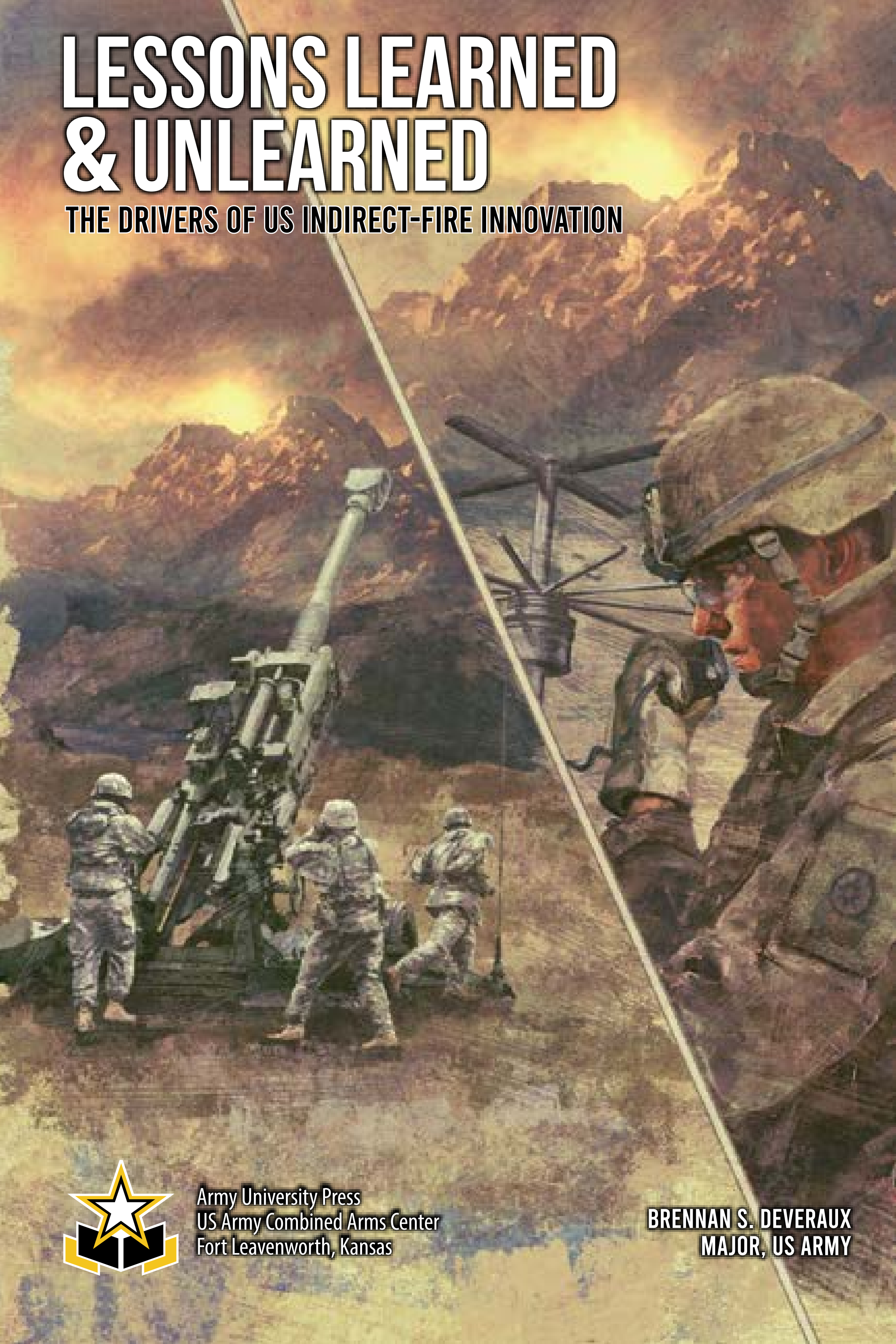
LESSONS LEARNED & UNLEARNED

THE DRIVERS OF US INDIRECT-FIRE INNOVATION



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BRENNAN S. DEVERAUX
MAJOR, US ARMY

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Brennan S. Deveraux, Major, US Army
Fort Leavenworth, Kansas

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Acronyms and Abbreviations

ATACMS	Army Tactical Missile System
BCT	Brigade Combat Team
COIN	counterinsurgency
DIVARTY	division artillery
DPICM	dual-purpose improved conventional munitions
ER-MLRS	extended-range multiple launch rockets
FDC	fire-direction center
FPF	final protective fires
FSCL	fire support coordination line
GMLRS	guided multiple launch rockets
GPS	global positioning system
GWOT	Global War on Terror
HE	high explosive
HIMARS	High-Mobility Army Rocket System
ICM	improved conventional munitions
INF	Intermediate-Range Nuclear Forces
MLRS	Multiple Launch Rocket System
MRSI	multiple-round simultaneous impact mission
NATO	North Atlantic Treaty Organization
PGK	precision-guidance kit
PGM	precision-guided munitions
ROAD	Reorganization Objective Army Division
SADARM	sense and destroy armor munition
TOT	time-on-target
UAV	unmanned aerial vehicle
UN	United Nations
VT	variable time

Introduction

"INCOMING! INCOMING! INCOMING!" A single, haunting sound drowns out the shouts, a whistle synonymous with death and destruction. There is no enemy in sight. It comes from nowhere. It comes from everywhere. The soldier has no option but to wait, to hope. Those who survive will never forget the whistle. They will never forget the sound of indirect fire.

Indirect fire is the art and science of firing a projectile at a target that the shooting element cannot see or use as an aiming point. In modern conflicts, it is an essential capability of every fighting force. However, the indirect-fire equipment and doctrine of different militaries vary based on how they adapted over time to emerging technology, lessons from combat experience, and external threats that the nation faced. For example, North Korea employs long-range artillery near its border to cause massive destruction in Seoul, insurgent forces in the Middle East indiscriminately lob inexpensive rockets and mortars onto fortified bases, and the US military incorporates indirect fire with maneuver forces to create a combined-arms dilemma.[1]

With such divergent paths between nations, understanding military innovation requires answering a fundamental question: What adaptive pressure (or pressures) creates change? For indirect fire, this question begins with historical context. Although the idea of artillery can be traced back to the days of catapults and trebuchets, indirect fire emerged in the First World War and earned artillery its nickname—The King of Battle.

A Historical Starting Point

The US Army's professionalization of artillery was in its infancy before World War I. The community published its first *The Field Artillery Journal* volume in 1911.[2] In the same year, the "School of Fire" opened its doors at Fort Sill, Oklahoma, for its first class—albeit with only four faculty and a class of fourteen captains.[3] Consequently, field artillery historian Janice McKenney contends that the war was a "watershed" moment for field artillery.[4] Technological innovations just before and during WWI led to the introduction of indirect fire, and its successful application in combat created what British Maj. Gen. Jonathon Bailey coined the "Modern Style of Warfare."[5] He argues that the WWI shift from a linear battle to a three-dimensional battle was "the most significant development in the history of warfare to date, and remains so."[6] While the character of warfare continually evolves, technological innovations and doctrinal adaptations have been bound to this three-dimensional framework for the last century.

Although the basic technology required for long-range bombardment existed before World War I, supplementary innovations such as the introduction of aerial observers and photography, detailed mapping with trench lines, survey equipment advancements that provided accurate locations of friendly firing units, and rudimentary means to communicate adjustments from the observer to the firing battery, all made indirect fire both a credible threat and a tool that planners seized upon as a potential solution to the stalemate. Bailey explains that indirect fire became the "foundation of planning at the tactical, operational, and strategic levels of war."[7] Instead of enveloping an enemy, indirect fire helped a force break through enemy defenses using simultaneous attacks on rear or reserve elements. Bailey concludes that "by 1918, artillery firepower had restored to the battlefield the [maneuver] which the infantry had eradicated in 1914."[8] By the war's end, indirect fire had caused the preponderance of casualties and earned its nickname; however, artillery would have to continue adapting to maintain its moniker.

In this context, the end of WWI serves as a starting point for studying indirect fire. After the war, the United States collaborated with other great powers to understand the role of artillery at division, corps, and army levels with a detailed look at what type of systems would be needed to support maneuver operations in a future war.[9] Following WWI, militaries solidified the science of indirect fire, and the US military emerged as a global leader in artillery employment. The next chapter will examine this foundational time for artillery—the interwar years through World War II. It is meant as a prelude, providing prerequisite information to evaluate innovation and adaptation themes across time.

Analysis of artillery innovation and adaptation begins in 1945 with the creation of the modern international system generally still in place today, the formalization of the US Defense Department, and the solidification of the United States as a great power. This status ensured the development of a perpetual global competition between the United States and the Soviet Union and, in more modern times, Russia and China. Notably, the development of US artillery from WWII to the present is not unique; all modern armies are subject to technological and institutional pressures. But the US experience is undoubtedly exemplary by virtue of the scale of resources involved. Additionally, the country's preeminent military role has ensured that the US artillery community has had ample opportunity to assess emerging threats as well as develop and integrate the latest technological innovations, even during the “long peace” of the Cold War.

A Path to the Present

This book is broken into six sections that chronologically extend from the conclusion of WWI to operations in Iraq and beyond. Each chapter assesses innovation and adaptation through the lenses of incorporation of new technology, application of lessons learned from combat experience, and assessment of external threats—explained in understandable terms rather than using military jargon.

Chapter 1, A Prelude: The Foundation of Modern Artillery, establishes the baseline for artillery development. This chapter covers a broad period that focuses first on the Army’s examination of indirect fire after WWI by highlighting two research boards that examined the role of artillery by echelon and sparked a decades-long debate concerning artillery mobility. Second, it identifies key themes from artillery’s employment in WWII, including the centralization of fires, the challenge of high ammunition expenditures, and artillery adaptability.

Chapter 2, The Korean War and the Development of Nuclear Artillery, examines Korean War field artillery lessons, highlighting the need for increased range to distance friendly cannons from the enemy, increased mobility to adapt to the changing tactical situation on the ground, and greater lethality to solve the ammunition expenditure problems inherent in a modern conflict. Subsequent technological and organizational innovations of the early Cold War directly impacted the Army’s tactical nuclear program and ushered in the missile age of indirect fires.

Chapter 3, The Vietnam War and Cold War Modernizations, assesses artillery during the Vietnam War, specifically firebase operations and developing new capabilities such as helicopter-aided artillery and direct fire techniques. Although peace followed this period, indirect-fire modernization—particularly the development of new munitions—was in direct response to the growing Soviet tank threat and the acceptance of a numerical mismatch, not the lessons from the previous conflict.

Chapter 4, The Gulf War and a Deliberate Effort to Innovate, examines the application of modern munitions in a conventional conflict and discusses indirect fire in the Gulf War. Post-war innovation efforts faced ample challenges as the US Army attempted to continue modernizing in the absence of the external threat that the Soviet Union had posed during the Cold War.

Chapter 5, The Global War on Terror and the Rise of Precision Munitions, analyzes counterinsurgency (COIN) operation challenges in Iraq and Afghanistan, and the corresponding transition from the destructive capacity of wars past to collateral damage assessment, which limited the use of precision munitions to fight the asymmetric threat. Efforts to avoid collateral damage limited capabilities, particularly the US military's ability to adapt given the often-transient nature of lessons learned through combat.

Chapter 6, Assessing Innovation Drivers and a Look to the Future, synthesizes the impact of varying innovation drivers and presents insights into future artillery modernization challenges. The final section offers recommendations for future artillery adaptations based on findings from the historical analysis.

Forms of Adaptive Pressure and Artillery Themes

The role of indirect fire on the battlefield has been repeatedly reshaped by new technologies on the one hand, and by organizational and doctrinal changes on the other. This has led to both successful and unsuccessful US field artillery adaptations in conflict and peace. While many factors undoubtedly work in tandem to drive military innovation and influence leaders, three forms of adaptive pressure stand out for indirect fire: incorporation of new technology, application of lessons learned from combat experience, and assessment of external threats.

The technical requirements of indirect fire mean the branch is always incorporating new technological innovations on the battlefield. Technical innovation can be both a product of assessed capability gaps or needs and, inversely, the driver of change and modernization. Additionally, combat experience has provided the US military with a testing venue for its current and emerging equipment across the full spectrum of conflict, including conventional and COIN operations. These conflicts, and peaceful periods between them, enabled both informal assessment through the professional writing of those who experienced the fighting and formal conferences to outline lessons learned. Outside of conflict, assessment of external threats also catalyzes change. Consequently, the artillery branch is forced to regularly assess threats to match the increasing survivability, lethality, and mobility of enemy forces. The emergence of nuclear weapons, tanks, or unmanned aerial vehicles (UAV), for example, significantly changes the battlefield, altering how indirect fire is implemented and organized to support maneuver forces.

With a broad scope covering nearly a century, these innovations and adaptations highlight artillery themes that transcend individual conflicts, doctrine, or leaders. As the "King," artillery innovations continually improve lethality, from increasing the size of delivery systems to modernizing munitions. While artillery is an area-effect tool, there is still an underlying requirement to strike where intended. Improvements in calculation methods and tools, as well as target identification and communication doctrine, improve accuracy and lethality. Additionally, indirect fire must be timely. Whether supporting troops in desperate need or striking a critical enemy target, battlefield opportunities are fleeting. Consequently, the fight for responsiveness has led to mobility innovations, constant pursuit of range improvements for delivery systems, and unique doctrinal approaches to managing the clearance of fires—deconflicting airspace and mitigating potential fratricide. Finally, because mobility is required to support operations on a fluid battlefield and a necessity for artillery survival, the speed at which artillery can be moved in or out of position remains critical for artillery innovation.

Notably, large rounds—cannons and rockets alike—are consumed on the battlefield at high rates. The sheer ordnance tonnage associated with indirect-fire employment poses logistical challenges for the Army and, on occasion, limits its use. Because of this operational impact, combined with the changing character of conflicts, discussions about which Army echelon should plan for and execute indirect fire have been contentious—and are ongoing.

Combined, these themes of destructive capacity, accuracy, responsiveness, mobility, and centralized versus decentralized control represent the essence of US artillery adaptation and innovation. While their prioritization varies through time, the themes provide an underlying historical reference point for this analytical journey from WWII to the present.

Moving forward, it is unknown where, when, or how the next war will be fought. Regardless, military forces will have to adapt indirect-fire capabilities to the conflict at hand and continuing technological innovations. Studying successful and unsuccessful historical adaptations of indirect-fire capabilities offers insights into future problems that US field artillery will face. Former US Chief of Artillery Maj. Gen. Toney Stricklin astutely noted this sentiment in a message to the artillery community: "Learning from the lessons of the past, we must prepare for the future."[10] Technological innovations and transitions in and out of various types of warfare will continue to present challenges going forward, just as they did throughout the Cold War and during the Gulf conflicts. Whether future artillery requires armor-destroying munitions to support conventional warfare in Europe, anti-ship missiles in the South China Sea, artillery-launched drones into the "Gray Zone," or even unmanned artillery ground vehicles relying on artificial intelligence, understanding successful past adaptation and innovation will facilitate future development.

Notes

1. Department of the Army, Field Manual (FM) 3-09, *Field Artillery Operations and Fire Support* (Washington, DC: Department of the Army, 2014), https://armypubs.army.mil/epubs/DR_pubs/DR_a/pdf/web/fm3_09.pdf; Niall McCarthy, "Why The North Korean Artillery Factor Makes Military Action Extremely Risky," *Forbes*, 2 October 2017, https://www.forbes.com/sites/niallmccarthy/2017/10/02/why-the-north-korean-artillery-factor-makes-military-action-extremely-risky-infographic/; and John Ismay, "Insight Into How Insurgents Fought in Iraq," *At War Blog* (blog), 17 October 2013, https://atwar.blogs.nytimes.com/2013/10/17/insight-into-how-insurgents-fought-in-iraq/.

2. "Field Artillery Journal," United States Field Artillery Association, accessed 21 July 2022, https://www.fieldartillery.org/news/artillery-journal. The journal recently came under new management and was subsequently moved behind a paywall. Its homepage reads: "The *Field Artillery Journal* maintains the same purpose as stated in the first *Field Artillery Journal* published in 1911—To publish a journal for disseminating professional knowledge and furnishing information as to the artillery's progress, development, and best use in campaign; to cultivate with the other arms, a common understanding of the powers and limitations of each; to foster a feeling of interdependence among the different arms and of hearty cooperation by all; and to promote understanding between the regular and militia forces by forging a closer bond; all of which objects are worthy and contribute to the good of our country." These articles are used throughout this work as they capture lessons from the leaders of the time, both as bottom-up suggestions from the field and top-down guidance from Fort Sill.

3. Riley Sunderland, *History of the Field Artillery School: 1911–1942*, vol. 1 (Fort Sill, OK: Army Field Artillery School, 1942), 37–38, https://morrisswett.contentdm.oclc.org/digital/collection/p15766coll2/id/141/rec/10.

4. Janice E. McKenney, *The Organizational History of Field Artillery 1775–2003*, Army Lineage Series (Washington, DC: US Army Center of Military History, 2007), 121.

5. Jonathan Bailey, *The First World War and the Birth of the Modern Style of Warfare*, The Occasional 22 (United Kingdom: The Strategic and Combat Studies Institute, 1996), 3.

6. Bailey, 1.

7. Bailey, 1.

8. Bailey, 17.

9. William Westervelt et al., *The Report of the Westervelt Board* (Washington, DC: War Department, 1919), https://morrisswett.contentdm.oclc.org/digital/collection/p15766coll2/id/529/. The Westervelt Board is examined in detail in Chapter 1. While America ran the Westervelt Board, the resulting analysis was a collaboration between French, English, Italian, and US artillery officers.

International concurrences and disagreements are noted regarding specific board recommendations.

10. Toney Stricklin, “Learning from the Past to Prepare for the Future,” *Field Artillery: A Professional Bulletin for Redlegs*, July 2000, 1.

Chapter 1
A Prelude: The Foundation of Modern Artillery

Artillery reigned king in the First World War. Lethality innovations had caught up to the mobilization revolutions that shaped nineteenth-century warfare. Casualties were measured in the thousands in previous great-power conflicts like the 1870 Franco-Prussian War and the 1904 Russo-Japanese War. In contrast, millions died or were wounded within the first months of World War I. The million-man armies faced machine guns and inordinate amounts of indirect fire, making trench warfare necessary for survival. Consequently, the armies built coordinated trench networks spanning hundreds of miles across Europe and fought pitched battles for inconsequential terrain gains. The sheer size and scope of the war meant that manning requirements, casualties, and ammunition expenditures were drastically higher than planners had predicted. Beyond simply being larger in scale, the final WWI battles gave belligerents a glimpse of future conflict. The tank, for example, demonstrated the capability to destroy wire and deliver mobile firepower directly to infantry forces. Similarly, airplanes provided unique real-time reconnaissance and forward observation of fires, and developed as a complementary bombardment tool to artillery.

By 1918, technological innovations and mass manufacturing foreshadowed what warfare could become. Historian Hew Strachan highlights this point, noting that "aerial combat at the start of the war was an affair of individuals," but "by 1917–18, it was a matter of masses."[1] Tanks and aircraft represented war's future, and by the end of WWI, the Allies were producing them by the thousands. While indirect fire remained essential, militaries would have to adapt its application to their respective visions of future warfare. Indirect fire was the new means of employing artillery, but it was unclear exactly how the US military would leverage the new science amidst technological breakthroughs of the time.

From these warfare experiences, the US military deliberately assessed future artillery requirements and reshaped how the Army understood artillery's role on the battlefield at the division, corps, and army levels. The subsequent findings drove modernization efforts during the interwar period. While the service failed to realize many of its innovation goals, some successes proved fruitful, creating enduring artillery capabilities. Arguably, the most important of these endeavors was the development of the fire direction center (FDC), which enabled the Army to conduct indirect fire as a science. After decades of modernizing, the United States again found itself engaged in global conflict, a war that served as a venue to test warfare assumptions and new equipment. For the artillery, the WWII combat experience highlighted enduring themes concerning centralization of fires, the challenge of high ammunition expenditures, and artillery adaptability in combat. Combined, modernization efforts in the interwar years and WWII combat experiences set the foundation of modern artillery.

Future Artillery Requirements

As WW1 ended, the US military quickly transitioned to a learning organization, assessing a broad range of topics to distill the most pertinent combat lessons; artillery was no exception. While these assessments captured lessons from those who experienced the fighting, they went beyond simply studying the conflict. Instead, senior artillery officers used the experience to outline a vision for what artillery had to become to thrive on a future battlefield. The most noteworthy of these was the Hero and Westervelt Boards.

Hero Board Lays the Groundwork for US Artillery Modernization

Less than a month after the Armistice was signed ending WWI, the artillery community began assessing lessons learned. On 9 December 1918, the Chief of Artillery for the American Expeditionary Forces, Maj. Gen. Ernest Hinds, appointed an officer team to study the experiences of artillerymen who fought and led others in the war. The board's three members were Brig. Gen. Andrew Hero, its president and namesake; Brig. Gen. John Kilbreth, and Lt. Col. Curtis Nance. The three visited the headquarters of fourteen units and sent letters to artillery officers who commanded brigades, regiments, and schools in France during the war. The Hero Board's goal was to assess post-war artillery reorganization, implications of mechanical transport, effectiveness of liaisons, and armament across different echelons.[2] The members spent months gathering information from artillerymen still in Europe, eventually proposing recommendations and synthesizing recommendations from officers who shared feedback. At its conclusion, the board published twenty recommendations, four of which stand out as they heavily influenced the path of US artillery modernization.

The first of these influential recommendations was for the US Army to provide division artillery (DIVARTY) "with a howitzer of smaller caliber than the 155-mm howitzer."[3] Field artillery historian Boyd Dastrup suggests that this lighter howitzer fit into the board's envisioned "system of mutually dependent" artillery pieces of varying sizes.[4] Second, the board examined artillery unit mobility—particularly near the war's end—and recommended "that study and experiment should be energetically continued looking toward the early motorization of every piece of artillery that can be successfully adapted to motor traction."[5] Notably, these two concepts, later echoed by the Westervelt Board, consumed artillery modernization in the interwar years. The last two board recommendations that drove modernization efforts concerned improving liaison efforts—both ground and air—and enhancing communication capabilities.[6] These supplementary indirect-fire adaptations enabled the eventual creation of the FDC and proved invaluable to artillery employment in WWII.

In addition to making recommendations, the Hero Board consolidated feedback it received from the artillery officers who participated in the study. While many of the officer comments reinforced the board recommendations, three are worth further examination. First, the artillery officers recognized the importance of improving relations with their infantry counterparts, challenging that "there should be a greater amount of time devoted to the combined training of our infantry and field artillery."[7] Second, field officers offered a warning regarding artillery motorization: "it cannot be claimed at the moment that we have reached the point where the horse-drawn light guns can be discarded" but added that the Army must "keep in the forefront of progress by continual study and experiment."[8] This argument would resurface in the interwar years as a contentious and long-standing debate regarding artillery mobility.

Finally, the officers discussed a significant materiel challenge, foreshadowing problems the US military would face for generations. The refined recommendation contended that moving forward, "it is indispensable that an adequate reserve of Materiel and equipment, particularly of ordnance, for our needs upon the outbreak of war be accumulated and maintained in time of peace."[9] The leaders argued that "had we not been able to obtain ordnance from the French and the British, we would have been a negligible factor in the war until the end of 1918."[10] Col. J. H. Burns of the Ordnance Department raised this issue in a more public setting, reminding fellow artillery officers in July 1919 that "we could not, in the recent war, have waged even a day's battle with our armies if we had been able to utilize only the munitions furnished by our factories."[11] Insightful as these officers were, the United States likely could not have amassed "adequate" materiel for the war it would face a few decades later.

In March 1919, General Hinds submitted the Hero Board's findings to Maj. Gen. William Snow, US Army Chief of Artillery. However, these were not the only findings Snow was waiting on, as Assistant Artillery Chief Brig. Gen. William Westervelt was conducting a separate assessment concurrent with the Hero Board.

Westervelt Board Outlines the Future of US Artillery

While the Hero Board focused on the experiences of the American Expeditionary Forces, a second group of officers was assigned to conduct a more holistic assessment of artillery in the war. In December 1918, the Army assigned a seven-person board led by Brigadier General Westervelt to study "the Armament, Calibers, and Types of Materiel, Kinds and Proportion of Ammunition, and Methods of Transport of the Artillery to be assigned to a Field Army."[12] Whereas the Hero Board met with senior US artillery officers and traveled to unit headquarters, the Westervelt Board—also named after its president—visited partner nations to gain a broader understanding of artillery's role on the battlefield.

The team began its assessment in January 1919 in France, visiting manufacturing plants and interviewing French officers; they repeated this process with trips to Italy and England before concluding its study in the United States.[13] The Westervelt Board eventually published its findings in May 1919, offering numerous complementary recommendations to the Hero Board. Overall, the board concluded that the US Army needed to overhaul its artillery equipment. Dastrup justified the board's recommendations, explaining that "the war, after all, had revealed the inadequacy of the field artillery."[14] The board's most important finding as it pertains to this research was its assessment on the varying roles of artillery by echelon and the corresponding weapon system recommendations. The Westervelt Board divided the role of artillery into three categories based on the echelon the weapons supported—division, corps, and army.

At the division level, the board emphasized mobility, challenging that "division artillery . . . must have the mobility that will permit it to accompany the infantry of a division."[15] They acknowledged, however, that if there was an echelon that could wait on motorization, it was the division: "While there is no question that the tendency is towards complete motorization, the Board . . . does not feel justified at the present time in recommending complete motorization of all division artillery."[16] Additionally, the members made a modest recommendation on lethality—tying artillery lethality at this echelon to dismounted forces rather than pressing for the most destructive munitions. They contended: "Division artillery must fire accurately a man-killing projectile" and "its objective must be primarily the infantry of the opposing division."[17] This potential lethality reduction would become a contentious issue in the interwar period.

The Westervelt board members examined the weapon systems needed at the division to accomplish the mission as they understood it. Like the Hero Board, they determined the 155-mm howitzer was the incorrect choice. First, it must be noted that at that time the division artillery (DIVARTY) paired a "gun" and a "howitzer." The gun represented a more traditional artillery piece with a flat trajectory, while the howitzer was the modern tool for indirect fire. The board did not recommend moving away from the 75-mm flat trajectory division gun—a WWII eventuality. Instead, it focused on improving the pairing. The members challenged that the 155-mm howitzer "was not sufficiently mobile to be a suitable companion piece for the 75-mm gun" and "its volume of fire is insufficient."[18] Consequently, the board recommended the Army develop a light 105-mm howitzer with a range exceeding ten kilometers and a carriage that allowed 360-degree rotation.[19] This flexibility recommendation with the carriage was critical, foreshadowing the problems artillery units would face on Korea and Vietnam battlefields with non-contiguous boundaries. Sadly, this 360-traverse did not become a reality for field artillery units until the 1960s—examined further in Chapter 3.

The board's division recommendations raised an important question regarding the centralization of artillery. Knowing this, the members addressed this contentious issue:

> In connection with the support of the division infantry by the division artillery, the war has intensified the old question of accompanying guns for infantry. A solution of this question by the assignment of batteries of field artillery has been tried, but the general opinion is that the field artillery gun is not satisfactory for this purpose; it is too vulnerable a target in motion; the ammunition supply is difficult; it is not sufficiently mobile because it cannot be man-handled; and from the division artillery standpoint, the loss of the control of these batteries breaks down the power of the division artillery.[20]

A follow-up study released by the US Artillery Association in 1920 reinforced these points:

> This close association of infantry and artillery commands does not involve, however, parceling out the artillery among the minor infantry commands, and making of the division a number of

> small separate combined commands. This would mean losing the ability to concentrate and to adapt the power of the artillery to meet the larger phases of the action. The commander must preserve the ability to use his artillery in this larger way, and to influence its action when he sees fit through the intermediary of his divisional artillery commander.[21]

This conversation would reemerge repeatedly through varying conflicts, becoming a continual artillery theme. The Westervelt Board's assessment, particularly that the division would be weakened by decentralizing its artillery, provided the foundational argument that artillery leaders would leverage the next time this debate flared during the 1950s Pentomic Era—examined in Chapter 2.

The Westervelt Board framed the corps artillery's mission through a lens of a shaping mission—albeit using a different term. The members noted that "the division artillery missions did not include their own protection against enemy artillery," contending that "the mission of counter-battering the enemy's gun belongs to the corps, which has the proper agencies for determining the position of enemy guns and for coordinating this work."[22] Because artillery is well suited to destroy artillery, this "duel" would remain a consistent focus of the artillery community. Additionally, the board envisioned the corps artillery conducting "extensive harassing and interdicting fire along the corps front," and providing "destructive fire on strong points as well as on railroad facilities and points of supply."[23] To accomplish these shaping missions, the board recommended retaining the Schneider 155-mm howitzer used in the war but work to improve its maximum range to sixteen kilometers. The members noted that "in the opinion of the French, the Italians, the British, and the Americans, the 155-mm. howitzer (Schneider) was conspicuously successful."[24] This howitzer caliber would eventually become the staple of post-Cold War cannon artillery.

The final mission-set the board examined was artillery for army support. The purpose of these artillery units was threefold. First, the board argued that given the scope of a future conflict, some missions undoubtedly would fall outside the capability of the systems at the division or corps. Second, the members contended that army-level artillery must maintain a surplus of weapons to reinforce division or corps artillery. Finally, they outlined the need to maintain specific specialty systems such as trench artillery, railway guns, and incredibly large-caliber systems known as super guns.[25] Combined, the board's discussion on these three mission-sets established the foundation for artillery roles by echelon.

A Path Forward

The US artillery's detailed examinations after WWI went beyond attempting to learn lessons from combat experience. For the artillery community, WWI was not a war that simply challenged its employment doctrine. Instead, with the establishment of indirect fire as a science, WWI fundamentally altered the role of artillery units in warfare. In turn, the Hero Board and the Westervelt Board represented a deliberate effort by senior artillery leaders to reframe its paradigm for the broader community. Historian Janice McKenney argues that these reports "became the basis of field artillery development, both in weapons and in organization, for the next twenty years."[26] By conducting these assessments concurrently, the artillery community leveraged the experiences of allies and crowd-sourced bottom-up suggestions from US artillerymen to produce tangible recommendations.

While the studies were underway, the US Field Artillery Association continued to publish *The Field Artillery Journal,* distributing four issues in 1918 and five in 1919. Importantly, these included the complete Westervelt Board findings, creating a high level of transparency concerning the direction of the branch.[27] Overall, the open and broad approaches by the artillery community, combined with detailed discussions and recommendations, help set the Army's interwar modernization path.

Modernizing Artillery during the Interwar Years

The interwar period was not a revolutionary time for the artillery the same way it was for armored vehicles or aircraft. Military historian Allan Millet highlights this point in his research on the period: "In ordnance technology, the great advances predated World War I and found validation in that conflict, and postwar development of infantry and artillery firepower simply carried the established lines of innovation along known paths."[28] Instead, he notes, "the chemistry of explosive charges, fuzing, and shell design improved incrementally to enhance destructiveness."[29] However, while the improvements in this period were less tangible for the artillery, they were still profound. Following the path identified by the Hero and Westervelt Boards, the Army addressed artillery mobility, wrestled with the makeup of DIVARTY, pursued a light howitzer, and, most importantly, leveraged emerging technology to develop foundational fire direction procedures.

Enhancing Artillery Mobility

The Army's experiences in WWI, particularly the latter half, highlighted a need for increased artillery mobility, as reinforced by both the Hero and Westervelt Boards. However, the notion of abandoning the horse for a motorized prime-mover vehicle was met with contention. In 1922, Maj. W. E. Burr challenged the artillery community to move toward a compromise on the topic: "One extreme advocates the use of the tractor for all gun traction, and the other prefers the horse exclusively. . . . [The] moderate course would seem to be to admit that the tractor has great possibilities but that its complete adoption is not warranted yet."[30] The Army's artillery motorization experiments showed progress, but the conversation on whether to move away from the horse would last the entirety of the interwar period.

The Field Artillery Journal staff regularly updated the force on motorization progress. In 1929, the staff shared War Department guidance on horse-drawn artillery at the division level:

> The War Department contemplates no departure at present from the principle that divisional light artillery is horse-drawn. Experimentation with other forms of traction for field artillery is being considered in the light of developing such for special uses and assignment.[31]

As technology continued to evolve and experimentation with motorization demonstrated success, however, these official attitudes began to shift.

