

Adam RADOMYSKI ⁽⁰⁾ Polish Air Force University, Faculty of Aviation Safety, Dęblin, Poland

Development of Air Defence in the United States between 1917 and 1945

Rozwój obrony powietrznej w Stanach Zjednoczonych w latach 1917–1945

• Abstract •

The article presents the results of academic research focusing on the origins and development of anti-aircraft artillery in the United States which was to guarantee the safety of American soldiers fighting in the First and Second World Wars. The findings of this study confirm that, in the early days, knowledge of the phenomena occurring in the air dimension of armed struggle was primarily empirical. As early as 1916, Alexander Graham Bell warned of the possibility of air raids on the United States. Over the next 25 years, experts conducted research into air defence, which became crucial in its subsequent development. The basis for the development of air defence was the emergence of a new weapon at the end of the First World War, i.e., anti-aircraft artillery. Basing on the experience of the United States from the First World War in the interwar period, air defence began to be seen in terms of a system whose main task was to detect and destroy enemy aviation, attacking troops, civilians and facilities at the rear of the front. Considering the outlined problem scenario and the subject of the research, it was assumed that the aim of the article will be to discuss the stages of the development of air defence in the United States in the years 1917-1945 and

• Abstrakt •

W artykule przedstawiono wyniki badań dotyczących genezy i rozwoju artylerii przeciwlotniczej w Stanach Zjednoczonych, która miała być gwarantem bezpieczeństwa żołnierzy amerykańskich walczących na frontach I i II wojny światowej. Wyniki tych badań potwierdzają, że w początkowym okresie wiedza o zjawiskach zachodzących w sferze walki zbrojnej w powietrzu miała charakter przede wszystkim empiryczny. Już w 1916 roku Aleksander Graham Bell ostrzegał przed możliwością nalotów na Stany Zjednoczone. Przez następne 25 lat eksperci prowadzili badania nad obroną przeciwlotniczą, które stały się kluczem do jej dalszego rozwoju. Podstawą rozwoju obrony powietrznej było pojawienie się pod koniec I wojny światowej nowej broni, czyli artylerii przeciwlotniczej. Opierając się na doświadczeniach Stanów Zjednoczonych z I wojny światowej w okresie międzywojennym, zaczęto postrzegać obronę powietrzną jako system, którego głównym zadaniem było wykrywanie i niszczenie lotnictwa wroga atakującego oddziały wojska, ludność cywilną i obiekty znajdujące się na tyłach frontu. Biorąc pod uwagę zarysowaną problematykę oraz przedmiot badań, przyjęto, że celem artykułu będzie omówienie etapów rozwoju the experience of US anti-aircraft artillery gained on the fronts of the First and Second World Wars. obrony powietrznej w Stanach Zjednoczonych w latach 1917–1945 oraz doświadczeń amerykańskiej artylerii lotniczej zdobytych na frontach I i II wojny światowej.

Keywords: air defence; combat aircraft; anti-aircraft artillery; searchlight; barrage balloon Słowa kluczowe: obrona powietrzna; samoloty bojowe; artyleria przeciwlotnicza; reflektor; balon zaporowy

Introduction

Based on the adopted study assumptions, the results of the study indicate that the initiated development of military aviation in the First World War made the US military realise that its armed forces lacked effective means to combat enemy aircraft from the ground. For these reasons, the decision was taken in the United States in 1917 to create a system of protection for soldiers who were part of the American Expeditionary Corps, sent to the war raging in Europe since 1914.

Thus, the process of the formation of air defence units was initiated in the United States.¹ However, this does not mean that until 1917 air defence issues were not raised in the US. Before the outbreak of the First World War, at a Congress meeting in August 1913, James Hay, chairman of the Military Affairs Committee, raised the issue of defence against aircraft. The debate was held as part of works on the project to increase funding for military aviation. A participant in this debate, acting as a military expert, was Brig. Gen. George P. Scriven.² During the debate, he outlined the seriousness of the air threat by presenting a scenario in which the enemy's air fleet might be out of range of US coastal defence artillery weapons and its aircraft could attack sensitive inland facilities with impunity. This threat scenario was based on an analysis he had made in 1915, which was based on information provided by American attachés and other

¹ The term 'air defence' was probably used for the first time in the UK when the Air Defence of Great Britain (ADGB) was established in 1925 as the air force command of the Royal Air Force. Until then, the commonly used terms for air defence were Anti-Aircraft (AA), Anti-Aircraft Artillery (AAA), or the WW1 British name 'Archie', presumably in honour of Amyas Borton of the Royal Flying Corps (RFC), who had a habit of shouting the words of the popular song from George Robey's musical *Archibald, Certainly Not!* when trying to avoid enemy missiles.

² He commanded the Air Division (1913–1914) and later the Air Section (1914–1917), which was part of the structure of the American Communications Corps. He was the forerunner of the United States Air Force. Scriven was also the first chairman of the National Advisory Committee on Aeronautics from 1915 to 1916 and a precursor in the founding of NASA.

observers of the war effort in Europe. Following its execution, General Scriven published a report on the new status of aviation in Europe. He pointed out that the aircraft were not only used for reconnaissance tasks. They also carried out attacks on manpower and civilian infrastructure facilities (Johnson, 2014). He also noted that the aircraft was very quickly adapted by military planners to perform a variety of missions, from surveillance to long-range bombing raids that threaten military and civilian facilities deployed behind a front line.³ This was feasible because in 1915, the Germans introduced Gotha bombers to terrorise Paris, and in 1917 – they crossed the English Channel, successfully bombing London. With the threat of an air attack diagnosed in this way, the important issue was to find measures that could effectively combat all types of military aircraft. This function was to be fulfilled by the air defence created from scratch and its main task was to detect enemy aircraft and destroy them in the air. A key problem during this period was hitting a target moving through the airspace. Therefore, the development of air defence required the creation of specialised detection, technical fire control equipment, fire assets and means of command and communication. The scale of the difficulties was exacerbated by the fact that in the early 20th century they were very primitive or non-existent. Initially, detection was conducted with optical and acoustic devices developed during the First World War and developed in the 1930s.

