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THESIS

LESSONS LEARNED AND UNLEARNED: U.S. FIELD ARTILLERY SINCE THE END OF WWII

by

Brennan S. Deveraux

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Thesis Advisor: Daniel J. Moran
Second Reader: John M. Sheehan

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13. ABSTRACT (maximum 200 words)

This thesis examines the adaptation of U.S. indirect-fire capabilities since 1945, with reference to three potential drivers of military innovation: new technology, combat experience, and external threats. Throughout this period U.S. artillery platforms and munitions—alongside the maneuver forces they were designed to support—have grown in complexity, lethality, accuracy, range, and mobility. Current U.S. artillery munitions nevertheless lag behind those of other modern militaries in important respects, including target-seeking rounds and the destruction of armor. In addition, today's artillery platforms—towed and self-propelled alike—are too slow for a high-tempo fight. Thus, although capabilities have developed dramatically, in a large-scale combat operation, modern U.S. artillery would likely play a minor role.

This thesis examines 70 years of artillery development, and concludes that apart from the immediate pressures of active conflict, external threats are the primary driver of adaptation. Thus, current and future projects are likely to revolve around a singular focus: preparing to combat a peer adversary. In this regard, this thesis offers developmental recommendations to help the artillery branch maintain its hard-won historical position as the King of Battle.

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**LESSONS LEARNED AND UNLEARNED:
U.S. FIELD ARTILLERY SINCE THE END OF WWII**

Brennan S. Deveraux
Captain, United States Army
BA, University of Washington, 2009

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Approved by: Daniel J. Moran
Advisor

John M. Sheehan
Second Reader

Afshon P. Ostovar
Associate Chair for Research
Department of National Security Affairs

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LIST OF ACRONYMS AND ABBREVIATIONS

1CAV	First Cavalry Division
3ID	Third Infantry Division
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
FCoE	Fires Center of Excellence
GMLRS	guided multiple launch rockets
GPS	global positioning system
GWOT	Global War on Terror
HE	high-explosive
ICM	improved conventional munitions
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
UN	United Nations

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I. INTRODUCTION

Indirect fire is the art and science of firing an artillery projectile at a target that the shooting element cannot see or use as an aiming point. In modern conflicts, it is a key capability of every fighting force. The artillery equipment and doctrine of militaries vary based on the threats they face and how they adapt to it. 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 U.S. forces incorporate indirect fire with maneuver forces to create a combined arms dilemma.[1] Although the idea of artillery can be traced back to the days of catapults and trebuchets, it is the world wars that solidified the science of indirect fire.[2] As a science, indirect fire is technology-dependent, and the different threats each nation faced since the world wars illuminate how and why it developed and incorporated new technology, as well as adapted as a whole.

A. RESEARCH QUESTION

This thesis asks the following question: How has the United States adapted its Indirect Fire capabilities since the end of WWII with respect to the incorporation of new technology, the application of lessons learned from combat experience, and the assessment of external threats?

Specifically, this thesis will look to examine both successful and unsuccessful examples of adaptation for U.S. field artillery in conflict and peace, with a focus on the three forms of adaptive pressure listed above. First, the technical requirements of indirect fire mean that the branch is always incorporating new technological innovations on the

[1] Department of the Army, *Field Artillery Operations and Fire Support*, FM 3-09 (Washington, D.C.: 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 [Infographic]," Forbes, accessed November 25, 2019, https://www.forbes.com/sites/niallmccarthy/2017/10/02/why-the-north-korean-artillery-factor-makes-military-action-extremely-risky-infographic/; John Ismay, "Insight Into How Insurgents Fought in Iraq," *At War Blog* (blog), October 17, 2013, https://atwar.blogs.nytimes.com/2013/10/17/insight-into-how-insurgents-fought-in-iraq/.

[2] 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).

battlefield. In terms of adaptation, technical innovation can be both a product of assessed capability gaps or needs, and inversely, the driver of change and modernization. Second, cannon and rocket artillery has been utilized in combat from Asia to the Middle East, supporting the full spectrum of conflict to include both conventional and counterinsurgency (COIN) operations. These conflicts, and the peace between them, provided ample opportunity for both informal assessments through the professional writing of those who experienced the fighting and the formal conferences that deliberately outline lessons learned. Third, the artillery branch must regularly assess threats to match the increasing survivability, lethality, and mobility of potential enemy forces. The emergence of nuclear weapons, tanks, or even asymmetric warfare, for example, represent significant changes to the battlefield that alter how indirect fire is implemented and organized to be able to support maneuver forces.

Two key terms that must be established to understand the research question are "adapt" and "capability." Although military adaptation and innovation is a complex topic filled with a variety of definitions, for clarity purposes, in this thesis to adapt is the simple dictionary definition: "to make fit (as for a new use) often by modification."[3] Capabilities, in the context of indirect fire, refer to lethality, accuracy, and responsiveness to rapidly changing tactical conditions. Thus, the adaptation of indirect fire can be analyzed in terms of three distinct themes or dimensions: first, developments in munitions that increase the destructive capability, range, or accuracy of the weapons; second, adjustments in the platforms themselves through improvements in mobility and rates of fire; and lastly, organizational or doctrinal changes that alter how artillery is employed on the battlefield.

B. IMPORTANCE OF THE RESEARCH

It is unknown where, when, or how the next war will be fought. Regardless, indirect fire capabilities will attempt to adapt to the conflict at hand and the technological innovations of the time. An understanding of both successful and unsuccessful historical adaptations of indirect fire capabilities provides context to the future problems that the U.S.

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[3] "Definition of ADAPT," accessed October 4, 2019, https://www.merriam-webster.com/dictionary/adapt.

Field Artillery will face. The incorporation of technological innovation and transitions in and out of various types of warfare are not just current or future challenges, they were prevalent throughout the Cold War as well as in the conflicts in the Gulf. Whether future artillery requires armor destroying munitions in support of 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, an understanding of what historically made adaptation successful will facilitate future development. This sentiment is captured best by the former Chief of Artillery Major General Toney Stricklin, who astutely notes in a message to the artillery branch, "learning from the lessons of the past, we must prepare for the future."[4] In addition, an understanding of indirect fire adaptation will doubtless identify lessons applicable to other land warfare capabilities, and potentially military innovation as a whole.

C. BACKGROUND: MODERN WARFARE AND THE BIRTH OF INDIRECT FIRE

The incorporation of technological innovations leading up to and during WWI led to the introduction of indirect fire, and its successful application in combat created what British Major General Jonathon Bailey coined the "Modern Style of Warfare."[5] In his books, *The First World War and the Birth of the Modern Style of Warfare* and *Field Artillery and Firepower,* Bailey analyzes the adaptation of artillery capabilities throughout the World Wars and its effects on the battlefield.[6] He argues that the shift from a linear battle to a three-dimensional battle in WWI is "the most significant development in the history of warfare to date, and remains so."[7] Although the basic technology required for long-range bombardment existed before the war, Bailey concludes that supplementary innovations such as the introduction of aerial observers and photography, detailed mapping with trench lines, advancements in survey equipment that provided accurate locations of

[4] Toney Stricklin, "Learning from the Past to Prepare for the Future," *Field Artillery: A Professional Bulletin for Redlegs*, July 2000, 1, 1.

[5] Bailey, *The First World War and the Birth of the Modern Style of Warfare*, 3.

[6] Bailey; Jonathan Bailey, *Field Artillery and Firepower* (Oxford: The Military Press Oxford, 1989).

[7] Bailey, *The First World War and the Birth of the Modern Style of Warfare*, 1.

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 was seized upon by planners as a solution to stalemate. He claims that indirect fire became the "foundation of planning at the tactical, operational and strategic levels of war."[8]

Instead of enveloping an enemy, indirect fire facilitated breakthroughs of enemy defenses with 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."[9] By the end of the war, indirect fire had accounted for the preponderance of casualties and earned its nickname—The King of Battle. To maintain its moniker, however, the artillery would have to continue to adapt to the Modern Style of War.

The final battles of WWI gave the belligerents a glimpse at the future of conflict, as the offensives during 1918 demonstrated the sheer size and scope of what battle had become. General Bailey explains that "the First World War demonstrated the importance of firepower and fire mobility, but revealed the difficulty of providing these in close support during mobile operations."[10] In December 1918, the War Department assigned seven senior field artillery officers to assess "armament, calibers and types of materiel, kinds and proportion of ammunition, and methods of transport of the artillery."[11] What eventually became known as the Westervelt Board was a deliberate attempt to learn from combat experience and provided the framework for the motorization and mechanization of artillery for WWII.

Although numerous models of self-propelled artillery were created in the interwar period, the idea was generally abandoned. To achieve mobile fires required more than just automation, and before WWII, the military was lacking necessary supplementary equipment that supported radio communication, survey operations, and accurate fire

[8] Bailey, 1.

[9] Bailey, 17.

[10] Bailey, *Field Artillery and Firepower*, 165.

[11] William I Westervelt et al., *The Report of the Westervelt Board* (Washington, D.C.: War Department, 1919), https://morrisswett.contentdm.oclc.org/digital/collection/p15766coll2/id/529/.

missions.[12] During WWII, the mobility of artillery was reintroduced to support advances in technology. The artillery organization was also restructured to better support maneuver forces, which Bailey argues "resulted in fundamental changes in the relationship between different arms and their responsibility for providing fire support."[13] He concludes that technological advancements such as the battlefield radio and organizational shifts which included embedded observers created a direct link between artillery and maneuver forces and facilitated timely "concentrated fire on to targets specified by the supported arm, achieving a measure of co-operation not seen since the development of indirect fire."[14] The adaptability of indirect fire facilitated its success during the world wars by incorporating technological innovations, deliberately assessing experiences from combat during the interwar period, and adjusting doctrine and equipment to counter emerging threats.

D. LITERATURE REVIEW

This literature review will assess historical works on U.S. Field Artillery capabilities as they pertain to the research question. Books that cover the overarching history of the U.S. artillery create an understanding of the gradual development of the weapon systems, unit structure, and doctrine. Literature that isolates individual battles, units, or capabilities provides representative historical accounts on the application of indirect fire that is vital to understanding the capabilities at specific moments in history.

1. The History of Indirect Fire

Any research on U.S. indirect fire starts at the Fires Center of Excellence (FCoE), Fort Sill Oklahoma. For years field artillery command historian Dr. Boyd Dastrup has published detailed works on artillery that assess modernization during specific periods, compare capabilities across different conflicts, and provide a general history of the branch itself. Boyd's book *King of Battle: A Branch History of the U.S. Army's Field Artillery,*

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[12] Bailey, *Field Artillery and Firepower*, 165.

[13] Bailey, 206.

[14] Bailey, 335.

provides a historical analysis of U.S. field artillery from 1775–1988 with a focus on the "evolution of technology, tactics, doctrine, and organizations."[15] Although he concludes that development occurs at a varying pace based on the presence of an external threat, he does include the periods outside of conflict and argues that "during years of peace, foundations were laid that contributed to the successes or failures in combat."[16] More recently, in 2018, Boyd followed up his book with a modern assessment of U.S. artillery that covered the period from 1990–2016 and focused on the lessons learned from the Gulf War as well as the rapid development of capabilities during the War on Terror.[17] This contemporary analysis provides data that is essential to understanding the development and employment of precision-guided-munitions (PGM) in the artillery.[18]

The Army Lineage Series, published by the U.S. Army Center of Military History, also provides foundational literature on U.S. field artillery capabilities since the country's existence. Janice McKenney's *Field Artillery,* for example, captures the historical lineage of every U.S. artillery unit that has ever existed and outlines their heraldic information to include shoulder sleeve and distinctive unit insignia, as well as the unit's honors such as its campaign credit and decorations.[19] The most important work in the Army Lineage Series as it relates to this thesis, however, is McKenney's *The Organizational History of Field Artillery 1775–2003.* In this book, McKenney conducts a detailed analysis of the organization of artillery units and their development through every major war.[20] The Chief of Military History Jeffrey Clarke explains in the foreword, that it "highlights the rationale behind each major change in the branch's organization, weapons, and associated

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15 Boyd L. Dastrup, *King of Battle: A Branch History of the U.S. Army's Field Artillery*, TRADOC Branch History Series 1 (Fort Monroe, Virginia: United States Training and Doctrine Command, 1992, xi.

16 Dastrup, xi

17 Boyd L. Dastrup, *Artillery Strong: Modernizing the Field Artillery for the 21st Century* (Fort Leavenworth, Kansas: Combat Studies Institute, 2018).

18 Dastrup.

19 Janice E. McKenney, *Field Artillery Part 1*, 2nd ed., vol. 1, 2 vols., Army Lineage Series (Washington, D.C.: Center of Military History, 2010); Janice E. McKenney, *Field Artillery Part 2*, 2nd ed., vol. 2, 2 vols., Army Lineage Series (Washington, D.C.: Center of Military History, 2010).

20 Janice E. McKenney, *The Organizational History of Field Artillery 1775–2003*, Army Lineage Series (Washington, D.C.: Center of Military History, 2007).

equipment, and lays out for all field artillery soldiers the rich heritage and history of their chosen branch."[21]

2. The Korean War and the Development of Nuclear Artillery

After WWII, the artillery went through a massive reorganization that included the elimination of weapons from the arsenal, an increase of cannon caliber across the board, and an emphasis on the importance of self-propelled artillery.[22] Between the end of war review boards in Europe, and the artillery conferences held at Fort Sill, McKenney argues that "the Army devoted a great deal of time and effort to evaluating and analyzing performance and effectiveness in much the same manner as it had immediately after World War I."[23] The implementation of artillery post-WWII, however, demonstrates the struggle that the organization had in applying technological developments. Although mechanization had occurred and the Army leadership argued "that self-propelled weapons be provided to all field artillery units except pack and airborne organizations," when the Korean War began only 15 percent of active artillery battalions were self-propelled.[24]

The army did not incorporate the lessons of WWII before the Korean War began, and artillery units suffered the consequences. D.M. Giangreco's "Artillery in Korea: Massing Fires and Reinventing the Wheel," for example, provides a gruesome account of the challenges the artillery community faced in the Korean War.[25] Although indirect fire was very successful during the conflict for both belligerents, Giangreco describes the brutal consequences associated with the limitations of the artillery on the battlefield, explaining that "the first nine months of the Korean War saw U.S. Army field artillery units destroy or abandon their own guns on nearly a dozen occasions."[26] His focus on the 63d Artillery Battalion, in particular, demonstrates how the limited mobility of the U.S. artillery, coupled

[21] McKenney, vii.

[22] McKenney, 189–195.

[23] McKenney, 188.

[24] McKenney, 196.

[25] D.M. Giangreco, "Artillery in Korea: Massing Fires and Reinventing the Wheel," in *Korean War Anthology* (Fort Leavenworth, Kansas: Combat Studies Institute, 2003), 1–21.

[26] Giangreco, 1.

with the vulnerability of the vehicles that towed them, led to artillery pieces not only captured for future use by the enemy but also immediately turned against U.S. forces.[27]

Although the mechanization of WWII had tangible results for the artillery, it also greatly increased the survivability of maneuver forces. While artillery was fighting in Korea, it was also developing new capabilities to remain effective on the future battlefield. At the beginning of the 1950s, for example, nuclear technology was finally ready for tactical integration, and the Army fought to modernize its equipment.[28] A.J. Bacevich's *Pentomic Era* analyzes the challenges the U.S. Army faced in the years following the Korean War, specifically the integration of nuclear capabilities and the effect they had on Army doctrine.[29] He argues that in the 1950s, "weapons technology meant, above all, nuclear weapons," and that "most Army officers firmly believed that nuclear weapons of a tactical variety would decide the outcome of the next war."[30] Bacevich's work is the pinnacle piece on the development of artillery in this period, as it provides a detailed look at the challenges and successes of nuclear development as well as the secondary effects of ushering in the missile age. The president of the National Defense University, Lieutenant General Richard Lawrence, summarizes Bacevich's work in the foreword, explaining that it highlights that "the Army not only survived an institutional identity crisis—grappling to comprehend and define its national security role in a nuclear age—but grew to meet new challenges by pioneering the development of rockets and missiles."[31] His capability-based assessment is invaluable for understanding this transitional period for the artillery, and how the organization was able to adapt.

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27 Giangreco, 3–10.

28 McKenney, *The Organizational History of Field Artillery 1775–2003*, 209–242.

29 A.J. Bacevich, *The Pentomic Era: The U.S. Army Between Korea and Vietnam* (Washington, D.C., 1986).

30 Bacevich, 54.

31 Bacevich, xiii-xiv

3. The Vietnam War and the Cold War Modernization of Munitions

Vietnam served as a unique challenge to indirect fire capabilities, as there was a general inability to freely move throughout the battlefield. Major General David Ott's book *Field Artillery 1954–1973*, is the foundational literature on artillery in the Vietnam War, and it provides a detailed analysis of indirect fire across numerous battles.[32] On top of his examination on the impact of artillery during specific battles, Ott also assesses the impact of Vietnam on the artillery community: changing doctrine, organizational adjustments, and an emphasis on air mobility. As a career artillery officer, Major General Ott is uniquely situated to conduct this analysis, and he personally experienced the growth of the branch while fighting in WWII, Korea, and Vietnam.

The transition out of Vietnam and the growth of the Soviet Union forced the U.S. military to reassess its conventional capabilities. McKenney details in her book the artillery modernization efforts in this period, and it is one of the most detailed accounts of the creation of two incredibly important munition innovations: Improved Conventional Munitions (ICM) and the laser-guided Copperhead.[33]

4. The Gulf War and a Deliberate Effort to Innovate

The collapse of the Soviet Union created an opportunity for the U.S. military to look to the future without an external threat. Major General Robert Scales' article, "Forecasting the Future of Warfare," provides a detailed explanation of what was known as the Army After Next era, an attempt to predict future needs to guide development.[34] He shares his personal experiences, explaining that "we simply misjudged the rate at which essential technologies would mature. We then made the fatal mistake of trying to apply them too soon."[35] In the late 1990s, the Rand Corporation conducted a detailed assessment of the Army After Next and the Crusader program, the planned advancements in self-

[32] David Ott, *Field Artillery 1954–1973*, Vietnam Studies (Washington, D.C.: Department of the Army, 1995).

[33] McKenney, *The Organizational History of Field Artillery 1775–2003*, 285–310.

[34] Robert Scales, "Forecasting the Future of Warfare," War on the Rocks, April 9, 2018, https://warontherocks.com/2018/04/forecasting-the-future-of-warfare/.

[35] Scales.

propelled artillery.[36] The most recent literature, however, is focused on how to apply the lessons of this period to the current U.S. challenges in development. Dan Goure's "Creating the Army After Next, Again," for example, puts in perspective the challenge the Army faced after the Gulf War and applies it to the current goals of the force.[37]

5. The Global War on Terror: COIN and the Rise of Precision Munitions

COIN operations drove two main adaptations in the artillery: precision munitions and modularization. Boyd Dastrup's *Artillery Strong: Modernizing the Field Artillery for the 21st Century* is the premier work on the development of PGM capabilities in the U.S. Army Field Artillery from the start of the first Gulf War.[38] Not only does Dastrup detail the different adaptations over time, but he accounts for the military necessity that drove innovation. Dastrup explains that "from the Field Artillery's perspective, the requirement to conduct precision fires placed a conspicuous onus on target acquisition systems. They needed to locate targets with greater accuracy at greater ranges than ever before."[39] He analyzes the supplementary inventions that increased target acquisition capabilities of both artillery and maneuver units, and, similar to Bailey's assessment of WWI, Dastrup details how other innovations facilitated the evolution of PGMs. Finally, he concludes that the Global War on Terror (GWOT) "sped up the precision munition revolution; and transformed field artillery target acquisition, weapon platforms, support, and command and control."[40]

Modularization decentralized artillery training and mission planning—an organizational shift that drastically changed the role of indirect fire on the battlefield. In a

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36 John Matsumura, Randall Steeb, and John Gordon IV, *Assessment of Crusader: The Army's Next Self-Propelled Howitzer and Resupply Vehicle* (Santa Monica, California: RAND Corporation, 1998); John Matsumura et al., *The Army After Next: Exploring New Concepts for the Light Battle Force* (Santa Monica, California: RAND Corporation, 1998).

37 Dan Goure, "Creating the Army After Next, Again | RealClearDefense," accessed October 14, 2019, https://www.realcleardefense.com/articles/2019/08/16/creating_the_army_after_next_again_114670.html.