Many viewed motorization as a natural evolution of artillery mobility, challenging that the end of horse-drawn artillery was inevitable. In 1933, less than five years from the War Department's announcement, the *Journal* staff shared a significant update that ran directly counter to its previous note:

> The Field Artillery is actively engaged in determining to what extent commercial and special automotive vehicles can replace its animal transport in Division Artillery, with every prospect that within the next five years, if funds are made available, the horse will be entirely replaced in every Field Artillery function except possibly reconnaissance, where it may prove advantageous to retain him even to the extent of providing motor transport for a few animals per battalion or regiment. It is essential that the Field Artillery avail itself of the superior status of the automotive industry in this country. Recent tests indicate that the horse, as

> a means of field artillery transport, must go, and that the arm is now faced with the task of radically modifying its tactical and strategical doctrines due to this revolutionary change.[32]

Though the artillery community appeared ready to transition, the horse was slow to disappear.

Senior officers continued to challenge the artillery's decision to motorize. In 1937, an artillery colonel called the transition "alarming," raising concerns about excessive vehicle noise in the division area and highlighting the value of the horse's night vision.[33] Even Chief of Artillery Maj. Gen. Robert Danford joined the conversation. After sixteen horses died during a 1939 training exercise, Danford addressed the community and offered techniques to better care for the animals during strenuous training, omitting the branch's modernization objectives.[34] Although this two-decade-long debate concerning the horse was not unique to the artillery community, it does highlight a cultural resistance to change and provides necessary context to understand artillery officer aversion to a more radical change—self-propelled artillery.

Technological innovations during the interwar period sparked one of the most controversial questions concerning the employment of artillery: Do artillery cannons need to be towed, or can the Army mount howitzers directly on vehicles? While movement away from the horse dominated the artillery-mobility conversation, the potential for self-propelled artillery systems surfaced shortly after WWI. In 1928, Maj. Rene Hoyle, assistant commandant of the School of Fire for Field Artillery during WWI, outlined the differences between motorization and mechanization, and highlighted how the development of tracked vehicles could impact artillery. He challenged that if the Army developed a mechanized force, it would be "absolutely necessary" to support it with self-propelled artillery.[35] Hoyle conceded that the technology was not yet ready, arguing that the artillery community should avoid designing a slow-moving "land battleship," but that potential future systems would allow artillery units to rapidly emplace, require less personnel to employ, and would lead to fewer US casualties.[36]

In 1939, Germany's invasion of Poland demonstrated the potential of mechanized forces to the world. Under this new warfare reality, Italian Army Brig. Gen. Guiseppe de Stafanis examined the challenges artillery units face in supporting an armored division. He explained that the mechanized fight was simply faster, contending that artillery units must be equipped with self-propelled systems that could rapidly adjust to changing objectives and require minimal time to emplace or set up for fire missions.[37] Mobility technology progressed dramatically during the interwar period. While many artillery officers clung to the notion of horse-drawn artillery, the battlefield had changed, and artillery units needed increased mobility to remain relevant. With the outbreak of WWII, the artillery community put motorization to the ultimate test, introducing the first US self-propelled artillery. Adding to this mobility conversation in the interwar years was the Army's pursuit of a lightweight division howitzer.

Division Artillery and the Light Howitzer

At the end of WWI, it was not a foregone conclusion that the Army would pursue a lightweight division howitzer. While the Hero and Westervelt Boards recommended this innovation, the sentiment was not unanimous. After reviewing the boards' results, the US Field Artillery Association challenged the conclusions. Instead, the association's internal assessment reached different conclusions:

> The 155-mm has shown itself in this war to have the necessary mobility, when horse-drawn, and now that it is motor-drawn it appears to have an ample margin of mobility. By retaining it for our divisional artillery, as well as corps artillery, we have an all-around gun that can be used interchangeably for both purposes . . . it is considered that the 155-mm should be retained as our divisional howitzer. It is the weapon that has stood the test in this war as a divisional howitzer, both for ourselves and for the French.[38]

Opinions differed even before development of a new system began.

For many, the shift away from the 155-mm howitzer represented a sacrifice in lethality. While a smaller howitzer would improve mobility, responsiveness, and rates of fire, it also meant smaller munitions. In 1922, Major Burr challenged the branch to avoid this loss of destructive capacity, contending the artillery community must "find a substitute which has the same power at least" before abandoning the 155-mm howitzer.[39] Regardless of the arguments, the artillery branch began testing a US-made 105-mm howitzer against captured German equipment; by 1927, this model was standardized, but experimentation was minimal because of limited funding.[40]

Notably, *The Field Artillery Journal* staff updates concerning the potential new howitzer were not as transparent as those regarding artillery mobility experiments and policy. This created confusion, and in 1925, Maj. Maxwell Murray demanded updates and an open conversation on the new weapon. He explained that "many field artillery officers have no clear idea as to what the light howitzer is, its power, the characteristics of its fire, or its adaptability to the missions of division artillery."[41] Even though the Hero and Westervelt Boards had deemed the lighter howitzer a significant combat lesson, the peacetime military did not necessarily have an incentive to invest in its development. Murray argued that while peacetime routines might lead officers to have a "natural tendency to accept existing organization as final," the artillery community needed to keep the Army "aware of the existence of this fine weapon—alive to its possibilities, and insistent upon its use when the occasion arises."[42] That occasion would eventually come, but it was still more than a decade away.

Experimentation resumed in the 1930s. Again, the Army standardized a model, and again, funds limited the Army's ability to manufacture it.[43] At the same time, concerns about reduced lethality resurfaced, particularly regarding the division's ability to provide general support. In fact, a 1938 Field Artillery School study suggested the new lightweight howitzer should "replace the 75-mm gun instead of the 155-mm howitzer."[44] The Army's desire to reorganize the division provided artillery leadership with an opportunity to assess the light howitzer's potential.

In January 1940, just as the Army was finalizing its Triangular Division Reorganization, General Danford learned from questionnaires sent to the force that most responding officers challenged the Army to abandon the 75-mm gun and pursue a combination of 105-mm and 155-mm howitzers.[45] The War Department reached similar conclusions, creating the new division with three 105-mm howitzer battalions and a 155-mm battalion.[46] Simultaneous with these broad Army changes, the artillery community focused on an internal change to improve its fire direction capabilities.

The Fire Direction Center and the Principle of Mass

While mobility and delivery system upgrades were important, the Army needed to holistically assess how it would employ artillery in a future fight, particularly concerning emerging technology. Peter Mansoor, Ohio State University military history chair, argues that WWI artillery was inflexible because of limited communication technology, which restricted the ability of artillery units to adjust to changing circumstances and forced them to primarily rely on preplanned fires.[47] Supplemental radio-technology innovations in the interwar period, coupled with artillery community investments in its observer teams and signal support elements, reduced much of this friction. Theoretically, these updates enabled artillery units to rapidly respond to targets of opportunity. This feat, however, required a new approach to conducting firing calculations, henceforth referred to as fire direction.

In the late 1920s, a conversation emerged concerning which echelon would plan for and conduct fire missions, elevating the importance of two essential principles of war—mass and unity of command. If an observer team identified a critical target or targets, the question became how much destruction an artillery unit could bring to bear quickly. Under the leadership of Majors Carlos Brewer and Orlando Ward, the Field Artillery School Gunnery Department began testing field artillery adjustment techniques and combining the fire of multiple batteries to mass artillery effects.[48] Fort Sill put on demonstrations of these new massing techniques starting in 1931, and by the mid-1930s, the gunnery department codified its new fire-direction procedures.[49]

In 1935, the conversation regarding fire-direction advancements extended beyond Fort Sill. Capt. Rex Chandler was one of the first to publicly argue that "battle conditions may dictate that the battalion commander employ a system of fire direction wherein he and his staff will direct and *conduct* the fire of three or more widely dispersed batteries."[50] The general argument focused on mass. Even if the battery could fire the same volume of rounds as a battalion, it could not do it as quickly. Additionally, the fewer the number of howitzers firing, the less the cumulative effect; one howitzer firing eight rounds would inherently produce a lesser initial effect than eight howitzers firing a single round.

The question was not whether this logic could scale up to the battalion or even to the division level. Instead, the debate was whether to coordinate and synchronize this type of employment. Notably, this sentiment was not well received at the time because it challenged established norms regarding the conduct of fire. As Lt. Col. Frank Ratliff explained in his historical analysis of the FDC: "The battery commander was a king in his own right;" senior commanders were expected to "refrain from interfering in the details of conduct of fire or the service of the guns."[51] Consequently, these employment adaptations were a culture shock for many in the artillery community.

While the Fort Sill team continued to make progress, procedural upgrades generally stagnated until Col. H. L. C. Jones arrived at the gunnery department in 1939. Specifically, he introduced fire-direction techniques developed in his former battalion and established a department goal to mass fires at any observed target within three minutes of receiving a request.[52] Through continued experimentation, the department successfully scaled and refined its techniques to the division level and demonstrated its potential to General Danford, who subsequently approved the technique and facilitated its transition into doctrine.[53] With this official codification of new techniques and procedures, the battalion FDC was born. By demonstrating the capability to conduct fire direction at the division level, these noteworthy adaptations enabled commanders to leverage unity of command for artillery employment. Consequently, fire-direction innovations reinforced artillery centralization arguments that the US Army would navigate through in WWII and beyond.

Lessons Learned from the Interwar Period

After WWI, the Army deliberately assessed potential indirect-fire lessons learned by examining the combat experience of artillery officers from each of the belligerents. Instead of simply building on techniques developed during the war, the branch set out to understand how the war had changed artillery's role on the battlefield. Though these studies created clear and tangible modernization paths, the innovation efforts that followed were not without challenges. While organizational and doctrinal developments may have altered how the Army would employ indirect fire, self-propelled systems and division lightweight howitzers did not come to fruition until the United States fought its next war. Regardless, the period highlighted the value of innovation driven by combat lessons. It also demonstrated the *Artillery Journal*'s essential role as a professional venue for discourse within the force and as a tool to distribute information for the Field Artillery School, the Field Artillery Association, and the Chief of Artillery.

While historically overshadowed by significant armored forces and aircraft technology innovations, the US Army transformed its artillery capabilities during the interwar period to leverage the new science of indirect fire. McKenney notes that "field artillery, despite problems in resources, had undergone dramatic changes during the interwar years, . . . changes that became decisive factors in winning the next war."[54] That next war, a conflict of an unimaginable scale, provided the Army with the ultimate test to validate its indirect-fire modernization efforts.

World War II: A Validation of Interwar Modernization

In December 1941, the United States officially entered the Second World War. With its allies besieged, the US military soon was fighting on multiple continents in a conflict of scope and scale never experienced before. These different theaters challenged the military in distinct ways and, collectively, provided foundational combat experience that validated and challenged the US Army's indirect-fire modernization efforts. Notably, the Army of the time was ill-equipped to support the conflict's scale. In turn, the active number of field artillery batteries grew fivefold from 1937 to 1942.[55]

World War II was not simply greater in scale than past wars but drastically different technologically. The motorization and mechanization of European forces—particularly Germany—added a fast-paced and highly destructive character to the fighting. Apart from a short nuclear-centric period in the 1950s—examined in Chapter 2—the development of mechanized warfare and integrated air power would become the baseline for understanding land combat for decades. While there were many lessons for future artillery innovation and adaptation, WWII highlighted three artillery themes that persisted as development challenges for the US military: centralized artillery control, supporting high ammunition expenditures, and combat adaptation.

Centralized Control

The Army's new approach to fire direction allowed commanders to centralize control of their artillery to mass indirect-fire effects against critical enemy targets or weigh the main effort of an operation. While each theater of the war was distinct, division and corps commanders often utilized the new technique to leverage all the available assets at their disposal. For example, North African Campaign commanders were able to mass "up to twelve battalions (144 guns) to attack enemy positions."[56] This unity of command regarding artillery employment changed the tactical situation for units. For Africa, Dastrup argues, "effective field artillery support during the battles around Kasserine Pass came only when command was centralized."[57] Consequently, centralizing artillery enabled commanders to mass destruction on a single objective, and the new method would prove critical throughout the war.

Army units used this successful technique as the war progressed and expanded into Italy. At Anzio, for example, Maj. Gen. Lucian Truscott centralized control of his artillery after taking command of the VI Corps. In February 1944 actions against the Germans, the corps conducted a time-on-target (TOT) artillery barrage with all its available artillery systems, demonstrating the potential of massing fires. Using this technique, artillery units fire designated howitzers at a predetermined location using calculated firing data to have near-simultaneous impacts at a prescribed time. Notably, howitzers are not necessarily fired at the same time; their locations in relation to the target influence flight time. The TOT technique demonstrated what massing indirect-fire capabilities could achieve. In his analysis of the VI Corps engagement, Mansoor described the TOT effects as "nothing less than devastating," neutralizing a German attack.[58] Centralizing control of artillery to mass indirect-fire effects became commonplace. Dastrup explains that "massing artillery fire from an entire corps was not unusual in Italy."[59] The Army continued to build on these lessons, and the transition to the European Theater provided a new venue for continued refinement.

The scale of the European Theater allowed division and corps commanders to bring to bear an enormous amount of firepower on critical targets, leveraging an inordinate number of howitzers to support single missions. Notably, the flexibility of these artillery units—their ability to adapt to emerging threats and the changing tactical situation—directly affected the sheer quantity of artillery battalions a division or corps commander could take under their control. For example, in March 1944, the 9th Infantry Division took responsibility for a bridgehead east of the Rhine River and leveraged centralized artillery to maintain it. Mansoor explains that "the division artillery controlled all indirect fires in the area," noting that "at one point Brigadier General Reese Howell, the artillery commander, had seventeen battalions of artillery under his command."[60] The drastic increase of available artillery assets fundamentally altered the impact indirect fire could have on an operation.

This centralized artillery control at the division level allowed the maneuver commander to mass effects where needed, limiting the enemy's ability to organize or sustain a counterattack against the operationally significant bridgehead. Engagements in the Lorraine Campaign provide similar examples. On a single morning in October 1944, the XII Corp artillery combined the effects of seventeen artillery battalions, firing more than an hour of preparatory fires before an attack.[61] In the same month, twenty-six artillery battalions combined to fire nearly 19,000 rounds over the course of twelve hours.[62] By massing effects in this manner, division and corps commanders could concentrate their firepower resources onto a single and potentially critical target area, creating cascading effects for enemy operations.

Notably, not all tactical situations required commanders to centralize their artillery or mass the effects; however, the inability to do so when it was tactically necessary was potentially disastrous. For example, the 106th Infantry Division failed to leverage area indirect-fire assets during the December 1944 battle of Saint Vith, and disaster followed. Peter Mansoor assessed this battle: "The most powerful asset at the American's disposal was the big guns of the numerous corps artillery battalions in the area, but lack of central coordination by the division artillery prevented the massing of fires on critical targets."[63] Instead, two division regiments either surrendered or were captured, and the division became combat ineffective. Mansoor notes that "the devastation was so complete that American leaders decided not to reconstitute the division after the battle—the only American division destroyed as a unit by the German army in World War II."[64] While the division's inability to employ reinforcing artillery battalions was only a single factor, the additional firepower would have undoubtedly improved the unit's situation.

Overall, fire-direction technique advancements during the interwar period built on the science of indirect fire that emerged in WWI. These adaptations provided division and corps commanders with unity of command for their artillery. Battles in varying theaters validated the new techniques and demonstrated the destructive potential that units could achieve by centralizing control of their artillery. Mansoor explains that in WWII, "American artillery had the ability to mass fire on the enemy that impressed both friend and foe alike."[65] However, massing artillery required high ammunition expenditures, which quickly created a logistical challenge that the Army had to address in its campaign planning.

Ammunition Expenditures

While different theaters and campaigns presented distinct challenges, massive artillery bombardments provided readily available solutions to most tactical problems. The sheer volume of fire reinforced the importance of artillery, highlighting that even with the maneuver technology advancements, the successful employment of indirect fire remained critical to land warfare. Just as important, however, these expenditures strained logistics capabilities from the tactical to the strategic levels. Historian Roland Ruppenthal highlights this point in his analysis of logistical challenges in the European Theater: "In the entire eleven months of operations on the Continent, no supply problem plagued US forces more persistently or constricted their operations more seriously than the shortage of field artillery ammunition."[66] Consequently, artillery ammunition, or lack thereof, had the potential to stall a unit's offensive operations or limit the indirect-fire options that an artillery unit could support.

High artillery expenditures were often tactically necessary to defeat an attacking enemy force or weaken one before conducting an offensive operation. In June 1944, because ammunition stocks "were far below planned," First Army began rationing artillery ammunition, limiting how many rounds each of its howitzers could fire per day.[67] While limited in time, these restrictions became commonplace. Additionally, commanders focused on articulating their targeting prioritization to subordinates and supporting artillery units to minimize unnecessary or excessive expenditures. Ruppenthal recounts guidance from the XX Corps artillery commander, who restricted "the use of artillery for anything but counterattacks endangering the battle position, counterbattery against active enemy guns, and observed fire on only the most lucrative targets."[68] These restrictions limited tactical options, forcing each unit to deliberately plan the massing of its artillery.

Regardless of the logistics challenges regarding artillery, the tactical situation demanded that Army units plan for enormous expenditures to be successful. For example, during Operation COBRA in July 1944, "the army allocated the VII Corps almost 140,000 rounds of artillery ammunition" for a five-day operation.[69] When analyzing the battle of Saint-Malo that occurred in August and September 1944, historian Martin Blumenson explains: "The uncertainty of ammunition hampered operations," and "fire plans were often curtailed."[70] He highlighted a specific example, noting that "no artillery preceded an infantry attack launched on 9 August . . . and on the following day the stockpiles of shells were so low that only five rounds per piece were available . . . for several days, some of the battalions fired four rounds per gun per day."[71] In turn, the cost of high ammunition expenditures was often felt by maneuver forces who, outside of major operations, had to operate with limited artillery support.

These expenditures, and the associated logistics challenge, were not isolated to any one unit or operation. For many commanders, having large quantities of artillery ammunition was a prerequisite for large-scale operations. In September 1944, artillery ammunition shortages supporting the battle of Metz created problems for tactical and operational commanders alike. For example, the XX Corps artillery had to limit its usage for missions like counterbattery or harassing fires after firing roughly 40,000 rounds in two days.[72] By the end of September, Hugh Cole—the 1944 Deputy Theater Historian, European Theater of Operations—writes that "the shortage of artillery ammunition had become a critical problem."[73] On 25 September, this shortage led General Omar Bradley to cancel scheduled air support for Metz because "there was insufficient artillery ammunition to support an all-out ground attack against the Metz forts."[74] Additionally, because the European Theater was not fought on a single line of operations, ammunition across the continent could not be relocated to support a single battle or campaign.

During the same month the US Third Army fought at Metz, other US forces hitting the German West Wall had to overcome similar logistical challenges. Historian and WWII veteran Charles MacDonald comments that "a shortage of artillery ammunition" in the initial US assaults "denied the infantry large-scale fire support and had afforded German guns an immunity that otherwise would not have existed."[75] US artillery units were conducting counterfire missions; however, ammunition shortages often forced US commanders to restrict the number of artillery rounds fired for counterfire. Under these circumstances, US forces could suppress German artillery units but struggled to destroy them. For example, on a single day in October 1944, the XIX Corps artillery fired nearly 100 counterbattery missions, but the Germans continued to rain indirect fire on US forces.[76] MacDonald highlights this point in his assessment of German artillery effectiveness at the West Wall. He notes that because US artillery units could not allocate enough rounds for counterfire, "US gunners could hope to do no more than silence the enemy guns temporarily."[77] Artillery units could not commit the requisite ammunition to saturate potential enemy artillery areas. Consequently, because the desired battlefield effects required an incredible amount of ammunition, units were often only able to mass artillery fire for short periods.

High ammunition expenditures continued into the winter with the occasional surge in the number of rounds fired per day. XII Corps artillery, for example, maintained a sustained rate around 9,000 rounds per day going into December, but on 8 November fired 21,933 rounds.[78] The unit again surged on 4 December, tripling its daily consumption rates and firing more than 27,000 rounds.[79] The XX Corps artillery had a similar spike in expenditures, firing 21,377 rounds in a 24-hour period in what Cole called a "tremendous rise in ammunition consumption" compared to daily rates.[80] The same was true for the VII Corps artillery in the Siegfried Line Campaign. In his assessment of the campaign, MacDonald highlights that "artillery ammunition expenditures were high, despite scarcities in supply," adding that "during the period 1–16 December . . . divisional and corps artillery within the VII Corps fired 258,779 rounds."[81] Additionally, theater-level distribution warned field commands that they would likely only receive 60 percent of their desired December allocations for 105-mm and 155-mm ammunition.[82]

Overall, high artillery expenditures were the norm in WWII, regardless of the associated logistics challenge. While the concentrated missions provided US forces with a devastating capability, the limited ammunition outside those surges often left units in precarious situations. This included senior leaders changing operation timelines, commanders limiting artillery expenditures for essential missions like counterfire, and maneuver units relying on aircraft for fire support. These ammunition limitations, coupled with other tactical challenges, forced artillery units to adapt.

Combat Adaptability

WWII forced artillery units to adapt to myriad problems, and the size and scope provided ample opportunities to experiment with new equipment and doctrine. One of the most important US artillery adaptations was using captured enemy ammunition and equipment. Ruppenthal highlights that "both First and Third Armies . . . made maximum use of captured enemy guns and ammunition."[83] US howitzers could fire some of the captured rounds; though others required the corresponding systems, US artillery units fully leveraged these captures. For example, during the last week of October 1944, roughly 80 percent of XX Corps artillery missions were fired with captured ammunition.[84] In another instance, First Army created two provisional battalions with soldiers from the 32nd Field Artillery Brigade armed with forty-eight captured German howitzers with 20,000 rounds.[85]

Another approach for adapting to high ammunition expenditures was increasing the lethality of artillery rounds through the invention of a new fuze. Generally speaking, there were only two types of fuzing options before WWII—detonation on impact and setting a fuze to explode at a prescribed time after launch. While the time fuze had ample potential, calculations to ensure it exploded when needed were a challenge and relied on observers to validate. Introducing a proximity fuze simplified this process and enhanced the lethality of US artillery units. The variable-time (VT) fuze—also referred to by code name POZIT—would enhance air defense capabilities, using radio waves to identify when a projectile was near enough to a target that its explosion would have effects.[86] The fuze greatly enhanced naval vessel proficiency in bringing down enemy aircraft, preserving the finite ammo a ship could carry and reducing the time it faced a threat. Analyzing the fuze's impact on the fighting, military analyst Logan Nye commented that the introduction of the VT fuze "may have actually tipped the war in America's favor."[87] The application of this fuze innovation extended beyond its intended defensive capability, eventually providing a unique and asymmetrical advantage to the US Army when it was added to the artillery inventory.

While the Navy found success with the system, the military did not use "smart" artillery rounds in ground combat until December 1944. A standard point-detonation fuze spreads shrapnel laterally, meaning that cover—particularly the type provided by digging a hole, a la WWI trench warfare—could protect individuals to an extent. In contrast, the VT fuze had an internal sensor that identified the ground and exploded the shell at a predetermined height, raining shrapnel downward against dismounted troops. This addition was the first step in modernizing artillery munitions. McKenney notes that this method of delivering shrapnel "greatly increased the effectiveness of artillery fire" during WWII.[88]

In the Ardennes, the US military surprised the German military with this new capability, achieving significant tactical results. Cole explains that "on the first day of use of the new POZIT fuze, the Germans were roughly dealt with, . . . nearly a hundred were killed by the shellbursts and for a moment panic spread among them."[89] He added that "time after time the forward artillery observer called for battalion concentrations, watching the bursts with the POZIT fuze thirty feet over the heads of the fleeing Germans and the murderous effects therefrom."[90] Even General George Patton famously commented on the VT fuze, highlighting its effectiveness and impact on land warfare in a letter to the War Department: "The new shell with the funny fuze is devastating. . . . I think that when all armies get this shell, we will have to devise some new method of warfare. I am glad you all thought of it first."[91] More important than the new fuze's tactical effects in limited engagements, technological advances like this boosted artillery lethality without increasing the size of the howitzers.

In addition to artillery lethality, the branch adapted its mobility by introducing self-propelled artillery. While interwar conversations identified the need for self-propelled artillery, developing a new system was not a priority. Major General Danford refused to pursue the new technology, remaining a towed-artillery proponent.[92] Consequently, the United States had to rapidly develop a new system to field self-propelled artillery in WWII. Dastrup commented that "introduction of self-propelled artillery represented improvisation at its best."[93] He describes the weapon's development:

> Driven by expediency, the department experimented with wheeled carriages, half-tracks, and medium tank chassis rather than constructing a mount designed especially for the 105-mm howitzer. In view of the need for mobility, the Ordnance Depart-

> ment picked a medium tank chassis. It reduced the chassis' armor, dispensed with the closed turret, deliberately rejected incorporating 360-degree traverse because it would increase the weight of the weapon, placed a M2 105-mm howitzer on the vehicle, and named the weapon the M7 105-mm self-propelled howitzer.[94]

These new systems dramatically increased the flexibility of artillery units to support maneuver operations on a fluid battlefield.

The new systems fundamentally altered how artillery units could operate. Dastrup comments that self-propelled artillery "had the ability to move into position more rapidly to deliver fire, then to displace quickly to avoid counterbattery fire, and to follow armor over terrain impassable for towed artillery."[95] However, while many saw value in self-propelled artillery, it was not without its critics. Historians Kent Greenfield, Robert Palmer, and Bell Wiley note that self-propelled artillery "required more ship space than towed artillery, was more vulnerable on the battlefield, devoured more gasoline, and was too heavy for light bridges."[96] In turn, self-propelled systems were a contentious introduction to the artillery mobility debate.

Self-propelled systems offered more advantages than just mobility for offensive operations. US artillery units were often forced into direct contact with German maneuver elements because of the fluidity of the front line. For example, during the destruction of the 106th Division, the German attack forced the nearby corps artillery to displace. Dastrup explains that "towed 155-mm and 8-inch howitzer battalions took long to limber and to find a place on the crowded roads that led west. As a result, some fell victim to German infantry and tanks."[97] In this instance, self-propelled systems could have provided enhanced mobility and protection.

In the Pacific Theater, the battle of Guadalcanal highlighted a different protection issue. Japanese encircling tactics forced US artillery units to provide 360-degree fire support coverage. Dastrup notes that "gun crews had to position a battery of guns in an irregular diamond pattern to fend off attacks from any direction."[98] Notably, the Westervelt Board's proposed 360-degree carriage would have provided more flexibility to these artillery units and potentially mitigated some threats. Because the Army did not develop a 360-degree carriage for its howitzers, artillery units could only address these threats through tactical adaptations in how the battery positioned the howitzers. These protection challenges would appear again in both the Korean and Vietnam wars.

Lessons Learned from Combat Experience

Whereas WWI fundamentally challenged artillery's role on the battlefield with the introduction of indirect fire, WWII validated peacetime modernization efforts and reinforced the principles of mass and unity of command. Dastrup argues that "the necessity of firepower and centralized command were the overriding lessons from the war."[99] Among other artillery lessons, massing of artillery effects provided commanders with an essential tactical tool, but the high expenditures and associated logistics challenges could put operations at risk. Increased lethality was a potential solution; the VT fuze demonstrated how technological innovations could transform a projectile's effects. Additionally, the scale of WWII exacerbated the contentious artillery mobility debate that began at the previous war's end. While few fought to restore horse-drawn artillery, there was no consensus on the future of self-propelled systems. Instead, the mobility debate raged on. Finally, the war illuminated the danger of artillery units being overrun by a mobile enemy or encircled on a battlefield with non-contiguous boundaries.

At the end of WWII, the Army methodically assessed the lessons learned—with mixed results. Texas A&M Professor Brian Linn commented that "selecting the correct lessons of the war spurred much debate."[100] He adds that groups with varying schools of thought "interpreted the war as vindicating its beliefs, . . . each sought to incorporate its lessons into a distinct vision of future conflict."[101] The differing conclusions concerning lessons learned was not unique to WWII, reappearing after conflicts like the Vietnam War and the Yom Kippur War. This challenge of establishing a vision of future war is examined in more detail in Chapter 3.

The artillery branch participated in efforts to distill critical lessons learned from the war, identifying capability gaps in maneuverability and lethality. In 1946, Fort Sill hosted a two-week artillery conference led by General Jacob Devers that included representatives from all the services and foreign military leaders.[102] The group made drastic recommendations—later validated by the War Department—to improve mobility and destructive power. This included moving to a 100-percent self-propelled force, developing larger projectiles with ranges out to thirty miles, and investing in rocket artillery.[103] For the artillery, the lessons of WWII were clear: it needed more destructive capacity, increased mobility, and increased range, all of which would allow it to remain independent from airpower.

Conclusion

The World Wars, and the peace between them, set the foundation for US indirect fire. By delineating the roles and responsibilities of artillery units by echelon, the branch enabled materiel and organizational innovations and adaptations. Concurrently, the branch continued to professionalize through the US Field Artillery School, the US Field Artillery Association, and *The Field Artillery Journal*. Essential organizations and tools like these created transparency across the force, fostered open-forum learning, and facilitated revolutionary doctrinal updates. While the artillery retained its crown as the king of battle, the post-WWII environment presented new and unprecedented challenges for the US military. Consequently, the artillery community would have to adapt to emerging technological innovations, the lessons it learned from combat, and the external threat posed by the other new superpower—the Soviet Union.

Notes

1. Hew Strachan, *The First World War* (New York: Penguin Books, 2004), 313.

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Chapter 2
The Korean War and the Development of Nuclear Artillery

The early years of the Cold War provided the US military with ample reasons to innovate and adapt. The 1947 National Security Act and corresponding Executive Order created the modern military establishment, separated the Air Force from the Army, and codified service roles, all of which inherently reframed any approach to addressing lessons from World War II.[1] Additionally, the service roles and missions that President Harry Truman established were initially contentious—particularly between the Air Force and the Navy—leading to numerous conferences involving the Joint Chiefs of Staff and the newly created Secretary of Defense to reach compromises and clarity.[2] While all were important, the 1950 "Assignment of Responsibility for Guided Missiles" was particularly critical for understanding indirect-fire innovation and adaptation through the 1950s as it enabled each military service to embark on its own unique, albeit somewhat overlapping, missile development path.[3]

Adding to the complexity of the time, the Korean War began five years after WWII ended, providing new combat experiences and opportunities to innovate. The US Army artillery attempted to learn from this new conflict, including hosting Lt. Gen. Edward Almond at the Field Artillery School to gain his insights on how indirect fire influenced the X Corps operations in Korea under his command.[4] The Korean War was fought exclusively with conventional munitions—non-nuclear—and reinforced many of the lessons from WWII. Although the adaptations in the years that followed the Korean War addressed the problems with artillery lethality and the logistical burden associated with a high volume of missions, combat experience in Korea was not the driving factor of innovation. Instead, a desire to incorporate emerging nuclear and missile technology drove the Army's 1950s innovation efforts. The tactical nuclear weapons that the United States developed during this period would never be used in combat; however, the nuclear battlefield adaptations created a lasting air-mobility capability and the foundation for non-nuclear rocket artillery employment doctrine.

The Korean War: Reinforcing Logistics/Protection Challenges

In June 1950, the Democratic People's Republic of Korea invaded its neighbor to the south, the Republic of Korea, sparking the deployment of a

United Nations (UN) force. In early July, the United States fought its first battle, the first of many defeats that drove all UN forces to the southern tip of the peninsula by August. The successful Inchon landing and subsequent recapture of Seoul in September helped turn the tide, and in October, UN forces were driving toward China. The Chinese military entered the war, forcing UN forces to again withdraw. By the spring of 1951, the territory spanning the entirety of the peninsula had shifted back and forth, resulting in a stalemate near the pre-war borders.[5]

The drastic shifts in territorial control early in the war created a tactical situation that challenged the limited mobility of towed artillery. Many cannons were destroyed or abandoned due to the high tempo, and others could not even be employed.[6] The US military keenly felt the absence of indirect fire on the battlefield, and it was not until the gradual stagnation of offensive operations that artillery could be employed effectively. Indirect fire halted enemy advances and was especially effective against dismounted troops, the most common enemy on the Korean battlefield. Artillery success undoubtedly facilitated the transition of the war to a stalemate. Similar to WWII, however, the increased ammunition expenditures needed to support the more static battlefield created a logistical crisis, as continuous fire across a large and complex battlefield outpaced the logistic support designed to sustain it.

