefs to analyze terrain and the tactical situation to ensure survivability while delivering fire. These requirements will continue with the fielding of completely autonomous weapon systems.

The use of terrain continues to be a challenge as the employment doctrine for the Paladin continues to evolve. Colonel David Valcourt commanded the first Paladin battalion, the 2d Battalion, 17th Field Artillery, Fort Sill, Oklahoma. As the battalion trained with the Paladin in 1992, they decided that the paired howitzer technique was the best method for employment. He stated:

> It provides the best tactical trade-offs and the greatest flexibility. The paired-howitzer technique calls for two Paladin howitzers to form a "fire team," each platoon having two fire teams. Survivability, tactical movement, survey, logistics and threat are the factors that led us to this preferred choice of employment. Howitzer pairs are clearly the most survivable against enemy counterfire and can be positioned in areas that would not accommodate larger groups of howitzers. We found that Paladin pairs maximize scarce terrain resources and still maintain the ability to accurately mass fires.[73]

More recently, Lieutenant Colonel Robert Fronzaglia, commander of the Paladin equipped 3d Battalion, 41st Field Artillery, Fort Stewart, Georgia, stated that selecting terrain "that is large enough to conduct proper survivability moves and that is defensible is tough business."[74] He stated that land management was more difficult as the battalion tried to find sufficient space in which to operate. Supported maneuver units had been

used to assigning position areas to artillery units. Now artillery units were asking for much larger sectors throughout the battlefield to operate within.[75]

The requirement for greater masses of terrain in which to operate differs greatly from the thoughts of those who first extolled the virtues of the Paladin. An article on the Paladin in the October, 1990 issue of Field Artillery, stated that the

> Paladin requires less terrain than the M109A3. Single, widely dispersed gun positions, which might be too small for a platoon, are now usable. Free from the necessity of laying wire and the requirement to locate close to other platoon vehicles or a survey point, each Paladin can use previously untenable positions or share positions with other units.[76]

The ability of the Paladin to operate semiautonomously does allow it to use terrain that previously might not have been suitable as a platoon or battery position area. However, the shoot and scoot tactics that it uses to avoid counterfire (and that the MLRS uses) requires large areas in which it can operate. This threat of counterfire likewise discourages other units from operating too close to it. These same fundamentals will apply equally, if not more, to the employment of the Crusader and other future weapon delivery systems.

Because of the capabilities of future artillery systems, it is likely that many commanders will treat artillery units much like maneuver units. However, it is clear that these future systems will bring with them the requirement for vast amounts of terrain. Changing terrain allocation will require a fundamental shift in the thinking of future commanders.

Management of Resources.

Personnel Utilization. The technologies that will allow howitzer sections to be separated from other sections and small crews to accomplish the tasks previously done by much larger crews will also quickly fatigue those crews. The automation of tasks will require less physical exertion, but will also require greater mental awareness and agility. Consisting of only three or four crewmembers and being separated from other sections, (thus not able to share certain responsibilities), it will be difficult, if not impossible, to maintain 24-hour operations. Some might argue that tank and Bradley Fighting Vehicle crews do just that. However, the fact that artillery units are never in reserve put them into a separate category. While focusing on the capabilities of technology, the army can't lose sight of the fact that soldiers are the most critical resource. They will require alert minds to fully capitalize on the available technologies.

Command, Control, and Communications.

Span of Control. The ability of weapon systems to disperse on the battlefield will require the artillery to adopt decentralized methods of operation. This is a stark contrast to current centralized practices of operating and the artillery fundamental of maintaining maximum feasible centralized control. The challenge will be to operate decentralized while maintaining positive control. A critical task for the commander will be to monitor the weapon and ammunition status of assigned weapons to ensure meeting the maneuver commander's intent for indirect fires. Monitoring the status of subordinate weapons systems will require maintaining positive control of subordinates while simultaneously

operating in a highly decentralized environment. The artillery does not currently teach or practice this skill. Decentralized operations will not mean decentralized control.

Communications Efficiency. The ability of the field artillery to develop combat power depends upon its ability to communicate efficiently and effectively on the battlefield. Emerging technology will provide as many communication challenges as it will solutions.

Technology that will allow almost every soldier and vehicle on the battlefield to be a sensor will provide a significant challenge for the artillery. This challenge will increase as battlefield dispersion increases and the distances between the sensor and the shooter expand beyond their ability to communicate. It is possible that artillery weapon systems might only be able to communicate and respond to fire requests from those systems that are close to them on the battlefield. This communication challenge will only increase as one recognizes the fact that the enemy will attempt to disrupt battlefield communications. Future artillerymen will have to resolve issues of target duplication and redundancy, targeting priorities, and sensor information overload. Maintaining effective communications with the most critical sensors, who will likely be the furthest removed from the shooters, will require much effort.

