Wings for the Baron

Innovation and Profiteering Among the German Aircraft Industries during World War I

This journal contains interesting historical information about the subjects covered in this game. Enjoy!

The Aeroplane Manufacturers

World War I was the first time that aeroplanes were used in support of military operations on a large scale. Initially employed chiefly for reconnaissance, technology soon enabled aircraft to be adapted to a variety of new and deadly roles.

At the start of the war, Germany was already an influential player in the fledgling aviation industry. Known for their innovative approach to design and efficiency in manufacturing, the Germans introduced a number of aviation firsts that set the standard throughout the war: synchronized forward-firing machine guns, all-metal monoplanes, and cantilevered wings.

While the impact of aircraft on the course of the fighting was mostly tactical rather than strategic, the balance of power in the air shifted repeatedly throughout the war. But the quest for new and better aeroplanes was not just between the combatant Great Powers, it was also between the competing aircraft manufacturers, eager to turn a profit while providing the new "Knights of the Air" with their increasingly deadly mounts.

Albatros Flugzeugwerke

Albatros Flugzeugwerke was the leaderer of the German manufacturers, producing by far the greatest number of aeroplanes, including trainers, scouts, two-seaters, and seaplanes. Established in 1910, it concentrated on two-seater types until technical director Robert Thelen and engineer Rudolf Schubert designed the D.I scout. With a sturdy, streamlined fuselage, a powerful inline engine, and twin machine guns, the D.I (and similar D.II) arrived at the front in late 1916 and wrested control of the air from the Allies.

But further development of the Albatros D-types was to prove disappointing. Influenced by the sesquiplane arrangement (see The Standard Game Technologies) of captured Nieuport 11 scouts, Albatros produced the D.III model, which adapted that wing structure to the D.II type. But the new smaller wing had a tendency to snap off during fast dives, a problem which subsequent models (the D.V and D.Va, shown on the player mat) failed to correct.

By the war's end, with diminished demand for Albatros' own scouts, the factory was mostly devoted to license production of the Fokker D.VII.

After the war, Albatros struggled to survive, as did all the aeroplane manufacturers of both sides. Eventually it was absorbed into the Focke-Wulf factory of World War II fighter fame.

Fokker Aviatik

Dutchman Anthony Fokker began Fokker Aviatik (later Fokker Aeroplanbau, then Fokker Flugzeugwerke) in 1912, mostly selling small quantities of aeroplanes to the Germans. It seems strange for Germany to rely on a foreigner for an important military asset, but before the war, Germany's own aero interests concentrated on airships, leaving plenty of room for foreigners to provide heavier-than-air craft.

Fokker's company struggled until the outbreak of war, when the growing need for aeroplanes resulted in a steady stream of contracts – after he applied for German citizenship. At the time, these contracts were for unarmed monoplane types loosely based on prewar French Morane Saulnier designs.

When the Germans captured Frenchman Roland Garros in 1915, his aeroplane was found to have fixed wedge-shaped blocks on the propeller. These deflected machine gun bullets that would otherwise hit the propeller as Garros fired through it. Impressed, German authorities asked for a similar device from their own manufacturers.

Fokker went one better and devised an interrupter gear which stopped the machine gun from firing whenever the propeller was in the way. The resulting design, the E.III monoplane, began the Fokker Scourge in late 1915. Though never very numerous, the machines terrified the Allies out of proportion to their numbers because they were the first aeroplanes which could be reliably expected to shoot down an enemy.

Unfortunately for Fokker, his follow-up designs were lackluster. When the Allies began to reassert aerial superiority in early 1916 with the British DH-2 and French Nieuport types, the German government turned elsewhere for scout designs.

Fokker continued to tinker, and in mid-1917, when the Albatros D series was getting long in the tooth, his triplane prototype came to the notice of Manfred von Richthofen. With that Ace's backing, the government tested it, finding it was production-worthy. Showing up at the front shortly thereafter as the Fokker Dr.I, it became the iconic example of WWI aeroplanes in the public eye.

With thick, cantilevered wings, the Dr.I was a fast climber and outstandingly nimble, but it suffered from slow speed and Fokker continued to experiment in search of a still-better machine. By keeping the thick, wireless wings of the Dr.I, but switching back to a biplane design (for less drag), lengthening the fuselage (for stability), and going to a more

powerful inline engine, Fokker came up with what was, by consensus, the best scout of the war from either side, the D.VII (see player mat). This design was the mainstay of the German air force from April 1918 until the Armistice.

In the chaos after the war, Fokker smuggled as much material as he could out of Germany and resumed aeroplane manufacture in the Netherlands.

Though Fokker himself died in 1939 as a result of complications from surgery, his company continued until it went bankrupt in 1996.

Halberstädter Flugzeugwerke

Halberstädter Flugzeugwerke was a small-time player as far as scout aeroplanes were concerned. Formed in 1912, it produced mostly trainers until the German government, pushed by leading airman Oswald Boelcke, prodded manufacturers for a biplane design in response to the nimble enemy Nieuports. Halberstadt converted its biplane B.II trainer to carry a single machine gun and use a more powerful engine, resulting in the D.II and D.III types.Though never produced in large numbers, these were great improvements over the Fokker and Pfalz E-types then in service. However, the Halberstadt models were in turn quickly eclipsed by the Albatros D-types, showing up at the front lines a few months later.

Halberstadt never produced another scout of its own design. Instead, it concentrated on the CL type (nimble two-seaters designed for ground support) and the excellent C.V artillery cooperation machine. After the war, Halberstadt turned to the manufacture of agricultural machinery, but was never successful. Its assets were sold off in 1920.