In studying the war from an artillery perspective, military historian Janice McKenney concludes that the "field artillery learned few new lessons during the war, but the importance of the arm was reconfirmed."[7] Even though the branch was not reshaped during the conflict, the challenges of excessive ammunition expenditures and force protection failures reinforced WWII's artillery lessons. Eventually, they led to revolutionary changes in indirect-fire capabilities through rocket and missile artillery development.

The Logistical Challenge of Artillery Ammunition

Indirect fire—specifically the ability to mass large quantities of munitions—became an essential tool for the United States to hold territory in the Korean War. Compared to the WWII European theater, the rugged Korean Peninsula terrain limited the use and dispersion of armored formations.[8] In turn, indirect fire against North Korean advances created high casualties, neutralizing dismounts and lightly armored vehicles with what General Almond termed "protective curtains of fire for friendly units."[9] For the artillery community, lessons learned from WWII emphasized two critical principles of war: unity of command to prioritize artillery fire where needed and mass to achieve necessary effects to halt enemy attacks.

Although desperately needed, artillery systems and corresponding munitions were in limited supply, particularly early in the war. In February 1952, General Almond explained the situation at an artillery conference designed to study the war's implications for indirect fire: "There was neither enough artillery nor all the proper types available and, had there been, it is doubtful if the road and rail net could have sustained the logistical support required since there were times when our Eighth Army was scarcely able to support the artillery that was available."[10] Consequently, the Army had to deliberately manage ammunition expenditures.

Restricting ammunition was the primary method to address these limitations while supporting the principles of mass and unity of command. Almond highlighted this approach in his address at the 1952 Fort Sill Conference:

> Until just prior to the Chinese April (1951) offensive, all artillery units in the Eighth Army had been rationed on the use of artillery ammunition to fifty rounds of 105-mm, thirty-five rounds of 155-mm howitzer and twenty rounds of 155-mm Gun and 8-inch howitzer per gun per day. This restriction was necessitated primarily by the inability to keep the forward areas stocked, but also by the overall shortage of ammunition in Korea.[11]

For operational reasons, these restrictions were continually adjusted. During the May 1951 Battle of the Soyang River, for example, "105-mm ammunition was increased to 250 rounds per gun per day and there was no limit on 155-mm ammunition."[12] Almond noted: "During this battle, the lifting of the restriction on the use of ammunition permitted the artillery to function—for the first time in Korean operations—to the limit of its capability for a limited period."[13] While successful in this instance, the low number of US artillery pieces available in Korea stressed any ammunition restriction plans.

Artillery units were forced to maintain a high-volume of fire to make up for the lack of assets. "Although this amount of artillery . . . was meager by World War II European standards," Almond commented, "it made up, as much as possible, in volume of fire for what it lacked in numbers of weapons."[14] Though necessary, increased fire volume taxed soldiers and weapons. Historian Roy Appleman describes a situation where "ten 105-

mm howitzers fired 120 rounds in seventy seconds, an average of one round every six seconds for each gun."[15] He notes that during another engagement in 1950, the 77th Artillery Battalion fired roughly 1,850 rounds, damaging the unit's gun tubes.[16]

Artillery mission effects are based on munition type and quantity. There is an inverse relationship between the number of systems firing and the number of rounds each one must fire to achieve comparable effects. Because of the nature of the conflict in Korea, massive artillery missions—the quantity needed to break the will of a determined attacking force—remained in high demand and were often tactical necessities, even with the less-than-optimal quantity of guns.

Artillery ammunition consumption during these short engagements was staggering and created a huge logistical challenge. Almond put these numbers into perspective for the artillery officers at Fort Sill:

> On one occasion, during a twelve-hour period, the 38th Field Artillery Battalion of the 2nd Infantry Division established a new record by firing 11,600 rounds in twelve hours and a total of 11,891 rounds for the twenty-four-hour period. This record was later broken by the 15th Field Artillery Battalion of the same division in support of the attack on "Bloody Ridge" in August 1951, when they fired 14,200 rounds during a twenty-four-hour period.[17]

These expenditures continued throughout the war. At the Battle of Pork Chop Hill in 1953, for example, field artillery historian Boyd Dastrup explains that "nine battalions fired over thirty-seven thousand rounds in twenty-four hours."[18] He notes that although this massive expenditure challenged the supply system, to include creating shortages elsewhere, it "reaffirmed the American reliance upon massed artillery to stop enemy attacks."[19] General Matthew Ridgway described the balance between ammunition rationing and tactical success: "Artillery has been and remains the great killer of Communists. It remains the great saver of soldiers, American and Allied. There is a direct relation between the piles of shells in the Ammunition supply points and the piles of [enemy] corpses in the graves registration collecting points."[20] Notably, the enemy's ability to infiltrate friendly lines complicated the Army's ability to leverage its artillery.

Problems with Protection

Because of the limited ranges of artillery during the Korean War, artillery units were forced to a forward and often dangerous position to support maneuver forces.[21] Almond described the situation for X Corps: "To support these patrol bases and to reach enemy communication routes, advanced artillery positions were established, on a temporary basis, well in front of the battle position."[22] Because of battlefield fluidity, artillery units were often exposed, particularly during transitions from offensive to defensive operations.

It was generally disastrous when artillery units came in direct contact with enemy infantry forces. Enemy forces concentrated firepower against ammunition and resupply trucks, as well as prime mover vehicles; cannons were often destroyed, abandoned, or in worst-case scenarios, turned against friendly forces.[23] Such situations were more frequent early in the war, as the transitionary nature of the front line created engagements unfavorable to artillery units. In 1952, Almond warned the artillery officers at Fort Sill: "Destruction of artillery units is a primary enemy objective. All units must stress defense against infiltration tactics, train for anti-guerrilla measures and be prepared for all-around defense. . . . automatic weapons within artillery units must be ready at all times to defend their positions whether on the move or in position."[24] These challenges reinforced WWII Pacific Theater lessons regarding the 360-degree fight against encirclements and infiltration.

Limited mobility, specifically towed artillery emplacement and displacement, reduced the ability of artillery units to protect their howitzers. Transitioning from offense to defense exacerbated these issues. Military affairs editor D. M. Giangreco notes that the military abandoned more than 100 intact howitzers when the United States hastily withdrew from the north and "the Chinese were more than happy to add the captured weapons to their inventory."[25] The loss of A Battery, 503rd Field Artillery Battalion, during the February 1951 Battle of Hoengsong is a prime example of this challenge. Historian Billy Mossman explained that a "Chinese raiding party dashed onto the road from the east, captured the battery commander, first sergeant, and several men, and took them back into the hills. . . . Chinese gunners meanwhile concentrated fire on vehicles, damaging many and killing or wounding several drivers."[26] The battery left behind five 155-mm howitzers and one 105-mm howitzer that infantry forces later identified and subsequently destroyed with an air strike so the equipment would not fall into enemy hands.[27]

The worst of these experiences was arguably the collapse of the 63rd Field Artillery Battalion in July 1950. On the afternoon of 14 July, the North Korean 16th Regiment captured a machine gun outpost, turned it on the Headquarters Battery, and simultaneously began firing its mortars. In conjunction with striking the headquarters, roughly 100 dismounts assaulted A Battery's position. Although numerous soldiers fought bravely, enemy forces overran both positions, and the unit suffered heavy casualties. Once complete, the North Koreans quickly reorganized and shifted their efforts toward B Battery, which fared slightly better against the now 400-person assault.[28] Appleman highlights the destruction that occurred in this short but sobering engagement:

> An hour and a half after the first enemy appeared at the artillery position the entire 63rd Field Artillery Battalion, with the exception of Service Battery, had been overrun, losing ten 105-mm howitzers with their ammunition and from sixty to eighty vehicles. The five guns of A Battery fell to the enemy intact. In B Battery, enemy mortar fire destroyed two howitzers; artillerymen removed the sights and firing locks from the other three before abandoning them. Meanwhile, Service Battery had received word of the enemy attack and prepared to withdraw at once. A few men from the overrun batteries got back to it and rode its trucks fifteen miles south to Nonsan. Stragglers from the overrun artillery battalion came in to the Nonsan area during the night and next morning. Eleven officers and 125 enlisted men of the battalion were missing in action.[29]

Such capability loss drastically affected a military already limited in its available indirect-fire assets.

Though frequently successful, North Korean dismounts did not overrun every artillery unit they faced. C Battery, 61st Field Artillery Battalion, effectively employed its howitzers as direct fire weapons against attacking forces in November 1950. Once initially engaged, the battery commander, Capt. Howard Moore, put every soldier not manning a howitzer on the perimeter to fire automatic weapons. To defend the position and prevent Chinese forces from cutting off the brigade's withdrawal route, the battery direct fired roughly 1,400 artillery rounds at targets as close as fifty yards away.[30] Sadly, it would take another decade, and another conflict, for the artillery community to adapt its direct-fire techniques to better protect artillery positions from dismounted threats. Chapter 3 examines these adaptations in detail.

Coupled with limited range, artillery mobility problems—particularly prime mover vulnerability and slow displacement of towed artillery—

reinforced the assessments made during the Westervelt Board and at the 1946 Fort Sill Conference regarding transition to a self-propelled force. Notably, the debate regarding the motorization/mechanization of artillery forces that began in 1919 has continued for a century, regularly reemerging with the changing character of war. The biggest wrinkle in this debate was the eventual incorporation of the helicopter, as it transitioned the mobility conversation to lighter, air-mobile artillery platforms.

Lessons Learned from Combat Experience

Although the Korean War itself is not a prime example of military innovation in the artillery community, it set the conditions for change by reinforcing WWII lessons: artillery needed increased range to distance friendly cannons from the enemy, increased mobility to adapt to the changing tactical situation on the ground, and greater lethality to solve the ammunition expenditure problems of a modern conflict. Boston University professor and retired Army Col. A. J. Bacevich commented that on top of these lessons, the US consensus was that "relying on conventional military means to stop communist expansion was folly," and that the problem of the Korean War "stemmed from [US] refusal to use precisely those weapons that advanced technology had provided."[31] In short, massive casualties of a major conflict were no longer acceptable. Bacevich concludes that the United States wanted to end future conflicts "by capitalizing on American strengths, particularly technology, rather than by squandering American manpower."[32] Technology had changed warfare; the innovation efforts following the Korean War would have to account for nuclear weapons.

Technology as the Driver of Innovation: Nuclear Artillery

Shortly after President Dwight Eisenhower took office in 1953, he implemented a strategy that profoundly affected how the United States would conduct future land combat. The "New Look" policy and subsequent "Massive Retaliation" concept normalized the use of nuclear weapons. From the declassified top-secret NSC 162/2 document: "In the event of hostilities, the United States will consider nuclear weapons to be as available for use as other munitions."[33] This was a drastic change for the Army and, subsequently, the artillery community. Texas A&M History Professor Brian Linn comments: "Whether intended or not," the New Look "provided a justification for the army's vision of the tactical atomic battlefield."[34] This vision was contentious, however, as it required significant adjustments to how the army would conduct land combat.

Fighting and winning on this new battlefield would require a new approach to land warfare. Linn explains challenges with the transformation:

> The atomic army theorists faced three essential problems. The first was to prove the army was still relevant in the Cold War. The second problem was how to transform the army's existing doctrine, organization, equipment, and personnel to fight on the atomic battlefield. The last problem was how to reverse the army's decline in prestige and funding, win public and political support, inspire those who wore its uniform and restore the service's preeminent role in national defense.[35]

For the artillery, this was a challenge of both lethality and protection. Bacevich explains: "The tempo and expansiveness of an atomic battlefield would demand technologies providing improvements in speed, flexibility, range, and precision."[36] The Army looked to the King of Battle for the next level of destructive capacity. So too, however, the enemy would look to remove these nuclear systems from the battlefield. The rapid innovation process that followed saw the creation of numerous models of guided and unguided short- and long-range tactical nuclear weapons. In addition, the process created a lasting capability for modern forces by ushering in the missile age for field artillery.

The Beginning of Nuclear Artillery

In the spring of 1953, atomic artillery became a reality when Atomic Annie, a 280-mm gun, successfully test-fired a nuclear warhead. The new cannon, however, proved more of a burden on the battlefield than an asset. Bacevich describes the 280-mm atomic gun as "absurdly obsolete as soon as it arrived in the field. It possessed none of the qualities that the Army deemed necessary for the new battlefield of the 1950s."[37] This was partly because Atomic Annie weighed more than eighty tons, required two tractors to move, and could only travel on roads. Linn explains that new cannon "proved to be all but unusable in any foreseeable combat scenario," adding that "its instability and propensity to slide or tip when maneuvered on anything but firm and level ground earned it the nickname the 'Widow Maker.'"[38] Coupled with its limited seventeen-mile maximum range, the cannon "would impose heavy security requirements on the local ground commander."[39] Additionally, the ballistics required to launch a large projectile out of a cannon limited both the payload capacity and range, making cannon artillery a poor choice for delivering nuclear munitions. In a nuclear arena, these limitations reinforced the need for a new type of delivery system.

Figure 2.1. Atomic Annie. Source: Janice E. McKenney, *The Organizational History of Field Artillery 1775–2003*, Army Lineage Series (Washington, DC: US Army Center of Military History, 2007), 244.

A New Design for Indirect Fire: Rocket and Missile Artillery

In 1949, the Joint Chiefs of Staff established a policy that encouraged every military branch to develop missiles, which until then had been pursued mainly as strategic weapons, along the lines of the German V-2. The Army gained responsibility for "surface-launched guided missiles which supplement, extend the capabilities of, or replace the fire of artillery."[40] Consequently, Korean War defense spending on missiles capable of carrying lighter warheads increased ten-fold, from less than $75 million in 1950 to more than $750 million by 1953.[41] McKenney argues that the Army had the most to lose with the emphasis on nuclear warfare but that the development of tactical nuclear missiles could keep the service from becoming dependent on the Air Force. The missiles, she explains, would have "long ranges, could be fired from mobile carriers, could concentrate great amounts of firepower on selected targets, and could be employed without waiting for air superiority or favorable weather conditions."[42] Consequently, rockets and missiles could keep the Army relevant on the changing battlefield.

Missiles expanded artillery's role on the battlefield as they were capable of greater range and destructive capacity than cannons. These attributes allowed tactical nuclear missiles to fill a mission-set that cannons could not. Bacevich explains that missiles gave the military "an improved capability to strike targets deep in an enemy's rear, a capability that nothing—not darkness, nor weather, nor enemy defenses—could stop."[43] The Army invested heavily in the new capability in the decade from 1954 to 1964 and developed numerous surface-to-surface nuclear missiles in three categories based on varying support priorities, with corresponding ranges to distinguish them: five- to thirty-five-mile range tactical-mobile rockets for corps support, twenty- to 150-mile range missiles for army support, and 150- to 750-mile range theater-support missiles.[44]

The Army's first rockets emphasized mobility and a limited support structure that allowed them to support maneuver units at the tactical level. In May 1950, Army Chief of Ordnance Maj. Gen. Elbert Ford ordered "a preliminary design study of a special purpose, large caliber field artillery rocket."[45] In the summer of 1951, Secretary of the Army Frank Pace approved full-scale production of the Army's first short-range unguided missile—the MGR-1, Honest John.[46] The Honest John was the first in a rapid string of tactical nuclear rockets designed to provide nuclear capability directly to maneuver forces and replace nuclear cannon artillery.

The Honest John was fielded in 1954 with a limited range of sixteen miles; an improved version fielded in 1961 extended the range to twenty-five miles.[47] The system was able to deliver a 1,500-pound warhead as close as five miles; in addition to delivering nuclear munitions, it could fire chemical and fragmentation rockets.[48] McKenney describes the Honest John as groundbreaking because "it was the first large-caliber rocket to carry an atomic warhead," and provided "the first opportunity of linking a nuclear warhead with a mobile surface vehicle."[49] The system fired like a cannon and was easy to maneuver around the battlefield. Because of the system's sheer weight, however, it could not be lifted by a helicopter, which created a potential tactical problem. Dastrup explains: "The Army envisioned that the mobility offered by aircraft was a way to neutralize tactical 'atomic weapons' firepower."[50] Coupled with its limited range, this movement limitation would force the Honest John to continually occupy positions near the front lines, a problem that Korean War artillery units were all too familiar with.

While developing the Honest John, the Army also began testing its first medium-range missile, the MGM-5, Corporal. The Army's missile

Figure 2.2. The Honest John. Source: Redstone Arsenal Historical Information, https://history.redstone.army.mil/miss.html.

team at Redstone Arsenal conducted numerous Corporal flight tests from 1949 to 1951.[51] Whereas accuracy was not a priority when developing the Honest John, the Corporal was to become the Army's first precision missile. By June 1953, after firing more than fifty tests, the missiles achieved accuracy within 100 meters.[52] The forty-five-foot-long Corporal, fielded in 1955, dramatically extended the range of artillery as the guided missile could hit targets out nearly eighty miles. The Corporal required a guidance platoon with radar and Doppler radio to track, compute corrections, send commands, and shut off the propellant.[53]

The system, however, had numerous flaws. Sheer size hampered its mobility; coupled with its slow fueling process and thirty-mile minimum range, Corporal was an incredibly unresponsive platform for any mission other than a pre-planned target. Bacevich contends that "like the 280-mm gun, Corporal provided no more than an interim solution," serving as a technological steppingstone for understanding nuclear artillery as an emerging technology.[54] The Corporal remained in service until 1964 and was replaced by the Sergeant.

Figure 2.3. The Corporal. Source: Redstone Arsenal Historical Information, https://history.redstone.army.mil/miss.html.

Longer-range missiles enabled the Army to strike the enemy deep in its rear, dramatically extending the battlefield. The Army began developing its first theater-support missile—the PGM-11, Redstone—in the summer of 1951 to "supplement and extend the range or firepower of the existing artillery and shorter-range missiles, to provide increased support for deployed ground combat forces, and to compensate for the expanding dimensions of the battle area."[55] Although testing began in August 1953, numerous technical challenges arose, delaying the fielding until 1958.[56] The Army established a 500-mile goal range as a service requirement for theater-support missiles; however, the Redstone failed to achieve this, only reaching 175 miles.[57] Notably, this 500-mile requirement became fluid in the 1950s, reaching 1,500 miles and creating inter-service tensions with the Air Force over missile development responsibilities.[58] The Redstone was liquid-fueled like the Corporal, and the Army announced its replacement the same year it was finally fielded.[59]

The Army's long-range missile goals faced a significant setback in November 1956 when Secretary of Defense Charles Wilson published his “Clarification of Roles and Missions to Improve the Effectiveness of Operation of the Department of Defense.”[60] In the memorandum, Wilson explained, “Operational employment of the land-based Intermediate Range Ballistic Missile system will be the sole responsibility of the US Air Force.”[61] Additionally, he clarified that “the US Army will not plan at this time for the operational employment . . . of any other missiles with ranges beyond 200 miles.”[62] This restrictive policy altered Army plans to exploit the potential that missiles represented. Brian Linn highlights this point, noting that the new policy not only “destroyed the service’s space rocket program but also undercut its ability to wage the long-range, mobile, deep-penetration operations called for in its atomic war doctrine.”[63] This setback was temporary, however, and the Army would reengage the issue the instant a new Secretary of Defense was appointed.

Figure 2.4. The Redstone. Source: Redstone Arsenal Historical Information, https://history.redstone.army.mil/miss.html.

To improve the accuracy of its tactical rockets, the military developed the MGM-18, Lacrosse, rocket platform that could fire a guided rocket. Built for mobility—the equipment was vehicle-mounted and capable of airlift; the new system had the potential to be a useful addition to the artillery arsenal.[64] Fielded in 1960 to the Army, the Lacrosse was originally designed for the Marine Corps to augment its conventional artillery, and was created with a maximum range of twenty miles.[65] Although a handful of Lacrosse battalions were fielded, the system had too many problems to be useful, primarily with its guidance equipment. The battalions were deactivated in 1963. Termination of the Lacrosse created a capability gap for a short-range precision rocket that was not filled until a decade later with the MGM-52, Lance—examined in Chapter 3. McKenney comments that the Lance "did not have the capability originally desired by the Marines—that of precision accuracy."[66] This desire for precision would eventually become a focal point of rocket artillery modernization efforts.

Figure 2.5. The Lacrosse. Source: Redstone Arsenal Historical Information, https://history.redstone.army.mil/miss.html.

In 1961, the Army invested in a small platform intended to support airborne and light infantry operations. The new system, the MGR-3, Little John, was lightweight and helicopter transportable, but only had a maximum range of twelve miles. This design allowed for rapid infiltration, mission processing, and displacement within ten minutes, which dramatically changed the way rocket artillery could be used. As Morris Keller explained in his 1960 *Artillery Trends* article, "This rapid-fire and quick displacement concept is no longer a 'future' hope, but is a reality with the Little John rocket."[67] Similar to the Honest John, Little John was unguided and could fire both nuclear and conventional rockets. The Little John provided a tactical nuclear capability to the lowest possible echelon and remained in service until 1968; its capability was eventually filled by the Lance.

Figure 2.6. The Little John. Source: Redstone Arsenal Historical Information, https://history.redstone.army.mil/miss.html.

The second attempt at a medium-range missile—the MGM-29, Sergeant—was fielded in 1962. This thirty-five-foot weapon was a major capability upgrade over its predecessor. The Sergeant had a similar range window to that of the Corporal but was lighter weight and more efficient to fire. In addition to being air-transportable, the Sergeant used solid fuel, which dramatically improved its responsiveness. McKenney explains: "Its highly reliable solid-propellant motor was ready to fire within minutes;" in contrast, Army units required hours to prepare to launch the Corporal because of its liquid propulsion system.[68]

Figure 2.7. The Sergeant. Source: Redstone Arsenal Historical Information, https://history.redstone.army.mil/miss.html.

To build on this progress and continue its long-range missile pursuits, the Army would need a Defense Department policy change. On 12 August 1957, in a meeting with President Eisenhower, Secretary of the Army Wilber Brucker and General Lyman Lemnitzer argued that the Army had a "definite need for a missile of the 500-mile range, not so much to reach out into the enemy territory as to provide security for the missile itself by placing it well to the rear to fire in support of front line troops."[69]

On 14 October 1957, newly appointed Secretary of Defense Neil McElroy approved the Army's pursuit of a 500-mile-range missile.[70]

The MGM-31, Pershing, which replaced the Redstone in 1964, had an extended range of 460 miles and an upgrade to solid propellant that greatly expedited the firing process. The platform was assimilated into the North Atlantic Treaty Organization (NATO) defense plan, and NATO took control of the theater-wide weapon in 1965.[71] This transition affected the Army's plan for a potential clash with the Soviet Union, as NATO control stripped the Army of valuable capabilities. McKenney explains that "during the critical early phase of potential conflict, army and corps commanders . . . had lost their organic long-range general support nuclear firepower."[72] Unlike the Army's other missile pursuits, however, the Pershing remained a viable tool for the Defense Department for nearly thirty years—albeit with upgrades—until the United States was forced to destroy the system as a result of the 1987 Intermediate-Range Nuclear Forces (INF) Treaty.[73]

Figure 2.8. The Pershing. Source: Redstone Arsenal Historical Information, https://history.redstone.army.mil/miss.html.

Lessons from Incorporating New Technology

By fielding tactical nuclear weapons after the Korean War, the Army demonstrated its desire to ensure that maneuver forces were nuclear-capable and not solely reliant on support from the Air Force. The problem, however, was that identified capability needs did not drive the innovation. This is not to say that capability requirements were an insignificant factor in the weapons development process, but rather that the early models were more to create a tactical nuclear weapon the artillery could call its own. The vision of what nuclear artillery could accomplish far outpaced what was technically capable at the time. The desire for such weapons was derived, at least indirectly, from combat experiences. Army leaders believed incorporating nuclear artillery would increase the standoff distance of artillery units, reduce the logistical burden of ammunition expenditures, and provide a tool to help maneuver forces on the new battlefield.

This rapid incorporation of technology, however, led to inefficient and impractical systems that were quickly discontinued. The Army faced an identity crisis during this period; atomic weapons challenged the Army's land-warfare paradigm, and the limited budget was allocated to a new type of war. Adrian Lewis, a University of Kansas history professor, highlights how these pressures led a culture shift in the Army, one driven by technology:

> To defend itself, the Army tried to become something it wasn't. It bought into pop culture, science fiction, and a different set of values. It tried to compete with the Air Force by becoming more like the Air Force. The Army went into the high technology business; the nuclear business; the missile business; and research and development business for cutting edge, high speed, exotic technologies. The Army believed that it needed high-tech weapons, particularly nuclear weapons and missiles, to survive. The Army tried to create a Hollywood image that it could sell to Congress and the American people.[74]

Although more modern rocket and missile platforms were eventually developed with increased range, lethality, and mobility, the failures that preceded them demonstrated a desire to incorporate new technology for its own sake instead of a process to develop or tailor technology to provide a capability. Notably, these materiel solutions reflected a fundamental change in the Army's vision of a future war, requiring more than just new technology.

Adapting to a Nuclear Battlefield

The proliferation of tactical surface-to-surface nuclear weapons created a new US capability and an emerging problem: the nuclear battlefield. The subsequent reorganization of forces into the "Pentomic Division" sparked a conversation about decentralizing indirect fire and employing rocket artillery forced the artillery branch to create new doctrine.

The Pentomic Division: Organizational Adaptation

The Army needed to adapt to fight in a nuclear environment—emphasizing survivability by focusing on small units, dispersion, and mobility. The nuclear battlefield threatened the idea of the large massed forces that had fought in WWII and the Korean War. Specifically, the Army acknowledged that these formations would become targets for a nuclear attack. Linn highlights comments from General James Gavin, a proponent of the Army's nuclear transitions: "Gavin had pointed out . . . that the concentration of troops and materiel necessary for the Normandy landings would be suicidal against an opponent armed with atomic weapons."[75] Instead, for Gavin, the "solution was to field combat formations so small and so dispersed as to present unsuitable targets for atomic weapons, yet they would have sufficient mobility to rapidly seize strategic points, and then, just as rapidly, disperse to avoid retaliatory atomic strikes."[76] These characteristics were the foundation for the Army's future formation, albeit with more combat power.

In 1954, Army Chief of Staff General Matthew Ridgway ordered an assessment on how to restructure Army divisions, specifically shrinking the formation size and emphasizing mobility without sacrificing lethality.[77] Dispersion became the key to survival; however, this strained sustainment and required units to become more autonomous. The Army created the "Pentomic Division," an organization comprised of five platoons per company, five companies per battle group, and five battle groups in each division. The battle group design was built around a self-contained model and resembled a modern-day brigade combat team (BCT) concept of modularity—examined in Chapter 5. Linn details the Army's vision for this new organization: "'Battle groups' would be speedily transported to the target from widely separated locations; they would concentrate to seize the objective; then rapidly depart before the enemy could launch a nuclear counterstrike."[78] Consequently, this dispersion—necessary for survival—changed how the division could employ its artillery.

The advent of self-contained battle groups weakened the division artillery (DIVARTY), because it required a detached firing battery for each battle group to be autonomous. Bacevich explains this relationship change: "While artillery formally remained a division asset, its organization into five separate units lent itself to semi-permanent distribution among each of the division's five battle groups."[79] This new relationship challenged DIVARTY's fundamental role, leading to uncertainty about who had the responsibility to plan and the authority to execute indirect fires.

This organizational shift directly contrasted with established combat lessons learned. According to Dastrup, many senior field artillery officers of the time opposed the detachment of field artillery batteries away from the division headquarters because it "violated two sacred artillery tenets—unity of command and massing fire."[80] As previously discussed, these tenets—which also serve as principles of warfare—heavily influenced operations during WWII and the Korean War. In turn, senior artillery officers of the time—including Maj. Gen. Edward Williams, the Artillery and Guided Missile School commandant, and Brig. Gen. Donald Harriott, the Tenth Infantry DIVARTY commander, openly challenged the change.[81]

Fighting in a Nuclear Environment: Doctrinal Adaptation

Adapting to the nuclear battlefield went beyond new equipment and reorganizing the force; it required a change in how the artillery fought. Col. W. E. Showalter, the 1957 field artillery director of gunnery, commented: "The tactical concepts necessitated by the atomic battlefield . . . have made it imperative that the artillery be able to attack targets in any direction with equal speed and effectiveness."[82] He described the situation as the "6400-mil problem," forecasting the type of fighting the artillery would see in battles with noncontiguous front lines.[83] For the non-artilleryman, mils, or milliradians, are simply another means to measure a circle; 6400 mils is another way of saying 360 degrees. Therefore, the 6400-mil problem is not only a call back to the challenge many artillery units faced in Korea—and would soon face again in Vietnam—but to the 1919 Westervelt Board's emphasis on full-traverse howitzers. This issue is explored further in the Chapter 3 analysis of the Vietnam War.

Field artillery officers advising maneuver commanders on the new battlefield now required unique knowledge of nuclear weapons. Artillery officers not only facilitated employment of the new systems; commanders expected them to make nuclear target recommendations—distinct from conventional targets and debated in detail at the US Army Artillery and Missile School.[84] On top of basic fire support requirements, the 1958 Field

Manual (FM) 6-20, *Field Artillery Tactics and Techniques*, outlined that one primary responsibility for the deputy army artillery commander was "to provide the army (corps) commander with predictions of the radioactive fallout from friendly nuclear weapons."[85] In November 1957, the artillery added two new courses to its officer professional education program to facilitate the extra knowledge requirements: Subcourse 80, The Employment of Atomic Weapons, and Subcourse 74, Field Artillery Rockets and Guided Missiles.[86]

The artillery community adapted to how nuclear weapons changed the battlefield and to the fact that missile artillery—conventional or nuclear—was a new concept with limitations and challenges for artillery batteries to overcome. For example, early missile systems required lengthy and personnel-intensive reload after firing a single rocket. The Army eventually fixed this problem in 1983 with the modern-day Multiple Launch Rocket System (MLRS). In addition, unlike cannon fire, every rocket or missile fired left indelible traces that gave away the platform's position, exposing the firing battery to enemy counterbattery and increasing the risk of casualties.

The artillery community identified new fighting methods that set the foundation for modern-day rocket and missile artillery doctrine. To address the unique challenges with the shift to missiles, the artillery developed four distinct methods of employment, and the Artillery Department of Tactics and Combined Arms published them in October 1958.[87] The author, Lt. Col. Kenneth Stark, explained that "which method or variation [the commander] uses depends on the situation, the mission, and the enemy's capabilities."[88] Consequently, a commander could modify or combine the methods as needed.

The first method kept the artillery battalion together. This reduced challenges such as resupply, security, and reload time but endangered the entire battalion if a launch detection triggered an enemy response. This method was not practical, as even a single mission could compromise the unit, forcing the battalion commander to either displace after every fire mission or assume a force-protection risk.

The second approach was designed to mitigate battalion displacement problems by putting the onus of protection on the battery. The firing battery did not co-locate with the battalion headquarters and thus did not expose the battalion during fire missions; however, this increased demands on battalion sustainment operations. Although modern rocket artillery doctrine separates the firing elements from the battalion headquarters, this method created planning and resource challenges given 1950s technology—supplying basic needs such as food and water, as well as resupplying massive rockets.

The third variation combined the benefits of the first two by eliminating the need for battalion displacement requirements and facilitating a central logistics point at the battalion level. The entire battalion was located together, but the battery moved to designated firing areas to execute missions then returned to the headquarters after firing. This approach created the idea of a rocket "firing point," a concept still applied today.

Under the final method, the battery established numerous firing points and moved between them after each mission. Similar to the second method, it strained the battalion's ability to support the battery for an extended period. The US Army did not test this new rocket and missile artillery doctrine against enemy forces until Operation Desert Storm, but experimentation in training that stemmed from the rapid technological innovation of the 1950s created the foundation for modern-day rocket artillery doctrine.[89]

Strategic Shift to Conventional Conflict, Enduring Adaptations

Despite the investment of millions of dollars and countless resources, the "Massive Retaliation" strategy and the nuclear battlefield concept were ultimately short-lived. Throughout the 1950s, members of Congress openly challenged the overreliance on nuclear weapons, and Army Chiefs of Staff Generals Matthew Ridgway and Maxwell Taylor argued for a continued focus on conventional forces, even if only on a limited scale. During the 1950s, the creation of missile and nuclear weapons consumed the Army's research and development budget, at the expense of modernizing conventional equipment. Western Illinois history professor Walter Kretchik highlights this point:

> Tactical nuclear weapons research and development consumed service funds at an alarming rate, and other equipment suffered for it. In 1957 alone, nearly half of the service's research and development budget went toward missiles and nuclear weapons compared with 4.5 percent for new vehicles, 4.3 percent for artillery, and 4 percent for aircraft.[90]

This funding disparity and the associated opportunity cost limited the Army's ability to prepare for the most likely outcome: a conventional conflict.

