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Developing cooperation between British air, land and naval forces: 1903–1918

Abstract

In 1914 the British Army went to war supported by a new branch of the British Armed Forces: The Royal Flying Corps. It has long been argued that the British were slow on the uptake regarding the military potential of the Wright brothers' technological breakthrough, and that this consequently caused that Britain lagged behind her continental allies and rivals at the outbreak of The Great War. This article has been written to address and correct this viewpoint, highlighting that the lack of central direction actually enabled free-thinking spirits to develop a variety of military applications for airplanes. This ultimately ensured that Britain maintained a technological advantage throughout the war, and resulted in the Royal Air Force enjoying unparalleled dominance in the air by 1918.

Key words: military aviation, Royal Air Force, Royal Flying Corps, naval aviation, World War I

Introduction

The desire to master the skies has accompanied man since ancient times and is reflected in numerous ancient myths, such as the story of Icarus and Daedalus. Flight was initially achieved in Paris, where, in November 1793, the first balloon flight took place. One of the prime inspirations to achieve flight was the accomplishment of military tasks as, according to legend, Joseph Montgolfier was inspired in his work by the possibility of inventing a way to capture the fortress of Gibraltar,

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which at the time was considered impregnable. His idea was to use lighter-than-air balloons to launch an attack, since all previous attempts to capture the fortress from land and sea had failed spectacularly (Harding 1945: 28).

Despite the obvious advantages offered by the possibility of observing the battlefield "from a bird's eye view," both Napoleon and other great strategists failed to see the potential inherent in flying, and it wasn't until the middle of the 19th century that the British themselves began to take an interest in flying. The issue was taken up by two members of the Corps of Engineers, who were looking for a way to show High Command the benefits of using balloons for aerial reconnaissance. The first designs were rejected as involving too much force and resources, but before 1878 a Balloon Equipment Depot was established at Woolwich Arsenal. A permanent ballooning section was organised under the Corps of Engineers in 1890 at Aldershot. The unit was used three times during operations in the African colonies and was an important part of artillery reconnaissance during the Second Boer War (1899–1902) (Harding 1945: 30). However, with the advent of aviation based on heavier-than-air structures, the role of balloons quickly lost its importance. Armies around the world, and especially in Europe, began to look for ways to use the new invention militarily.

This article presents and analyses British efforts related to the practical use of airpower with particular emphasis on its application during land and naval warfare. Each of these aspects is, of course, worthy of separate and exhaustive analysis. The purpose of this paper, however, is to present British efforts to enable cooperation between aircraft and land and naval forces, and to show that, despite the lack of central coordination and direction that characterised British research efforts, there is a clear and consistent link between pre-war attempts to find a use for aircraft and their subsequent utilisation during the war. The article is divided into two parts focusing first on pre-war research and development and then the use of aircraft on the battlefields and at sea. The work is not entirely chronological, as I believe that such a form would distort its message. Ultimately, it is hoped to demonstrate that the haphazard, laissez-faire approach adopted by the British in the period prior to the war not only did not have a detrimental effect on Britain's preparedness for the war in aviation terms, but also placed British armed forces on a firm footing to be able to take advantage of this fledgling weapons platform as the war developed, meaning that by November 1918 the RAF was the premiere air force in the world in terms of its sheer size and structure.

1903–1914

Perhaps the most interesting early direction in the development of British military aviation was the attempt to create a stable flying machine. This attempt was independently undertaken by Corporal Dunne, who was one of the pioneers of British military aviation. This effort was due to the fact that prolonged operation of the Wright brothers' machine was extremely tiring for pilots, whose main task at the time was to carry out reconnaissance. The resulting instability of the design was therefore an obvious disadvantage (Driver 1997: 58). However, any initial achievements were overshadowed by two key events. The first was the successful test flight of British Army Airship Number 1 (which was given the nickname *Nulli Secundus*) on September 10, 1907. It was a lighter-than-air aircraft that managed to complete a three-hour flight over central London, a distance of about 80 kilometres.[2] The second event was political in nature and partly resulted from the first. The Committee of Imperial Defence (CID) took a keen interest in the development of aviation and its practical military application. In early 1908, General Douglas Haig[3] had a conversation with Colonel Capper to determine the best direction for official policy. Capper's frank answer shows the thinking of the time. He argued that airships were the best type of strategic offensive weapon because they could be used against enemy targets as bombers, while airplanes were still a song of the future (Capper avoided speculation during this conversation):

"It seems that the immediate application of the flying machine is quite limited. So far, only short flights have been carried out, and it is not yet known whether humans can withstand the stresses of being in the air for long periods of time without extensive prior training. They may be useful against airships if they manage to take to the air during an attack (...) it is likely, however, that an airship, unless severely damaged, will

[2] Coincidentally, the engine that was used by Samuel Franklin Cody in the first powered flight by a British plane used was first used to power the airship. This plane was referred to as either British Army Aeroplane No 1, or Cody 1. It achieved sustained flight on October 16, 1908, almost five years after the Wright brothers, and ten months after Louis Bleriot in France.

[3] Given the role he played during World War I (including commanding the British Expeditionary Corps from 1915 to 1918), his early interest in the development of aviation is key to understanding how aircraft, despite the skepticism of traditionalists and conservatives, became such an important part of the British war machine. It is, however, equally important to note that there was an external impetus as all of the major powers of Europe (and beyond), especially the French and the Germans, were investigating the military application of aircraft.

always manage to escape (...) When they are eventually improved, they will probably have great offensive potential (...) and will displace airships from the aerial battlefield; until the first machines are tested, however, there is no point in speculating on their capabilities." (Gollin 1979: 56)

The Admiralty's first serious contact with aircraft took place in July 1910, when Lieutenant George Colmore became the first "seaman" with pilot qualifications, which he earned in three days, between July 19 and 21 (Philpott 2013: 23). Interestingly, referring to Colmore's success, it can be inferred that, since he was the first seaplane pilot, the first seaplane was the Short S.26,[4] which he used during his successful test (Philpott 2013: 24).[5] The aircraft was loaned to Colmore by Francis McClean,[6] who later became a very influential figure in naval aviation. The aircraft's manufacturers were also to have a significant impact on the development of naval aviation, as many subsequent breakthroughs were made using Shorts aircraft. The land forces also had their own "experts," including one of the leading aviation promoters Geoffrey de Havilland, who was hired at Farnborough to continue work on developing a stable reconnaissance machine. His efforts bore fruit on December 11, 1911, when the first aircraft developed by the Royal Balloon Factory at Farnborough, designated B.E. 1, took to the air.[7] Shortly thereafter, in February 1912 (Driver 1997: 24), the B.E. 2 made its first flight. The two aircraft differed only in the engine installed in them. Most importantly, both designs met CID requirements for stability in the air (Edgerton 1991: 13). Stability was considered an essential feature of aircraft, then used mainly for reconnaissance. The B.E. 2's low accident rate and high performance made it the standard aircraft on the British Army's equipment at the outbreak of hostilities in 1914. Another technological breakthrough was the installation of a wireless machine developed by R. Widdington in the B.E. 2 and the successful testing, during which it was possible to maintain effective communications over a distance of more than 3 kilometres. This led, on April 11, 1912, to the first military exercises by the British Army involving directing artillery fire from an aircraft (*Farnborough Air Sciences Trust*: 3).