Guided by the findings of the preliminary research and the directive assumptions made in the study proceedings, it was assumed that the purpose of this article is to outline stages in the development of air defence in the United States between 1917 and 1945 and the experiences gathered on the fronts of the First and Second World Wars, on which US troops fought.

Based on the adopted objective, it was considered that its achievement would be possible as a result of solving the main research problem, which was formulated in the form of a question with the following content: How was air defence developed in the United States between 1917 and 1945, and what experience did US troops fighting on the fronts of the First and Second World Wars gather in this regard?

In the research process, the author mainly used theoretical methods. Firstly, a literature analysis of the research subject was applied. Subsequently, the leading

³ Earlier raids consisted in manually throwing bombs over the side of aircraft, thus attacking a surface target of a considerable size. A good example might be the German air attacks on British facilities by Zeppelin airships. German air raids using Zeppelins allowed bomb loads to be transported over greater distances and created the conditions for the development of more precise bomb targeting systems. However, the large size, slowness and high sensitivity of the hydrogen-filled Zeppelin led to their replacement by the first bomber aircraft in 1917.

methods were synthesis, comparison, and generalisation, which made it possible to formulate the closing remarks contained in the conclusion of this article.

The emergence and development of air defence in the United States Army during the First World War

Given the rapid growth of military aviation and the need to ensure the safety of the American soldiers who were part of the American Expeditionary Force that the United States was sending to Europe in 1917, the mission to organise a new type of air defence force was entrusted to Col. James Shipton. On July 26, 1917, he set off with the first US subdivisions for France (Kirkpatrick, 1984, p. 17). General Shipton was accompanied by two other officers, Captains Glenn Preston Anderson and George F. Humbert. They travelled to France to study the issues of air defence developed by the British and French in academia and at the front.

The three officers mentioned above were tasked with organising anti-aircraft defence of the US Expeditionary Corps, which in fact led to the creation of anti-aircraft defence in the US Army. General Shipton concentrated mainly on logistical issues, while Anderson and Humbert were involved in matters of training and organising the structures of anti-aircraft artillery units.

On September 26, 1917 in France, the first 25 American officers received training at the anti-aircraft artillery school at Langres. France played a particularly large role in the development of air defence in the United States, as it prepared skilled officers with a great deal of knowledge in the use of artillery. These officers later acted as instructors. On October 10, 1917, General Shipton became the first anti-aircraft defence commander and remained in this position until June 29, 1918. He was later replaced by Colonel Jay P. Hopkins, former commandant of the Anti-Aircraft Artillery School, who had previously worked closely with Shipton.

The National Defence Act of 1920 formally assigned the mission of creating air defence units to the Coast Artillery Corps. In 1921, four battalions were formed and in 1924, as part of a major reorganisation of the Coast Artillery, the battalions were reorganised into regiments.

In 1922, an anti-aircraft artillery training centre was established. This was the place where qualified personnel were trained for the new type of anti-aircraft defence troops being formed in the Coastal Defence Corps. Soon two new specialities were created at the training centre: machine guns and searchlights. Machine gun training was provided by infantry officers, whereas classes for searchlight maintenance were conducted by mechanics officers. In total, by the end of the First World War, the Americans had trained 659 officers and 12,000 enlisted personnel at their anti-aircraft artillery training centre. Despite the operation of a training centre in the USA, some officer personnel continued to be trained in France. In addition, officers from the Coastal Defence Corps were also sent to the anti-aircraft artillery school at Steenwerk in the UK.

Because of its close connection to French air defence theory, it was on the basis of this theory that the principles and methods of air defence were developed and implemented into US air defence practice. This was reflected in the anti-aircraft defence doctrine and instructions, which for the most part, were fairly faithful translations of French documents. It was also planned to equip anti-aircraft artillery units with 75 mm French-made cannons. Buying them from the French, however, proved more difficult than it was initially anticipated. This was mainly due to the French manufacturers' problems in meeting the needs of their own army, which they prioritised. In this situation, initially the armament of the American anti-aircraft artillery subdivisions consisted of older generation cannons. However, over time, taking advantage of the experience of the European countries, also their own production of anti-aircraft cannons and auxiliary equipment was gradually developed (Crabtree, 1994, pp. 37–38).

Type of	Regular army (operational troops)			National Guard on a permanent basis			Regular army (units)			Total
equipment	post	actual state	none	post	actual state	none	post	actual state	none	Iotai
3-inch anti-aircraft cannon	48	40	8	120	20	100	132	0	132	240
Fire control device	12	9	3	30	8	22	33	0	33	58
Recon- naissance equipment	12	10	2	30	0	30	33	0	33	65
Listening devices	60	39	21	150	10	140	165	0	165	326
Anti-aircraft searchlight	60	23	37	150	14	136	165	0	165	338
Machine gun 50 cal.	240	160	80	600	0	600	1,200	0	1,200	1,880

Table 1. Peacetime Status of Armaments and Equipment for National Air Defence in 1936 in the United States

Source: Author's own elaboration based on: Milburn, 1936, p. 6.

Diagnosis of anti-aircraft artillery tactics against enemy aviation during the First World War

In anti-aircraft artillery units, there was a principle that it is essential to be well prepared to counter air targets. This belief was particularly important due to the high inaccuracy that characterised the 75 mm calibre cannons. This was essentially due to the inability to carry out the so-called precise aimed fire. In practice, therefore, the soldiers operating these cannons applied adjustment of fire. It consisted of barrage fire, which required several anti-aircraft guns to fire a simultaneous salvo. The adoption of this solution was also due to the way military aircraft operated at the time, where pilots used ground to navigate, leading to a linear profile flight. Determining the flight techniques of the planes allowed anti-aircraft artillery units to develop plans that involved the use of cannons on their anticipated flight paths. An important element in the operational tactics of air defence units was the delegation of fire effort. It meant that, due to the different ranges of various fire assets, anti-aircraft machine guns sprayed fire on aircraft flying at a low altitude, while 75 mm cannons concentrated their efforts on destroying enemy aircraft, operating at higher altitudes.

