"The Ships," American Expeditionary Forces, Second Air Instructional Center, Tours Aerodrome, France, late 1918 (Lester F. Kirchner Collection, U.S. Army Air Service)

Defending the AEF

Combat Adaptation and Jointness in the Skies over France

By Bryon Greenwald

As Americans commemorate the centennial of World War I, we should note that one of the most unusual battles of the war occurred in the skies over Western Europe. Not surprisingly, given the newness of the airplane, every combatant had difficulty exploiting the opportunities offered by airpower. The warring powers, however, found it even harder to devise schemes to defend against air attack, particularly later in the war as airplanes became more technologically viable and numerous. By 1917, 3 years into the war, the French, British, and Germans had begun to figure it out. Unfortunately, in 1917 the American Expeditionary Forces (AEF) was a brand new organization, and, like every other aspect of its transition to large-scale warfare on a foreign shore, it faced a steep learning curve uninformed by early trial and error. Still, by the Armistice on November 11, 1918, the AEF Antiaircraft Service had acquitted itself in this new dimension of combat. It had learned quickly from its British and French counterparts, demonstrated a significant amount of combat adaptation, shot down 58 German aircraft in a short time at the front, and began a century's worth of joint integration between air and antiair forces that continues today.

This article details how an untrained cadre of men modified existing French

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equipment and doctrine to build a small but effective antiaircraft force and initiate joint air-antiair integration 100 years ago. It also highlights how the U.S. military responded to a threat that did not exist a mere decade earlier, one that it failed to anticipate despite obvious indicators. In many respects, this type of challenge is timeless. It is certainly familiar to contemporary observers who have watched the American military and others struggle with counterinsurgency over the last 15 years and points to a number of larger, more important questions. How does a military organization learn and modify its practices in the face of a new challenge, particularly one it should have recognized earlier? What changes in organization, doctrine, training, or equipment are necessary to address the challenge? Where does change emerge—is it top-down leadership, bottom-up reform, or middle-out problem-solving, or a combination of all three?[1] These are a few of the larger questions considered in this brief discussion of the origin, structure, and achievements of the American Antiaircraft Service during World War I.

Failure to Anticipate the Problem

Of all the advances in modern warfare present at the turn of the 19th century, nothing awed the public more than the airplane. Described both as a "mechanical messiah whose coming would transform life and society" and as a "bird of hell" whose fiery power would turn New York City into "a furnace of crimson flames," the technological potential of the airplane seemed boundless and ominous.[2] Although the airplane was invented in the United States in 1903, a country protected by vast oceans and aloof to Europe's turmoil, the Nation spent only $430,000 on its air force between 1908 and 1914. During that same period, both France and Germany spent close to $22 million each, Russia about $12 million, and tiny Belgium almost $2 million on military aviation.[3]

When war broke out in Europe on July 28, 1914, the Aeronautical Division of the U.S. Army Signal Corps owned six airplanes,[4] 532 3-inch field artillery guns, and absolutely no antiaircraft weaponry.[5] By April 6, 1917, when America entered World War I, not much had changed. Brigadier General Benjamin Foulois, Chief of the AEF Air Service (1917–1918), pointedly complained that only 6 of the 65 officers and none of the 1,100 enlisted men assigned to him had any experience in the organization of large numbers of men and materiel or the tactical use of aircraft.[6]

If the U.S. Army had no doctrine, trained manpower, or equipment with which to build an Air Service, it certainly had not considered how to defend ground troops from air attack. While individual officers published articles that highlighted the airplane's military potential and suggested ways to shoot it down, the institutional force was slow to react. In 1909, when Major General William P. Duvall, Commander of the Philippines Division, perhaps influenced by one of these articles, wrote to the War Department with concerns of an airship attack on Manila, the Chief of Ordnance responded that he saw no future in "balloon artillery" and suggested that 500 shotguns would relieve Duvall's worries.[7] By 1913, the idea of antiaircraft artillery advanced slightly when Congressman James Hay (D-VA) of the House Committee on Military Affairs raised it during a discussion of the Panama Canal defenses. The Army's witness, Brigadier General George Scriven, Chief of the Signal Corps, dismissed the need for a gun to shoot at airplanes, preferring instead to champion the use of airplanes, for which he was responsible at the time, to defeat any attack. When Hay asked about a gun capable of shooting at airplanes, Scriven responded that the "Ordnance Department had been experimenting, but I do not know that they have yet devised a gun."[8] Indeed, both the Ordnance Department, which would build the guns, and the Coast Artillery Corps (CAC), which would man them, were unimpressed with the airplane as a weapon of war and focused their efforts instead on shooting down much slower and less maneuverable balloons and powered dirigibles. In early 1917, a board of officers, led by artilleryman Colonel Charles Treat, convened to study the problem and, on April 2, 1917, the same day that President Woodrow Wilson asked Congress for a declaration of war, recommended creating 168 total antiaircraft batteries, enough to protect 15 infantry corps, 4 cavalry divisions, and rear area supply depots.[9] This study, however, was highly conceptual. It did not write doctrine, provide equipment, or train gunners. Those tasks required time, a coherent production capacity, and tactical know-how, none of which the Army had in abundance.