Although the National Security Council emphasized the inclusion of nuclear weapons into the force in 1956, historian Robert Watson notes that the members also identified that "with the coming of nuclear parity, the ability to apply force 'selectively and flexibly' would become increasingly important."[91] Historians Lawrence Kaplan, Ronald Landa, and Edward Drea questioned "the validity and efficacy of the massive retaliation doctrine" because of the Soviet Union's growing strength and increasing and varied global challenges to US interests.[92] They noted that President John Kennedy was critical of Eisenhower's strategic policies when he entered office and was "intent on changing the doctrine of massive retaliation."[93] At its heart, this change was a movement away from the normalization of nuclear weapons as just another warfare tool.

Kennedy's strategic shift to a "Flexible Response" led to a reassessment of the nuclear posture. After inspections of nuclear weapons forward-deployed to Europe, McKenney explains that senior US leaders "became concerned over the possibility of inadvertent or deliberate unauthorized firing of nuclear weapons."[94] This mindset carried into general strategy; historian Richard Weitz comments: "Government officials and civilian strategists increasingly questioned the credibility of using [tactical nuclear weapons] and of the entire doctrine of limited nuclear war."[95] As nuclear arsenals grew, it became clear that their principal value was a deterrent; therefore, the military required other approaches to fighting.

Early methods and experimentation with the use of tactical nuclear weapons led to the development of conventional rocket and missile artillery doctrine; one of the more immediately applicable adaptations, however, was mobility, specifically air mobility. Dastrup notes: "[The] appearance of nuclear weapons, air transportability, especially for division artillery, became even more important. It would allow more rapid movement across the large nuclear battlefield than towed or even self-propelled artillery would permit."[96] This emphasis on air mobility across the field artillery branch, coupled with the 6400-mil battlefield concept, prepared the artillery to operate on a more fluid battlefield. Additionally, it added a new layer to the debate concerning towed versus self-propelled artillery, a conversation that continues today.

Conclusion

Although technological advancements drove the development of tactical surface-to-surface nuclear weapons during this period, the platforms also addressed capability gaps identified in both WWII and the Korean War. Nuclear warhead miniaturization provided a solution, of a kind, to the ammunition consumption problem that emerged during WWII and was reinforced during the Korean War. The destructive power of a nuclear round eliminated the need for large continuous volleys, a fact highlighted in FM 6-20: "A single nuclear weapon is capable of providing massed fire greater than anything heretofore known on the battlefield."[97] The extended range of the Sergeant, and eventually the Lance, allowed artillery batteries to pull back from the front lines, and the emphasis on air mobility facilitated rapid movement around the battlefield; both addressed force protection issues.

The technology-driven innovation process in the 1950s produced sub-optimal artillery equipment that was quickly discontinued and replaced. Linn concludes: "In assessing the Army's effort to transform itself after the atomic revolution, one would have to judge it a failure."[98] However, the new equipment changed the battlefield and forced the artillery community to adapt. Although the nuclear battlefield never fully developed, the artillery community rapidly adapted to technological innovations, developed enduring rocket artillery doctrine, and, as Dastrup explains, created weapons that "brought unprecedented firepower to the battlefield and greatly extended the range of the field artillery."[99] The suggested innovations identified during the 1946 Fort Sill artillery conference were tangentially addressed by the introduction of the nuclear battlefield, to some extent to the detriment of conventional artillery innovation. The nuclear age was short-lived, and the conflict in Vietnam would again force the artillery to adapt to a different type of warfare.

Notes

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58. Brennan Deveraux, *Whose Role Is It Anyway? Inter-Service Competition and the Development of Intermediate-Range Ballistic Missiles*, Art of War Papers (Fort Leavenworth, KS: Army University Press, 2023), https://www.armyupress.army.mil/Portals/7/Research%20and%20Books/2023/AOW%20Deveraux%20Whose%20Role%20interactive%20book%2012May2023.pdf. This book examines Defense Department (DoD) management of surface-to-surface missile development in the early Cold War, building to the Army's Jupiter intermediate-range ballistic missile pursuit. During these efforts, emerging missile technology challenged the DoD's ability to mitigate inter-service competition and duplicative efforts. Although the Army articulated the potential for long-range missiles, it failed to justify why it should be the service to develop and operate said weapons. Instead, the Army leveraged ambiguous wording in the 1950 and 1954 missile agreements and applied its land-combat function broadly, encroaching on perceived Air Force missions. This resulted in multiple services competing for finite resources and capitalizing on the then-unforeseen advantages of immature technology, ultimately resulting in redundancy. This research finds that DoD management of missile development in the 1950s strained a dwindling defense budget, limited the modernization of conventional capabilities, and exacerbated tenuous relationships between the service branches.

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Chapter 3
The Vietnam War and Cold War Modernizations

Indirect-fire capabilities were developed in the latter half of the Cold War under two separate and often-conflicting adaptive pressures: the combat experiences of the Vietnam War and the growing threat of the Soviet Union mechanized force. The Army transitioned in the 1960s from an organization created for the nuclear battlefield to a conventional military prepared to fight a modern war across a variety of intensities and terrain. In 1961, the Secretary of the Army approved the Reorganization Objective Army Division (ROAD) concept, an organizational change that initially focused on creating infantry, armored, and mechanized divisions. Just as the Pentomic Divisions of the 1950s fit President Dwight Eisenhower's policy of massive retaliation, military historian Janice McKenney notes that "the ROAD structure was a reflection of the new administration's theory of flexible response."[1] The ROAD concept allowed the Army to operate at all levels of conflict, from a small engagement to nuclear war. For artillery, this transition ended the Army's reliance on nuclear weapons and paired artillery platform types to specific divisions: self-propelled artillery was assigned to armored and mechanized divisions and towed artillery to infantry divisions.

The establishment of an air assault division within the ROAD concept created an emphasis on helicopter lift that proved vital in the conflict that followed—the Vietnam War. The war validated the ROAD concept and the transition away from the nuclear battlefield. The Vietnam War also shifted focus away from the Soviet Union, the overarching threat to the United States and an adversary that continued to modernize and mechanize its forces during this period. Vietnam provided combat experience for artillery operations that emphasized the importance of air mobility, airspace deconfliction, and direct-fire artillery operations. It was not the Vietnam War, however, but the assessment of the growing threat of Soviet mechanized forces in Europe that created a need for an anti-armor artillery capability and drove lasting technological innovation and adaptations during the late Cold War. This chapter addresses the adaptability of artillery in the Vietnam War first then analyzes changes to indirect-fire capabilities that stemmed from the Soviet threat.

The Vietnam War: Adapting to a Noncontiguous Battlefield

The Vietnam War was a multi-faceted conflict with noncontiguous battle lines. The fighting differed drastically from the engagements of the

World Wars or Korea. Although the United States faced a conventional threat from the North Vietnamese Army, defeating it on the battlefield would not be enough to secure a strategic victory. Simultaneously, the Viet Cong conducted guerrilla operations anywhere and everywhere, melting into the population and complicating US military actions. Army Historian John Carland explains the complex nature of the war:

> From one angle, it was an area war involving not only North and South Vietnam but also Laos and Cambodia. From another, it constituted a range of simultaneous conflicts that ran in stages, from a classic small unit/guerrilla contest at one end to a conventional large unit/main force war on the other. And intermingled was the contest to win the allegiance of the South Vietnamese people, the pacification war.[2]

These problems facilitated minor skirmishes throughout the country that balanced short, pitched battles with coordinated hit-and-run attacks by the enemy. Combined, these engagements forced US artillery units to cover an immense potential battlefield.

Consequently, the unconventional nature of the fighting required the artillery to adapt and adjust how it provided support. Successful integration of the helicopter proved key to employing indirect fire in this environment, allowing artillery units to be broken down into small elements and dispersed, supporting as much area as possible. The helicopter facilitated a new type of warfare by inserting artillery units deep into potential enemy territory where vehicles could not drive. Additionally, helicopters provided resupply and support to tactical artillery bases that remained forward with maneuver forces. Overall, the introduction of helicopter-aided artillery altered the mobility debate regarding self-propelled and towed artillery and forced artillery units into semi-static fire bases they were required to defend.

Helicopter-Aided Artillery and Firebase Operations

The ability of helicopters to move artillery equipment around the battlefield solved numerous mobility problems identified in WWII and the Korean War. As Richard Kedzior of the RAND Corporation explains, "Putting troops and fire support in rapid, highly mobile vehicles—helicopters—helped the division to achieve heretofore-unimaginable levels of maneuverability."[3] The 11th Air Assault Division (Test) began testing in 1963 to validate the airmobile concept at all levels from the squad to division, culminating with a two-division exercise from September to November 1964.[4]

Col. William Becker, the 11th Air Assault Division Artillery (DIVARTY) commander, and his team captured the lessons learned from these tests and published tactics, techniques, and procedures in numerous articles. Becker outlined his intent in the April 1965 issue of *Artillery Trends*: "The articles serve not only to chronicle experiences gained and the tactics and techniques evolved during the Air Assault experiment but also . . . to stimulate independent minds to further development of air assault tactics and techniques."[5] The journal featured these articles in three consecutive issues, highlighting a learning mentality in the community. In the same context, *Artillery Trends* proved an effective tool for broadly relaying these lessons and the subsequent lessons that combat forces would identify in the Vietnam War.

While the 11th DIVARTY lessons were generally technical, Becker also foreshadowed numerous friction points that units would face in Vietnam. Specifically, he highlighted the limited ground mobility of helicopter-aided artillery units, the challenge of airspace deconfliction for fire support operations, and the potential for artillery units to come into direct contact with the enemy.[6] While Colonel Becker acknowledged the high risk associated with operating in enemy territory, he was optimistic and borderline dismissive of the threat. He outlined why enemy dismounts would not overrun air-assault artillery units as had happened in the Korean War:

> [Air-assault artillery units] have some distinct new advantages. They can be airlifted into position areas which are relatively inaccessible to the enemy and are not exposed en route to enemy ground action. Units can be quickly lifted out of position if a threat approaches, or air-assault infantry (on alert with their lift) can react quickly to assist a seriously threatened artillery unit.[7]

Shortly after completing the assessment with the 11th Air Assault Division, the North Vietnamese Army gave helicopter-aided artillery units the opportunity to test Colonel Becker's tactics and techniques on the battlefield.

By the summer of 1965, the Army accepted the new force structure and reconfigured the 1st Cavalry Division as an airmobile division. Just months after its reconfiguration was complete, the 1st Cavalry Division combat tested the airmobile concept in the first significant engagement of the war—the Battle of the Ia Drang Valley. Throughout the thirty-five-day battle, helicopters rapidly resupplied the DIVARTY and moved artillery units around the battlefield to provide continuous coverage for maneuver forces. Of the seventy-nine artillery moves during the campaign, sixty-seven were by helicopter.[8]

The ability to insert these troops and associated equipment around the battlefield changed how the United States could approach its campaign designs. After the war, Lt. Gen. Willard Pearson, the 101st Airborne Division commander during Vietnam, recalled that during Operation Pegasus in April 1968, "the enemy was either unable to, or did not know how to, react against airmobile maneuvering of large numbers of combat troops and supporting artillery around and behind enemy positions."[9] This method of vertically enveloping the North Vietnamese Army forces reinforced the noncontiguous nature of the battlefield. This new approach, coupled with a distinct air power advantage, theoretically allowed the United States to select the battlefield.

Planning for this new capability extended beyond vertical envelopment. Helicopters enabled artillery units to emplace in areas once thought impossible due to terrain or limited access routes. Commenting on the air-mobility concept, Lt. Gen. John Tolson explained that only helicopters "could place artillery on the mountain tops and resupply these isolated bases."[10] He added that for helicopters like the Chinook, "the most spectacular mission in Vietnam . . . was the placing of artillery batteries in perilous mountain positions that were inaccessible by any other means, and then keeping them resupplied with large quantities of ammunition."[11] Additionally, this increased mobility facilitated the concept of an artillery raid: artillery units were airlifted deep into enemy territory to fire a preset number of missions then withdraw. Although these artillery raids were combined arms operations, the support role was reversed; maneuver forces supported artillery operations, extending US combat power without committing forces to an engagement.[12]

Helicopters supported numerous missions beside moving forces, from direct enemy engagement with rocket and machine-gun fire to evacuating casualties. Importantly, artillery was not the only combat element flown around the battlefield, as many infantry units conducted airmobile operations. Thus, the Army had a limited number of helicopters that could move or resupply howitzers. As a result, once artillery pieces were inserted, they stayed put for an extended period. Although airmobile artillery was part of the solution to the mobility problems of WWII and the Korean War, its complexity and resource-heavy requirements limited the military's ability to apply this new approach.

Even in the context of the Vietnam War, helicopter-aided artillery had an inherent weakness—post-insertion mobility. Artillery historian Boyd Dastrup notes that although battles like "Ia Drang vindicated the airmobile concept and showed the field artillery's capacity to provide close support in difficult terrain, . . . artillery lacked sufficient mobility to respond to fast-moving situations."[13] To overcome this limitation, artillery units established semi-static firebases to conduct operations.

Artillery units tended to establish firebases alongside the infantry battalion they supported based on three principles: suitable terrain for helicopter operations, the ability to provide fire support to maneuver elements in the area, and within the range of another artillery unit that could help defend the firebase. Because the absence of prime-mover vehicles limited the short-term mobility of helicopter-inserted artillery, their positions needed an increased level of security.

Distinct from the Korean War, where Chinese or North Korean tactical success put artillery units into precarious situations, the Vietnam War's noncontiguous battlefield meant these units could come under direct attack at any point. Carland highlights this challenge:

> Whether an engagement pitted a small American patrol against a few guerrillas or an American battalion against a main force unit, the enemy usually decided when to fight and when to withdraw. Beyond that, the American soldier normally fought from the tactical defensive even if he was supposedly on the offensive. On numerous occasions an American company, battalion, or brigade would enter an area suspected of harboring enemy units and find signs of them but no soldiers. Then the Viet Cong or North Vietnamese would attack, sometimes before, sometimes after the American unit had established a defensive position. Regardless of when the assault occurred, the Americans would almost always wind up fighting back from within a 360-degree perimeter.[14]

The artillery defended this perimeter with 105-mm howitzers and machine guns.

The US military's emphasis on air mobility during the Vietnam War challenged the conventional wisdom of artillery employment; instead of focusing on destructive power and range, the priority was tactical agility. This made the 105-mm howitzer the most prominent artillery piece on the battlefield. McKenney notes that this smaller, less destructive cannon "was easier to handle, was more suitable for transport by helicopter, and had a higher rate of fire."[15] At the peak of the conflict, the US Army had more than sixty artillery battalions in Vietnam; nearly two-thirds were the lightweight 105-mm cannon battalions.[16]

The 105-mm howitzer used in Vietnam, even with its limited maximum range of roughly eleven kilometers, was essential to firebase operations. In his study of artillery in Vietnam, Lt. Gen. David Ott notes that despite its relatively short range, the howitzer's "high rate of fire made it the ideal weapon for moving with light infantry forces and responding quickly with high volumes of close-in fire."[17] Early in the war, however, these systems were not designed for the 360-degree/6400-mil battlefield. As discussed in Chapter 1, the Westervelt Board's 1919 report identified that the ideal lightweight howitzer should be capable of a 360-degree traverse, foreshadowing problems experienced in Korea and Vietnam. Korean War combat experience reinforced this notion, and senior artillery leaders stressed the importance of the 360-fight when examining the nuclear battlefield. Nevertheless, the M101A1 WWII-era 105-mm howitzer was the initial US lightweight howitzer in the Vietnam War.

In 1966, the Army began fielding the upgraded M102 105-mm howitzer to units in Vietnam. This newer model weighed one ton less than its predecessor, freeing up weight for more ammunition when airlifted.[18] More important to firebase operations, it had full traverse capability. Whereas the older model required the crew to lift the stabilizing legs and readjust the entire piece to traverse beyond twenty-three degrees in either direction, the new M102 model allowed the crew to traverse the howitzer in a complete circle.[19] This improvement dramatically enhanced the responsiveness of artillery units and was vital for their survival. Because artillery units remained in place for extended periods without organic transport capabilities, direct contact with dismounted forces was not uncommon.

Adapting to Protection Problems

Given the nature of the Vietnam War, artillery units were constantly under threat of an attack. Even successful operations often exposed artillery units, necessitating new tactics, techniques, and procedures to defend firebases. General Tolson highlighted this aspect of the conflict: "In this 'war without front lines,' the artilleryman found himself often confronting the enemy face-to-face."[20] The North Vietnamese attacked numerous firebases during the war, forcing artillery units to direct fire the howitzers against dismounts in self-defense. While defending Firebase CUDGEL in November 1967, the occupying artillery unit direct fired more than 600 artillery rounds and still had half the battery wounded and two of its four howitzers destroyed.[21] At Firebase BUELL nearly a year later in September 1968, the occupying artillery unit direct fired more than 1,300 rounds, killing at least seventy-five attackers.[22]

Figure 3.1. A 105-mm howitzer firing in the Ia Drang Battle. Source: Janice E. McKenney, *The Organizational History of Field Artillery 1775–2003*, Army Lineage Series (Washington, DC: US Army Center of Military History, 2007), 278.

While enemy forces may have viewed the firebases as soft targets, the US military successfully defended many of these positions because of developed tactics and techniques that collocated artillery with maneuver forces, established 360-degree perimeters, and ensured firebases had overlapping artillery coverage. Artillery units applied these techniques in November 1968 when a determined North Vietnamese Army force numbering roughly 800 dismounts attacked Firebase RITA. The units occupying the base conducted numerous counterattacks before turning the howitzers directly on the attackers, firing more than 1,300 direct-fire rounds, with an additional 800 indirect-fire rounds from Firebase DOT and air strikes from numerous platforms.[23]

While dismounted enemy forces regularly overran artillery positions in the Korean War, US artillery units in the Vietnam War took measures that reduced the threat posed by enemy infantrymen. Knowing the firebase concept would force artillery units into direct contact with the enemy, direct-fire capabilities were developed to enable their defense. Artillery units had two distinct methods to direct fire cannons at the enemy: the shotgun-style "Beehive round" and a creative adaptation of a time fuze.

The M546 APERS-T (Antipersonnel-Tracer) Beehive munition allowed artillery units to defend themselves against dismounted enemy infantry, as each round fired 8,000 flechettes out to approximately 300 meters.[24] The standard fuze setting, which forced the round to burst instantly after leaving the howitzer, could be adjusted so the round would burst farther away from defensive positions, such as down a main avenue of approach.[25] This was especially important as the flechettes, which *The Field Artillery Journal* describes as "similar to a small nail with the head stamped into four fins so that it will fly like an arrow," could cause massive casualties to friendly forces.[26] When a unit fired a Beehive round, everyone in the defensive position needed to be alerted to take cover. The firing element often accomplished this through simple means such as horns, flares, or shouting out specific code words.[27]

The Beehive round proved very effective at defeating enemy infantry in Vietnam compared to direct-firing a high-explosive artillery round. The Army first employed the munition in November 1966, and a single round killed nine enemy dismounts and subsequently repelled the attack.[28] Just a month later in December 1966, artillery units adopted the Beehive round as a staple of the war during the defense of Landing Zone BIRD. During the battle, the Beehive tore into enemy forces that attempted to overrun the landing zone. Although the United States lost thirty service members in the attack, the defenders killed more than 250 enemy fighters.[29] Ott noted that operations at Landing Zone BIRD validated the Beehive round as "a tremendously valuable asset to the over-all firebase defense program," adding that the munition "had gained the confidence and respect of both artillerymen and infantrymen."[30] This addition to the artillery arsenal significantly improved the ability of artillery units to defend themselves against enemy dismounts.

The Beehive was not a perfect solution, however, as enemy troops in the prone position or behind cover could avoid the effects of the massive shotgun blast of flechettes. Lt. Gen. John Hay discussed this limitation in his examination of tactical and materiel innovations during the war:

> In October 1967 during the battle of Xa Cat, which involved an attack by several enemy battalions on the 1st Infantry Division's Fire Base CAISSON VI, artillery firing beehive ammunition had little effect on attacking enemy troops, because

> they approached the perimeter by crawling. However, a switch to time-fuzed explosives stopped the advance.[31]

Leaders in the field refined this time-fuze approach, which eventually became a doctrinal tool for employing direct-fire artillery.

The time-fuze adaption earned the nickname "Killer Junior." This bottom-up adaptation of existing technology allowed a conventional high-explosive (HE) round to explode thirty feet above the ground between 200 and 1,000 meters from the cannon.[32] The name "Killer" corresponded to the callsign of the 1st Battalion, 8th Field Artillery Regiment under the 25th Infantry DIVARTY; its commander, Lt. Col. Robert Dean perfected the technique.[33] The "Junior" referred to the cannon in question—105-mm and 155-mm. Notably, a "Killer Senior" technique was also adapted for larger-caliber howitzers. Artillery units experimented with time-fuze settings, angle of fire, and cannon charge to get the technique right. When perfected, they created cheat sheets and shared the information across the force. Ott explains that "to speed the delivery of fire, the crew of each weapon used a firing table containing the quadrant, fuze settings, and charge appropriate for each range at which direct fire targets could be acquired."[34] By standardizing the process and communicating these adjustments with the force, artillery units across Vietnam were able to leverage the new technique to defend their firing points.

The Killer Junior method proved effective, and artillery units used it throughout the war. On a single day in September 1968, 6th Artillery Battalion artillery units fired roughly 500 HE rounds this way, killing nearly 200 enemy attackers.[35] This technique also proved effective in the June 1969 defense of Firebase CROOK; coupled with indirect fire from supporting medium and heavy artillery, this direct-fire defense was pivotal to repelling the enemy attack.[36]

Lt. Gen. (Retired) David Barno and Nora Bensahel highlight this type of bottom-up doctrinal/technical adjustment in their recent analysis on combat adaptation. They note that such adaptations are often in response "to immediate battlefield problems" and "become more effective and consequential when they are adopted more broadly throughout the force."[37] This is what happened with the Killer Junior technique. After the first artillery units successfully adapted the Killer Junior method in combat, they shared the calculations with the rest of the artillery community. Eventually, this method found its way into fire-support doctrine. The 2016 Army Training Publication (ATP) 3-09.50, *The Field Artillery Cannon*

Battery, dedicated an entire annex to its execution.[38] Although the Beehive round eventually disappeared from its arsenal, many modern US artillery pieces still have similar Killer Junior direct-fire charts to help cannon section chiefs engage an enemy up-close.

Other innovative approaches to protecting artillery units emerged during the war. For example, the US Army Artillery and Missile School analyzed direct-fire tools beyond the Beehive and time fuze for repelling dismounting attacks against firebases and noted that "of considerable value is the white phosphorus projectile, which, in addition to being a casualty producer, has a psychological impact on the attacker and can provide an effective screen for the defended position."[39] Another creative method was the artillery ambush developed by the 1st Battalion, 77th Field Artillery Regiment of the 1st Cavalry DIVARTY to engage attacking forces before they reached the firebase. Hay explains this method:

> The ambush involved the covert planning of a homemade trip flare device with the trip wire running across the road. A fire unit was laid on this grid and fired on the flare signal. Two flares of different colors could be used to determine the direction of travel of the target unit. Later, with the arrival of the modern sensor devices, the technique was further refined.[40]

More recent discussions address the development of sensor devices, particularly with the rise of unmanned aerial vehicles (UAV) as artillery observers. However, the concept of unobserved fires—shooting artillery at probable enemy positions that friendly forces cannot see—is critical for understanding artillery in the Vietnam War. This approach, which the Army used to harass enemy forces, heavily influenced ammunition consumption and shifted artillery's role on the battlefield.

High Expenditures and Crowded Airspace

In contrast to the large battles that the United States experienced in previous wars, the nature of the Vietnam War forced the US military to design operations to search and destroy the enemy. Because of the illusiveness of enemy forces and scattered semi-static firebases, the role of artillery became drastically different from the Korean War or WWII. McKenney notes that this "piecemeal, static application of artillery went completely against the usual American practice of massed battalion fires."[41] However, high artillery expenditures and logistical challenges were similar to previous conflicts. The distinction was the targets that friendly forces prosecuted.

In addition to assisting maneuver forces engaged with the enemy and preparing areas for an assault, US artillery in Vietnam was often used as a standalone capability. Carland explains:

> Up against an elusive opponent and fighting on terrain that often favored the Viet Cong and North Vietnamese, commanders expanded the role of firepower, transforming it from an effort to soften a target in preparation for a final infantry assault to an outright attempt to eradicate all resistance.[42]

This transition included massive artillery expenditures against suspected enemy areas and terrain deemed operationally significant. Carland notes, however, that US troops had difficulty ascertaining "the degree to which artillery actually finished off the Viet Cong and North Vietnamese in a given instance . . . because of their skill at withdrawing from battle and removing their dead and wounded."[43] This lack of accurate battle damage assessments was not a deterrent to the method.

Instead, this harassing fire relied on a psychological element—a perceived enemy deterrent and a friendly morale boost. In 1966, nearly eighty-five percent of all artillery fired was in support of harassment and interdiction missions.[44] The specific technique to harass enemy forces varied by situation. The US Army Field Artillery and Missile School highlighted that one effective technique was firing the variable time (VT) proximity fuze at night on roads known for enemy travel and logistics.[45] While unobserved, these missions restricted the use of the roads by establishing a deterrent and potentially catching enemy forces off guard with a high-casualty-producing proximity round. Regardless of the technique, harassment and interdiction missions increased artillery ammunition expenditures.

Beyond harassment fire, artillery and other fire support tools remained critical tools for major operations. For example, in May 1966, artillery units supported Operation Crazy Horse with roughly 12,000 artillery rounds per day.[46] A few months later during a single day of intense Operation Attleboro fighting, the 1st Infantry Division fired more than 14,000 rounds.[47] Similarly, during the first two weeks of April 1968, artillery units fired around 150,000 rounds supporting Operation Pegasus.[48] While Vietnam War ammunition expenditures were less than Korean War or WWII, these numbers created daunting logistical challenges. Helicopter-aided artillery came with inherent advantages but was resource-intensive. General Tolson discussed air mobility during the war:

> Artillery has always been notorious for consuming large tonnages of ammunition. . . . However, in Vietnam where practical-

ly every round had to be delivered by air, artillery ammunition proved to be one of the biggest logistics problems. Commanders had to exert supervision at all levels to make sure that the right fire support means was chosen for the target of the moment. A wise commander did not spend too much ammunition on harassment and interdiction fires that could not be observed.[49]

Distinct from previous conflicts, US troops relied heavily on helicopters in Vietnam to move thousands of rounds.

Airspace deconfliction added a new challenge to artillery employment, a challenge that has increased in complexity with increasingly crowded airspace. In Vietnam, this crowded airspace could limit the United States from employing all its fire-support assets. Historian George MacGarrigle comments about the difficulties of deconflicting fires in 1967 for Operation Junction City: "The allies took special care in the use of airspace, including the establishment of artillery warning control centers at the artillery battalion level to provide timely and accurate advisories to aircraft."[50] He added that "even with this measure, ground commanders would still have trouble obtaining air and artillery support simultaneously."[51] Some units were better at airspace deconfliction than others, however, and were able to overcome much of the difficulty surrounding simultaneous strikes.

Leaders on the ground used numerous methods to manage airspace without limiting the use of critical assets. During the Battle of Prek Klok in March 1967, the unit established a fire coordination line to separate assets laterally. Lt. Gen. Bernard Rogers, who served as the 1st Infantry Division assistant commander during the battle, highlighted this simple-yet-effective approach:

When the first Air Force flight had arrived in the area, Route 4 was declared a fire coordination line between the artillery and the aircraft. To the west of the road the artillery fired and broke the enemy's assault and prohibited him from regrouping, while to the east the fighters covered the area with bombs, rockets, and 20-mm cannon fire. The massive and devastating use of air strikes and artillery broke the back of the attack.[52]

Although effective, this type of deconfliction was not always feasible because of varying tactical situations. In 1971, Charles Montgomery, a tactics instructor at the US Army Field Artillery School, identified that some artillery units failed to fire at "lucrative targets" due to airspace concerns with friendly aircraft.[53] He challenged that moving beyond Vietnam, "resolution of airspace authority is critical to the field artillery" to ensure "the safety and effectiveness of friendly aircraft and the effective and timely use of all fire support available to a ground force commander."[54] While some methods proved effective, airspace deconfliction would become an enduring problem.

Lessons Learned from Combat Experience

The dispersed and sporadic fighting that characterized the Vietnam War created a unique problem set for employing indirect fire. Air mobility provided a solution. Helicopters allowed artillery to maneuver around the battlefield in ways that even a self-propelled howitzer could not.

While helicopter-aided artillery raids and firebases were essential to artillery success in Vietnam, such methods would be less effective in a conflict characterized by more high-intensity engagements and a greater concentration of enemy forces. Delivering the high volume of ammunition required for artillery would be difficult for the limited number of helicopters the Army could dedicate to supporting artillery operations. Continuous air movement also assumes airspace superiority, which is not assured against a more capable opponent.

One unexpected consequence of the US Army's Vietnam War reliance on helicopter mobility and firebase operations was the reduction of the role of the DIVARTY. The maneuver commander on the ground built relationships with the artillery that supported him, as envisioned by the Pentomic Division concept in the 1950s, but the DIVARTY was still responsible for all its artillery battalions. Although the volume of fire was not the same as during the Korean War, artillery missions still presented a logistical challenge. McKenney explains: "With elements so widely dispersed, [the DIVARTY commander] saw his supply and maintenance responsibilities increase and his tactical ones decrease."[55] The DIVARTY commander's role in combat continues to fluctuate, remaining a contentious issue today.

While artillery adaptation in the Vietnam War was specific to the conflict at hand, several adaptations have endured. First, artillery raid operations in Vietnam validated the "shoot-and-scoot" concept that the Little John rocket system introduced a decade prior. This concept remains prevalent in the artillery community. Second, to support air mobility, the artillery works to ensure that future towed howitzers are light enough for helicopter transport. Third, emerging airspace deconfliction techniques set the historical foundation for joint fires doctrine, a conversation that would reemerge during Operation Desert Storm. Lastly, the artillery maintained the ability for howitzers to engage targets via direct fire. Today's howitzer crews still train with "cheat sheets" like those developed during the Vietnam War for this last resort approach, and the Killer Junior method remains part of US artillery doctrine. The Vietnam War presented the military with ample experience and numerous lessons; however, these experiences were not expected to translate for future wars. Instead, a resurgent focus on the Soviet Union would dominate the innovations and adaptations that followed the conflict.

Modernizing for The Soviet Threat

The end of the Vietnam War marked a change of focus for the US military. While the United States fought in Vietnam, its true rival, the Soviet Union, continued to grow and modernize its military. McKenney noted that during the Vietnam War, field artillery "delayed critical technological improvements needed to successfully meet an attack by a more formidable enemy in Europe."[56] Accordingly, the US artillery's focus shifted to modernizing for a peer-level adversary that posed an existential threat to the United States. Just as the lessons of WWI helped the military assess the character of a future war, Vietnam War combat experience illuminated potential future war challenges and a need to modernize. These modernizations encompassed the entire system of indirect fire—including communication, protection, mobility, mission processing, doctrine, and observation—but emphasized destruction through the continuation of rocket artillery and munition adaptations.

Shifting Focus: Preparing for the Future War

Critical to the Defense Department's incorporation of Vietnam War lessons was a unified vision of future war, tempered by lingering debates from the 1950s. Specifically, questions remained about how nuclear weapons would influence the character of war. While the United States had abandoned the nuclear battlefield concept, planners could not dismiss the potential impact that nuclear weapons could have on the character of war. In 1972, Lt. Col. William Hauser detailed the contrasting modernization paths that were prevalent among Army officers—a counterinsurgency (COIN) "school of thought" and the "linear war school."[57] Hauser noted that the first group operated under "the strategic premise that conventional warfare [had] been deterred by mutual fear of nuclear escalation."[58] The second believed "the US Army should concentrate on preparing to fight a linear war against Warsaw Pact Forces in Europe or to meet overt aggression elsewhere."[59] Just as the Vietnam War came to a close, however, a short but intense conflict broke out abroad, providing a glimpse of what a future conflict with a near-peer could entail.

