The Radio: A Study in Information Technology Implementation

A Monograph

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Commanders across branches and services will always do whatever they can to gain and share information with their formations, because information is capital in the economy of war. As technology continues to evolve inside the Army, across the Joint Force, and in the commercial sector, a clear network architecture facilitates efficient integration with other networks and avoids disjointed communication efforts. This monograph studies the implementation of the radio in the US Army during World War I and separately during the Interwar Period through the lenses of organizations, training and doctrine, and equipment to evaluate how the US Army integrated a new information technology. To better understand the implementation of the radio during World War I and the Interwar Period, this monograph also draws on the works of two theorists, Daniel Kahneman and Hernando DeSoto. As information technology becomes more prevalent in civilian society, it is dangerous to presume familiarity with civilian systems translates to operators innately understanding how to integrate and operate military systems. The faster and more efficiently information is shared across the Joint Force, the more effective the military is at bringing all its resources to bear on the battlefield. In order to fully leverage evolving communication technology to enable efficient information sharing, the Department of Defense (DOD) should implement and maintain a deliberate process to standardize its network architecture, policies, and doctrine across the Joint Force that guides training of operators and informs system development.

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Abstract

The Radio: A Study in Information Technology Implementation, by MAJ Liberty F. Lobdell, 34 pages.

Commanders across branches and services will always do whatever they can to gain and share information with their formations, because information is capital in the economy of war. As technology continues to evolve inside the Army, across the Joint Force, and in the commercial sector, a clear network architecture facilitates efficient integration with other networks and avoids disjointed communication efforts. This monograph studies the implementation of the radio in the US Army during World War I and separately during the Interwar Period through the lenses of organizations, training and doctrine, and equipment to evaluate how the US Army integrated a new information technology. To better understand the implementation of the radio during World War I and the Interwar Period, this monograph also draws on the works of two theorists, Daniel Kahneman and Hernando DeSoto. As information technology becomes more prevalent in civilian society, it is dangerous to presume familiarity with civilian systems translates to operators innately understanding how to integrate and operate military systems. The faster and more efficiently information is shared across the Joint Force, the more effective the military is at bringing all its resources to bear on the battlefield. In order to fully leverage evolving communication technology to enable efficient information sharing, the Department of Defense (DOD) should implement and maintain a deliberate process to standardize its network architecture, policies, and doctrine across the Joint Force that guides training of operators and informs system development.

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Abbreviations

AEF	American Expeditionary Force
BEF	British Expeditionary Force
C2	Command and Control
CMH	Center of Military History
DOD	Department of Defense
FM	Field Manual
GHQ	General Headquarters
JADC2	Joint All Domain Command and Control
TM	Technical Manual

Introduction

> The first rapid survey made by the Signal Corps officers who accompanied Gen. Pershing to France established beyond doubt the fact that were we to bring ourselves up to the standard which was being maintained by the signal corps of our Allies and our enemies and to maintain such a position after we had reached it would call for the best brains in the United States. Not only had methods and instruments in the Signal Service, as we knew it, advanced in an almost unbelievable manner, but special services had been introduced which had never formed a part of our Signal Service nor had been represented in any way in any of the branches of our Army.
>
> —Major General George O. Squier, Chief Signal Officer

In today's world it is difficult to imagine a time when people could not share information in real-time. On September 11, 2001, Secretary of State Colin Powell was able to call thousands of miles away over a radio from an airplane flying over South America back to Washington, DC. Within moments he was receiving updates about a terrorist attack taking place in the United States.[1] A century prior, receiving actionable information about an ongoing battle thousands of miles away was impossible, at least not unless tethered to a preplaced wire.

In stark contrast, the American Expeditionary Force's (AEF) "Lost Battalion" during the 1918 Meuse-Argonne Offensive is an example of the efforts one commander and his higher headquarters made to communicate during World War I. It was a time when battlefields were larger and more lethal than ever before, a result of the Industrial Revolution's technological and production boom. Commanders grappled with how to use new and improved tools of their craft, to gain an advantage over their enemy.[2] However, one emerging technology was not available to Maj. Charles Whittlesey, commander of the infamous battalion; a radio. Instead, he and the 77th Division relied on runners, pigeons, and aircraft to pass messages, mostly unsuccessfully.

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[1] Bob Woodward, *Bush at War* (New York: Simon and Schuster Paperbacks, 2005), 10.

[2] David Zabecki, *The Generals' War: Operational Level Command on the Western Front in 1918* (Bloomington, IN: Indiana University Press, 2018), 3.

At 12:50 pm on October 2, 1918 Maj. Whittlesey led the 308th Infantry Battalion and augmentees from the 77th Division, a force of about 500 men, into the Argonne Forest to break through the German line, establish a hold at Charlevaux Mill, and await further instructions.[3] Five hours later the 308th reached its objective. Whittlesey communicated his success to the 77th through a series of runners that he established during the advance and expected to resume the attack as soon as the remainder of the 77th Division forces caught up with him. He was unable to liaison with his flanks due to heavily wooded terrain and diminishing light, so was unaware that his battalion achieved the only successful breakthrough of the German line.[4]

The next morning, unaware that the Germans had surrounded his battalion during the night, Maj. Whittlesey sent patrols to liaison with his flanks. At 10:30 am, over three hours after they left, only a portion of the reconnaissance returned. The 308th was surrounded. Meanwhile, Whittlesey used his first of several pigeon messages to call for counterfire in response to an enemy artillery barrage. According to time stamps on the recorded messages, it took about two hours for the pigeon to reach its destination and the message to be relayed to a commander. Whittlesey sent two more pigeon messages that day. They contained grid coordinates of his position and his estimation of the enemy's position. Two friendly airplanes attempting to drop supplies and messages the next day, October 4, as soldiers signaled their position with white, provided the only confirmation that the 77th Division received Whittlesey's messages. Unfortunately, German forces intercepted the rations and messages dropped from the two planes.[5]

Over the next four days Maj. Whittlesey continued to send pigeon messages to the 77th. He even sent a pigeon begging them to quit firing on his position: "For heaven's sake, stop it."

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[3]Army War College Historical Section, "The Operation of the So-Called 'Lost Battalion' October 2nd to October 8th, 1918" (Washington, DC: US War Department), exhibit 3, accessed March 31, 2021, https://catalog.archives.gov/OpaAPI/media/301662/content/arcmedia/media/images/15/19/15-1883a.gif.

[4] Ibid., exhibit 4.

[5] Ibid., exhibit 6.

However, the message arrived hours after the shelling ended.[6] Whittlesey attempted to send squads to relay messages to the 77th, but the Germans beat back all their attempts.[7] Relief finally came on October 7. Over the course of the week the 308th sustained approximately 200 casualties.[8] Neither of the messages that the 77th Infantry Division attempted to send Whittlesey during the week, first ordering him to hold his position and then to withdraw, ever reached him.[9] If Maj. Whittlesey had a radio, the situation might have played out very differently.

The technology existed but was still emerging within the US Army. In fact, radio communication made its US Army debut during the Spanish-American War in 1898. By the time the US entered World War I in 1917 the technology was still relatively unfamiliar to the average American soldier or even leader. In October 1918 radios were large, cumbersome, and the AEF had a limited number to distribute among their forces. Runners, pigeons, and wired telephone were all viable alternatives to radio, and in some regards considered more reliable to coordinate elements on the battlefield as well as communicate orders up and down the chain of command. Radios were used for intelligence gathering and coordinating aircraft and field artillery at division or above. They ran on generator power and required a team of at least two men to find the correct frequency and manipulate the antenna to ensure they could find their corresponding distant end. Radios were also prone to interference from other nearby radios and were often used to triangulate the location of enemy forces.[10] As a relatively unknown form of communication, it was easier to highlight radio's risks than the efficiency it provided.

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[6] Army War College Historical Section, "The Operation of the So-Called 'Lost Battalion'," exhibit 15.

[7] Ibid., exhibit 8.

[8] Ibid., exhibit 10.

[9] Ibid., exhibit 16.

[10] US War Department, Radio Pamphlet, no. 40, *The Principles Underlying Radio Communication* (Washington, DC: Government Printing Office, 1919), 246, accessed March 31, 2021, https://archive.org/details/underlprinciples00unitrich/page/246/mode/2up.

However, accounting for risks, there were people within the Army who understood radio's potential. Out of necessity, artillery and another new technology, the airplane, used the radio where wires could not go or were easily destroyed. Before the Army could broadly propagate the technology throughout the force it had to first organize and train to leverage the improved ability to command and control (C2) over vast distances. Studying the radio during World War I and the Interwar Period illustrates two challenges critical to the implementation of any new information technology. The first, which is apparent in the US Army during World War I, is the need to create a foundation of knowledge around how to operate new technology and to organize that capacity across the force. The second challenge, which the Army struggled to realize during the Interwar Period, is the requirement to create an architecture of rules and policy that form the foundation of the communication system.