38 Dastrup, *Artillery Strong: Modernizing the Field Artillery for the 21st Century*.

39 Dastrup, 38.

40 Dastrup, iv.

2012 RAND report, *A Review of the Army's Modular Force Structure,* Stuart Johnson, John Peters, Karin Kitchens, Aaron Martin, and Jordan Fischbach provide an assessment of "modularity" and its effect on the force from 2002–2008.[41] The report describes how "the Army replaced its division-centric force structure with a force whose constituent building blocks" is the Brigade Combat Team (BCT).[42] The report identified that the modular shift created mass force reductions and reorganizations of the Army to include a nearly 50 percent drop in field artillery brigades and inserted direct-support field artillery battalions into maneuver units. This represented a dramatic shift in how U.S. Artillery historically organized. Modularity, however, came with unintended effects, and in the 2007 white paper "The King and I: The Impending Crisis in Field Artillery's ability to provide Fire Support to Maneuver Commanders," Colonels Sean MacFarland, Michael Shields, and Jeffrey Snow expressed their concern about the future of indirect fires.[43] This document not only outlines problems but also offers solutions, and the authors challenge the force structure. On top of this, numerous officers have completed master's theses from institutions such as the Army War College, Army Command and Staff College, and the Marine Corps Command and Staff College detailing the negative effects of the GWOT on the field artillery branch.[44]

6. Contribution to the Literature

Although the history of indirect fire is thorough, this thesis strives to add to the literature by assessing specific drivers of the innovation process. The detailed histories of

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[41] Stuart Johnson et al., *A Review of the Army's Modular Force Structure* (Santa Monica, California: RAND Corporation, 2012).

[42] Johnson et al., iii.

[43] Sean MacFarland, Michael Shields, and Jeffrey Snow, "The King and I: The Impending Crisis in Field Artillery's Ability to Provide Fire Support to Maneuver Commanders," 2007.

[44] Julian Urquidez, "The King Is Dead:· Regaining the Throne: The Current State of the Field Artillery, Core Competency Atrophy, and the Way Ahead" (Quantico, Virginia: The United States Marine Corps Command and Staff College, 2011); Stephen Kaplachinski, "Killing of a King: The Increasing Marginalization of the Field Artillery Branch in Current Counterinsurgency Operations" (Fort Leavenworth, Kansas: Army Command and General Staff College, 2010); Noel T. Nicolle, "Effect of Modularity on the Field Artillery Branch" (ARMY WAR COLL CARLISLE BARRACKS PA, March 2009), https://apps.dtic.mil/docs/citations/ADA497749; Michael Hartig, "The Future of the Field Artillery" (Carlisle, Pennsylvania: U.S. Army War College, 2010).

the U.S. field artillery tell the story of the branch's development, but are lacking the "why." Using historical resources from authors who focused on specific battles and artillery officers that shared their unique experiences, the analysis of this thesis provides the context of artillery adaptation over time. In addition to gaining an understanding of the innovation process, this thesis identifies recurrent historical indirect-fire developmental themes to offer future innovation recommendations to the artillery community.

7. Primary Resources

Outside of general books and articles, the majority of the data for this thesis is compiled from personal experiences and three major databases: The Morris Swett Technical Library, the U.S. Army Center for Military History, and the Fires Bulletin.

a. Personal Experience

As a field artillery officer, professional experience and training provide a unique context for the assessment of indirect-fire literature. This includes planning and executing rocket artillery missions in combat, as well as ample training with self-propelled artillery in simulated force-on-force scenarios. Overall, personal experiences create a distinct ability to assess and analyze field artillery planning and the effectiveness of indirect fire capabilities.

b. Morris Swett Technical Library[45]

The Morris Swett Technical Library at Fort Sill, according to its mission statement, "provides in-depth academic research, information resources and technical support for the training mission of the FCOE, Warfighters and independent researchers worldwide."[46] A majority of the library has been digitized and is available to the public as a "consortium of documents, images, letters, and papers of and relating to the United States Army Field

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45 "Morris Swett Technical Library – Fires Center of Excellence – U.S. Army," accessed September 28, 2019, https://sill-www.army.mil/MorrisSwett/; "Morris Swett Digital Collections & Archives - Morris Swett Digital Collections & Archives," accessed September 25, 2019, https://morrisswett.contentdm.oclc.org/digital/.

46 "Morris Swett Technical Library – Fires Center of Excellence – U.S. Army."

Artillery."[47] The collection contains the works of the field artillery command historian, historical selected student papers dating back to 1915, and general historical documents that affected the field artillery community. The most important aspect of this database for this thesis, however, is the primary source documents that have been preserved, such as the original 1919 Westervelt Board Report.[48]

c. The U.S. Army Center for Military History[49]

The U.S. Army Center for Military History, according to its mission statement, is responsible for "recording the official history of the Army in both peace and war, while advising the Army Staff on historical matters."[50] The center publishes numerous books and monographs on every major conflict, as well as individual unit histories over time, totaling over 600 publications.

d. The Fires Bulletin[51]

The *Fires Bulletin* is a military professional journal that focuses on tactics, techniques, and procedures for the training and employment of artillery. Officers and non-commissioned officers publish articles that outline the challenges their units face and how they overcame them, often recommending major changes to doctrine or equipment. On top of articles from military members, the journal editors conduct and publish articles based on interviews with senior flag grade officers in important billets or with unique experiences

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47 "Morris Swett Digital Collections & Archives - Morris Swett Digital Collections & Archives."

48 Westervelt et al., *The Report of the Westervelt Board*.

49 "U.S. Army Center of Military History," U.S. Army Center of Military History, accessed September 28, 2019, https://history.army.mil/index.html.

50 "An Overview - U.S. Army Center of Military History," accessed September 28, 2019, https://history.army.mil/html/about/overview.html.

51 "Fires Bulletin | Fort Sill | Oklahoma," accessed September 27, 2019, https://sill-www.army.mil/firesbulletin/.

such as the Commander of U.S. Forces Central Command.[52] The most important aspect of this database, however, is the archives section which dates back to 1911 and provides articles from military members during crucial times of adaptation in the artillery branch.[53]

E. RESEARCH DESIGN

This thesis will analyze the development of U.S. indirect fire systems since the end of the Second World War, with particular attention to the ways in which the artillery branch has sought to keep pace with and adapt to, the parallel evolution of maneuver forces—those it must support as well as those it is intended to oppose. Its focus is on the role of artillery on the battlefield, and on how that role has been repeatedly reshaped by new technologies on the one hand, and by organizational and doctrinal changes on the other. The development of U.S. artillery in this period is not unique: all modern armies are subject to some version of the same technological and institutional pressures. But the U.S. experience is undoubtedly exemplary, by virtue of the scale of resources involved, and because of the country's preeminent military role, which has ensured that U.S. artillery 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.

The thesis is broken into five distinct sections that chronologically extend from the conclusion of WWII to operations in Iraq and beyond, each assessing adaptation through the lens of the incorporation of new technology, the application of lessons learned from combat experience, and the assessment of external threats.

1. An examination of the lessons of the Korean War, and the subsequent technological and organizational innovations of the early Cold War, to

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[52] Patrecia Hollis, "2007 Surge of Ground Forces in Iraq- Risks, Challenges and Successes: Interview with Lieutenant General Raymond T. Odierno," *Field Artillery: A Joint Magazine for U.S. Field Artillerymen*, March 2008, 5–10; Patrecia Hollis, "Second Battle of Fallujah- Urban Operations in a New Kind of War: Interview with Lieutenant General John F. Sattler," *Field Artillery: A Joint Magazine for U.S. Field Artillerymen*, March 2006, 4–9; Patrecia Hollis, "Today's Army in Change- An Exciting Place to Be: Interview with Lieutenant General James J. Lovelace Jr.," *Field Artillery: A Joint Magazine for U.S. Field Artillerymen*, May 2006, 6–8; Patrecia Hollis, "Pentathletes in the 82nd Airborne Division- Developing Critical Capabilities for the Army: Interview with Major General William B. Caldwell IV," *Field Artillery: A Joint Magazine for U.S. Field Artillerymen*, July 2006, 4–6.

[53] "Historical Archives," Fires Bulletin, accessed September 27, 2019, https://sill-www.army.mil/firesbulletin/archives/.

gain an understanding of the tactical nuclear program and how it ushered in the missile age of indirect fires.

2. An assessment of artillery during the Vietnam War, specifically firebase operations, and the modernization of indirect fire munitions in the late Cold War in response to the growing Soviet tank threat.

3. The application of modern munitions in a conventional conflict with a discussion of indirect fire in the Gulf War, and the U.S. Army's attempt to continue to modernize with the absence of the external threat of the Soviet Union.

4. An analysis of the challenges of COIN operations in Iraq and Afghanistan, and the transition to collateral damage limiting precision munitions to fight the asymmetric threat.

5. A conclusion that examines the drivers of innovation and offers recommendations for future adaptations based on the historical analysis of the thesis.

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II. THE KOREAN WAR AND THE DEVELOPMENT OF NUCLEAR ARTILLERY

At the end of WWII, the artillery branch methodically assessed the lessons learned from the war and identified capability gaps in maneuverability and lethality. In 1946, for example, Fort Sill hosted an artillery conference that made drastic recommendations to improve mobility and destructive power, including moving to a 100 percent self-propelled force, the development of larger projectiles with ranges out to 30 miles, and investment in rocket artillery that, according to Boyd Dastrup, senior field artillery officers believed "would eventually render heavy artillery obsolete sometime in the future."[54] These assessments were validated by the War Department Equipment Board, which recommended "that future artillery pieces should be more mobile … and that the Army should develop rockets and guided missiles to give the service long-range, all-weather weapons to be employed when tactical air could not be deployed."[55] For the artillery, the lessons of WWII were clear: it needed more destructive capacity, increased mobility, and an increased range, all of which would allow it to remain independent from airpower.[56]

The problem with integrating these adjustments, however, was that five years after WWII ended, a new war began. Dastrup explains in his book that after WWII "the field artillery outlined an aggressive program to incorporate the lessons of the war … before the effect of the reforms could be felt, however, the Korean War broke out."[57] The Korean War was fought exclusively with conventional munitions. Although the adaptations in the years that followed the Korean War addressed the problems of artillery lethality and the logistical burden associated with a high volume of missions, it was the incorporation of emerging nuclear and missile technology, not combat experience, that was the driving factor of innovation in the 1950s. The tactical nuclear weapons that developed were never

[54] Dastrup, *King of Battle: A Branch History of the U.S. Army's Field Artillery*, 244.

[55] Dastrup, 245.

[56] Dastrup, 241–251.

[57] Dastrup, 241.

employed in combat, but the adaptation to the nuclear battlefield did create a lasting air-mobility capability as well as rocket artillery employment doctrine.

A. THE KOREAN WAR

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 U.S. saw its first battle, which was the first of many defeats that drove all UN forces to the southern tip of the peninsula by August.[58] The successful Inchon landing and subsequent recapturing of Seoul in September helped turn the tide, and in October, UN forces were driving towards China.[59] The Chinese military entered the war forcing UN forces to again withdraw, and 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.[60]

The drastic shifts in territorial control early in the war created a tactical situation that towed-artillery was unable to support. Not only were many cannons destroyed and abandoned due to the high tempo, but they were often unable to even be employed. The absence of indirect fire on the battlefield was keenly felt by the U.S. military, 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. The increased ammunition expenditures that were 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, Janice McKenney concludes that the "field artillery learned few new lessons during the war, but the importance of the arm

58 T.R. Fehrenbach, *This Kind of War* (Dulles, Virginia: Potomac Books, 2008), xv–xl.

59 Fehrenbach, xv-xl.

60 Fehrenbach, xv-xl.

was reconfirmed."[61] Even though the branch was not reshaped during the conflict, the challenges of excessive ammunition expenditures and failures of force protection reinforced artillery lessons from WWII and eventually led to revolutionary changes in indirect-fire capabilities through the development of rocket and missile artillery.

1. The Logistical Challenge of Artillery Ammunition

When the Korean War eventually settled into a stalemate, artillery—specifically the ability to mass large quantities of munitions—became an essential tool for the U.S. to hold territory. McKenney argues that "the static nature of the war tested the field artillery's weapons and equipment under conditions similar to those of World War I."[62] During the peak of the conflict, artillery ammunition consumption grew dramatically, and D.M. Giangreco explains that "the per-gun 105-mm daily rate was raised from 50 to 300 rounds, the 155-mm from 33 to 250, and the 8-inch from 20 to 200."[63] He argues that even with this dramatic increase, the commanders on the ground were not satisfied because it was still not enough ammunition to neutralize the enemy's aggressive attacks.

On top of ammunition restrictions during the war, the limited number of howitzers that supported individual battles limited the Army's ability to maintain a high-volume of artillery fire without a dramatic increase in the number of rounds per tube. Giangreco explains that with a less optimal quantity of guns, "the best way to achieve an appropriate volume of ordnance on targets was to shoot at exceptionally rapid rates and keep the ammunition coming."[64] He argues that this method was common practice, especially in defensive operations, and eventually led to a battalion of 105-mm cannons damaging their gun tubes. At the Battle of Pork Chop Hill in 1953, for example, Dastrup explains that "nine battalions fired over thirty-seven thousand rounds in twenty-four hours."[65] He argues that although this massive expenditure challenged the supply system, to include creating

61 McKenney, *The Organizational History of Field Artillery 1775–2003*, 205.

62 McKenney, 203.

63 Giangreco, "Artillery in Korea: Massing Fires and Reinventing the Wheel," 12.

64 Giangreco, 7.

65 Dastrup, *King of Battle: A Branch History of the U.S. Army's Field Artillery*, 258.

shortages elsewhere, it "reaffirmed the American reliance upon massed artillery to stop enemy attacks."[66] Historian and WWII veteran Walter Hermes details the Army's challenges with artillery ammunition management during the Korean War in his book, *Truce Tent and Fighting Front.*[67] He references General Ridgeway's feelings about 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 corpses in the graves registration collecting points."[68]

2. Problems with Protection: Limited Range and Mobility

The limited ranges of artillery during the Korean War forced units to a forward and often dangerous position to be able to support maneuver forces.[69] For example, Giangreco explains that "to cover its extended front, the First Cavalry Division (1CAV) placed individual batteries 7,000 yards behind the lines."[70] This created disaster early in the war, as the U.S. was not prepared for the intensity of the opposing forces; the front line was regularly pushed back, putting artillery units in direct contact with enemy infantry forces. Enemy forces concentrated firepower against ammunition and resupply trucks, as well as prime mover vehicles, often leaving cannons destroyed, abandoned, or in the worst-case scenario, turned against friendly forces.[71]

Similar to WWII, limited mobility was also a factor in the protection of the weapons, especially when transitioning from offense to defense. Giangreco notes that over 100 howitzers were abandoned intact when the U.S. hastily withdrew from the north, and

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[66] Dastrup, 258.

[67] Walter Hermes, *Truce Tent and Fighting Front*, The United States Army in the Korean War 2 (Washington, D.C.: Center of Military History, 1992).

[68] Hermes, 227.

[69] "Korean War Artillery (1950-1953)," accessed December 8, 2019, https://www.militaryfactory.com/armor/korean-war-artillery.asp. Note: The two primary systems during the Korean War were the towed 105-mm howitzer and the various models had 5–7 mile maximum ranges and the towed 155-mm howitzer which had a maximum range of 9 miles.

[70] Giangreco, "Artillery in Korea: Massing Fires and Reinventing the Wheel," 7.

[71] Giangreco, 4.

that "the Chinese were more than happy to add the captured weapons to their inventory."[72] These problems in mobility reinforced the assessments made at the 1946 Fort Sill Conference to transition to a self-propelled force, but the eventual incorporation of the helicopter transitioned the mobility conversation to lighter, air-mobile artillery platforms.

3. Lessons Learned from Combat Experience

Although the Korean War itself does not provide a prime example of military innovation in the artillery community, it set the conditions for change by reinforcing the lessons of WWII: artillery needed an 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. A.J. Bacevich argues, however, that on top of these lessons, the U.S. consensus was that "relying on conventional military means to stop communist expansion was folly," and that the problem of the Korean War "stemmed from [U.S.] refusal to use precisely those weapons that advanced technology had provided."[73]

In short, the massive casualties of a major conflict were no longer acceptable. Technology had changed warfare, and Bacevich concludes that the U.S. wanted to end future conflicts "by capitalizing on American strengths, particularly technology, rather than by squandering American manpower."[74] By the end of the Korean War, the U.S. was no longer the only nuclear power, and the country's leadership made it clear that nuclear weapons were going to be integrated into any future conflict.

B. TECHNOLOGY AS THE DRIVER OF INNOVATION: NUCLEAR ARTILLERY

President Eisenhower took office in 1953 and soon implemented a strategy that portended a profound effect on how future land combat would be conducted. The new U.S. policy of "Massive Retaliation" emphasized the use of nuclear weapons over conventional

[72] Giangreco, 8.

[73] Bacevich, *The Pentomic Era: The U.S. Army Between Korea and Vietnam*, 10.

[74] Bacevich, 10.

forces, introducing the concept of a nuclear battlefield.[75] As Bacevich explains, "the tempo and expansiveness of an atomic battlefield would demand technologies providing improvements in speed, flexibility, range, and precision."[76] For the artillery community, this meant drastic change, a fact reinforced by senior leaders like Lieutenant General Lyman Lemnitzer during the 1954 artillery conference.[77] The sentiment of the conference, Dastrup explains, was that "if vast improvements were not made, the field artillery would not have the capability to support the infantry or armor on the nuclear battlefield."[78] There was a recognized need by artillerymen to create a new arsenal of weapons specifically designed to employ nuclear munitions.[79] The rapid process of innovation 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 the field artillery.

1. 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, was more of a burden on the battlefield than an asset. Bacevich explains that "the 280-mm atomic gun was 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."[80] This was in part because Atomic Annie weighed over 80 tons, needed two tractors to move, and was only able to travel on roads.[81] Couple these limitations with its 17-mile maximum range, and according to Bacevich, the cannon "would impose heavy security requirements on the local

[75] Richard Leighton, *Strategy, Money, and the New Look: 1953–1956*, History of the Office of the Secretary of Defense, III (Washington, D.C.: Historical Office, Office of the Secretary of Defense, 2001).

[76] Bacevich, *The Pentomic Era: The U.S. Army Between Korea and Vietnam*, 71.

[77] Dastrup, *King of Battle: A Branch History of the U.S. Army's Field Artillery*, 269.

[78] Dastrup, 269.

[79] Dastrup, 269–270.

[80] Bacevich, *The Pentomic Era: The U.S. Army Between Korea and Vietnam*, 82.

[81] Bacevich, 82–84.

ground commander."[82] Although this nuclear cannon was the first piece of nuclear artillery, it was quickly rendered unnecessary with the development of nuclear ammunition that could be fired by standard artillery cannons. Cannon artillery as a whole, however, was technologically incapable of meeting the requirements for a suitable nuclear weapon. The ballistics required to launch a large projectile out of a cannon limit both the payload capacity and range, and in a nuclear arena, these limitations reinforced the need for a new type of delivery system.[83]

2. 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 pursue the development of missiles, which until then had been pursued mainly as strategic weapons, along the lines of the German V-2.[84] During the Korean War, defense spending on missiles capable of carrying lighter warheads increased ten-fold, from under $75 million in 1950 to over $750 million by 1953.[85] McKenney explains that the Army was responsible for "ground-launched short-range surface-to-surface guided missiles supplanting or extending the capabilities of conventional artillery."[86] She 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 organization relevant, and not dependent on the Air Force. The missiles, McKenney 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."[87]

Missiles expanded the role of artillery on the battlefield as they were capable of greater range and destructive capacity than cannons. Bacevich argues that the introduction

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82 Bacevich, 83.

83 Department of the Army, *Field Artillery Tactics and Techniques*, FM 6-20 (Washington, D.C.: Department of the Army, 1958), https://www.bits.de/NRANEU/others/amd-us-archive/FM6-20%2858%29.pdf.

84 McKenney, *The Organizational History of Field Artillery 1775–2003*, 211.

85 Doris Condit, *The Test of War: 1950–1953*, History of the Office of the Secretary of Defense, II (Washington, D.C.: Historical Office, Office of the Secretary of Defense, 1988).

86 McKenney, *The Organizational History of Field Artillery 1775–2003*, 211.

87 McKenney, 242.

of missiles “promised radical improvements in range … and when combined with nuclear warheads, in destructive potential.”[88] 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.”[89] The Army invested heavily in the new capability in the decade from 1954–1964 and developed numerous surface-to-surface nuclear missiles along a two-pronged approach: tactical nuclear missiles that could be utilized at the lowest echelon and long-range strategic missiles.[90]

3. Tactical Mobile Rockets

The first type of rockets that the Army produced provided an emphasis on mobility and a limited support structure that allowed them to be attached to and support maneuver units at the tactical level. The Honest John was the first in a rapid string of these tactical nuclear rockets that were designed to provide a nuclear capability directly to maneuver forces as well as replace nuclear cannon artillery. The Honest John was fielded in 1954 with a limited range of 16 miles, and an improved version fielded in 1961 that extended the range out to 25 miles.[91] The system was able to deliver a 1500-pound warhead as close as five miles, and on top of nuclear munitions, it could fire chemical and fragmentation rockets.[92] McKenney argues that the Honest John was groundbreaking, explaining that “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.”[93] In addition, the

88 Bacevich, *The Pentomic Era: The U.S. Army Between Korea and Vietnam*, 73.

89 Bacevich, 74.

90 McKenney, *The Organizational History of Field Artillery 1775–2003, 209–240*; Bacevich, *The Pentomic Era: The U.S. Army Between Korea and Vietnam*.

91 McKenney, *The Organizational History of Field Artillery 1775–2003*, 212–216.

92 “Last Name-John, First Name-Honest, Occupation-Artillery Weapon,” *Artillery Trends*, June 1958, 49–51.