Pfalz Flugzeugwerke

When the war broke out in 1914, the Pfalz Flugzeugwerke was a recent arrival to aeroplane construction. Two Eversbusch brothers, Alfred and Ernst, together with their brother-in-law and several other investors, founded the company in 1913. Their first major production, the Pfalz E series, were copies of the French Morane Saulnier monoplane designs. (After the war, Alfred Eversbusch honored the contract with Morane Saulnier and paid them all the license fees owed for wartime production, a sum of more than a million marks.)

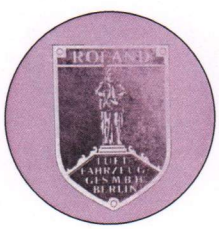
The Pfalz E aeroplanes were pretty poor fighters, inferior to the contemporary Fokker E series which were in turn eclipsed by the newer Allied types reaching the lines by 1916. As a result, contracts for Pfalz designs dried up and the factory turned to producing Roland D-types. This gave Pfalz experience with producing durable wood veneer designs, an idea which was incorporated into a new design by engineer Rudolf Geringer, who joined the company in November 1916. The result was the Pfalz D.III, a tough, sturdy plane, solid in a dive, but perhaps a tad slow in maneuvering. By April 1918, about a third of the frontline aeroplanes were Pfalz D.IIIs.

But by then the design was obsolete. Further research into designs using the available rotary engines resulted in the Pfalz D.VIII and Dr.I, but these were overshadowed by the Fokker Dr.I and saw limited production.

The last major Pfalz production model was the D.XII, similar in configuration to the Fokker D.VII but still using wired wing bracing, making it less popular with the pilots because of the increased drag and also with the maintenance crews, which had to adjust the wires to keep the wings in trim.

After the war, the Pfalz factory was ransacked by the French Army and the company went out of business. A brief re-establishment after the war in other lines of business was dissolved during the Great Depression.

Luft–Fahrzeug–Gesellschaft (Roland)



Formed in 1908, Luft-Fahrzeug-Gesellschaft (LFG) began business as an airship manufacturer, producing the Parseval series of airships for the German military. When French aviation entrepreneur Edouard Nieuport died in a flying accident in 1911, one of his engineer protégés, Franz Schneider, joined LFG and started producing aeroplane designs under the trade name "Roland" (after the legendary medieval knight) and a logo inspired by the famous statue of Roland in Bremen erected to celebrate Bremen's freedom in 1404.

The company's first (and most successful) design was the Roland C.II Walfisch "whale", a reconnaissance plane using a unique layered plywood skin (called Wickelrumpf, or "wrapped body") which created a highly aerodynamic fuselage. This same patented technique was later licensed to the Pfalz company for construction of their D.III and D.VIII designs. Although the C.II had excellent performance, and was often used as a long-range escort for bombers, it was too slow to be an effective fighter.

Roland attempted to adapt the C.II into a pure fighter by thinning the fuselage and mounting an improved engine, but the resulting Roland D.I and D.II designs were inferior to competitor aircraft, and the inherent complexity and time-consuming nature of the Wickelrumpf technique meant that only about 250 of them were ever built. Roland's output was further impacted by a major fire in their Adlershof factory on 6 September, 1916 (allegedly set by the British Secret Service) that forced them to relocate all production to a secondary facility in Charlottenburg.

Toward the end of the war Roland submitted a conventional biplane fighter design (designated D.VI) for consideration, but lost out to the Fokker D.VII. The D.VI was still ordered into production, but at a reduced rate and with a different engine – about 350 Roland D.VIs were delivered by the war's end. Roland's final fighter design submission was a parasol monoplane, the D.XVI, but it again lost out to the Fokker entry (the D.VIII).

Roland continued producing aircraft and airships for civilian use until 1933, at which point the final factory, at Seddin on the Baltic coast, was closed.

THE STANDARD GAME TECHNOLOGIES

In the early days of aviation, aeroplane design was still quite informal. It was not unheard of for the "blueprint" of a design to be no more than a chalk outline in a workshop. As with design, so with test: The only way to determine a prototype's worth was to take it out for a spin – all too often quite literally. Many a test pilot was lost when his aeroplane proved too hard to handle.

To minimize that risk, various forms of analysis were used to ensure that airframes were strong enough to withstand the stresses of flight. The German government required each manufacturer to provide three samples of each aeroplane for evaluation. One of these was taken apart and its subassemblies loaded with sand until they collapsed. This tested the static forces operating on the aeroplane well enough. Unfortunately, the dynamic forces acting on a flying craft were not understood. When pilots reported that the sesquiplane wing arrangement of the Albatros D.V was prone to cracking up in a fast dive, engineers could not figure out why. They tried reinforcing the wing and strut but the wings continued to collapse.

Modern analysis has shown that the Albatros wing configuration was subject to flutter while diving. The smaller lower wing jittered back-and-forth until eventual disintegration. However, such analysis was beyond the capabilities of the aeronautical engineers during World War I.

Agile

An Agile aeroplane tends to have smaller wings, allowing quicker turns. Control response also affected agility. (A number of designs were reported as heavy on the controls and hence tiring to fly). Conversely, controls that were too responsive were also undesirable because they required constant pilot attention, leaving less energy and time to search for the enemy. Designs with the Agile technology have their controls in the sweet spot in between.

Ailerons

Ailerons are the small moveable tabs at the ends of the wings. They could be unbalanced (with the entire moveable portion behind the axis of rotation) or balanced (with a small portion in front of the rotation). The latter was easier on the pilots because the slipstream helped move the aileron. But any aileron was better than none, in which case the pilot had to physically twist the entire wing structure to turn the machine.

Better Engines

The single best indicator of an aeroplane's performance was its engine. As Better Engines became available, competition between the manufacturers would get fierce in hopes of obtaining some of the inevitably short supply.

There were two basic engine layouts, named for the arrangement of their cylinders: inline, and radial.

Rotary engines were a subset of the latter. These had the propeller attached to the engine, with both of them rotating around the stationary crankshaft. Since the crankcase was rotating at high speed, it dissipated heat without the need of external coolants, which the inline and radial engines required. This gave the rotary engines a favorable horsepower-to-weight ratio.