[4] The Shorts was a biplane based on the Farman design with an engine in a push-pull arrangement, in which the propeller was attached to the rear of the engine.

[5] Coleman was the fifteenth pilot to gain qualifications under the Royal Aero Club, which had been granted the authority to issue pilot licenses since early 1910.

[6] McClean himself, a founding member of the Royal Aero Club, was awarded certificate number 21.

[7] The B.E. designation came from Bleriot Experimental and was a cover for a new concept of aircraft produced by de Havilland.

1911 also saw the transformation of the Balloon Section of the Corps of Engineers into an independent Air Battalion. Headquarters and (Air) Company No. 1 were located at Farnborough, while (Air) Company No. 2 was to be based at Larkhill on Salisbury Plain (the British Army's main training ground) (Short History of the Royal Air Force: 3). This division showed a tacit recognition of the need to develop and use heavier-than-air aircraft, despite the reluctance of some in the command (e.g., Nicholson). Initial requirements for pilots were to have: an Aviator's Certificate (which cost £75, later reimbursed by the War Ministry), sailing skills, mechanical skills, map reading and drawing skills (Short History of the Royal Air Force: 3). These requirements were based on the fact that the planes were to be used for reconnaissance. This requirement was entirely in line with the general thinking concerning the optimal military application of aircraft, as it was not until well after the outbreak of the War that other uses were envisaged (Abżółtowski 1925: 16).

The year 1911 saw several momentous events in the development of naval aviation, the most important of which happened in November and December. First, and also quite logically, Commodore Oliver Schwann (deputy to Murray Sueter, commander of the Aviation Department in the Royal Navy) managed to launch an aircraft from the surface for the first time. He did so in a machine he had ordered from Avro[8] for the fabulous sum of £700 and which was later converted into a water plane.[9] Interestingly, Schwann crashed the plane after climbing less than 500 feet – the reason may be that he didn't get his pilot's license until later, in 1912 (Philpott 2013: 28). Exactly one week after this event, on November 25, the first successful takeoff from the ground and landing on the water in a modified Curtiss was made. Finally, on December 1, Lieutenant Longmore succeeded in the amazing feat of taking off and landing on water, after which his aircraft was pulled out of the water for further use. This milestone was set using Naval Biplane No. 2 (which was a modified Short 28 in which Longmore had earned his license and which belonged to McClean). While all this was going on, engineers were in the process of attaching a platform to the reserve battleship HMS Africa,[10] with the intention of conducting an experimental launch from the craft. Lieutenant Samson, the initiator of the project, became the first man to success-

[8] Instead of relying on machines produced by the Royal Aircraft Factory, the Admiralty sought designs from private manufacturers.

[9] In this type of seaplane, the entire fuselage floats above the surface of the water and is supported by several (usually 3) floats, making it a water-landing design.

[10] HMS Africa was a pre-dreadnaught battleship, and was assigned for the testing of aircraft while a part of the Home Fleet.

fully launch a wheeled aircraft from a ship, on January 10, 1912. True, the HMS Africa was at anchor at the time, but in May of the same year Samson became the first man to successfully launch an aircraft from a moving ship. He did so from the deck of HMS Hibernia during the annual Fleet Review (Philpott 2013: 29–30).

With developments aimed at increasingly reliable and stable aircraft, the Admiralty's attention was drawn to the question of how best to take advantage of the fact that aircraft can take off from a ship. The high-flyer class cruiser HMS Hermes was therefore refitted so that it could take part in manoeuvres in 1913 to test the potential role of aircraft in fleet operations and to assess their endurance during naval operations (Farquharson-Roberts 2014: 36–38).[11] On May 7, HMS Hermes entered service as the Royal Navy's first seaplane tender.[12] On its deck was a runway and a special crane installed to pull aircraft out after water landings. After modifications, the ship was able to take "as many as" three aircraft. The machines were to serve a reconnaissance role and were equipped with wireless radio transmitters. Due to the great size of these devices and the weight restrictions on carrier-based operations (which had been their curse over the years), it was found that the only effective way to use the aircraft was to take off and observe and then land next to the ship, which in turn relayed the information gathered over a greater distance. During these exercises, HMS Hermes was assigned to the Red Fleet (traditionally representing the Royal Navy's main enemy), which was commanded by Vice Admiral John Jellicoe, who had been an important naval figure during World War I. Jellicoe was later to use his experience with aircraft in the Grand Fleet, particularly during the Battle of Jutland in 1916 (Horowitz 2010: 65–69).

In 1914, at the outbreak of World War I, 63 aircraft were ready for use as part of the British Expeditionary Force (BEF). Interestingly, according to the documents, it appears that the Royal Naval Air Service (RNAS)[13] entered the war with a larger force than the Royal Flying Corps (RFC). The Admiralty had 95 aircraft, including 55 seaplanes, six

[11] The Royal Navy were not the pioneers of seaplane tenders, with the French Navy modifying Foudre for a similar purpose in 1911 (Moulin 2020: 15).

[12] On the basis of existing Royal Navy terminology, the word tender was applied to ships whose role was to provide support for other vessels that acted independently. In this case, Seaplanes were lowered into the water for takeoff, and then collected by crane once they had landed at the end of their mission, thus the idea of a 'tender' rather than 'carrier'.