The Army Looks for Solutions

Shortly after the United States declared war on Germany, the Allies initiated a series of liaison missions designed to exchange information and speed the Nation's mobilization and active participation in the fighting. Unfortunately, information provided by the French and British missions contradicted each other and succeeded in confusing an already disorganized mobilization effort. Indeed, the animus between the two missions was such that on more than one occasion the Chief of Staff's office would telephone the War College faculty located at present day Fort Lesley J. McNair, where the preponderance of war planning occurred, and urge them to hasten the departure of one mission as members of the other mission were on their way over to discuss the war.[10]

To obtain a clear view of conditions, Secretary of War Newton Baker, in an example of top-down problem-solving, dispatched groups of officers to Europe to observe operations for themselves. One group, led by the recently commissioned corporate lawyer and civil aeronautics expert Major Raynal Bolling, reported that "fighting airplanes and bombers" held significant military potential but that great numbers of antiaircraft artillery could reduce the effectiveness of bombing operations.[11] Another group, led by Quartermaster Colonel Chauncey Baker, concluded that airpower played an important role on the battlefield and, in response to the threat the airplane posed to ground forces, recommended that the Army establish antiaircraft schools and training facilities in the United States and France.[12]

Starting from Scratch

Acting on the Baker Board's recommendation, General John J. Pershing directed his staff to incorporate antiaircraft defense into the AEF's organizational scheme. Drafted by Major Hugh Drum of the Operations Section, the plan assigned one antiaircraft gun battalion with four batteries of three 3-inch guns each as well as one machine gun battalion of 48 guns to each corps, the equivalent of one 3-gun battery and 12 antiaircraft machine guns to each combat division.[13] This parsimonious distribution of forces reflected both the density of combat formations and the appreciation that the AEF was building this portion of its force from scratch. By comparison, during World War II each division had *at least* one antiaircraft *battalion* to defend it from air attack. To protect installations in the rear area, Drum added an additional 20 antiaircraft gun platoons. The total force of 100 guns was much smaller and, as it would turn out, more realistic than the 336 recommended by the Treat Board. But as the Army would soon find out, it was still far beyond the Ordnance Department's capacity to deliver.[14]

To implement these plans for an antiaircraft service, Pershing summoned three Coast Artillery Corps officers—Brigadier General James A. Shipton, Captain Glenn P. Anderson, and Captain George F. Humbert—to Europe in late July 1917. The assignment of Shipton, Anderson, and Humbert is an example of the Army's effort to apply the most appropriate expertise and experience to create an antiaircraft artillery organization where none had existed previously. Shipton was a seasoned artilleryman and combat commander in the Philippines with a decade of experience in the CAC. Anderson and Humbert were experts in artillery gunnery and the mathematics underpinning that discipline. Their background predisposed them to a more scientific approach to antiaircraft artillery as opposed to the point-and-shoot style of some Allies.

When the Army decided in spring 1917 to assign the antiaircraft mission to the CAC, Shipton, Humbert, and Anderson, as well as a number of underutilized seacoast artillerymen, became available to man Pershing's fledgling Antiaircraft Service. With the British naval blockade confining the German High Seas Fleet to European waters, the CAC released men from its traditional seacoast and harbor defense mission and trained them in railway and tractor artillery and trench mortars and the emerging task of antiaircraft defense. Further reinforcing the Army's decision to assign the antiaircraft mission to the CAC was the acknowledged ability of seacoast artillerymen to fire at ships moving in two dimensions. By logical extension, this ability made them the most appropriate candidates to attempt to fire at airplanes moving in three dimensions.[15]

While en route to Pershing's headquarters, Shipton, Anderson, and Humbert stopped in England to investigate British antiaircraft methods, visited the French Antiaircraft School at Arnouville-lès-Gonesse, north of Paris, and went to the frontlines to observe French methods. With the American and French forces occupying adjacent combat zones, Shipton decided to leverage the opportunity to train his men in French antiaircraft techniques and accepted the offer of a château at Arnouville as the location for the AEF antiaircraft school. On September 26, 1917, two semi-English-speaking French officers began an awkward effort to teach antiaircraft theory to a platoon of American officers. Shortly thereafter, on October 10, 1917, the AEF General Headquarters established the Antiaircraft and Trench Mortar Schools at Langres, France, and placed Shipton in charge of both. On November 1, the Antiaircraft Headquarters and School moved from Arnouville to Langres. These actions laid the foundation for the future development of the AEF antiaircraft artillery organization.[16]

Shipton quickly realized he had to establish an antiaircraft school and training center for the troops scheduled to arrive in December 1917. He had no men or equipment, and only 25 officers trained—a generous classification—in the antiaircraft theory and technique. To organize the command, Shipton, Humbert, and Anderson drafted plans for an Antiaircraft Service consisting of seven sections, three of which—the Artillery, Machine Gun, and Searchlight and Balloon sections—formed the nucleus of the Antiaircraft School and mirrored the composite nature of the Antiaircraft Service.

Shipton's initial desire was that all training would occur at the Antiaircraft School, but equipment shortage and limits on training areas forced him to separate the artillery and machine gunnery courses, in particular, sending some units back to Arnouville and the Paris defenses to share French artillery pieces. Colonel Jay P. Hopkins, who replaced Shipton as Chief of the Antiaircraft Service in October 1918, noted that this move gave the American antiaircraft artillery gunners training at the school the opportunity to practice with actual guns instead of relying on purely theoretical instruction. Moreover, it provided the French, who experienced constant manpower shortages, with personnel to man the guns defending their capital. As more trained units became available, Shipton and Hopkins continued the policy and sent more units into the frontlines to augment critically short French units. Hopkins later wrote that the men "invariably displayed such aptitude that they were given equal opportunity with the French for firing." He also noted that sometimes French units were so shorthanded that they surrendered total control to the Americans.[17]

Antiaircraft Gunnery

Shipton's secondary motive for collocating with the French was that American officers could keep abreast of the latest developments in antiaircraft techniques and therefore be better qualified to instruct their men. His attitude toward "technical shooting" further reinforced this preference, as he believed that the French had taken the lead in antiaircraft gunnery, while the British seemed content to rely on the unscientific and inconsistent technique of visually adjusting the round on target.[18]