To better understand the implementation of the radio during World War I and the Interwar Period, this monograph draws on the works of two theorists, Daniel Kahneman and Hernando DeSoto. Kahneman, in *Thinking Fast and Slow,* describes System 1 and System 2 thinking as the two ways people process information. System 1 or the "innate system" thinking, which contains automatic and learned thought patterns, "operates automatically and quickly, with little or no effort and no sense of voluntary control."[11] The "deliberate system" or System 2, operates deliberately and can influence and program a person's system 1 given time. It "allocates attention to the effortful mental activities that demand it, including complex computations."[12] The two systems are not independent, rather they are complementary. Innate thinking allows people to minimize time, solving routine problems based on mental models of familiar situations. Deliberate thinking confirms innate thinking most of the time and only disrupts the automatic system when a person encounters an unfamiliar situation or when deliberate evaluation expects

[11] Daniel Kahneman, *Thinking, Fast and Slow* (New York: Farrar, Straus and Giroux, 2013), 20.

[12] Ibid., 21.

innate thinking to err.[13] The Joint Force's innate system is the organic way that information passes within and across services, most apparent in how commanders innately build processes to gain and pass information they need to bring effects to the battlefield. Information technology does not automatically overlay on commanders' individual processes. The Joint Force must engage its deliberate thinking to understand and fully integrate new technology to maximizes information's potential. To realize the full benefit of information technology's ability to enhance information sharing processes the Department of Defense (DOD) should implement and maintain a deliberate process that guides training of operators and informs system development across the Joint Force.

The second theorist drawn upon is the economist Hernando De Soto. His *The Mystery of Capitalism: Why Capitalism Triumphs in the West and Fails Everywhere Else* focuses on developing countries' inability to reproduce capital in order to grow economically. While his work discusses the establishment of property rights, it translates to the establishment of a network architecture. De Soto concluded that to introduce a regulatory structure into a community, first observe existing practices, similar to Kahneman's innate processes, and then build standards based on those practices. Those standards allow governments to leverage their financial capital, rather than introducing unfamiliar processes that add complexity to a previously unregulated system.[14] In the military, information is C2's capital. The Joint Force's network architecture, policies, and doctrine require standardization to allow the military to fully leverage information's power.

[13] Daniel Kahneman, *Thinking, Fast and Slow*, 25.

[14] Hernando De Soto, *The Mystery of Capital: Why Capitalism Triumphs in the West and Fails Everywhere Else* (New York: Basic Books, 2000), 226.

Literature Review

Historiography of Military Radio in the early 20th Century

There is limited literature discussing the implementation of the radio during World War I and the Interwar Period. However, the preponderance of literature discussing the impact of radio focuses on the British military experience. Mike Bullock and Laurence A. Lyons address the impact that communication technology had on both the operational and strategic level of war in *Missed Signals on the Western Front: How the Slow Adoption of Wireless Restricted British Strategy and Operations in World War I*. While they acknowledge that radio as a technology posed some risks, Bullock and Lyons argue that wireless technology was not more widely used due to institutional biases within the British Army.[15] Narrating three counterfactual examples, they contend that radio could have been used more extensively and brought the war to a swifter conclusion with fewer lives lost. However, their arguments are focused on the Signal Service and give little recognition to how the Signal Service integrated with the greater British Expeditionary Force (BEF). Their work contributes to the argument that it is not enough for a tool or platform to offer a capability. That platform must be culturally accepted by its practitioners; a challenge that is not unique to radio technology or even information technology.

Brian N. Hall offers a much more comprehensive view of the BEF's communication structure and C2 system throughout World War I in *Communications and British Operations on the Western Front, 1914-1918*. Focused broadly on the communication system within the BEF, and not narrowly on its wireless capability like Bullock and Lyons, Hall is more forgiving of the BEF's communication abilities. He argues that there were missed opportunities with the implementation of new communications technology. However, in the greater context of the time,

[15] Mike Bullock and Laurence A. Lyons, *Missed Signals on the Western Front: How the Slow Adoption of Wireless Restricted British Strategy and Operations in World War I* (Jefferson, NC: McFarland and Company, Inc., 2010), 12.

the BEF improved their capabilities throughout the war and became a model for its ally, the United States, to follow.[16] However, his work is limited to evaluation of the British military with only intermittent reference to the AEF and his analysis concludes with the creation of the Royal Corps of Signals in 1920.

The most comprehensive view of the US Army's communication capabilities and the use of the radio during World War I and the Interwar Period comes from Rebecca Robbins Raines. Raines' *Getting the Message Through: A Branch History of the US Army Signal Corps* argues that radio during World War I was still in its infancy and underwent technological advances during the Interwar Period that led to its wider acceptance as a tool for communication during World War II. She argues that the radio was not utilized more extensively during World War I because of limited distribution to the force prior to the Armistice.[17] As the title suggests, Raines' work focused on the Signal Corps as a whole from its inception to its participation in Desert Storm, thus her discussion of the radio is from a capability standpoint with an evaluation of how it was used during World War I and the Interwar Period.

Case Study: The Radio in World War I

In the summer of 1914, while most of Europe was succumbing to the opening battles of World War I, the US Army was making use of a relatively new technology, radio transmission. It was conducting operations along the United States' southern border as well as in the Philippines and Hawaii where running traditional telegraph wires was impractical over long distances and archipelagos.[18] For the most part the Army's radios remained stationary. What distinguished

[16] Brian N. Hall, *Communications and British Operations on the Western Front, 1914-1918* (New York: Cambridge University Press, 2017), 306-307.

[17] Rebecca R. Raines, *Getting the Message Through: A Branch History of the US Army Signal Corps* (Washington, DC: Center of Military History, 1996), 172.

[18] US War Department, *Report of the Chief Signal Officer to the Secretary of War, 1919* (Washington, DC: Government Publishing Office, 1919), 24, accessed March 31, 2021, https://play.google.com/books/reader?id=jBFAAAAAYAAJ&hl=en&pg=GBS.PA24.

radio from the wired telegraph alternative was the lack of wires. In fact, due to the new capability radio provided to facilitate communication at sea, both ship to shore and between ships, the US Navy adopted radio faster than other government agencies.[19]

Even though the Navy led in radio development, Maj. Gen. George O. Squier, the Army's Chief of Signal throughout World War I, appreciated the new technology's applicability to modern warfare prior to 1914. He also recognized that the US Army lacked expertise to enable an informed, deliberate expansion of the Army's radio capability. As early as 1898 he began discussing with commercial industry how the Army could capitalize on radio and the radio industry. However, as the United States entered the war the Army innately still used the radio in a primarily stationary capacity consigned to the division or higher for communication.

The technology was capable of employment on the move; the US Navy and other navies had demonstrated that capability in the Pacific. However, the US Army had not engaged in a conflict prior to World War I that necessitated a deliberate process to refine radio and its application for land battles. The Signal Corps experimented with radio during Gen. John J. Pershing's Mexican expedition, but World War I was the crisis that highlighted the value of reliable, wireless, beyond the line-of-sight communication. The size and scale of the war was not the only thing that made the use of the radio invaluable. There were new technologies, such as the airplane, whose capabilities were more fully realized using wireless telephone, or what most people recognize as the radio today. There were also evolving tactics, such as defense in depth that necessitated communicating with repositioning artillery.

In a relatively short period of time the US Army had to build a communication network, based on innate requirements that incorporated new technologies and was flexible enough to adapt to emerging tactics. The network also had to reach from training camps and research centers in the United States, across the Atlantic, and all the way to the frontline. The flexibility

[19] Raines, *Getting the Message Through*, 136-137.

and reach of that network was due to the incorporation of the original wireless electric technology, the radio. Leading up to the United States' entry into the war and during their relatively brief engagement in the Great War, the successful implementation of the radio was due to the US Army's deliberate approach. It deliberately designed training and doctrine addressing wireless technology, as well as implemented organizational changes primarily in the Signal Corps to meet a growing demand. Those processes built a foundation of radio knowledge and familiarity throughout the force.

Training and Doctrine

While information technology was not increasing at quite as rapid a pace as the beginning of the 20th century, there were still relatively rapid changes occurring. The Signal Corps' 1916 manual *Radiotelegraphy* notes that any 1912 field radios still in use were made obsolete by the 1913 version of the field radio.[20] Unfortunately, most signal officers before World War I were officers detailed from other branches, who served four years as signal officers before returning to their branch.[21] This was not long enough to form a foundation of technical knowledge in the Signal Corps and across the Army. As a result, the Army relied on innate communication processes, passing information in ways the force was familiar with, even as technology evolved.

Maj. Gen. Squier understood that he did not have adequate expertise within the Signal Corps, nor the time required to build an expertise base to inform the development and use of the radio capability within the Army using a deliberate approach. The technology was needed immediately on the European battlefield. As he stated in his 1919 annual report to the Secretary of War, he had to build a network that encompassed every training camp, research facility, and War Department building in the United States. It needed to stretch across the Atlantic Ocean to

[20] US War Department, *Radiotelegraphy* (Washington, DC: Government Printing Office, 1916), 104, accessed March 31, 2021, https://archive.org/details/telegraphyradiou00unitrich/page/104/mode/2up.