Because US artillery did not fight in the Yom Kippur War—and because it was not an artillery-centric fight—this book does not examine that battle in detail. However, this conflict illuminated trends that the artillery community addressed through its modernization efforts in the decades that followed. Notably, learning or applying lessons from another's experience is inherently challenging. Since they were not personally involved with the war, US military analysts could justify or excuse anomalies of a conflict to avoid a Kuhnian Crisis and accept that warfare is changing.[60] At the same time, these observations—accurate or not—can confirm warfare assumptions.

In October 1973, an Arab coalition launched a surprise attack against Israel. Contrary to the jungles of Vietnam, which required a focus on air mobility and dismounted operations, the Yom Kippur War was a mechanized fight in open terrain. At the most basic level, the tank- and airpower-centric fight reinforced the linear-battle mindset that a high-intensity mechanized conflict was in the future for US forces. Even before the conflict, Hauser noted that the resurgent emphasis on mechanization warfare reflected "the tendency of many senior Army officers to regard Vietnam as an aberration, a violation of the principles of war best corrected by a return to traditional doctrine."[61] He was not alone in this general assertion. While not heavily addressed in this work, the US military leadership's conventional focus reappears after the wars in Iraq and Afghanistan.

Nevertheless, the United States officially assessed the impacts of the Yom Kippur War to distill lessons and validate or challenge its military modernization efforts. Secretary of Defense James Schlesinger ordered the assessment immediately following the ceasefire, and the department took numerous formal and informal approaches. The US Military Operational Survey Team and the US Military Equipment Validation Team Israel, part of the formal path, provided ample feedback on the impact of specific weapon types during the three-week conflict.[62] Two critical findings from this research were the effectiveness of surface-to-air missiles and the high level of attrition and materiel consumption.[63]

The surface-to-air missile threat was not new and had influenced the US military's modernization choices since the beginning of the Cold War.[64] However, the contested airspace in the Middle East contradicted lessons learned from the US military's reliance on helicopter-aided operations in Vietnam. The Arab Coalition destroyed roughly eighty-five Israeli aircraft in just a few weeks.[65] In addition to the loss of aircraft, this air-defense bubble limited Israel's offensive operations. Historian Walter Poole explains that 14 October 1973 proved a decisive day for Israel because Egyptian forces advanced beyond "their [surface-to-air missile]-protected bridgehead," and, in turn, "suffered heavy tank losses" from Israeli aircraft.[66] Artillery leaders recognized the importance of air-defense suppression to enable aircraft survivability and employment. Schlesinger reported to Congress that "the intensity and effectiveness displayed by the ground air defenses in the Middle East conflict impressed upon us even more compellingly the need . . . to enhance the defense-suppression capabilities of our tactical forces."[67] To accomplish this with indirect fire required area effects, a field artillery development focus in the years to come.

Materiel consumption drew the United States indirectly into the conflict. Roughly twenty-four hours after the invasion, Poole explains, "the Israeli Embassy presented an urgent appeal for 200 Sidewinder air-to-air missiles, . . . 300 M-60A1 tanks; 40 F-4Es; and electronic systems to jam the SA-6 surface-to-air missiles."[68] Three days later, the requests shifted to ammunition as the Israeli consumption rates were dramatically higher than their planning assumptions. On 10 October 1973, in addition to more aircraft, the Israeli Embassy requested "270,000 rounds of 105-mm ammunition, chaff loads, Rockeyes, and cluster bombs."[69] While the request for thousands of artillery rounds reinforced the conventional wisdom of mass artillery employment, the emphasis on cluster munitions signified a critical warfare necessity: anti-tank munitions. Israel succeeded with cluster bombs against Egyptian armor, expending its pre-war inventory of more than 4,500 bombs and another 1,600 US replacement munitions.[70] The ability to destroy armored and mechanized vehicles would be critical in a future war against the Soviet Union.

US mechanized forces in Europe (and, indeed, everywhere) were outnumbered by those of the Soviet Union. The artillery community was concerned that in a conflict with the Soviet Union, the Air Force would be too busy with the air war to interdict against the threat of Soviet tanks—the ultimate direct fire threat to artillery; measures like the Beehive round and Killer Junior would be useless. McKenney explains: "Cannon artillery could not fire a round powerful enough to penetrate and destroy tanks, often only slowing them down, disrupting their radio communications, and separating them from supporting infantry."[71] In response to the threat of Soviet armored vehicles, the US artillery would have to modernize its munitions.

The 1973 Yom Kippur War provided US military planners with a conventional warfare lens to analyze their own experiences in Vietnam. Vietnam had reiterated the basic inferences already drawn from WWII and Korea: that artillery needed more destructive power to increase its effects on the battlefield and to use fewer rounds for each fire mission, thus lowering the logistical burden of indirect fire. Late in the Cold War, this need for destructive power was reinforced by the numerical mismatch of armor units between the United States and the Soviet Union. Although nuclear artillery adoption had supposedly resolved Korean War ammunition problems, the Vietnam War and Yom Kippur War demonstrated that a conventional conflict was still a real possibility.

While indirect fire faced similar historical challenges, technology allowed for distinct and creative solutions. In October 1973, WWII and Korean War veteran William Wood wrote that non-nuclear artillery had stagnated since the 1940s and that artillery needed to evolve.[72] He challenged the artillery community to seek innovative solutions and provided an ominous warning if they did not:

> We cannot continue to rest on past laurels, namely the honor of being the greatest killer on the battlefield—in fact, we now face the somewhat unpleasant prospect of being blown off it. Rigidity of thought is no less a danger than the threat itself, and the problem ignored will not disappear. Either we come up with a sound response, or the field artillery may do something it has never done in the past: let down the supported combat arms.[73]

The US Army continued to develop and upgrade its rocket artillery systems despite the fact that some Cold War modernization efforts were barely in the conceptional stage.

Modernizing Rocket Artillery

Building on the experience gained from developing rocket and missile artillery during the 1950s, the Army created a versatile tactical dual-use system to meet its destruction and survivability requirements—the MGM-52, Lance. The Lance was to replace Army tactical systems by accurately delivering a 1,000-pound nuclear and non-nuclear warhead up to seventy-five kilometers in support of division and corps operations.[74] The Army conceived the system in 1956, during the height of the pentomic era, but did not field it until 1973.[75] The Lance addressed mobility, responsiveness, and accuracy concerns highlighted by its predecessors, eventually replacing the Honest John and the Sergeant.[76]

The Lance was a dramatic improvement over its predecessors. Shortly before its fielding, *The Field Artilleryman* referred to this innovation as "a giant step . . . toward achieving one of the field artillery's ultimate objectives—a missile system which is as simple, as rugged, as mobile, and as reliable as conventional cannon artillery."[77] The artillery community was excited about the new weapon's potential. McKenney highlights its improved features:

> The Lance's mobility over rough terrain made it possible for the crew (eight men) to fire from positions unsuitable for a rocket;

Figure 3.2. The Lance. Source: Redstone Arsenal Historical Information, https://history.redstone.army.mil/miss.html

> it had a low silhouette and the general appearance of a vehicle common to the battlefield; it was small and easy to conceal and more difficult to identify as a nuclear-delivery vehicle; it could operate under all weather conditions in which infantry, armor, mechanized, or airborne troops might be committed; and its advanced guidance system was invulnerable to all known electronic countermeasures. Maintenance problems were minuscule in comparison to earlier missile systems, and the requirement for specially trained technical personnel diminished.[78]

The Army fielded eight Lance battalions—six of which remained forward in Europe—and sold the system to NATO allies and a non-nuclear version to Israel.[79] The Lance's one critical weakness was that it fired a single rocket.

The artillery branch needed a new weapon system capable of engaging multiple targets with a high volume of fire to defeat Soviet Union armored formations. As identified by the Pentomic Divisions, the most significant challenge for rocket artillery was the requirement to conduct time-intensive reloads after every mission. Wood proposed developing a multi-rail launcher to fill this void, warning that the Army must keep it simple to avoid development problems it faced in the 1950s: "We cannot afford to haggle over all sorts of 'improved' gadgetry and lose sight of our goals by trying to develop some superweapon."[80] In 1974, the Field Artillery School studied developing such a rocket platform—the multiple-launch rocket system (MLRS). The schoolhouse study concluded that the MLRS would be "capable of achieving longer ranges without the great weight of cannon artillery, would permit a greater volume of fire support without displacement, and would provide the needed indirect fire support across a wider front."[81] In 1983, the Army fielded the new system, greatly increasing artillery lethality.

The Army designed the MLRS with a more straightforward reload process to allow the system to fire numerous rockets before the launcher needed to reload. McKenney highlights that a single MLRS platform "could deliver the same firepower as twenty-eight 8-inch howitzers."[82] The launcher could carry two six-rocket pods and fire a single rocket or multiple rockets with only a few seconds between each launch. To reload, the crew used a crane to remove the expended pod and load a new one. A July 1980 article in *The Field Artillery Journal* highlights that the MLRS "permits a three-man crew with minimum training to accurately shoot a complete twelve-rocket load, quickly reload, and fire again."[83] However, "quickly" was relative to previous missile and rocket artillery systems.

While the MLRS was capable of large-volume bursts of fire and the crew could reload it exponentially faster than earlier systems, rocket artillery systems remained inherently limited in their ability to sustain fire compared to their cannon counterparts.

The MLRS could shoot-and-scoot around the battlefield while providing a high level of firepower. The firing system was built on top of an adapted mechanized infantry vehicle, allowing it to move off-road effectively and taking it places that rocket artillery of old could not go. The MLRS automated system allowed the crew to move to its firing point, process a mission, and quickly leave without exiting the cab. In emergencies, a single person could operate it for a short period.[84] Tactically, the system leveraged the same rocket-artillery concepts that the Artillery Department of Tactics and Combined Arms outlined in 1958.[85] According to Dastrup, the MLRS offered significant potential capability improvements compared to its cannon artillery:

> Compared with a 155-mm howitzer, one MLRS launcher, firing twelve rockets, was the equivalent of 3.6 howitzer battalion vol-

Figure 3.3. The Multiple Launch Rocket System. Source: Redstone Arsenal Historical Information, https://history.redstone.army.mil/miss.html

leys. One battery of nine launchers, firing 108 rockets, was comparable to thirty-three battalion volleys by tube artillery. The rocket system gave the field artillery an unprecedented ability to mass huge amounts of fire on a target rapidly and accurately with fewer people than any field artillery weapon system in the Army's inventory. Equally important, the MLRS was designed for hitting area targets and rapid emplacement, engagement, and displacement (shoot-and-scoot tactics) to protect it from hostile field artillery fire.[86]

Unlike its predecessors, however, the MLRS was not built for nuclear operations, and a simple HE rocket would not suffice for armored enemy forces.

Modernizing Munitions: A Need to Destroy Armor

At its core, indirect fire is an area-effect weapon. Against a fast, mechanized force, the more area an artillery round can affect, the higher the probability it will influence the fight. The battlefield calculus required for indirect fire to hit a moving target traveling off-road is daunting, and with conventional HE artillery rounds, only direct hits would matter. To interdict or destroy a mechanized force on the move, the indirect fire would need to saturate large areas with numerous rounds as fast as possible. Therefore, to be relevant in large-scale combat operations, field artillery would need to develop a new munition powerful enough to affect armored vehicles without a direct hit and cover enough area to suppress enemy air defenses.

While the MLRS could launch numerous rockets across the battlefield, the Army also needed a non-nuclear munition capable of mass destruction. The military designed a cluster-munition rocket that released and scattered tiny bomblets across a large area: improved conventional munitions (ICM) and its eventual dual-purpose upgrade (DPICM). The first DPICM rocket carried more than 600 of these submunitions, each with the destructive capability of a fragmentation grenade coupled with a shaped charge to penetrate armor.[87] A single M26, one of the first-generation rockets, had a maximum range of thirty-two kilometers, and its bomblets could affect an area the size of six football fields.[88]

The MLRS was a solution to challenges associated with high-intensity conflicts. Author Bill Rittenhouse highlighted this point in his article about the development of MLRS munitions: "The combination of smart munitions and MLRS gives the Field Artillery the capability to attack and kill more threat systems with fewer launch platforms, in a shorter time, using less ammunition, than ever before."[89] In parallel with area-effects modernizations, the artillery refocused on precision, this time for cannons.

The goal of precision-guided munitions (PGM) is to achieve a high probability of first-round impact on enemy targets. With precision, each howitzer can engage more targets with less ammunition, reducing the logistical challenges that a potential European conflict with the Soviet Union would pose. To help create an understanding of PGMs, military analysts John Yager and Jeffrey Froyslan organized them into three categories: "externally guided, self-directing and (or) inertially guided, and target-locating smart munitions."[90] Although the technology for self-directing artillery did not fully develop until the twenty-first century, externally guided and target-locating munitions were a technological possibility after the Vietnam War. The Corporal and Sergeant missiles—discussed in Chapter 2—were the Army's first attempts to externally guide a munition. However, adjusting the ballistic path of a cannon round mid-flight proved much more complex than redirecting a rocket capable of receiving commands from a guidance platoon.

The M712 Copperhead round was the first guided cannon projectile. Designed for the 155-mm cannon, it had the potential to revolutionize artillery. Although the initial development of the Copperhead began shortly after the Vietnam War, the Army did not begin fielding the munition until the early 1980s. Its internal laser-homing device created a high probability of a first-round hit out to twenty kilometers and it contained an anti-armor warhead to destroy hardened targets. Combined, this accuracy and destructive capacity would greatly enhance the lethality of artillery units on a future battlefield. Maj. Michael Hustead explained PGM effects on fire support operations: "Technology has finally progressed to the point where the artillery's indirect fires have the potential to effectively counter that long-standing countermeasure to artillery—armor!"[91] In practice, however, employing the Copperhead proved challenging.

Though effective, employing the round to its potential was complex and prone to error. To home-in on the target, the Copperhead required an observer to maintain clear sight of the target and to "paint" it with a specific coded laser from their designator. This coordination between the firing battery and the observer inherently left room for human error. Consequently, the National Training Center reported that human error was the primary issue with Copperhead employment. These errors produced over-

Figure 3.4. Copperhead Test Fire. Source: Janice E. McKenney, *The Organizational History of Field Artillery 1775–2003*, Army Lineage Series (Washington, DC: US Army Center of Military History, 2007), 287.

all success rates of under seventy percent; some units had no successful hits on the target during training.[92]

The low percentage of Copperhead direct hits during training led the Department of Defense to reduce funding for the round. The *Washington Post* reported that the 1983 defense authorization bill effectively ended Copperhead production and only allowed the Army to produce 8,000 of the planned 44,000 shells.[93] The author, Walter Pincus, explained that the

Secretary of Defense ordered that production rates be reduced by seventy percent "until the Army could show that it had achieved an eighty-percent hit average with test shells."[94] This goal would prove too difficult.

On top of human error, weather and atmospheric conditions such as fog or dust limit the effectiveness of laser-guided munitions. Yager and Froysland noted that environment posed an added problem: "The success of Copperhead hinges on an observer being able to see the target."[95] That was not always possible in the rugged Middle East terrain, where the round experienced its first combat test. Though the Copperhead munition was revolutionary as the first externally guided cannon round, it was only a short-term solution to the precision challenge. The Army intended for the munition to reduce the logistical burden required from a volume of artillery fire, but the Copperhead ended up imposing unmanageable complexity. Overall, these modernization efforts provided the artillery branch with tools for its potentially expanded role on the future battlefield.

Artillery's Expanding Role

In Vietnam, artillery shifted beyond its traditional role of supporting maneuver operations to instead focus on harassment missions. However, in a potential future war with the Soviet Union, a clash that would rival WWII, artillery units could not survive in static firebases. Nor could thousands of rounds be fired unobserved to produce a psychological effect on the enemy. Instead, this future conflict required three unique mission sets for indirect fire: close support, counterfire, and interdiction.[96]

The first mission set, close support, had always been indirect fire's fundamental role, employed in concert with maneuver forces. Close support is how artillery units directly influence the tactical fight—providing smoke, illumination, and explosive rounds in conjunction with maneuver operations or to support troops in contact. In a high-tempo fight, however, artillery is not expected to defeat the enemy; instead, it facilitates maneuver forces engaged with the enemy by obscuring tanks with smoke or separating them from the infantry with HE rounds.[97] Additionally, the untested Copperhead and ICM had the potential to directly impact the battle by destroying or neutralizing armored vehicles.

The second mission set, counterfire, is the deliberate positioning of artillery assets to find and destroy enemy artillery pieces. Like close support, counterfire had been an indirect fire staple, as artillery is one of the best weapons to kill artillery. Although this mission did not change, planners needed to understand how it could affect the battlefield. In 1981, the Field Artillery Tactics Department explained that artillerymen had to move beyond thinking "of counterfire as an artillery duel which had little impact on the frontline."[98] Suppressing enemy artillery pieces would reduce a potential threat to maneuver forces, allowing maximum application of direct fire systems in the close battle against the numerically superior Soviet Union. With the destructive capacity of tanks and infantry fighting vehicles, even an individual vehicle could turn the tide of a battle.

The final mission set, interdiction, is how artillery units shape the battlefield by removing an enemy's capabilities or disrupting its ability to deploy assets. The Field Artillery Tactics Department commented that "by reducing the enemy's forward momentum and commitment flexibility, interdiction gives the friendly force commander the opportunity to maneuver."[99] This mission relies on upgraded indirect fire maximum ranges and artillery raids to influence enemy formations before the battle, reducing the number of vehicles an enemy can commit to an engagement. Although the MLRS extended the artillery's most lethal round beyond thirty kilometers, continued improvements would be needed to fulfill the task of interdiction. If the maximum range did not improve, artillery units would be forced to cross into enemy territory and rely on dangerous raid operations.

A critical effect of this transition back to a large conventional conflict was the renewed importance of the DIVARTY commander, a position that played a reduced role during the Vietnam War. The challenge for the DIVARTY commander was three-fold: determine where to position units to support all required missions, decide which elements to allocate to a maneuver unit for direct support, and establish priorities among the three artillery mission sets. Contrary to Pentomic Divisions battlegroups and the way that indirect fire was employed in the Vietnam War, establishing relationships between artillery units and the maneuver forces they supported would no longer be the priority. Regarding allocation of artillery for the direct-support relationship in a future conflict, the Artillery School explained: "Faced with the requirement to attack three distinct target sets concurrently, the division commander simply can't afford to farm away up to two-thirds of his field artillery for a single purpose."[100] This conversation would reemerge in the 2000s as part of the Army's modularity concept—examined in Chapter 5.

Lessons Learned from the Changing Threat Assessment

The threat posed by the overwhelming Soviet mechanized force drove US technological innovation and adaptation in the late Cold War.

Unlike development of rocket and missile artillery in the 1950s, the modernization of US rocket-artillery systems and anti-armor munitions in the 1970s and 1980s was slow and methodical, often altered and adjusted through testing and experimentation. This process resulted in both success and failure. While DPICM became the most lethal non-nuclear artillery round, the Copperhead was an inconsistent and overly complex precision munition. As a result, only a couple of thousand rounds were produced.

The Lance provided the Army with a tactical-nuclear weapon, but its single rocket limited its application in a non-nuclear context. The development of the MLRS stemmed from a needs-based conference at Fort Sill and successfully applied lessons learned from earlier rocket artillery systems such as the Honest John. The DPICM rockets employed by the MLRS shared two positive attributes of rockets compared to cannons: destructive capacity and extended range. Additionally, MLRS pod modularity avoided the long reload times that had plagued past rocket systems. Lastly, building the system on a modified tracked infantry fighting vehicle demonstrated the Army's focus on improving artillery mobility for increased survivability on the battlefield and to rapidly adjust to the tactical situation. At the same time, the increasing emphasis on interdiction via indirect fire again emphasized the importance of maximum range, something the artillery would need to continue improving.

Conclusion

By the late 1980s, the US Army was solely focused on preparing for a high-intensity conflict with the Soviet Union. While the Vietnam War forced the artillery to adapt to asymmetric conflict, the associated adjustments to helicopter insertion and firebase operations were quickly relegated to secondary or niche capabilities. Only a single division continued to prioritize helicopter-based artillery operations, and the firebase concept was abandoned to focus on a peer fight that would not allow artillery units to remain static for fear of enemy counterfire. This decision would affect future COIN operations in the Middle East, where the value of firebases would be rediscovered. Additionally, the artillery community ceased to emphasize direct-fire capabilities for force protection—another priority imposed by the Vietnam War that was subsequently neglected—in favor of an increasing focus on new munitions and how to employ them.

After the Vietnam War, the field artillery branch conducted detailed studies and conferences to predict the character of future wars. This included a detailed analysis of the Yom Kippur War and the growing mechanized

Soviet threat. During this period, the artillery successfully developed new technology and expanded its role based on the Army's assessment of the threat posed by mass mechanized forces. As the Cold War drew to a close, the artillery branch focused on preparing for these new challenges. Although the Soviet threat would disappear without a fight, a new foe would rise in the Middle East to provide the artillery with a testbed for its Cold War modernizations.

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Chapter 4
The Gulf War and a Deliberate Effort to Innovate

A declared war with the Soviet Union never came to pass. Even as its adversary began to decline, the US military continued to modernize its equipment in the latter half of the Cold War to defeat a mechanized force. The 1991 Gulf War provided an opportunity for the US military to test, among other things, its new artillery systems and munitions. Although the United States fought minor skirmishes late in the Cold War, the 1991 Gulf War was the first major conventional conflict after the Vietnam War. Consequently, the short and decisive engagement became the foundation for the US military's vision of a future conflict in the post-Cold War environment. Overall, the Gulf War combat experience validated many successful indirect-fire innovations like the multiple-launch rocket system (MLRS) and its dual-purpose improved conventional munitions (DPICM). Simultaneously, the war highlighted areas for continued indirect-fire innovation.

Without an external threat for the first time in decades, however, the US military was unclear about which potential adversary to prepare for. In the decade following the Gulf War, the Army invested in safer and more destructive anti-armor artillery rounds and an improved self-propelled artillery platform. Although the post-Gulf War period was riddled with failed innovation attempts, the artillery community continued to apply the lessons learned from its most recent combat experiences. This chapter first analyzes the successful employment of new indirect-fire capabilities in the Gulf War then examines the US military's challenge to leverage combat experience and continue modernizing its systems and munitions in the absence of an external threat.

The Gulf War: Validating Cold War Modernizations

When Iraq invaded Kuwait in August 1990, the United States was quick to mobilize the military in response. The ready brigade of the 82nd Airborne Division deployed forces; in just over two months, the Army amassed a military force in Saudi Arabia composed of more than 120,000 soldiers, 2,000 mechanized vehicles and tanks, and 600 artillery pieces.[1] Over the next couple of months, the Army deployed more than 500,000 soldiers to the region. Offensive operations began in January 1991, marking the beginning of Operation Desert Storm. After about a month of continuous air and missile bombardments, Coalition forces stretched across a 300-mile front line in preparation for a ground war that would last less than a week.

Commanded by General H. Norman Schwarzkopf, the Coalition ground forces were organized under the VII and the XVIII Corps. Retired field artillery officer Richard Swain describes the distinct yet complementary missions of these two units:

> The two corps were significantly different in composition, and their missions were fundamentally different in character. VII Corps, a homogeneous (though combined US-UK) heavy corps, was assigned a "force oriented" mission, destruction of the RGFC [Republican Guard Forces Command] in zone. The primary mission of XVIII Corps, a mixed medium-heavy-light force (US-French), was terrain oriented and designed to block the Iraqi routes of withdrawal or reinforcement, then to fall in with its heavy forces on VII Corps' left and drive east toward Basrah. These tasks were fundamentally different, as were the formations to which they were assigned. The latter would require decentralized execution, the former something quite different indeed.[2]

While different, both mission sets required responsive artillery to accomplish two tasks: destroy critical Iraqi equipment and keep pace with the rapid advance.

Artillery had a dominant presence in the Gulf War; in addition to nearly 850 howitzers, the Army deployed 189 MLRS platforms.[3] The artillery in the VII Corps—the heavy corps—was organized to provide mobile lethality for its "force-oriented" mission, putting self-propelled artillery and the MLRS to the test. The VII Corps Artillery had four field artillery brigades comprised of three MLRS battalions, five 155-mm self-propelled artillery battalions, and three 8-inch self-propelled artillery battalions.[4] Additionally, the DIVARTYs operating within the Corps—1st Infantry Division, 1st Armored Division, 3rd Armored Division, and 1st Cavalry Division—each had three 155-mm self-propelled artillery battalions and a standalone MLRS battery for general support fires.[5] In contrast, the towed-artillery battalions resided in the XVIII Corps. Notably, while it is not examined in detail in this book, most of these DIVARTY units were furnished with a target acquisition battery that employed highly effective counterbattery radar systems.

Unlike the Korean and Vietnam wars, the Gulf War was not a stress test for American artillery. However, the conflict was not without challenges. The fast-paced warfare and changing tactical situation reinforced the importance of artillery mobility, and the introduction of Army missiles complicated the increasingly difficult task of managing airspace to mass effects. Overall, the Gulf War highlighted the role of Army missiles and rockets in shaping the battlefield alongside the Air Force, validated Cold War lethality modernizations, and illuminated potential protection and mobility challenges.

Missile Warfare and the Deconfliction of Airspace

Influencing the battlefield at different depths had been fundamental to Army modernization efforts since WWII. Until Desert Storm, policy decisions had sidelined the Army's pursuit of long-range strike capabilities—the 1956 adjustment of roles and responsibilities, the relegation of nuclear weapons to deterrence systems, the transition of the *Pershing* missile system into NATO control, and the intermediate-range nuclear forces treaty. However, in the late Cold War, the Army developed a long-range and conventionally-armed missile that could extend the influence of indirect fire out to roughly 150 kilometers.

Known as the Army Tactical Missile System (ATACMS), the new missile was fired from the MLRS and contained 950 DPICM submunitions designed to destroy lightly armored vehicles and personnel.[6] The MLRS pod system that had enabled rapid reloading also allowed for the integration of this new munition. Instead of six rockets, an MLRS pod could hold a single ATACMS. However, the Army did not design the ATACMS as simply another indirect-fire tool to support normal maneuver operations. Instead, according to a report from the Institute of Land Warfare, these strategic missiles were "viewed as a precious asset and placed under Army Central Command control to limit expenditures to high-value targets."[7] Notably, these new missiles enabled the Army to shape the battlefield by striking deep targets, a task historically conducted by the Air Force.

The Army and the Air Force had long recognized the need for inter-service coordination to manage airspace and concurrently leverage all the military's firepower. In May 1984, the services signed a "Memorandum of Agreement on US Army-US Air Force Joint Force Development Process" to enable this cooperation.[8] The memorandum outlined numerous focus points, including emphasizing joint suppression of enemy air defenses and initiatives to improve battlefield air interdiction and close air support.[9] The services affirmed the need to "organize, train, and equip a compatible, complementary and affordable Total Force that will maximize our joint combat capability to execute airland combat operations."[10] The agreement emphasized the Battlefield Coordination Element—the Army's liaison element to the Air Force's Tactical Air Control Center. The Army's introduction of ATACMS stressed these early joint concepts, forcing both services to work through and adapt their air clearance procedures.

The opportunity to test airspace deconfliction came on the first day of the air campaign, 17 January 1991. The first ATACMS mission, roughly a 150-kilometer strike, was an enemy surface-to-air missile site in Kuwait that was positioned to limit US Air Force operations.[11] After nearly four hours of coordination, the 75th Field Artillery Brigade fired "the first precision strike by an Army missile in history," and two minutes later, "the missile disgorged a thousand baseball-size bomblets directly over the Iraqi missile site with catastrophic effect."[12] The process was repeated later that night and again the next night to destroy numerous antiaircraft missile batteries.[13]

While these missiles provided the force with a new capability, their impact was more to validate the munition than evaluate its actual battlefield impact, especially compared to the destruction produced by aircraft and rocket artillery. Brig. Gen. Robert Scales, while serving as the chief of staff of the Field Artillery Center and School, commented that "the launch of thirty-two Army tactical missiles during the air phase went largely unnoticed."[14] He contended that "too few missiles were available to cause extensive damage and the complex clearance procedures necessary before each launch made them relatively unresponsive."[15] Instead, Scales repeated missile arguments the Army had proclaimed for generations, noting the weapon's inherent responsiveness and risk advantages over aircraft.[16] However, airspace coordination challenges undermined the responsiveness argument that artillerymen continue to present regarding missiles.

While airspace coordination was manageable in the deliberate air campaign, the dynamic ground component challenged the techniques and procedures for massing joint effects. One of the first aspects that senior leadership had to overcome was the placement and subsequent adjustments of the fire support coordination line (FSCL). The FSCL provides a separation of fires, allowing the Air Force to strike beyond it without fear that friendly forces are in the area. Swain highlights that the ATACMS provided the Army with "a weapons system whose range permitted ground forces to fire beyond the FSCL, something the Air Force worried about given the density of planes in the airspace."[17] Given the fluid nature of the battlefield and the rapid advance of maneuver forces, US Central Command maintained control of the FSCL and used it as a boundary between the Air Force and the Army.[18] This overarching control limited the flexibility of air support. A Third Army after-action report highlighted this challenge:

> The end result, ironically, was that the high level of success attained on the ground frequently led to a loss of air support, since

Figure 4.1. The Army Tactical Missile System. Source: Redstone Arsenal Historical Information, https://history.redstone.army.mil/miss.html

> bombers could no longer execute their mission, and because the mission manager didn't have the necessary lead time to successfully divert the mission to another target.[19]

Though the authorities regarding these formal airspace measures were inflexible and held at the highest levels, innovative leaders could still adapt to their specific situation.

On 26 February 1991, the 3rd Armored Division simultaneously employed its indirect fires and leveraged air power in the battle of 73 Easting. When F-16 and A-10 aircraft arrived to provide support, Maj. Gen. Paul E. Funk, the division commander, created an informal airspace coordination area that used grid lines to separate artillery fire and aircraft with a lateral method similar to the one used in the Vietnam War.[20] Scales notes that beyond providing "friendly aircraft a block of airspace free of friendly surface fires," it allowed the 3rd Armored Division to continue attacking targets in conjunction with the air support.[21] Even in this example—which serves more as an outlier than the norm—aircraft were limited in how close they could operate in relation to friendly forces. Overall, Desert Storm proved that "the execution of close interdiction by the Air Force in support of the Army's major operations" was "beyond the abilities" of the US military services at the time, according to Swain.[22] The Army's lethal munition modernizations did succeed in reducing the ground force's reliance on the Air Force. While ATACMS usage may have been limited, it was not the Army's only new indirect-fire tool for shaping the battlefield.

Lethality Modernizations

Desert Storm allowed the Army to evaluate numerous innovations that developed in the latter half of the Cold War. Historically, the Army's "Big Five" projects—Apache AH-64 helicopter, UH-60 Black Hawk Helicopter, M1 Abrams Tank, M2 Bradley Fighting Vehicle, and MIM-104 Patriot Missile System—often overshadow the indirect-fire innovations of the time. Analysts should not overlook how the MLRS platform, DPICM rockets, and Copperhead precision munition altered how the Army fought. The MLRS platforms proved invaluable during the conflict. In the short engagement, the land forces fired more than 17,000 rockets from the new system, releasing more than 11 million submunitions across the country.[23] The immense amount of DPICM submunitions that littered the battlefield—644 fragmentation bomblets per rocket—created an effect described by some in the Iraqi military as "Steel Rain."[24] Notably, the Army started raining this submunition down on the Iraqi military well before US ground forces began their march into Kuwait.

VII Corps leveraged its MLRS systems to conduct artillery raids in the buildup to the eventual breaching operation. Scales describe the 13 February raid when VII Corps moved three MLRS batteries to the berm to destroy enemy artillery positions and command nodes with DPICM rockets and bait the Iraqi military into an artillery duel:

> At precisely 1815, soldiers standing at the berm watched as 216 rockets rippled away with successive roars, leaving behind white smoky fingers pointing toward Iraq. A few seconds later, a succession of white puffs appeared just above the horizon as warheads popped open to disgorge 140,000 bomblets on top of the hapless Iraqi batteries. . . . Should the Iraqi artillery shoot back, only a few seconds would be needed for the radar to pinpoint the target and the rocket battery to smother it with another 70,000 bomblets.[25]

Historian Stephen Bourque notes that "in most cases, the Iraqis failed to respond," but when they did, Iraqi artillery units "were ruthlessly suppressed."[26] Though the Iraqi military had capable artillery systems, it could not win this duel.