[13] The RNAS was established on July 1, 1914 as an attempt by the Admiralty to maintain control over the independent development of its own air formation. In theory, the issue of military aviation was resolved once and for all by the creation of a unified RFC. However, the jealousy caused by the creation of a rival formation meant that the Royal Navy was unwilling to cooperate in any form.

airships and two observation balloons (Cooksley 2014: 37). What's more, these aircraft were perfectly equipped for the role they came to play. The B.E. 2 was a very stable platform from which reconnaissance could be carried out (not long after the outbreak of war it was possible to mount cameras on the sides of the aircraft) (Kennett 1991: 25–37). The RNAS developed simple bombs,[14] which could be thrown over the side of the aircraft and even made strides toward producing a workable targeting system, and machine guns[15] were mounted on some aircraft[16] (despite their reconnaissance purpose). It even became possible to conduct night flights (thanks to Lieutenant Carmichael, who worked with his mechanic on switchable compass and tachometer lighting) (Kennett 1991: 52–54). What's more, the newly formed RNAS was able to make one last breakthrough. On July 28, it was able to drop a 14-inch, 850-pound Whitehead torpedo from a Short-branded trailing-edge biplane, thus marking a new use for the aircraft as a potential offensive naval weapon (Grove 2011: 29).

To sum up the first part of the article, it can be said with considerable certainty that the British entered the war in 1914 with a clear concept of a range of military applications for flying machines. The only thing they lacked was practical testing of their theories. On the other hand, however, similar "ignorance" was exhibited by all major participants in the conflict. From the British point of view, their concepts needed only a few adjustments to adapt to real combat conditions.

World War I

August 4, 1914. The British joined the war against Germany, obliged by an agreement 80 years earlier to maintain and defend Belgium's neutrality. While France and Germany had huge armies, the Brit-

[14] The 9-kilogram Hales bombs, invented and improved in 1907-14, were designed for heavier-than-air aircraft. The RFC and RNAS, by the time hostilities began, had 9.07-kilogram, 45.36-kilogram and 50.8-kilogram bombs available. The first type of bombs were intended against "soft" targets and were equipped with a wire handle that allowed the pilot or observer to more accurately drop them on the target. The other two types of bombs were used against buildings, railroad tracks and bridges.

[15] The most popular mounted machine guns were Vickers 7.7mm or Lewis 7.7mm.

[16] One of the reasons why the Vickers Company is famous is its intended production of the world's first fighter aircraft, the E.F.B 1 (Experimental Fighting Biplane, called Destroyer by the manufacturer). It was a response to the Admiralty's request for an aircraft that could play an offensive role against the German Zeppelins. It was a prototype and only 1 demonstration aircraft was produced. It crashed during its first flight, but the concept itself was so promising that further research was conducted, resulting in the Vickers F.B. 5 Gunbus.

ish Expeditionary Corps, sent under the terms of the Triple Alliance, consisted of two infantry corps (each consisting of two divisions) and a cavalry division (together with an independent cavalry brigade). The BEF was supported by 4 squadrons (numbers 2, 3, 4 and 5), which together numbered 48 aircraft (out of a total of 63 British aircraft).[17] Squadrons 2 and 4 were equipped with B.E. 2 machines, squadron 3 with Bleriot XI and Farman M.F. 7, and squadron 5 with Avro 504 and B.E 8 (Carradice 2012: 40–41). An interesting fact is the lack of balloons, caused by the temporary transfer of the 1st balloon squadron to the RNAS (which were tasked with carrying out air attacks against the Germans), which meant that in 1914. The RFC did not have a single balloon at its disposal (it was not until 1915 that the balloon squadron was transferred to the Western Front) (Bruce 1957: 38).

Touching on the RNAS, it should be mentioned that the formation was assigned three main roles, the most important of which was initially to perform reconnaissance for the fleet. The second role of the formation, previously envisioned by Churchill, was to defend the coast and fight airships.[18] The third type of task was to bomb German installations located on the coast in order to weaken the strength of the German Ocean Fleet, and to destroy airships standing in hangars when they were most vulnerable (Halpern 1995: 69–70). Therefore, when at the very beginning of the war, on August 13, three of the four active RFC squadrons were transferred to France, while the RNAS were left in place to deal with the defence of the islands. It is interesting to note that as the demand for aircraft at the front increased, especially after the situation became more stable in November, more and more RNAS

[17] By comparison, the French *Aeronautique Militaire* had 21 squadrons with 132 operable aircraft, and Germany's *Die Fliegertruppen des deutschen Kaiserreiches* had 180 operable aircraft at the start of hostilities. When one compares the size of the army at the start of mobilisation and the length of the front lines, it becomes clear that the BEF had the highest ratio of operable aircraft per division. Also, given that aviation had observation roles, the sheer number of aircraft was less of a factor in attempts to achieve air superiority, which at the time was not a doctrinal concept.

[18] Winston Churchill explained the lack of airships on RNAS equipment when he was asked in Parliament about the alleged British stagnation compared to the development of the German Zeppelin program. In response to the criticism, Churchill said "compared to the navies of other countries, the British Air Force has got off to a very good start... I have a less satisfactory view as far as airships are concerned. Their development has been delayed by many factors. The accident at Barrow, in which a May-fly, or perhaps better a Won't-fly (a play on words: May-fly – can fly, Won't-fly – won't fly) was destroyed, was a very serious setback damaging the development of the airship program." Given such clearly expressed support, it should come as no surprise that Churchill himself, on May 18, 1914, recommended to the RNAS the creation of a wartime squadron of ten fighter aircraft equipped with Vickers machine guns (Philpott 2013: 47).

units were designated to support ground forces, thus becoming almost a rival service to the RFC.[19]

For the RFC, the war began in a somewhat unfortunate manner. The first losses were suffered while still transporting units – an aircraft crashed shortly after takeoff from the RFC's main base at Larkhill (and indeed, accidents of this type proved to be a major threat to pilots before the planes were not used in significant numbers on the battlefield of the Somme in 1916). Eventually, after a circuitous route, the RFCs merged with the Expeditionary Corps in Amiens and moved together toward Belgium to confront the approaching Germans. The first air operation took place on August 19, but had to be aborted due to a combination of bad weather and poor planning – it was decided not to take an observer so that the aircraft could stay in the air longer. The first casualty of combat operations came rather quickly – Avro 504 of the 5th squadron was shot down over Belgium by German infantry as early as August 22. However, on the same day the RFC scored its first tactical victory, as Captain L.E.O. Charlton (observer), located the German First Army's approach to the BEF's right flank. As a result, Field Marshal French was able to regroup his forces and successfully[20] face the Germans in the Battle of Mons. This action and subsequent actions meant that the combat value of the RFC was quickly recognised by the commanders; Sir John French was able to report in a September 7 dispatch how the planes had proven their usefulness: "I would particularly like to draw Your Lordships' attention to the splendid work done by the Royal Air Corps. They provided the most accurate and complete information possible, which is invaluable in the operations carried out. Shot at constantly by enemies and their own and not hesitating to fly in any weather without a word of complaint, they continue their mission." (Carradice 2012: 37–39)

While ground warfare became a static, stuck-in-the-trenches struggle, the importance of aircraft grew dynamically. Pilots' tasks included photographic reconnaissance and directing artillery fire.[21] The use of

[19] Interestingly, on April 1, 1918, when the RNAS AND RFC were merged to form the RAF, the size of these formations was almost identical, with 53,000 and 57,000 soldiers and officers, respectively.