Air defence also used aircraft deterrence tactics. On its basis, US anti-aircraft artillery cadets were taught techniques for deterring aircraft and keeping them at a distance. The instructors instilled in the students information that forcing an aircraft to fly at a higher altitude reduces the precision of its attack, and that effective and massive fire could discourage the pilot from continuing the mission.

It should be noted that it was mainly American air defence units that used searchlights during the First World War. A total of 34 searchlight platoons were organised in anti-aircraft artillery units, which took part in battles in Europe.⁴ Most European servicemen felt that searchlights were impractical and, by directing their light at enemy aircraft, betrayed the positions of their own fire assets. The Americans used searchlights mainly to defend facilities at the rear of the front. In practice, searchlights proved useful because they discouraged the enemy from carrying out

⁴ The participation of US military forces was an aftermath of America abandoning its neutrality and joining the war on the side of the Allies on April 17, 1917. However, it should be stressed that, at the beginning of 1917, the US Army was in European terms a small force. Its total strength was 287,000 officers and enlisted personnel, and its artillery strength, excluding the permanent naval defence artillery, was under 1,000 guns of various calibres. The US preparation of an expeditionary corps required an increase in the size of the army to over one million men. In addition, the new recruits had to be trained and, above all, they had to be clothed, equipped, and ultimately sent to Europe. It was a time consuming process.

night bombings and their strong light very often blinded pilots, who lost their orientation and abandoned their combat mission.

By the time the American expeditionary force arrived in France in 1917, anti-aircraft artillery units had been using French equipment, including the Mle 1914 Hotchkiss heavy machine guns (Christensen, 2018). The Americans used these weapons in both infantry and air defence subunits.

The use of machine guns as anti-aircraft weapons meant that their operators often had to improvise, looking for ways to elevate the cannons, since standard field artillery was not designed to shoot at air targets. As is often the case in war, necessity is the mother of invention – all sides in the war found effective solutions. The need to use small arms and conventional artillery for airborne fire resulted from the fact that specialised anti-aircraft guns, despite their increased production, were still insufficient in relation to the needs of the battlefield. In total, the artillery units comprising the American Expeditionary Corps had 4,194 cannons of which 3,532 were from France, 160 were from Britain, and 502 came from the United States (Gourley, 1985, p. 26).

During that period, the most famous victim of anti-aircraft fire was Manfred von Richthofen, the Red Baron. The German fighter ace was killed by a single bullet, which proved fatal. The evidence suggests that he may have been killed by Cedric Popkin, the gunner from 24th Australian Machine Gun Company, which operated the Vickers machine gun, or by W.J. Evans from 53rd Battery, 14th Australian Field Artillery Regiment, operating the Lewis machine gun. Although there is no certainty as for the date or the person who exactly fired the fatal shot, it can definitely be assumed that it was fired from an anti-aircraft gun.

The high point for US anti-aircraft artillery proved to be May 18, 1918, when a German reconnaissance aircraft LVG⁵ conducted aerial surveillance south-east of Verdun. The aircraft attempted to gather information on the positions of French and US troops. There was an American 2 anti-aircraft battery in the area approximately 2,700 m from the aircraft, which was armed with two French 75 mm guns. Upon detection of the German aircraft, the cannon crews set time fuses so that the shells would burst at a proper altitude. Lt. A.T. Slaten made quick calculations on the target's data: range, location and its speed. Soon afterwards, a cannon salvo was fired towards the German aircraft, which began to dive. The aircraft eventually hit

⁵ Luftverkehrsgesellschaft mbH (LVG) was a German aircraft manufacturer based in Berlin – Johannisthal, which started building aircraft in 1912, manufacturing Farman aircraft. The company built many reconnaissance aircraft and light bombers during the First World War. Also in the 1916 attack on London, one LVG C.IV was used. It dropped bombs near London Victoria station but was shot down by French anti-aircraft gunners on its return way home.

the ground, yet the crew managed to survive the crash since they were seen making their way from the wreckage of the aircraft towards the German defence lines. On that night, a French infantry patrol set off towards the wreckage of the plane to remove machine guns and other useful equipment from it. The patrol also managed to cut off a piece of the aircraft's airframe, which was handed over to the American battery commander, Capt. E.A. Mellon, in commemoration of the first downing of an enemy aircraft by US anti-aircraft artillery. Gen. Shipton himself was very excited by this fact and sent a piece of the downed aircraft to Colonel F.K. Ferguson, Commandant of the Coastal Defence Artillery Corps. However, it should be stressed that, according to the US Army's procedures, an individual could only apply for official recognition of a shoot-down if it was achieved with indigenous weaponry. In this case, the German aircraft was shot down with French-made cannons (Gourley, 1985, p. 26). Consequently, it was not officially recognised.

Despite this, US anti-aircraft artillery managed to shoot down 58 enemy aircraft by the end of the war. By the end of the First World War, American anti-aircraft artillery was considered the most effective. This is also confirmed by data according to which a British anti-aircraft artillery battery needed to fire 10,000 shells to shoot down one aircraft and a French battery needed to fire 6,000. In 1914, a German anti-aircraft gun battery had to use an average of 11,500 shells to shoot down an aircraft and in 1918, this average was reduced to 5,040 shells (*WWI Antiaircraft Weapons*, 2016). Judging by the above, the US anti-aircraft battery looked the best as it only needed an average of 600 rounds to shoot down one aircraft. This success was undoubtedly due to good training, the development of good operating principles and tactics, and the high skill and discipline of the soldiers operating the weapon systems.