93 McKenney, *The Organizational History of Field Artillery 1775–2003*, 212.

system itself was built simply so that it fired similar to a cannon, and it was easy to maneuver around the battlefield.[94]

Although the Honest John had many strengths, it also had weaknesses. Its range was limited and it was not guided, which drastically hindered accuracy, something McKenney notes, "was an absolute necessity with short ranges and nuclear warheads."[95] Numerous officers argued, however, that although an unguided rocket is inherently inaccurate, emphasis on extra care of the equipment as well as detailed gunnery and survey procedures could dramatically improve the Honest John's accuracy.[96] On top of these issues, the sheer weight of the system made it impossible to be lifted by a helicopter, which created a major tactical problem, as air mobility was considered a prerequisite for the future battlefield. As Dastrup explains, "the Army envisioned that the mobility offered by aircraft was a way to neutralize tactical 'atomic weapons' firepower."[97]

To improve upon the inaccuracy of the Honest John, the military developed the Lacrosse rocket platform which was capable of firing a guided rocket. Built for mobility—the equipment was vehicle-mounted and capable of airlift—the new system had the potential to be a successful addition to the artillery arsenal.[98] Fielded in 1960 by the Army, the Lacrosse was originally designed for the Marine Corps with the intent to reinforce conventional artillery, and it was created with a maximum range of 20 miles.[99] Although a handful of Lacrosse battalions were created, the system had too many problems to be useful, primarily with the guidance equipment, and all of the units were deactivated in 1963.[100] The termination of the Lacrosse created a capability gap for a short-range precision rocket that was not filled until a decade later with the Lance, but McKenney

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[94] McKenney, 212–216.

[95] McKenney, 230.

[96] Benjamin Meadows, "Good Gunnery Means Improved Honest John Accuracy," *Artillery Trends*, October 1958, 50–53; Horace Macintire, "Honest John Accuracy," *The Tactical and Technical Trends in Artillery for Instruction*, October 1957, 67–69.

[97] Dastrup, *King of Battle: A Branch History of the U.S. Army's Field Artillery*, 260–261

[98] "Lacrosse- From Bunker Busting to General Support," *Artillery Trends*, December 1959, 7–17.

[99] McKenney, *The Organizational History of Field Artillery 1775–2003*, 222–226.

[100] McKenney, 222–226.

argues that "even then, the Lance did not have the capability originally desired by the Marines— that of precision accuracy."[101]

In 1961, the Army invested in a small platform intended to support airborne and light infantry operations.[102] The new system, the Little John, was lightweight and helicopter transportable, but only had a maximum range of 12 miles.[103] This design allowed for rapid infiltration, mission processing, and displacement, all within 10 minutes, which dramatically changed the way rocket artillery could be utilized.[104] As Morris Keller explained in his 1960 article in *Artillery Trends*, "this rapid-fire and quick displacement concept is no longer a 'future' hope, but is a reality with the Little John rocket."[105] 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.[106]

4. Long-Range Strategic Missiles

Long-range missiles provided the Army a capability to strike the enemy deep in its rear, dramatically extending the battlefield. The first of these missiles, the Corporal, was fielded in 1955 and fired a 45-foot guided missile.[107] The missile dramatically extended the range of artillery as the missile ranged out nearly 80 miles.[108] The Corporal required a guidance platoon with radar and Doppler radio to track, compute corrections, send commands, and shutoff the propellant.[109] The system, however, was full of flaws. The sheer size of it hampered its mobility; couple that with its slow fueling process and a 30-

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[101] McKenney, 226.

[102] McKenney, 228–230.

[103] McKenney, 228–230.

[104] Morris Keller, "Little John- The Mighty Mite," *Artillery Trends*, July 1960, 20–25.

[105] Keller, 20.

[106] McKenney, *The Organizational History of Field Artillery 1775–2003*, 241.

[107] McKenney, 214–216.

[108] McKenney, 214–216.

[109] Vincent Elmore, "The Corporal Firing Battery," *The Tactical and Technical Trends in Artillery for Instruction*, June 1957, 28–29.

mile minimum range, and it was an incredibly unresponsive platform for any mission other than of a pre-planned target.[110] Bacevich concludes that "like the 280-mm gun, Corporal provided no more than an interim solution."[111] The Corporal remained in service until 1964 and was replaced by the Sergeant.[112]

The second attempt at a long-range missile—the Sergeant—was fielded in 1962, and the 35-foot weapon was a major capability upgrade over its predecessor.[113] The Sergeant had a similar range window to that of the Corporal but it was lighter and more efficient. Not only was the system air-transportable, but its transition to solid fuel sped up the responsiveness dramatically.[114] As McKenney explains, "its highly reliable solid-propellant motor was ready to fire within minutes, while the Corporal's liquid propulsion system required hours of preparation."[115]

On top of long-range missiles for Army operations, two missiles, the Redstone and Pershing, were developed as theater-level weapons. The Redstone was fielded in 1958 and achieved a range of 200 miles, but it was liquid-fueled like the Corporal and its replacement was announced that same year it was fielded.[116] The Pershing replaced the Redstone in 1964 with an extended range out to 460 miles and an upgrade to solid propellant that greatly expedited the firing process.[117] The platform was quickly assimilated into the North Atlantic Treaty Organization (NATO) defense plan, and in 1965, the organization took control of the theater-wide weapon.[118] This transition affected the Army's plan for a potential clash with the Soviet Union, as NATO control over the Pershing missile stripped the Army of valuable weapons. McKenney explains that "during the critical early phase of

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[110] McKenney, *The Organizational History of Field Artillery 1775–2003*, 214–216.

[111] Bacevich, *The Pentomic Era: The U.S. Army Between Korea and Vietnam*, 86.

[112] McKenney, *The Organizational History of Field Artillery 1775–2003*, 241.

[113] McKenney, 226–228.

[114] McKenney, 226–228.

[115] McKenney, 227.

[116] McKenney, 216–219.

[117] McKenney, 230–234.

[118] McKenney, 230–234.

potential conflict, army and corps commanders … had lost their organic long-range general support nuclear firepower."[119]

5. Lessons from the Incorporation of New Technology

The Army's fielding of tactical nuclear weapons after the Korean War demonstrated a desire by the military 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 were not the driving force of innovation. This is not to say that capabilities were insignificant to weapons development, but rather that the early models were driven more by a desire to simply have 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: it was thought that the incorporation of nuclear artillery would increase the standoff distance of artillery units, reduce the logistical burden of ammunition expenditures, and provide maneuver forces a tool to help them on the new battlefield.

This rapid incorporation of technology, however, led to inefficient and impractical systems that were quickly discontinued. For example, the first nuclear cannon had zero mobility and was considered more of a hamper to operations than an asset. Tactical rockets such as the Honest John and Little John had such limited ranges that maneuver forces were required to operate in and around nuclear fallout. The Corporal long-range missile took hours to set up and process a mission, and it was so ineffective that its replacement was announced in the same year that it was fielded. Although more modern platforms eventually developed to increase range, lethality, and mobility, the failures that preceded them demonstrate a desire to simply incorporate new technology for its own sake, instead of a process to develop or tailor technology to provide a capability.

C. ADAPTING TO A NUCLEAR BATTLEFIELD

The proliferation of tactical surface-to-surface nuclear weapons not only created a new capability for the U.S., but it represented an emerging problem: the nuclear battlefield.

[119] McKenney, 232.

The reorganization of forces into what would become the "Pentomic Division" created a conversation about the decentralization of the control of indirect fire, and the employment of rocket artillery forced the branch to create new doctrine.

1. The Pentomic Division: Organizational Adaptation

To fight in the nuclear environment, the Army needed to organizationally adapt with a focus on small independent units, dispersion, and mobility. In 1954, Army Chief of Staff General Matthew Ridgway ordered an assessment of how to restructure Army divisions, specifically shrinking the size of the formation and emphasizing mobility without sacrificing lethality.[120] The nuclear battlefield threatened the idea of the large massed forces that had fought in WWII and the Korean War. Dispersion became the key to survival, which strained sustainment operations, and also forced 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.[121] The battle group design was built around a self-contained model and resembled a modern-day BCT. The advent of the self-contained battle groups weakened the division artillery (DIVARTY) as it required the detachment of a firing battery for each battlegroup to give it autonomy. Bacevich notes, however, that "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."[122]

This new relationship challenged the fundamental role of DIVARTY, which put into question who had the authority to plan and execute indirect fires. Dastrup explains that 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."[123] He outlines how Major General Edward Williams, the Commandant of the Artillery and Guided Missile School, for example,

[120] McKenney, 245.

[121] Bacevich, *The Pentomic Era: The U.S. Army Between Korea and Vietnam*, 107.

[122] Bacevich, 105–106.

[123] Dastrup, *King of Battle: A Branch History of the U.S. Army's Field Artillery*, 268.

openly challenged the reorganization and argued against decentralizing the control of fires. The critiques of Brigadier General Donald Harriott, the commander of the Tenth Infantry DIVARTY, provides another example. After a training exercise he argued that the organizational adaptation limited the artillery's ability to mass fires and that for maneuver forces to be supported, there must be unity of command for indirect fires.[124]

2. Fighting in a Nuclear Environment: Doctrinal Adaptation

Adaptation to the nuclear battlefield went beyond new equipment and the reorganization of the force; it required a change in how the artillery fought. Colonel W.E. Showalter, the 1957 field artillery director of gunnery, argued that "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."[125] He coined this situation the "6400-mil problem," forecasting the type of fighting the artillery would see in any battle with noncontiguous front lines.[126] For field artillery officers advising maneuver commanders on the new battlefield, unique knowledge of nuclear weapons became a necessity. Artillery officers not only facilitated the employment of the new systems but were expected to make nuclear target recommendations—distinct from conventional targets and debated in detail at the U.S. Army Artillery and Missile School.[127] On top of basic fire support requirements, the 1958 Field Manual *Field Artillery Tactics and Techniques* (FM 6-20) outlined that one of the primary responsibilities of the deputy army artillery commander was "to provide the army (corps) commander with predictions of the radioactive fallout from friendly nuclear weapons."[128] To facilitate the extra knowledge requirements, the artillery added two new courses to its officer

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[124] Dastrup, 272–273.

[125] W.E. Showalter, "An All Around Problem," *The Tactical and Technical Trends in Artillery for Instruction*, June 1957, 16–18, 16.

[126] Showalter. Note: 6400 mils is equivalent to 360 degrees. The artillery community utilizes mils, short for milliradians, to enable more detailed calculations with one degree equivalent to roughly 17.8 mils.

[127] Burris Dale, "Atomic Targets of Opportunity- Definition and Brief Discussion," *The Tactical and Technical Trends in Artillery for Instruction*, October 1957, 100–103.

[128] Department of the Army, *Field Artillery Tactics and Techniques*, 15.

professional education program in November 1957: “Subcourse 80, The Employment of Atomic Weapons” and “Subcourse 74, Field Artillery Rockets and Guided Missiles.”[129]

The artillery community not only adjusted to how nuclear weapons changed the battlefield but also in the fact that missile artillery, conventional or nuclear, was a new concept that included limitations and challenges for the artillery batteries themselves. For example, early missile systems required lengthy and personnel-intensive reloads after firing a single rocket, a problem that was eventually fixed in 1983 with the advent of the modern-day Multiple Launch Rocket System (MLRS).[130] In addition, and unlike cannon-fire, each shot left indelible traces that gave away the platform’s position. The lingering trail in the sky greatly aided the enemy’s counter-battery problem, which endangered any forces in the general proximity of the launch.

The artillery community identified new ways to fight that set the foundation for the modern-day rocket and missile artillery doctrine. Given the unique challenges that the shift to missiles presented, the artillery developed four distinct methods of employment, which in October 1958, were published by the Artillery Department of Tactics and Combined Arms.[131] The methods were not mutually exclusive and were designed for a commander to modify or combine them as needed.[132] As Lieutenant Colonel Kenneth Stark explains, “which method or variation [the commander] uses depends on the situation, the mission, and the enemy’s capabilities.”[133]

The first method kept the artillery battalion together, which reduced administrative challenges such as resupply, security, and reload time, but endangered the entire battalion if a launch detection triggered an enemy response.[134] This method was not practical, as

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[129] A.S. Britt, “Why the Increased Interest of USAR Officer in the Extension Course Program?,” *The Tactical and Technical Trends in Artillery for Instruction*, October 1957, 53–57, 54.

[130] McKenney, *The Organizational History of Field Artillery 1775–2003*.

[131] Kenneth Stark, “Methods of Deploying Cannon and Missile Field Artillery,” *Artillery Trends*, October 1958, 5–8.

[132] Stark, 5–8.

[133] Stark, 5.

[134] Stark, 5.

even a single-fire mission would compromise the unit, and forced the commander to either displace after every shot or assume a heavy risk. The second method attempted to mitigate the displacement problems of the battalion by putting the onus on the battery. The firing battery did not co-locate with the battalion headquarters, but in turn, strained all support operations.[135] Although modern rocket artillery separates the firing elements from the battalion headquarters, with batteries even capable of performing extended autonomous operations, 1950s technology made supporting this method with basic needs such as food and water, not to mention resupplying massive rockets, a large burden.

The third method combined the benefits of the first two by eliminating the need for battalion displacement requirements and facilitating a central logistics point. The entire battalion located together, but the battery pushed out to designated firing areas to execute missions and then return to the headquarters after firing.[136] Most important, however, was that this approach created the idea of a rocket "firing point," a concept still applied today. The final method had the battery establish numerous firing points and move between them after each mission, and similar to the second method, it strained the battalion's ability to support the battery for an extended period.[137] Although the new rocket and missile artillery doctrine would not be validated against enemy forces until Operation DESERT STORM, the experimentation in training that stemmed from the rapid technological innovation of the 1950s created the foundation for modern-day doctrine.

D. A STRATEGIC SHIFT BACK TO CONVENTIONAL CONFLICT AND ENDURING ADAPTATIONS

Despite millions of dollars and countless resources, the strategy of "Massive Retaliation," and the concept of the nuclear battlefield, 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

[135] Stark, 7.

[136] Stark, 7.

[137] Stark, 7–8.

scale.[138] Although in 1956 the National Security Council emphasized the inclusion of nuclear weapons into the force, historian Robert Watson explains, they also identified that "with the coming of nuclear parity, the ability to apply force 'selectively and flexibly' would become increasingly important.[139] Historians Lawerence Kaplan, Ronald Landa, and Edward Drea questioned "the validity and efficacy of the massive retaliation doctrine" because of the growing strength of the Soviet Union as well as the increasing global challenges to U.S. interests at varying scales.[140] They conclude that upon entering the office, President Kennedy was critical of Eisenhower's strategic policies and was "intent on changing the doctrine of massive retaliation."[141]

President Kennedy's strategic shift to a "Flexible Response" led to a reassessment of the nuclear posture. After inspections were conducted of the nuclear weapons forward-deployed to Europe, McKenney explains that senior leaders in the U.S. "became concerned over the possibility of inadvertent or deliberate unauthorized firing of nuclear weapons."[142] This mindset carried into general strategy; Richard Weitz argues that "government officials and civilian strategists increasingly questioned the credibility of using [tactical nuclear weapons] and of the entire doctrine of limited nuclear war."[143] It had become clear, as nuclear arsenals had grown, that their main value was a deterrent, and therefore other means of fighting would be required. During the 1950s, the creation of missile and nuclear weapons consumed the Army's research and development budget, at the expense of modernizing conventional artillery. McKenney argues that the strategic shift

[138] Leighton, *Strategy, Money, and the New Look: 1953–1956*.

[139] Robert Watson, *Into the Missile Age: 1956–1960*, History of the Office of the Secretary of Defense, IV (Washington, D.C.: Historical Office, Office of the Secretary of Defense, 1997), 36.

[140] Lawrence Kaplan, Ronald Landa, and Edward Drea, *The McNamara Ascendancy: 1961–1965*, History of the Office of the Secretary of Defense, V (Washington, D.C.: Historical Office, Office of the Secretary of Defense, 2006), 293.

[141] Kaplan, Landa, and Drea, 293.

[142] McKenney, *The Organizational History of Field Artillery 1775–2003*, 222.

[143] Richard Weitz, "The Historical Context," in *Tactical Nuclear Weapons and NATO*, ed. Tom Nichols, Douglas Stuart, and Jeffrey D. McCausland (Carlisle, Pennsylvania: Strategic Studies Institute, 2012), 3–12, https://ssi.armywarcollege.edu/pdffiles/pub1103.pdf, 5.

of the 1960s, however, "emphasized conventional forces and essentially relegated nuclear weapons to a role of secondary importance in ground warfare."[144]

Even though tactical nuclear weapons stopped being the priority, the wheels of innovation were already in motion and the Army continued the development of nuclear-capable rocket and missile artillery. In 1973, the Army fielded the Lance, which supported varying operations with a range between 5 and 80 miles and the versatility to maneuver and operate in rough terrain.[145] The Lance became the only surface-to-surface tactical nuclear weapon, replacing all of the earlier models and remaining operational until 1992 when it too was replaced, but by modern, conventionally armed rocket artillery: The MLRS.[146]

Early methods and experimentation with the employment of the tactical nuclear weapons directly 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 argues that with 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."[147] 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.

E. CONCLUSION

During this time period, although the development of tactical surface-to-surface nuclear weapons was driven by technological advancements, the platforms also addressed capability gaps identified in both WWII and the Korean War. The miniaturization of nuclear warheads provided a solution, of a kind, to the problem of ammunition consumption that had emerged during the Korean War. The destructive power of a nuclear

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144 McKenney, *The Organizational History of Field Artillery 1775–2003*, 242.

145 McKenney, 234–237.

146 McKenney, 241.

147 Dastrup, *King of Battle: A Branch History of the U.S. Army's Field Artillery*, 271.

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."[148] 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.

In addition, the technology-driven innovation process in the 1950s produced sub-optimal artillery equipment that was quickly discontinued and replaced. The new equipment, however, changed the battlefield and forced the artillery community to adapt. Dastrup argues that "despite the limitations of the first atomic artillery weapons, they revolutionized warfare."[149] Although the nuclear battlefield never came to fruition, the artillery community rapidly adapted to technological innovations, developed enduring doctrine for rocket artillery, and as Dastrup explains, created weapons that "brought unprecedented firepower to the battlefield and greatly extended the range of the field artillery."[150] Thus, the innovations called for at the 1946 Fort Sill artillery conference were tangentially addressed by the introduction of the nuclear battlefield, though to some extent to the detriment of conventional artillery innovation. The nuclear age was short-lived, and the conflict in Vietnam would once again force the artillery to adapt to a different type of warfare altogether.

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[148] Department of the Army, *Field Artillery Tactics and Techniques*, 28.

[149] Dastrup, *King of Battle: A Branch History of the U.S. Army's Field Artillery*, 261.

[150] Dastrup, 261.

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III. THE VIETNAM WAR AND THE COLD WAR MODERNIZATION OF MUNITIONS

Indirect-fire capabilities developed in the latter half of the Cold War under two separate 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 the creation of infantry, armored, and mechanized divisions.[151] Just as the Pentomic Divisions of the 1950s fit Eisenhower's policy of massive retaliation, McKenney explains that "the ROAD structure was a reflection of the new administration's theory of flexible response."[152] The ROAD concept allowed the Army to operate at all levels of conflict, from a small engagement up to a nuclear war. For artillery, this transition ended the Army's reliance on nuclear weapons and it paired artillery platform types to specific divisions: self-propelled artillery was assigned to armored and mechanized divisions, and towed artillery to the infantry divisions.[153]

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 U.S., 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 and other niche capabilities such as direct-fire 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 the lasting technological innovation and adaptation of the late Cold

[151] McKenney, *The Organizational History of Field Artillery 1775–2003*, 258–260.

[152] McKenney, 258.

[153] Dastrup, *King of Battle: A Branch History of the U.S. Army's Field Artillery*, 276–277.

War. This chapter addresses the adaptability of artillery in the Vietnam War first, and then analyzes the changes to indirect-fire capabilities that stemmed from the Soviet threat.

A. THE VIETNAM WAR

The Vietnam War was an asymmetrical conflict with noncontiguous battle lines, and thus the fighting differed drastically from the engagements of the World Wars or Korea. As McKenney explains, "localized civil warfare was the norm; well-defined battle areas or front lines were nonexistent; and the enemy was elusive, often indistinguishable from the local populace."[154] These problems facilitated small skirmishes throughout the country that emphasized random hit-and-run attacks by the enemy that forced the artillery to cover an immense potential battlefield. The unconventional nature of the fighting required the artillery to adapt and adjust the way it provided support.

Successful integration of the helicopter was the key to successfully employing indirect fire in this unconventional conflict, allowing artillery units to be broken down into small elements and dispersed, supporting as much area as possible. These units were often left in static firebases for extended periods. McKenney argues that this "piecemeal, static application of artillery went completely against the usual American practice of massed battalion fires."[155] The helicopter facilitated a new type of warfare by inserting artillery units deep into potential enemy territory where vehicles could not drive. In addition, helicopters also provided resupply and support to tactical artillery bases that remained forward with maneuver forces.