[20] The word success is quite a relative term in this case, as the traditional perception of the "brave little army" has been replaced in recent historiography by a somewhat more critical analysis, taking into account the mistakes made by the BEF at Mons and the general incompetence of the command, especially Sir John French (Hastings 2014: 203–212).

[21] The French were the pioneers of photo-reconnaissance, as can be seen by the comprehensive treatise on air warfare written by the French theoretician, Commandant Marcel Jauneaud, in which he described the optimal methods for photographic reconnais-

photography for accurate terrain mapping was first tested by the British in September 1914 (Kennett 1991: 35). The first method of photography was for the observer to hold a camera over the side of the aircraft or to take pictures through a special hole in the floor. It was not until mid-1915 that cameras began to be mounted on aircraft fuselages. The high resolution of the photos taken from an altitude of 4,500 meters allowed accurate analysis of 3–4 square kilometres of terrain (Kennett 1991: 36). As a result, for the first major offensive conducted in the spring of 1915, the Battle of Neuve Chapelle (March 10–13, 1915), the British entered equipped with accurate photographs of the terrain and enemy units. The battlefield was photographed to a depth of 1.3 kilometres, which made it possible to create accurate maps with which each platoon was equipped. This tactic was used unchanged until the end of the war, only the speed of the planes and the quality of the cameras were improved.

When it came to directing artillery fire, the key to success was the effective transmission of information from the aircraft to the gun batteries on the ground. Wireless communication, however, was not the best solution. At the beginning of the war, a radio communication set weighed about 35 kg[22] and once it was installed in the aircraft, there was already not enough room for the observer. As a result, the pilot had the task of maintaining stable flight, observing where artillery shells hit (which was already an incredibly difficult task in itself), avoiding enemy fire and tapping out information using Morse Code (Carradice 2012: 51). Another problem was the antennas used in wireless transmitters. They were more than 75 meters long and often became entangled in the aircraft's mechanisms, causing obvious problems with control of the machine. Moreover, the pilot had to unroll such an antenna before each transmission and cut it off if more violent manoeuvres were necessary. Hence, in the beginning, the transmission system was based on paper messages. The observer would record the location of the missile hit, drop the message to the advanced ground observer and return to observe the fire correction. This was, clearly, an incredibly labor-intensive and inefficient system. Various other ways of transmitting information were tested, such as marking targets with smoke bombs, flares or flashlights and flags. However, an accurate and effective way of directing fire from the air became possible only after the invention of the Sterling light wireless set, in early 1915. It was also at this time that the first squadron special-

sance and details of both tactical and strategic reconnaissance flights (including number of planes and recommended altitude of individual missions (Jauneaud 1925: 20–85).

[22] The heaviest sets could weigh as much as 75 kg

ising in wireless communications was formed. It was numbered 9 and commanded by Major Hugh Dowding. The only thing left to develop was an effective reporting procedure, which was also achieved in 1915. Two young officers from the Wireless Communications Unit headquarters developed the so-called "grid" system, in which maps were divided into square sections, allowing the observer to transmit accurate reports of shell hits using a simple alphanumeric code (Kennett 1991: 40–41). However, the system had one disadvantage – wireless communication was only in one direction, pilots had no receivers and it was very difficult to communicate with them after the aircraft took off. The most common solution was to use a flag code to confirm receipt of a message. However, there was no way to transmit new orders about targets, etc. Nevertheless, the effectiveness of directing fire from the air was proven beyond doubt and, in 1915, each corps was assigned a corresponding unit equipped with wireless communications (Bruce 1957: 104–107). The issue of two-way communication was finally solved by a team of engineers from the Marconi Company, who, as early as the second half of 1915, managed to equip aircraft with a wireless "telephone" allowing the pure transmission and reception of voice information at distances of up to 25 km.

But, returning to the subject of naval aviation, the early-war actions of the RNAS were, in part, shaped by Winston Churchill, who had a rather offensive attitude.[23] This aggressive approach is evident in the British response to the Zeppelin threat, which manifested itself during the first few weeks of the war. The Committee of Imperial Defence was fully aware of this threat and convinced that the Germans would not use the airships merely for reconnaissance tasks, having bombed Liege and Antwerp with their help during the first three weeks of hostilities.[24] Churchill instructed the RNAS to begin preparing an air raid plan to destroy the Zeppelin bases in Cologne and Dusseldorf, assuming that the airships could be destroyed while they stood moored in hangars. This strategy was chosen with the hope that it would finally provide an opportunity to "shoot down a Zeppelin." Given the aircraft's limitations in terms of attainable altitude and ability to mount weapons on them, a successful attempt to shoot down an airship during a raid was unlikely,

[23] Evidence of this can be seen in his surprising intervention as First Lord of the Admiralty during the first stage of the war, when he created an ad hoc division consisting of naval personnel (mainly Marines) to carry out a completely unplanned and unapproved by anyone defence of the city of Antwerp (Hastings 2014: 448–451).

[24] Liege was bombed on August 3, and Antwerp was bombed several times, with the first raid taking place on August 25 (Garvin 2013: 4–6).

to say the least. Two of the key figures behind the planning of the raid were Air Division commander Murray Sueter and eccentric flying enthusiast Noel Pemberton Billing, appointed as project coordinator (Kennett 1991: 189–194). The first step was to acquire aircraft suitable for the mission, which was done by requisitioning two BE reconnaissance aircraft. 2 and two Sopwith Tabloids. The first raid by the RNAS took place on September 22, 1914, and was a complete failure.[25] A combination of bad weather and unreliable equipment meant that only one of the four machines reached its target, and only one of the bombs dropped exploded, without doing any damage (Garvin 2013: 18-19). The psychological rather than real effect of the incident encouraged Sueter to pursue further ventures, but these were already bombing raids carried out from bases located on land. This experience, on the other hand, led to one of the most important breakthroughs in the development of naval aviation because the RNAS commander was encouraged to experiment with the concept of raids on German territory using aircraft launched from the sea.