Despite the successes achieved by US anti-aircraft artillery units on the fronts of the First World War, its development encountered several difficulties in subsequent years (Gourley, 1985, pp. 20–21). They were essentially the result of different views on air defence issues that clashed in the United States. In this regard, mainly in the late 1930s, some of the high-ranking officers such as US Army Chief of Staff General George C. Marshall advocated the creation of manoeuvrable anti-aircraft units in the ground troops corps. However, for some officers who could not free themselves from the doctrine of the First World War for many years, this was hardly a topic of interest for deeper consideration. The great calmness of the US military was also partly due to the statements of some politicians and senior military officers. One of these was Gen. John J. Pershing, who in 1938 wrote: "Despite the successes of the German air force during the Spanish Civil War, it can be said that only anti-aircraft artillery can gain an advantage over the aeroplane" (Sunderland, 1940). At the same time, Texas Senator Morris Sheppard was also praising US anti-aircraft artillery as the best in

the world, which was clearly not true (Sheppard, 1937, p. 3). In a similar way, the commander of the Coastal Defence Artillery Corps, Major General Archibald Henry Sunderland, also stated that US anti-aircraft artillery equipment is state-of-the-art, and that the main problem that remains to be solved is to increase its quantity. Despite general satisfaction with the organisation of anti-aircraft artillery units, funding for the development of anti-aircraft defence was increased 12-fold in 1937. In this respect, a real breakthrough was the 1939 War Department decision, which directed the individual commands to develop an anti-aircraft defence doctrine and to create structures for anti-aircraft artillery units to be incorporated into the corps and divisions of the army.

Organisation of the air defence of the US territory in the 1940s

The United States closely observed and analysed the air threat in Europe and the Pacific region. Actions that were closely monitored in the late 1930s were the air raids on civilians at Guernica in 1937 during the Spanish Civil War and the bombing of Warsaw in 1939 by the German Luftwaffe. Another important experience for US air defence was the Battle of Britain in 1940, and the Japanese attack on Nanking in 1937.

From 1940, US air defence doctrine covered the continental US, overseas garrisons and theatres of operations where US ground forces were located. The general air defence system was tasked with countering air threats, using any means available to decrease (limit) the effectiveness of hostile aviation. The scheme included both active and passive undertakings. At this point, it should be noted that the structure of the air defence system did not deviate from the generally accepted model in most European countries. It should be emphasised that during the Second World War, the organisation of the air defence system was not uniform, since each country participating in the war, due to different financial capabilities, terrain specifics and military doctrines, created their own structure.

For the US, active measures included any means designed to destroy enemy aircraft and their crews in the air (*Army Air Forces, Field Manual FM 1-25*, 1943). These included fighter aviation, anti-aircraft artillery, barrage balloons, and anti-aircraft searchlights. The second integral element was passive measures aimed at assisting their own aviation in searching for and destroying enemy aircraft in order to secure the basic needs of aviation including, in particular, the protection of aircraft manufacturing facilities and civilians. Passive air defence was regarded as one of the most important elements of the country's defence against hostile air actions.

The activation of passive air defence in times of war or national security threat lay within the competence of the chief defence commanders, who were assisted by civil defence elements. The main tasks of the defence commanders included controlling the civilian population in emergency situations, evacuating the population from designated areas, protecting critical installations, clearing unexploded ordnance, and exercising lighting control (*Army Air Forces, Field Manual FM 1-25*, 1943). A very important role in the air defence system was played by the observation and reporting service subsystem, which was responsible for collecting and assessing information about enemy aircraft and warning of air raids. Posts deployed at some distance from the cities were to report on enemy aircraft in terms of their number, altitude and heading. This allowed air defences to be better prepared to combat aircraft either by using barrage anti-aircraft artillery fire on long-range approaches to the defended object or by deploying their own fighter aircraft.

These were mainly visual observation posts, connected by telephone lines to the report points. Warnings of the threat of air attack were passed on to civil defence, offices responsible for national defence, and local authorities. The Office of Civil for Air Defence acted as the federal coordinating the centre for civil service activities, which included relations between the federal government, state agencies, local governments, island estates, and the District of Columbia.

Responsibility for active air defence rested on air and ground force commanders. It concerned the definition of requirements for anti-aircraft units, the training of personnel, the provision of equipment and other necessary facilities, as well as the preparation of the necessary plans covering development, organisation, equipment, training, tactical operations, and supplies. The tasks of the command authorities also included sending appropriate personnel and anti-aircraft equipment to the expeditionary (overseas) forces. The commands of different branches were also responsible for defining the tactical doctrine governing the interaction of fighter aviation with anti-aircraft artillery, barrage balloons and anti-aircraft searchlights. In the theatre of war, air defence organisation and command of its elements were the responsibility of the fighter aviation commanders of the air defence regions. Outside the air defence region, commanders of anti-aircraft units were responsible for covering ground (local) forces. Generally, the fighter aviation commander was responsible for coordinating the activities of fighters and anti-aircraft artillery, so as to exploit the possibilities of combating enemy air targets as much as possible. Coordination was carried out both during the planning of air defence and the conduct and control phase. Control was most often implemented in the form of directives and was based on compliance with existing operational procedures. In specific cases, fire restrictions for anti-aircraft

weapons, the operation of anti-aircraft searchlights and the use of barrage balloons were introduced as part of the control.