1. A New Type of Mobility: Helicopter-Aided Artillery

The ability of helicopters to move artillery equipment around the battlefield solved numerous mobility problems identified in WWII and the Korean War. The first air assault division began testing in 1963 to validate the airmobile concept at all levels from the squad to division.[156] By the summer of 1965, the Army accepted the new force structure and

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[154] McKenney, *The Organizational History of Field Artillery 1775–2003*, 267.

[155] McKenney, 267.

[156] McKenney, 264.

reconfigured the 1CAV to be airmobile.[157] Just months after its reconfiguration was complete, the unit combat tested the airmobile concept in the first major engagement of the war—the Battle of the Ia Drang Valley. Over the course of the 35-day battle, helicopters rapidly resupplied the DIVARTY, and the organization fired over 33,000 rounds from its 105-mm cannons. In addition to resupply operation during the battle, helicopters facilitated nearly 70 tactical air movements with the cannons to provide continuous coverage for maneuver forces.[158] Dastrup argues, however, that although "the battles of Ia Drang vindicated the airmobile concept and showed the field artillery's capacity to provide close support in difficult terrain," without the vehicles to tow the cannons, "artillery lacked sufficient mobility to respond to fast-moving situations."[159] Airmobile artillery was part of the solution to the mobility problem, but its complexity and resource-heavy requirements made it a niche capability.

The U.S. military's emphasis on air mobility during the Vietnam War challenged the conventional wisdom of artillery employment; instead of a focus 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 argues that this smaller, less destructive cannon, "was easier to handle, was more suitable for transport by helicopter, and had a higher rate of fire."[160] At the peak of the conflict, there were over 60 U.S. artillery battalions in the country—nearly two-thirds were the lightweight 105-mm cannon.[161] In the latter half of the war, however, the number of artillery battalions in the country dropped dramatically, and to compensate, artillery units were airlifted deep into enemy territory to quickly fire a preset number of missions, and then withdraw. Although these artillery raids were often combined arms operations, the role of support was reversed

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[157] McKenney, 276–278.

[158] McKenney, 276–278.

[159] Dastrup, *King of Battle: A Branch History of the U.S. Army's Field Artillery*, 281–282.

[160] McKenney, *The Organizational History of Field Artillery 1775–2003*, 271.

[161] McKenney, 269.

and the maneuver forces supported the artillery with the intent, as McKenney explains, "to extend available combat power into remote areas."[162]

Apart from moving forces around the country, helicopters also maintained numerous mission sets, from the direct engagement of the enemy with rocket and machine-gun fire, to evacuating casualties from the battlefield. On top of these missions, artillery was not the only combat element being flown around the battlefield, as many infantry operations were also being conducted as airmobile operations. Thus, only a limited number of helicopters at any given time could be dedicated to moving or resupplying howitzers, which meant that, once artillery pieces were inserted, they stayed put for an extended period.

2. Artillery in Asymmetric Warfare: Firebase Operations

Because the short-term mobility of helicopter-inserted artillery was limited by the absence of prime mover vehicles, their positions needed an increased level of security to remain able to provide support. These firebases were thus commonly established alongside the infantry battalion that was being supported, based on three key principles: suitable terrain for helicopter operations, the ability to provide fire support to maneuver elements in the area, and a need to be within the range of another artillery unit that could help in the defense of the firebase.[163]

The 105-mm howitzer utilized in Vietnam, even with a limited maximum range of roughly 11 kilometers, was essential to firebase operations. General David Ott argued that, despite its relatively small radius of action, its "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."[164] The initial 105-mm system employed—the M101A1 howitzer—was a WWII-era weapon but by 1966 the Army upgraded to the M102 model.[165] This upgrade incorporated a key lesson from the pentomic era and the Korean War—the 360-degree

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162 McKenney, 279.

163 McKenney, 272–283.

164 Ott, *Field Artillery 1954–1973*, 49.

165 Ott, 49.

fight. The older model had a limited traverse capability that required the crew to physically lift the stabilizing legs and readjust the entire piece to traverse beyond 23 degrees in either direction, whereas the new M102 allowed the howitzer to traverse in a complete circle.[166] Understandably, this improvement dramatically enhanced the responsiveness of artillery units.

3. Adapting to Problems of Protection: The Advancement of a Direct-Fire Capability

While artillery positions in the Korean War were regularly overrun, 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, the cannons developed a direct fire capability to defend themselves. To direct fire the cannons at the enemy, artillery units had two distinct methods: the shotgun-style “Beehive round” and a creative adaptation of a time fuze.[167]

The Beehive munition allowed artillery units to defend themselves against dismounted enemy infantry, as each round fired 8,000 flechettes out to approximately 300 meters.[168] Although the standard fuze setting forced the round to burst instantly after leaving the howitzer, it could be adjusted to have the round function farther away from defensive positions, such as down a main avenue of approach.[169] This was especially important as the flechettes, which the artillery journal explains are “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.[170] When a Beehive was fired, everyone in the defensive position needed to be alerted to take cover, and this was often accomplished through simple means such as horns, flares, or shouting out specific code words.[171]

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166 United States Army Artillery and Missile School, “Field Artillery Equipment: Weapons,” *Artillery Trends*, July 1968, 5–17.

167 Ott, *Field Artillery 1954–1973*, 61.

168 “Use of Beehive In- Defense of the Battery Position,” *Artillery Trends*, May 1968, 60–61.

169 “Use of Beehive In- Defense of the Battery Position,” 60-61.

170 “Use of Beehive In- Defense of the Battery Position,” 60.

171 “Use of Beehive In- Defense of the Battery Position,” 60-61.

The Beehive round proved very effective at defeating enemy infantry in Vietnam. It was first employed in November 1966, and a single round killed nine enemy dismounts and subsequently repelled the attack.[172] Just a month later in December of 1966, the defense of Landing Zone BIRD, in the Kim Son Valley of Binh Dinh province, made the Beehive round a staple of the war.[173] During the battle, the Beehive tore into enemy forces that attempted to overrun the landing zone, and although the U.S. lost 30 service members in the attack, the defenders killed over 250 enemy fighters.[174] General Ott argues that Landing Zone BIRD validated that the "Beehive round was a tremendously valuable asset to the over-all firebase defense program," and most importantly, "it had gained the confidence and respect of both artillerymen and infantrymen."[175] The Beehive was not a perfect solution, however, as enemy troops in the prone position or behind cover were able to avoid the effects of the massive shotgun blast of flechettes.[176]

The second tool for direct fire, nicknamed "Killer Junior," was a bottom-up adaptation that allowed a conventional high-explosive (HE) round to explode 30 feet above the ground between 200 and 1,000 meters from the cannon.[177] To accomplish this, units experimented with the time-fuze settings, the angle of fire, and the charge of the cannon. After the first artillery units successfully adapted the Killer Junior method, they shared the calculations with the rest of the artillery community. As General Ott explains, "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."[178] The Killer Junior method proved effective and used throughout the war. For example, on a single day in September 1968, artillery units from the 6th Artillery Battalion

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172 Ott, *Field Artillery 1954–1973*, 108-110.

173 Ott, 108–110.

174 Ott, 108–110.

175 Ott, 110.

176 Ott, 61.

177 Ott, 61.

178 Ott, 61.

fired roughly 500 HE rounds this way and killed nearly 200 enemy attackers.[179] Although the Beehive round eventually disappeared from the arsenal, many modern U.S. artillery pieces still have similar Killer Junior direct-fire charts on hand to help cannon section chiefs engage an enemy up close, if necessary.

4. Lessons Learned from Combat Experience

The dispersed and sporadic fighting that characterized the Vietnam War created a unique problem set for the application of indirect fire. Air mobility provided a creative, if partial, solution. Helicopters allowed artillery to maneuver around the battlefield in ways that even a self-propelled howitzer could not, and, as McKenney explains, the innovation of the firebase concept was "the key for mobile large-unit operations deep into enemy territory."[180]

While helicopter-aided airmobile operations and firebases were essential to the success of artillery in Vietnam, such methods can only serve a limited purpose in a conflict characterized by more high-intensity conflict and a greater concentration of enemy forces. The logistical burden of the high volume of ammunition required for artillery would strain the limited number of helicopters that could be dedicated to supporting artillery operations. Continuous air movement also assumes non-contested airspace, something not assured against a more capable opponent. On top of this, modern self-propelled artillery platforms such as the Paladin can conduct an artillery raid without the use of a helicopter. For these reasons, helicopter-aided artillery movement is still trained today, but it is more of a niche capability.

One unexpected consequence of the reliance on helicopter mobility and firebase operations in the Vietnam War was the reduction of the role of the DIVARTY. The maneuver commander on the ground was able to build habitual relationships with the artillery that supported him, as had been envisioned by the Pentomic Division concept in the 1950s. On top of the loss of light artillery, the heavy artillery rarely moved around the

179 Ott, 164–165.

180 McKenney, *The Organizational History of Field Artillery 1775–2003*, 276.

battlefield except to preposition for an operation.[181] The DIVARTY was still responsible for all of its artillery battalions, and although the volume of fire was not at the same level as that of the Korean War, artillery missions still presented a logistical challenge. As McKenney explains, "with elements so widely dispersed, [the DIVARTY commander] saw his supply and maintenance responsibilities increase and his tactical ones decrease."[182]

While the adaptation of artillery 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 began with the Little John rocket system a decade prior. This concept remains prevalent in the artillery community. Second, to support air mobility, the artillery has made a conscious effort to ensure that all future towed howitzers are light enough for helicopter transport. Lastly, the artillery maintained the ability of howitzers to engage targets via direct fire if necessary. Although this remains the last resort, modern-day cannon crews still train with "cheat sheets" similar to those developed during the Vietnam War.

B. THE SOVIET THREAT: A NEED TO DESTROY ARMOR

The end of the Vietnam War signified a major change of focus for the U.S. military. While the U.S. fought in Vietnam, its true rival, the Soviet Union, continued to grow and modernize its military. By the 1970s, large-scale combat operations in the Fulda Gap was a distinct possibility.[183] Accordingly, the focus of U.S. artillery shifted to the modernization of munitions.

In this respect, Vietnam merely reiterated the basic inferences already drawn from WWII and Korea: artillery needed more destructive power to increase its effects on the battlefield, and it needed to use fewer rounds for each fire mission, so as to lower the

[181] McKenney, 272–273.

[182] McKenney, 274.

[183] Department of the Army, *Operations*, ADP 3–0 (Washington, D.C.: Department of the Army, 2019), https://armypubs.army.mil/epubs/DR_pubs/DR_a/pdf/web/ARN18010_ADP%203-0%20FINAL%20WEB.pdf. For clarity purposes, Large-Scale Combat Operations is defined as "Extensive joint combat operations in terms of scope and size of forces committed, conducted as a campaign aimed at achieving operational and strategic objectives," pg. Glossary-6.

logistical burden of indirect fire. Late in the Cold War, this resurgent need for destructive power was reinforced by the numerical mismatch of armor units between the U.S. and the Soviet Union. Although the ammunition problems identified during the Korean War were supposed to have been resolved with the adoption of nuclear artillery, the Vietnam War demonstrated that a conventional conflict was still a real possibility, even while drawing attention away from the pursuit of firepower per se, in favor of greater tactical agility. For the field artillery, McKenney argues, the Vietnam War "had delayed critical technological improvements needed to successfully meet an attack by a more formidable enemy in Europe."[184]

The U.S. mechanized forces in Europe (and, indeed, everywhere) were outnumbered by those of the Soviet Union, and the artillery community was concerned that should a conflict with the Soviet Union materialize, 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, against which measures like the Beehive round and Killer Junior were useless.[185] As 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."[186] In response to the threat of Soviet armored vehicles, the U.S. artillery modernized its munitions.

1. Modernizing "Smart" Munitions

The concept of "smart" artillery munitions had existed since WWII when U.S. forces employed the variable time proximity fuze—a munition still in use today—against the German Army. The fuze itself was equipped with a sensor, but as McKenney explains, "these devices could not steer the rounds to the target, only trigger them electronically when to explode."[187] The sensor identifies the ground and explodes the shell at a predetermined height, sending shrapnel down against dismounted troops. This addition was

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[184] McKenney, *The Organizational History of Field Artillery 1775–2003*, 285.

[185] McKenney, 285–286.

[186] McKenney, 286.

[187] McKenney, 286.

the first step in modernizing artillery munitions, and McKenney argues that its method of delivering shrapnel "greatly increased the effectiveness of artillery fire" during WWII.[188] Technology progressed dramatically in the 30 years after the introduction of the variable time fuze, and after Vietnam, the Army was ready to once again invest in conventional artillery. In the decades that followed the war, the artillery modernized munitions to fill the anti-armor capability gap in two distinct ways: PGMs, and area effects weapons capable of attacking armored formations.

2. A Focus on Precision: Defeating the Numerical Mismatch

The goal of PGMs is to achieve a high probability of a first-round impact on enemy targets. This allows each howitzer to engage more targets with less ammunition, which would, in turn, reduce the logistical challenges that a potential European conflict with the Soviet Union would pose. To help create an understanding of PGMs, John Yager and Jeffrey Froyslan organize them into three separate categories: "externally guided, self-directing and (or) inertially guided, and target-locating smart munitions." [189] Although the technology for self-directing artillery did not become prevalent until the twenty-first century, externally guided and target-locating munitions were a technological possibility after the Vietnam War. In fact, the Corporal and Sergeant Missiles—discussed in Chapter II—were the first attempts by the Army to externally guide a munition. Adjusting the ballistic path of a cannon round mid-flight, however, proved much more difficult than that of a rocket capable of receiving commands from a guidance platoon.

The Copperhead round was the first guided cannon projectile— designed for the 155-mm howitzer—and it effectively revolutionized artillery. Although its original development began shortly after the Vietnam War, the munition was not fielded until the early 1980s.[190] It contained an internal laser-homing device that created a high probability of a first-round hit out to 20 kilometers and an anti-armor warhead to destroy hardened

[188] McKenney, 186.

[189] John Yager and Jeffrey Froysland, "Improving the Effects of Fires with Precision Munitions," *Field Artillery: A Professional Bulletin for Redlegs* 97, no. 2 (April 1997): 5–7, 5.

[190] McKenney, *The Organizational History of Field Artillery 1775–2003*, 286–288.

targets.[191] As Major Michael Hustead explained in his article on 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!"[192] The actual execution of the round, however, was complex and prone to error. To hone 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 left room for human error. For example, the National Training Center reported that human error was the primary issue with Copperhead employment, and this produced overall success rates of under 70 percent, with some units not having any successful hits on the target during training.[193]

The low percentage of Copperhead direct hits during training subsequently led the Department of Defense to dramatically reducing funding for the round. The *Washington Post* reported that the 1983 defense authorization bill effectively ended the production of Copperhead and only allowed the Army to produce 8,000 of the originally planned 44,000 shells.[194] The author, Walter Pincus, explained that the Secretary of Defense ordered a 70 percent drop in production rates "until the Army could show that it had achieved an 80 percent hit average with test shells."[195] On top of human error, laser-guided munitions can also be affected by the weather and atmospheric conditions such as fog or dust. As Yager and Froysland simply state, "the success of Copperhead hinges on an observer being able to see the target," a situation which creates a potential problem in a region like the Middle East, where the round would experience its first combat test.[196] Overall, the Copperhead

[191] McKenney, 286–288.

[192] Michael Hustead, "Fire Support Mission Area Analysis: Impact of Precision Guided Munitions," *Field Artillery Journal* 49, no. 3 (June 1981): 19–22, 19.

[193] Yager and Froysland, "Improving the Effects of Fires with Precision Munitions," 5-7.

[194] Walter Pincus, "After $630 Million, Army Plans to Kill Laser-Guided Shell," *Washington Post*, September 8, 1982, https://www.washingtonpost.com/archive/politics/1982/09/08/after-630-million-army-plans-to-kill-laser-guided-shell/0810bd66-f994-428d-87ed-7aee132e0092/.

[195] Pincus.

[196] Yager and Froysland, "Improving the Effects of Fires with Precision Munitions," 5.

munition was revolutionary as the first externally guided cannon round, but it was only a short-term solution regarding the problem of precision.

3. Area Effects Weapons: Fighting the Horde

At its core, indirect fire is an area-effect weapon, and against a fast, mechanized force, the more area an artillery round can affect, the higher the probability of actually influencing the fight. The battlefield calculus required to use indirect fire to successfully hit a moving target traveling off-road is daunting, and with conventional HE artillery rounds, only direct hits would matter. Thus, to interdict or destroy a large mechanized force on the move, the indirect fire would need to saturate a large area with numerous rounds as fast as possible. To be relevant in large-scale combat operations required the field artillery to develop a new munition that was powerful enough to affect armored vehicles without direct hits, and also a platform capable of rapidly putting the new munition downrange.

To defeat the armored formation of the Soviet Union, the artillery branch needed a new weapon system capable of engaging multiple targets with a high volume of fire. In 1974, the Field Artillery School conducted a study on the potential development of a rocket system to fill this new void.[197] The largest challenge with rocket artillery, as identified by the Pentomic Divisions, was the requirement to conduct time-intensive reloads after every mission. New technology, however, allowed for the development of a new platform—the MLRS—that not only had a simpler reload process, but was capable of firing numerous rockets before the launcher needed to reload. The schoolhouse study concluded, according to McKenney, 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."[198]

Fielded in 1983, the MLRS was designed to be able to 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, which allowed it to move off-road effectively,

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[197] McKenney, *The Organizational History of Field Artillery 1775–2003*, 291.

[198] McKenney, 291.

taking it places the rocket artillery of old could not go.[199] The launcher could carry two rocket pods that each carried six rockets, and the vehicle could fire a single rocket or multiple rockets with only a few seconds between each launch. As McKenney explains, a single MLRS platform "could deliver the same firepower as twenty-eight 8-inch howitzers."[200] The MLRS was simple; it took advantage of the shoot-and-scoot method validated by the artillery raids in the Vietnam War, and it provided the potential to rapidly fire a dozen rockets without creating a logistical burden. As advertised by the *Field Artillery Journal*, the MLRS "permits a 3-man crew with minimum training to accurately shoot a complete 12-rocket load, quickly reload, and fire again."[201] In contrast to its predecessors, the MLRS automated system allowed the crew to move to their firing point, process a mission, and quickly leave, all without leaving the cab, and in emergencies, a single person could operate it for a short period of time.[202] Tactically, the employment methods of the system were built around the same rocket-artillery concepts that the Artillery Department of Tactics and Combined Arms outlined in 1958.[203]

While the new weapon system could launch numerous rockets across the battlefield, the army also needed a non-nuclear munition capable of massive destruction. Unlike its predecessors, the MLRS was not built for nuclear operations, and a simple HE rocket would not suffice for armored enemy forces. The military designed a cluster-munition rocket—ICM round and its eventual dual-purpose upgrade (DPICM)—that released and scattered tiny bomblets across a large area. The first ICM rocket carried over 600 of these submunitions, each with the destructive capability of a fragmentation grenade coupled with a shaped charge to penetrate armor.[204] A single one of the first generation

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199 McKenney, 291.

200 McKenney, 291.

201 Mary Corrales, "MLRS—The Soldier's System," *Field Artillery Journal* 48, no. 4 (July 1980): 8–11, 9.

202 Corrales, 8–11.

203 Stark, "Methods of Deploying Cannon and Missile Field Artillery"; Robert Smith, "MLRS Tactical Options: Shoot, Scoot and Survive to Shoot Again," *Field Artillery: A Professional Bulletin for Redlegs*, August 1987, 42–45.

204 Corrales, "MLRS—The Soldier's System," 8–11.

rockets, the M26, had a maximum range of 32 kilometers and its bomblets could affect an area the size of six football fields.[205] The MLRS was a solution to the challenges of large-scale combat operations. As Bill Rinnehouse argues 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."[206]

4. Adapting to the New Fight: The AirLand Battle

The threat of a massive battle in Europe forced changes not only in equipment and munitions, but also in how the Army would fight. The new concept, AirLand Battle, envisioned a partnership between the Army and the Air Force to attack the Soviet Union in-depth.[207] Although this transition did not restructure the artillery in the same way that the Pentomic Division or the ROAD concept had, it dramatically altered the role of indirect fire on the battlefield. The Field Artillery School Department of Tactics, Combined Arms, and Doctrine outlined the challenges of the new way to fight in *The Artillery Journal* and explained that "the mission of the Field Artillery remains unchanged in the AirLand Battle." The department also noted, however, that the mission had "become more complex in terms of execution due to the increase in requirements."[208] In simplified terms, AirLand Battle was a plan to overcome the numerical mismatch of mechanized vehicles with the Soviet Union by maximizing the number of friendly forces available for the close fight, while limiting the number of enemy vehicles that could engage them. To support this new plan and enable maneuver forces, AirLand Battle required three unique mission sets for indirect fire: close support, counterfire, and interdiction.[209]

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[205] Corrales, 8–11.

[206] Bill Rittenhouse, "MLRS Smart Munitions," *Field Artillery: A Professional Bulletin for Redlegs*, August 1987, 46–48, 48.

[207] Field Artillery School Department of Tactics, Combined Arms, and Doctrine, "Implementing the AirLand Battle," *Field Artillery Journal* 49, no. 5 (September 1981): 20–27.