The last raid that the RNAS organised in 1914 also required an enormous amount of preparation, as the target was the Nordholz base near Cuxhaven at the mouth of the Elbe River. The target was beyond the limited range of ground base-based aviation, so a new approach was required to succeed. The roots of the raid go back to Admiral Jellicoe's forward-looking experiments on the ship Hermes. Exactly one week after joining the war, the Admiralty handed over three Channel-floating steamers for immediate conversion into seaplane tenders, and thus HMS Engadine, HMS Riviera and HMS Empress were created, which played a leading role in the Cuxhaven raid (Farquharson-Roberts 2014: 140–144). The Admiralty formed a battle group called the Harwich Force, which included these three tenders supported by light cruisers and destroyers (one member of the planning committee hoped that part of the German High Seas Fleet would leave the harbour in search of the strike group, enabling the Royal Navy to engage and sink some German ships), and Admiral Jellicoe timed the order to leave so that the raid could take place on Christmas Day. Each aircraft carrier had three seaplanes on board, but on the morning of December 25, due to the cold weather, only seven of them were mechanically fit for action. Thus, the first Royal Navy air attack from the water began at 7 a.m. and seven machines took

[25] This was not, however, the first ever sea-launched air raid, as the Japanese beat the British to this particular accolade by the small margin of 17 days. On 5 September, 1914, the Japanese Seaplane Carrier Wakamiya launched its two seaplanes on a variety of bombing raids during the Siege of Qingdao, which ultimately resulted in the surrender of the German forces in the area (Hitoshi 2005: 184).

part, all of which were modifications of the Short Folder aircraft,[26] developed in Eastchurch before the war. The raid failed in terms of its main objective, which was to destroy the hangars at Nordholz, as well as its second objective which was to lure the German fleet out of the harbour. It did, however, record two successes – the first was that all seven crews survived, even if only three of the planes returned to the carriers. The other three made an emergency landing near a British submarine, which picked up the crews and sank the planes, and one of the pilots landed aground and was picked up by a Dutch trawler with his crew (Garvin 2013: 24–27). The second success was the withdrawal of the German fleet from the Cuxhaven base and its dispersal to various points in the Kiel Canal. The raids had another effect – they influenced Sueter himself. During a discussion with aircraft designer Frederick Handley Page, Sueter brought up the ineffectiveness of bombing raids, pointing out the ridiculously low payload capacity of the planes. In conclusion, he said the following "what we need is a damn flying destroyer." (Kennet 1991: 89) After this conversation, Handley Page began the process of developing "O" series bombers (about which more will be said later). In addition to offensive operations related to coastal defence against Zeppelin attacks, the RNAS also supported the RFC on the Western Front (especially by bombing targets behind enemy lines, such as railroad stations and marshalling yards). The Navy, still worth mentioning, took delivery of its first purpose-built seaplane tender, HMS Ark Royal, on December 10. In the end, it proved too slow to take part in fleet operations and was thus intended to be a foothold for RNAS operations on other fronts (O'Hara 2010: 136–139).

One of the most important changes that took place in 1915 (aside from issues strictly related to the use of aircraft as reconnaissance machines and as fighters)[27] was the appointment of Major Hugh Trenchard as commander of the RFC in France. Trenchard was already an influential figure during the first stage of the war struggle, as commander of the RFC's First Wing. Because of his close relationship with General Douglas Haig (commander of the First Army and later the BEF) and his strong belief in the use of aircraft during ground operations, RFC aircraft were

[26] Models 74, 81 and 135, each loaded with three 9-kilogram bombs, took part in this raid (Bruce 1957: 156).

[27] It was the French and Germans, almost in unison, who were to produce the first designated fighter planes (the Fokker E. III and the Nieuport 11 respectively), although fighters were initially used simply as escorts for reconnaissance planes. The Germans were the first to use a designated fighter squadron over Verdun, although this was quickly countered by the French (Abżółtowski 1924: 58–59; Neumann 1920: 4).

used, for example, for direct support, bombing railroad stations and approaching columns of German reserves.[28] Trenchard, who was to remain commander of the RFC until the unit's incorporation into the Royal Air Force in 1918 (at which time Trenchard was appointed Chief of the Air Staff),[29] was guided by a few simple beliefs and goals to achieve, which proved decisive in shaping the RFC's role during World War I. One was the development of an integrated pilot training system, which led to a huge reduction in non-combat-related fatalities (during the entire war, 50% of RFC pilots died in such accidents, and during the offensive on the Somme it was as high as 80%). The system was also needed due to the ever-increasing demand for pilots caused by the growing role of aviation in military operations. In addition to creating an adequate infrastructure, Trenchard had three simple operational priorities: disrupting enemy ground supply lines with bombing; believing in the effect of aircraft on enemy morale - Trenchard believed that the sight of aircraft in the sky weakened the Germans' will to fight; the use of fighter planes to allow for air superiority over the battlefield to allow reconnaissance planes to fly with relative impunity; and, finally, using the RFC as a major offensive force, although he was a fervent opponent of using valuable RFC assets for strategic bombing inside Germany.[30]

Trenchard's dream did not come true until two years later, in the spring of 1917, when machines capable of supporting ground units appeared. Previously, pilots had simply dropped the aforementioned Hales bombs on exposed infantry, but this had the hallmarks of coordinated cooperation between ground forces and their "air support." In May and June 1917. Trenchard ordered squadrons supporting ground troops over the Somme to deliberately smash exposed enemy formations on or behind the front line. Since better aircraft were needed for this task, it was decided to use the Sopwith Pup and Sopwith Camel designs,[31] ,mainly

[28] For the occasion, bomb holders were installed under the wings of the planes, which the pilot could release by pulling a cable. This made bombing very easy, as previously the pilot or observer simply threw bombs over the side of the aircraft (Cooksley 2014: 124–125).

[29] Because of his achievements in developing the RFC and his subsequent command of the RAF, Trenchard is often referred to as the "Father of the RAF".

[30] This final task was mainly entrusted to the RNAS, which ordered dedicated bombers, notably the Sopwith 1½ Strutter and the Handley Page Type O. The RFC admittedly used bombers, but Trenchard advocated their use for land operations.