[21] US War Department, *Report of the Chief Signal Officer,* 10.

the frontlines in Europe.[22] In order to build such a vast network, Squier needed to recruit a force who could deliberately evaluate the fastest and most reliable ways to enable communication capabilities.

Squier worked with commercial industry to recruit that expertise. Through negotiating and building relationships with AT&T, General Electric, and Western Union, Squier recruited some of the leading telephone and wireless experts in the United States to serve as part of the Army's Signal Corps. The main source of friction was ensuring private companies' ability to service the homefront while also supporting the war effort. He remarked, "How could we pick from these organizations and other similar utilities the men and equipment needed immediately without crippling that essential service in the United States, where additional demands would be made in the vast industrial preparations required at home also?"[23] Both commercial industry and the Army recognized the requirement for a whole of nation approach for the war effort, not just a whole-of-government one.

As a result of the negotiations five executives from commercial industry received emergency US Army commissions in mid-1917 and they, in turn, picked teams to fill twelve battalions that would train together in their corporate offices prior to their European deployment.[24] This allowed the Army to capitalize on their subject matter expertise quickly as they arrived in France to establish the AEF network. The Army valued their knowledge of electronic communication more than it valued their ability to execute other soldier tasks. The time they gained in their offices allowed them to work on the best equipment available in the United States while establishing team cohesion.[25]

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[22] US War Department, *Report of the Chief Signal Officer*, 6.

[23] Ibid., 10.

[24] Ibid., 8.

[25] Ibid.

Signal doctrine prior to the United States' entry into World War I reflected an audience of experts. The 1916 manual *Radiotelegraphy* published by the US Army Signal Corps began abruptly with a technical description of electrical charges and currents and their relationship with radio technology: "If a wire connects a charged body with an uncharged or oppositely charged one, the static charge will flow through the wire from the charged to the uncharged body, or from the positively charged body to the negatively charged one, and become a *current* while so flowing, that is, a *current* is a moving charge or succession of charges."[26] While an infantry or cavalry officer at the time might have been overwhelmed by these descriptions, it is safe to assume that the initial men transferred from commercial industry easily understood the terms and concepts described in the manual.

The Army's ability to directly commission wireless communication experts unquestionably improved the AEF's ability to leverage new communication technology. However, the Signal Corps had to train additional radio operators to deliberately build a foundation of radio knowledge and processes, enabling the network it was constructing to facilitate innate communication requirements. Like many of its fellow branches, the Signal Corps established a six-week training program in France for new radio operators arriving from the United States.[27] Men without backgrounds in telephone and telegraph struggled to pick up the new skills that were unlike anything they knew. Soldiers directly supporting infantry regiments were often used for non-radio specific communication tasks, such as a designated runner, once

[26] US War Department, *Radiotelegraphy*, 4.

[27] US Department of the Army, Center of Military History (CMH) Publication 23-18, *United States Army in the World War 1917-1919: Reports of the Commander-in-Chief*, vol. 12, *Staff Sections and Services* (Washington, DC: US Army Center of Military History, 1991), 155.

they reached their units.[28] Without a strong radio foundation and no structure or time to reinforce their initial training, weak skills often deteriorated further.

Unlike infantry regiments where radio was not prevalent, the Air Service relied on radio to communicate with command posts and artillery units on the ground. In June 1917, while airplanes were still technically part of the Signal Corps, the Army published War Department Document, no. 666, *The Means of Communication Between Aeroplanes and the Ground*. The opening line of the text emphasizes just how important radio was to emerging aircraft: "Wireless telegraphy will be the method always employed whenever it is possible to use it, as experience has shown that it gives about ten times better results than any other."[29] While it included details of the technical workings of the aircraft radio, as the title suggests, the newest manual expanded on the capability that the radio offered while also expanding on the risks associated with wireless communication. Other methods of enabling a pilot's innate communication needs worked. However, the radio provided the most efficient means for carrying out those processes.

The pamphlet detailed all communication options between airplanes and ground forces while also highlighting the risks of each, implying the need for redundant communication methods. No means of communication was impervious to interference or failure. The conclusion of the communication methods section provides insight into information technology that is still relevant today. It explains the importance of training not just the operators of the technology, but commanders who receive information over the technology, "It is necessary that these commanders, having studied the practical operation, should understand exactly what can be expected of each method, when the use of each is preferable, and what errors are liable to occur

[28] Headquarters 1st Division, American Expeditionary Forces, "Extract from Report of Chief Signal Officer, December 22, 1917," *World War Records, 1st Division, American Expeditionary Forces, Regular: Operations Reports and Field Messages*, 61, accessed March 31, 2021, https://cgsc.contentdm.oclc.org/digital/collection/p4013coll7/id/1022/rec/2761.

[29] US War Department, War Department Document, no. 666, *The Means of Communication Between Aeroplanes and the Ground* (Washington, DC: Army War College, 1917), 7.

as a result of their respective limitations."[30] Ultimately, an operator could obtain a better result if he deliberately evaluated the risks and opportunities provided by available communication means. In the absence of innate knowledge of those means, War Department Document, no. 666 was an accessible reference.

Similarly, Part III of the AEF's *Heavy Artillery Signal Manual*, published in December 1918 and prepared by the heavy artillery school in France, provided a deliberate evaluation for the land advantages of radio. The manual explained how smoke from extended fire made visual signaling unreliable and wires were susceptible to destruction by shells falling. That may seem obvious, but in 1918 when many soldiers had no innate understanding of wireless technology, those descriptions outlined radio's applicability on the battlefield. The manual also appealed to radio operators' innate survival instincts when it concluded with, "Not the least important use of the radio apparatus in military operations is that which the alert operator makes of it as a means of anticipating destructive shell fire on his own battery position."[31] It explained that the radio operator had the important job of notifying the battery commander to cease firing if he heard enemy traffic on the radio. This ensured the battery's position remained concealed. Further appealing to an operator's survival instincts, the final sentence of the introduction states, "A timely warning made to the battery commander under these circumstances has saved the lives of many artillery men."[32]

As the war progressed, in what might seem a counterintuitive change, Signal doctrine also revised to become more accessible. While subject matter experts remained in research and development positions, the average radio operator in November 1918 did not have a radio or

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[30] Ibid., 24.

[31] General Headquarters, American Expeditionary Forces (AEF), *Heavy Artillery Signal Manual, United States Army (Provisional), Part III, Radio* (Angers, France: US Army Heavy Artillery School, 1918), 7, accessed March 31, 2021, https://cgsc.contentdm.oclc.org/digital/collection/p4013coll9/id/683/rec/1.

[32] Ibid., 8.

electrician background before entering the Army. The audience for the 1918 Signal Corps publication Radio Pamphlet No. 40, *The Principles Underlying Radio Communication* was clearly less technically savvy than the one reading the 1916 manual *Radiotelegraphy*. The 1918 document's preface acknowledged that its audience lacked an innate foundation of knowledge. The pamphlet stated, "it has been necessary at times to use definitions, illustrations, and analogies which would not be used in a work prepared for more advanced students."[33] Throughout the pamphlet technical concepts were compared to everyday events and objects that the average soldier at the time could relate to:

> A useful illustration of the electric circuit is a closed circuit of pipe…completely filled with water, and provided with a pump…or some other device for causing the water to circulate. The amount of water which leaves a given point in each second is just the same as the amount which arrives in the same length of time. Now in the electric circuit we have no material fluid, but we suppose that there exists a substance, which we call electricity.[34]

Doctrine written for a more technical audience might have provided more depth of knowledge for soldiers with prior technical knowledge. However, that would have decreased the number of operators who understood the doctrine, minimizing the effective radio operator force.

Organization Changes

The Chief of Signal recognized that the Signal Corps' previous structure was inadequate to build a deliberate system to evaluate the increasing demands for radio in the lead up to entering the Great War. Prior to April 1917, within the Office of the Chief of Signal in Washington, DC only three divisions existed: administration, aeronautical, and engineering. The responsibilities of these divisions encompassed everything from recruiting and training to the design, construction, and maintenance of communication equipment.[35] As responsibilities increased with the

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[33] US War Department, Radio Pamphlet no. 40, *The Principles Underlying Radio Communication* (Washington, DC: Government Printing Office, 1919), 4, accessed March 31, 2021, https://archive.org/details/underlprinciples00unitrich/page/4/mode/2up.

[34] US War Department, Radio Pamphlet no. 40, 16.