[208] Field Artillery School Department of Tactics, Combined Arms, and Doctrine, 21.

[209] Field Artillery School Department of Tactics, Combined Arms, and Doctrine, 21.

The first mission set, close support, had always been the fundamental role of indirect fire, employed in concert with maneuver forces. In a high-tempo fight, however, artillery was not expected to defeat the enemy; instead, it could facilitate maneuver forces engaged with the enemy by obscuring tanks with smoke or separating them from the infantry with HE rounds.[210] On top of this, the untested Copperhead and ICM had the potential to directly affect the battle through the destruction or neutralization of lightly-armored vehicles.

The second mission set, counterfire of enemy artillery, had also been a staple of indirect fire, as artillery is one of the best weapons to kill artillery. This mission did not change, but the way planners understood how it could affect the battlefield did. As the Field Artillery Tactics Department explained, artillerymen often thought "of counterfire as an artillery duel which had little impact on the frontline," but the AirLand Battle concept reinforced the importance of counterfire for maneuver elements.[211] The suppression of enemy artillery pieces would reduce a potential threat to them, which would allow the application of the most possible direct fire systems in the close battle against the Soviet Union.[212] 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, relied on upgraded indirect fire maximum ranges, as well as artillery raids to influence enemy formations before the battle, thus reducing the number of vehicles an enemy could commit to any engagement. Although the MLRS had extended the artillery's most lethal round beyond 30 kilometers, continued improvements were 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. In an assessment of the importance of interdiction missions, the Field Artillery Tactics Department argued that "by reducing the enemy's forward momentum

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210 Field Artillery School Department of Tactics, Combined Arms, and Doctrine, 21.

211 Field Artillery School Department of Tactics, Combined Arms, and Doctrine, 21.

212 Field Artillery School Department of Tactics, Combined Arms, and Doctrine, 21-22.

and commitment flexibility, interdiction gives the friendly force commander the opportunity to maneuver."[213]

One effect of the AirLand Battle concept was the reemphasized the importance of the DIVARTY commander, a position that had a reduced role in the Vietnam War. The challenge for the DIVARTY commander was three-fold: determine where to position units to support all necessary missions, decide what elements they could afford to allocate to a maneuver unit for direct support, and establish priorities among the three artillery mission sets. Contrary to the battlegroups in the Pentomic Divisions and the way that indirect fire was employed in the Vietnam War, the habitual relationships between artillery units and the maneuver forces they supported would no longer be the natural priority. When it came to the allocation of artillery for the direct-support relationship as part of the AirLand Battle Concept, the Artillery School explained that "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."[214]

5. Lessons Learned from the Changing Threat Assessment

The threat of the overwhelming Soviet mechanized force drove technological innovation and adaptation in the late Cold War. Unlike the development of rocket and missile artillery in the 1950s, the modernization of artillery munitions in the 1970s and 1980s was slow and methodical, often altered and adjusted through testing and experimentation. This process created both success and failure. The first guided cannon round—the Copperhead—was intended to reduce the logistical burden required from a volume of artillery fire but ended up imposing unmanageable complexity in pursuit of precision. Although the round itself was effective when used properly, the complexity created room for human error, and in turn limited success in training. Although the Copperhead taught the artillery about the requirements of precision, the round failed to provide the branch with an enduring capability to achieve a high chance of a first-round strike, and only a couple of thousand rounds were produced.

[213] Field Artillery School Department of Tactics, Combined Arms, and Doctrine, 21.

[214] Field Artillery School Department of Tactics, Combined Arms, and Doctrine, 24.

The development of the MLRS stemmed from a needs-based conference at Fort Sill, and successfully applied key lessons learned from earlier rocket artillery systems, such as the Honest John. The ICM rockets employed by the MLRS embodied two of the most positive attributes of rockets compared to cannons: destructive capacity and extended range. Additionally, MLRS pod modularity solved the problem of long reload times that had plagued the rocket systems of the past. Lastly, the choice to build the system on a modified tracked infantry fighting vehicle demonstrated a focus on the improvement of artillery mobility for both increased survivability on the battlefield and the ability to rapidly adjust to the tactical situation. All of these developments were crucial to helping the artillery fit into the AirLand Battle concept. At the same time, the increasing emphasis on interdiction via indirect fire once again emphasized the importance of maximum range, something the artillery would need to continue to improve.

C. CONCLUSION

By the late 1980s, the U.S. Army was solely focused on preparing for a large-scale combat operation with the Soviet Union. While the Vietnam War forced the artillery to adapt to an asymmetric type of conflict, afterward, the adjustments of 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 was a decision that would affect future COIN operations in the Middle East, where the value of firebases would be rediscovered. The shift to AirLand Battle meant that the artillery ceased to emphasize direct-fire capabilities for force protection, another priority imposed by the Vietnam war that was subsequently neglected, in favor of increasing focus on new munitions, and new techniques for employing them. After the Vietnam War, the field artillery conducted detailed studies and conferences to assess the Soviet threat and its role in fighting it. This period saw the artillery successfully innovate new technology and doctrine based on the Army's assessment of the threat posed by massed mechanized forces, and as the Cold War drew to a close, this was the kind of war the artillery branch was best prepared to wage.

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IV. THE GULF WAR AND A DELIBERATE EFFORT TO INNOVATE

As we know, a major war with the Soviet Union never came to pass. Even as the Soviet Union began to decline, however, the U.S. military continued to modernize its equipment to support the AirLand Battle concept. For the artillery, this meant a munition with the range to perform the new role of interdiction. The army developed a long-range missile that could extend the influence of indirect fire out to over 70 kilometers.[215] 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 as well as personnel.[216]

The latter half of the Cold War had prepared the U.S. military to defeat a mechanized force. The 1991 Gulf War provided an opportunity for it to do so, and in the process to test both the AirLand Battle concept and its new artillery munitions. Overall, the combat experience of the Gulf War validated the successful innovations of the MLRS platform and its DPICM rockets. In addition, the rapidly changing tactical situation created by this high-tempo warfare reinforced the importance of mobility for artillery. In the decade that followed the Gulf War, the Army invested in safer and more destructive anti-armor artillery rounds as well as an improved self-propelled artillery platform. Although the post-Gulf War period was riddled with failed attempts at innovation, it nevertheless demonstrated a sustained effort by the artillery community to apply the lessons learned from its most recent combat experience.

A. THE GULF WAR ASSESSMENTS FROM THE GROUND

Although the U.S. fought small skirmishes late in the Cold War, the 1991 Gulf War was the first major conventional conflict to follow the Vietnam War. Iraq invaded Kuwait in August 1990, and the U.S. was quick to mobilize the military in response. The ready

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[215] Leighton Duitsman, "Army TACMS," *Field Artillery: A Professional Bulletin for Redlegs*, February 1991, 38–41.

[216] Duitsman, 38–41.

brigade of the 82nd Airborne Division deployed forces, and in just over two months the Army amassed a military force in Saudi Arabia composed of over 120,000 Soldiers, 2,000 mechanized vehicles and tanks, and 600 artillery pieces.[217] Over the next couple of months, the Army deployed over 500,000 soldiers to the region.[218] Offensive operations began in January 1991, marking the beginning of Operation DESERT STORM.[219] After about a month of continuous air and missile bombardments, coalition forces stretched across a 300-mile front line in preparation for the ground war that would last less than a week.[220]

Artillery had a dominant presence in the Gulf War; in addition to the nearly 850 howitzers utilized, the Army deployed 189 MLRS platforms.[221] In the short engagement, over 17,000 rockets were fired from the new system, which in total released more than 11-million submunitions across the country.[222] The immense amount DPCIM submunitions that littered the battlefield created an effect infamously described by the Iraqi military as "Steel Rain."[223]

The Gulf War was a one-sided conflict that favored the U.S. military, which suffered only 383 deaths, of which 147 were from the enemy.[224] In contrast, Richard Stewart explains that by the ceasefire, "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."[225]

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217 Richard W. Stewart, *War in the Persian Gulf Operations DESERT SHIELD and DESERT STORM: August 1990-March 1991*, CMH Pub 70 (Washington, D.C: Center of Military History, U.S. Army, 2010), 3–4.

218 Dastrup, *Artillery Strong: Modernizing the Field Artillery for the 21st Century*, 1.

219 Stewart, *War in the Persian Gulf Operations DESERT SHIELD and DESERT STORM: August 1990-March 1991*, 29.

220 Stewart, 29–63.

221 "Field Artillery Desert Facts," *Field Artillery: A Professional Bulletin for Redlegs* 91, no. 5 (October 1991): 2–3.

222 "Field Artillery Desert Facts," 2-3.

223 "Field Artillery Desert Facts," 2-3.

224 Anne Leland and Mari-Jana Oboroceanu, "American War and Military Operations Casualties: Lists and Statistics," 2010, http://www.dtic.mil/docs/citations/ADA516440.

225 Stewart, *War in the Persian Gulf Operations DESERT SHIELD and DESERT STORM: August 1990-March 1991*, 63.

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."[226] Unlike the Korean and Vietnam Wars, the Gulf War was not a stress test for American artillery. Therefore, its role is best understood through an examination of key actors who planned and assessed artillery missions, rather than an analysis of the overall effect on an overmatched enemy.

1. The Artillery of the 1st Armored Division

The 1st Armored Division was one of the main combat elements in the Gulf War, and in a very short time, the unit effectively applied a high volume of artillery rocket and cannon fire against the Iraqi Army. Colonel Vollney Corn Jr., the DIVARTY commander, explains that "in the course of an 87-hour, 218-mile attack, the 1st Armored Division Force Artillery delivered 1,213 rockets and more than 9,500 rounds of cannon fire."[227] The tempo of the fight created a rapidly changing tactical situation, thus mobility was key to the employment of artillery. In this regard, self-propelled artillery was 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 1950s. As Corn explains, it "proved its effectiveness in every battle with the Iraqi Army."[228]

What truly allowed the DIVARTY to influence the fight against the Iraqi Army, however, was the incorporation of rocket artillery. An MLRS battery was attached to the 1st Armored Division throughout the ground war: Alpha Battery, 94th Field Artillery Regiment. The battery fired over 600 rockets, and the majority of the missions were fired against targets near the system's maximum range of roughly 30 kilometers.[229] The volume and range of missions gave the system a live combat test, one it passed according to the artillery leaders on the ground. As Corn explains: "We relied on the MLRS as our primary

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226 Gary Langford, "Iron Rain: MLRS Storms onto the Battlefield," *Field Artillery: A Professional Bulletin for Redlegs* 91, no. 6 (December 1991): 50–54, 51.

227 Vollney Corn and Richard Lacquemont, "Silver Bullets," *Field Artillery: A Professional Bulletin for Redlegs* 91, no. 5 (October 1991): 10–15, 10.

228 Corn and Lacquemont, 12.

229 Langford, "Iron Rain: MLRS Storms onto the Battlefield," 50–54.

counterfire weapon, and in this role, we silenced all enemy artillery that fired at us."[230] Alpha Battery demonstrated the reliability of the platform by conducting a time-on-target mission that fired 108 rockets in a single minute.[231] The unit also proved the lethality of the new rockets against a massive tank formation, and the DPICM submunitions were able to neutralize 25–30 of the armored vehicles in a single mission.[232] In discussing the addition of the MLRS to the fight, Corn notes that "the system's accuracy and lethality quickly established itself as a critical part of our force artillery firepower."[233]

Although the MLRS was very effective, it also had two key faults: limited range and an excessive number of duds. Captain Gary Langford, the Alpha Battery Commander, expressed concerns about the limited range of the rockets.[234] He argued that for the MLRS to remain relevant as a counterfire and deep-attack system, the maximum range should expand to at least 50 kilometers; these sentiments echoed up the chain. Corn not only agreed with a range increase out to 50 kilometers but argued that, in this respect, the U.S. artillery was outmatched by the Iraqi Army. He noted 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."[235] To overcome the limited range, Corn concluded that it was superior U.S. target acquisition, coupled with Allied air supremacy, that allowed indirect fire assets to be employed successfully. More importantly in his assessment, the DIVARTY commander acknowledged the inherent danger of DPICM; he noted that "the dud rate of the submunitions, while low, left many unexploded bomblets that later caused some injuries and death to friendly forces."[236] Although not the central focus of lessons learned from the war, reducing the number of duds would become a focus of future munition development.

[230] Corn and Lacquemont, "Silver Bullets," 10.

[231] Langford, "Iron Rain: MLRS Storms onto the Battlefield," 51.

[232] Langford, 51.

[233] Corn and Lacquemont, "Silver Bullets," 10.

[234] Langford, "Iron Rain: MLRS Storms onto the Battlefield," 50–54.

[235] Corn and Lacquemont, 11.

[236] Corn and Lacquemont. 14.

2. 1CAV and the First Employment of Copperhead

Although the 1CAV eventually served as the VII Corps reserve element in the Gulf War, its initial mission was to conduct a massive feint operation that put the division in direct contact with enemy forces early on.[237] The successful feint drew the attention of five enemy divisions, and this allowed the 1CAV to fire some of the first artillery missions of the war.[238] One of these early artillery missions occurred on February 7, 1991, when the division successfully employed the first Copperhead munition in combat.[239] The target was two hardened observation posts that provided the Iraqis a view of the terrain for miles near the border of Saudi Arabia.[240] Lieutenant Colonel Timothy Puckett explains that the forward observer was "to attack the buildings with Copperhead," and then to "observe the impact of cannon-delivered [DPICM]."[241] The observer provided laser designation for the smart round, and 30 seconds after the direct impacts on the observation posts, 46 rounds of DPICM were fired to complete the destruction.[242]

At the time, Puckett argued that the Copperhead should be utilized only against high-value targets because of the coordination challenges associated with its employment. On top of that, he recommended that other artillery units follow up Copperhead missions with DPICM, a tactic that would exploit the success of the first round and greatly increase the overall destructive effect. Although the desert climate made laser guidance difficult, over 90 Copperhead missions were fired in the Gulf War.[243]

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[237] Stewart, *War in the Persian Gulf Operations DESERT SHIELD and DESERT STORM: August 1990-March 1991*, 28–29.

[238] Stewart, 28–29.

[239] Timothy Puckett, "Copperhead: More than a Tank Killer," *Field Artillery: A Professional Bulletin for Redlegs*, October 1994, 20–23.

[240] Puckett, 20–23.

[241] Puckett, 20.

[242] Puckett, 20–23.

[243] Fred Marty, "On The Move: FA On Target in the Storm," *Field Artillery: A Professional Bulletin for Redlegs* 91, no. 5 (October 1991): 1.

3. The Assessment from Fort Sill

The FCoE at Fort Sill, Oklahoma is responsible for the training and doctrine of the artillery community.[244] As such, the organization maintains numerous departments to evaluate the employment of indirect fire. According to its website, a key task to keep the artillery branch strong is to "collect observations, insights and lessons learned and incorporate them into doctrine."[245] At the end of the Gulf War, the FCoE conducted detailed assessments that examined the role of artillery in the war, and it published the findings in the *Field Artillery Journal*, some of which are detailed below.

For example, Major General Fred Marty, the Chief of the Field Artillery during the Gulf War, described the importance of indirect fire during the conflict in his article, "On the Move: FA On Target in the Storm."[246] Artillery was dominant on the battlefield and facilitated the successful maneuver of ground commanders, and Marty argued that the introduction of DPICM devastated enemy artillery and logistic positions. On top of the MLRS rockets, 105 ATACMS were deployed to support key preparatory missions for both the ground war and the air campaign, and this allowed the artillery to effectively engage targets beyond 70 kilometers.[247] As the branch chief, he concluded that "not since World War II has fire support in general and the FA in particular proved such a major force for the combined-arms team."[248]

Looking at the situation from a different angle, Colonel David Rolston, the Director of the Fire Support and Combined Arms Operations Department of the FA School, summarized the field artillery lessons learned from the Gulf War in his article "A View of

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244 "Fort Sill - Fires Center of Excellence - U.S. Army," accessed December 23, 2019, https://sill-www.army.mil/DOTD/divisions.html.

245 "Fort Sill - Fires Center of Excellence - U.S. Army."

246 Marty, "On The Move: FA On Target in the Storm."

247 The Institute of Land Warfare, "Army Equipment Systems Performance in Operation DESERT STORM," AUSA Background Brief (The Association of the United States Army, April 1991), https://www.ausa.org/sites/default/files/BB-34-Army-Equipment-Systems-Performance-in-Operation-Desert-Storm.pdf, 2.

248 Marty, "On The Move: FA On Target in the Storm," 1.

the Storm: Forward Observations."[249] He argued that one of the main challenges for artillery was the intelligence process, specifically that it lacked support for targeting, often focusing only on the battle damage assessment after strikes. This emphasis, however, not only helped create an operational picture for the ground commander, but it also facilitated the assessment of some of the modern artillery that had never performed in combat. Rolston explained 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."[250] He concluded, however, that the U.S. was successful "despite the fact that most of the cannon systems represented 1960s or earlier technology," and to remain relevant, "extending the range of both cannon and rocket systems must be a high priority."[251]

4. Lessons Learned from Combat Experience

On the whole, the modernized munitions that developed after the Vietnam War proved effective against the Iraqi Army, a weak opponent that nevertheless presented a realistic array of tactical problems. The emphasis on the development of anti-armor capabilities allowed indirect fire to be influential against mechanized and armored vehicles. DPICM was seen as a major improvement to conventional artillery rounds by both artillerymen and maneuver forces. Although it was also fired from cannons, the MLRS rockets carried nearly ten times the number of submunitions per round as a 155-mm howitzer, and this made each rocket an exceptionally lethal tool.[252]

As always, however, not all innovations performed well, and others still had room for growth and continued development. For example, although precision cannon rounds made their combat debut, they did not play an important role in the Gulf War. Only a couple

[249] David Rolston, "A View of the Storm: Forward Observations," *Field Artillery: A Professional Bulletin for Redlegs* 91, no. 5 (October 1991): 4–6.

[250] Rolston, 5.

[251] Rolston, 5.

[252] Mark Gebicke, "Operation DESERT STORM: Casualties Caused by Improper Handling of Unexploded U.S. Submunitions," Report for Congressional Requesters (Washington, D.C: United States. General Accounting Office, 1993), http://archive.gao.gov/t2pbat5/149647.pdf, 2.

of thousand Copperhead rounds were produced before the munition was defunded. When employed, Copperhead was accurate and effective, which greatly reduced the number of rounds needed to accomplish a mission. Even though this lessened the logistical burden, it created a separate burden of complexity. The feedback from the soldiers on the ground demonstrated that although the PGM served a purpose, its coordination requirements made it a niche capability. The round was not funded after the war and gradually disappeared from the arsenal.

Although artillery achieved great destructive capability with DPICM, a large number of submunitions did not perform correctly and even led to U.S. casualties. The rocket component littered the battlefield with potential unexploded ordinance because rockets were not held to the less-than 5 percent dud rate that was enforced on cannon DPICM.[253] In fact, certain models of rockets tested with dud rates in excess of 20 percent.[254] According to a congressional report on the handling of the unexploded ordinance during the Gulf War, it was assumed that if a single launcher fired its full load of twelve rockets, there would be anywhere from 154–1,777 unexploded bomblets left on the battlefield.[255]

The short conflict included thousands of rockets fired, and it required American forces to travel regularly through minefields they had created themselves. After the war Mark Gebicke, the Director of Military Operations and Capabilities Issues, revealed in a congressional report that over 25 U.S. military members were killed by U.S. submunitions, and many others were injured.[256] He explained that DPICM was intended for the Soviet mechanized threat, and in such a conflict, "U.S. troops would probably be in a defensive position. Therefore, U.S. soldiers were not expected to occupy submunition-contaminated areas."[257] Now that the Soviet Union was no longer a major threat, any future anti-armor artillery capability would need to reduce the risk to friendly forces. The Gulf War

[253] Gebicke, 5-6.

[254] Gebicke, 5-6.

[255] Gebicke, 5-6.

[256] Gebicke, 1.

[257] Gebicke, 7.

demonstrated not only how fast the tactical situation on the ground could change, but also the benefits of a force who took advantage of that high tempo. As Richard Stewart explains, "Army units moved so fast that they found their enemy consistently out of position and oriented in the wrong direction."[258] For artillery, this meant a focus on two factors: range and mobility.

Although rocket artillery was successful during the Gulf War, the limited range of the weapon system left much to be desired. The consensus was that rockets would need to nearly double their 30km range for a conflict against a near-peer adversary. The Army did successfully employ the new ATACMS, and it fired over 30 missiles at critical targets that included enemy long-range and air-defense missile sites, as well as key logistics nodes.[259] However, ATACMS was not designed to support normal maneuver operations. 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."[260]

As for mobility, even self-propelled artillery struggled to maintain the tempo of the fight. As Stewart explains, self-propelled howitzers "proved too underpowered to keep pace with mechanized and armored assaults."[261] This, in turn, challenged the relevancy of towed artillery in a modern conflict. If ever-improving mechanization represents the future of warfare, the artillery will need to invest in self-propelled artillery that can keep up with the armor and mechanized units it will be expected to support.

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258 Stewart, *War in the Persian Gulf Operations DESERT SHIELD and DESERT STORM: August 1990-March 1991*, 64.