This reliance on French "technical shooting" demanded a high degree of scientific skill and mathematical ability. First, it required an accurate, rapid measurement of the airplane's speed, altitude, and course in order to calculate the lateral and vertical deflection to the target. When computed correctly, this information yielded a predicted target flight path. Second, crews had to factor in the known trajectory and velocity of the artillery round as well as the fuse setting. If everything worked properly the round exploded near the target. Typically, the round crossed behind the aircraft because crews could not make the proper adjustments fast enough to lead the target. The greatest flaw in the French process, however, was the assumption that the pilot would maintain a steady course in order to preserve his altitude as a means of escape in the event of malfunction or attack. In reality, when under fire most pilots adopted what the British called the "wobble her about a bit" method, making dramatic changes in altitude and direction or "zig-zagging."[19]

Before an American antiaircraft crew could fire a shell from the 75mm gun,[20] they had to prepare the gun-pit and ready the gun—a process that could take all day. Laboring more like gravediggers than antiaircraft men, they slung picks and shovels for hours to excavate a hole that measured 12 feet across and 3 feet deep, with a 7-foot conical depression sunk in the center to a depth of 4 feet, all while avoiding observation by the Germans a few miles away. Next, they placed the foundation for the semi-fixed French 75mm by laying a circular running board around the outer rim of the inner conical depression and leveling it. Then they dropped a "receiving standard" in the bottom of the cone and bolted the slanting struts from the running board to the receiving standard. With the assistance of ropes and pulleys, the crew wheeled the gun in front of the hole, lowered its rear into the receiving standard, and bolted it down. They then rearranged the camouflage and excavated spots for cases of ammunition and tool boxes. While not a fast process, it mirrored the way the French fought the war, with spades and artillery in a slow and methodical fashion.[21]


U.S. Army Air Service Second Lieutenant Erwin R. Bleckley, 50th Aero Squadron, in observer's seat of DH-4, circa 1918 (U.S. Air Force)

What made the French 75mm such an excellent weapon was its hydropneumatic recoil mechanism, a first of its kind, which returned the gun to its original position after firing. In this way, the crew could fire the gun rapidly without re-aiming it after each shot. The recoil process took about 2 seconds, meaning that a well-trained crew could fire the gun up to 30 times a minute. Despite these advances, it still took about 25 men—vertical and lateral spotters, telemetry men, fuse setters, telephone operators, loaders, and gun crew—moving in orchestrated chaos to operate the gun and its associated equipment.

Occasionally, training and luck combined to catch a German pilot unaware.

U.S. Marines attaching bomb to DH-4 (de Havilland) "Liberty Plane," circa 1918 (Zimmer/Naval History and Heritage Command)

In one instance in late September 1918, the crewmen in Battery B, 2nd Battalion Antiaircraft Artillery, spotted a flight of six Fokkers flying along the front at "an altitude of 2,000 meters, some 7,400 meters away." The two-gun battery performed well enough to fire 10 rounds in quick succession into the formation. As crewman Ernest Stone of Los Angeles, California, noted, the airplane "dived northwards then after an abnormal curve, fell." It was one of two German aircraft downed by his battery; its sister unit, Battery A, accounted for another three.[22]

Machine Gunnery

The second course taught by the Antiaircraft School was machine gunnery. In a process similar to what occurred with the artillery course, the school chose an officer familiar with the equipment to lead the instruction, in this case, Major William Simpson of the Infantry. Unfortunately, Simpson died from appendicitis in January 1918. His replacement was another Infantryman, Marine Major Andrew Drum, an innovative officer who founded the Marine Corps' first Armored Car Squadron in 1916. Drum, a cousin of Major Hugh Drum, previously commanded an infantry company with the 5th Marine Regiment. From May to November, Drum achieved great success in training over 4,500 personnel, partly because, unlike the antiaircraft artillery gun course, the units attending machine gun instruction had plenty of machine guns and did not have to collocate with another unit in order to train. Equally important, however, was Drum's innovative ability to create a realistic training environment for his Soldiers.[23]

One of the first tasks thrust upon Drum and the staff of the Machine Gun Section was to select a machine gun. While an adequate number of the French-made Hotchkiss M1914 and St. Etienne M1907 machine guns existed, the section discovered that the St. Etienne was more delicate, would foul in muddy conditions, and could not fire at all angles of elevation. As a result, the section adopted the Hotchkiss machine gun. It also experimented with various antiaircraft machine gun sights and found a French sight known appropriately as the "Infantry Corrector," which offset the normal ground sight and provided for super-elevation, the most effective.[24]

Concerned about the quality of the troop training, Drum moved his School Detachment about 8 kilometers away from Langres to take advantage of an area known as the Courcelles-en-Montagne Antiaircraft Firing Ground. Through ingenuity and zeal, Drum turned the 25-square-mile ravine into an excellent range. He conducted ground firing against the ravine walls. To simulate fast, realistic aerial targets, Drum ordered a motorcycle driver to tow an airplane-shaped target along the ridge above the ravine. With the driver protected by a stone wall, the Soldiers below saw only the target and could practice live-fire traverse and elevation without endangering the rider. This type of middle-out adaptive training paid large dividends once units reached the frontlines as the two Antiaircraft Artillery Machine Gun Battalions fielded during the war downed a total of 41 German planes. Equally important, they drove away hundreds more, including 117 during the Battle of Saint-Mihiel.[25]

Searchlights and Barrage Balloons

The final element in the Antiaircraft Service triad of weapons was the searchlight. Early on, the Army discovered that the strength of the beam did not outrange enemy artillery but possessed enough candlepower to illuminate incoming aircraft. As a result, the Antiaircraft Service incorporated searchlight training into its curriculum in June 1918. As it had with the other two legs of the triad, the Antiaircraft School asked the Army organization responsible for searchlights—the 56th Engineer Regiment (Searchlights)—to teach the course. Not only did it make sense for experts to teach the course, but it also made for good combat coordination as the 56th Regiment supported the other elements of the Antiaircraft Service once they reached the field.[26]