[35] US War Department, *Report of the Chief Signal Officer*, 12.

declaration of war, especially with regards to the recruitment for technical experts for radio, the Office of the Chief of Signal underwent an organizational overhaul. A new organization structure added a specific Radio Division in July 1917 for research and development as well as for recruiting and training personnel brought in for the express purpose of operating and maintaining radios.[36] As a testament to the emphasis placed on developing the radio capability, the section expanded from three officers and one civilian when it stood up to a total of over 400 officers, enlisted soldiers, and civilians by July 1918.[37]

However, the Radio Division was short-lived, not because of its lack of importance or significance to communication capabilities, but because the danger of organizing expertise and deliberate processes according to a particular mode of communication became clear when the Air Service completed its separation from the Signal Corps in July 1918. Most of the new divisions, including the Radio Division, had some personnel and administrative processes that were sent with the new Air Service. As the Signal Corps restructured again, rather than dividing along technology specific lines, the branch dispersed expertise throughout an Equipment Division, a Supply and Accounts Division, a Training and Instruction Division, an Engineering and Research Division, and a body of experts that worked directly for the Office of the Chief of Signal and advised all divisions.[38] The radio research facilities were absorbed into the Engineering and Research Division as the Radio Development Section.[39] This allowed for an economy of resources to be leveraged toward developing multiple forms of communication and the soldiers to operate those capabilities in a more deliberate and integrated process.

Operationally as the role of the airplane in warfare grew, the radio allowed innate processes to develop between pilots and ground forces. As the *Heavy Artillery Signal Manual* put

[36] Ibid., 13.

[37] Ibid., 244.

[38] US War Department, *Report of the Chief Signal Officer*, 13.

[39] Ibid., 248.

it, “Great as is the value of the airplane in extending the range of vision of the army, yet their effectiveness in directing artillery fire onto enemy targets is only made possible by the instantaneous means of communication between plane and battery afforded by the radio apparatus.”[40] To support its need for radio communication, which outgrew the support provided by the Corps’ radio section, a radio section was created for each air squadron in the AEF.[41] Because the Signal Corps maintained radio expertise, the AEF Chief of Air Service and Chief of Signal agreed the Signal Corps retained training responsibility for the radio personnel, as well as supply and maintenance of the radios in the air squadrons, while the Air Service maintained operational control.[42] By Spring 1918 each air squadron in the AEF had a trained radio officer who then recruited from within his respective squadron to train radio operators.[43] This expanded a deliberate process that the Air Service could leverage to realize the full benefit of airplanes on the battlefield.

In addition to the Air Service, the War Department’s *General Order Number 152* in September 1918 clarified the Signal Corps’ responsibility. Regardless of which type of unit was employing radio: “the Chief Signal Officer, American E. F. will exercise general supervision and control of all radio operations in the A. E. F., including those of the Artillery, Air Service, Tank Corps and other special services.”[44] They also approved a Signal Corps’ request in August 1918 that an Army Radio Section consisting of nine officers and 337 soldiers be added to each AEF army.[45] This ensured a consistent, deliberate process for evaluating and implementing radio and technical communication throughout the force.

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[40] General Headquarters, AEF, *Heavy Artillery Signal Manual*, 7.

[41] US War Department, War Department Document, no. 666, 25.

[42] US War Department, *Report of the Chief Signal Officer*, 312.

[43] Ibid., 310.

[44] US Department of the Army, CMH Publication 23-6, *United States Army in the World War 1917-1919*, vol. 1, *Organization of the American Expeditionary Forces* (Washington, DC: US Army Center of Military History, 1988), 134.

[45] Ibid., 135.

Equipment

In addition to innate communication processes, there were also intelligence collection opportunities realized by radio, both by intercepting enemy communication and by developing triangulation techniques. As the First Army radio intelligence officer, Capt. Charles Matx wrote following the St. Mihiel offensive in late September 1918, "The location of all enemy radio stations in their proper places by means of gonio bearings on the night before the attack was the determining factor in the decision of the chief of intelligence that the enemy had not already withdrawn from the St. Mihiel Salient."[46]

Another recognized benefit of radio through a deliberate evaluation: it provided redundancy for previously established communication methods. Transatlantic telephone and telegraph cables were susceptible to cutting, whether by accident or on purpose. In response to a concern that German submarines were intentionally tapping and cutting transatlantic cables in the summer of 1917, the US Army and Navy worked together along with the French on a project to ensure the AEF could communicate back to Washington, DC.[47] The Navy installed high powered radio transmitters in both Paris and Annapolis, Maryland. The Army placed one of their experts acquired from the commercial sector, Maj. JJ Carty, on the project. Carty was Chief Engineer and a vice president of AT&T before the United States entered the war. Not only was he invaluable to the early establishment of a communication network for the AEF, but he also led the Army's contribution to the joint radio network that would provide redundancy for telegraph lines.[48]

For their part, through a deliberate process enabled by Carty's subject matter expertise, the Army studied which of their land stations was least susceptible to static and interference. The

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[46] US War Department, *Report of the Chief Signal Officer*, 323.

[47] Ibid., 215.

[48] Johnson Hagood, *The Services of Supply: A Memoir of the Great War* (Cambridge, MA: Houghton Mifflin Company, 1927), 348, accessed March 31, 2021, https://archive.org/details/servicesofsupply00john/page/348/mode/2up.

selected sites throughout the United States, connected by telegraph lines to Washington, DC, were programmed to constantly receive messages from Paris. The concept was relatively simple: any station that received a message from the AEF would transmit the message via wire to Washington. If any part of a message were missing due to interference or poor reception, gaps could be filled in from another station that had received the same message. Enough partial messages could be pieced together to ensure critical information was not lost in transmission.[49]

The Army-Navy cooperation was not new to military radio. When the Army's Signal Corps established its radio lab, it co-located with the Navy's lab at the Bureau of Standards in Washington.[50] This allowed a deliberate, robust evaluation process for common problems and probably contributed to early interoperability between Army and Navy equipment. In fact, prior to 1917 most of the Army's field radios were constructed in that radio lab. However, even after partnering with General Electric to produce additional radios needed for the war effort, the US Army did not have the capacity of pack radios to meet its own demand as it prepared for war.[51]

The United States was dependent on French equipment to augment its lack of radio production ability, both in the radio itself and repair parts. The AEF operated French radios for the entirety of their participation in World War I due to a lack of radio production capacity in the United States. For that reason, France provided the equipment standardization and regulations that formed the backbone of the AEF network architecture.[52] The United States did not develop a large production capability until 1918, and even then, when sixty airplane radios finally arrived in France, they were determined to be, "totally unfit for use at the front."[53] However, it should be

[49] US War Department, *Report of the Chief Signal Officer*, 137.

[50] Ibid., 216.

[51] Ibid., 217.

[52] Ibid., 306.

[53] Ibid., 311.

noted that the shortage of radio equipment was not entirely due to inadequate radio production in the US. All the branches suffered due to a lack of available trans-Atlantic shipping.[54]

The United States' commercial base, with companies like AT&T, and General Electric contributed technical expertise and production capacity. However, the need for Army-specific radio technology quickly became apparent during the war. To answer demand, the Signal Corps established additional research centers in the United States and France. As the Chief Signal Officer put it, the rented radio lab in New Jersey was a place where subject matter experts could "devote their entire energies to the problems constantly arising in the extension of methods of intercommunication now appearing as never before."[55] As part of a deliberate evaluation process, the lab focused on experimenting with and refining the already existing technology, not necessarily creating new technology.

The research center that the Army established in France provided a unique opportunity to gather immediate feedback from combat experiences. The center sent valuable information back to the US labs, outlining the Army's wartime use and requirements for the radio. The minimal equipment sent from the United States was tested at the center in France to ensure it met force and French requirements before issuing the radios to units at the front. Despite production challenges in the US, two American advances came from this collaboration: the improvement of the vacuum tube, which allowed voice to transmit and be received over radio waves; and the improvement of batteries for radios, rather than larger and more cumbersome power generators. Unfortunately, due to the production timeline, these improvements to radio technology did not make it to implementation in Europe before the Armistice.[56]

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[54] John J. Pershing, *Report of General John J. Pershing, Commander-in-Chief, American Expeditionary Forces* (Paris: GHQ, AEF, 1918), 6.

[55] US War Department, *Report of the Chief Signal Officer*, 9.

[56] Benedict Crowell, *America's Munitions 1917-1918*, bk. 7, chap. 1, accessed March 31, 2021, http://www.gutenberg.org/files/48428/48428-h/48428-h.htm#Page_567.

While the advancements in vacuum tubes and batteries were critical and improved radio as a possible communication tool, neither were new inventions during the war. Both vacuum tubes and battery technology existed within the United States prior to World War I. However, its application in warfare was new. The radios the Army was using in 1917 did not easily translate to a maneuvering land force. One of the reasons commanders struggled to conceptualize that radio could transmit on the move in the early 20th century was due to its large size and operating requirements. Hauled on wheels, they required a hand-cranked generator, antennas upwards of 85-feet, and at least two operators to adjust the frequencies and antenna position simultaneously. All of this was better achieved while stationary. They also powerfully transmitted in all directions, making interception by enemy forces more likely. The omnidirectional, open transmission also meant that on a battlefield, friendly transmissions could interfere with one another, making it difficult for radio operators to determine which line of communication was intended for them.[57] The deliberate system the US Army established led to the refinement of radio, which allowed it to better enable innate communication demands.