As a result, rotary engines were very popular, particularly in the early part of the war when power was low and saving weight was therefore particularly important. They also aided maneuverability, with the gyroscopic precession caused by all that rotating metal jerking an aeroplane around to the right quite smartly.

But rotary engines proved hard to improve – early war rotaries had delivered 80hp, and late war rotaries were still generally in the 120hp range. By the end of the war rotary engines had fallen out of favor.

Inline engines were more reliable. The initial Halberstadt types used a 120hp inline, but the workhorse of the German air force was the Mercedes D.III, delivering 160hp. By the end of the war the 185hp BMW engine, which could maintain its power at higher altitudes, was providing excellent service.

Radial engines played only a small part in the Great War, and were not used by the Germans.

Biplane

The Biplane (two wing) configuration was the standard for aeroplanes of the time. It provided the best compromise between lift and drag given the limited power and weak structural support of standard construction techniques. (This technology does not show up on the cards – if your design does not include Monoplane or Triplane, it is assumed to be a biplane.)

Cantilevered Wings

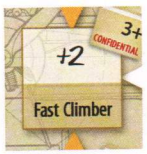
One of the biggest drag-inducing elements of early aeroplane designs was the large amount of rigging needed to support the wings. With the development of thick wings, stronger internal support could be used, with no further need of external bracing. The result was Cantilevered Wings, and a speed boost of several miles per hour.

Dual Machine Guns

Aeroplanes were not serious fighters until they mounted machine guns. Given the limited power of early machines, the weight of one machine gun and its ammunition was all that could be carried. However, as engines got more powerful, more armament could be added.

With Dual Machine Guns, scouts were much more than twice as effective. Since early machine guns were so prone to jamming, an extra machine gun sometimes was the difference between being a fighting machine and a sitting duck.

Fast Climber



A Fast Climber was important to the outnumbered Germans, as it allowed their forces, after spotting an Allied mission, to dispatch interceptors with some chance of success.

Aerodynamically, fast climbing was achieved through large wing area and/or more powerful engines.

Machine Gun Synchronizing Gear

Machine guns were still a relatively new invention in the First World War, and then-current manufacturing processes were not up to making them shoot smoothly. As a result, jams were frequent, and so the guns had to be mounted near the pilot so the jam could be cleared.

From the pilot's perspective the best mounting place for the gun was above his cockpit controls. Then, aiming the aeroplane at the target would also aim the gun at the same time. However, the propeller was in the way and trying to shoot through the moving propeller had a good chance of damaging it, or breaking it off entirely.

The solution was mechanical devices that prevented the gun from firing when the propeller was in the way (interrupter gear) or, alternately, allowed the gun to fire only when the coast was clear (synchronizing gear).

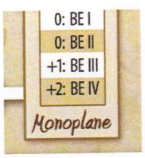
The Germans developed this in late 1915, so such gear does not show up directly in the game – all the players have this from the outset.

Curiously, the Allies did not deploy such gear until mid-1916. Until then, they solved the problem by using pusher aircraft (with the propeller mounted behind the cockpit) or guns mounted so as to fire outside the propeller arc; for example, on the top wing of the aeroplane.

Metal Construction

Hugo Junkers, a name familiar to students of the Luftwaffe, was experimenting with Metal Construction early in the war. But the engines of the time were not up to the weight requirements until 1918, when, at the very end of the war, a few all-metal D.I fighters entered service. With its no-rigging monoplane wing mounted underneath the fuselage, the D.I had a surprisingly modern appearance, barring its unusual corrugated metal skin. However, the improvements of an enclosed cockpit, retractable landing gear, and wing-mounted machine guns would not appear before the end of the war.

Monoplane



The Monoplane (single wing) configuration was the most common pre-war aeroplane configuration, as it provided the greatest visibility to the pilot and observer.

The stresses of dogfighting tended to be too much for the unsupported monoplane wing, leading to the stronger biplane design. As construction techniques and engine power improved, however, monoplanes came back into vogue.

Sesquiplane

The Sesquiplane configuration is a variation of the biplane, where the bottom wing is much narrower than the top wing. This technology does not show up directly in the game, being just another variant of biplane, but was historically used by the Albatros D.III and D.V (copied from captured French Nieuports).

The smaller wings saved weight and increased pilot visibility, but at the cost of tending to break during a strenuous dive.

Streamlining

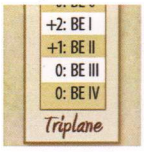
The standard fuselage shape of the early war was a box shape, complete with sharp angles and flat nose (usually mounting a rotary engine). Various techniques were used to increase performance via Streamlining, such as more rounded fuselage shapes, more aerodynamic tails and fins, or burying the engine and/or machine guns into the fuselage.

Thick Wings

Thick Wings were an innovation of Junkers that Fokker incorporated into his later designs. The consensus of the time was that thin wings were the key to performance because of reduced wing resistance. But Junkers discovered that the greater wind resistance of thicker wings was more than made up for by the increased lift and resistance to stalling.

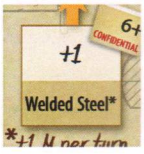
Triplane

The Triplane (three wing) arrangement developed from the impressive performance of the Sopwith Triplane against the then-current Albatros designs. Triplanes tended to perform poorly due to the increased drag caused by the extra wing, but Fokker's famous design, with its high-lift thick wings and light, maneuver-enhancing rotary engine, was a key player at the front until it in turn was overshadowed by Fokker's D.VII.



Welded Steel

To use Welded Steel construction required skills not easily found with a largely unskilled workforce. The needed raw materials, too, became increasingly hard to find as the war continued. But hollow steel tubing was lighter and faster to assemble than the traditional wood.