The largest element in the air defence structure was the region. Its size depended on the forces and resources at the disposal of the air defence commander of the region, including mainly the volume of fighter jets and access to communication networks. In the continental part of the United States, the regions were divided into areas and these were further divided into districts. Urban districts were further subdivided into wards, which were the smallest element of the territorial division. The size of the area and their number depended on the forces and resources at hand and the location of potential targets for enemy aircraft, including mainly airfields that were of strategic importance (Army Air Forces, Field Manual FM 1-25, 1943). Decentralisation of security operations and flexibility were fundamental in directing active combat measures. Air threat warning was provided in the form of orders from the fighter aircraft commander to the civilian defence agencies. In case the command posts were destroyed, deputies were appointed to direct operations from spare command posts that had been prepared in advance. The wing commander was responsible for organising the air defence of the region. The persons responsible for the proper functioning of the air defence area were the area controller and the anti-aircraft artillery commanders, who reported to the air defence wing commander. The area air controller was responsible for implementing all orders received from the wing commander (Air Defence, Field Manual FM 44-8, 1944). At the lower levels of command of anti-aircraft artillery units, forming part of air defence wings that operated in regions or areas, the command was decentralised. Reconnaissance elements organised in anti-aircraft artillery units (Anti-Aircraft Artillery Intelligence Service - AAAIS) and the communications, command and control system played an important role in the smooth operation of the air defence system. The essential task of these elements was to collect, evaluate and distribute up-to-date and accurate information for anti-aircraft artillery units. The provision of information about own aviation, which was considered essential to effectively control the operation of fighters, anti-aircraft artillery, anti-aircraft searchlights and barrage balloons (Air Defence, Field Manual FM 44-8, 1944), was equally important. These messages were vital when fighter aircraft and anti-aircraft searchlights were conducting operations at night. On March 9, 1942, the Air Defence Command was established in Washington, DC, and in 1944, the anti-aircraft artillery school was moved to Fort Bliss (Stiller, 2010).

In order to summarise the above discussion, it can be concluded that all anti-aircraft artillery units operating within the air defence area were subordinate to the fighter aviation command. The situation was different with anti-aircraft artillery units covering ground troops, which were not under the formal command of fighter aviation, but were obliged to establish rules of interaction with neighbouring air units that were in a given air defence area. Establishing an interaction between these elements was aimed at receiving intelligence on a possible threat and identifying aircraft in terms of 'friend' or 'foe'. In this respect, an important role was played by the messaging subsystem, under which the rules for firing on air targets were defined. Apart from this, it must be stated that the air defence system was well organised, but due to the absence of a US air threat throughout the war, it was difficult to assess its actual capability and efficiency under conditions of a national air threat.

The issue of organisation of the air defence of the US military, which conducted combat operations in three geographical areas, i.e., North Africa, Europe, and the south-west Pacific, looked far better from the point of view of being verified under air threat conditions.

Analysis of US anti-aircraft artillery operations on the fronts of World War II

The greatest experience of the organisation and operation of anti-aircraft artillery in covering the ground troops was gained in combat against the aviation of the 'Axis' states in the three theatres of war in North Africa, the Pacific, and Europe. The experience was even more valuable for air defence, as it was gained in different geographical and climatic conditions. They had not only a theoretical but also empirical value. During the operations in North Africa, particularly during the defence of the Kasserine Pass, it became apparent that the anti-aircraft artillery forces grouped there were unable to provide cover for ground units. The main reason was negligence of senior general military officers, resulting from their reluctance to relevance of the organisation of air defence.⁶ On the basis of these events, the need to amass forces to cover only the most important facilities was postulated.

⁶ This is confirmed, among other things, by a report produced by Major George Crocker in February 1943 describing negligence in matters of air defence. His inspection of ten battalions and five anti-aircraft artillery regiments indicated that the anti-aircraft cannon fire skills of the troops, trained at home and deployed to North Africa, was on a low level. He suggested that the training was too theoretical and did not focus on the practical skills of operating the equipment. He argued that more emphasis should be placed on field fortification skills in order to rectify the situation, with anti-aircraft artillery needing longer training and more difficult testing standards (*Letter, HQ AGF to Subordinate Commands*, 1943).

This demand was justified during the advance of Rommel's corps, when 105 mm anti-aircraft artillery was concentrated to defend the logistical facilities at Tebessa and to cover the most important elements of the frontline fighting forces including the artillery at Jebel el Hamra. Attention was also drawn to greater manoeuvrability of anti-aircraft artillery units, which required equipment and training changes that were, in point of fact, made after the war.

In operations in the Pacific, the main air defence effort was focused on covering the main airfields and seaports. A good example might be Pearl Harbor, which was heavily defended after the tragic events of December 7, 1941. A total of 187 anti-aircraft artillery batteries, with 27,000 soldiers, were assigned to cover the port and other facilities (airfields, troop concentration areas, and equipment depots). In Douglas MacArthur's campaign plan regarding the capture of the Pacific islands, anti-aircraft artillery was to shield the landing forces from air attacks. This required close interaction of anti-aircraft artillery with the navy and air force (United States Strategic Bombing Survey, 1946, pp. 326–328). Anti-aircraft artillery also proved to be the only force capable of taking effective action against Japanese 'kamikaze' suicide pilots. In addition, it also supported US troops against Japanese ground forces. After twenty days of fighting in the Philippines, anti-aircraft artillery units armed with 90 mm guns destroyed 75 caves, 40 bunkers and 32 machine gun positions. During the battle of Bougainville in March 1944, 90 mm anti-aircraft guns supported US units firing on Japanese army positions that were out of range of infantry fire. In turn, anti-aircraft artillery units equipped with 40 mm 'Bofors' destroyed 71 Japanese bunkers during jungle fighting. Also on Saipan, 90 mm and 40 mm anti-aircraft guns were used to fire directly into the caves.

In the defence of Morotai, anti-aircraft artillery destroyed 37 enemy aircraft in one day, out of the 200 used by the Japanese. During combat operations in Leyte from October to December 1944, the 32nd Anti-Aircraft Artillery Brigade destroyed 251 Japanese aircraft. During the fighting in Okinawa, suicide attacks by kamikaze pilots were the greatest threat. The operations in Okinawa were the bloodiest campaign of the Pacific War and claimed the lives of 49,000 soldiers, in which the US lost 763 aircraft and 36 ships with another 386 damaged. Of these, Japanese kamikazes sank 26 ships and damaged 164. Japanese losses, however, were much higher, amounting to approximately 110,000 dead soldiers and 100,000 civilian casualties. The Japanese air force lost 7,830 aircraft, of which 1,900 were kamikazes. On April 6, 1945, the Japanese initiated the first and one of the largest attacks using suicide pilots. It was directed against US forces located near Okinawa. In an attack involving a total of 700 aircraft, as many as 355 were kamikazes. During the attack, kamikaze pilots destroyed several ships (Appleman et al., 2001, pp. 115–282). Another air attack took place on April 12–13. It was performed by 392 aircraft and kamikaze planes. The third raid took place from April 15 to 16. 498 aircraft were involved in the raid, including 165 kamikaze pilots. At the end of April (24–25), the Japanese carried out a raid involving 115 kamikaze machines. During the seventh raid in May, there were 5 bombers in addition to 165 kamikaze fighters to destroy the Yontan airfield along with 120 Japanese soldiers from the elite commando corps. US ground forces and naval guns destroyed four bombers.