By the conclusion of World War I, Chief Signal Officer Squier, in his annual report to the Secretary of War in 1919, acknowledged the impact the radio would have on the future. Squier began the report by declaring that the radio and its ability to work in conjunction with wired networks, "portends the day which I believe is not far distant, when we can reach the ultimate goal so that any individual anywhere on earth will be able to communicate directly by spoken word to any other individual wherever he may be."[58]

Case Study: The Radio During the Interwar Period

As the world emerged from the Great War, both the civilian world and the military began to realize the full potential of radio technology. Maj. Gen. Squier was not alone in his view that

[57]US War Department, *Radiotelegraphy*, 10.

[58] US War Department, *Report of the Chief Signal Officer*, 6.

radio was changing the way people communicated with one another. Less than two years after the Armistice was signed, the announcement of the Warren Harding and James Cox presidential election returns broadcast on KDKA out of Pittsburgh became the first commercial broadcast in the United States. Less than a year later the Jack Dempsey vs. Georges Carpentier boxing match became the first broadcast sporting event.[59] By 1937 Fort Leavenworth offered its residents the ability to hear radio broadcasts in their quarters.[60] The ubiquity of radio in American homes by the end of the 1930s meant that most citizens could tune into President Franklin Roosevelt's radio broadcasts of his fireside chats, but perhaps the response to Orson Wells' *War of the Worlds* broadcast in 1938 most clearly emphasizes the power the radio wielded.[61]

As the country explored the benefits and entertainment value of the radio, the Army grappled with how the new technology enabled its organization. An inflated wartime Army had to downsize during a time of relative peace and prioritize expenditures during subsequent economic hardship. Those organizational decisions, debated throughout the interwar period and reflected in Army doctrine, impacted the organization of signal formations, affected how soldiers were trained on the radio, and hindered the American establishment of a tactical radio network to enable combined-arms maneuvering. As late as the 1940 Louisiana Maneuvers radio was only an alternate means of communication, after the wired telephone and telegraph, and primarily located only at division and higher headquarters in infantry formations. For the large-scale exercise only 3% of the almost 9,000 messages sent through the IV Corps message center were radio messages.

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[59] "First Program Broadcast by KDKA Six Years Ago," *New York Times*, October 31, 1926, accessed March 31, 2021, https://timesmachine.nytimes.com/timesmachine/1926/10/31/100006105.html?pageNumber=218.

[60] US War Department, *The Signal Corps Bulletin no. 97* (Washington, DC: Office of the Chief Signal Officer, accessed March 31, 2021), 19, https://www.nsa.gov/Portals/70/documents/news-features/declassified-documents/friedman-documents/publications/FOLDER_206/41762469080162.pdf.

[61] A. Brad Schwartz, "The Infamous 'War of the Worlds' Radio Broadcast Was a Magnificent Fluke," *Smithsonian Magazine*, May 6, 2015, accessed March 31, 2021, https://www.smithsonianmag.com/history/infamous-war-worlds-radio-broadcast-was-magnificent-fluke-180955180/.

Some of the relatively limited use of radio was due to the lack of a standardized regulatory structure for the US Army's radio network architecture, as defined by doctrine and policies and enabled by a trained force. However, demand across the force for a better communication system for the military had been growing and the potential for radio use was clear.[62]

Organization Changes

As the United States and the Army pulled out of Europe and attempted to make sense of the lessons learned during the Great War, organizational changes influenced radio's use throughout the force. The Signal Corps was only given responsibility for communications at the division and above following the publishing of the AEF Superior Board's findings.[63] While this reduced the number of signal soldiers required to operate radios, this meant that infantry, field artillery, and cavalry soldiers took on responsibility to provide deliberate feedback for radio capabilities. Perhaps the ubiquity of radios in American life led decision makers to think that with minimal training anyone could operate a radio adequately and inform their respective commanders of its technical capabilities to meet the needs of smaller maneuver units.

The reorganization also meant that there was no architecture to regulate radio networks across the force below the division level. Maj. Gen. Squier, still the Chief of Signal in 1920, argued that rather than a fully integrated system, this reorganization would create numerous different radio networks, not required to communicate with one another. However, the benefit of radio communication is fully realized by coordinating outside of organizations, whether with artillery or air support or neighboring units, rather than internally.[64] During a speech at the Army War College in 1928, the new Chief of Signal, Maj. Gen. George Gibbs, expanded on the risks.

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[62] Dulany Terrett, *The Signal Corps: The Emergency (to December 1941)* (Washington, DC: Office of the Chief of Military History, 1956), 155.

[63] Ibid., 23.

[64] Ibid.

He argued that in addition to the network confusion, not maintaining trained operators would lead to ineffective support, especially on more technical equipment such as the radio.[65]

In a peacetime army, it can be challenging to maintain trained technical equipment operators. Casualties on a scale of the Great War increase the turnover of trained operators. Without a regulated, standardized network architecture throughout the US Army, a large-scale conflict would add complexity to radio networks, siloed within branches or units. Numerous units suddenly trying to integrate and communicate on a kinetic battlefield required skilled operators and a standardized architecture. The Chiefs of Signal were expressing concerns that using radios to communicate was not an innate process. It required deliberate processes, executed by operators trained on a standardized and regulated architecture.

Operating an Army radio and deconflicting its supporting network was more complicated than allocating radios to forces, turning them on, and tuning them to the correct channel like on a home radio. A monograph written at the Command and General Staff School at Fort Leavenworth in 1930 illustrates the scale of the problem the Signal Corps believed it might face. Maj. C. K. Sadtler calculated that a field army could have as many as 1,344 radio sets on potentially 238 different radio nets. Whether enough frequencies existed and who would deconflict the network below the division on that scale was one problem.[66]

The second problem Sadtler identified was how to train and replace so many radio operators during wartime. He argued that to be effective, all radio operators needed to be trained to a standard level of proficiency and familiarity with the network architecture, from the frontline all the way back to the rear. Radio only enhanced communication across dispersed formations if

[65] Edwin D. Patrick, "The Training and Replacement of Infantry Signal Communication Personnel (Officers and Enlisted Men) in the Theater of Operations" (Individual Research Paper, The Command and General Staff School, Ft Leavenworth, KS, 1934), 4.

[66] C. K. Sadtler, "Radio in the American Army" (Individual Research Paper, The Command and General Staff School, Ft Leavenworth, KS, 1930), 9.

the radios were also dispersed.[67] Even if the Army recruited all the competent amateur radio operators away from the commercial sector in 1930, once the Army considered age and fitness, there were significantly less than what the Army needed.[68] Maj. Edwin Patrick, an infantry officer writing a monograph in 1934, echoed Sadtler's concerns of relying on the amateur radio community. Patrick added that while the Federal Radio Commission provided raw numbers of civilian operators, it did not measure proficiency.[69] The standards for amateur radio operators did not meet Army requirements. Many civilian radio operators required training to operate the Army's systems and could not be expected to immediately backfill Army operators. A network is only as strong as its weakest point and an individual proficient operator is ineffective if he has no other operators to transmit to.

In contrast to the Chief of Signal's arguments, Maj. Gen. Stephen Fuqua, the Chief of Infantry from 1929-1933, argued that nobody understood the communication needs of the Infantry like an infantry soldier.[70] Early Signal Corps doctrine called for the establishment of message centers that operated at the division and higher headquarters. While the message centers worked at higher echelons, they did not scale down to the faster paced battalion level. In response, battalion commanders often created ad hoc solutions with the men and equipment available that reinforced their innate processes. They credited those processes for their improved communication efficiency.[71] However, this failed to appreciate the value of the technical skills the Signal School provided to radio soldiers, especially as the prevalence of radio in everyday life made the technology seem simpler and more accessible than military radios. The Infantry community's dissatisfaction with Signal Corps policy seemed to conflate disagreement over

[67] Sadtler, "Radio in the American Army," 9.

[68] Ibid., 11.

[69] Patrick, "The Training and Replacement of Infantry Signal Communication Personnel," 20.

[70] Ibid., 7.

[71] Ibid., 8.

architecture recommendations and distrust of the technical skills soldiers were taught at the Signal School.

Upon gaining control of their communication capabilities, infantry regiments added a communications platoon.[72] An infantry battalion's communication section came from the communication platoon at its superior regimental headquarters.[73] Reflective of the Chief of Infantry and the Infantry School's view, these sections were manned by infantry soldiers equipped with radios and other signal equipment. Soldiers could be sent to a course at the Signal School, which lasted a year for officers or anywhere from four month to a year for enlisted soldiers, a considerable time investment for a unit to make to train a soldier in what for some was a temporary duty. Reflective of that, in garrison environments some communication platoons were used for special duties, not necessarily radio or communication related.[74] There was no process or regulation that standardized the training and proficiency of radio operators within infantry formations.

In the August 1941 issue of *The Field Artillery Journal,* an article discussing German use of radio communications emphasized the need for the Infantry and Field Artillery to work together to ensure reliable communications.[75] In contrast to the Infantry's lack of attention given to their signal sections, the Field Artillery standardized an architecture containing liaison officers with radios and at times radios organized down to the battery level.[76] Liaison officers providing

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[72] Patrick, "The Training and Replacement of Infantry Signal Communication Personnel," 5.