[31] After the first actions of this type, the RFC ordered an aircraft dedicated to supporting ground forces, featuring an armoured cockpit. The Sopwith Salamander went into production in March 1918, and 1,500 of the machine were ordered. However, the sudden

because of the machine guns installed on them that enabled them to fire on the battlefield. It also happened that the more enterprising pilots installed simple bomb holders under the fuselages of the machines, but due to the rather unpredictable course of the first raids on ground targets, most of them were carried out only with machine guns. In his autobiography from his service during World War I, William Sholto Douglas describes his first order to carry out a raid on a specific ground target and the accompanying sense of "making history". His assignment was to attack a formation of German troops gathering in trenches in the Bullecourt sector of the Hindenburg Line. Information on troop movements was obtained through aerial reconnaissance carried out a little earlier. Sholto Douglas describes the results of the mission as relatively satisfactory, but attributes them to the element of surprise (Sholto Douglas 1962: 193–194). He concludes the story by mentioning the "lack of casualties," but the casualty rate once the Germans became accustomed to the new type of threat was extremely high – according to the official RFC report, more than 30 percent of missions ended with the loss of an aircraft and more than 90 percent of the machines that managed to return were damaged to some degree (Hallion 2011: 20–21). By the time of the Battle of Cambrai taking place in November and December 1917, the terms "aerial shelling of trenches" and "aerial shelling of ground targets" had become part of the terminology used by the RFC. The difference between the two was that the former meant firing at trenches from a low-flying aircraft using a machine gun, while the latter usually involved dropping bombs – and was a rather primitive way of creating confusion among the units under attack. As one can imagine, these were not the most pleasant tasks, as the description of one frontline Camel pilot confirms:

"[...] flying under the clouds [in formation] ... firing at targets on the ground, and in response, all the 'hatred' the enemy could direct at us in the form of machine gun fire, cannons and anti-aircraft guns ... We almost always returned to base in damaged machines." (Hallion 2011: 24–25)

The apogee of air attacks on ground targets occurred in 1918 during the failed German offensives. The RFC reported the consumption of an astounding 200,000 rounds of ammunition during raids in the first four days (with this figure not including ammunition consumed during air battles). Although the RFC did not directly contribute to the final defeat

retreat of German forces during the Hundred Days Offensive and the armistice meant that only two machines made it to France for testing.

of the Germans, the formation certainly had a hand in slowing the march of German forces, allowing Pétain and Haig to regroup their forces and face the new threat. Later, the still fledgling RAF was to become a key element of support for the advancing troops. This is evidenced by the amount of ammunition used in a single day for just one sector – on August 8 at Amiens, 1,563 bombs were dropped to support the infantry and 122,150 rounds of ammunition were fired. Although such high figures do not refer exclusively to the British, they clearly show that Trenchard's dream of RFC/RAF becoming a major offensive weapon had come true.

Disrupting the chronology a bit, let's return to the RNAS. The year 1915 saw the expansion of the formation's activities in the Mediterranean, in support of operations against the Ottoman Empire. Preparations for the Dardanelles campaign involved part of the RNAS and meant the transfer to the Mediterranean of the 3rd Squadron and the aforementioned HMS Ark Royal, which was dispatched in February (Farquharson-Roberts 2014: 157). The Ark Royal could accommodate 8 seaplanes and was initially equipped with Sopwith Tabloid and Wight Pusher machines. However, these aircraft proved to be extremely unreliable and were quickly upgraded and the Tabloids were replaced with one Type 166 Short, two Sopwith 860s, two single-seat Sopwiths Schneider and another Wight Pusher (O'Hara 2010: 137–138). The Sopwith 860 was the most advanced aircraft in British possession during the Dardanelles campaign. It was capable of carrying a single 367 kg torpedo and had folding wings for easy storage aboard the Ark Royal (O'Hara 2010: 139). The other aircraft were initially used for reconnaissance and artillery guidance, but RNAS weer soon assigned further tasks in the face of their relative lack of efficacy (Korzeniowski 2018: 53–56). The most important of these were mine detection and bombing. The formation didn't quite manage the first of these tasks, as pilots and observers needed calm seas to succeed. In general, faith was lost in the prowess of the RNAS when, on March 18, 1915, three liners were sunk and three more severely damaged while crossing the Dardanelles Strait. Initial blame was placed on the observers from the air, but it was later determined that an undetected Ottoman torpedo boat had sewn a string of mines in the Morto Bay following a reconnaissance flight (Halpern 1995: 53–55).

In May 1915, Ark Royal was joined by a second seaplane tender, HMS Ben-my-Chree.[32] Ben-my-Chree had on board two experimental

[32] It was a converted steamer that had previously sailed in the Irish Sea between the Isle of Mann and Liverpool. It was the only Royal Navy aircraft carrier lost during the

Short Type 184 watercraft,[33] which were built specifically to carry the Royal Navy's standard 14-inch torpedo.[34] These two aircraft and the ship had the honour of being the pioneers of torpedo bombing. On August 12, Flight Commander Charles Edmonds was the first pilot in the world to fire a torpedo from an aircraft during wartime operations. The only problem was that his target was already lying on shore, having previously been damaged by a torpedo fired from a submarine and subsequent attempts by the crew to scuttle the ship. Edwards compensated for the incident and five days later dropped another torpedo, this time sinking an Ottoman transport ship. Edwards' wingman, who had to land due to engine problems, spotted the small Ottoman boat. Having repaired the malfunction, he brought the aircraft into position, fired a torpedo and sank the ship. Over the next few minutes, RNAS managed to sink another two ships. This allowed the superiority of shipborne aircraft over heavy warships to be seen for the first time.[35] In the end, efforts to eliminate the Ottomans from the war proved fruitless, but not for lack of support from the RNAS, which was tasked with operating in the Middle East until 1918, mimicking RFC operations conducted on the Western Front.

Continuing with the topic of naval operations, the main goal of the designers' efforts was to develop a way to allow aircraft to take off, return and take off again from the deck of a ship. This was successful as early as 1912, when Commodore Samson managed to take off from the gun turret of the ship HMS Hibernia, but the outbreak of war forced the Admiralty to temporarily halt work on the development of ship-bases. However, as the possible uses of aircraft and the power of their engines increased, so did the potential for the development of aircraft carriers as they are understood in the modern sense. All that was needed was a suitable machine. It appeared in 1916, after the RNAS command placed an order for two prototypes, which were made by Sopwith and tentatively

war – it was sunk by Turkish guns while scouting for French forces conducting a land operation on the island of Kastellorizo (Halpern 1995: 56).