No.	Date of attack	Suicide attacks (kamikaze)
1	April 6–7, 1945	355
2	April 12–13, 1945	185
3	April 15–16, 1945	165
4	April 27–28, 1945	115
5	May 3–4, 1945	125
6	May 10–11, 1945	150
7	May 24–25, 1945	165
8	May 27–28, 1945	110
9	June 3–7, 1945	50
10	June 21–22, 1945	45
To	1465	
Other attacks – per	435	
To	ıtal	1900

Table 2. Suicide Attacks by Japanese Kamikazes in Okinawa in 1945

Source: Author's own elaboration based on: United States Strategic Bombing Survey, 1946, p. 328.

In summary, US anti-aircraft artillery in the entire Okinawa campaign destroyed 127 Japanese aircraft, presumably 20 destroyed or damaged, a total of at least 56 aircraft (*Kamikaze*, 1994, pp. 58–62). By the end of the war, anti-aircraft artillery involved in the Pacific war effort had destroyed 882 Japanese aircraft. These were not extraordinary achievements compared to the operations in Europe, yet it can be seen as an important contribution to defeating the Japanese forces (Naval Analysis Division, 1946, pp. 326–328).

Land forces' anti-aircraft defence in operations in the Pacific was supported by naval anti-aircraft artillery. More than 4 billion dollars was spent on the air defence of US warships during the Second World War. Half of this sum was the cost of purchasing anti-aircraft munitions. The primary anti-aircraft weapon mounted on the ships was the 40 mm 'Bofors' cannon, whose purchase was signed in a contract of June 1941 by the US Government (Sherrod, 1952, pp. 221–234, 401). By June

1945, the US fleet had already had 5,140 'Bofors' cannons at its disposal. During June 1944, 18% of Japanese aviation was destroyed using 40 mm anti-aircraft guns and between October 1944 and March 1945, their effectiveness was even higher at 50%. The US ships were also armed with a 38 mm anti-aircraft gun, manufactured at home. By July 1940, the fleet had 611 such guns and by June 1945, their number had risen to 2,868 (Werrell, 2002, p. 52). By mid-1944, it was estimated that the effectiveness of these guns equalled 31% (Sherrod, 1952, pp. 220, 266, 283, 286). By the end of the war, the US fleet possessed 12,561 20 mm calibre anti-aircraft guns on board their ships. A total of \$787 million was spent on their purchase and, together with the purchase of ammunition, the cost exceeded \$1 billion. The 1944 war effort confirmed their effectiveness, as they destroyed 32% of the total number of Japanese aircraft engaged in combat during this period. At other times, the average effectiveness of 20 mm anti-aircraft guns was equal to 25% (Werrell, 2002, p. 51). Despite their good performance, 20 mm guns were gradually replaced by 40 mm 'Bofors' cannons.

American anti-aircraft artillery carried out its tasks in Europe as actively and effectively as in North Africa and in the Pacific region. During the Normandy campaign (June 7-30, 1944), 682 strikes were made by Luftwaffe aircraft. Repelling their attacks, US anti-aircraft artillery destroyed 96 aircraft. Between July 31 and August 6, the German air force engaged 1,312 aircraft in action. Despite the fact that anti-aircraft artillery destroyed only 58 aircraft, the Germans did not manage to destroy any of the important facilities. On December 3, 1944, the Luftwaffe used 80–100 aircraft against the US 1st Army. Within 45 minutes alone, the Luftwaffe lost between 30 and 40 aircraft from anti-aircraft artillery fire. Between December 16, 1944 and January 1, 1945, during the Battle of Bulge, the German Luftwaffe made 1,178 sorties during which the anti-aircraft artillery of the 1st Army destroyed 366 aircraft (Werrell, 2002). On January 1, 1945, an extraordinary event took place as the Luftwaffe sent 900 Ju-88 night fighters tasked with attacking 16 Anglo-American airfields. As a result of a lack of coordination, German anti-aircraft artillery destroyed around 100 of their own aircraft. According to German sources, 304 aircraft were lost in action and 232 pilots were killed. Allied sources claim that 102 German aircraft were shot down in the air battles and anti-aircraft artillery destroyed between 185 and 394 enemy aircraft. According to experts, 57 German aircraft were destroyed by fighter aviation and 80 by anti-aircraft artillery (USAF Credits for the Destruction of Enemy Aircraft, World War II, 1978, pp. 412-413). Several months later, US anti-aircraft artillery units achieved another success. It was associated with the defence of the Rhine railway bridge in Remagen. From March 7, 1945, the Germans took intensive measures to

destroy it. By March 14, the Americans had concentrated a large force of anti-aircraft artillery: 64×90 mm anti-aircraft guns, 216×40 mm anti-aircraft guns, 24×37 mm anti-aircraft guns, 228 anti-aircraft machine guns to defend the bridge. While covering the bridge, anti-aircraft defences destroyed 142 German aircraft, out of 442 that attacked the defended structure. As a result of strong anti-aircraft defences, the German air force failed to destroy the bridge at Remagen (Werrell, 2002, p. 23).