[73] US War Department, Field Manual (FM) 7-5, *Infantry Field Manual, Organization and Tactics of Infantry, the Rifle Battalion* (Washington, DC: Government Printing Office, 1940), 277, accessed March 31, 2021, https://cgsc.contentdm.oclc.org/digital/collection/p4013coll9/id/741/rec/4.

[74] Patrick, "The Training and Replacement of Infantry Signal Communication Personnel," 9.

[75] "German Signal Communications," *The Field Artillery Journal* 31, no. 8 (August 1941): 582, accessed March 31, 2021, https://sill-www.army.mil/fires-bulletin-archive/archives/1941/AUG_1941/AUG_1941_FULL_EDITION.pdf.

[76] "From the Chief's Office," *The Field Artillery Journal* 31, no. 8 (August 1941): 628, accessed March 31, 2021, https://sill-www.army.mil/fires-bulletin-archive/archives/1941/AUG_1941/AUG_1941_FULL_EDITION.pdf.

support to sister branches brought radios and operated on frequencies designated by their home unit. However, without a standardized radio architecture and an increasing number of liaisons distributed throughout the battlefield, risk of interference with neighboring units' radios increased.

Echoing Maj. Sadtler's 1930 monograph, *The Field Artillery Journal* from 1941 contained an article titled "Lessons from the Maneuvers." The article observed that during the Louisiana Maneuvers, poorly trained radio operators contributed to poor coordination between infantry and artillery. The article reiterated the need for cooperation and emphasizes that Field Artillery Commanders, and every person within their system, should do everything they can to ensure coordination with supported Infantry units because, "An infantry battle and an artillery battle should not be fought—but rather an infantry-artillery battle."[77] However, as Maj. Sadtler pointed out in 1930, a radio network is only as strong as its weakest link. A communication network must be a whole of military approach, with standards for its operators as well as infrastructure operating according to a defined network architecture.

Training and Doctrine

The US Army's doctrine in the late 1930s and early 1940s reflected the Infantry branch's success campaigning to maintain control of its radio personnel and equipment. The 1941 publication of Field Manual (FM) 100-5, *Operations* limited the Signal Corps' responsibility for radio communication to the division and higher level and vague technical supervision at lower echelons. The manual goes on to specify that other arms and services were responsible for their own communication networks using Signal Corps supplied equipment, like the radio.[78] When cross referenced with infantry, field artillery, and signal doctrine from the same period, radio

[77] "From the Chief's Office," *The Field Artillery Journal* 31, no. 8, 628.

[78] US War Department, FM 100-5, *Field Service Regulations, Operations*, (Washington, DC: Government Printing Office, 1941), accessed March 31, 2021, 16, https://cgsc.contentdm.oclc.org/digital/collection/p4013coll9/id/978/rec/1016-17.

networks were siloed within the respective arm they supported. This may be sufficient in a controlled training environment. However, radio coordination across branches during battle requires network integration, made possible by a standardized architecture.

The lack of integration for radio networks was reflected in the Army's first publication of FM 24-5, *Signal Communication* in 1939; a manual to provide basic technical information for anyone responsible for deliberate evaluation of technical communication within a division or smaller unit.[79] The manual described networks that were unique to each command and overseen by their respective G-3s or S-3s.[80] It stressed the importance of teamwork across formations "regardless of unit, arm, or service. There must exist a spirit of mutual helpfulness and cooperation."[81] Without a formal architecture, teamwork was critical for establishing radio networks that could integrate. That teamwork relied on soldiers who had a shared foundation of radio knowledge. However, there still were no Signal Corps soldiers below the division echelon and communication soldiers were responsible for engineering their own radio architecture for each unit.

FM 24-5 differentiated between Signal Corps officers, located at the division or higher, and communication officers in subordinate units. The primary difference between a signal officer and a communication officer's responsibility was which network they were responsible for. Because there were no signal soldiers in brigades and battalions, communication officers were also responsible for selecting potential radio operators from within their formations and training them.[82] The Signal Corps published Technical Manual (TM) 11-454, *The Radio Operator* as training and selection aids. The TM included guidance for administering an aptitude test within

[79] US War Department, FM 24-5, *Basic Field Manual, Signal Communication* (Washington, DC: Government Printing Office, 1939), 1.

[80] Ibid., 251.

[81] Ibid., 5.

[82] Ibid., 8.

units “because of the relatively great length of time required to train radio operators,” and suggests testing twice the number needed due to a high failure rate.[83] Due to the effort involved training soldiers on the radio, in 1923 the Infantry School had experimented with incorporating radio courses into their curriculum for both officers and enlisted men. As the course lengthened, some within the Signal Corps argued that this showed the need for signal soldiers in Combat Arms units.[84] Ultimately the course was minimized to make room for other subjects.

While FM 7-5, *Organization and Tactics of Infantry, the Rifle Battalion*, published in 1940, contained no specific section outlining C2 procedures, perhaps because a commander was expected to be physically with his troops to observe battles unfolding and give guidance in person.[85] However, the manual mentioned the benefit of technical communication, like radio, for the rapid transmission of information, and specifically recommended radio for reconnaissance elements or, if more radios were available, communicating with aircraft.[86] For coordination with cavalry or field artillery units on the battlefield, FM 7-5 advocated using liaisons. Infantry liaisons brought their own communication method to cavalry units and field artillery liaisons brought their own equipment to infantry units.[87] As previously mentioned, without a standardized radio architecture, an increased number of liaisons increased the likelihood of friendly interference.

Perhaps to mitigate radio interference or because wire communication was perceived as more reliable, FM 7-5 recommended the field artillery liaison officer communicate to the artillery commander via wire, not radio.[88] Whatever the reason, FM 7-5 contrasted with FM 6-20, *Field*

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[83] US War Department, Technical Manual 11-454, *Technical Manual, the Radio Operator* (Washington, DC: Government Printing Office, 1942), 3, accessed March 31, 2021, https://radionerds.com/images/5/5c/TM_11-454_THE_RADIO_OPERATOR.pdf.

[84] Patrick, “The Training and Replacement of Infantry Signal Communication Personnel,” 6.

[85] US War Department, FM 7-5, 6.

[86] Ibid., 286.

[87] Ibid., 130.

[88] Ibid., 119.

Artillery Field Manual, Tactics and Technique, updated in 1941. The field artillery doctrine dictated the number of radio frequencies specifically allocated for forward observers and liaisons by battalion.[89] In fact, FM 6-20 included a comprehensive description of how field artillery units should construct all communication networks, including radio networks. When the manual stated, "Standard procedures in the training of personnel and in the installation and operation of communication systems are essential in the Field Artillery to ensure coordinated action with the other arms,"[90] it advocated for a standardized network architecture. While a necessary step toward a standardized architecture for field artillery units, it was insufficient for addressing the Army's need to standardize across arms to enable efficient cross-arm coordination.

Equipment

While equipment became smaller and more reliable during the interwar period, on the eve of World War II branches were still struggling to understand what their requirements for radio were. In 1939 *The Field Artillery Journal* published "Has the Close-Support Problem Been Solved," which proposed that radio could improve the call for fire network architecture. As it was, an attacking commander initiated the process face-to-face with his assigned liaison officer, who used a wired telephone to call the forward radio operator, who used the radio to call the fire-direction center, which then called the necessary guns using a wired telephone.[91] The author argued that fire control nets on the radio would make the process more efficient. The fire-control nets would span multiple units, reducing the likelihood of friendly radio interference, and would enable "the battalion to be well dispersed, bother laterally and in depth if the need should arise."[92]

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[89] US War Department, Field Manual 6-20, *Field Artillery Field Manual, Tactics and Technique*, (Washington, DC: Government Printing Office, 1940), 4, accessed March 31, 2021, https://cgsc.contentdm.oclc.org/digital/collection/p4013coll9/id/738/rec/1.

[90] Ibid., 41.

[91] Conrad L. Boyle, "Has the Close-Support Problem Been Solved?" *The Field Artillery Journal* 29, no. 5 (September-October 1939): 398, accessed March 31, 2021, https://sill-www.army.mil/fires-bulletin-archive/archives/1939/SEP_OCT_1939/SEP_OCT_1939_FULL_EDITION.pdf.

[92] Ibid., 400.

However, first radios needed, "choice of an operating band, power, and the proper design of equipment."[93] The operating band the author described spoke to the need for network architecture across the Army. The second two requirements he outlined described equipment concerns shared by the US Army's Cavalry community. In late 1939 the "Notes from the Cavalry Board" section of *The Cavalry Journal* also discussed radio improvements needed to support their networks and they echoed the recommendations in *The Field Artillery Journal*. The cavalry notes argued for standardized frequencies, similar to the operating bands in the field artillery article, and greater power generation for their radios.[94] While each branch had distinct requirements for the equipment, their shared interests of power and frequencies concerned enabling radios to reach and communicate with other radios in a network architecture.