259 The Institute of Land Warfare, "Army Equipment Systems Performance in Operation DESERT STORM," 2.

260 The Institute of Land Warfare, 2.

261 Stewart, *War in the Persian Gulf Operations DESERT SHIELD and DESERT STORM: August 1990-March 1991*, 66.

B. APPLYING LESSONS FROM THE GULF: CAPABILITIES-BASED INNOVATION

The general defense drawdown that followed the collapse of the Soviet Union made military innovation in the post-Gulf War period a challenge. As McKenney explains, "with the loss of a credible enemy, the Army faced substantial reductions. As the size of the Army decreased, so did that of the field artillery."[262] By the end of the decade, only 141 artillery battalions remained of the 218 battalions that were active for the Gulf War.[263] Part of this dramatic 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 disappeared from the arsenal.[264] The role of all of these platforms was essentially replaced by the MLRS.

In the summer of 1991, the Field Artillery School at Fort Sill conducted a conference to address the continued modernization of equipment and munitions.[265] Overall, the lessons of the Gulf War were primarily positive. In his assessment of the war, Corn provides one of the best descriptions of the success of the artillery: "Though the Desert Storm ground war lasted only 100 hours, the U.S. moved more forces, farther, in a shorter period of time, bringing more firepower on the enemy than in any campaign in U.S. history."[266] For the U.S. to maintain the dominance it displayed during the Gulf War, however, it needed to continue to innovate and adapt. Moving forward, artillery innovation after the Gulf War fit into two distinct categories: mobility improvements and the enhancement of anti-armor munitions.

1. Investment in Mobility

The high operational tempo of Desert Storm solidified the importance of mobility for the artillery: the speed of the general advance coupled with rapid changes in the tactical

[262] McKenney, *The Organizational History of Field Artillery 1775–2003*, 317.

[263] McKenney, 318.

[264] McKenney, 318.

[265] Dastrup, *Artillery Strong: Modernizing the Field Artillery for the 21st Century*. 5.

[266] Corn and Lacquemont, "Silver Bullets," 15.

situation forced indirect fire assets to quickly adapt and travel across a large battlefield. A general concern for rapid crisis response also created a need for lightweight and deployable equipment.[267] As Dastrup explains: “Strategically deployable, survivable, and lethal field artillery systems would replace the heavy systems fielded during the Cold War.”[268] Thus, after the war, the artillery community focused on the improvement of mobility for all types of indirect fire assets. For towed cannons, this meant the development of lighter howitzers that were easily moved via helicopter.[269] Even the MLRS was assessed for strategic lift requirements, and the Army decided to create a wheeled rocket launcher variant—High Mobility Army Rocket System—to maintain the lethality of DPICM rockets with a platform that was easier to deploy in a crisis.[270] The Army did not invest in strategic mobility for self-propelled artillery, however, and instead focused on tactical mobility improvements to better perform in a high-tempo conflict. To accomplish this, the development followed two separate paths: the modernization of an existing system and the creation of a new one.

a. Integrating New Technology into an Old Platform: The M109A6 Paladin

The M109A6 Paladin evolved from a platform that had provided support to maneuver forces since the 1950s, but it was 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 Colonel John Rudman, the Chief of the Paladin New Equipment Training Team, explained that the Paladin can “just do it all better, faster, more accurately and with a better chance of surviving the first encounter.”[271] As a new benchmark, the Army established key requirements for the platform to accomplish in a 24-hour period, which included the ability for each cannon to fire 254 rounds, make 22 survivability moves of 300–800 meters to avoid counterfire, and make two tactical movements of at least seven

[267] Dastrup, *Artillery Strong: Modernizing the Field Artillery for the 21st Century*, 109–110.

[268] Dastrup, 110.

[269] Dastrup, 118–129.

[270] Dastrup, 118–129.

[271] John Rudman, “Myths and Misconceptions about the Paladin,” *Field Artillery: A Professional Bulletin for Redlegs* 93, no. 5 (October 1993): 36–37, 37.

kilometers.[272] Lieutenant Colonel David Valcourt, commander of the first Paladin battalion, explained, "we stressed the Paladin by firing over 12,000 rounds with four Paladins in just 30 field days."[273] In its first rotation at the National Training Center, the Paladin proved it would be an asset for future conflicts. In an assessment of the unit's experience, the battalion commander concluded that the upgrade allowed artillery to "maneuver like armor and infantry—our challenge is to master the techniques that allow us to do so."[274]

Although specific upgrades enhanced the vehicle's speed and engine power, which allowed the Paladin to move more efficiently across the battlefield, it was adjustments to the responsiveness of the vehicle that truly impacted its mobility. Unlike older self-propelled models, the Paladin did not require any of the crew to exit the vehicle to support a fire mission, and the incorporation of the global position system (GPS) allowed the vehicle to stop, shoot, and then quickly move again.[275] Building off of the shoot-and-scoot success of the MLRS, the Paladin developed the capability to process a mission on the move, formally known as a "Hip Shoot." At any point while on the move, the Paladin could receive a mission digitally into its fire-processing computer, and in approximately 60 seconds, be able to shoot at a target.[276] Compared to previous models that would take around 10–11 minutes to accomplish this task, a 60-second Hip Shoot provided maneuver forces with timely fire support, which also allowed the artillery unit to continue its movement quickly after it received the mission.[277] This process greatly enhanced the artillery's ability to move cannons around the battlefield and continuously adapt to changes in the tactical situation. Additionally, this technique allowed artillery units to conduct

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[272] David Valcourt and Jack Riley, "Paladin- A Revolution in Cannon Artillery," *Field Artillery: A Professional Bulletin for Redlegs* 92, no. 6 (December 1992): 47–51.

[273] Valcourt and Riley, 51.

[274] Robert Fronzaglia, "The Paladin Battalion at the NTC- A Commander's Perspective," *Field Artillery: A Professional Bulletin for Redlegs* 95, no. 4 (September 1995): 12–14, 14.

[275] Valcourt and Riley, "Paladin- A Revolution in Cannon Artillery," 50.

[276] Dastrup, *Artillery Strong: Modernizing the Field Artillery for the 21st Century*, 41.

[277] Dastrup, 41.

interdiction raids deep into enemy territory in a way that limited exposure to enemy counterfire.

However, although the Paladin represented a major improvement in self-propelled artillery, it was not regarded as the platform of the future, even while under development. Major General Joseph DeFrancisco, commander of the first division that fielded the new Paladins, asserted: “Paladin is great, but it’s an interim step. It bridges the gap between our old friend, the basic M109 howitzer originally built in the 1950s, and Crusader—a new weapon system for the 21st century.”[278] The Paladin completed fielding by 1998, with a new platform planned to replace it as early as 2005.[279]

b. The Future of Self-Propelled Artillery: The Crusader

Scheduled to replace the Paladin at the beginning of the 21st century, the Crusader self-propelled howitzer represented the future of cannon artillery through the incorporation of 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.”[280] The Crusader had an increased rate of fire of nearly three times that of the Paladin and a maximum range of 40 kilometers, and it could maximize the firing capability for a short period by shooting 10–12 rounds per minute, for up to five minutes.[281] To accomplish this, the Crusader utilized modern technology to automate numerous tasks such as loading rounds into the tube, reloading the vehicle, and processing multiple aspects of the fire missions. This allowed the Crusader to reload much faster than the Paladin, which facilitated the potential for more missions in a high-tempo battle. The platform was capable of a 60-round reload and refuel in 12 minutes—

[278] Patrecia Hollis, “FA Fighting Forward: Paladins in the Victory Division- Interview with Major General Joseph DeFrancisco,” *Field Artillery: A Professional Bulletin for Redlegs* 95, no. 4 (September 1995): 4–6, 5.

[279] Randall Rigby, “Mapping the Future: State of the Branch 1996,” *Field Artillery: A Professional Bulletin for Redlegs* 96, no. 6 (November 1996): 1–9.

[280] Matsumura, Steeb, and Gordon IV, *Assessment of Crusader: The Army’s Next Self-Propelled Howitzer and Resupply Vehicle*, 13.

[281] “FY 2002 Annual Report for the Director, Operation Test & Evaluation,” Annual (Washington, D.C.: Department of Defense, December 2002), https://www.dote.osd.mil/annualreport/, 73.

approximately half the time it would take the Paladin just to complete a reload.[282] The difference in the general fire support capability of the Crusader compared to the Paladin was substantial. According to the RAND assessment on the 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."[283]

On top of the general improvements in fire support capability, the Crusader created a new unique type of mission set that would greatly increase the ability of the artillery to mass fire: multiple-round simultaneous impact (MRSI). To conduct an MRSI mission, a single howitzer would fire numerous rounds in quick succession at different angles to allow all the rounds to hit the target at the same time. In 2001, the Operation Test and Evaluation Division successfully conducted a four-round MRSI with a Crusader, which validated the concept.[284] Despite this success, field tests of the Crusader identified minor technical issues, primarily with software—an essential aspect of the new system.[285] On top of this, the priority shift of the Army to a more lightweight military forced the artillery branch to redesign the Crusader so that a single C-17 aircraft could carry two of them.[286] This overhaul, coupled with competing requirements to support a national strategy chiefly concerned with crisis response, raised questions about the future of the platform.

The RAND Corporation concluded that although the Crusader would be a huge capability improvement, the Paladin was able to cover the current mission set for cannon artillery.[287] The RAND report proposed that the continued development of rocket artillery would see cannon artillery phased out so that the investment required for the Crusader

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[282] Matsumura, Steeb, and Gordon IV, *Assessment of Crusader: The Army's Next Self-Propelled Howitzer and Resupply Vehicle*, 19.

[283] Matsumura, Steeb, and Gordon IV, 22.

[284] "FY 2002 Annual Report for the Director, Operation Test & Evaluation," 73.

[285] "FY 2001 Annual Report for the Office of the Director, Operational Test & Evaluation," Annual (Washington, D.C.: Department of Defense, February 2002), https://www.dote.osd.mil/annualreport/, 37-38.

[286] "FY 2001 Annual Report for the Office of the Director, Operational Test & Evaluation," 37-38.

[287] Matsumura, Steeb, and Gordon IV, *Assessment of Crusader: The Army's Next Self-Propelled Howitzer and Resupply Vehicle*, 33.

would be better applied to other weapons programs; the Crusader was therefore canceled in 2002. Secretary of Defense Rumsfeld declared that future enemy threats did not require an advanced self-propelled artillery system and decided to invest instead in other emergent technologies.[288] The Crusader thus became the first major artillery system whose development was cut short by financial considerations alone. Absent a capable near-peer adversary, the budgetary ceiling for innovation in the artillery branch is likely to remain lower, in relative terms, than it has been since the end of the Second World War.

2. Destructive Capacity: Improving Anti-Armor Capabilities

Although DPIMC was effective in the Gulf War, the unexploded duds endangered U.S. forces and the civilian non-combatants. To address this problem, the Army enhanced its current DPICM rockets and developed a target-seeking replacement round.

a. The Enhancement of DPICM Rockets

The evolution of the M26 rocket after the Gulf War focused on the improvement of range and the reduction of duds. A new program—known as extended-range MLRS (ER-MLRS)—developed an improved model of the rocket with a range exceeding 40 kilometers.[289] An official report from the DOD 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."[290] To achieve the extra distance, the rocket motor size was increased while the warhead size decreased, and this led to a decrease in the number of submunitions each rocket carried, from 644 to 518.[291]

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[288] Dastrup, *Artillery Strong: Modernizing the Field Artillery for the 21st Century*, 108–109.

[289] "FY 1999 Annual Report for the Office of the Director, Operational Test & Evaluation," Annual (Washington, D.C.: Department of Defense, February 2000), https://www.dote.osd.mil/annualreport/, 127-130.

[290] "FY 1999 Annual Report for the Office of the Director, Operational Test & Evaluation," 128.

[291] "FY 1999 Annual Report for the Office of the Director, Operational Test & Evaluation," 128.

The first attempted upgrade—M26A1—also included a new submunition with a self-destruct feature on each bomblet.[292] This greatly reduces the number of duds and made the DPICM more viable to support maneuver operations. The new submunition, however, continually ran into 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 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.

b. An Alternative to DPICM: SADARM

Although the new ER-MLRS rocket was an improvement on the Gulf-War model, it never moved into full production. The DOD 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 U.S. Forces, Korea."[293] 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. [294]

To resolve these issues, the Army designed a safer alternative munition that replicated DPICM destructive capability and increased accuracy against armored vehicles. The new sense-and-destroy-armor munition (SADARM) was fired like a normal 155-mm projectile, and it was the first target-locating smart munition. It was designed to identify and destroy lightly armored vehicles. Each projectile ejected two parachute-dropped sub-munitions that utilized infrared and millimeter-wave sensors to scan a 150-meter diameter circular area.[295] If a target was identified by the sensors, the submunition created an

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[292] "FY 1999 Annual Report for the Office of the Director, Operational Test & Evaluation," 128.

[293] "FY 1999 Annual Report for the Office of the Director, Operational Test & Evaluation," 128.

[294] "FY 1999 Annual Report for the Office of the Director, Operational Test & Evaluation," 127-130.

[295] "FY 2000 Annual Report for the Office of the Director, Operational Test & Evaluation," Annual (Washington, D.C.: Department of Defense), accessed November 9, 2019, https://www.dote.osd.mil/annualreport/, 165-166.

explosively formed projectile that was unleashed into the top of the enemy vehicle.[296] To ensure no unexploded ordnance was left on the battlefield, the submunition was designed to self-destruct if the sensors did not locate a target.[297]

The initial testing of SADARM began in the summer of 1993, and although it was successful at short ranges, it initially had limited success beyond 15 kilometers and mid-air collisions of the submunitions when numerous volleys were fired.[298] The Army projected a need of roughly 47,000 SADARM projectiles, however, the round repeatedly failed to achieve the required 80 percent reliability rate; thus, full production was not funded.[299] Although only a limited supply was produced, SADARM exceeded destructive capability estimations. Not only did it destroy enemy self-propelled artillery as intended, but it also proved effective against tanks. In 1999, as part of one of the final tests, M109A6 Paladins fired 96 SADARM projectiles at armored vehicles that utilized radar-defeating camouflage and berms as countermeasures to the sensors.[300] In an assessment of the tests, Lieutenant Colonel Michael Walker and Major John Gillette explain that "the munition is more lethal than any 155-mm round in the world, a direct hit with SADARM is catastrophic to armored vehicles."[301]

The SADARM greatly enhanced the artillery arsenal with the destructive power comparable to or greater than ICM, and target precision without the complexity of Copperhead.[302] Major General Toney Stricklin, the 1999–2001 Chief of Artillery, explains that SADARM "significantly enhances proactive counterfire while reducing our munitions logistical burden … the force requires fewer transport assets to bring the same or greater

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[296] "FY 2000 Annual Report for the Office of the Director, Operational Test & Evaluation," 166.

[297] "FY 2000 Annual Report for the Office of the Director, Operational Test & Evaluation," 166.

[298] "FY 1997 Annual Report for the Office of the Director, Operational Test & Evaluation," Annual (Washington, D.C.: Department of Defense, February 1998), https://www.dote.osd.mil/annualreport/, 94-95.

[299] "FY 2000 Annual Report for the Office of the Director, Operational Test & Evaluation," 165.

[300] Michael Walker and John Gillette, "SADARM: Deadly Against Armor in Testing," *Field Artillery: A Professional Bulletin for Redlegs*, July 2000, 36–39.

[301] Walker and Gillette, 36.

[302] John Holland, "SADARM Success," *Field Artillery: A Professional Bulletin for Redlegs*, October 1994, 35.

munitions lethality to the battlefield."[303] In addition to requiring fewer rounds, the new munition achieved a high level of 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, the expectation for the future of SADARM munitions was high. For example, in the Summer of 2000, Major James Chapman argued that they were the "most lethal munitions in the world today," explaining that it was a "smart munition that can kill artillery or render entire tank formations combat ineffective from long distances in a matter of minutes."[304] Although the round was defunded after only a small number was produced, the artillery community believed it was a valuable tool, and in 2003, it would be tested in combat.

3. Lessons Learned from the Incorporation of New Technology

The decade that followed the Gulf War featured persistent attempts by the artillery community 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 U.S. military. New technology was not abandoned because it was too complex, but primarily for budgetary reasons. Additionally, the process from concept to completion was often long enough to span numerous administrations, whose changing priorities may have resulted in the termination of some programs. In any case, it is apparent that technology-intensive innovation produced only partial solutions to the capability needs identified in the Gulf War.

The continued development of anti-armor munitions, while structured to fix specific issues, produced only minor improvements. For example, the lessons of the Gulf War prescribed a range increase in the DPICM rockets out to at least 50 kilometers, yet the range of the ER-MLRS fell well short. On top of this, the new and safer submunition that was designed to prevent U.S. and civilian casualties was abandoned. The SADARM round also represented a safer alternative to DPICM with an improvement upon destructive

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[303] Stricklin, "Learning from the Past to Prepare for the Future." 1.

[304] James Chapman, "SADARM: An All-Weather, Long-Distance Armor-Killer," *Field Artillery: A Professional Bulletin for Redlegs*, July 2000, 39.

capability, reduced logistical burden and an added level of precision. Although the production of SADARM was terminated after only a few thousand rounds, the Army would have the opportunity to test the munition in the next conflict to determine its viability.

For mobility—a key lesson of the Gulf War—the artillery chose to both adapt its current weapon system as well as innovate a new platform. The Paladin—an adaptation of a very old piece of equipment—was a dramatic leap in capabilities that allowed artillery units to rapidly process fire missions while on the move. However, it did not advance self-propelled artillery in the ways that senior leaders demanded. 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 need to be utilized. Despite these features, before the Crusader was fielded to units, its advanced capabilities were deemed unnecessary, and the program was terminated.

In short, innovation in the period that followed the Gulf War was grand in scope but limited in output. Although key equipment was adapted to better fill capability needs, lengthy and deliberate projects to develop new technology failed to come to fruition.

C. CONCLUSION

As the 1990s drew to a close, the role of a large and powerful military was in question for the United States. 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 the limitation of collateral damage over firepower. Although post- Gulf War innovations were direct reflections of combat lessons learned, there was no assurance that the form the combat had taken was representative of future requirements. Such conditions did not prove conducive to the further improvement of Army capabilities, but the artillery branch was still ready for high-intensity conflict, given a threat assessment that did not include a peer level adversary.

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V. THE GLOBAL WAR ON TERROR: COUNTERINSURGENCY AND THE RISE OF PRECISION MUNITIONS

The attacks on 11 September 2001, and the GWOT that followed, provided the U.S. military a new purpose and ample combat experiences to facilitate adaptation to a unique type of warfare. The wars in Iraq and Afghanistan, while primarily COIN operations, were also filled with short surges of more conventional action that required the employment of indirect fire. The 2003 invasion of Iraq, specifically, reinforced the 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. The transition to COIN and the period of innovation that followed, however, demonstrated a disregard of previous lessons learned. The abandonment of destructive capacity, the dissolution of the divisional artillery (DIVARTY) organization, and an emphasis on precision-only development, all put into question the application of combat experience as a driving factor of adaptation for the U.S. military. This chapter assesses the employment of indirect fire during the invasion of Iraq, then evaluates artillery innovation in the GWOT period. Finally, it discusses the organizational adaptation that deactivated the DIVARTY headquarters.

A. THE INVASION OF IRAQ: A TESTBED FOR RECENT INNOVATIONS

In the spring of 2003, the U.S. made the strategic decision to overthrow Saddam Hussein's government in Iraq. Like the Gulf War a decade earlier, the invasion of Iraq required the U.S. military to rapidly cover a vast area of terrain in a short amount of time to attain its tactical objectives. The initial invasion plan envisioned the deployment of forces through both Kuwait and Turkey, but as the operation approached, the Turkish government denied the U.S. access.[305] This constraint altered the invasion plan, so that the U.S. deployed mainly from Kuwait, in a mechanized race to secure Baghdad.[306] The initial invasion began on 19 March, and approximately one month later the conventional phase of

[305] Pirnie et al., 88.

[306] Pirnie et al., 88.

the conflict ended with a presidential declaration that major combat operations were complete.[307]

In general, field artillery had a large presence in the 2003 invasion. Artillery forces included 54 Paladin 155mm-self-propelled artillery vehicles from the Third Infantry Division (3ID), 62 105mm-towed howitzers, 110 155mm-towed howitzers from the USMC, 73 MLRS vehicles supporting V Corps, and three High Mobility Army Rocket Systems in support of special operations.[308] However, as Lieutenant Colonel William Pitts, the Field Artillery Chief of Doctrine Division during the Iraq Invasion, explained, the conflict had "the lowest ratio of artillery pieces-to-troops in war since before WWI."[309]

1. The 21-Day Ground War: 3ID's Race to Baghdad

The 3ID led the charge from Kuwait to Saddam's presidential palace, given that they had a preponderance of the mechanized forces. In an interview with *The Field Artillery Journal,* Brigadier General Lloyd Austin, the 3ID commander during the invasion, detailed the experiences of the 21-day mission in which the division traveled over 700 kilometers.[310] In the short conflict, the division fired nearly 14,000 cannon rounds and 800 MLRS rockets, and Austin noted that despite the challenge of the massive dispersion of the units, "artillery support was absolutely magnificent."[311] There was never much doubt that the U.S. artillery would outperform the Iraqi artillery. Major Robert Rooker, the assistant operations officer for 3rd ID DIVARTY in OIF, conducted a detailed analysis of battle and explained that the 3ID DIVARTY "destroyed 526 enemy tanks, trucks and artillery pieces; 67 buildings, OPs and bunkers; and 2,754 enemy soldiers without losing a

[307] Pirnie et al., 183.