THE CAMPAIGN GAME TECHNOLOGIES

Reconnaissance aeroplanes (which would be improved, armed, and evolve into Fighters) and heavier-than-air Bombers (as opposed to the great airships of the day, such as Zeppelins), were not merely the slow, defenseless victims of air combat as so often portrayed: Their impact on and contributions to the war effort were measurable and greater than the more glamorous Fighters and their legendary Aces.

The development of Reconnaissance aeroplanes helped to gather intelligence in an accurate and timely manner, changing the nature of warfare by improving the accuracy of the devastating artillery barrages (which accounted for most of the war's casualties). Pilot and observer mortality rates were very high as air crews suffered from both nature (weather and cold – at altitudes of 12,000+ feet in an open-air cockpit, often an observer needed a half-hour to thaw out before they could stop shivering long enough to present a coherent report) and man (mechanical failure, ground fire, and sometimes being hit by the very artillery shells they were directing!).

As the war on the ground stalemated, it became another function of aeroplanes to bomb the enemy's supplies behind the trench lines. From this grew the notion of strategic bombing which began with German Zeppelin raids early in the war. By 1917, heavier-than-air Gotha G bombers began to be used for strategic bombing. This diverted twelve squadrons and over 17,000 men to British air defense and saw the war-weary civilians lamenting that "the bombers always get through" and could not be effectively stopped.

These two-seat Reconnaissance and Bomber aeroplanes were slow and vulnerable, but they were not defenseless with their rear-firing machine guns. Generally, the pilot operated a fixed forward machine gun while the crewman in the rear seat (the observer or bombardier) controlled one with a broad firing arc to the rear of the aircraft. Interestingly, many high scoring Aces of the war were shot down pursuing two-seater aeroplanes and fell victim to their rear machine gun.

Aerial Mapping

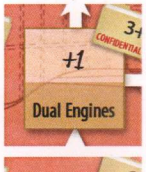
After attaching bulky, high resolution cameras to the outside of the aeroplane's fuselage to photograph the terrain directly below the aircraft, interpreting the details about the enemy's elaborate trench systems became a vital military occupation. Soon, photo mosaics leapt beyond the accuracy of that era's cartography. Adapting a popular entertainment of that day, intelligence analysts improved their view of the battlespace by employing stereoscopic imagery (using a dual-lensed camera that took two simultaneous exposures). This provided a three-dimensional view of the terrain that revealed even the most cleverly camouflaged buildings and gun emplacements.

Bomb Rack

Early in the war, aviators simply released hand-held bombs over the side of their aeroplane to conduct a "bombing attack." This technique generally limited the size of ordnance to no more than 20 pounds and meant, as a practical matter, that they could only deliver a single bomb at a time. Development of bomb racks allowed for carrying heavier ordnance and permitted releasing multiple bombs simultaneously. Coupled with early bomb sights, this new technology yielded a significant increase in the deadliness of aerial bombing.

Dual Engines

Germany was quick to appreciate the potential of aerial bombing and soon realized that more engines meant greater payloads (upwards of 500 pounds). By 1915, the Luftsreitkräfte accepted twin-engine bomber designs from AEG, Gotha, and Rumpler, which were then put into production.



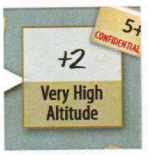
Enclosed Cockpit

Enclosed cockpits meant less drag, allowing greater payloads to be carried on longer flights and at higher altitudes. The first German bomber to employ this feature was the Zeppelin-Staaken R.VI, which flew raids on the Eastern Front and against London without any of the aircraft being lost due to enemy action.

Görz Camera

Germany adopted the first aerial camera for military use in 1913, and maintained a lead in photo-reconnaissance for much of the war. The light-weight Görz cameras were easy to operate and had a long focal plane, making them among the best candidates for aerial photography.

High and Very High Altitude



Being able to operate at higher altitudes made it much more difficult for enemy anti-aircraft batteries to engage bombers, and also meant that the bombers were harder to spot from the ground. This could often allow them to approach the target, deliver their payload, and depart the area before interceptors were able to scramble and climb to an altitude where they could engage the attacking bombers. As engine technology improved, aircraft were capable of reaching greater altitudes faster, and it became a constant race to design bombers that could fly above the fighters, and fighters that could reach high enough to intercept the bombers.

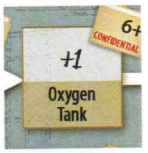
In-Flight Mechanics

Early aircraft engines were temperamental, requiring constant maintenance to keep them functioning at peak efficiency. Designing an aircraft that allowed one of the crew to access the engines during flight to perform mid-air adjustments and minor repairs provided a significant increase in reliability, especially during longer missions (such as the strategic bombing raids against London).

Internal Bomb Bay

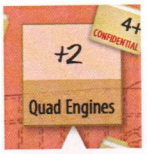
Like enclosed cockpits, internal bomb bays resulted in bombers with faster speeds, longer operational ranges, and greater payloads. First developed by the Russians, the Germans reverse-engineered the technology from a shot-down Sikorsky Ilya Muromets Type-V (the world's first "design for purpose" heavy bomber) in 1916.

Oxygen Tank



Although pioneered by the British as early as 1916, the Germans began equipping some of their aircraft with oxygen generators in the final year of the war. This allowed their bomber and recon planes to fly well above altitudes where most Allied fighters could operate. One of the first of these was the Rumpler C.VII, a fast two-seater recon plane used to make long flights deep into the rear of the Allied lines.

Quad Engines



If two engines allowed for greater payloads and longer ranges, four engines were better. By the end of the war the Germans were operating a wide array of multi-engine (both four and six) bombers, and regularly bombing targets deep in the Allied rear areas, including London.

Rear Machine Gun

Without a rear gunner, a bomber or recon plane was easy prey for patrolling Allied fighters. Typically the observer or bombardier did double-duty as the aircraft's rear gunner, several of whom became Aces during the course of the war. Allied fighter pilots came to respect the danger of the rear-facing Spandau machine gun on most German two-seaters.