The need for a standardized architecture to facilitate field artillery and cavalry integration was demonstrated during the 1939 First Army Maneuvers in Manassas. Col. George S. Patton, Jr., Commander of the 3rd United States Cavalry, observed that all of his unit's radio communication passed through the field artillery liaison during the exercise. The failing convinced Patton that the cavalry needed to use the same radio field artillery units used and the need for an expanded radio network. In contrast to his other observations, he added: "Despite the failure of the radios with the cavalry it is believed that communication for this arm is adequate, because in war the various highly specialized means of communication will not stand up and it is well to learn to operate in consonance with a prearranged plan for the attainment of satisfactory results."[95]

Patton's comment understating radio's role aligned well with the 1939 edition of the Infantry School's *Infantry in Battle*. The book emphasized the potential failing of technical means

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[93] Boyle, "Has the Close-Support Problem Been Solved?," 388.

[94] "Notes from the Cavalry Board," *The Cavalry Journal* 48, no. 5 (September-October, 1939): 428, accessed March 31, 2021, https://mcoepublic.blob.core.usgovcloudapi.net/library/CavalryArmorJournal/1930s/1939Jul-Dec.pdf.

[95] "Cavalry Participation in First Army Maneuvers, Manassas Phase," *The Cavalry Journal* 48, no. 5 (September-October, 1939): 429, accessed March 31, 2021, https://mcoepublic.blob.core.usgovcloudapi.net/library/CavalryArmorJournal/1930s/1939Jul-Dec.pdf.

of communication and advocated that commanders use a network of runners and telephone lines instead. In combat a battalion commander "should move forward along the announced axis of signal communication. If, for any reason, he leaves this axis, a runner should be left behind who knows where he can be located…Runners must be relied upon for communication within the battalion."[96] A reflection of the Infantry's lack of radio for communication was the lack of radios assigned to a battalion. When a communication section was attached to an infantry battalion they were issued one radio for communicating with their superior regiment and two radios for intra-battalion communication.[97] With so few radios, there was less demand from the Infantry community for a standardized radio network architecture. Infantry units mitigated the potential failings or lack of technical communication by emphasizing the importance of a concept that still reverberates through modern doctrine; shared commander's intent: "In every operation there must run from the highest to the lowest unit the sturdy life-line of a guiding idea; from this will be spun the intricate web that binds an army into an invincible unit embodying a single thought and a single goal."[98]

Conclusion and Recommendations

No form of communication is impervious to enemy exploitation and the US military should never be dependent on one form of communication. Like the Infantry community emphasized emerging from World War I, technology is not a substitute for a shared understanding of a commander's intent. However, as Gen. Harbord, Chief of Staff for the AEF predicted, "There still will be nothing new in the principle of using every possible means of communication if the day comes when the perfected television flashes to our armies the exact

[96] The Infantry Journal, *Infantry in Battle* (Washington, DC: Infantry Journal, Inc., 1939), 194, accessed March 31, 2021, https://cgsc.contentdm.oclc.org/digital/collection/p16040coll3/id/146.

[97] US War Department, FM 7-5, 321.

[98] The Infantry Journal, *Infantry in Battle*, 139.

appearance of enemy territory or 'no mans land' as seen by an 'electric eye' from an unmanned airplane guided by remote control."[99]

Commanders across branches and services innately will always do whatever they can to gain and share information with their formations that gives them an advantage over an adversary, because information is capital in the economy of war. In order to fully leverage existing communication technology, the DOD should implement and maintain a deliberate process to standardize its network architecture, policies, and doctrine across the joint force that guides training of operators and informs system development across the Joint Force.

Like issues the US Army and Joint Force grapple with today regarding gaining an information advantage, the use of radio during World War I and its further evolution during the Interwar Period is one historical example of how the US Army adjusted to using technology to gain an information advantage. Prior to World War I there was no innate or deliberate process for all Army leaders to understand how to leverage radio communication. The example of the radio showed that a deliberate process, informed by innate communication requirements was required to fully integrate the radio into the force. Maj. Gen. Squier leveraged civilian industry leaders to provide deliberate subject matter expertise to compensate for the lack of innate knowledge within the Army, similar to Kahneman's deliberate and innate systems respectively. The Signal Corps also wrote doctrine designed to educate people who had never worked with electronic communication before, rather than writing it for an expert audience. These deliberate efforts were critical to the successful incorporation of the radio. They laid a foundation that allowed the radio to begin to propagate throughout the force. Today, even though commercially available information technology is ubiquitous in everyday life, familiarity with smart phones and computers is not a substitute for training on military systems. The Joint Force should enforce a

[99] G. M. Palmer, "The Effects of Modern Communications (Radio, Airplane, etc.) on a Cavalry Raid" (Individual Research Paper, The Command and General Staff School, Ft Leavenworth, KS, 1936), 11.

standard level of training and proficiency across its network operators, regardless of service to ensure a solid foundation of network knowledge, as one piece of a necessary standardized architecture.

To maximize a well-trained force, they must operate within a standardized architecture, minimizing retraining requirements as mission requirements or organization structures fluctuate. Information technology's architecture is not just the physical components, like a radio. Similar to DeSoto's concept of property rights, it includes standards for programming and rules, expressed through policy and doctrine, that allow for the efficient transfer of information across a range of sensors, which a commander can action faster than his or her adversary. The architecture allows for the effective integration of diverse technologies across the force, future expansion of the network, and it strengthens network security capabilities by clarifying how the DOD's cyber territory is constructed. In turn, that conceptual terrain guides future operator training efforts as it evolves.

In contrast, after the Armistice, without French regulation, the US Army struggled to create a radio architecture. As commercial radio became more prevalent in civilian life, some within the Army assumed there was adequate expertise and familiarity within the organization to form a foundation of knowledge. As a result, less emphasis was placed on radio education, which deteriorated the radio knowledge base across the force. In turn this deteriorated the deliberate process for evaluating how radio technology could enhance innate information requirements in smaller formations.

Additionally, the Army lacked comprehensive rules for how to organize and program networks below the division level. Without the critical network architecture to stretch across branches, the Army struggled to realize the full potential of radio communication. Radios interfered with one another on the battlefield and communication process were convoluted. In the absence of a regulated radio architecture, Field Artillery and Cavalry established their own innate processes that while effective individually, did not easily integrate with one another. As DeSoto

explained in his theory, communication processes took place, they just needed formalized rules to leverage the full power of C2 capabilities. These issues are critical to understanding challenges that still exist today within the military's networks.

The faster and more efficiently information is shared across the Joint Force, the more effective the military is at bringing all its resources to bear on the battlefield. The DOD's Joint All-Domain Command and Control (JADC2) concept is an attempt to do that. However, to realize the full potential of information exchange within the military, the networks must integrate across systems and across services using a standardized network architecture. In the absence of a standardized architecture across all systems and services, commanders will create ad hoc solutions to gain an advantage over adversaries. However, ad hoc solutions by their very nature are not permanent, nor are they as effective at integrating across all resources when siloed within a particular command.

Technology and its components will continue to evolve and change, challenging how leaders observe their operational environment. A network architecture shaped by standardized infrastructure, programming, and policies across the DOD allows them to scale from a small team on the ground to a coalition or joint headquarters at multiple echelons. As technology continues to evolve inside the Army, across the Joint Force, and in the commercial sector, a clear architecture facilitates efficient integration with other networks and avoids disjointed communication efforts. It also allows for the military to better defend its networks and more easily identify cyber threats. The policies and rules that bound the network are not rigid. Just as property rights or other laws evolve to accommodate changing circumstances, so can the rules that govern the DOD's networks. However, rules can only change or adjust if they have a foundation to start from.

Bibliography

Army War College Historical Section. "The Operation of the So-Called 'Lost Battalion' October 2nd to October 8th, 1918." Washington, DC: US War Department, 1928. Accessed March 31, 2021. National Archives Catalog. https://catalog.archives.gov/id/301662.

Arnold, John H. *History: A Very Short Introduction*. New York: Oxford University Press, 2000.

Boyle, Conrad L. "Has the Close-Support Problem Been Solved?" *The Field Artillery Journal* 29, no. 5 (September-October 1939): 385-402. Accessed March 31, 2021. https://sill-www.army.mil/fires-bulletin-archive/archives/1939/SEP_OCT_1939/SEP_OCT_1939_FULL_EDITION.pdf.

Bullock, Mike, and Laurence A. Lyons. *Missed Signals on the Western Front: How the Slow Adoption of Wireless Restricted British Strategy and Operations in World War I*. Jefferson, NC: McFarland and Company, Inc., 2010.

"Cavalry Participation in First Army Maneuvers, Manassas Phase." *The Cavalry Journal* 48, no. 5 (September-October 1939): 429. Accessed March 31, 2021. https://mcoepublic.blob.core.usgovcloudapi.net/library/CavalryArmorJournal/1930s/1939Jul-Dec.pdf.

Crowell, Benedict. *America's Munitions 1917-1918*. Washington, DC: Government Printing Office, 1919. Accessed March 31, 2021. http://www.gutenberg.org/files/48428/48428-h/48428-h.htm#Page_567.