These raids, which also included the VII Corps artillery cannon battalions, continued regularly until ground forces began breaching operations. Bourque summarizes the last week of these raids and their impact on the initial hours of the ground war:

> VII Corps fired over 14,000 rounds of artillery and over 4,900 MLRS rockets at the Iraqi VII Corps during their raids. . . . These attacks during the week of 17–23 February destroyed much of the Iraqi VII Corps' artillery, leaving almost nothing left to contend with the US VII Corps ground attack. They also caused many of the front-line forces to desert their posts, leaving most of the forward brigades with less half of their soldiers on G-day.[27]

The XVIII Corps conducted similar raids; however, its area of responsibility did not have the same number and types of lucrative targets.[28] The last of these preparatory bombardments was to support the breach and the transition to the land war.

On 24 February 1991, the ground war began. At 1430, the VII Corps conducted an artillery barrage to reduce Iraqi capabilities, limit enemy defensive actions, and enable friendly breaching operations. Brig. Gen. Creighton Abrams, VII Corps artillery commander, conducted this thirty-minute fire mission in a fashion not too different from WWII artillery barrages. General Scales details the sheer scope of this mission:

> General Abrams had allocated the 75th, 42nd, and 142nd Field Artillery Brigades, two divisional artillery groups, and ten MLRS batteries to create a Soviet-style "strike sector" over the breach area. These units fired 11,000 rounds of artillery and 414 MLRS rockets, dispersing more than 600,000 explosive bomblets into the 20x40-kilometer sector. More than 350 howitzers covered the attack with twenty-two artillery pieces for each kilometer of the attack zone.[29]

This application of Corps fires assets reinforces the principles of mass and unity of command, which VII Corps maintained through the dynamic portion of the ground war.

The VII Corps artillery was organized to be responsive. Bourque explains that the VII Corps kept its artillery "forward and engaged," noting that if the maneuver forces had been stopped, General Abrams "could have quickly massed 30 to 60 percent of the entire corps' artillery on any target."[30] General Funk and the 3rd Armored Division epitomized this forward and engaged mindset. Bourque details the unit's creative approach to employing its indirect fire in a way that enabled the division to rapidly mass its effects:

> Two distinct concentrations of artillery—as many as fifty guns and rockets apiece—were kept close so that when a major obstacle appeared, they could be immediately ordered into action to deliver an overwhelming mass of firepower. . . . Given the signal, battalions of rockets and guns would halt in place and orient themselves. . . . Then, under the control of the brigade fire support officer, guns of all calibers would open fire in unison.[31]

Employing artillery like this required two platform characteristics: the range to reach critical targets and the mobility to adapt to the rapidly changing front line. Consequently, range and mobility improvements became significant indirect-fire modernization factors after the war. In contrast, the artillery had ample destructive capacity for the first time since WWI, limiting the post-war emphasis on lethality.

Overall, the MLRS and highly destructive DPICM were successful additions to the force. Col. Vollney Corn Jr., the 1st Armored DIVARTY commander, and Capt. Richard Lacquement, the 1st Armored DIVARTY assistant operations officer, commented: "The system's accuracy and lethality quickly established itself as a critical part of our force artillery firepower."[32] They added that the DIVARTY "relied on the MLRS as our primary counterfire weapon, and in this role, we silenced all enemy artillery that fired at us."[33] In a similar assessment, Col. David Rolston, director of the Fire Support and Combined Arms Operations Department of the Field Artillery School, noted that the MLRS "decisively demonstrated its ability to shoot, move, and survive while inflicting tremendous damage," and its DPICM rockets "proved to be even more lethal than anticipated."[34] Though the artillery's area effects munitions proved their worth, its externally-guided precision round was less successful.

On 7 February 1991, the 1st Battalion of the 82nd Field Artillery fired the first Copperhead mission in the Gulf War, targeting two hardened observation posts that Iraqis used to view the terrain for miles near the Saudi Arabian border.[35] Lt. Col. Timothy Puckett, the fire support officer who coordinated the mission, explains that the forward observer was "to attack the buildings with Copperhead," then "observe the impact of cannon-delivered [DPICM]."[36] The observer provided laser designation for the smart round, then thirty seconds after the direct impacts on the observation posts, forty-six rounds of DPICM were fired to complete the destruction.[37] The brigade repeated this process over the next couple of days, firing four more Copperhead rounds and destroying two more observation posts before the ground war began; all four rounds were laser-guided and struck their intended targets.[38] However, not all Copperhead missions were successful. Other units reported missing their target, one by roughly 200 meters.[39]

Copperhead was accurate and effective, minus a few outliers, significantly reducing the number of rounds needed to accomplish a mission. Although the desert climate made laser guidance difficult, the Army fired more than ninety Copperhead missions in the Gulf War.[40] While the round's precision reduced certain sustainment challenges associated with high expenditures, the firing process was complex. The necessary coordination between the firing element and observer—who must employ their laser designation on the target to guide the round—inherently creates friction. Pucket, who experienced these challenges firsthand, warned future artillerymen that "employing Copperhead is not a trivial endeavor and has significant overhead."[41] He recommended that the resource-intensive Copperhead only be used against the most critical targets.[42]

Overall, Copperhead munitions did not play a significant role in the Gulf War. Because of the munition's performance in the war, only a couple thousand of these precision rounds were produced. Copperhead munitions were not funded after the war and gradually disappeared from the arsenal. While late Cold War lethality modernization provided the artillery with new capabilities, the developing technology also exposed potential protection problems.

Avoiding Protection Issues

Unlike their predecessors in previous wars, American artillery units in Desert Storm did not face the threat of encirclement or an overwhelming dismounted attack. Instead, these units faced two threats, one from enemy artillery and one from its own. Although the United States resoundingly won the artillery duel, a few instances during the war highlighted the potential threat posed by Iraqi artillery. During the battle of Medina Ridge, an Iraqi artillery battery launched rockets that wounded twenty-three soldiers and damaged several vehicles.[43] In another instance, Iraqi artillery units massed their indirect-fire systems against the 1st Armored Division while the unit conducted resupply operations, albeit with minimal effect. Bourque explains: "Hundreds of rounds landed . . . behind preregistered markers," and "for over twenty minutes, the Iraqi artillery pounded the empty desert without a single adjustment."[44] He described it as "a matter of poor Iraqi training rather than poor equipment," but warned "there was always potential for more effective action."[45] For US artillery units, these engagements could have been disastrous.

Field artillery units were exposed for two main reasons. First, Iraqi systems had better range. Corn Jr. and Lacquement explain that during the Gulf War, the Iraqi Army "had four cannon systems (GHN45, G-5, GCT and M-46) and two tactical multiple rocket launch systems (BM-21 and ASTROS) that could outrange MLRS."[46] Second, the VII Corps indirect-fire employment plan meant artillery units were perpetually near the front line. In the 3rd Armored Division, for example, Scales notes that the unit's leadership "pushed the artillery as far forward as possible to take advantage of every available meter of range."[47] At times, MLRS units were so far forward that launchers had to turn around and move back to get outside their minimum eight-kilometer safe distance range.[48] Because of the limited range of US artillery systems and the VII Corps indirect-fire employment plan, artillery units regularly found themselves well within striking range of and potentially outmatched by Iraqi artillery.

While the Iraqi military failed to capitalize on this advantage, the situation exposed a potential vulnerability that US artillery units could face on a post-Cold War battlefield. General Scales commented: "Although the Iraqis were never able to adjust fires to capitalize on the superior range of many of their artillery cannon weapons, they did highlight the pressing need to increase the reach of American cannons."[49] Capt. Gary Langford, who commanded an MLRS Battery during the war; Corn; and Lacquement all suggested that the MLRS maximum range should expand to at least fifty kilometers so the weapon would remain relevant as a counterfire and deep-attack system.[50] Similarly, Rolston commented that the US military was successful "despite the fact that most of the cannon systems represented 1950s or earlier technology," adding that "extending the range of both cannon and rocket systems must be a high priority."[51] US artillery platforms would need increased range to survive against a more competent adversary.

While enemy artillery posed a significant potential threat, the US military also needed to account for the danger presented by tiny bomblets from MLRS duds that littered the battlefield, waiting to strike an unsuspecting victim—friend or foe. The MLRS rockets, which were an exceptionally lethal tool, carried nearly ten times the number of submunitions per round as a 155-mm howitzer.[52] Although effective, these rockets were not held to the less-than-5-percent dud rate that was enforced on cannon DPICM.[53] In fact, certain models of rockets tested with dud rates in excess of 20 percent.[54] A congressional report on the handling of unexploded ordinance during the Gulf War estimated that if a single launcher fired its full load of twelve rockets, there would be anywhere from 154 to 1,777 unexploded bomblets left on the battlefield.[55] The US military fired thousands of these rockets in the short conflict, requiring American forces to travel regularly through minefields they had created.

The unexploded duds posed a danger, particularly when soldiers tried to collect them. Bourque explains that "these shiny metallic balls, each a little larger than a golf ball, were tempting acquisitions for novice souvenir hunters" as they "looked harmless and attractive."[56] The first 2nd Armored Cavalry Regiment casualty of the war resulted when a soldier picked up one of the bomblets and tossed it into his vehicle; the subsequent explosion wounded two soldiers.[57] After the Iraqi Army was defeated, these bomblets became one of the US military's toughest leadership challenges. Destroyed Iraqi military equipment became makeshift minefields. However, the danger was not limited to engagement areas where the Army could restrict movement around. Instead, DPICM munitions—designed to impact a large area with destructive effects—scattered these bomblets across the desert.

Despite ample warnings, soldiers from numerous units attempted to collect the bomblets as trinkets, often with fatal results. Bourque notes that these duds were "a problem that most leaders, including General Franks, believed the Army needed to address in the future."[58] Although not a central lesson learned from the war, reducing the number of duds would become a focus for future munition development as the unexploded ordnance problem started to garner political attention domestically and internationally.

In a congressional report after the war, Mark Gebicke, director of military operations and capabilities issues, noted that US submunitions killed at least twenty-five US military members, and many others were injured.[59] He explained that DPICM was intended for the Soviet mechanized threat where "US troops would probably be in a defensive position. Therefore, US soldiers were not expected to occupy submunition-contaminated areas."[60] Given the reduced threat from the Soviet Union, any future anti-armor artillery capability would need to reduce the risk to friendly forces.

Mobile Artillery

The final challenge for artillery was mobility. The rapid changes to the operational environment generated exploitable opportunities for friendly forces relative to the enemy. As a result, mobility would be key to the employment of indirect fire; self-propelled artillery would be essential to the division's mission. In particular, the M109 self-propelled howitzer was a very capable weapon for the Gulf War, even though it had been around since the 1960s. Corn and Lacquement explain that the M109 "proved its effectiveness in every battle with the Iraqi Army."[61] However, the system received mixed reviews.

The Gulf War demonstrated how fast the tactical situation on the ground could change, and artillery, even self-propelled artillery, struggled to match the speed of the maneuver forces it was assigned to support. Historian Richard Stewart comments that the US self-propelled howitzers "proved too underpowered to keep pace with mechanized and armored assaults."[62] Historians Frank Schubert and Theresa Kraus similarly concluded that although "the M109 155-mm. field artillery piece won praise for fire effect on targets," its mobility was lacking.[63] Scales acknowledged the same fault, concluding that "self-propelled cannon artillery can accompany the general pace of the advance but lack the 'dash' speed to conform to the close-in maneuver of modern direct fire fighting vehicles."[64] The Army needed to modernize its self-propelled system.

To improve mechanization, the artillery branch would need to invest in self-propelled artillery that can keep up with the armor and mechanized units it supports. Simultaneously, improvements needed to focus on increasing artillery ranges so that artillery units could provide support without staying abreast with maneuver forces. While this mobility conversation focused on self-propelled systems, it added to the overall mobility debate and raised questions about the future of towed artillery. If the 3rd Armored Division DIVARTY had used towed-artillery battalions instead of self-propelled battalions, would these units have been able to stay forward and engaged? While a four-day conflict does not provide enough information to dismiss towed artillery as a capability, it did highlight that towed equipment may not be designed to support some mission sets.

Lessons Learned from Combat Experience

The Gulf War was a one-sided conflict that favored the US military, which suffered only 383 deaths, of which 147 were from the enemy.[65] In contrast, Richard Stewart explains, "the Iraqis lost 3,847 of their 4,280 tanks, over half of their 2,880 armored personnel carriers, and nearly all of their 3,100 artillery pieces."[66] An MLRS battery commander during the war described the conflict as a "world-class live-fire exercise and test bed for America's latest generation of weapons."[67] Overall, the indirect-fire modernizations developed after the Vietnam War proved effective against the Iraqi Army, an opponent that presented a realistic array of tactical problems.

Army missiles showed promise but also highlighted airspace management challenges. While concerning, Scales argues that "problems with procedure and philosophy . . . should not diminish the fact that in Desert Storm the United States raised the execution of joint warfare to an unprecedented level of competence."[68] The development of anti-armor capabilities allowed indirect fire to be influential against mechanized and armored vehicles. Both artillerymen and maneuver forces viewed DPICM as a significant improvement to conventional artillery rounds. However, the Army acknowledged the need to mitigate the dud problem.

Rocket artillery proved its worth with its destructive capacity and ability to perform high-volume area-effects missions. McKenney notes that the war "highlighted the need for an organic rocket battalion rather than a battery in the division artillery."[69] In addition to arguing for longer ranges like many others, McKenney identified the MLRS's strategic mobility problem: "a wheeled rocket system, with the ability to be transported on C–130 aircraft, was needed for light and early deploying contingency forces."[70] Notably, this strategic mobility debate would heavily influence modernization efforts in the peace that followed the war.

While the US military secured a resounding victory, the Gulf War highlighted the dangers of a modern battlefield, particularly against a near-peer adversary. McKenney comments: "The precision-munitions revolution made forces vulnerable throughout the battlefield, and any firing system that could be detected risked being detected, engaged, and destroyed within minutes."[71] Though precision munitions made an appearance, the "revolution" would not consume the artillery community until the US military became bogged down in Iraq and Afghanistan over a decade later—examined in Chapter 6.

Applying Lessons from the Gulf: Capabilities-Based Innovation

The general defense drawdown that followed the Soviet Union collapse created challenges for military innovation in the post-Gulf War period. Texas A&M history professor Brian Linn comments: "The primary justification for the post-World War II military buildup had disappeared."[72] Consequently, the Army made drastic manpower reductions in the 1990s, shrinking by more than 250,000 soldiers. The field artillery branch was no exception. By the end of the decade, only 141 artillery battalions remained of the 218 battalions that were active during the Gulf War.[73] Part of this reduction included the dissolution of the remaining Pershing and Lance missile battalions—which officially ended nuclear artillery. Eight-inch howitzers, the largest caliber cannon, also were removed from the arsenal. The MLRS essentially assumed the role of all these platforms.

In the summer of 1991, the Field Artillery School conducted a conference to address the continued modernization of equipment and munitions.[74] Overall, Gulf War lessons were primarily positive. In their assessment of the war, Corn and Lacquement provide one of the best descriptions of the artillery's success: "Though the Desert Storm ground war lasted only 100 hours, the United States moved more forces, farther, in a shorter period of time, bringing more firepower on the enemy than in any campaign in US history."[75] To maintain the dominance it displayed during the Gulf War, however, the United States would need to continue to innovate and adapt. Moving forward, artillery innovation fit into two distinct categories: modernizing self-propelled artillery systems and enhancing anti-armor munitions.

Modernizing Self-Propelled Artillery

Desert Storm's high operational tempo solidified the importance of mobility for the artillery: the speed of the general advance coupled with rapid changes in the tactical situation forced indirect-fire assets to quickly adapt and travel across a large battlefield. To deliver the required rapid crisis response, the Army would need to create lightweight and deployable equipment. According to field artillery historian Boyd Dastrup, military leaders believed “strategically deployable, survivable, and lethal field artillery systems would replace the heavy systems fielded during the Cold War.”[76] After the war, the artillery community focused on mobility improvement for all types of indirect-fire assets. For towed cannons, this meant development of lighter howitzers that could be moved via helicopter. Even the MLRS was assessed for strategic lift requirements, and the Army decided to create a wheeled rocket launcher variant—the High Mobility Army Rocket System (HIMARS)—to maintain the lethality of DPICM rockets with a platform that was easier to deploy in a crisis.

This book focuses on tactical improvements to the Army’s self-propelled artillery systems. Desert Storm provided the Army with a glimpse at what a future mechanized conflict could entail. While successful during the war, self-propelled systems needed to improve to perform more effectively in a high-tempo conflict. To accomplish this, the development followed two separate paths: modernization of an existing system and creation of a new one.

Integrating New Technology into an Old Platform: M109A6 Paladin

The M109A6 Paladin evolved from a platform that had provided support to maneuver forces since the 1960s—upgraded and tested to ensure it could support modern operations. The Paladin was designed to conduct the same missions as the earlier M109 models, but as Col. John Rudman, chief of the Paladin New Equipment Training Team, described: “just do it all better, faster, more accurately and with a better chance of surviving the first encounter.”[77] As a benchmark, the Army established key requirements for each cannon to accomplish in a twenty-four-hour period: fire 254 rounds, make twenty-two survivability moves of 300–800 meters to avoid counterfire, and make two tactical movements of at least seven kilometers.[78] Lt. Col. David Valcourt, commander of the first Paladin battalion, explained: “We stressed the Paladin by firing over 12,000 rounds with four Paladins in just thirty field days.”[79] The battalion commander added that the upgrade allowed artillery to “maneuver like armor and infantry—our challenge is to master the techniques that allow us to do so.”[80] In its first rotation at the National Training Center, the Paladin proved its potential value for future conflicts.

Upgrades enhanced the vehicle’s speed and engine power, allowing the Paladin to move more efficiently across the battlefield; however, the most critical adjustments were to the vehicle’s responsiveness, truly impacting its mobility. Unlike older self-propelled models, the Paladin did not require any crew members to exit the vehicle to support a fire mission. Additionally, incorporation of a global position system (GPS) allowed the vehicle to stop, shoot, and then quickly move again. Building off the shoot-and-scoot success of the MLRS, the Paladin developed the capability to process a mission on the move, known as a "hip shoot." While moving, a Paladin could receive a mission digitally into its fire-processing computer then adjust and shoot at a target within about sixty seconds.[81] Compared to previous models that typically took ten to eleven minutes to accomplish this task, a sixty-second hip shoot provided maneuver forces with timely fire support while also enabling the artillery unit to resume its movement quickly after it received the mission.[82] This process greatly enhanced the artillery's ability to move cannons around the battlefield and continuously adapt to tactical situation changes. Additionally, this technique allowed artillery units to conduct interdiction raids deep into enemy territory while limiting their exposure to enemy counterfire.

Though the Paladin was a major improvement in self-propelled artillery, it was not regarded as the platform of the future, even while under development. Maj. Gen. Joseph DeFrancisco, commander of the first divi-

Figure 4.2. Paladin deployed to Iraq. Source: Janice E. McKenney, *The Organizational History of Field Artillery 1775–2003*, Army Lineage Series (Washington, DC: US Army Center of Military History, 2007), 321.

sion that fielded the new Paladin, described it as "great, but it's an interim step. It bridges the gap between our old friend, the basic M109 howitzer originally built in the 1960s, and Crusader—a new weapon system for the twenty-first century."[83] The Paladin completed fielding by 1998, with a new platform planned to replace it as early as 2005.[84]

The Future of Self-Propelled Artillery: The Crusader

Scheduled to replace the Paladin at the beginning of the twenty-first century, the Crusader self-propelled howitzer represented the future of cannon artillery by incorporating modern technology and equipment. The RAND Corporation explains that the "Paladin remains a very capable weapon, but it is increasingly clear that it is no longer on the leading edge of howitzer development."[85] The Crusader had an increased rate of fire of nearly three times that of the Paladin and a maximum range of forty kilometers; it could maximize its firing capability for a short period by shooting ten to twelve rounds per minute for up to five minutes.[86] To accomplish this, the Crusader used modern technology to automate numerous tasks, including loading rounds into the tube, reloading the vehicle, and processing multiple aspects of the fire missions. Consequently, the Crusader could reload much faster than the Paladin, potentially allowing more missions in a high-tempo battle.

The new system also reduced some logistical challenges associated with resupply. The Crusader was capable of a sixty-round reload and refuel in twelve minutes—approximately half the time to complete a Paladin reload.[87] The Crusader's general fire support capability also was substantially better than the Paladin. According to the RAND assessment on the new platform: "The efficiency of Crusader may allow a battery to carry out the mission of a battalion, or a single gun to replace a platoon, so that force size, logistics burden, and deployment load may be reduced."[88] This efficiency was more than just firing rounds faster; the Crusader could perform a new unique mission set that would greatly increase the ability of artillery units to mass effects: the multiple-round simultaneous impact (MRSI) mission.

To conduct an MRSI mission, a single howitzer fired numerous rounds in quick succession at different angles, allowing all the rounds to hit the target near simultaneously. In 2001, the Operational Test and Evaluation Division validated the concept, successfully conducting a four-round MRSI with a Crusader.[89] Despite this success, Crusader field tests identified minor technical issues, primarily with software—an essential aspect

Figure 4.3. Crusader Test Fire. Source: "FY 2000 Annual Report for the Office of the Director, Operational Test & Evaluation" (annual report, Department of Defense, Washington, DC, February 2001), 59, https://www.dote.osd.mil/annualreport/.

of the new system.[90] Additionally, the Army's shift to a more lightweight force meant that the artillery branch needed to redesign the Crusader so that a single C-17 aircraft could carry two.[91] This overhaul, coupled with competing requirements to support a national strategy focused on crisis response, raised questions about the future of the platform.

RAND Corporation analysts concluded that although the Crusader would be a huge capability improvement, the Paladin was able to cover the current mission set for cannon artillery.[92] Their report proposed continued development of rocket artillery and phasing out cannon artillery so funds required for Crusader development could be applied to other weapons programs. The Crusader was subsequently canceled in 2002. Secretary of Defense Donald Rumsfeld declared that future enemy threats did not require an advanced self-propelled artillery system and decided to invest instead in other emergent technologies.[93] Absent a capable near-peer adversary, the artillery branch's budgetary ceiling for innovation is likely to remain lower, in relative terms, than since the end of the Second World War. Concurrent to pursuing new platforms, the Army had to balance its limited budget to address a much more pressing problem, its dangerous dud-producing munition.

Destructive Capacity: Improving Anti-Armor Capabilities

Although DPIMC was effective in the Gulf War, the unexploded duds endangered US forces and the civilian non-combatants. This issue gained international attention and brought leadership in front of Congress to discuss the issue. The Army addressed the dud issue as it did self-propelled systems by enhancing its current DPICM rockets and developing a less-dangerous replacement round.

While the evolution of the M26 DPICM rocket after the Gulf War focused on the reduction of duds, it also addressed range issues identified during the war. A new program—known as extended-range MLRS (ER-MLRS)—developed an improved model of the rocket with a range exceeding forty kilometers. A Defense Department report explained that the need to increase the range of the DPICM rockets was "based on the experiences of Operation Desert Storm and the continued threat of the proliferation of longer-range artillery systems."[94] To achieve the extra distance, the rocket motor size was increased and the warhead size decreased, reducing the number of submunitions each rocket carried from 644 to 518.[95]

The first attempted upgrade—the M26A1—included a new submunition with a self-destruct feature on each bomblet.[96] This would greatly reduce the number of duds and made the DPICM more viable to support maneuver operations. The new submunition, however, repeatedly experienced issues during testing, and the new rocket was in danger of not being fielded. The Army decided to move forward with the new rocket but gave up on the more efficient submunition. Given the problem that duds created in the Gulf War, this decision raises questions about the importance of lessons learned in combat, as it directly conflicts with assessments from senior leaders who were involved.

Although the new ER-MLRS rocket was better than the Gulf War model, it never moved into full production. The Defense Department established that only 4,332 extended-range rockets would be created and that the limited "quantities [would] be used to meet an urgent need for extended range capability by US Forces, Korea."[97] Without a tangible threat to drive development, however, the priority for research had started to shift toward precision for crisis management, a capability that would become the forefront of innovation in the next decade. For the future war, the extended-range DPICM rockets were limited in quantity and remained prone to leaving duds on the battlefield.

To resolve these issues, the Army designed a safer alternative munition that replicated DPICM's destructive capability and increased its accuracy against armored vehicles. The new sense and destroy armor (SADARM) munition was fired like a normal 155-mm projectile, and it was the Army's first target-locating indirect-fire munition. The Army designed the new munition to identify and destroy lightly armored vehicles. Each projectile ejected two parachute-dropped sub-munitions that used infrared and millimeter-wave sensors to scan a 150-meter diameter circular area. If a target was identified by the sensors, the submunition created an explosively formed projectile that was unleashed into the top of the enemy vehicle. To ensure that no unexploded ordnance was left on the battlefield, the submunition self-destructed if the sensors did not locate a target.[98]

Initial SADARM testing, which began in the summer of 1993, ran into numerous issues. Although the munition was successful at short range, it initially had limited success beyond fifteen kilometers, and the submunitions often had mid-air collisions when multiple volleys were fired.[99] The Army projected a need for roughly 47,000 SADARM projectiles; however, because the round repeatedly failed to achieve the required 80-percent reliability rate, full production was not funded.[100] Although only a limited supply was produced, SADARM exceeded destructive capability estimates. It not only destroyed enemy self-propelled artillery as

Figure 4.4. SADARM Test Fire. Source: "FY 2000 Annual Report for the Office of the Director, Operational Test & Evaluation" (annual report, Department of Defense, Washington, DC, 2001), 165, https://www.dote.osd.mil/annualreport/.

intended, but also proved effective against tanks. In 1999, as part of one of the final tests, M109A6 Paladins fired ninety-six SADARM projectiles at armored vehicles that were leveraging radar-defeating camouflage and berms as countermeasures to the sensors.[101] Lt. Col. Michael Walker and Maj. John Gillette described the new munition as "more lethal than any 155-mm round in the world," adding that "a direct hit with SADARM is catastrophic to armored vehicles."[102] The new munition had the potential to alter artillery's role on the battlefield.

The SADARM greatly enhanced the artillery arsenal, offering destructive power comparable to or greater than an ICM and target precision without the complexity of Copperhead. Maj. Gen. Toney Stricklin, the 1999–2001 chief of artillery, noted that SADARM "significantly enhances proactive counterfire while reducing our munitions logistical burden. . . . The force requires fewer transport assets to bring the same or greater munitions lethality to the battlefield."[103] In addition to requiring fewer rounds, the new munition achieved high accuracy without a need to spot the target, thus remedying the coordination challenge that plagued the Copperhead round. Before the Iraq War began in 2003, Army leaders were optimistic about the future of SADARM munitions. In a summer 2000 article, Maj. James Chapman referred to the SADARM as the "most lethal munitions in the world today . . . [a] smart munition that can kill artillery or render entire tank formations combat-ineffective from long distances in a matter of minutes."[104] The round was defunded after only a small number was produced; however, the artillery community believed it was a valuable tool, and the Army would test its effectiveness in combat in 2003.

Lessons Learned from Incorporating New Technology

During the decade that followed the Gulf War, the artillery community persistently attempted to apply new technology via lessons learned from combat. Many projects from this period were abandoned, which naturally raises questions about how well this form of innovation suits the US military—primarily for budgetary reasons rather than because it was too complex. Additionally, the lengthy process from concept to completion often spanned numerous administrations; changing priorities may have resulted in the termination of some programs. In any case, technology-intensive innovation produced only partial solutions to capability needs identified in the Gulf War.

The continued development of anti-armor munitions, while structured to fix specific issues, produced only minor improvements. Although lessons from the Gulf War identified the need for a DPICM rocket range increase out to at least fifty kilometers, the range of the ER-MLRS fell well short. On top of this, the Army abandoned its new and safer submunition that was designed to prevent US and civilian casualties. The SADARM round also represented a safer alternative to DPICM with improved destructive capability, reduced logistical burden, and better precision. Although SADARM production was terminated after only a few thousand rounds, the Army would test the munition in the next conflict to determine its viability.

Regarding mobility—a key Gulf War lesson—the artillery chose to adapt its current weapon system as well as develop a new platform. The Paladin—an adaptation of a very old piece of equipment—offered significantly improved capability, allowing artillery units to rapidly process fire missions while on the move. However, it did not advance self-propelled artillery as senior leaders had desired. The Crusader, on the other hand, not only fired rounds farther and faster, but its capabilities outperformed the Paladin by such extremes that far fewer artillery pieces would be needed. Despite these features, the Crusader's advanced capabilities were deemed unnecessary before it was fielded to units, and the program was terminated.

In short, innovation following the Gulf War was grand in scope but limited in effect. Although key equipment was adapted to address capability needs, innovation efforts failed to produce desired results.

Conclusion

As the 1990s drew to a close, the US Army's reputation as a large and powerful military was in question. The concern with large-scale combat operations that dominated the late Cold War was replaced by a rising concern with crisis response, a strategic framing that prioritized agility, precision, and collateral damage avoidance over firepower. While post-Gulf War innovations attempted to address combat lessons learned, the efforts failed. Although Army capabilities had not improved, the artillery branch was still ready for high-intensity conflict—as long as the threat did not involve a peer-level adversary.

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Chapter 5
The Global War on Terror and the Rise of Precision Munitions

The 11 September 2001 attacks, and the Global War on Terror (GWOT) that followed, provided the US military with a new purpose and ample combat experience to adapt to a less conventional type of warfare. The wars in Iraq and Afghanistan, while primarily counterinsurgency (COIN) operations, also included short surges of more conventional operations that required employing indirect fire. The 2003 invasion of Iraq, specifically, reinforced lessons and challenges of a high-tempo conflict. This short and decisive battle tested the field artillery platform and munition innovations from the prior decade. However, the transition to COIN and the period of innovation that followed demonstrated a disregard of previous lessons learned. The field artillery abandoned destructive capacity, dissolved its division artillery (DIVARTY) organization, and emphasized precision-only development, resulting in questions about whether combat experience should drive adaptation by the US military.

The recent GWOT period and the general absence of an external threat make this chapter distinct. Consequently, the following analysis does not follow the structural delineation of earlier sections, which began with an examination of combat experience followed by peace-time innovations. Instead, it acknowledges that continuing conflicts in Iraq and Afghanistan highlighted how the shifts in the character of war and the artillery's changing role drove indirect-fire innovation and adaption. This chapter assesses employment of indirect fire during the invasion of Iraq, then evaluates artillery innovation during the GWOT period. Finally, it discusses the organizational adaptation that deactivated the DIVARTY headquarters.

A Tale of Two Invasions

For roughly two decades, operations in Afghanistan and Iraq consumed the US military's attention. While often lumped together as broader GWOT-era conflicts, these wars presented drastically different problem sets. Consequently, their impact on indirect-fire capabilities innovation and adaptation is not weighed the same. This analysis focuses on indirect fire's role in these conflicts. The Iraq conflict, particularly in the early years, deserves more attention, because it was a testbed for modern capabilities. The Army's early indirect-fire employment mirrored that of a high-intensity conflict—albeit on a much smaller scale. In contrast, the role of artillery in the initial Afghanistan invasion was essentially absent.

When the United States invaded Afghanistan, indirect-fire platforms like howitzers and the highly destructive multiple-launch rocket system (MLRS) were not part of the initial package. Historian Richard Stewart explains that the mission relied on the "application of discrete military power," leveraging airpower as the ground force's primary tool of destruction.[1] Terrain played a significant role in this tactical decision. While road networks in Iraq supported more conventional ground movement, Afghanistan required a reliance on airlift, complicating any artillery employment and sustainment. Although the Vietnam War prepared the artillery community to move and distribute howitzers around an austere and dispersed battlefield, the tactical situation did not necessitate establishment of dispersed tactical firebases on mountaintops—at least not yet. This is not to say that the howitzers were not missed. Historians Richard Kugler, Michael Baranick, and Hans Binnendijk note that in Operation ANACONDA in 2002, "even a few artillery tubes . . . would have made a helpful difference."[2] However, even as artillery's role in Afghanistan grew, it remained comparatively limited.

While the Army eventually leveraged indirect fire to support dispersed operations, it did not play the preeminent role it had in previous wars. In examining the early parts of the Afghanistan campaign, historians Charles Briscoe, Richard Kiper, James Schroder, and Kalev Sepp commented: "Artillery was never a factor in this war."[3] In contrast, other prominent GWOT engagements during the invasion relied heavily on indirect fire.