In conclusion, during the European campaign, the 12th US Army Group recorded 1,476 Luftwaffe attacks. During their implementation, anti-aircraft artillery confirmed the destruction of 2,070 aircraft. In the entire war, the German side recorded a loss of 29,953 aircraft, of which 14,938 were shot down over Germany. Of this number, 2,598 aircraft were destroyed by anti-aircraft artillery (Werrell, 2002, p. 24). Besides, based on the obtained results, it should be noted that any doubts about the role and importance of American anti-aircraft defence during the Second World War are dispelled by substantial concrete facts including statistics: from the day of the invasion (D-day) in Normandy until May 8, 1945, anti-aircraft artillery destroyed or seriously damaged 3,151 aircraft of the 'Axis' states. During the Normandy campaign (June 7-30, 1944) alone, 96 of 682 Luftwaffe aircraft were destroyed. The main effort of the anti-aircraft artillery units was focused on defending the landing forces on Omaha beach. Based on the source documents, it can be concluded that American anti-aircraft artillery destroyed, during operations in Europe, at least 3,675 enemy aircraft and damaged 1,514, a total of 5,189 aircraft. In comparison, the US Air Force destroyed 15,811 aircraft in air combat, although the financial expenditures for their expansion was several hundred times greater in the US than the expenditure on anti-aircraft artillery. American military historians estimate that out of a total of 21,000 aircraft destroyed by the 'Axis' countries, American anti-aircraft artillery destroyed more than 25% of the machines (Cibula, 1946, pp. 209–211). This number must also be supplemented by 236 enemy aircraft that managed to reach their base locations despite damage from anti-aircraft fire.

Theatre of operations	Destroyed planes	Planes that were presuma- bly destroyed	Damaged aircraft	A total of the theatre of operations
Europe (June 6, 1944 – May 8, 1945)	2,138	1,013	no data available	3,151
Southwest Pacific up to March 15, 1945	402	244	236	882

Table 3. Summary of the Performance of US Anti-Aircraft Artillery during World War II

Theatre of operations	Destroyed planes	Planes that were presuma- bly destroyed	Damaged aircraft	A total of the theatre of operations
North Africa (November 1942 – December 1945)	526	no data available	no data available	526
Sicily (July 9 – Oc- tober 12, 1943)	120	_	_	120
Italy (until March 15, 1945)	473	246	—	719
Corsica and Sardinia	8	4	—	12
the south of France	8	7	_	15
Total	3,675	1,514	236	5,425

Source: Author's own elaboration based on: Cibula, 1946, pp. 209-210.

Paradoxically, anti-aircraft artillery in the USA was effective against enemy aviation despite the systematic reduction of its manpower. By March 1945, the number of personnel in the anti-aircraft artillery had fallen to 270,535, a decrease of 16.3%. In contrast, the number of personnel in the air force increased over the same period to a figure of 270,535, which constituted 16.3 per cent of the army's total. This increased further in the final period of the war to a figure of 1,831,091, representing 22.4% (Greenfield, Palmer, & Wiley, 1987, p. 161).

Table 4.	Comparison of Personnel	Levels in the	Various	Military	Branches	of the U	JS Armed	Forces
between	1941 and 1945							

Type of armed	December 31, 1941		December 31, 1942		December 31, 1943		March 31, 1945	
Torces	amount	%	amount	%	amount	%	amount	%
Ground troops (excluding air defence)	690,083	41.4	1,512,730	28	1,960,068	24.9	2,423,075	29.7
Coastal Defence Artillery Corps (air defence)	177,79	10.7	425,8 297,00	7.9 5	590.939 431,00	7.9 5.7	330,42 246,00	4.1 3.0
Air Force	270,35	16.3	1,270,677	23.5	1,810,900	24.2	1,31,91	22.4
Support units	435,69	26.3	1,857,042	34.4	2,735,076	36.5	3,095,020	37.9
Officers of the air force and other branches	83,391	5.0	333,252	6.2	485,451	6.5	477,758	5.9
Total	1,657,157	100.0	5,400,888	100.0	7,482,434	100.0	8,157,386	100.0

Source: Author's own elaboration based on: Greenfield et al., 1987, pp. 161-162, 203.

Conclusion

In summary, on the basis of the considerations presented in this article, it can be concluded that the dynamically changing environment in which countries in Europe, Asia, and the United States operated had a varied impact on the development of military air defence and national air defence. In the United States in the 1920s and 1930s, there were heated debates over the final shape of the air defence of the country's troops and territory being created from scratch. In this respect, an interesting conclusion was reached by Kenneth Hamburger, who, while focusing mainly on the subject of US coastal defence technology, doctrine and policy between 1880 and 1945, also highlighted some of the difficulties associated with the development of anti-aircraft artillery. On this point, Hamburger argues that the Coastal Defence Artillery Corps being the original structure for anti-aircraft artillery, never fully assumed responsibility for the development of the anti-aircraft element. Moreover, in the inter-war period it continued to focus its attention on the coastal part of the artillery and its development despite the diminishing threat from the sea.

In the historical race for the development of anti-aircraft defence and air attack assets, the need for special rules and the development of individual ways of performing tasks by anti-aircraft artillery, taking into account the specifics of the fight against air targets, was not recognised in the initial period. However, as time went by, this specificity and the need to develop separate rules and modus operandi for air defence units began to be recognised. This led to the emergence of air defence subunit tactics, characterised by a high degree of flexibility and versatility in methods and forms of action, which could be effectively implemented in combat operations conducted under different terrain and climatic conditions.

The emergence and development of anti-aircraft artillery in the United States between the wars was determined by two factors. The first one is the air defence experience gained by US forces participating in the war effort in Europe. The second one – the majority of the so-called 'technical' battles, which were using the latest military inventions, took place on the Western Front. These were the best conditions for gathering experience in the use of aviation and anti-aircraft artillery.⁷

⁷ The effectiveness of anti-aircraft artillery is confirmed by the published statistics. It was calculated that in the years 1914–1918, German anti-aircraft artillery fire was responsible for shooting down 1,580 Allied aircraft, which constituted 19% in relation to the total number of Allied aircraft shot down on the Western Front. Most of them (1,537) were shot down in the years 1915–1918. In 1915, this number constituted 25% in relation to the total number of Allied aircraft shot down on the Western Front. These indicators increased over the subsequent years of the war and reached 47% in the last ten months of the war (Westermann, 2001, pp. 24–27).