Rear Seat

Early aeroplanes were notoriously difficult to fly, and it was asking a lot for a pilot to also act as an observer, photographer, or bombardier in addition to maintaining control of his machine. Designers realized early on that adding an additional crewman to perform the mission tasks, thus leaving the pilot free to fly the aircraft, was a necessity.

Three Seater

More crewmen meant more defensive armament to protect the lumbering multi-engine bombers against the threat of Allied fighters. The most typical configuration was a bombardier/gunner in front of the pilot and a rear-gunner/mechanic/radio operator in the rear. By the end of the war the Germans were operating bombers (the Linke-Hoffmann R.II and Siemens-Schuckert R.VIII) with crews of up to eight, including gunners whose positions were out on the wings!

Wireless Transmitter

One of the main purposes of reconnaissance planes was to act as aerial forward observers to direct artillery fire on the enemy trench lines. However, communicating coordinates in a timely manner was problematic. Early techniques, including hand signals, Aldis lamps, wing-wagging, and dropping handwritten notes were all largely unsuccessful. The French adopted the expedient of simply building landing strips near many of their artillery direction centers so that observers could confer directly with the battery commanders.

The obvious solution was radio, but the size and weight of early sets (and their associated lead-cell batteries) made it

impractical to incorporate them aboard aircraft. Eventually, radio transmitters were developed which were small and lightweight enough to fit on planes, but it was strictly for one-way use (from the plane to the ground) and relied on telegraphy (Morse code) rather than voice transmission; still, it was better than the alternatives. By the end of the war the Germans were equipping their largest aircraft with full two-way radio sets, and those planes relied in part on radio transmissions from ground stations to help them navigate on their night bombing missions to southern England.

Zeiss Lens

The German optics industry was the acknowledged pre-war masters of the art of lens-making, and Zeiss lenses were considered the crème de la crème. Both the British and Americans put out calls for civilian owners of cameras, telescopes, and binoculars with Zeiss lenses to donate their instruments for military use for the duration of the war.

The War Status Events

Of course, our story of the development of Germany's WWI aircraft is told within the larger context of the war itself. The senior military of the army and navy were where the war would be won or lost, so the great events on land and sea heralded necessary changes in the air war.

01 Blockade

A naval Blockade to choke off German trade with the outside world was a key element of Allied strategy, and it was very effective. Luxury items came into short supply almost immediately. Combined with a disastrous harvest in the autumn of 1916, even basic staples became scarce. The resulting dissatisfaction on the home front, combined with the military reversals after the Kaiserschlacht, led to the fall of the German military government.

02 Battle of Verdun

Battle of Verdun (Feb-Dec 1916) was the first big German offensive in the west since 1914. Designed to cause unacceptable casualties to knock the French out of the war, the battle cost an enormous number of German casualties as well. Unable to afford further losses at this scale, the Germans remained on the defensive until the Kaiserschlacht in 1918.

03 Battle of Jutland

Although the naval rivalry between Great Britain and Germany was a key factor in driving Britain into reconciliation with traditional rivals France and Russia, the two fleets met only once, at the Battle of Jutland (May-Jun 1916). The Germans got a propaganda victory from blowing up several British battlecruisers, while the British took some solace in chasing the Germans back to port. The outcome pleased neither government, and the admirals on both sides were later replaced.

04 Battle of the Somme

To help reduce pressure on the French due to the German attack at Verdun, the British launched the Battle of the Somme (Jul-Nov 1916). Despite a week's worth of artillery bombardment, the first day's casualties (including 20,000 deaths) were an unfortunate record for the British army. But the Germans bled, too, and, distracted by the ongoing Verdun battle and complacent in developing new technology, the British air squadrons achieved a superiority they would not attain again until the very end of the war.

05 Romania Overrun

Though tied to the Central Powers before the war through blood and alliance, Romania remained neutral at the outbreak of the war. As Austria began to wilt under the pressure of Russian attacks, the Allied offers of Austrian territory proved too hard to resist and the Romanians entered the war on the side of the Allies (Aug 1916). Unfortunately, by then the Austrians – with German help – had stopped the Russians. A combined Austrian-German-Bulgarian force was able to quickly Overrun Romania, yielding valuable grain and oil supplies for the Central Powers.

06 All Quiet on the Western Front

Taken from the title of the famous novel by Erich Maria Remarque, this event refers to those periods which the Generals referred to as inactivity while the men in the trenches continued to suffer in horrific conditions. Through bad weather, exhaustion, or preparing for the next assault, both sides' heroes soldiered on. Snipers, trench raids, and harassing artillery fire continued to make life difficult even during these "quiet" periods.

07 War Weariness

Morale on all sides, initially high, plummeted as the war continued with no end in sight. This War Weariness manifested itself in labor unrest, protests, and agitation for government reform.

08 German Withdrawal

After the Verdun battles, the Germans went on the defensive in the West in 1917. The German Withdrawal that February was a strategic effort to shorten their lines to more defensible positions by withdrawing from the salient south of Arras back to the heavily fortified Hindenburg Line.

09 U.S. Enters the War

Balancing the exit of Russia was the fact that the U.S. Entered the War in April 1917. Fresh men and economic resources were a great boost to Allied morale. For the Germans, the countdown clock started ticking to win the war before the U.S. could mobilize its resources and have its presence felt at the front lines.

10 Bloody April

The British and French agreed to simultaneous offensives in the Spring of 1917, believing the Germans could not defend against both. If the British army was ready to attack, the Royal Flying Corps was not. Superior German aeroplane types shot down unheard-of numbers of their RFC opponents during what became known to the British as Bloody April (Apr 1917).