[308] William Pitts, "Overview: Field Artillery in Operation Iraqi Freedom," *Field Artillery: A Professional Bulletin for Redlegs*, September 2003, 2–4.

[309] Pitts, 2.

[310] Patrecia Hollis, "3d ID in OIF: Fires for the Distributed Battlefield- An Interview with Brigadier General Lloyd Austin III," *Field Artillery: A Professional Bulletin for Redlegs*, September 2003, 10–12.

[311] Hollis, 10.

single soldier or piece of equipment to enemy indirect fire—truly a one-sided artillery fight."[312]

The massive geographic scale and high tempo of the invasion required the oversight of the DIVARTY to ensure the successful employment of artillery. The headquarters deployed with a dedicated MLRS battalion, which provided it an organic ability to conduct counterfire operations with DPICM rockets as well as deep-shaping fires with the ATACMS.[313] The integration of MLRS into the DIVARTY was a lesson learned in the Gulf War, where the high level of responsiveness of rocket artillery created devastating results on the battlefield. Overall, the experiences of the 2003 invasion 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. Thus, strong central control of indirect-fire assets ensures missions are prioritized for the overall operation. This sentiment is reinforced by Austin, who concludes that "when the division goes into a fight, the [DIVARTY] is a critical piece of it."[314]

Along with DIVARTY, the technological innovations of the 1990s also played a significant role in the decisive conflict, specifically the use of SADARM. The first SADARM rounds were fired on 22 March 2003, and the mission destroyed two enemy tanks.[315] Although DPICM was still the primary munition for the destruction of armored vehicles, in the 21 days of fighting, the 3ID fired 108 SADARM rounds and destroyed 48 vehicles.[316] Austin was impressed with the effectiveness of the SADARM round, declaring it to be "incredible."[317] These missions validated the new munition as a safer

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312 Robert Rooker, "Historical Recounting of Marne Thunder in OIF," *Field Artillery: A Professional Bulletin for Redlegs*, September 2003, 17–22.

313 Pitts, "Overview: Field Artillery in Operation Iraqi Freedom," 2-4.

314 Hollis, "3d ID in OIF: Fires for the Distributed Battlefield- An Interview with Brigadier General Lloyd Austin III," 12.

315 Rooker, "Historical Recounting of Marne Thunder in OIF," 18.

316 Rooker, 17–22.

317 Hollis, "3d ID in OIF: Fires for the Distributed Battlefield- An Interview with Brigadier General Lloyd Austin III," 11.

alternative to DPICM, as the destructive capacity of the round destroyed and dispersed Iraqi armored vehicles without creating a minefield. In his assessment of the new munition, Austin explained: “We killed a number of them quickly with SADARM—that’s a keeper.”[318]

In tandem with SADARM, the ATACMS was also heavily utilized in the invasion. The missile had been an emerging technology during the Gulf War, and roughly 30 were fired in that conflict.[319] In contrast, over 400 missiles were fired in the 2003 invasion.[320] This included the introduction of a unitary variant, of which 13 were fired.[321] Instead of DPICM submunitions, the unitary variant was a simple HE missile with effects comparable to a 500-pound bomb dropped from an airplane.[322]

2. Lessons Learned from Combat Experience

Overall, artillery was highly effective against the Iraqi military in 2003, and the conflict reinforced the effectiveness of anti-armor artillery. As Pitts explains: “Without a doubt, Operation Iraqi Freedom brought to the forefront that indirect fires remain the biggest force multiplier and killer on the modern battlefield.”[323] The implementation of the ATACMS provided the Army a strategic-level munition, and the unitary variant gave the Army capabilities comparable to those of the Air Force. The success of the unitary ATACMS would drive innovation in the decade to follow as the military would be forced to support continuous urban operations.

Although the 3ID displayed to the world the effectiveness of the U.S. military in the one-sided conflict, senior leaders of the division identified numerous issues for improvement. In the summer of 2003, Colonel Thomas Torrance, the commander of 3ID

[318] Hollis, 11.

[319] The Institute of Land Warfare, “Army Equipment Systems Performance in Operation DESERT STORM,” 2.

[320] Pitts, “Overview: Field Artillery in Operation Iraqi Freedom,” 3.

[321] Pitts, 2–4.

[322] Pitts, 2–4.

[323] Pitts, 3.

DIVARTY, and Lieutenant Colonel Noel Nicolle, the Deputy Fire Support Coordinator for 3ID, shared the experiences of the DIVARTY in their article, "Observations from Iraq: The 3d Div Arty in OIF."[324] Although they detail the successes of the organization, they also provide a valuable assessment of artillery shortcomings during the conflict. One of the major deficiencies identified during the high-intensity fighting was the limited range of U.S. artillery. Torrance and Nicolle explained that "the Paladin was easily outranged by Iraqi cannon systems." The effective employment of American guns meant "we had to position well forward in the maneuver formations during movements …. This created force protection concerns."[325]

It was not only cannons, however, that faced issues with range: only a limited supply of ER-MLRS had been fielded in 2003, and the standard DPICM rocket barely reached 30 kilometers. Similar to the problems faced by the 1CAV in the Korean War, the limited range of U.S. artillery in Iraq forced the 3ID artillery platforms into precarious positions. On 20 separate occasions, the 3ID DIVARTY acquired enemy artillery but were unable to fire against them because of the limited MLRS range.[326] To put this range mismatch into perspective, the DIVARTY leadership noted that "the Iraqis had four cannon systems and two rocket systems that outranged MLRS."[327] Unlike the North Koreans a half-century earlier, the Iraqi military was not able to capitalize on this advantage, so the repercussions amounted to no more than missed opportunities, rather than equipment abandoned and destroyed. Afterward, the leadership of the 3ID identified the need to extend the range of artillery out to 50 kilometers, a lesson nearly identical to that of the Gulf War.[328]

In addition to addressing range issues, the 3ID was forced to deal with the same dud problem posed by DPICM rockets, which had inadvertently killed U.S. service

[324] Thomas Torrance and Noel Nicolle, "Observation from Iraq: The 3D Div Arty in OIF," *Field Artillery: A Professional Bulletin for Redlegs*, July 2003, 30–35.

[325] Torrance and Nicolle, 31.

[326] Torrance and Nicolle, 30–35.

[327] Torrance and Nicolle, 33.

[328] Torrance and Nicolle, 30–35.

members a decade prior. Referencing this issue, Torrance and Nicolle explained that "the duds produced by these weapons became a major concern in post-combat stability and support operations (SASO) as they littered the battlefield and created a hazard to the local populace."[329]

B. A SHIFT TO COUNTERINSURGENCY: AN URGENT NEED FOR PRECISION

However instructive the Iraq war may appear to have been, innovation over the following decade would be driven not by combat experience, but by the drastic change in military objectives: from defeating a military to stabilizing a country. The emergence of COIN as the dominant form of fighting in Iraq and Afghanistan changed the role of indirect fire in the conflicts. This idea is conveyed by Major General David Ralston, the 2005–2007 Chief of Field Artillery, who astutely noted that "even successful stability and nation-building operations have brief spikes of intensity calling for rapid, pinpoint lethality."[330] An assessment conducted by the Commander of Multi-National Corps-Iraq in late 2004 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.[331] The cancellation of the Crusader self-propelled artillery program, coupled with the termination of the SADARM munition procurement, freed up funds that could be allocated to create new munitions better suited to support operations in Iraq and Afghanistan.[332]

The use of indirect fire in a COIN conflict requires a level of caution and precision beyond that of a conventional conflict, because victory is not determined simply by killing enemy forces, and civilian casualties or damage to infrastructure strengthens the enemy's cause. Lieutenant General John Sattler, commander of U.S. Marine Forces Central

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[329] Torrance and Nicolle. 33.

[330] David Ralston and Patrecia Hollis, "PGM Effects for the BCT Commander," *Fires: A Joint Professional Bulletin for U.S. Field & Air Defense Artilleryman*, January 2009, 22–27, 22.

[331] Gary Kinne, John Tanzi, and Jeffrey Yaeger, "FA PGMs: Revolutionizing Fires for the Ground Force Commander," *Field Artillery: A Professional Bulletin for Redlegs*, May 2006, 16–21.

[332] Dastrup, *Artillery Strong: Modernizing the Field Artillery for the 21st Century*, 108–110.

Command, discussed the importance of indirect fire in the Second Battle of Fallujah, and noted that Marines "fired more than 6,000 artillery rounds during the battle."[333] Unlike operations in the Korean and Vietnam Wars where artillery bombardments were used to prepare an objective for an assault or simply harass enemy forces, indirect-fire missions in the urban environment of Iraq were conducted in direct response to enemy action and required dedicated forward observers.

As a result, the unusually high priority assigned to the protection of civilians and infrastructure changes the way indirect fire operates in COIN warfare. Although the tactical objectives in Fallujah were achieved, the damage to the city raised questions about the long-term effects of the tactics employed. In all, roughly 18,000 buildings were damaged or destroyed—nearly half of all the buildings in the city.[334] When asked if PGMs could have helped in the battle, General Sattler simply replied, "absolutely I could have used them."[335] The combat lessons of the Iraq invasion, such as the importance of anti-armor artillery, were relegated to the history books, and the sole focus of artillery development became precision.

1. The Evolution of Rockets: From Massive Destruction to Low Collateral Damage

As early as the 1950s, rocket artillery demonstrated a greater potential for precision than cannon munitions. In response to the urgent need for precision in the Middle East, the U.S Army expedited its project to develop a guided-MLRS rocket (GMLRS). The GMLRS provided a precision addition to the already highly effective MLRS. The internally guided rocket carried a 200-pound fragmentation warhead that could range upwards of 70 kilometers.[336] Additionally, because of the pod construction of the MLRS, a single multi-

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[333] Hollis, "Second Battle of Fallujah- Urban Operations in a New Kind of War: Interview with Lieutenant General John F. Sattler," 7.

[334] Catherine Dale, "Operation Iraqi Freedom: Strategies, Approaches, Results, and Issues for Congress," Report for Congress (Washington, D.C.: Congressional Research Service, April 2, 2009), https://fas.org/sgp/crs/natsec/RL34387.pdf, 63.

[335] Hollis, "Second Battle of Fallujah- Urban Operations in a New Kind of War: Interview with Lieutenant General John F. Sattler," 7.

[336] "Excalibur and GMLRS Unitary Stats and Specs," *Fires: A Joint Professional Bulletin for U.S. Field & Air Defense Artilleryman*, January 2009, 27.

rocket platform could fire six rockets at six distinct aim points within proximity of each other and have only a five-second interval between each rocket fired.[337] Similar to the Copperhead round developed after the Vietnam War, a high level of accuracy also required a high level of complexity. The GMLRS rockets traversed long distances and required ample 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.[338]

The first GMLRS rockets were rapidly fielded to Iraq and immediately produced devastating effects. In September 2005, for example, the first GMLRS combat mission fired eight rockets over 50 kilometers that destroyed two enemy strongholds and killed 48 insurgents.[339] Within less than a year of being introduced, GMLRS-equipped units fired over 100 rockets, and the Army approved the rapid production of 1,000 more.[340] In addition to the unitary round, the DOD also approved the development of a secondary warhead containing DPICM.[341]

2. Loss of Destructive Capacity: The End of DPICM

The duds left on the battlefield in both Gulf Wars from DPICM submunitions 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

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337 "Excalibur and GMLRS Unitary Stats and Specs," 27.

338 Brennan Deveraux, "Responsive Rockets Through Proactive Airspace Management," *Fires: A Joint Professional Bulletin for U.S. Field & Air Defense Artilleryman* 17, no. 3 (May 2017): 33–37. This article outlines the challenges with airspace clearance procedures for GMLRS and attempts to create techniques to speed up the fire mission process.

339 Kinne, Tanzi, and Yaeger, "FA PGMs: Revolutionizing Fires for the Ground Force Commander," 18.

340 "FY 2006 Annual Report for the Office of the Director, Operational Test & Evaluation," Annual (Washington, D.C.: Department of Defense, December 2006), https://www.dote.osd.mil/annualreport/, 73-74.

341 "FY 2006 Annual Report for the Office of the Director, Operational Test & Evaluation," 73-74.

the desired dud rate of one percent or less.[342] Even though the new rocket failed to effectively reduce the dud rate, 4,600 rockets were still created, although they were never fielded.[343] 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.[344] It notes that "the weapons are prone to indiscriminate effects," and argues that they create an international problem because "unexploded bomblets can kill or maim civilians long after a conflict has ended."[345] Although the U.S. did not sign the treaty, Secretary of Defense Robert Gates decreed shortly after its entering into force that "by the end of 2018, DOD will no longer use cluster munitions."[346]

To fill the gap left by DPCIM, 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.[347] The Alternate Warhead was built as a GMLRS variant, and thus it shared all the complexities of coordination that plagued precision rockets. The rocket went into full production in April of 2015 with a procurement goal of over 18,000 rockets.[348] Because the Alternate Warhead was a transition 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 cluster-munition policy to allow continued use past the 2018

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342 "FY 2006 Annual Report for the Office of the Director, Operational Test & Evaluation," 73-74.

343 "FY 2005 Annual Report for the Office of the Director, Operational Test & Evaluation," Annual (Washington, D.C.: Department of Defense, December 2005), https://www.dote.osd.mil/annualreport/, 65-66.

344 "Convention on Cluster Munitions – UNODA," accessed January 12, 2020, https://www.un.org/disarmament/ccm/.

345 "Convention on Cluster Munitions – UNODA."

346 "Department of Defense Releases New Cluster Munitions Policy (Press Release)," U.S. Mission to International Organizations in Geneva, July 9, 2008, https://geneva.usmission.gov/2008/07/09/dod-press-release-jul9-2008/; "Convention Text | The Convention on Cluster Munitions," accessed September 24, 2019, http://www.clusterconvention.org/the-convention/convention-text/.

347 "FY 2015 Annual Report for the Office of the Director, Operational Test & Evaluation," Annual (Washington, D.C.: Department of Defense, January 2016), https://www.dote.osd.mil/annualreport/, 113-114.

348 "FY 2015 Annual Report for the Office of the Director, Operational Test & Evaluation," 113-114.

deadline, which would allow for the future development of DPCIM-GMLRS.[349] However, the round would not be used as it had been in previous conflicts. Going forward, similar to ATACMS, the release authority of DPICM would be retained at the highest levels of the military, by way of acknowledging the humanitarian concerns these weapons have inspired.

3. The First Self-Correcting Cannon Round: Excalibur

The employment of the Copperhead round in the Gulf War taught the artillery community two key lessons about precision cannon munitions: small mid-flight corrections to a ballistic trajectory could facilitate precision accuracy, and the reliance on humans to make such corrections could induce error. To build on these lessons, the Army developed the Excalibur round as the first self-correcting cannon round. The munition carried a 50-pound warhead and followed an adjusted ballistic trajectory that allowed it to impact targets at a near straight downward angle.[350] This type of impact limited collateral damage and allowed friendly troops to be safely within 200-meters of the impact.[351] Unique to the Excalibur, if the round experienced any problems mid-flight it did not correct to the target area, and would instead head to a predetermined ballistic impact point.[352] The Excalibur concept initially incorporated both DPICM and SADARM submunitions, on top of the standard unitary round. However, the termination of SADARM, as well as the dud issues that surrounded DPICM, led senior leaders such as Field Artillery Commandant Major General Toney Stricklin to recommend that the artillery community shift its entire focus to the collateral-damage-limiting unitary round.[353]

Similar to the GMLRS rockets, in support of the urgent need for precision, the Army accelerated a limited fielding of the Excalibur. In 2005, the DOD contracted the

[349] Patrick Shanahan, *DOD Policy on Cluster Munitions*, Official Memorandum (Washington, D.C.: Department of Defense, 2017), https://fas.org/man/eprint/cluster.pdf.

[350] "Excalibur and GMLRS Unitary Stats and Specs," 27.

[351] "Excalibur and GMLRS Unitary Stats and Specs," 27.

[352] "Excalibur and GMLRS Unitary Stats and Specs," 27.

[353] Dastrup, *Artillery Strong: Modernizing the Field Artillery for the 21st Century*, 170–171.

Raytheon company to build and ship 165 of the new projectiles as soon as possible, with major fielding planned for 2009.[354] The initial Excalibur model had a maximum range of 24 kilometers, but an eventual upgrade increased the range out to 37 kilometers.[355] Although these early Excalibur rounds had relatively short maximum ranges, they were still utilized for important missions. The rapidly fielded Excalibur was first fired in combat by the 1CAV on 5 May 2007, destroying an insurgent safe house, and in July 2007 an Excalibur mission killed the leader of al Qaeda in Iraq, Abu Jurah.[356]

The early Excalibur successes reinforced the idea that the Army could use fewer rounds and still achieve its desired effects. In response, the Army reduced its desired fielding quantity from 30,000 to 6,264.[357] By 2012, only 600 Excalibur rounds had been fired in support of operations in Iraq and Afghanistan, and the reported success rate was near 90 percent—meaning the round impacted the target grid and not the designated ballistic impact point.[358] As the wars in Afghanistan and Iraq dragged on, the Army continued to improve upon the Excalibur. The initial costs of each Excalibur round neared $150,000, but continued development reduced production costs by more than half, which lowered each round to under $70,000.[359] The 2014 tests of an extended-range model of the Excalibur yielded an average accuracy within two meters, which was dramatically

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[354] Irv Blickstein et al., *Excalibur Artillery Projectile and the Navy Enterprise Resource Planning Program, with an Approach to Analyzing Program Complexity and Risk*, Root Cause Analyses of Nunn-McCurdy Breaches 2 (Santa Monica, California: RAND Corporation, 2012), 13.

[355] Dastrup, *Artillery Strong: Modernizing the Field Artillery for the 21st Century*, 225.

[356] Ralston and Hollis, "PGM Effects for the BCT Commander," 23.

[357] Blickstein et al., *Excalibur Artillery Projectile and the Navy Enterprise Resource Planning Program, with an Approach to Analyzing Program Complexity and Risk*, 13.

[358] "FY 2012 Annual Report for the Office of the Director, Operational Test & Evaluation," Annual (Washington, D.C.: Department of Defense, December 2012), https://www.dote.osd.mil/annualreport/, 93-94.

[359] "Artillery: When Cheaper Is Better and More Popular," accessed January 13, 2020, https://www.strategypage.com/htmw/htart/articles/20170723.aspx.

better than the established 10-meter goal for precision munitions.[360] By June 2014, the Army funded the development of 757 extended-range Excalibur munitions.[361]

4. Economical Accuracy: The Precision Guidance Kit

PGMs are expensive, complex, and serve a special purpose that is well beyond the level of accuracy needed for many artillery missions. Thus, the Army needed a more cost-effective way to increase accuracy without necessarily achieving precision. This economical need for better accuracy was identified early in the Iraq War, and by 2004, the Precision Guidance Kit (PGK) concept was introduced.[362] The PGK was designed to make a "dumb" artillery round "smart." Simply stated, the PGK was a fuze—capable of attaching to a regular artillery shell—that utilized GPS both to track the position of the round and make small adjustments to the trajectory mid-flight.[363]

The fielding timeline for PGK was expedited to support the continued need for precision in counterterrorism operations, and successfully reduced 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.[364] Initial testing of the round went poorly, however, forcing the Army Systems Acquisition Review Board to dramatically shift the fielding timeline.[365] In 2014 testing, the PGK had a median miss distance of fewer than 22 meters, finally making the fuze a viable near-precision capability—an accuracy of better than 50 meters.[366] The final production cost per round was also nearly 85 percent less than

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360 "FY 2014 Annual Report for the Office of the Director, Operational Test & Evaluation," Annual (Washington, D.C.: Department of Defense, January 2015), https://www.dote.osd.mil/annualreport/, 107-108.

361 "FY 2014 Annual Report for the Office of the Director, Operational Test & Evaluation," 107-108.

362 Dastrup, *Artillery Strong: Modernizing the Field Artillery for the 21st Century*, 168.

363 Dastrup, 168.

364 Dastrup, 169.

365 Dastrup, 169.

366 "FY 2014 Annual Report for the Office of the Director, Operational Test & Evaluation," 135-136.

the Excalibur it was designed to augment.[367] The PGK is still in use today as an alternative to Excalibur.