The use of searchlights remained the one area uninfluenced by the French, who did not use searchlights at night, but instead relied on sound detectors to find aircraft and provide gunners with a firing azimuth. Unimpressed with the French method, the Americans followed the British example and employed both sound locators and searchlights to find the target. A precursor to the highly effective radar of World War II, sound locators were a large and complex collection of megaphone-shaped tubes that—like an enlarged gramophone operating in reverse—picked up and amplified aircraft noise so that an operator could determine its general direction and provide the searchlights with a rough initial azimuth. Once the searchlights illuminated the target, the gunners set their aiming mechanisms and fired. Given the difficulty of supply over muddy roads, this procedure saved ammunition by enabling the gunners to calculate trajectory more accurately than the French, who literally fired blind. More importantly, searchlights had "a great moral effect on the enemy aviator."[27] Blinded by the light and waiting an upcoming barrage, most pilots lost either their resolve or their way to the target.

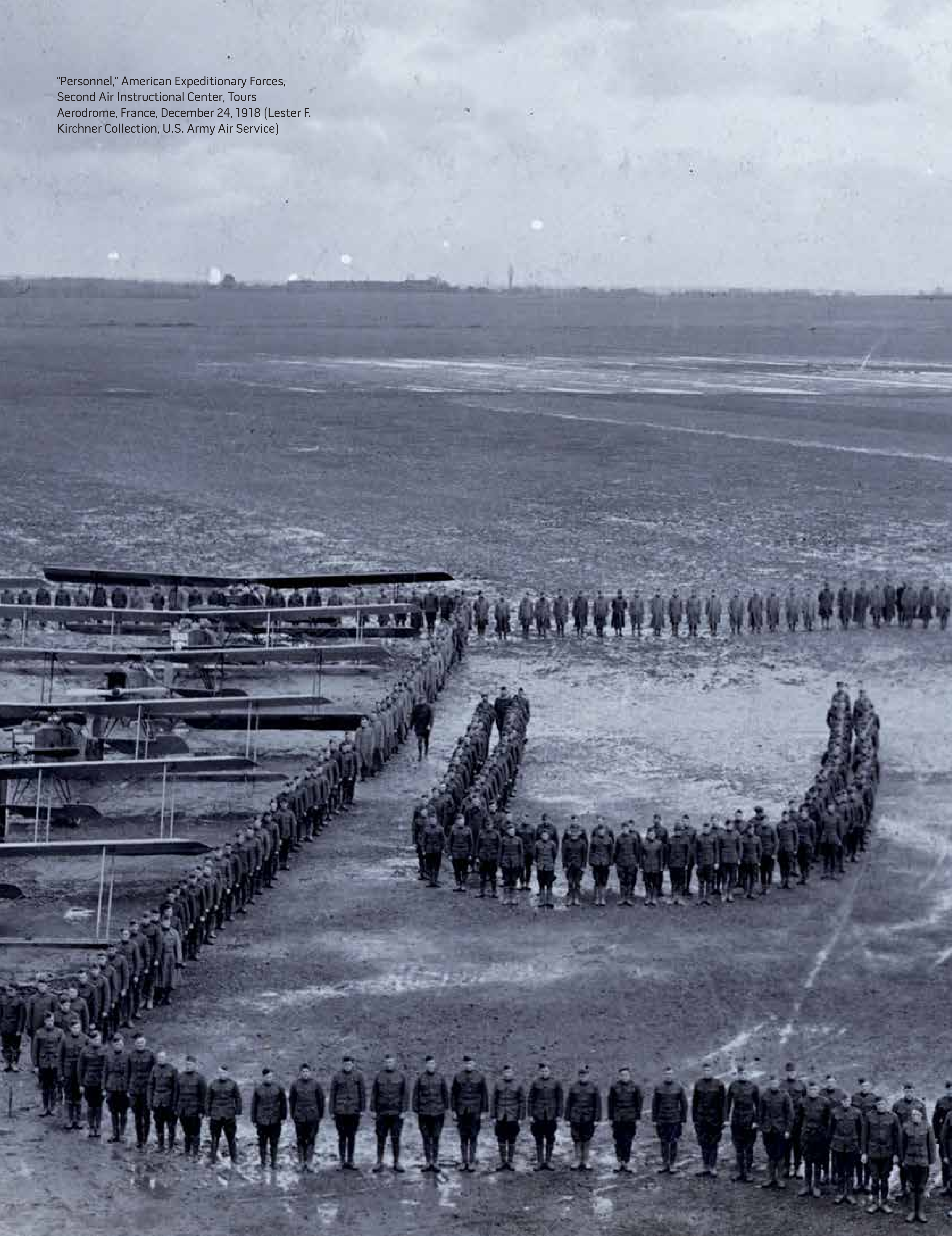
Interestingly, although the French, British, Germans, and Italians used protective or barrage balloons, the Antiaircraft Service did not. The balloons, tethered to the ground by long wires and often lashed together with horizontal connectors dangling more wires, were ideal for blocking specific aerial approaches. Fearful of crashing into a wire, pilots spotting the balloons would fly around them only to find themselves illuminated by searchlights and targeted by antiaircraft fire. Shipton wanted to use them, but a shortage of both manpower and balloons as well as bureaucratic infighting with the Air Service killed the idea. Initially, the Air Service, which used balloons to observe artillery fire and enemy movements, wanted them to protect airfields until it learned that Air Service personnel would handle the balloons, but antiaircraft officers would command them. With this revelation, the threat to airfields declined and the Air Service ended its request for barrage balloons. Of the four proposed barrage balloon battalions, none was created.[28] In fairness, the Air Service experienced a marked shortage of observation balloons and could not spare any for antiaircraft barrage balloon protection, even of its own airfields. The issue of barrage balloons lay fallow until the early 1920s when both the Army Air Service and CAC fought for bureaucratic control over air defense assets.[29]