In the spring of 2003, the United States made a strategic decision to overthrow Saddam Hussein's government. Like the Gulf War a decade earlier, the invasion of Iraq required the US military to rapidly cover a vast area in a short amount of time to attain its tactical objectives. Although the initial invasion plan involved deploying forces through Kuwait and Turkey, the Turkish government denied the United States access as the operation approached.[4] This constraint altered the invasion plan; US troops deployed mainly from Kuwait in a mechanized race to secure Baghdad.[5] Approximately a month after the initial 19 March invasion, the conventional phase of the conflict ended with a presidential declaration that major combat operations were complete.

During the invasion, the Army's combat forces fell under the V Corps, and a small contingent supported the I Marine Expeditionary Force. These forces included the 1st Armored Division, 3rd Infantry Division, 101st Air Assault Division, a task force from the 82nd Airborne Division, and 4th Infantry Division. In contrast to the limited role that indirect fire played in the Afghanistan invasion, the US military brought ample artillery to the Iraqi border before conducting operations.

The 3rd Infantry Division provided mobile firepower as the V Corps' lead element. The division had eighteen MLRS platforms and fifty-four Paladins across its formation; in contrast, the towed artillery—sixty platforms—resided in the 101st Air Assault Division.[6] Notably, the 3rd Infantry Division DIVARTY and 4th Infantry Division DIVARTY had MLRS battalions for the Iraq invasion, in contrast with the MLRS battery that was generally allocated to support divisions in the Gulf War.[7] The V Corps Artillery also retained control of the 17th and 41st Field Artillery Brigades—five MLRS battalions, a Paladin battalion, and numerous target acquisition detachments—to provide general support fires across the theater.[8] Additionally, the Army employed three high-mobility rocket systems (HIMARS) to support special operations; this was the first use of the new lightweight MLRS variant.[9] While artillery was abundant, Lt. Col. William Pitts, field artillery chief of Doctrine Division during the Iraq Invasion, noted that the conflict had "the lowest ratio of artillery pieces-to-troops in war since before WWI."[10] Consequently, maneuver forces leveraged airpower—fixed and rotary wing systems—in conjunction with indirect fire.

The 3rd Infantry Division led the charge from Kuwait to Saddam's presidential palace. Similar to a decade prior during the Gulf War, the MLRS batteries shaped the battlefield with Army tactical missile systems (ATACMS) and dual-purpose improved conventional munition (DPICM) rockets to open the war for the Army.[11] Artillery units also enabled the initial breach, balancing the requirement to provide shaping fires with joining the maneuver forces in the race to Baghdad. Military historians Gregory Fontenot, E. J. Degen, and David Tohn detail this initial indirect-fire mission:

> Five artillery battalions supported the breach, firing simultaneously against eleven targets with a total of 458 artillery rounds. The direct support battalions, assigned to provide artillery fires primarily for their respective BCTs [brigade combat teams], fired from positions that facilitated their ability to move with the units they supported. Thus, the artillery could provide fires for the infantry and armor units during the breach and on through the attack.[12]

The three-week contest that followed gave the artillery a chance to test its capabilities in a one-sided conflict. While some issues identified during the Gulf War reappeared, indirect fire proved its worth in the initial phase of the war.

Retaining the Crown

The artillery earned its "King of Battle" moniker through its lethality. In the decade that followed the Gulf War, the Army's modernization efforts focused on making its most lethal tools safer. While a dud-free DPICM round did not come to fruition, the sense and destroy armor (SADARM) munition showed great promise during experimentation, even if it never reached full production. While limited in quantity, the SADARM munition was successfully employed during the initial days of the Iraq invasion and proved more lethal than expected. In fact, the first SADARM rounds fired destroyed a T-55 tank.[13]

Although DPICM was still the primary munition for destroying armored vehicles, in the twenty-one days of fighting, the 3rd Infantry Division fired 108 sense-and-destroy-armor munitions (SADARM), destroying forty-eight vehicles.[14] These missions validated the new munition as a safer alternative to DPICM, as the round destroyed and dispersed Iraqi armored vehicles without creating a minefield. In an interview with *The Field Artillery Journal,* Brig. Gen. Lloyd Austin, the 3rd Infantry Division deputy commander during the invasion, explained that his division "killed a number of [vehicles] quickly with SADARM," describing the new munition as "incredible" and "a keeper."[15] Austin was impressed with the effectiveness of the SADARM round.

While the Iraqi military would once again lose the artillery duel, the diversity of indirect fire missions tested the capabilities of US artillery units. The most pressing of these missions was providing close support to maneuver forces. Notably, the way the Iraqis fought emphasized the "close" aspect of this mission. The US military routinely called in artillery strikes and used aircraft for "danger-close" missions in close proximity to friendly forces. Fontenot, Degen, and Tohn explain that the rounds were "so close to the friendly troops that they were likely to produce both friendly and enemy casualties."[16] The tactical situation on the ground—the Iraqi fighting style combined with the urban terrain—made these danger-close missions a norm. The inherent risk to friendly troops did not deter the 3rd Infantry Division from leveraging the increased accuracy of indirect fire, calling in numerous danger close missions in the initial phase of the war.[17]

While the US military did not lose many of these engagements, some well-organized attacks threatened to create tactical disasters for the Army. The 1st Battalion, 10th Field Artillery Regiment, supported such an engagement, firing a final protective fire (FPF). An FPF is a last line of defense in which all available assets are committed to overwhelming the enemy with firepower at pre-designated targets. Fontenot, Degen, and Tohn detail the 7 April 2003 engagement:

> The 1-10 FA entered the firing data for [the] FPF and other planned missions into the computers of their Paladin howitzers and waited for the call. When the order came to fire the final protective fires, 1-10 FA unleashed thirty minutes of continuous rapid fire, pounding the attacking Iraqis and placing a protective wall in front of the hard-pressed [maneuver element]. . . . Artillery, air-delivered strikes and direct fires in combination stopped the enemy cold.[18]

Although indirect fire proved its worth, it was not without fault. Notably, many of the issues Army leaders identified had been addressed previously.

In the summer of 2003, Col. Thomas Torrance, 3rd Infantry Division DIVARTY commander, and Lt. Col. Noel Nicolle, 3rd Infantry Division deputy fire support coordinator, shared the DIVARTY's experiences in their article, "Observations from Iraq: The 3d Div Arty in OIF."[19] In addition to detailing the organization's successes, they provide a valuable assessment of artillery shortcomings during the conflict. One major deficiency during the high-intensity fighting was the limited range of US artillery. Torrance and Nicolle explained that "the Paladin was easily outranged by Iraqi cannon systems," adding that the unit often "had to position well forward in the maneuver formations during movements," creating "force protection concerns" for artillery.[20] This problem of limited range and the associated protection issues had plagued artillery units since the Korean War.

It was not only cannons, however, that faced issues with range. Only a limited supply of extended-range MLRS (ER-MLRS) had been fielded in 2003, and the standard DPICM rocket barely reached thirty kilometers. Overall, the limited range of US artillery systems in Iraq forced the 3rd Infantry Division artillery platforms into precarious positions. On twenty separate occasions, the 3rd Infantry Division DIVARTY acquired enemy artillery but could not fire against them because of the limited MLRS range.[21] Putting this range mismatch into perspective, the DIVARTY leadership noted that "the Iraqis had four cannon systems and two rocket systems that outranged MLRS."[22] Unlike the North Koreans a half-century earlier, however, the Iraqi military did not capitalize on this advantage, resulting in no more than missed opportunities, rather than equipment abandoned and destroyed. In after-action reports, 3rd Infantry Division leaders identified the need to extend the range of artillery to fifty kilometers, similar to recommendations following the Gulf War.[23]

In addition to range issues, the Army was forced to deal with the same dud problem posed by DPICM rockets that had inadvertently killed US service members a decade prior. Torrance and Nicolle explained that "the duds produced by these weapons became a major concern in post-combat stability and support operations . . . as they littered the battlefield and created a hazard to the local populace."[24] Leftover duds were not just a tactical challenge. In the years that followed, the international community would make a concerted effort to remove weapons like DPICM from the battlefield, significantly impacting the destructive capacity of artillery. Another often-overlooked concern was the coordination requirements of conducting indirect-fire missions in an increasingly congested sky.

Increased Coordination: Airspace Deconfliction and DIVARTY

In the decade following the Gulf War, the Army improved its ability to leverage all available fire support assets. Fontenot, Degen, and Tohn noted that "effective integration of artillery and Army attack aviation produced, in several instances, the kind of synergy conceived in joint manuals and practiced in training over the decade since Desert Storm."[25] While the Afghanistan invasion highlighted the Army's growing reliance on airpower, Iraq was an opportunity to leverage the air in conjunction with its organic indirect-fire assets.

Crowded airspace was not a new challenge for artillery units, but it was essential for the Iraq conflict. The US military applied airspace deconfliction techniques that had proved successful in Vietnam and Kuwait. In addition to previously discussed lateral separation of artillery fires and aircraft on different sides of terrain features, the Iraq approach included a highly coordinated temporal separation, so that effects impacted consecutively instead of concurrently. This coordination was critical for employing ATACMS, a weapon with an increased role on the Iraq battlefield.

The missile was an emerging technology during the Gulf War, with the Army firing roughly thirty in that conflict.[26] In contrast, the Army fired more than 400 of the missiles in the 2003 invasion.[27] Notably, the Army introduced a unitary missile variant, firing thirteen in the invasion.[28] Instead of DPICM submunitions, the unitary variant was a simple high-explosive (HE) missile with effects comparable to a 500-pound bomb dropped from an airplane. Beyond its pre-invasion shaping role, ATACMS provided the Army with a tool to enable airpower.

Suppressing enemy air defenses had become increasingly important since the Yom Kippur War, and ATACMS proved an invaluable asset in this endeavor. The missile's range and payload allowed the Army to impact a large swath of terrain, enabling safer passage for both fixed and rotary wing aircraft. These missions were often delineated by time, with an ATACMS salvo impacting just before the aircraft reached the area. However, Fontenot, Degen, and Tohn contend that "the Iraqi air defense 'system' was arguably not vulnerable to traditional SEAD [suppression of enemy air defenses] operations," adding that Army missiles and Air Force bombs "could not realistically suppress several hundred Iraqis distributed throughout a densely populated urban area firing small arms and light air defense artillery."[29] Nevertheless, this coordination, coupled with other indirect-fire challenges, reinforced the importance of the DIVARTY headquarters.

The 2003 invasion experiences validated the importance of the DIVARTY and raised questions about how much capability the organization would need in future conflicts. Large-scale combat operations require artillery assets to support distributed operations across large distances and coordinate with the joint force. Thus, strong central control of indirect-fire assets ensures missions are prioritized for the overall operation and assets are not wasted. Austin reinforced this sentiment: "When the division goes into a fight, the [DIVARTY] is a critical piece of it."[30] However, the age-old argument of allocating artillery to the lowest echelons soon resurfaced, reinforced by the increasing role of aircraft in land operations. As early as 2004, Fontenot, Degen, and Tohn commented that "the Army and joint community may find ways in which joint interdependence can reduce the number of certain kinds of formations. . . . If the air component will commit to attacking deep targets that support tasks assigned to the land component, the land component may require less artillery."[31] Changes of this nature are examined later in this chapter.

Overall, while artillery was absent from Afghanistan, it proved highly effective against the Iraqi military in 2003. Importantly, the conflict reinforced the effectiveness of anti-armor artillery. Pitts comments that the invasion "brought to the forefront that indirect fires remain the biggest force multiplier and killer on the modern battlefield."[32] Additionally, the ATACMS proved a strategic-level munition for the Army, and the unitary variant delivered capabilities that were comparable with Air Force bombs. The successful use of the unitary ATACMS in Iraq would drive innovation in the next decade as the military would be forced to support continuous urban operations, an environment that DPICM is not suited for.

Even before the conflict began morphing into a counterinsurgency, however, indirect fire had shown its potential to endanger civilians and infrastructure. At the forefront were the duds left behind by DPICM munitions, a problem that the Army would eventually address. Additionally, the urban aspect of the conflict meant that civilians were often on the battlefield. Fontenot, Degen, and Tohn note that the Iraqis "used human shields with fairly good effect," adding that "more than once aviators, who could see planned artillery targets from overhead, waved off fire missions due to the presence of civilians on the scene and intermingled with militia or Iraqi troops."[33] The battlefield was changing, and artillery munitions needed to change with it.

A Shift to Counterinsurgency and an Urgent Need for Precision

While the Iraq war was instructive, innovation over the following decade would be driven by the drastic change in military objectives rather than combat experience—shifting from defeating a military to stabilizing a country. In both the Iraq and Afghanistan conflicts, the Army's shift to COIN operations changed the role of indirect fire. Maneuver forces still needed indirect fire, but the Army would have to balance the tactical benefits of destruction with the operational risk of strengthening the insurgent's narrative. The most obvious solution was to improve accuracy. Maj. Gen. David Ralston, the 2005–2007 chief of field artillery, astutely noted that "even successful stability and nation-building operations have brief spikes of intensity calling for rapid, pinpoint lethality."[34] Consequently, a late 2004 assessment conducted by the commander of Multi-National Corps-Iraq identified an urgent need for a new type of indirect fire suited to urban operations, with three key attributes: limited collateral damage, target precision, and no unexploded ordnance.[35]

Use of indirect fire in a COIN conflict requires a higher level of caution and precision than a conventional conflict. Victory is not determined simply by killing enemy forces, and civilian casualties or damage to infrastructure strengthens the enemy's cause. During the first battle of Fallujah, the narrative of indiscriminate artillery barrages elevated the tactical military choices to the international level, creating operational effects. Military historian Jon Hoffman details this situation:

> When the al-Jazeera network reported that American artillery and air strikes were inflicting casualties on civilians, the Iraqi Governing Council asked Ambassador [Paul] Bremer to halt military operations. Other Sunni-dominated Arab nations also brought political pressure to bear on the United States, leading the Coalition to declare a unilateral cease-fire in Fallujah on 9 April.[36]

The realization that a ground commander's tactical choices could so rapidly garner international attention meant that the Army needed to retain release authority of such munitions at higher levels, one where a commander could weigh the risk to the forces against the overall risk to the mission. Historians Donald Wright and Timothy Reese discussed the need for control during the first two years of the Iraq conflict:

> More than a few celebrated cases of airstrikes and artillery missions that missed their targets or hit noncombatant targets indicate potential over-reliance on firepower and too much disregard for its imprecision and potential for collateral damage. Increasing precision continues to reduce the likelihood of error, but in stability and counterinsurgency operations, a more careful weighing of costs and benefits is imperative.[37]

This "careful weighing" meant choosing which indirect fire missions to execute and which to deny, often causing frustration to soldiers in need.

The Army regulated indirect fire in Iraq and Afghanistan to avoid unnecessary civilian casualties and damage to infrastructure. Often, this simply meant having clear rules of engagement. During 2007 in Afghanistan, US ground forces only targeted a building with indirect fire if hostile forces were actively engaging them from it or if they had confirmed that the building had been abandoned.[38] If indirect fire was not feasible due to collateral damage concerns, airpower provided a viable option for forces in direct contact. Consequently, although it is not examined in this work, many field artillery observers started receiving extra training in joint fires. The Army even created a certification course and a skill identifier. The more challenging indirect-fire mission to balance was counterfire.

To be effective, counterfire missions require a rapid response. GWOT insurgents often abandoned their mortar or rocket firing points as soon as they fired, and it took time for the US military to determine if the point of origin was free of civilians. As a result, these missions were generally ineffective or not conducted. Todd Brown, a 4th Infantry Division company commander in Iraq from 2003 to 2004, expressed his frustration with counterfire missions:

> The higher-ups won't fire counterfire despite what everyone says. . . . Every time they get a ten-digit Q36, we should fire it up with white phosphorus. That is the only way you will get them . . . unless it's in the town, but it hasn't been. I don't know. I guess we are concerned about the crops or something. The only way insurgents learn is through violence.[39]

Brown, like many officers in the war, struggled with the implications of selecting which tactical targets were worth the risk of employing the Army's most destructive tools. In one instance, he confesses to taking matters into his own hands, explaining that "since they wouldn't fire counterfire, we did. We went to the grid and stood on line with all the M203 gunners and lobbed rounds into the orchard."[40] He justified these actions, and unobserved fires as a concept, explaining that "shooting at unknown targets sucks and is sometimes cruel, but it definitely works. It is war, and more Americans will suffer and die if we fail to act."[41] Despite incidents when units were advised not to engage, indirect fire was still a necessity for large operations.

During Operation Rock Avalanche in Afghanistan in 2007, for example, maneuver forces relied on indirect fire to destroy the enemy's makeshift strongholds. Authors Brian Neumann and Colin Williams described the need for indirect fire in such situations: "Every family compound the Americans faced could become a hardened fort that could be cleared only with artillery support."[42] They also addressed the balance that the US military had to maintain: "Regrettably, such methods resulted in civilian casualties, which naturally intensified hostility from local villagers."[43] The second battle of Fallujah, a continuous battleground in the war, provides the ultimate example of this challenge.

In November 2004, the US military launched one of the bloodiest battles of the Iraq War when it sealed off the city of Fallujah and treated the insurgency inside like a conventional military. US forces, led by the US Marine Corps, employed aircraft, artillery, and mortars in a dense urban environment. The battle required synchronization of assets, as each battalion could employ rotary wing and artillery with minimal coordination while fixed wing aircraft maintained overhead close air support.[44] The unusually high priority assigned to protecting civilians and infrastructure adds an extra measure of complexity for militaries employing indirect fire in COIN warfare.

Consequently, even though the massing of these assets was tactically necessary, it had unintended consequences. Historians Timothy McWilliams and Nicholas Schlosser discussed the long-term effects of the battle:

> Although the Marines took great care to utilize artillery and air strikes as selectively as possible, there were civilian casualties, with an estimated 220 Iraqi civilians killed during the first two weeks of the fighting. Insurgent propaganda organs subsequent-

> ly exploited these events and characterized the Marine offensive as excessively brutal and heavy-handed.[45]

US troops achieved their tactical objectives in Fallujah, but the damage to the city had far broader implications, as Wright and Reese explain:

> Coalition forces directed thousands of artillery shells, mortar rounds, and bombs at targets in the city. Urban combat against a defender willing to fight hard has historically driven the attacker to use massive amounts of firepower; the second Battle for Fallujah was no exception. However, this reliance on firepower, especially indirect fire and close air support, created a different problem once the battle was over. How would the Coalition deal with the destruction it caused in Fallujah and avoid creating more insurgents out of those who had fled the city and lost their property?[46]

In all, roughly 18,000 buildings were damaged or destroyed—nearly half of all the buildings in the city.[47] Lt. Gen. John Sattler, commander of US Marine Forces Central Command, discussed the importance of indirect fire in the Second Battle of Fallujah, noting that the US military "fired more than 6,000 artillery rounds during the battle."[48] When asked if precision-guided munitions (PGM) could have helped in the battle, he simply replied, "absolutely I could have used them."[49] Precision and the avoidance of collateral damage would drive artillery innovation following the battle.

Combat lessons from the Iraq invasion, such as the importance of anti-armor artillery, were relegated to the history books. Instead, the military needed precision lethality to wage its insurgencies. Consequently, the US military changed the focus of its artillery development efforts to creating these new munitions. In turn, the artillery's destructive capabilities would diminish drastically during the GWOT era, a process that started with altering the role of rocket artillery.

The Evolution of Rockets to Low Collateral Damage

As early as the 1950s, rocket artillery demonstrated a greater potential for precision than cannon munitions. Responding to the urgent need for precision in the Middle East, the US Army expedited its project to develop a guided munition for the MLRS known as GMLRS (guided multiple-launch rocket system). The GMLRS provided a precision addition to the already highly effective MLRS. The internally guided rocket carries a 200-pound fragmentation warhead that could range upwards of seventy kilometers.[50] Additionally, because of the MLRS's pod construction, a single multi-rocket platform could fire six of these new rockets at six distinct aim points in proximity to each other and have only a five-second interval between each rocket fired.

Similar to the Copperhead round developed after the Vietnam War, however, ensuring accuracy was a highly complex process. The GMLRS rockets traveled long distances and required close coordination to ensure rockets did not collide with friendly aircraft along the way. This challenge not only limited aircraft operations while rockets were employed, but the initial process of clearing the airspace could be time-consuming, thus lowering the tactical responsiveness of the artillery units.[51]

The first GMLRS rockets were rapidly fielded to units in Iraq and immediately produced devastating effects. In September 2005, for example, an artillery unit fired eight rockets over fifty kilometers, destroying two enemy strongholds and killing forty-eight insurgents during the first GMLRS combat mission.[52] Less than a year after it was introduced, GMLRS-equipped units fired more than 100 rockets, and the Army approved the rapid production of 1,000 more.[53]

The new GMLRS rounds also proved effective in Afghanistan. With increased ranges compared to anything a howitzer could fire, rocket artillery units could support large operational areas. While small unit engagements rarely needed a high volume of these precision rounds, Wright details a September 2010 mass casualty situation that ended with a precision barrage. A small unit stumbled on a string of improvised explosive devices while preparing to clear a town—suffering numerous casualties. The unit then evacuated the area and leveraged artillery to destroy any remaining improvised explosive devices and critical equipment left behind in the evacuation. Convinced there were no civilians in the area, Wright explains, the battalion commander "changed the mission from clearing the town for an outpost to eliminating the settlement," firing forty to fifty GMLRS into the town the following day.[54] Though precise, the munition lacked the destructive power to destroy more conventional army targets like lightly armored vehicles. Therefore, the Defense Department approved the development of a secondary warhead containing DPICM rockets to supplement the unitary round.

Loss of Destructive Capacity: The End of DPICM

The DPICM submunition duds left on the battlefield in both Gulf Wars posed a potential long-term problem to civilian populations in the area. The dud-rate issue gradually forced the Army to move away from the DPICM submunition, which limited the development of a potential cluster-munition rocket. In 2006, the Army was developing a GMLRS that carried 404 DPICM bomblets per rocket, but none of the designs got below the desired dud rate of one percent or less.[55] Even though the new rocket failed to sufficiently reduce the dud rate, 4,600 rockets were created, although they were never fielded.[56]

The transition away from DPICM is also linked to the 2008 United Nations Convention on Cluster Munitions, which limits the use of dud-producing munitions. Specifically, the convention declared that "the weapons are prone to indiscriminate effects" and create an international problem because "unexploded bomblets can kill or maim civilians long after a conflict has ended."[57] Although the United States did not sign the treaty, then-Secretary of Defense Robert Gates announced that "by the end of 2018, DOD will no longer use cluster munitions."[58] This would require replacement munitions to ensure artillery missions could still have area effects.

To fill the gap left by DPICM, the Army designed a different type of area-effect weapon: the Alternate-Warhead rocket. Instead of a submunition, the new rocket contained roughly 180,000 tungsten balls designed for area-effects missions such as counterfire against enemy artillery.[59] The Alternate Warhead was built as a GMLRS variant; it shared all the complexities of coordination that plagued precision rockets. The rocket went into full production in April 2015 with a procurement goal of more than 18,000 rockets.[60] Because the Alternate Warhead transitioned away from explosive submunitions, it was ineffective against armored vehicles, and thus a dramatic loss of destructive capability for the artillery branch.

In 2017, Under Secretary of Defense Patrick Shanahan adjusted the policy to allow continued use of cluster munitions past the 2018 deadline, allowing for the future development of DPICM-GMLRS.[61] However, the round would not be used as it had been in previous conflicts. Going forward, authority to release the DPICM would be retained at the highest levels of the military, similar to ATACMS—acknowledging the humanitarian concerns these weapons inspired.

The First Self-Correcting Cannon Round: Excalibur

Use of the Copperhead round in the Gulf War taught the artillery community two critical lessons about precision cannon munitions: minor mid-flight corrections to a ballistic trajectory could facilitate precision accuracy, and relying on humans to make such corrections could result in errors. To build on these lessons, the Army developed the Excalibur round as the first self-correcting cannon round. The munition carried a fifty-pound warhead and followed an adjusted ballistic trajectory so it could impact targets at a near-straight downward angle. This type of impact limited collateral damage and allowed friendly troops to be safely within 200 meters of the impact.[62] Unique to the Excalibur, if the round experienced a mid-flight problem, it did not correct to the target area and would instead head to a predetermined ballistic impact point.[63] The Excalibur concept initially incorporated both DPICM and SADARM submunitions on top of the standard unitary round. However, the termination of SADARM and the dud issues that surrounded DPICM led senior leaders such as Field Artillery Commandant Maj. Gen. Toney Stricklin to recommend that the artillery community shift its entire focus to the collateral-damage-limiting unitary round.[64]

As it had with GMLRS rockets, the Army accelerated a limited fielding of the Excalibur to support the urgent combat need for precision. In 2005, the Defense Department contracted the Raytheon company to build and ship 165 new projectiles as soon as possible, with major fielding planned for 2009.[65] The initial Excalibur model had a maximum range of twenty-four kilometers, but an eventual upgrade increased the range to thirty-seven kilometers.

Although the early Excalibur rounds had relatively short maximum ranges, the Army used them for essential missions. The rapidly fielded Excalibur was first fired in combat by the 1st Cavalry Division on 5 May 2007, destroying an insurgent safe house; in July 2007, an Excalibur mission killed al Qaeda in Iraq leader Abu Jurah.[66] Historian Dal Andrade details this historic engagement:

> Guns from the 1st Battalion, 9th Field Artillery Regiment, attached to the 2nd Brigade at Forward Operating Base Kalsu, fired two precision-guided Excalibur 155-mm. artillery rounds. The house was completely destroyed, though overhead photos showed that none of the neighboring structures was damaged. This occasion was the first publicly acknowledged use of the Excalibur round in Iraq, and it marked an important new tool in the “smart” arsenal. Containing fifty pounds of explosives, the Excalibur round was much lighter than the precision munitions dropped from aircraft, and it was accurate to within six meters—so close, as the saying went, that it was like putting “warheads on foreheads.” In hostile-populated environments

like Arab Jabour—or even Baghdad—where the enemy hid among civilians, this was an important weapon.[67]

The Excalibur round reintroduced cannon artillery to the urban environment, expanding a ground commander's options in the COIN fight.

The early Excalibur successes reinforced that the Army could use fewer rounds and still achieve its desired effects. Consequently, the Army reduced its desired fielding quantity from 30,000 to 6,264.[68] By 2012, the US military fired roughly 600 Excalibur rounds in Iraq and Afghanistan with a reported success rate near ninety percent—meaning the round impacted the target grid and not the designated ballistic impact point.[69] As the wars in Afghanistan and Iraq dragged on, the Army continued to improve on the Excalibur. The initial costs of each Excalibur round neared $150,000, but continued development reduced production costs by more than half, lowering each round to less than $70,000.[70] Additionally, 2014 tests of an extended-range Excalibur averaged accuracy within two meters, dramatically better than the established ten-meter goal for precision

Figure 5.1. Excalibur Projectile. Source: "FY 2009 Annual Report for the Office of the Director, Operational Test & Evaluation" (annual report, Department of Defense, Washington, DC), 75, https://www.dote.osd.mil/annualreport.

munitions.[71] By June 2014, the Army funded the development of 757 extended-range Excalibur munitions.[72]

Economical Accuracy: The Precision Guidance Kit

PGMs are expensive, complex, and more accurate than required for many indirect-fire missions. The Army needed a more cost-effective way to increase accuracy without necessarily achieving precision. This economic need for better accuracy was identified early in the Iraq War, and by 2004, the Precision Guidance Kit (PGK) concept was introduced. The PGK was designed to make a "dumb" artillery round "smart." Simply stated, the PGK was a fuze capable of attaching to a standard artillery shell that leveraged the global positioning system (GPS) to track the round's position and make minor adjustments to the trajectory mid-flight.

Fielding of the PGK was expedited to support the continued need for precision in counterterrorism operations and reduce the economic burden of accuracy. As early as 2010, the Army planned an incremental release of the PGK fuze, starting with a basic model for 155-mm shells.[73] Initial testing of the round went poorly, however, forcing the Army Systems Acquisition Review Board to shift the fielding timeline. [74] During 2014 testing, the PGK had a median miss distance of fewer than twenty-two meters, finally making the fuze a viable near-precision capability—an accuracy of better than fifty meters.[75] The final production cost per round was also nearly eighty percent less than the Excalibur it was designed to augment.[76] The PGK is still in use today as an alternative to Excalibur.

Lessons Learned from Innovation

Overall, the transition away from Cold War artillery capabilities facilitated COIN operations success. Field artillery historian Boyd Dastrup comments: "Ultimately, Excalibur and other precision munitions would provide more capability at equal or less cost than fielding the Crusader."[77] Many senior military officers shared Dastrup's assessment regarding the importance of PGMs. Lt. Gen. James Lovelace, who was Army deputy chief of staff in 2006, discussed this technological innovation's dramatic impact on operations: "Organic, surface-to-surface PGMs add significantly to ground force commanders' options."[78] Additionally, Lt. Gen. Raymond Odierno, the 2007 Multi-National Corps-Iraq commander, described PGMs as "extremely effective" and commented that "GMLRS and Excalibur were my brigade commanders' weapons of choice."[79] PGMs kept artillery units relevant in the fight against insurgents and terrorists.

Figure 5.2. Attached PGK Fuzes. Source: “FY 2014 Annual Report for the Office of the Director, Operational Test & Evaluation” (annual report, Department of Defense, Washington, DC), 135, https://www.dote.osd.mil/annualreport/.

Indirect-fire innovation to support counterterrorism focused on two fundamental principles: precision and collateral damage. Early in this period, the Army rapidly fielded both cannon and rocket precision projectiles based on capability requirements. These needs were based on feedback from maneuver commanders engaged in the conflicts. This deliberate innovation cycle produced tangible successes, and valuable long-term lessons. Notably, the Army demonstrated it could field new technology at a pace comparable to that of nuclear artillery in the 1950s, while still executing a deliberate experimentation process.

The GWOT era highlighted Army artillery's ability to adapt its capabilities to the enemy at hand. By balancing deliberate development and rapid fielding, the Army provided small supplies of desired equipment promptly to forces on the ground while moving forward with development. Additionally, the COIN mission remained a top priority through numerous administrations, allowing continued development and refinement of new technology and reducing program cancellations. Notably, the artillery's long-term commitment to COIN was in direct contrast to the anti-armor priority in the post-Gulf War era, which was quickly overtaken by the contrasting requirements of crisis response and counterterrorism.

Despite these advancements, however, the transition away from DPICM submunitions and the termination of the SADARM munition created an anti-armor capability gap. The resulting sacrifice of destructive capacity is not consistent with indirect-fire lessons from previous conflicts. The accepted deterioration of anti-armor capabilities raises questions about the pressures of adaptation for the US military, specifically about the often-transient nature of lessons learned through combat. If innovation solely revolves around assessments of the current situation, the military may relive mistakes of the past.

Innovations during the GWOT period were designed to hit a GPS coordinate with high accuracy and destroy relatively soft targets with little collateral damage. It is difficult to foresee how such weapons could support future large-scale combat operations in which the main targets are mechanized and armored vehicles or other moving targets. To some extent, the Ukrainian military's employment of HIMARS in its ongoing war with Russia—examined briefly in the Conclusion chapter—is likely to shed light on the role of precision in a conventional conflict.

Organizational Adaptation: Modularization

From a big picture view, how the US military centralizes control of indirect fire has been debated since the First World War. Specifically, the artillery community has maintained an ongoing conversation regarding the assignment of direct-support artillery to maneuver units. As noted in this analysis of the Korean, Vietnam, and Gulf War conflicts, the DIVARTY headquarters has historically controlled artillery at the division level. However, certain tactical situations have sometimes dictated a more decentralized role. For example, the Pentomic Divisions created after the Korean War directly attached an artillery battery to Battle Groups. In addition, the dispersion of assets in the Vietnam War, coupled with reliance on helicopter movement and emplacement, allowed maneuver units to build habitual relationships with the artillery batteries that supported them. In the early part of the twenty-first century, this conversation culminated with the dissolution of the DIVARTY headquarters.