5. Precision on the Battlefield

Overall, the transition away from Cold War artillery capabilities facilitated success in COIN operations. As Dastrup argues: "Ultimately, Excalibur and other precision munitions would provide more capability at equal or less cost than fielding the Crusader."[368] Many senior military officers shared Dastrup's sentiment about the importance of PGMs. For example, the 2006 Deputy Chief of Staff of the Army, Lieutenant General James Lovelace, argued that this technological innovation had a dramatic impact on the operations and noted that "organic, surface-to-surface PGMs add significantly to ground force commanders' options."[369] Additionally, Lieutenant General Raymond Odierno, the 2007 Multi-National Corps-Iraq Commander, explained that PGMs "were extremely effective. In fact, GMLRS and Excalibur were my brigade commanders' weapons of choice."[370]

6. Lessons Learned from Innovation

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

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[367] "Artillery: When Cheaper Is Better and More Popular."

[368] Dastrup, *Artillery Strong: Modernizing the Field Artillery for the 21st Century*, 172.

[369] Hollis, "Today's Army in Change- An Exciting Place to Be: Interview with Lieutenant General James J. Lovelace Jr," 8.

[370] Hollis, "2007 Surge of Ground Forces in Iraq- Risks, Challenges and Successes: Interview with Lieutenant General Raymond T. Odierno," 9.

The GWOT era demonstrated the artillery's ability to adapt its capabilities to the enemy at hand. The balance between deliberate development and rapid fielding allowed the forces on the ground to receive small supplies of desired equipment promptly while the projects continued to progress. Additionally, the COIN mission remained a top priority through numerous administrations, allowing the continued development and refinement of new technology, while lessening 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. It is significant that the resulting sacrifice of destructive capacity is not consistent with the indirect-fire lessons of previous conflicts. The accepted deterioration of anti-armor capabilities raises questions about the pressures of adaptation for the U.S. military, and specifically about the often transient nature of lessons learned through combat. If innovation solely revolves around assessments of the current situation, the military may well be forced to relive the mistakes of the past. The innovations of the GWOT period were designed to hit a GPS coordinate with high accuracy and destroy relatively soft targets with limited 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.

C. ORGANIZATIONAL ADAPTATION: MODULARIZATION

If one takes a step back from innovation for a bigger picture view of how the U.S. military has dealt with indirect fire issues, it becomes evident that centralization of control over its employment has been a debate since the First World War, specifically an ongoing conversation in terms of the assignment of direct-support artillery to maneuver units. The analyses of the Korean, Vietnam, and Gulf Wars previously presented demonstrate that many maneuver commanders understood the advantages of dedicated artillery support to their respective missions. As General Austin explains, "ask any infantryman if he has enough artillery, and he always will answer, '*No*.'"[371] Throughout these recent conflicts, the DIVARTY headquarters have controlled artillery at the division level; but certain tactical situations have sometimes prescribed a more decentralized role. For example, the Pentomic Divisions after the Korean War directly attached an artillery battery to Battle Groups—comparable to a brigade-level command. In addition, the dispersion of assets in the Vietnam War, coupled with a 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 21st century, this conversation culminated with the dissolution of the DIVARTY headquarters.

1. Modularity

In late 2003, the Army began a reorganizational process known as "modularity," that similar to the Battle Groups in the 1950s, created autonomous units below the division level: the 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.[372] Under this structure, every BCT was assigned a direct support field artillery battalion. Similar to the ROAD concept of the 1960s, the type of artillery weapon system varied by the type of new BCT: infantry, heavy, or Stryker.[373]

Modularity did not simply restructure brigades; it removed the necessity of the division headquarters from combat, a decision that had drastic consequences for the employment of indirect fire. 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

[371] Hollis, "3d ID in OIF: Fires for the Distributed Battlefield- An Interview with Brigadier General Lloyd Austin III," 10.

[372] Johnson et al., *A Review of the Army's Modular Force Structure*, iii.

[373] Johnson et al., 21.

augmentation."[374] In this regard, BCTs assumed the responsibility for the employment of artillery. In turn, the Army deactivated ten active-duty DIVARTYs and four Corps Artillery Headquarters.[375] On top of this organizational change, there was a dramatic reduction of nearly half the field artillery brigades—which often supported Corps-level operations: 23 field artillery brigades in 2002 were reduced to only 13 by 2008.[376] In an Army War College strategic research report, *Effect of Modularity on the Field Artillery Branch,* Colonel Noel Nicolle explains: "The reduction in the number of field artillery brigades and the total elimination of both the Corps Artillery Headquarters and [DIVARTYs] is devastating" to the U.S. military's ability to effectively employ indirect fire.[377]

2. Artillery Degradation without DIVARTY

The termination of DIVARTY not only eliminated a battlefield coordination and resource distribution element, but it also removed a training organization designed to ensure all artillery units within the division were proficient in the employment of indirect fire. In a 2006 interview with the *Field Artillery Journal,* Major General William Caldwell IV, the 82nd Airborne Division Commander, optimistically explained that without a DIVARTY the new artillery relationship put the onus of training and oversight on the BCT commanders.[378] He argued: "Those are their jobs now. And they've got the Red Book (artillery training norms) as the non-negotiable standard."[379] This new expectation was not realistic, however, and the primary mission of artillery units—the employment of indirect fire—degraded over the first few years of the transformation. As Nicolle argued in 2009,

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374 Department of the Army, *Brigade Combat Team*, FM 3-90.6 (Washington, D.C.: Department of the Army, 2010), https://www.globalsecurity.org/military/library/policy/army/fm/3-90-6/fm3-90-6.pdf, 1–1.

375 Nicolle, "Effect of Modularity on the Field Artillery Branch," 14.

376 Johnson et al., *A Review of the Army's Modular Force Structure*, 17.

377 Nicolle, "Effect of Modularity on the Field Artillery Branch," 9.

378 Hollis, "Pentathletes in the 82nd Airborne Division- Developing Critical Capabilities for the Army: Interview with Major General William B. Caldwell IV," 5.

379 Hollis, 5.

five years after the modularity concept began, that the absence of DIVARTY created "a significant consequence that is only now becoming apparent."[380]

Not surprisingly, the degradation of indirect-fire proficiency was keenly felt on the battlefield. In 2007, three BCT commanders—Colonels Sean MacFarland, Michael Shields, and Jeffrey Snow—published the influential white paper *The King and I: The Impending Crisis in Field Artillery's ability to provide Fire Support to Maneuver Commanders*.[381] The white paper outlined long-term problems associated with the inability to synchronize indirect fire with maneuver operations, and the dangers of the continued capability decay. Contrary to Caldwell, these commanders argued that "modularization places responsibility for fire support training on maneuver commanders who are neither trained nor resourced to perform these tasks."[382]

The artillery white paper made clear the importance of indirect fire in future conflicts, and the commanders explained that artillery proficiency degradation was an Army-wide problem. MacFarland, Shields, and Snow concluded that it was "urgent that [the Army] take another look at the structure of this important combat arm."[383] These sentiments were echoed a couple of years later by Nicolle at the Army War College. After finishing his assessment of how modularity shaped indirect fire, Nicolle concluded that although the number of artillery battalions had increased in the six years since the invasion of Iraq, the force was less capable.[384] 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."[385]

The dissolution of DIVARTY was in direct contrast to Gulf War lessons identified by the 3ID, which noted the importance of the DIVARTY at coordinating artillery during

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[380] Nicolle, "Effect of Modularity on the Field Artillery Branch," 9.

[381] MacFarland, Shields, and Snow, "The King and I: The Impending Crisis in Field Artillery's Ability to Provide Fire Support to Maneuver Commanders."

[382] MacFarland, Shields, and Snow, 2.

[383] MacFarland, Shields, and Snow, 1.

[384] Nicolle, "Effect of Modularity on the Field Artillery Branch," 26.

[385] Nicolle, 26–27.

the conflict and argued for the continued development of the organization. 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 major difference, however, was that modularization removed key organizations above the brigade level, which demonstrated an abandonment of large-scale combat operations as a whole. The warnings of senior military officers about artillery degradation were eventually heeded by the Army. In fact, the U.S. Army Forces Command published a DIVARTY Implementation Order that outlined the resurgence of the headquarters to begin in 2014, with full implementation across the force two years after that.[386] Although numerous DIVARTYs were reconstituted, its role varies drastically from its Gulf War predecessor. Additionally, artillery battalions remain a part of BCTs, and therefore, the conversation of control continues today.

D. CONCLUSION

It can be argued that the adaptation of indirect fire in the GWOT era implied the abandonment of 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 whether they are 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 authorities held at upper echelons. Similar to the Vietnam War, the artillery during the GWOT period developed niche capabilities to fight the conflict at hand, which have largely superseded more traditional warfighting functions. If large-scale combat operations were once again required, indirect fire would be no more

[386] United States Army Field Artillery School, "DIVARTY: A Force Multiplier for the BCT and Division," *Redleg Update: The United States Army Field Artillery Branch's Newsletter* 04, no. 14 (April 2014): 3–6.

effective than it was in the 1970s, when the requirement to adapt to a near-peer adversary first emerged.

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VI. CONCLUSION: ASSESSING THE DRIVERS OF INNOVATION AND A LOOK TO THE FUTURE

After WWII, U.S. 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 highlight the deficiencies of modern U.S. indirect-fire capabilities that stemmed from the many trade-offs posed by these well-considered—but necessarily imperfect—choices. The purpose of this thesis was to understand how the choices were made and, more generally, the process of adaptation and innovation that led to the current artillery situation within the U.S. military.

A. THE DRIVING FACTORS OF INNOVATION

To assess the progression of artillery adaptation, the scope of the research covered roughly 70 years of indirect-fire development. The sheer amount of information available meant that many incidental developments have been left out. This included minor adjustments to equipment, as well as 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 the role of indirect fire on the battlefield.

Militaries adapt their techniques, structure, and equipment for a myriad of reasons. This thesis examined the adaptation of U.S. indirect fire capabilities since the end of 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.

1. Incorporation of New Technology

While a surface-level analysis of artillery innovation could lead one to believe that emerging technology was its major driving factor, the detailed analysis conducted in this thesis presented 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 away 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, new technology was successfully incorporated in the production of artillery platforms and munitions. The most prominent example of this is the incorporation of GPS. The demand for GPS-guided artillery munitions did not become prevalent until a decade after the technology became commonplace elsewhere in the military. This new requirement was driven by an assessed need to reduce collateral damage in COIN operations. At the same time, however, the development of the Paladin—an adaptation that focused on improved mobility and rapid-fire mission processing—incorporated GPS in the new platform to improve accuracy and increase responsiveness. The mere existence of new GPS technology was not a major driving factor of indirect-fire innovation; rather the artillery community successfully integrated it by way of adapting to a new challenge rooted in the requirements of effective counter-insurgency warfare.

2. Combat Experience

In addition to technology, lessons learned from combat experience served as a potential driving factor for artillery innovation. The artillery community diligently documented these lessons via multiple channels, such as *The Fires Bulletin* and the Morris Swett Library, and while these identified lessons from combat facilitated rapid mid-conflict adaptation, the lessons themselves often did not endure.[387] For example, analysis of the Vietnam War and the continuous conflict in Iraq shows that the artillery branch learned to rapidly adjust employment tactics and to field new equipment. The successful adaptations in both conflicts that were driven by actual combat experience, however, were temporary. In the case of Vietnam, these innovations were quickly relegated to niche capabilities, and the Army set aside the lessons learned from the conflict to instead prepare for the threat of the Soviet Union.

[387] "Fires Bulletin | Fort Sill | Oklahoma"; "Morris Swett Technical Library – Fires Center of Excellence – U.S. Army."

A second example of a lesson learned and disregarded is the successful use of anti-armor munitions that devastated the Iraqi Army in two separate wars. Despite the success of the weapons, they have since been defunded and regulated to a level that does not support maneuver operations. This seems counterintuitive, and furthermore, this deterioration of destructive capability—a development theme in every major conflict since Korea—suggests that the artillery community has a short-term memory concerning combat experience. The current U.S. artillery arsenal is without a direct-fire munition like the Beehive, which proved its value in Vietnam, and is restricted in the use of anti-armor rounds of the kind that dominated the battlefields in Iraq. Thus, in a future conflict, artillery units may well be forced to relive the mistakes of the past.

Looking forward, the lessons of past conflicts will likely not be a major factor in future indirect-fire capability development. This is especially true of the recent GWOT experiences, which were necessarily linked to the highly specific demands of counter-terrorism. If the artillery branch's short-term memory of U.S. combat operations is similar in other military communities, then this raises questions about U.S. military innovation in general.

3. External Threats

Apart from the immediate pressures of active conflict, preparation for shifting external threats has been the primary driver of field artillery adaptation and innovation. Analysis of artillery development throughout the Cold War—Chapters II and III—revealed that regardless of technological breakthroughs or lessons learned in actual combat, a potential clash with the Soviet military dictated enduring munition, platform, and organizational adaptations. After the Cold War, however, the U.S. no longer had an external threat, and this caused adaptation to be driven overwhelmingly by the crisis at hand, which often put the artillery branch on the wrong foot when new crises arose. For example, the precision-based innovations for COIN created unique artillery capabilities, but at a substantial cost to more conventional mission requirements. Not only did the U.S. fail in the GWOT era to continue to innovate and adapt for a large-scale combat operation, but also it allowed vital capabilities such as anti-armor munitions to disappear from the arsenal. This has created a capability disparity between the U.S. and a potential adversary such as Russia, whose modern military tradition reflects a heavy reliance on artillery. In fact, in 2016 Major General Robert Scales, the former commandant of the U.S. Army War College, assessed that "the performance of Russian artillery in Ukraine strongly demonstrates that, over the past two decades, the Russians have gotten a technological jump on us."[388]

Given this history, the future development of indirect-fire capabilities will rely heavily on the assessment of external threats, which have already started to shape development. In the 2018 National Defense Strategy, then-Secretary of Defense James Mattis declared that "inter-state strategic competition, not terrorism, is now the primary concern in U.S. national security."[389] This official transition has 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—current Secretary of Defense and Chairman of the Joint Chiefs—that outlined the Army's plan for future modernization.[390] The development of "Long-Range Precision Fires" tops the list as the number one priority, and the document challenges the field artillery community to reestablish "dominance in range, munitions, and target acquisition."[391] Similar to the development of artillery after the Vietnam War, current and future projects are likely to revolve around a singular focus: preparing to combat a peer adversary.

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[388] Robert Scales, "Russia's Superior New Weapons," The Washington Post, August 5, 2016, https://www.washingtonpost.com/opinions/global-opinions/russias-superior-new-weapons/2016/08/05/e86334ec-08c5-11e6-bdcb-0133da18418d_story.html.

[389] James Mattis, "National Defense Strategy 2018," National Security Strategy Archive, January 19, 2018, http://nssarchive.us/national-defense-strategy-2018/, 1.

[390] Mark Milley and Ryan McCarthy, *Modernization Priorities for the United States Army*, Official Memorandum (Washington, D.C.: Department of the Army, 2017), https://admin.govexec.com/media/untitled.pdf.

[391] Milley and McCarthy.

B. THE CURRENT STATE OF ARTILLERY AND A LOOK TO THE FUTURE

With the re-emergence of near-peer external threats to the U.S., artillery development is already underway with projects that reinforce the findings of this thesis.[392] Some of these projects include greatly extending the range of cannon and rocket artillery, as well as the development of munitions that can be used against moving targets.[393] 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.[394] He explains that the projects underway 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."[395]

The artillery community's short-term memory of combat experiences has periodically forced the branch to "reinvent the wheel" in order to stay relevant. The programmatic shift back to large-scale combat operations allows artillery units to reequip and relearn hard lessons in a training environment. The U.S. shift away from counter-terrorism provides the military an opportunity to turn the focus of innovation away from a novel type of war and back to perfecting artillery in the evolving mainstream of war.

[392] Dan Goure, "Army Artillery: Restoring the King of Battle to Its Throne," Defense News, January 31, 2019, https://www.defensenews.com/opinion/commentary/2019/01/31/restoring-the-king-of-battle-army-artillery-to-its-throne/; "New Artillery Doubles Attack Range, Outguns Russians," Military.com, June 16, 2018, https://www.military.com/daily-news/2018/06/16/new-army-artillery-doubles-attack-range-outguns-russian-equivalent.html; Matthew Cox, "Auto-Loader May Be a Challenge for Army's New Self-Propelled Cannon," Military.com, July 19, 2019, https://www.military.com/daily-news/2019/07/19/auto-loader-may-be-challenge-armys-new-self-propelled-cannon.html.

[393] Sydney Freedberg, "Army Will Field 100 Km Cannon, 500 Km Missiles: LRPF CFT," Defense industry news, analysis and commentary, Breaking Defense, accessed February 21, 2020, https://breakingdefense.com/2018/03/army-will-field-100-km-cannon-500-km-missiles-lrpf-cft/; "New Artillery Doubles Attack Range, Outguns Russians."

[394] Peter Burke and Tara Sarruda, "The King of Battle Gets Stronger," The United States Army, accessed February 21, 2020, https://www.army.mil/article/195413/the_king_of_battle_gets_stronger.

[395] Burke and Sarruda.

1. Further Research

This thesis raised questions about future field artillery development as well as the drivers of military innovation. Many of these questions merit further research, particularly in the context of today's artillery. Some examples include:

1. 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?
2. Without an anti-armor capability, is there a role for artillery in a large-scale combat operation?
3. Because operations-below-combat do not fit the category of an external threat, can potential munitions for competing in the "gray zone"—for example, artillery-launched drones, radar, or jamming munitions—develop without an active conflict?
4. If military innovation is driven primarily by external threats, how has this affected the military capabilities of countries such as Russia and China? How do they assess the threat that our artillery poses? How do we wish to influence their judgments on this score?

2. Recommendations

Looking to the future, the artillery branch can modernize across numerous categories to be more effective in a future war. First, the development of anti-armor munitions is vital for the artillery to be successful in a future conflict as most modern militaries are mechanized. While today's artillery is more accurate than any in the past, the loss of an anti-armor capability in the last decade has limited its lethality to that of basic WWII models. To restore this function, older munitions such as DPICM and SADARM—both proven successful in combat against armored vehicles—could simply be repurposed or upgraded to better complement current capabilities.

Second, a major investment in rocket artillery is necessary to bring these assets up to par with competing platforms and to take advantage of emerging technology. Precision munitions such as GMLRS are a niche capability designed for the engagement of important fixed-site targets. The requirement of clear air space that these munitions impose, coupled with their inability to strike a moving target, must inevitably limit their usefulness against a peer-level threat. In both Gulf Wars, rockets were invaluable to maneuver forces and they may represent the future of advanced artillery munitions compared to cannons: capable of greater 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 operating on a modern battlefield. Current platforms are too slow to be effective in a high-tempo conflict because more than half of all the active Army cannons, and all of the USMC cannons, are towed.[396] Additionally, the Paladin—the only U.S. 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 the continued advancement of self-propelled platforms, for artillery units to survive in the future fight, the military must abandon towed cannons, except in niche airborne and air assault units. This would best be done through the addition of 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.[397]

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 improve artillery unit survival against enemy target acquisition capabilities such as artillery radar and drones by dramatically increasing rates of fire. Apart from incidental exceptions like rocket-assisted projectiles and precision munitions, the range increases of artillery cannons over time have never reached the level demanded by military leaders.

[396] "Active U.S. Army and U.S. Marine Corps FA CONUS & OCONUS Units," *Fires: A Joint Professional Bulletin for U.S. Field & Air Defense Artilleryman* 19, no. 1 (January 2019): 15–17.

[397] "New Ukrainian-Made 2S22 Bohdana 155 mm 6x6 Self-Propelled Howitzer," Weapons Defence Industry Military Technology UK, September 6, 2018, https://www.armyrecognition.com/weapons_defence_industry_military_technology_uk/new_ukrainian-made_2s22_bohdana_155mm_6x6_self-propelled_howitzer.html.

Modern U.S. artillery now compares unfavorably with that of Russia and North Korea.[398] Colonel Liam Collins recently conducted an assessment of the role of artillery in a potential large-scale combat operation in Europe, and concluded that “Russian forces will surely use their long-range standoff to wreak havoc on U.S. forces whose artillery would remain severely outranged.”[399] Thus, artillery units are likely to operate in an environment where they are perpetually within range of enemy artillery. On top of increasing the output of each cannon, the addition of the automatic loader to self-propelled platforms facilitates the MRSI—a mission type that would reduce the overall threat of enemy counterfire.

Finally, the branch must utilize its greatest asset: its soldiers. History has shown that at all levels, from junior leaders to commanding generals, artillerymen are candid about sharing what their units learn on the battlefield and in training. The application of such knowledge may prevent the army from repeating costly mistakes in a future conflict. 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, artillery can work to maintain its hard-won historical position as the King of Battle.

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398 Charlie Gao, “Russia vs. America: Which Army Has the Best ‘Big Guns’?,” Text, The National Interest, March 3, 2018, https://nationalinterest.org/blog/the-buzz/russia-vs-america-which-army-has-the-best-big-guns-24733; Michael Peck, “The U.S. Army’s Artillery Is Outmatched By Russia’s Big Guns,” Text, The National Interest, December 21, 2019, https://nationalinterest.org/blog/buzz/us-army%E2%80%99s-artillery-outmatched-russia%E2%80%99s-big-guns-107526.

399 Liam Collins and Harrison Morgan, “King of Battle: Russia Breaks Out the Big Guns,” Association of the United States Army, January 22, 2019, https://www.ausa.org/articles/king-battle-russia-breaks-out-big-guns.

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