De Soto, Hernando. *The Mystery of Capital: Why Capitalism Triumphs in the West and Fails Everywhere Else*. New York: Basic Books, 2000.

Finnegan, Terrence J. *Shooting the Front: Allied Aerial Reconnaissance and Photographic Interpretation on the Western Front—World War I*. Washington, DC: National Defense Intelligence College, 2006.

"First Program Broadcast by KDKA Six Years Ago." *New York Times*, October 31, 1926. Accessed March 31, 2021. https://timesmachine.nytimes.com/timesmachine/1926/10/31/100006105.html?pageNumber=218.

Flicke, Wilhelm F. *War Secrets in the Ether*. Laguna Hills, CA: Aegean Park Press, 1977.

"From the Chief's Office." *The Field Artillery Journal* 31, no. 8 (August 1941): 627-629. Accessed March 31, 2021. https://sill-www.army.mil/fires-bulletin-archive/archives/1941/AUG_1941/AUG_1941_FULL_EDITION.pdf.

Gaddis, John Lewis. *The Landscape of History: How Historians Map the Past*. New York: Oxford University Press, 2002.

General Headquarters (GHQ), American Expeditionary Forces (AEF). *Heavy Artillery Signal Manual, United States Army (Provisional), Part III, Radio.* Angers, France: US Army Heavy Artillery School, 1918. Accessed March 31, 2021. https://cgsc.contentdm.oclc.org/digital/collection/p4013coll9/id/683/rec/1.

"German Signal Communications." *The Field Artillery Journal* 31, no. 8 (August 1941): 579-583. Accessed March 31, 2021. https://sill-www.army.mil/fires-bulletin-archive/archives/1941/AUG_1941/AUG_1941_FULL_EDITION.pdf.

Gordon, Andrew. *The Rules of the Game: Jutland and British Naval Command.* Annapolis, MD: Naval Institute Press, 1996.

Hagood, Johnson. *The Services of Supply: A Memoir of the Great War*. Cambridge, MA: Houghton Mifflin Company, 1927. Accessed March 31, 2021, Internet Archive. https://archive.org/details/servicesofsupply00john/mode/2up.

Hall, Brian N. *Communications and British Operations on the Western Front, 1914-1918.* New York: Cambridge University Press, 2017.

Headquarters 1st Division, American Expeditionary Forces. "Extract from Report of Chief Signal Officer, December 22, 1917." *World War Records, 1st Division, American Expeditionary Forces, Regular: Operations Reports and Field Messages*. Accessed March 31, 2021. https://cgsc.contentdm.oclc.org/digital/collection/p4013coll7/id/1022/rec/27.

Hedberg, Scott B. "The Army Amateur Radio System: 1925-1941." Masters Monograph, School of Advanced Military Studies, US Army Command and General Staff College, Ft. Leavenworth, KS, 2010.

The Infantry Journal. *Infantry in Battle*. Washington, DC: Infantry Journal, Inc., 1939. Accessed March 31, 2021. https://cgsc.contentdm.oclc.org/digital/collection/p16040coll3/id/146.

Kahneman, Daniel. *Thinking, Fast and Slow*. New York: Farrar, Straus and Giroux, 2011.

Keegan, John. *The First World War*. New York: Vintage Books, 1998.

Marconi, G. "The Inventor of Wireless Telegraphy: A Reply." *The Saturday Review of Politics, Literature, Science and Art*, May 3, 1902. Accessed September 25, 2020. https://books.google.com/books?id=gHVHAAAAYAAJ&pg=PA556#v=onepage&q=555&f=false.

"Notes from the Cavalry Board." *The Cavalry Journal* 48, no. 5 (September-October 1939): 428-429. Accessed March 31, 2021. https://mcoepublic.blob.core.usgovcloudapi.net/library/CavalryArmorJournal/1930s/1939Jul-Dec.pdf.

Palmer, G. M. "The Effects of Modern Communications (Radio, Airplane, etc.) on a Cavalry Raid." Individual Research Paper, The Command and General Staff School, Ft Leavenworth, KS, 1936.

Patrick, Edwin D. “The Training and Replacement of Infantry Signal Communication Personnel (Officers and Enlisted Men) in the Theater of Operations.” Individual Research Paper, The Command and General Staff School, Ft Leavenworth, KS, 1934.

Pershing, John J. *Report of General John J. Pershing, Commander-in-Chief, American Expeditionary Forces.* Paris: GHQ, AEF, 1918.

Raines, Rebecca R. *Getting the Message Through: A Branch History of the US Army Signal Corps.* Washington, DC: Center of Military History, 1996.

———. *Signal Corps.* Washington, DC: Center of Military History, 2005.

Sadtler, C. K. “Radio in the American Army.” Individual Research Paper, The Command and General Staff School, Ft Leavenworth, KS, 1930.

Schwartz, A. Brad. “The Infamous ‘War of the Worlds’ Radio Broadcast Was a Magnificent Fluke.” *Smithsonian Magazine*, May 6, 2015. Accessed March 31, 2021. https://www.smithsonianmag.com/history/infamous-war-worlds-radio-broadcast-was-magnificent-fluke-180955180/.

Terrett, Dulany. *The Signal Corps: The Emergency (to December 1941).* Washington, DC: Office of the Chief of Military History, 1956.

The Great War. “Beyond Wires and Pigeons—Communications in World War 1| THE GREAT WAR Special.” Directed by David Voss. Written by Indiana Neidell. Featuring Indiana Neidell. November 16, 2015. Accessed August 21, 2020. https://www.youtube.com/watch?v=aG7UzEgH4Co&list=PLbMbcr2UR9Ga6S8trHFZRNW0syhqtw-tX&index=3&t=0s.

US Department of the Army. Center of Military History Publication 23-6, *United States Army in the World War 1917-1919.* Vol. 1. *Organization of the American Expeditionary Forces.* Washington, DC: US Army Center of Military History, 1988.

———. CMH Publication 23-18, *United States Army in the World War 1917-1919.* Vol. 12. *Reports of the Commander-in-Chief, Staff Sections and Services.* Washington, DC: US Army Center of Military History, 1991.

———. CMH Publication 23-22, *United States Army in the World War 1917-1919.* Vol. 16. General Orders, GHQ, AEF. Washington, DC: US Army Center of Military History, 1992.

US War Department. Field Manual 6-20, *Field Artillery Field Manual, Tactics and Technique*. Washington, DC: Government Printing Office, 1940. Accessed March 31, 2021. https://cgsc.contentdm.oclc.org/digital/collection/p4013coll9/id/738/rec/1.

———. Field Manual 7-5, *Infantry Field Manual, Organization and Tactics of Infantry, the Rifle Battalion*. Washington, DC: Government Printing Office, 1940. Accessed March 31, 2021. https://cgsc.contentdm.oclc.org/digital/collection/p4013coll9/id/741/rec/4.

———. Field Manual 24-5, *Basic Field Manual, Signal Communication*. Washington, DC: Government Printing Office, 1939.

———. Field Manual 24-5, *Basic Field Manual, Signal Communication*. Washington, DC: Government Printing Office, 1942.

———. Field Manual 100-5, *Field Service Regulations, Operations*. Washington, DC: Government Printing Office, 1941. Accessed March 31, 2021. https://cgsc.contentdm.oclc.org/digital/collection/p4013coll9/id/978/rec/10.

———. Radio Pamphlet, no. 40, *The Principles Underlying Radio Communication.* Washington, DC: Government Printing Office, 1919. Accessed March 31, 2021. https://archive.org/details/underlprinciples00unitrich/mode/2up.

———. *Radiotelegraphy*. Washington, DC: Government Printing Office, 1916. Accessed March 31, 2021. https://archive.org/details/telegraphyradiou00unitrich/page/104/mode/2up.

———. *Report of the Chief Signal Officer to the Secretary of War, 1919*. Washington, DC: Government Printing Office, 1919. Accessed March 31, 2021. https://play.google.com/store/books/details?id=jBFAAAAAYAAJ.

———. *The Signal Corps Bulletin no. 97*. Washington, DC: Office of the Chief Signal Officer, July-September, 1937. Accessed March 31, 2021. https://www.nsa.gov/Portals/70/documents/news-features/declassified-documents/friedman-documents/publications/FOLDER_206/41762469080162.pdf.

———. Technical Manual 11-454, *Technical Manual, the Radio Operator*. Washington, DC: Government Printing Office, 1942. Accessed March 31, 2021. https://radionerds.com/images/5/5c/TM_11-454_THE_RADIO_OPERATOR.pdf.

———. War Department Document, no. 666, *The Means of Communication Between Aeroplanes and the Ground.* Washington, DC: Army War College, 1917.

Woodward, Bob. *Bush at War*. New York: Simon and Schuster Paperbacks, 2002.

Zabecki, David T. *The Generals' War: Operational Level Command on the Western Front in 1918.* Bloomington, IN: Indiana University Press, 2018.