The success of the artillery, more than ever before and more than any other combat arm, will be dependent upon its ability to communicate over great distances. The artillery can't survive based solely upon a clear understanding of the commander's intent. Observers will have to pass targeting information to the shooter. Headquarters will have

to pass targeting priorities to subordinates. Subordinates will have to communicate weapon and munitions status to their higher headquarters. Mission type orders can't replace calls for fire, nor can initiative by subordinates make up for the lack of a target location, description, or desired munitions. However capable the Crusader, or any other future artillery system, its ability to communicate with other battlefield systems will determine its ability to develop combat power. Efficient communications on future battlefields will require prior planning, redundant communication systems, and continual training.

Protection Effect

Exposure Limitation.

While future technologies will increase the survivability of weapon delivery systems from threat counterfire, individually dispersed weapon systems will be more susceptible to ground attack. Operating without the mutual support of other systems or from within a secure perimeter, enemy ground units are more likely to attack and defeat future artillery systems.

Damage Limitation.

Another result of the dispersed method of operating allowed by future technologies is the negative effect upon medical treatment and evacuation. National Training Center exercises indicate that artillery battalions don't effectively respond to casualties or conduct effective evacuation of casualties.[77] These poor results are not likely to improve in the future as artillery units increase their dispersion on the battlefield.

Leadership Effect

Technical Proficiency.

Technology will be of great worth in the educational process of future leaders. However, the challenge for artillerymen will be developing proficiency on a wide range of weapons and other fire support systems. Current leaders already have a difficult time becoming proficient with several different types of towed artillery systems, self-propelled howitzers (to include the most recent version, the Paladin), and the MLRS. Each has its own methods of employment, uses different munitions, and provides vastly different capabilities. Fire direction systems vary between light and heavy units. Fire supporters have other systems to become proficient on, as do those who command and control radars. Emerging technology will only increase the challenge of becoming proficient.

Dedication, Commitment, and Moral Force.

The dispersion of indirect fire systems allowed by future technology will effectively separate the leaders from the led. Operations centers will occupy secured positions safely separated from the delivery systems. Rather than walking the gun line as they do now, leaders will manage the functions of units via digital communications.[78] Paladin units are already beginning to experience some of the leadership challenges that come from using centralized methods of command and control for widely dispersed units.[79]

The ability of the leader to use moral force to transmit dedication and commitment to subordinates is very difficult when the only interaction he might have with them is through digitized communications from a "safe" environment somewhere behind them.

FM 100-5 establishes several key components of leadership: "inspiring and directing assigned forces and resources toward a purposeful end; establishing a teamwork climate that engenders success; demonstrating moral and physical courage in the face of adversity; providing the vision . . . "[80] Technology will make the transmission of data across the battlefield very easy; it will make the transmission of dedication and commitment very difficult.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The contributions from emerging artillery technologies that were discussed in Chapter 4 will clearly enhance the development of combat power. How then can the army improve upon these contributions to maximize combat power? What issues must the army address and resolve to leverage the emerging technological advancements? The discussions of the previous chapter lead us to the following conclusions.

The primary answer to the research question lies in the definition of the leadership element of combat power: "The most essential dynamic of combat power is . . . leadership."[81] Perhaps General Omar N. Bradley said it best when he said: "Leadership is an intangible. No weapon, no impersonal piece of machinery ever designed can take its place."[82] The most important thing that the army can do to leverage technology to maximize combat power is to develop junior leaders based upon future requirements, not upon past experiences.

Clearly, senior noncommissioned officers and junior officers will need to develop the skills and abilities required to work in decentralized, flat organizations, dispersed widely throughout the battlefield. Soldiers both supervising and supervised by these junior leaders will also need to acquire new skills. No longer will a gunnery sergeant, platoon

sergeant, platoon leader, another gun chief, or any other individuals be able to provide assistance when a gun section has a problem. Many current duties of platoon and battery leadership will become obsolete, while other command and control responsibilities will emerge. The field artillery must identify those responsibilities now and begin to develop the skills necessary to effectively lead in a dispersed environment that is currently foreign to artillerymen.