11 Chemin des Dames

Robert Nivelle took over as French Commander-in-Chief in early 1917 and began planning the French part of the simultaneous Allied Spring offensives. Nivelle was confident that his attack, centered on the ridge known as the Chemin des Dames, would be the decisive breakthrough that would end the war. So confident, in fact, that his security was lax and the Germans learned what was coming in time to prepare their defenses. The result was another slaughter for a French army already bled dry by its exertions at Verdun. Several divisions mutinied, and the repercussions – including the sacking of Nivelle – kept the French from launching any more major offensives until nearly the end of the war.

12 Russia Collapses

Russia's Tsarist regime had been tottering even before the war began. The generally bad news from the front did nothing to help, and in March 1917 the Tsar abdicated in favor of a democratic provisional government. With the Tsar went any Russian ability to meaningfully continue to fight; for purposes of the war, the revolution meant Russia Collapses. Germany was now fighting on one less front.

13 Kaiserschlacht

The end of 1917 saw the Central Powers in good shape. Russia and Romania had surrendered, the Allied army at Salonika was contained, and the Austrians were managing the Italian offensives. The fly in the ointment was the entry of the United States, bristling with money, men, and industry. The Kaiserschlacht (Mar-Jul 1918) was a series of battles designed to knock out the Allies before the U.S. war-making potential could make itself felt. With superior tactics and a little luck, the Germans broke through Allied lines and restored a fluidity not seen in the West since 1914. But the attacks lacked strategic direction – objectives changed over the weeks from the Channel ports to Paris – and the Allies were eventually able to contain the advances. Their bolt shot, the Germans again shifted to the defensive for the rest of the war.

14 Black Day of the German Army

The Black Day of the German Army (8 Aug 1918) was the opening day of the Allied counteroffensive after the failure of the Kaiserschlacht. Hungry and demoralized by Allied aerial and tank superiority, German soldiers surrendered in significant numbers, while the Allies had their greatest advance since 1914, pushing ahead seven miles and breaking through the German trenches.

15 Battle of Megiddo

The Battle of Megiddo (Sep 1918) – or Armageddon – was the culmination of General Allenby's campaign in Palestine. Turkish forces were no longer able to offer substantive resistance, and Turkey surrendered not long afterward.

16 Battle of Vittorio Veneto

Italy's entry into the war on the Allied side helped to pressure Austria. But the Italians tended to get the worst of the battles, with the same sort of horrendous casualties for little or no gain that characterized the Western Front. Vittorio Veneto (Oct 1918) was the great exception. A new Italian Commander-in-Chief and the steady erosion of Austrian morale led to a decisive battle and, shortly thereafter, Austrian surrender.

EVENT CARDS

Events great and small affected the German aeroplane industries of WWI. Everything from newspaper headlines to interpersonal relations could cause a shift in the business balance of power.

Accident Kills Ace! (59)

WWI aeroplanes were fragile and frail. Equipment failures and accidents frequently proved just as deadly as enemy gunfire. German pilots, unlike their Allied counterparts, were generally equipped with parachutes to protect their lives when in extremis. However, these early parachutes were not reliable, and Aces Erich Löwenhardt and Fritz Rumey were both killed when their parachutes failed to open after bailing out.

Ace (46, 64, 65, 66)

An Ace is a pilot credited with five or more victories in aerial combat. That is a pretty impressive feat, as more pilots were killed in training than combat, and once a pilot earned his wings his life expectancy in combat was about six weeks! German Aces were employed not only as leaders and trainers, but also as heroes in German propaganda. The top Ace of the war was Manfred von Richthofen with 80 confirmed victories.

America Program (47)

In the summer of 1916, Germany embarked on the poorly-planned and ineptly managed Hindenburg Programme to bolster its weapons production. Instead, the army was depleted of a million men, a transportation crisis ensued, and the coal shortage was made more pronounced. This resulted in the Army's withdrawal to the Hindenburg Line to protect its depleted, under-equipped forces, and launch unrestricted submarine warfare. Once America entered the war, the balance of war production that had previously favored Germany tipped to the Allies' advantage, which was fatal in a war of attrition. Germany needed a new program to compete, one with more assembly line mass production, even in the craftsmanship industries such as aeroplane manufacturing.

Blockade Causes Material Shortages (17)

The Allied blockade began promptly at the war's outset and within a year Germany's imports and exports fell by over 50%. The loss of vital raw materials such as coal was bad, but the blockade also starved Germany of fertilizer that was vital for producing staples such as grain, potatoes, meat, and dairy products. By the end of 1916, people were eating ersatz products (Kriegsbrot or "war bread") and drinking powdered milk. Although Germany went hungry, the rationing system kept most from starving to death and German victories in the East gave them access to the resources of Poland and Russia, which did much to counter these effects of the blockade, but by the end of the war public metal objects (e.g., a park bench, church bell, or guardrail) were often seized, melted down, and made into artillery shells.

Business Arrangements (27)

Corporations often cooperated to their mutual benefit, although not always on an entirely voluntary basis. The Roland company licensed their Wickelrumpf laminated plywood fuselages to Pfalz and received a fee for every Pfalz aircraft that used the technique. Fokker sold the rights to their synchronized machine gun technology to most other aeroplane manufacturers at the urging of the War Ministry (for obvious reasons), but only received token payments for doing so.

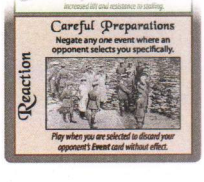
Business Mismanagement (33)

Many of the founders of early aeroplane companies were not entrepreneurs, but aviation enthusiasts. As such, their management practices were often inefficient or downright disruptive to smooth production. Anthony Fokker, in particular, was notorious for going down to the factory floor and having workers remove partially-completed aircraft from the line to make space for his next prototype project, completely throwing everything off schedule.