This issue aside, the Air and Antiaircraft Services worked well together in combat. The Air Service Assistant Chief of Staff, Colonel Edgar Gorrell, commended the Antiaircraft Service for its units' excellent liaison with Air Service elements, commenting that the batteries "acted as sentinels for pursuit aviation." To do so, antiaircraft units maintained direct telephone contact with air control centers and flashed the type and number of German aircraft, their heading, and altitude to Air Service group operations offices. This arrangement was critical to airdrome defense as these sites routinely had no other defense except some machine guns operated by mechanics. An example of this rapid alert occurred on April 14, 1918, when an antiaircraft battery reported sighting two single-seater German aircraft headed south in the Toul Sector (in the vicinity of Saint-Mihiel). In less than 4 minutes, two pilots from the 94th Aero Squadron, on its first day of operations in France, took off and intercepted the Germans 4 minutes later.[30] Interestingly, this well-developed liaison function seemed confined to the American forces as some observers noted that the French batteries did not keep up with Allied attacks and British antiaircraft batteries did not cooperate with the Royal Air Force.[31]

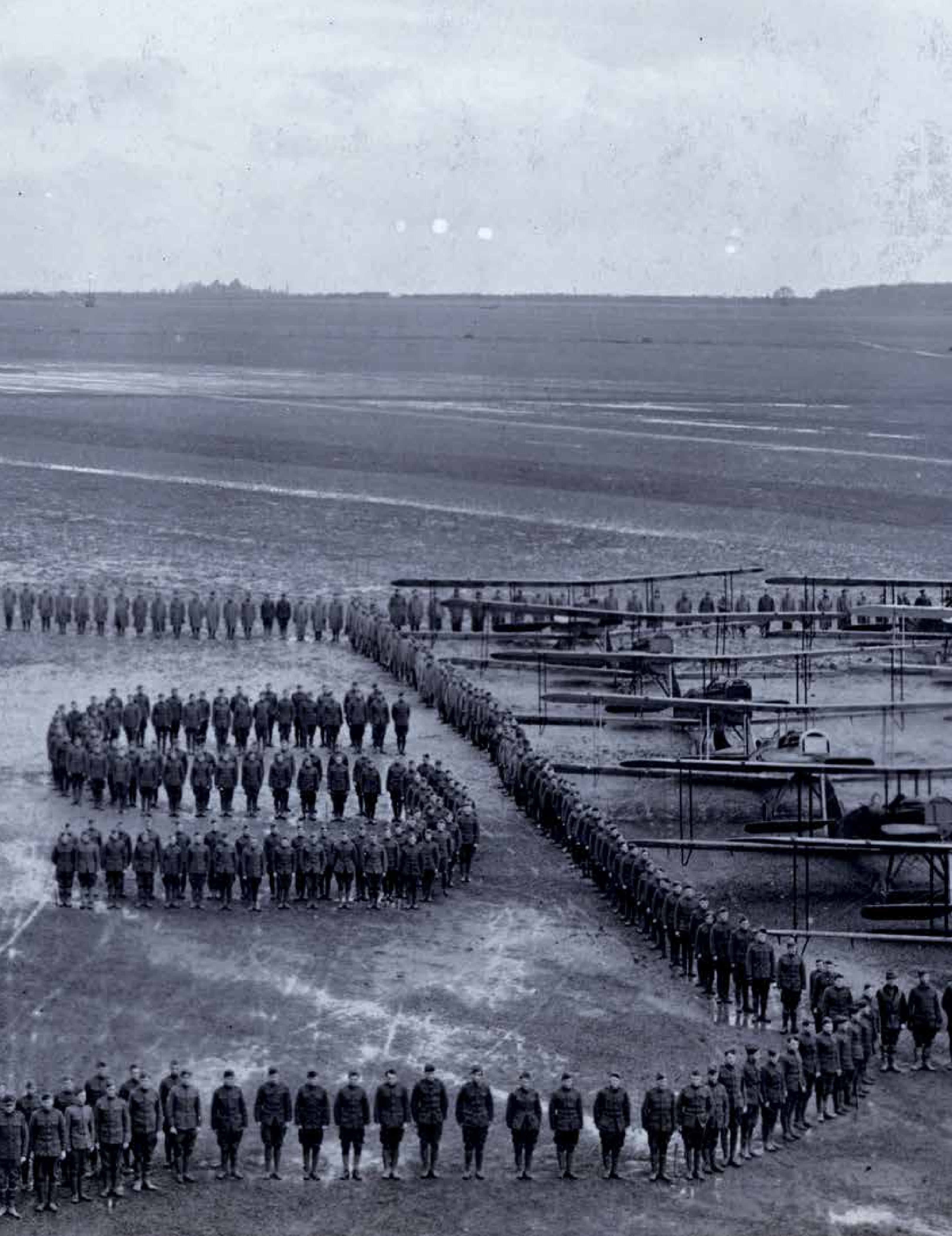
Another example of joint action between the Air and Antiaircraft Services occurred in defense of Air Service balloonists. Air Service pilots aloft in either French or American balloons made tempting targets for German aircraft, which attacked them 89 times and burned 35 balloons out of the sky.[32] One reason these attacks were relatively unsuccessful was that American antiaircraft gunners worked closely with balloonists to defeat the German air threat. For example, after German fighters had shot down 19 observation balloons in 1 day during the Meuse-Argonne Offensive, the First U.S. Army Corps Commander, Lieutenant General Hunter Liggett, ordered that it was "absolutely essential that antiaircraft artillery protection be furnished at once."[33] Responding to this directive, Battery A, 2nd Antiaircraft Battalion, using two borrowed French 75mm autocannons, deployed around two balloons about 1.5 kilometers behind the front. The battery stayed there for 13 days withstanding gas and artillery attacks before firing on a flight of German Fokkers, downing 2 in 10 minutes and another later that day.[34]