Future artillery systems will challenge leaders trying to sustain morale and inspire subordinates. It will be impossible to gather units, or unit leadership, almost anytime, anywhere, as can be done currently, to provide information, motivate, or transmit feelings of dedication and commitment. Leaders and commanders who are currently around their subordinates almost continually will no longer be present. The army must address this issue, find solutions, and then prepare its leaders, for as Ardant du Picq said: "When the battle becomes hot, [the soldiers] must see their commander, know him to be near. It does not matter even if he is without initiative, incapable of giving an order. His presence creates a belief that direction exists, that orders exist, and that is enough."[83]

The technologically advanced systems of the future will require a higher degree of technical proficiency by all who operate and supervise those systems. Leaders and operators will need to be smarter and will require far more training. To leverage these technologies to maximize combat power, the army must first decide how they will identify and groom those soldiers and leaders who will perform the duties required by these systems. Secondly, they need to determine how they will train and develop these specialists.

Besides addressing significant leadership issues, the army and the field artillery community must accept the reality (especially in today's environment) that budgets, not requirements, will decide which of these technologies will actually become reality. Currently, many weapon systems with varied capabilities are in one stage of development or another. Countless types of munitions that can attack and destroy almost countless types of targets at every range are possible. However, astronomical costs will prevent many of them from ever being developed or procured.

The army, as it makes the tough, costly acquisition decisions, needs to remember that "ammunition is artillery's true weapon, and the gun or launcher is merely the means of delivery."[84] The M109 clearly requires the new life given it by the Paladin and the Crusader is definitely a revolutionary weapon system. However, the army must avoid the temptation to spend additional scarce resources developing evolutionary weapon delivery enhancements at the costs of revolutionary munitions capabilities. The army will maximize combat power by focusing on target effects and remembering that the cannon is merely a delivery means.

Not only will costs prohibit the army from developing and using every weapon system or munition imaginable, but the entire issue of supply and munitions management will prevent the acquisition of so many types of technologically feasible munitions. It will be both economically unfeasible and logistically impossible to ensure sufficient on-hand quantities of a particular munition to accomplish a certain mission. In order for the army to maximize combat power through the application of emerging technology, it must first decide what effects it wants from the artillery of the future and then develop it.

One of technology's greatest contributions to the development of combat power is the ability it gives the artillery to operate dispersed on the battlefield. At the same time, this capability also brings with it many challenges. A significant issue of dispersion that the army must resolve is that of terrain management on tomorrow's battlefield. Chris Bellamy very accurately stated in The Future of Land Warfare that "artillery will certainly be widely dispersed, . . . All this dispersion *takes up space.*"[85] In order for the artillery to survive counterbattery fires, it must disperse. In order for the army to capitalize on future technology, it must allow the artillery to disperse. The army must resolve the issue of terrain management if it is going to maximize combat power.

Recommendations

The following recommendations don't necessarily contain the solutions to the challenges presented. However, they do provide some thoughts of how the army and the field artillery community might begin to look at the issues that lay before it as it leverages technology to maximize combat power.

Today's field artillery contains a variety of many different weapon systems and other fire support systems. The diversity will continue to expand as technology increases. The army must recognize that it will be almost impossible to expect officer leadership to become adequately proficient with each system. Cannoneers are currently required to be proficient with several different towed howitzers and self-propelled howitzers. Emerging technologies will likely add additional requirements. Just as the army created a new military occupational specialty for MLRS crew members, perhaps it needs to consider

doing the same for the Crusader and other systems. Additionally, the artillery might want to create separate heavy and light artillery specialties for its officers, or at least a separate track for those leading and supervising the Crusader. The skills and proficiencies required by those leading Crusader units will be much different from the skills required by other systems.

Rather than assuming that the current firing battery organization will need to remain the same in the future, the field artillery needs to look at a total restructuring of the battery organization. Units equipped with systems like the Crusader will no longer need to perform many current duties of the battery commander, platoon leader, fire direction officer, platoon sergeant, and gunnery sergeant.[86] A very flat organization could result. However, rather than deleting these individuals from the organization, they could become section chiefs of the weapon systems, organized like armor units currently are. These individuals could perform the duties not made obsolete by technology. They would better be able to command and control and could lead from the front. They would also resolve some of the issues of finding gun chiefs with sufficient experience and mental capacity to handle the high-tech requirements of the system.

The mission of the field artillery is not likely to change anytime soon. Commanders will continue to require the artillery to perform countless numbers of missions, and the capabilities of future systems and munitions will only serve to increase the expectations. A possible solution to some of the challenges of matching capabilities to missions would be to reexamine how the artillery organizes for combat. I'm not suggesting that the five fundamentals of organizing for combat are not adequate. What I am suggesting is the

specific tailoring of artillery units and the munitions available to them for particular missions. This tactical tailoring wouldn't be much different that the way we currently tailor fixed and rotary wing units for specific missions. Rather than a standard basic load of munitions, units could be specifically uploaded with the types of munitions that would meet the commander's intent for a specific mission, be it the destruction of a deep, mobile reserve by brilliant munitions, or the suppression of direct fire weapons during a breach by masses of dumb bombs.