[33] It was one of the most heavily produced naval aircraft of the War, with more than 900 units between 1915-18 (Bruce 1957: 304).

[34] During a meeting between Murray Sueter and the Admiralty regarding an aircraft designed to carry torpedoes, which was to stay in the air for at least two hours, Horrace Short immediately suggested that, if that's what the Admiralty really wanted, he would build such an aircraft. Holding him to his word, Sueter immediately ordered two prototypes. These were the very machines sent to the Dardanelles Strait in 1915 (Halpern 1995: 59–61).

[35] The transition from tenders to aircraft carriers as a basis for developing strategies is discussed in detail in Horowitz (2010: 65–72).

named Pup.[36] The main feature of this design, making it ideal for use aboard ship, was accurately described by British pilot James McCudden, who praised it in the following words: "It was an exceptionally well-made, versatile machine. It was so incredibly light and balanced that with a little practice, you could land it on a tennis court." (Brown 2013: 142) When you have an aircraft that can land anywhere, it seems obvious to try to land it on a moving ship, and a ship with a suitable deck must be found. Such a ship was to be HMS Furious, a converted Courageous-class cruiser, from which the forward gun turret was removed and a launch deck of (a then impressive) 49 meters in length was built.[37] And it was on this vessel, on August 2, 1917, that Squadron Leader Edwin Dunning made the world's first successful landing by aircraft aboard a moving ship.[38]

This achievement enabled one of the Royal Navy's most daring operations during World War I – the raid on Tondern, which took place on July 19, 1918. The target of the surprise attack was the Zeppelin hangars located in the small town. The raid was carried out using HMS Furious as the platform from which the naval versions of the Sopwith Camel aircraft took off.[39] The action was originally scheduled for June, but bad weather prevented the planes from taking off from aboard the Furious and the attack was postponed. Eventually, seven of the eight planes were launched in two waves. Two Zeppelins located in one of the hangars and an observation balloon were successfully destroyed. Of the seven Camels that took off, one was slightly damaged by air defence (losing one of its suspension components), one failed to reach its target through engine failure, and three pilots from the first wave decided to fly to Denmark, as they did not have enough fuel to return to Furious. The second wave, after returning from the mission, landed at sea, with two of the three aircraft managing to pull out.[40] All in all, with the loss of one pilot, the

[36] As a curiosity, it is interesting to note that, probably as a result of its alleged superior hierarchical position (and pre-war cooperation with the private sector), the RNAS regularly came into possession of new aircraft models much earlier than the RFC.

[37] The only minor problem with this layout was the need to manoeuvre around the ship's superstructure during the landing approach. This was until the British ordered HMS Argus, which had a full launch deck, much like modern aircraft carriers.

[38] Dunning died during the third landing, after which testing was temporarily suspended. However, the technique itself proved successful and, with the design of the first aircraft carrier, work on it went forward.

[39] This version had a shorter wingspan to allow storage aboard an aircraft carrier and was equipped with Lewis rifles positioned above the wings, instead of the standard synchronised Vickers.

[40] It is likely that Lieutenant Yeullet's plane ran out of fuel before it reached the landing zone, and the squadron was forced to return to base to avoid a German counterattack.

combined naval and air forces eliminated three enemy aircraft and forced the German Ocean Fleet to close the attacked base. The significance of HMS Furious was so great that information about the vessel was officially restricted by the Official Secrets Act, while the New York Times wrote in an article about the raid: "[T]his vessel is a great puzzle to the foe, and reference to her peculiarities is officially restricted to a statement that 'she is an airplane carrier'." (New York Times, Thursday July 25, 1918)

The success of the raid reinforced the Navy's belief in the great importance of operations conducted from aircraft carriers, and prompted Murray Sueter to propose that HMS Furious be used in an even bolder operation – to bomb the High Seas Fleet standing in port using the new Sopwith T1 (later known as the Cuckoo). Unfortunately, due to problems with landing gear strength and flight stability, the first operational Cuckoos were not delivered to the Naval Pilot School in Scotland until August 1918. They were then tested by pilots, and the concept of using them in combat was linked to the Navy's development of its first aircraft carrier, HMS Argus (Brown 1997: 115–120).[41] The ship underwent sea trials and entered service on September 16, 1918. However, despite hasty training, it was unable to conduct operations before the signing of the Armistice on November 11.[42] As well as HMS Argus, the Admiralty also worked on the conversion of two other hulls which became HMS Furious and HMS Vindictive (both of which were converted heavy cruisers). HMS Furious was rather impractical as the ship had its landing strip fore of the Superstructure, which meant pilots had to manoeuvre around this to land (ultimately, Furious was converted to have a full-length flight deck in the 1920s (Brown 1997: 112–115). The Admiralty's interest in aircraft carriers meant that in the inter-war period the Royal Navy was the leading maritime air power with 7 operational carriers and a further five under construction (the only other nations to take aircraft carriers seriously as a maritime weapon were the USA and Japan who had 6 and 4 carriers respectively in the 1930s). (Abżółtowski 1938: 254)

[41] HMS Argus was originally a flat-deck aircraft carrier with no superstructure. During sea trials, braking cables, a solution previously used on HMS Furious, were installed on it to facilitate deck landings. For a comprehensive discussion of the development of HMS Argus see Brown (1997: 115–123). It is interesting to note that HMS Argus was originally planned as a merchant ship, with the hull being converted. The first purpose-built aircraft carrier was the Japanese ship Hōshō, which was launched in 1922 (Jentschura, Jung & Mickel 1977: 40–42).

[42] The concept itself, however, was stored in the Navy's archives and reapplied in 1940 during the raid on Taranto, when Admiral Cunningham's Mediterranean Fleet used Fairey Swordfish torpedo-bomber aircraft to strike the Italian fleet at anchor in the harbour.