Fratricide

Close coordination with the Air Service notwithstanding, antiaircraft personnel and other Soldiers across the AEF



"Personnel," American Expeditionary Forces, Second Air Instructional Center, Tours Aerodrome, France, December 24, 1918 (Lester F. Kirchner Collection, U.S. Army Air Service)



Curtiss JN-4H, nicknamed "Jenny," at U.S. Marine Flying Field, Miami, Florida, circa 1918 (Naval History and Heritage Command)

occasionally shot at friendly aircraft. The Antiaircraft School trained all officers to identify friendly and enemy aircraft and published aircraft recognition charts, but the training of the enlisted men may have been lacking. That said, the two antiaircraft machine gun battalions sent to the front controlled just 96 of the 1,500 antiaircraft machine guns available throughout the American Expeditionary Forces, suggesting that while not blameless, the problem did not come primarily from antiaircraft units. Indeed, the rest of the force often operated on the belief that there was no such thing as a "friendly" aircraft and practiced poor fire discipline. Fearful of strafing by German aircraft, other units (for example, infantry, artillery, and air) not only manned their antiaircraft machine guns continuously, but they also often mounted whatever machine guns they could find on sunken poles or upended wagon or vehicle axles in a bottom-up adaptive effort to fire at attacking aircraft.[35] Greater liaison between antiaircraft batteries and other units might have reduced these incidents of mistaken identity.

Often blamed for these "blue-on-blue" engagements, antiaircraft units investigated them both to correct mistakes and to protect their reputation. In one instance, a sergeant sent to inform a nearby artillery battery that it had fired on several friendly planes was told that the commander had ordered the unit to shoot at all planes in its vicinity.[36] Another time, an American pilot completed his flight without spotting a German plane but found a bullet hole near his seat. Investigation revealed that the 21st Machine Gun Battalion, not one of the two antiaircraft machine gun battalions, had shot at the plane at long distance without identifying it. The problem became severe enough that the First Army Chief of Artillery ordered all men trained in aircraft recognition.[37]

Antiaircraft units, however, were not blameless. After the war, one antiaircraft battery commander admitted that his men fired at planes flying over his position even if they could not positively identify them as German. Another haughtily dismissed criticism that his unit fired on friendly aircraft over Is-sur-Tille, home to a huge American supply base, by claiming that no one could prove the aircraft were friendly.[38] After this incident, the sector commander suggested the creation of a restricted zone over the area that friendly planes would not enter at night and fly no higher than 2,000 meters during the day. Despite the value of the idea, the Air Service was extremely critical of the suggestion, perhaps concerned over the ability of its pilots to navigate precisely at night, and the AEF G3 (Operations) eventually disapproved the idea.[39] Sadly, the problem of fratricide would continue for the rest of the war and reemerge in World War II. In that war, the U.S. Army would eventually create restricted zones and, by mid-1944, mark friendly aircraft with invasion stripes—five alternating black and white bands—to aid recognition.

Conclusion

Despite the early problems of organization and training and the nagging worries over supply, the leaders of the Antiaircraft Service adjusted to newfound conditions and performed admirably. In less than 3 months at the front, both the machine gun units and the amalgamated artillery forces proved the value of solid technical training and good organization. The antiaircraft gunners using French 75mm guns shot down 17 aircraft with just 10,275 rounds of ammunition, an average of 605 rounds per airplane. By comparison, British antiaircraft gunners expended 10,000 rounds, improving to 4,000 per aircraft in 1918, and the French used 4,500 rounds for every airplane they downed. The machine gunners achieved even more impressive results. With just 225,115 rounds, the two battalions downed 41 German aircraft, about 5,500 rounds per plane. While the stated mission of the Antiaircraft Service involved preventing enemy aircraft from obtaining air superiority and endangering friendly ground troops, "comparative results in actual planes brought down give a very fair measure of the accuracy of the shooting."[40]

Regarding combat adaptation, the AEF antiaircraft experience offers a few general conclusions. First, innovation and adaptation succeed more often when there is an urgent need to solve a specific problem—how to shoot down airplanes—that focuses effort and removes most intra-Service parochialism and confusion about the objective. Second, the willingness to learn from others and adopt the best approaches avoids the "not invented here" syndrome, saves time, and increases eventual effectiveness. Third, despite inevitable shortages, the creative use of available resources improves the odds of success. Finally, as the story of the World War I Antiaircraft Service demonstrates, adaptation and learning occur at many levels—top-down, middle-out, and bottom-up—often simultaneously. Accordingly, leaders should avoid emphasizing single sources of change, particularly top-down driven change, and encourage innovation and adaptation at all levels.

These conclusions about the causes of adaptation and change are just as applicable today. Understanding the specific problem at hand is key, be it regime change, killing insurgents, or creating stable governance and popular support. Heeding the lessons of history and borrowing successful ideas from others, as commanders did from military theorists T.E. Lawrence and David Galula, are dramatically helpful. Perhaps appreciating that value and insight can come from every direction is most important. Top-down change brought counterinsurgency doctrine and Mine-Resistant Ambush Protected vehicles to Iraq and Afghanistan, but middle-out recognition of the emerging situation and bottom-up execution created the Sunni Awakening. Similarly, bottom-up blogs like "Company Commander" and others helped take the "single-loop" learning that occurred by trial and error in isolated units and spread it across the force, some of which found its way into the Army–Marine Corps counterinsurgency doctrine, a sign of "double-loop," or institutionalized learning. Better digital and onsite coordination between rotating units also helped ensure that not all progress was lost when units transferred into theater and replaced one another.