Lastly, the army needs to remember that "war is a conflict between people; machines are tools in that conflict."[87] To maximize combat power, the soldiers that use those tools must be adequately prepared and provided with the tactics and techniques for leveraging technology. History is full of examples of the death and destruction that needlessly occurs when doctrines are not developed during peacetime that support the capabilities of new technology. The army can develop a doctrine that will leverage technology to maximize combat power, but it must start now before it is too late.

APPENDIX A, FIREPOWER EFFECT MODEL[88]

FIREPOWER EFFECT, a function of:

VOLUME OF FIRE, a function of:

- Number of Delivery Means
- Supply Capability
- Rate of Fire of Weapons Systems

LETHALITY OF MUNITIONS, a function of:

- Design Characteristics
- Explosive Energy

ACCURACY OF FIRES, a function of:

- Weapon and Munition Design Characteristics
- Crew Proficiency
- Terrain Effects
- Visibility

TARGET ACQUISITION, a function of:

- Intelligence and Intelligence Analysis
- Location and Functioning of Observers and Sensors
- Transmission of Target Data

FLEXIBILITY OF EMPLOYMENT, a function of:

- Weapons Ranges
- Mobility
- Signature Effects
- Fire Control Systems
- Tactical Employment Doctrine

APPENDIX B, MANEUVER EFFECT MODEL[89]

MANEUVER EFFECT, a function of:

UNIT MOBILITY, a function of:

- Physical Fitness and Health of Individuals
- Unit Teamwork and Esprit
- Unit Equipment Capabilities
- Unit Equipment Maintenance
- Unit Mobility Skills

TACTICAL ANALYSIS, a function of:

- Intelligence and Knowledge of Enemy Tactics
- Understanding of Terrain Effects
- Understanding of Own Unit Capabilities

MANAGEMENT OF RESOURCES, a function of :

- Equipment Utilization
- Supplies Utilization
- Personnel Utilization
- Time Utilization
- Utilization of Energies of Subordinates

COMMAND, CONTROL, AND COMMUNICATIONS, a function of:

- Span of Control
- SOP's and Doctrine
- Staff Efficiency
- Communications Efficiency

APPENDIX C, PROTECTION EFFECT MODEL[90]

PROTECTION EFFECT, a function of:

CONCEALMENT, a function of:

Camouflage
Stealth
Equipment Design
Counter Enemy Intelligence Acquisition Means

EXPOSURE LIMITATION, a function of:

Minimize Potential Target Size
Minimize Potential Target Exposure Time
Complicate Potential Target Tracking

DAMAGE LIMITATION, a function of:

Individual Protective Equipment Design and Use
Use of Natural Cover
Use of Artificial Cover (incl field fortifications)
Combat Vehicle Design
Medical Treatment and Evacuation Systems
Combat Equipment Cannibalization and Repair
Alternate Command and Control Arrangements
Providing Personnel and Material Replacements
Misc. Efforts to Maintain Continued Combat Effectiveness of Units

APPENDIX D, LEADERSHIP EFFECT MODEL[91]

LEADERSHIP EFFECT, a function of:

TECHNICAL PROFICIENCY, a function of:

Training
Experience

UNDERSTANDING OF UNIT CAPABILITIES, a function of:

Training
Experience

ANALYTICAL SKILLS, a function of:

Selection
Training
Experience

COMMUNICATION SKILLS, a function of:

Selection
Training

DEDICATION, COMMITMENT, AND MORAL FORCE, a function of:

Selection
Motivation
Training

UNDERSTANDING OF BATTLEFIELD EFFECTS, a function of:

Combat experience
Training

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39. Nigel Evans in "Artillery Indirect Fire and Its Weapons," Military Technology (October 1995), p. 19, gives one of the most comprehensive definitions of "smart" munitions in today's literature. He defines "smart" munitions as those that carry sensor-fuzed submunitions. These

submunitions generally eject from the projectile some 1,000 feet above a target. Their descent is slowed by a parachute or streamer. This allows time for the sensor (infrared detector and/or millimetric wave radar) to scan and acquire an armored target in an area of about 150 meters in diameter. When within 200 meters of the target, the submunition fires an explosive penetrator at the target. The weakness of "smart" munitions is their lack of maneuverability. This limits their use against moving targets.

40. "Intelligent" munitions contain control surfaces and terminal homing devices that allow them to attack targets spread over several kilometers, instead of only a couple of hundred meters like the "smart" munitions. Ibid.

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