Captured Allied Aircraft (35, 38)

Not only were downed enemy aircraft quickly seized and their designs studied for possible advancements in engineering, but these planes were also scavenged for their engine oil! The rotary engine Fokker D.VIII (among others) suffered from poor reliability and short engine life due to their Voltol-based oil (which replaced scarce castor oil in wartime Germany). Captured and salvaged Allied aircraft (especially Sopwith Camels) were scrounged, therefore, not only for engines and equipment, but also for their lubricants.

Careful Preparations (56)



Not only was it important for proper craftsmanship of individual aeroplanes, but once superior aircraft were available they had to be used with improved tactics, and so careful preparations took wing after Russia collapsed in 1917 and Germany began to ready its great Kaiserschlacht offensive for the spring of 1918. With fresh troops arriving from the East, this last-chance offensive to win the war before the full weight of U.S. entry could be felt

began on 21 March 1918 with the main attack against the British sector of the front (reasoning that the French army, wracked by mutinies, would surrender soon afterward).

In the air, the battle was marked by the carefully coordinated use of the Schlachtstaffeln (battle squadrons) equipped with the light CL class two-seaters that proved effective during the German counter-attack at the Battle of Cambrai six months earlier. New German fighters, in particular the Fokker D.VII, failed to bring German air superiority as they had not reached the Jagdstaffeln (hunting groups) in sufficient numbers. Still, German success during the Kaiserschlacht, thanks to thorough planning and preparation, made deeper penetrations than had been achieved by either side since 1914. For the war in the air, this meant that many British airfields were abandoned to the advancing Germans in this renewed war of movement.

Design Breakthrough (51)

With operational necessity being the mother of military invention, new technological discoveries were frequently the result of trial-and-error, experimentation, or simply bringing in a new set of eyes to assess the situation. When French fighter pilot Roland Garros went down behind German lines, his specially modified Morane-Saulnier-L, with a machine gun that fired through the propeller, was captured intact. Attempts to reverse-engineer the system of deflector blocks attached to the propeller failed when the impact of the heavier steel-jacketed bullets fired by the German Spandau machine gun simply shattered the propeller blades even though the blocks were not penetrated. Although popular myth has it that Anthony Fokker then invented the interrupter gear (that synchronized machine guns to fire only when the propeller was not in the way) in just two days, the reality is that he and other designers had been working on an interrupter system for some time, but those efforts had all come to a standstill.

Under immense pressure to deliver a viable synchronized machine gun design to the Luftsreitkräfte before his competitors, Fokker brought in several of his engineers for the first time to help solve the problem. It was Heinrich Lübbe who, after examining the rudimentary synchronization system on Garros' downed plane, put two-and-two together and figured out how to make a cam-and-rod system (dubbed Stangensteuerung gear) work.

Design Dead End (43, 49)

Early aeronautical design was as much guesswork as methodical scientific research. Often an idea would be tried that simply did not pan out, or a promising technology would be pushed past the point of its effectiveness. When Fokker's Dr.I triplane proved successful, the Luftsreitkräfte ordered all other aeroplane manufacturers to submit their own triplane designs for evaluation. Pfalz and Halberstadt dutifully worked hard to craft prototypes, but both ultimately proved to be less effective than either their own standard biplane fighters or the Fokker Dr.I. Albatros, on the other hand, had already determined that the triplane concept held little promise for further advancement, and instead chose to fulfill the Luftsreitkräfte's directive by simply bolting an additional middle wing onto their existing D.II fighter, knowing full well that it was not going to work.

Design Innovations (24)

As the war waned, German airmen starting receiving the Fokker D.VII aeroplane. This kept them competitive when they really needed it as they confronted Sopwith Camels and SPADs over the battle line. So good was the D.VII's design that the Armistice terms specifically forced the Germans to surrender it to the Allies.

Among its innovations, the D.VII had a welded steel skeleton for the fuselage, wooden framing for the wings, a cloth covering, and a 160 hp Mercedes engine. The D.VII had a top speed of only 120 mph (which was slow by the war's end) and a ceiling of 23,000 feet (which was low by the time of the Armistice). Yet pilots claimed the plane handled extremely well, proving very forgiving to error in the heat of battle. According to the Germans, "It made good pilots out of bad ones, and Aces out of good ones."

Experimental Designs Attract Investors (29)

Design experimentation was a constant in the competitive German air industries of WWI. There were plenty of odd-looking civilian designs before the war, and the military designs took some to new levels. The breakthroughs in aviation design were usually born of experimental designs, and these were to attract patriotic investors filled with the love and excitement that surrounded every aspect of manned flight.

Most experimental designs earned their place in obscurity, but some were quite important. The Fokker V.1 was a small, experimental sesquiplane design from 1916 that featured an unbraced parasol wing that was an early experiment in cantilever wing construction. The "V," by the way, did not stand for Versuchs (experimental), but for Verspannungslos (without struts or cantilever).

The Junkers J.1 was the world's first practical all-metal aircraft, earning it the nickname "Tin Donkey." The Siemens-Schuckert D.IV was so advanced that the Treaty of Versailles specifically outlawed it.

Fine Tuning (22, 30)

Whenever introducing a new system, there were teething problems. For example, the early models of the Fokker-designed synchronization gear were unreliable and prone to failure. Both Oswald Boelcke and Max Immelmann survived incidents where their synchronization gear failed and damaged the propellers of their planes; in some cases the aircraft's engine would be pulled completely off its mountings when the engine became imbalanced due to damage to the propeller. Immelmann's death has even been attributed to an interrupter gear failure as his aircraft was seen to break up in mid-air during an engagement. Eventually, as word of these problems filtered back to the factory from the front, modifications were made to the equipment to improve its effectiveness and reliability. Although the much more reliable Zentralsteuerung synchronizer system was introduced in mid-1917 (just in time for it to be fitted to the Fokker Dr.I), Fokker continued to make improvements to their synchronizer gear for the remainder of the war.