During the First World War, American anti-aircraft artillery in combat against German aircraft gained combat experience that was very useful in verifying previous theoretical assumptions on the organisation of anti-aircraft defence of troops and national territory.

In addition, the First and Second World Wars solidly shaped air defence in two forms – active and passive. The use of natural terrain concealment, artificial masking, extinguished lights and darkened areas of military operations began to be used on a wider scale. Landmarks were also hidden in the field and decoy landmarks were created to confuse enemy pilots.

During the Second World War, the fundamental difference between the object of defence, which was the military, and the administrative, industrial and communications facilities lying deep in the country were recognised. Concepts such as 'frontal zone' and 'country area' appeared for the first time.⁸ As a result, after the late 1940s in the United States, air defence came to be seen as a system designed to prevent (or minimise) the possibility of enemy aviation impacting on troops, populations and facilities both at the front and in the rear.

The primary distinguishing feature of US air defence relative to other countries was the fact that it was largely developed during wartime, which was an extremely difficult undertaking. The development of air defence, including air defence in the United States, deserves attention because of its unprecedented scale and speed of development. However, achieving the high momentum of air defence development required a huge organisational and financial effort both from society and the state.

References:

- Air Defence, Field Manual FM 44-8. (1944, August 10). Antiaircraft Operations Room and Antiaircraft Artillery Intelligence Service. War Department. Chapter 1.
- Appleman, R.R., Burns, J.M., Gugeler, R.A., & Stevens, J. (2001). Okinawa: The Last Battle. Wahington, DC: Center of Military History.
- Army Air Forces, Field Manual FM 1-25 Air Defence. (1943, June 15). War Department. Section II.
- Christensen, D. (2018, March–April). Air Defense Artillery in World War I. *Fires*. Retrieved from: https://tradocfcoeccafcoepfwprod.blob.core.usgovcloudapi.net/fires-bulletin-archive/2018/mar-apr/mar-apr-2.pdf.
- Cibula, A.M. (1946). *The Antiaircraft Command and Center*. Army Ground Forces Study No. 26. Washington, DC: Army Ground Forces Historical Section.

 $^{^{8}\,}$ The frontal zone was then considered to be the area up to a depth of 50 km from the line of troop contact.

Crabtree, J.D. (1994). On Air Defense. Westport: Greenwood Publishing Group, Inc.

- Freeman, R.A. (1981). *The Mighty Eighth War Diary*. New York: Jane's Publishing Co. Ltd.
- Gourley, S.R. (1985, September–October). The Westervelt Anti-aircraft gun Deliberations. *The Field Artillery Journal*, 27–29.
- Greenfield, K.R., Palmer, R.R., & Wiley, B.I. (1987). The Organization of Ground Combat Troops, United States Army in World War II, The Army Ground Forces. Washington, DC: Center of Military History.
- Hamburger, H. (1986). The Technology, Doctrine, and Politics of U.S. Coast Defenses 1880– 1945: A Casy Study in U.S. Defense Planning. Duke University.
- Johnson, H.A. (2014). Wingless Eagle: US. Army Aviation through World War I. Chapel Hill: University of North Carolina Press.
- Kamikaze. (1994, May-June). Air Defence Artillery Magazine.
- Kirkpatrick, Ch.E. (1984). Archie in the A.E.F: The Creation of the Antiaircraft Service of the United States Army, 1917–1918. Fort Bliss, Texas: US Army Air Defense Artillery School.
- *Letter, HQ AGF to Subordinate Commands.* (1943, March 17). Sub: Observer Report, 319.1/43 (Foreign Observers) GNGBI, MHI.
- Milburn, B.L. (1936, October 23). Defense Against Aviation and Mechanized Units. United States Army War College, 1936–1937. Course: G-3. Report of Committee No. 6, No. 3-1937-6.
- Morison, S.E. (2001). Victory in the Pacific, 1945. Edison, NJ: Castle Books.
- Naval Analysis Division. (1946). *The Campaigns in the Pacific War*. Washington, DC: Government Printing Office.
- Schultz, W. (2011). 1000 ręcznej broni palnej. Ożarów Mazowiecki: Wyd. Olesiejuk.
- Sheppard, M. (1937). The Coast Artillery Corps. Coast Artillery Journal, 80(1), 3.
- Sherrod, R. (1952). *History of Marine Corps Aviation in World War II*. Washington, DC: Combat Forces Press.
- Stiller, J.H. (2010). ADA Branch: A Proud Heritage. Air Defense Artillery Online. Retrieved from: https://web.archive.org/web/20140729190051/http://www.airdefenseartillery. com/online/2010/ADA%20In%20Action/WorldWarI/Proud%20Heritage.pdf.
- Sunderland, A.H. (1940, May 3). *Notes on Antiaircraft Artillery* [Speech]. Chief of Coast Artillery File 666/FH, NA Box 698.
- United States Strategic Bombing Survey (Pacific). (1946). Naval Analysis Division. *The Campaigns in the Pacific War*. Washington, DC: Government Printing Office.
- US Air Forces in Europe. (1945, September 14). Air Staff Post Hostilities Intelligence Requirements on German Air Defenses [Report], Vol. 1, Sec. 4.
- USAF Credits for the Destruction of Enemy Aircraft, World War II. (1978). USAF Historical Study 85 Maxwell AFB, Ala.: USAF Historical Division, Air University. Retrieved from: https://apps.dtic.mil/sti/pdfs/ADA542272.pdf.
- Werrell, K.P. (2002). Archie, Flak, AAA, and SAM: A Short Operational History of Ground-Based Air Defense (5th Ed.). Alabama: Air University Press, Maxwell Air Force Base. Retrieved from: https://apps.dtic.mil/sti/pdfs/ADA421867.pdf.
- Westermann, E.B. (2001). *Flak: German Anti-Aircraft Defenses 1914–1945*. Lawrence: University Press of Kansas.
- WWI Antiaircraft Weapons. (2016). Retrieved from: https://weaponsandwarfare.com/2016/ 11/05/wwi-antiaircraft-weapons/.