Modularity: Redesigning the Army

In late 2003, the Army began a reorganization known as "modularity." Like the Battle Groups in the 1950s, this change created autonomous units below the division level: the brigade combat team (BCT). The Rand Corporation describes the transition as a shift from a "division-based force into a brigade-based force," with each BCT incorporating elements of maneuver, artillery, and combat support forces.[80] Under this structure, every BCT was assigned a direct support field artillery battalion. Similar to the Reorganization Objective Army Division (ROAD) concept of the 1960s, the type of artillery weapon system varied by the type of new BCT: infantry, heavy, or Stryker. Schlosser notes that this restructuring enabled the Army to improve its operations in Iraq and Afghanistan:

> By taking the supporting units previously attached to the corps and divisions and making them a permanent part of a brigade's organization, the Army created a new formation that was more robust and easier to deploy. It also enhanced the brigade's ability to function in an irregular warfare environment, where lower echelon units were required to operate as relatively autonomous formations.[81]

However, it quickly became apparent that these changes had unintended secondary consequences regarding the Army's ability to wage a high-intensity conflict.

Modularity did not simply restructure brigades; it essentially separated the division headquarters from combat, a decision that had drastic consequences for indirect fire employment. According to the 2010 BCT field manual, the new structure was designed to be "the smallest combined arms units that can be committed independently," and although able to work under a division, "the BCT can fight without augmentation."[82] In this regard, BCTs assumed responsibility for artillery employment. Consequently, the Army deactivated ten active-duty DIVARTYs and four Corps Artillery Headquarters.

On top of this organizational change, the US Army dramatically reduced nearly half its field artillery brigades—which often supported

Corps-level operations: from twenty-three field artillery brigades in 2002 to only thirteen by 2008.[83] In an Army War College strategic research report, "Effect of Modularity on the Field Artillery Branch," Col. Noel Nicolle describes the reduction in the number of field artillery brigades and elimination of both the Corps Artillery Headquarters and DIVARTYs as "devastating" to the US military's ability to effectively employ indirect fire.[84] Overall, modularization decentralized artillery training and mission planning—an organizational shift that drastically changed the role of indirect fire on the battlefield.

Limited Artillery and Skill Degradation

Termination of DIVARTY not only eliminated a battlefield coordination and resource distribution element but also removed a training organization designed to ensure that all artillery units within the division were proficient in employing indirect fire. In a 2006 *Field Artillery Journal* interview*,* Maj. Gen. William Caldwell IV, the 82nd Airborne Division commander, explained that without a DIVARTY, the new artillery relationship put the onus of training and oversight on the BCT commanders: "Those are their jobs now," adding that they have the "Red Book (artillery training norms) as the non-negotiable standard."[85] However, this new expectation was not realistic, and the primary mission of artillery units—the employment of indirect fire—degraded over the first few years after the transformation. Nicolle commented in 2009, five years after the modularity concept began, that the absence of DIVARTY created "a significant consequence that is only now becoming apparent."[86] Complicating this issue was the shifting role of many artillery units in Iraq and Afghanistan.

Indirect fire remained a combat necessity in both GWOT wars. However, the quantity of systems and ammunition supporting COIN operations decreased dramatically. Outside of a few exceptions of increased violence, indirect fire supported small unit engagements. While urban challenges complicated artillery missions in Iraq, the terrain in Afghanistan posed its own unique problem. In its examination of indirect-fire support during the 2008 battle of Wanat, the US Combat Studies Institute staff noted that "because of the elevation of the intervening terrain, artillery had to be fired in a high-angle trajectory," adding that the inherent variations in high-angle fire missions "made field artillery fire less precise."[87] Overall, Afghanistan terrain made accurate indirect fire challenging.

Even when terrain did not force artillery units to fire high-angle missions, it complicated the adjustment process. In his analysis of small-unit action in Afghanistan, Donald Wright describes how steep inclines in the mountainous terrain affected the effectiveness of indirect fire: "Where one might be afforded a little leeway in coordinating fires for a relatively flat target area, there was no such leeway in the mountains," adding that "calculation errors of only a few meters could render an artillery or air strike completely ineffective."[88] Additionally, like the Vietnam War, the US military found itself widely distributed across the nation.

Consequently, artillery firebases were created to support combat outposts. Neumann and Williams describe the situation for Regional Command-East units in 2007:

> Each battalion occupied a forward operating base and sent smaller contingents to combat outposts and firebases in remote positions. . . . Some of the outposts held only a platoon, with squads distributed in support positions. The battalions protected these isolated units with artillery and aerial support. Even so . . . the paratroopers in northern RC East occupied isolated positions and had limited offensive capabilities, making them vulnerable to enemy attack.[89]

To make matters worse, numerous artillery units in both theaters had been converted to makeshift infantry or other types of units.

As early as 2003, the Army required field artillery units to operate in a non-traditional role. In Iraq and Afghanistan, many artillery battalions became maneuver battalions, DIVARTYs transformed into a task force, and fire support officers assumed an "effects" role that focused them on non-kinetic means.[90] In 2004, for example, the 25th Infantry Division DIVARTY was converted to Task Force Thunder, becoming the "first ad hoc nonmaneuver brigade to have control of its own battlespace in Enduring Freedom."[91] Wright details these changes to artillery units:

> The most dramatic of these transformations was the conversion of field artillery and armor battalions to general maneuver units that conducted full spectrum operations instead of the primary combat missions for which their soldiers had trained. Often this meant parking many of their combat vehicles and conducting patrols and other operations on foot or in wheeled vehicles.[92]

To address their new mission, artillery units shifted their pre-deployment training away from combined arms warfare and massing artillery, focusing instead on counterinsurgency operations.

While artillery units at all echelons proved flexible to the character of the conflict they supported, it was not without cost. The Army's ability to employ indirect fires began degrading in the GWOT era as soon as the conflicts shifted to COIN-centric operations. This problem was exacerbated by the dissolution of DIVARTY, the organization that trained and certified artillery units. Notably, maneuver commanders—the ones supported by indirect fire—challenged the Army to address the issue of the degradation of artillery support.

In 2007, three BCT commanders—Colonels Sean MacFarland, Michael Shields, and Jeffrey Snow—published an influential white paper, *The King and I: The Impending Crisis in Field Artillery's ability to provide Fire Support to Maneuver Commanders*. They outlined long-term problems with being unable to synchronize indirect fire with maneuver operations and the dangers of continued capability decay. Contrary to Caldwell, the commanders expressed concern that "modularization places responsibility for fire support training on maneuver commanders who are neither trained nor resourced to perform these tasks."[93] MacFarland, Shields, and Snow reinforced the importance of indirect fire for future conflicts and identified artillery proficiency degradation as an Army-wide problem, concluding it was "urgent that [the Army] take another look at the structure of this important combat arm."[94] Their assessment sparked dialogue and was a catalyst for change.

Nicolle expressed similar concerns a couple of years later in an Army War College paper on how modularity shaped indirect fire, concluding that although the number of artillery battalions had increased in the six years since the Iraq invasion, the force was less capable. He warned that "if course corrections regarding the field artillery are not made in the immediate future, the United States Army's reason for existence—the ability to win its nation's wars—is no longer a certain outcome."[95] The artillery community struggled to deal with the unintended consequences of DIVARTY's end.

Lessons From Organizational Adaptation

The dissolution of DIVARTY was in direct contrast to Gulf War lessons identified by the 3rd Infantry Division, which noted the organization's importance in coordinating artillery during the conflict and argued for its continued development. Similar to the development of the Pentomic Divisions and the ROAD concept, modularization was designed to allow the Army to be successful in a new type of conflict. The significant difference, however, was that modularization removed key organizations above the brigade level, essentially abandoning large-scale combat operations. The Army eventually heeded senior military officer warnings about artillery degradation. US Army Forces Command published a DIVARTY Implementation Order that outlined a plan to reestablish the headquarters beginning in 2014, with full implementation across the force two years later.[96] Although numerous DIVARTYs were reconstituted, the design varies drastically from the Gulf War and its future role is unclear.

However, the Army's resurgent emphasis on large-scale combat operations complicates this ambiguity. Contrary to its earlier design, the modern DIVARTY does not have organic firing units but instead receives them when required. Outside of National Guard units or a corps headquarters potentially allocating rocket artillery support to DIVARTY, the division's artillery is exclusively the cannon battalions assigned to the BCTs. Therefore, the brigade-centric Army faces a potential issue if DIVARTY intends to centralize control or reallocate the assigned direct-support artillery from maneuver units to shape the battlefield for a shift back to division operations. To adapt the BCT model for large-scale combat operations, the Army will need to clarify DIVARTY's role soon. Any change, particularly if it directly impacts the combat power of the current BCTs, will need to be worked out through training and experimentation rather than on the next battlefield.

Conclusion

It can be argued that the adaptation of indirect fire in the GWOT era abandoned recent lessons from combat, even while demonstrating the artillery's ability to rapidly produce and field new equipment for new forms of active conflict. This inevitably raises the question of whether combat "lessons learned" can drive long-term adaptation or is simply a tool to adjust to current conditions. The issue is highlighted by the decline of artillery's destructive capability. With the absence of area effects and the termination of anti-armor munitions, cannon artillery systems in the GWOT era were no more destructive than their WWII predecessors (albeit far more accurate). Rocket artillery transitioned away from supporting maneuver operations, and the new, more complex rockets required release approval from upper echelons. Similar to the Vietnam War, the artillery during the GWOT period adapted specifically to fight the conflict at hand, largely superseding more traditional warfighting functions. If large-scale combat operations were again required, indirect fire would be no more effective than in the 1970s, when the requirement to adapt to a near-peer adversary first emerged.

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Chapter 6
Assessing the Drivers of Innovation and a Look to the Future

After World War II, US artillery platforms and munitions—alongside the maneuver forces they were designed to support—grew in complexity, destructive capability, accuracy, range, and mobility. The analysis in the previous chapters highlights the deficiencies of modern US indirect-fire capabilities that stemmed from the many trade-offs posed by these well-considered—but necessarily imperfect—choices. This book explains how the choices were made and, more generally, the adaptation and innovation process that led to the current artillery situation within the US military.

The Driving Factors of Innovation

To assess the progression of artillery adaptation, this research covered roughly 100 years of indirect-fire development. Because of the massive amount of information available, many incidental and supplemental developments were omitted. This included minor equipment adjustments and advances in external tools such as mission-processing computers and handheld range-finding equipment. Instead, the focus remained on adaptation and innovation that directly affected indirect fire's role on the battlefield.

Militaries adapt their techniques, structure, and equipment for many reasons. After establishing the foundational period for indirect fire, this research examined adaptation of US indirect-fire capabilities since WWII to assess three potential drivers of military innovation: the incorporation of new technology, the application of combat experience, and the assessment of external threats.

Incorporating New Technology

While a surface-level analysis of artillery innovation could indicate that emerging technology was its major driving factor, the detailed analysis conducted in this work presents a different perspective. Although the first dramatic changes to the role of indirect fire—post-Korean War nuclear artillery development—were driven by the need to incorporate nuclear technology, this example is an outlier. In fact, this technology-focused approach led to numerous artillery platforms that were more of a burden than an asset to maneuver forces. Wisely, after the transition from the nuclear battlefield, the Army deliberately assessed capability gaps and developed new artillery equipment and doctrine accordingly.

Although emerging technology did not drive innovation, the military leveraged new technologies when producing its artillery platforms and munitions. This distinction is important. The most prominent example of this is the global positioning system (GPS). Demand for GPS-guided artillery munitions did not intensify until a decade after the technology was commonly used elsewhere in the military. This new requirement was driven by an assessed need to reduce collateral damage in counterinsurgency (COIN) operations. At the same time, however, the Paladin—an adaptation focused on improved mobility and rapid-fire mission processing—incorporated GPS to improve accuracy and increase responsiveness. The mere existence of new GPS technology was not a major driver of indirect-fire innovation; rather, the artillery community successfully integrated it by adapting to a new challenge presented by counterinsurgency warfare.

Combat Experience and Temporary Adaptations

In addition to technology, combat lessons learned drove artillery innovation. The artillery community diligently documented these lessons via multiple channels, such as *The Fires Bulletin* and the Morris Swett Library. While these lessons from combat facilitated rapid mid-conflict adaptation, they often did not endure. During the Vietnam War and the continuous conflict in Iraq, the artillery branch learned to rapidly adjust employment tactics and field new equipment. These successful adaptations driven by combat experience, however, were temporary. Many Vietnam War innovations were quickly relegated to niche capabilities, and the Army set aside lessons learned from the conflict to instead prepare for the threat of the Soviet Union.

Another lesson learned and disregarded was the successful use of anti-armor munitions that devastated the Iraqi Army during two separate wars. Despite their success, these weapons were defunded and regulated to a level that does not support maneuver operations. This seems counterintuitive; furthermore, this deterioration of destructive capability—a development theme in every major conflict since Korea—suggests the artillery community has a short-term memory concerning combat experience. The current US artillery arsenal has no direct-fire munition like the Beehive, which proved its value in Vietnam, and only restricted use of anti-armor rounds of the kind that dominated Iraq battlefields. Consequently, in a future conflict, artillery units may well be forced to relive the mistakes of the past.

Looking forward, lessons from past conflicts likely will not be a significant factor in indirect-fire capability development. This is especially true of recent GWOT experiences linked to the highly specific demands of counterterrorism. If the artillery branch's short-term memory of US combat operations is similar to other communities within the US military, innovation driven from combat experience in general may be questionable.

External Threats: An Underlying Driver of Innovation

Apart from the immediate pressures of active conflict, the need to prepare for shifting external threats has been the primary driver for field artillery adaptation and innovation. As noted in the Chapter 2 and 3 analysis of artillery development throughout the Cold War, a potential clash with the Soviet military dictated enduring munition, platform, and organizational adaptations—regardless of technological breakthroughs or lessons learned in combat. After the Cold War, however, the United States no longer faced an external threat; as a result, adaptation was driven overwhelmingly by the crisis at hand, which often put the artillery branch on the wrong foot when new crises arose. Precision-based innovations for COIN created unique artillery capabilities, but at a substantial cost to more conventional mission requirements.

During the GWOT era, the United States failed to continue innovating and adapting for a large-scale combat operation and, more importantly, allowed vital capabilities such as anti-armor munitions to disappear from the arsenal. This created a capability disparity between the United States and a potential adversary such as Russia, whose modern military tradition reflects a heavy reliance on artillery. In 2016, Maj. Gen. Robert Scales, former US Army War College commandant, commented on Russian artillery in the 2014 Ukraine invasion: "The performance of Russian artillery in Ukraine strongly demonstrates that, over the past two decades, the Russians have gotten a technological jump on us."[1] Russia's more recent experience with its 2022 Ukraine invasion might undermine these types of conclusions, but does not negate the current US situation.

Given this history, the US military's future development of indirect-fire capabilities will rely heavily on assessment of external threats, which have already started to shape artillery development. In the 2018 National Defense Strategy, Secretary of Defense James Mattis declared: "Inter-state strategic competition, not terrorism, is now the primary concern in US national security."[2] This official transition reopened the conversation about large-scale combat operations and will likely require the artillery to adapt to a new role. The Army began this transition a year prior with a 2017 joint memorandum from Secretary of the Army Ryan McCarthy and Army Chief of Staff General Mark Milley that outlined the Army's plan for future modernization. The document lists development of "Long-Range Precision Fires" as the number one priority, and challenges the field artillery community to reestablish "dominance in range, munitions, and target acquisition."[3] Similar to the development of artillery after the Vietnam War, current and future projects are likely to focus on preparing for combat against a peer adversary.

The Current State of Artillery and a Look to the Future

With the re-emergence of near-peer external threats, the US military is already moving forward with artillery development that reinforces the findings presented.[4] Peter Burke, the deputy project manager for combat ammunition systems, explains that the shift back to planning for near-peer conflict has created "a new framework of strategic thinking and analysis" for weapons development.[5] He notes that current projects will provide the artillery with "modernized assets that will perform effectively in longer-range missions, with increased lethality . . . to combat both near-term and future engagements with precision area effects and against capabilities from personnel to heavy armor."[6] Some of these projects include greatly extending cannon and rocket artillery range and developing munitions that can be used against moving targets.

The artillery community's short-term memory of combat experiences has periodically forced the branch to "reinvent the wheel" to stay relevant. The pragmatic shift back to large-scale combat operations allows artillery units to re-equip and relearn hard lessons in a training environment. Now that the United States has shifted from counterterrorism, the military can focus its innovation on perfecting artillery in the evolving mainstream of war and away from a novel type of war.

While it is unclear what the future holds for the artillery community, the indirect fire innovation and adaptation drivers discussed in this book can provide a lens for viewing the future. In this context, examining emerging technological innovations, global combat events, and rising external threats can illuminate a potential path for US indirect-fire innovation.

Emerging Technology—Loitering Munitions

Drone technology enabled indirect fire during the GWOT era through target identification and observation. Loitering munitions, which are effectively miniature externally guided missiles, build on this relationship by augmenting conventional approaches to indirect fire. Once airborne, these systems "loiter" and hunt for a target. Notably, this loiter time varies drastically between models, with some measured in minutes while others are measured in hours.[7] Although most of the systems are directed by an operator at a control station, more advanced models are capable of autonomous flight. Some even have the authority to strike designated targets without human approval. Once it identifies a target, a loitering munition, commonly referred to as a "kamikaze drone," crashes into its target and detonates.

While militaries employed loitering munitions during Afghanistan, Syria, and Yemen conflicts, the 2020 Nagorno-Karabakh War was the first time the world took notice.[8] In 2020, Azerbaijan overwhelmed the Armenian military with advanced Israeli-made loitering munitions, destroying air defense systems and armored vehicles in a conventional mechanized conflict.[9] Using top-down strike capability and anti-armor warheads Azerbaijan destroyed Armenian forces in built-up defensive positions. The conflict highlighted a potential change to the character of war. In 2017, analyst J. Noel Williams foreshadowed the impact of these new systems, commenting that loitering munition technology advancements "will impact the character of warfare more substantially than the introduction of the machine gun . . . a revolution hiding in plain sight."[10] Kelsey Atherton, a military technology journalist, wrote after the Nagorno-Karabakh War that "loitering munitions can now serve a range of functions in war once reserved for crewed aircraft or artillery," providing "a test-bed for using weapons on a battlefield independent of human control."[11] The proliferation of autonomous strike systems will directly impact the indirect fire community.

The use of loitering munitions in modern conflicts challenges longstanding warfare assumptions, particularly regarding long-range strike capabilities. Suppose dismounted infantry squads dispersed around the battlefield could employ highly accurate and destructive loitering munitions at more than ten kilometers. The artillery community must examine whether indirect fire is even needed for the close support of troops. While loitering munitions cannot and should not replace artillery, they can augment indirect-fire capabilities, particularly at the division level. The emerging technology is its own surveillance platform, minimizing the commitment of other assets. Additionally, the persistent observation gained through loitering allows the system to act as a makeshift observer for conventional artillery assets.

The combination of loitering time and coverage area would allow the division to mass fires or repurpose airborne assets based on dynamic


Figure 6.1. US Marine Corps launches the Switchblade-300. Source: Defense Visual Information Distribution Service, https://www.dvidshub.net/image/5861379/.

environmental changes. If a loitering munition identifies a large formation of enemy armored vehicles staging or moving in a column under the enemy's air-defense umbrella, the controlling headquarters could repurpose loitering munitions from other targeted areas of interest, converging an incredible amount of lethality on a time-sensitive critical target. This strike flexibility could produce devastating effects without exposing friendly forces or equipment to enemy counterfire.

The US military has begun building its own arsenal of loitering munitions but is generally relegating this unique tool to supporting small-unit tactics. The United States employed its Switchblade-300 loitering munition in Afghanistan for years to support special operations. The system weighs just over five pounds and takes less than two minutes to set up and launch; it has a range of ten kilometers and fifteen minutes of flight time but cannot penetrate armor.[12] More recently, the same company developed a heavier but still man-portable variant—the Switchblade-600—that weighs fifty pounds and takes approximately ten minutes to set up and fire.[13] This upgraded version has a forty-kilometer range, a loiter time of more than forty minutes, and, most importantly, an anti-tank warhead.[14]

Manufacturers around the globe are saturating the market with varying loitering munition types, and advanced models will soon be available that can search hundreds of kilometers, stay airborne for hours, find and validate their own targets, and strike with devastating lethality. The democratization of loitering munitions both internationally and down to the individual combatant ensures that this emerging technology will appear on future battlefields. Therefore, the artillery community will need to examine how this new technology could augment conventional indirect-fire capabilities. Like howitzers, militaries can design these systems to support operations from the tactical to the strategic level.

To leverage this system to its fullest, the US military will need to conduct a modern-day Westervelt Board to assess how this emerging technology will fit its doctrine at each echelon. The recently published "Leveraging Loitering Munitions" post in *The Wavell Room* provides a starting point for such an analysis.[15] Observing the ongoing war between Russia and Ukraine will provide the United States with an opportunity to assess this emerging technology, including the performance of the hundreds of Switchblades sent to Ukraine as military aid.[16] Notably, this is not the only US indirect-fire capability that military analysts can assess in Ukraine.

Combat Experience in Ukraine

After the United States transitioned out of the Vietnam War, the Yom Kippur War provided a glimpse of what a future conventional conflict could entail. In modern times, Russia's invasion of Ukraine is offering invaluable and not-yet-understood combat experience—albeit indirectly. The United States has furnished Ukraine with ample indirect-fire capabilities, including loitering munitions, to enable its fight against Russia. In turn, the Ukraine conflict is an opportunity for the US military to assess its capabilities through a proxy. These aid packages have included 126 155-mm howitzers with corresponding prime mover vehicles and more than 800,000 rounds of ammunition. If anything, this aspect of the aid package reinforces the principle of mass and highlights the high ammunition expenditures associated with indirect fire.[17]

Simultaneously, the United States provided Ukraine with High Mobility Army Rocket Systems (HIMARS) and precision rockets. To date, Ukraine has received sixteen launchers, and the United States has committed to double that number.[18] While the current rocket artillery munitions cannot destroy Russian armored vehicles, the US Defense Department has described Ukraine's integration of HIMARS into the conflict as a success.[19] Secretary of Defense Lloyd Austin comments that HIMARS have created a "change in the battlefield dynamics," praising Ukraine for using the precision rockets to attack targets like logistical stores and command and control centers.[20] Ukraine's successful use of HIMARS raises questions about the role of precision—often associated with limited collateral damage and COIN operations—in a fast-paced mechanized fight. While such a capability could be discredited, this conflict will likely illuminate the value of using precision munitions to attack mechanized vehicles indirectly by destroying bulk fuel sites, maintenance areas, and other components required to sustain a mechanized fight. Consequently, precision indirect-fire capabilities on a battlefield saturated with sensors can significantly impact the non-kinetic warfare means like sustainment units and command elements.

During the ongoing Russian-Ukraine War, however, it is challenging to separate truth from a potential narrative—the ability to draw hard lessons versus simply making observations. As it has with most conflicts, the US military should conduct a detailed and deliberate examination of indirect fire use in Ukraine. Notably, though Russia has dominated the international narrative with its controversial military actions, it is not the only nation the United States must consider when designing future warfare concepts.

External Threats—The Return of Missile Warfare

In more recent years, the United States has shifted its focus to China, the only nation capable of mounting a "sustained challenge to a stable and open international system."[21] Because China was not a signatory to the Intermediate-Range Nuclear Forces (INF) Treaty, it became a world leader in intermediate-range missile technology. Jacob Stokes, a fellow at the Center for a New American Security, comments: "Since the mid-1990s, Beijing has built up the world's largest and most diverse arsenal of ground-launched missiles . . . approximately ninety-five percent of which, according to US officials, would violate the INF Treaty if China were a signatory."[22] For years, INF Treaty critics have focused on the relative advantage that the bilateral treaty provides China over the United States.

In place since 1988, the INF Treaty between the United States and the Soviet Union eliminated a specific delivery system: surface-to-surface missiles with ranges between 500 and 5,500 kilometers.[23] For US artillery, this meant the loss of its Pershing missile and the associated tactical-nuclear strategy. Overall, the treaty fostered the destruction of nearly 3,000 missiles—846 American and 1,846 Soviet.[24] Therefore, the treaty's 2019 demise paves the way for the US military to reintroduce these missiles and reinvigorate its long-range strike aspirations. With the Pacific Theater's geographic challenges, these missiles would allow the Army to expand its role in the Defense Department's vision of future warfare.

Before the treaty's official termination in August 2019, the US Army had prepared to test-fire a missile in the restricted ranges, anticipating that restrictions would be lifted.[25] Since the treaty's end, the military has continued down this modernization path. The Army has embarked on numerous long-range strike projects at varying ranges, including a moderate range increase from its current systems to a 500- to 600-kilometer-range precision strike missile and a more strategically designed 2,700-kilometer-range hypersonic missile.[26]

Notably, the United States is designing these missiles specifically for conventional purposes. As a Congressional Research Service report notes, "The United States was considering only conventional options and did not, at this time, plan to develop new nuclear-armed INF-range missiles."[27] In this context, the US proliferation of conventional missiles implies an attempt to normalize missiles into land warfare, potentially altering indirect-fire doctrine by introducing a theater-level strike capability that goes beyond a deterrent.

Consequently, the US Army has incorporated conventional missiles into its envisioned role in future warfare, outlined in US Army Training and Doctrine Command (TRADOC) Pamphlet 525-3-1, *The US Army in Multi-Domain Operations 2028*.[28] The Army's central mission for conventional missiles is to "penetrate and disintegrate enemy anti-access and area denial (A2/AD) systems and exploit the resultant freedom of maneuver to achieve strategic objectives (win) and force a return to competition on

Figure 6.2. High-Mobility Artillery Rocket System launches a Precision Strike Missile on 10 December 2019 at White Sands Missile Range, New Mexico. Source: Defense Visual Information Distribution Service, https://www.dvidshub.net/image/6414676/.

favorable terms."[29] The Army highlights the growing importance of missiles, comparing them to aircraft and offering numerous advantages that make potential missile acquisitions critical for the joint force. Specifically, missiles do "not require suppression of enemy defenses for access, can be ready to fire in case the precise time of engagement is unknown, and can engage opportunity targets over large areas."[30] The Army made similar arguments when it first began developing missiles in the 1950s.

In addition to outlining the importance of long-range missiles in its doctrine, the Army is focused on missile normalization and incorporation of a theater-level indirect fire asset. In 2019, the Army published a detailed modernization strategy—built on its initial 2017 priorities list—that justified investments in missile technology, noting that "long-range precision fires enable multi-domain forces to penetrate and neutralize enemy A2/AD capabilities."[31] This strategy emphasizes the importance of long-range strike capabilities and implies that other systems, such as aircraft, are limited in their ability to address A2/AD systems. This mission-set is not new; instead, it is a resurgent recognition from both the initial missile pursuits of the 1950s and lessons learned from the Yom Kippur War. However, like the future role of loitering munitions and potential lessons from Ukraine, it remains unclear what impact current Army missile modernization efforts will have on its approach to warfare.

Future Innovation Challenges and Closing Recommendations

This research raised questions about future field artillery development and, more generally, overall drivers of military innovation. Many of these questions about long-term US modernization merit further examination, including these pressing themes:

- With the modern battlefield continuing to grow larger and more complex, does the inherently limited range of cannons make rockets and missiles the future of artillery?
- Without an anti-armor capability, what is the role of indirect fire in a large-scale combat operation?
- Because operations-below-combat do not fit the category of an external threat, can potential munitions for competing in the "gray zone" develop without an active conflict?
- What is the role of emerging technology in indirect-fire doctrine? Can loitering munitions augment the close-support artillery mission? Will the Army retain release authority over theater-support missiles?

Looking to the future, the artillery branch can modernize across numerous categories to be more effective in a future war. First, developing anti-armor munitions is vital for the artillery to succeed in a future conflict, as most modern militaries are mechanized. While today's artillery is more accurate than any in the past, loss of its anti-armor capability in the last decade limited US Army artillery lethality to that of basic WWII models. To restore this function, older munitions such as dual-purpose improved conventional munitions (DPICM) and sense and destroy armor (SADARM)—both proven successful in combat against armored vehicles—could simply be repurposed or upgraded to complement current capabilities. Concurrently, the artillery community can look to loitering munitions like the Switchblade-600 to augment the close support mission, particularly concerning destructive capacity.

Second, a significant investment in rocket artillery is necessary to bring these assets up to par with competing platforms and take advantage of emerging technology. Precision munitions are a niche capability designed to engage fixed-site targets. These precision rockets can limit an enemy's ability to wage war by destroying critical targets like sustainment capabilities or command and control areas, but this cannot be the only task for division and corps artillery systems. These munitions require clear air space and are not able to strike a moving target, characteristics that inevitably limit their usefulness against a peer-level threat. In both Gulf Wars, rockets were invaluable to maneuver forces; they may represent the future of advanced artillery munitions compared to cannons—capable of increased range, a heavier payload for destruction, and technological capabilities such as target finding and internal guidance.

Third, improved mobility—towed and self-propelled alike—is a prerequisite to operate on a modern battlefield that is becoming increasingly transparent. With limited sanctuary for artillery units and the demands of a high-tempo conflict, current platforms are simply too slow. More than half of all active Army cannons, and all Marine Corps cannons, are towed. Additionally, the Paladin—the only US self-propelled platform—is an adaptation of a model that has been in service since the 1950s, albeit updated through numerous upgrade cycles. In addition to continuing to advance self-propelled platforms, the military will need to abandon towed cannons, except in niche airborne and air assault units. This would best be done by adding a wheeled variant of the 155-mm cannon to better support Stryker Brigades. The new wheeled artillery could be developed through innovation or by purchasing a foreign platform such as the newly produced Ukrainian 2S22 Bohdana, which is designed according to NATO standards.[32]

Fourth, in addition to extending the range of current weapon systems, a reinvestment in an automatic loader—similar to what was developed for the Crusader—would dramatically increase rates of fire, improving artillery unit survival against enemy target acquisition capabilities such as counter-battery radar and drones. Apart from exceptions like rocket-assisted projectiles and precision munitions, artillery cannon range increases over time have never reached the level demanded by military leaders. Modern US artillery now compares unfavorably with Russian and North Korean weapons. Col. Liam Collins, the former director of the Modern War Institute at the United States Military Academy West Point, recently assessed the role of artillery in a potential large-scale combat operation in Europe: "Russian forces will surely use their long-range standoff to wreak havoc on US forces, whose artillery would remain severely outranged."[33] Consequently, US artillery units are likely to operate in an environment that is perpetually within range of enemy artillery. On top of increasing the output of each cannon, adding an automatic loader to self-propelled platforms will facilitate multiple-round simultaneous impact (MRSI)—a mission type that would reduce the overall threat of enemy counterfire and unmask fewer systems when massing fires.

Finally, the branch must use its greatest asset: its soldiers. From junior leaders to commanding generals, artillerymen candidly share what their units learn on the battlefield and in training. Applying such knowledge may prevent the Army from repeating costly mistakes in future conflicts. This means crowdsourcing insights through call-for-papers and mirroring the 1919 Hero Board's methods of synthesizing lessons from the field. Just as important will be transparency within the branch and an emphasis on the role of critical organizations like the US Field Artillery School, the US Field Artillery Association, and *The Field Artillery Journal.* With a deliberate effort to prepare the branch for a large-scale combat operation, coupled with a historical understanding of artillery innovation drivers and needs, the artillery community can work to maintain its hard-won reputation as the King of Battle.

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About the Author

Maj. Brennan S. Deveraux is an Army strategist and an Art of War Scholar with more than fourteen years of active military service. Before functionally designating as a strategist, he served in numerous leadership positions within the artillery community, including deploying three times in support of the Global War on Terror: twice to Iraq and once to Djibouti, Africa. Major Deveraux has a bachelor's degree in political science from the University of Washington, a master's in security studies from the Naval Postgraduate School, a master of military art and science degree from the Army Command and General Staff College, and a master's in military operations from the School of Advanced Military Studies. This is his second book; his first, *Whose Role Is It Anyway? The Inter-Service Race to Develop Intermediate-Range Ballistic Missiles,* was published by Army University Press in 2023.

DEVERAUX

LESSONS LEARNED AND UNLEARNED: THE DRIVERS OF US INDIRECT FIRE INNOVATION

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Lessons Learned and Unlearned analyzes nearly 100 years of US artillery innovation and adaptation, focusing on the pressures of incorporating new technology, applying combat experience, and assessing external threats. Indirect fire's role on the battlefield has been repeatedly reshaped by new technologies on the one hand and organizational and doctrinal changes on the other. This research examines successful and unsuccessful historical indirect-fire adaptations since the birth of indirect fire—identifying innovation themes, insights into future issues, and recommendations for more effective indirect fire.

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