Fire! (57)

In an era before workplace health and safety were considered important, industrial accidents were commonplace. Sometimes accidents were blamed on enemy saboteurs to cover up slipshod practices by incompetent managers (an example being the fire at Roland's primary factory at Adlershof which burned that facility to the ground on 6 September, 1916).

Forced Labor from Belgium and Poland (25)

German authorities first tried voluntary recruitment of labor from the occupied territories, which seemed promising given the massive unemployment there. However, the coercive nature of the work in Germany along with the abysmal conditions under which these Civil Workers' Battalions were housed and fed, became a public relations debacle for the Germans, and Belgian deportations were suspended by Imperial decree in 1917.

German Ace Shot Down! (52)

The air war was deadly: Half of the top ten German Aces were either killed in action or flying accidents, and most of the others were wounded. Oswald Boelcke died in a mid-air collision with one of his squadron mates; Manfred von Richthofen was shot down by ground-based AA fire.

Job Offer (44)

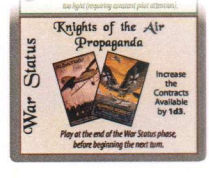
It was relatively unusual for professionals in turn-of-the-century Imperial Germany to move from one company to another. Once you had a position with a firm, you pretty much stayed with them for your entire working life until retirement. However, circumstances occasionally arose where a skilled designer or engineer might become available for hiring by a competitor. Franz Schneider, for example, was hired by airship manufacturer LFG in 1911 and established the Roland line of aircraft when his French mentor, Edouard Nieuport, died and his company began forcing out all their non-French employees.

In 1918, Werner Zorn was fired by AEG after they made him the scapegoat for the crash of their R.21 prototype (even though he had warned company executives that the multi-engine bomber was not ready for flight testing yet); he was hired by Hansa-Brandenburg just a few weeks later.

Kaiserliche Marine Contracts (41)

The German Navy used, primarily, reconnaissance Zeppelins, but they also commissioned fixed wing aircraft, both floatplanes (such as the Friedrichshafen FF.33e) and flying boats (such as the Hansa-Brandenburg CC). The Marinefliegerkorps of pilots had their share of victories, too, with the leading Naval Ace, Gotthard Sachsenberg having 31 victories.

Knights of the Air Propaganda (20)



German propaganda posters frequently depicted heroic knights defending Germany, so it was natural that as aviators evolved into war heroes, they would be hailed as "Knights of the Air." As Aces emerged from among these pilots, these Knights of the Air were the most famous of Germany's Knights. Interestingly, Manfred von Richthofen was not dubbed the "Red Baron" until long after the war. Through the war and well into the 1920s, he was known as the "Red Knight."

Labor Shortages Affect Quality Standards (39)

At the start of the war, German industry was still largely functioning under the guild system. Restricting factories was the Gesetz zur Ordnung des Handwerks (Crafts and Trades Regulations) system, defining who could work on certain jobs. With employees having to pass through lengthy apprenticeship programs, there was always a bottleneck in training new workers. When mobilization occurred, sending most workers to the front, the lack of skilled labor became a significant issue, exacerbated when the demand for increased production of war materials further stressed the system. Predictably, under these pressures, quality control suffered.

The situation became so bad in some companies that it forced the War Ministry to intervene. The Fokker works

in particular had major problems, with reports of poor workmanship on their aircraft. In 1917 the company was officially warned to improve standards, but quality control issues continued to plague Fokker's machines. When the war ended, the War Ministry was preparing to file charges against Anthony Fokker for negligence.

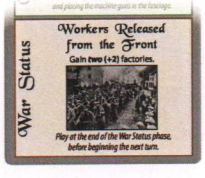
Prototype Crashes (23, 37)

Early aircraft design was often a hit-or-miss proposition. Designers would come up with ideas and engineers would attempt to implement them, but the science behind flight was only partially understood at the time. For example, when manufacturers submitted a new design for evaluation, the War Ministry required them to provide three prototypes. One of them was disassembled and each of its structural elements would be stress-tested by hanging weights from it equal to three times the force that engineers calculated that piece would need to stand up to during actual flight. However, because sympathetic vibration and torsion elements were not fully considered, this meant that components that performed well in the static tests were occasionally prone to failure when confronted by the demands of actual aerobatic flight. And to perform the aerobatic flight tests, the standard practice was to recall an experienced pilot from the front to put the prototype through its paces – occasionally with fatal results!

Shoddy Construction (36)

Quality control was a constant problem for some manufacturers. Newly-delivered Fokker Dr.I triplanes experienced a string of sudden fatal accidents in late 1917, with the upper wings frequently ripping off under the stress of aerobatic combat flying; this grounded the Dr.I type for over a month as being too dangerous to fly. A German military inquiry concluded that substandard workmanship and poor supervision at the Fokker factory were to blame. Fokker received a stern warning about future conduct, but unfortunately the same scenario repeated itself a few months later with the introduction of the E.V/D.VIII monoplane. German authorities intended to file criminal charges, but Anthony Fokker fled to the Netherlands when the war ended, thus escaping prosecution.

Workers Released from the Front (55)



Like most nations during the Great War, Germany mobilized the bulk of the male population at the start of hostilities, expecting the war to be a short one with their victorious troops returning home "before the leaves fall." No provisions to exempt key professionals were made to sustain the nation's industrial output.

As the war dragged on, even though it became increasingly obvious that shortages of experienced workers in critical defense industries were impacting the nation's ability to prosecute the war, the high command was reluctant to release troops from military service. Corporations were required to submit requests for the discharge of specific soldiers directly to the War Ministry in Berlin, explaining in detail why that individual soldier was essential to the war effort – and even if their request was approved, generals in the field had the authority to veto that approval. Eventually, largely at the urging of Walter Rathenau, Director of the Kriegsrohstoffabteilung (War Raw Materials Department), these restrictions were relaxed and the manpower needs of industry began to be addressed in a more realistic fashion.

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