As for jointness, the Interwar Period (1919–1941) saw increased fighting at the bureaucratic level between the Army, Coast Artillery, Air Service (after 1926, the Air Corps), and antiaircraft artillery, especially as the economy sank into the Great Depression. Some of this internecine bickering about the value of airpower and how best to defend against it continued into the early stages of World War II, but quickly faded as the Nation rapidly expanded the military to fight a global conflict. To a certain degree, as money flowed to the bureaucracies and men died in tactical battles, arguments stopped and cooperation started. By the end of that war, airmen and antiaircraft artillerymen combined to shoot down over 21,000 Axis aircraft, clearing the skies and pointing the way for a joint and combined victory.[41]

Perhaps expectedly, this trend of peacetime inter-Service carping and wartime cooperation reemerged at the political and institutional levels after the Korean War and generally correlates with the level of interwar fiscal support available to the Services. It improved slightly after the Goldwater-Nichols Department of Defense Reorganization Act of 1986, but is ever present in the Pentagon, where jointness is often the last item added to a Service program when money exists and the first item cut when budgets are tight. This ebb and flow of institutional and programmatic support for joint systems, particularly command, control, communication, computers, intelligence, surveillance, and reconnaissance systems, creates gaps in the Nation's ability to fight as effectively as possible. Thankfully, when bullets are flying, Soldiers, Marines, Sailors, and Airmen focus on the task at hand and, as demonstrated a century ago in World War I and every conflict hence, cooperate and adapt at the operational and tactical levels, fighting jointly, side by side, as brothers in arms. **JFQ**

Notes

[1] There is a rich literature on military innovation and adaptation. For a quick overview, read the excellent literature review by Adam Grissom, "The Future of Military Innovation Studies," *Journal of Strategic Studies* 29, no. 5 (October 2006), 905–934. Although there are many new additions, Barry R. Posen's *The Sources of Military Doctrine: France, Britain, and Germany Between the World Wars* (Ithaca, NY: Cornell University Press, 1984) best represents the top-down school of military innovation, otherwise known as the civil-military model. This model posits that top-down innovation occurs when civilian leaders partner with mavericks from within a Service to gain insight on necessary changes. The inter-Service model suggests that innovation occurs as the Services compete against each other for more budget authority. The intra-Service model holds that the Services are not monolithic and that competition among branches (for example, infantry, armor) spurs innovation. An early pacesetter in this school was Stephen Peter Rosen's *Winning the Next War: Innovation and the Modern Military* (Ithaca, NY: Cornell University Press, 1991). Rosen is partially responsible for the "middle-out" school of innovation, as senior leaders provide political and professional security for mid-grade reformers to change their institution from the inside. Paul Kennedy, *Engineers of Victory: The Problem Solvers Who Turned the Tide in the Second World War* (New York: Random House, 2013), is a superb example of middle-out adaptation during wartime. The bottom-up school is less well defined in the existing literature, but no less apparent when one takes a wide view of military history. Still, it seems that bottom-up adaptation cannot succeed

without some combination of top-down and/or middle-out support. Moreover, organizational learning is necessary to help those across an organization realize that problems exist as do potential solutions to those problems. For a good start at understanding bottom-up innovation and organizational learning, see Francis G. Hoffman, *Mars Adapting: Learning During Wartime* (Annapolis: U.S. Naval Institute Press, forthcoming). For a more historical look at innovation, see Williamson Murray and Allan R. Millett, eds., *Military Innovation in the Interwar Period* (Cambridge: Cambridge University Press, 1998), which analyzes the seven major innovations between World War I and World War II.

2 All characterizations taken from Michael Sherry, *The Rise of American Air Power: The Creation of Armageddon* (New Haven: Yale University Press, 1987), 4–9.

3 Edgar S. Gorrell, *The Measure of America's World War Aeronautical Effort* (Norwich, VT: Norwich University, 1940), 3.

4 Juliette A. Hennessy, *The United States Army Air Arm: April 1861 to April 1917* (Washington, DC: Office of Air Force History, 1985), 120.

5 Airplane statistics from the U.S. Air Force Museum and Joe Baugher, "1908–1921 USASC-USAAS Serial Numbers," June 24, 2017, available at <www.joebaugher.com/usaf_serials/1908-1920.html>; artillery figures as of July 10, 1915, from Harvey A. DeWeerd, "Production Lag in the American Ordnance Program, 1917–1918" (Ph.D. diss., University of Michigan, 1936), 40–42.

6 "Memorandum, Brig. Gen. Benjamin D. Foulois, to Chief of the Air Service, AEF [American Expeditionary Forces], 29 January 1919," series A, volume 1, 82, in Edgar S. Gorrell, *History of the American Expeditionary Forces Air Service, 1917–1919*, U.S. National Archives and Records Administration (hereafter NARA), record group (RG) 120, microfilm publication M990, roll 4.

7 "William P. Duvall [Commanding General Philippines Division] to AG [Adjutant General], Sub: Defense of Manila and Manila Bay, 19 October 1909," Adjutant General's Office document number (AGO) 1592073, entry 25, box 1, RG 94, NARA; and "LTC John T. Thompson to AG, 9 December 1909," AGO 1592073, entry 25, box 1, RG 94, NARA.

8 See Mauer Mauer, ed., *The U.S. Air Service in World War I, vol. 2, Early Concepts of Military Aviation* (Washington, DC: Office of Air Force History, 1978), 3; the Ordnance Department was not working on a new gun, but merely designing an antiaircraft mount to fire the 3-inch artillery piece at a higher angle.