In terms of naval warfare, one of the main roles assigned to the RNAS was the defence of coastal waters, with this role sometimes receding into the background. The newly-appointed First Lord of the Admiralty, Admiral Jellicoe, wanted to include aircraft (which, of course, compared to ships, were able to patrol larger areas more quickly) [43] in anti-submarine defence (ASD) operations (Howlett 2021: 77–85). The new ASD commander, Rear Admiral Alexander Duff, quickly proposed expanding the role of the RNAS and increased the area for submarine tracking patrols to cover the British coast from Scapa Flow in the north of Scotland through the English Channel to the furthest reaches of Cornwall. Duff believed that the threat from German aviation was far less momentous than the threat of German submarine attacks, and pushed through an agreement to relocate the force. In 1915, the RNAS had 22 airships and 120 heavier-than-air machines at its disposal.[44] By the end of 1917, these numbers had risen to 63 airships (however slowly they were withdrawn from service due to their vulnerability to German seaplanes) and 314 aircraft of various types used to track submarines (Howlett 2021: 94). Impressive was not only the number of machines, but also the development of the doctrine behind this, completely new, area of military operations. A very important achievement was the development of a patrolling tactic with the curious name of the Spider Web, designed to increase the detectability of German submarines. The heart of the system was a buoy located in the eastern part of the English Channel, around which 8 patrol zones were designated. When naval radio intelligence intercepted a signal from a German U-boat and was able to determine its position using the triangulation method, this position was plotted on a map and a pilot on duty was sent to search the area. Of course, due to a number of factors affecting navigation, such as wind, the system did not work perfectly, but 25% of all U-boat detections made by the navy in 1917 were made thanks to it. As German air activity increased, the RNAS introduced more mobile and reliable

[43] Prior to Jellicoe's appointment in December 1916, attempts to deal with the U-boat threat were rather chaotic. In fact, almost nothing was done to confront them, which resulted in increasing losses among merchant ships, especially in territorial waters.

[44] This figure includes aircraft operating from land as well as seaplanes operating from the sea, mainly from around Dover and Great Yarmouth. Their main task in 1915 was to intercept Zeppelins, at which the big American seaplanes were particularly targeted, because of their long range. The record-breaking long-range Zeppelin shoot-down, performed by the RNAS, took place less than 30 kilometres off the German coast.

fighters (usually Sopwith Camel or Airco DH. 9s) into patrol service,[45] and large seaplanes and flying boats were used in formations allowing more versatile use of the Vickers .303 machine guns on board.[46]

Finally, it is still worth mentioning the RFC/RAF's attempts at direct cooperation between aircraft and tanks. At Biggin Hill where the experimental air base was located, work was underway to establish a direct wireless telephone link between a radio-equipped BE2c and an obsolete Mark IV tank, which had been modified and also equipped for communications. Ultimately, the project collapsed due to the noise in the tank, which prevented the operator from hearing the information coming from the radio. A byproduct of this experiment was the Royal Tank Regiment's development of a system for recognising tanks from the air, which was one of the first attempts to avoid incidents of friendly fire from the air (Fletcher 2016: 87–89).

By the end of the war, with the unification of the RNAS and the RFC to create the RAF, the total number of aircraft in operation was just under 22,000, making the RAF the most numerous military air power. While the French and Germans had a greater number of front-line fighter units (the French had 3,450 machines in November 1918 with a plan to increase this to 6,000 by October 1919), the RAF was organised in such a way that for every front-line squadron there was a training squadron in place, thus guaranteeing a better supply of pilots to maintain the air effort (Abżółtowski 1925: 60). Also, when looking at the number of people involved in the various air forces, the RAF had a total of 291,175 personnel (which included over 67,000 women and children), while the French had approximately 90,000 and the Germans 80,000 (Higham 2001: 11-12). This meant that British military aviation was more than fit for its many and varied purposes at the end of the war, just as it had been (in its then envisaged role of reconnaissance) at the beginning.

Conclusion

The United Kingdom was the great power that was without a doubt the slowest to recognise and adopt the concept of military aviation, but

[45] While the Camel was developed as a fighter, the DH.9 was intended to be a bomber, but it was too slow and underpowered for operations over land and so, eventually, it was used to patrol the waters around the British Isles and the Mediterranean Sea

[46] The RNAS was served by standard British Felixstowe F.2 seaplanes or Curtiss flying boats H-series. Both machines were equipped with four machine guns, giving a squadron of three machines unprecedented firepower. Incidentally, Anglo-American bomber formations during World War II were based on this tactic.

this initial weakness was to lose relevance in the longer term. In the introduction, I made clear my intention to show the consistency in the British efforts to use aviation for military purposes, regardless of the success or general efficacy of the range of ventures undertaken, especially in the pre-war period.

Prior to the outbreak of World War I, the British Army's ground forces stood firm on the need to develop a platform that would allow for accurate and reliable reconnaissance, and they did just that. They were also open to other applications of the new invention and, by 1914, adequate work had been done on this front as well, both in terms of artillery guidance and more aggressive operations. The Royal Navy also had the ambition to use aircraft on ships and, as intended, by using a combination of torpedoes and aircraft it managed to prove that capital ships were slowly becoming obsolete. The navy also succeeded in using the advantage of aircraft to address the danger of submarines.

From today's point of view, we could possibly claim that not everything was done to adequately prepare for the outbreak of war, but this would be an example of ahistorical thinking, and it is necessary to try to envisage the position of military thinkers of the time, who were presented with a novel platform, about which they knew very little.

It is possible to claim with some confidence that the RFC and RNAS entered it prepared to perform their primary roles, with demonstrated adaptability to changing circumstances and the ability to change their priorities. It is possible to conclude by saying that by the end of the war, the pilots may have had their heads in the clouds, but with their feet firmly on the ground.

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Rozwój współpracy między brytyjskimi siłami powietrznymi, lądowymi i morskimi: 1903–1918

Streszczenie

W 1914 r. armia brytyjska wyruszyła na wojnę wspierana przez nową gałąź brytyjskich sił zbrojnych: Royal Flying Corps. Przez długi czas twierdzono, że Brytyjczycy nie nadążali za militarnym potencjałem przełomu technologicznego braci Wright, co w konsekwencji spowodowało, że Wielka Brytania pozostała w tyle za swoimi kontynentalnymi sojusznikami i rywalami w momencie wybuchu Wielkiej Wojny. Niniejszy artykuł został napisany w celu skorygowania tego punktu widzenia. Podkreślono w nim, że brak centralnego kierunku w rzeczywistości umożliwił wolnomyślicielom opracowanie różnorodnych zastosowań wojskowych dla samolotów. Ostatecznie zapewniło to Wielkiej Brytanii utrzymanie przewagi technologicznej przez całą wojnę i sprawiło, że Royal Airforce cieszyło się niezrównaną dominacją w powietrzu do 1918 r.

Słowa kluczowe: lotnictwo wojskowe, Royal Air Force, Royal Flying Corps, lotnictwo morskie, I wojna światowa