9 Colonel Charles Gould Treat, USA, a former artillery instructor and commandant of cadets at West Point, led a previous board (1915) that recommended significant changes in the Army's artillery force structure and warned of the time needed to prepare American industry for wartime production. See DeWeerd, 40–42; Ordnance Department, *Army Ordnance 1917–1919, Estimates and Requirements Division*, pamphlet no. 85 (Washington, DC: Government Printing Office [GPO], 1919), 38.

10 Frederick Palmer, *Newton D. Baker: America at War* (New York: Dodd, Mead & Company, 1931), 168.

11 "Letter, Major R.C. Bolling to Chief Signal Officer of the Army, 15 August 1917," series A, volume 1, 46 and 52, in Gorrell, *History.*

12 "Letter, Colonel Chauncey B. Baker, 'Report of the Baker Board,' 26 July 1917," Historical Division, Headquarters Department of the Army, in *United States Army in the World War, 1917–1919*, 17 vols. (Washington, DC: GPO, 1948) (hereafter, *USA/WW*), vol. 1, 55–89.

13 At this point, each Army corps contained four combat and two replacement divisions.

14 "Major H.A. Drum, Headquarters AEF, Office of the Chief of Staff, Operations Section, 'Report on Organization,' 10 July 1917," *USA/WW*, vol. 1, 93–101. The 75mm artillery piece used by U.S. antiaircraft batteries was made by the French. Poor industrial management decisions led the AEF to rely on the British and French for almost all equipment. This management fiasco, on the heels of the disastrous 1898 mobilization for the Spanish-American War, led to the creation of the Industrial College of the Armed Forces, now the Dwight D. Eisenhower School for National Security and Resource Strategy, at the National Defense University.

15 Robert Arthur, *The Coast Artillery School, 1824–1927* (Fort Monroe, VA: Coast Artillery School Press, 1928), 62; Charles E. Kirkpatrick, *Archie in the AEF: The Creation of the Antiaircraft Service of the United States Army, 1917–1918* (Fort Bliss, TX: U.S. Army Air Defense Artillery School, 1984), 1.

16 Colonel Jay P. Hopkins, "Final Report of the Chief of the Antiaircraft Service, 28 December 1918," *USA/WW*, vol. 15, 209; Kirkpatrick, 8–17.

17 Hopkins, "Final Report," 209–215.

18 Ibid., 210; Kirkpatrick, 22. For a concurring British opinion, see comments by the commander of the London Air Defense Area, Major General Edward Bailey Ashmore, in Ashmore, *Air Defence* (London: Longmans, Green and Co., 1929), 97–99.

19 Jay P. Hopkins, "Antiaircraft Artillery," lecture, U.S. Army Center of Artillery Studies, Treves, Germany, May 21, 1919, 666/M, box 139, entry 9, RG 177, NARA, 2–3; Major Elmer J. Wallace, "Anti-aircraft Weapons," *Journal of the United States Artillery* 47 (May–June 1917), 309.

20 The French autocannon was a 75mm artillery piece mounted on the back of a truck. Its official French designation was Matériel de 75mm Mle 1897. It was also known as the Canon de 75 modèle 1897.

21 Ernest Stone, *Battery B: Thru the Fires of France* (Los Angeles: Wayside Press, 1919), 152.

22 "Technical Report on an Aeroplane Brought Down, HQ, 2nd Army Antiaircraft Artillery Service, September 1918, AAS Records, Reel 8," cited in Kirkpatrick, 84; Stone, 152.

23 The 5th Marine Regiment operated under the Army's 1st and 2nd Infantry Divisions. Information about Andrew B. Drum is from *New York Times*, January 24, 1955, obituaries, 23. For number of men trained, see Hopkins, "Final Report," 211–212.

24 Super-elevation is the creation of additional elevation of the barrel of the weapon so as to offset the effects of gravity on the trajectory or flight of the round. The faster the muzzle velocity of the round, the flatter the trajectory. Weapons with faster muzzle velocities required less super-elevation.

25 Hopkins, "Final Report," 212; Kirkpatrick, 27 and 112.

26 Hopkins, "Final Report," 213–214; Kirkpatrick, 28–30.

27 Hopkins, "Final Report," 214; Hopkins, "Lecture," 4–8.

28 Kirkpatrick, 74.

29 U.S. Army Air Forces, *Barrage Balloon Development in the United States Army Air Corps, 1923–1942* (Washington, DC: Assistant Chief of the Air Staff, Intelligence Section, Historical Division, 1943), 3.

30 Maurer Maurer, ed., *The U.S. Air Service in World War I*, vol. 1, *The Final Report, and A Tactical History* (Washington, DC: Office of Air Force History, 1978), 175, 222, 284.

31 Ibid., 308, 336.

32 Ibid., 138. All pilots parachuted to the ground safely. One pilot died after his burning balloon and basket landed on him.

33 "Telegram, Hunter Liggett to GHQ AEF, 8 July 1918, AAS Records, Reel 11," cited in Kirkpatrick, 106.

34 Ibid., 112–113.

35 Enlisted training schedules did not show time for aircraft recognition. Hopkins, "Final Report," 216–217; Kirkpatrick, 114.

36 Kirkpatrick, 119.

37 Ibid., 120.

38 Antonin Guillot, *Le Camp Américain d'Allerey (1918–1919)*, Groupe d'Etudes Historiques de Verdun-sur-le-Doubs, 1999, available in English at <http://net.lib.byu.edu/~rdh7/wwi/comment/Allerey/Allerey02e.html>.

39 Kirkpatrick, 93–95.

40 Hopkins, "Final Report," 217; Hopkins, "Lecture," 4; Kirkpatrick, 57; Ashmore, 98.

41 See Bryon Greenwald, *Clear the Skies: American Antiaircraft Artillery and the Battle for Legitimacy, 1917–1945* (Norman: University of Oklahoma Press, forthcoming).