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Open Source Philosophy and the Dawn of Aviation

Bento Silva de Mattos*
Instituto Tecnológico de Aeronáutica - São José dos Campos/SP – Brazil

Abstract: *In the early 20th century, Aviation pioneers in North America and Europe experienced quite different working ambiences. The Europeans, except for those living in England, embodied the spirit of the French Revolution; the Americans incorporated the ideas from the Industrial Revolution or, according to many historians, the English Revolution. Due to this fact, Aviation in Europe and in the United States evolved quite differently. In order to justify the establishment of those connections, the present work has described the way aviation pioneers designed and built their flying machines and the state of aviation in North America and in Europe in the early 20th century. A collaborative working atmosphere was present among the European pioneers thanks to the French Revolution ideas that found general acceptance in Europe. The European aviation pioneers frequently exchanged information regarding aeronautical experience or even whole designs. Contrary to this, in the United States aviation, its development suffered from lack of information from the people who were competing for the first flight. Indeed, a fierce competition among the individuals was established. The knowledge coming from Europe, noticeably from the Germans Lilienthal brothers and George Cayley, was being retransmitted by open-minded people like Octave Chanute. That is the reason why America fell behind Europe in regard to airplane technology before the broke out of World War I and a patent war started in the United States among their aviation pioneers. In France, the Aéro-Club de France was created in the last years of the 19th century. Among its objectives, one was to attest the first person to perform a flight with a heavier-than-air machine. After the Brazilian Santos-Dumont's flight with his 14bis biplane in 1906, in Paris, Wilbur Wright went to Europe in 1907 and established a workshop to continue improving the Flyer concept. Wright's supporter, Octave Chanute, had warned him that the aviation world was catching up fast, especially in France. However, Wilbur was only able to get the Flyer airborne in August 1908 in France, with disappointing results. However, impressive flights took place in late 1908 and the Wright brothers' European Flyer was the basic airplane they were able to sell to the US armed forces for the first time in 1909. After Santos-Dumont's success in flying his 14bis airplane in 1906, many of his comrades established airplane factories. Those Dumont's friends were eager to sell planes to the French government, and a competitive atmosphere settled down in the old continent. In addition, the collaborative ambience ceased because the World War I was only a matter of time.*

Keywords: *Aviation, Aircraft design, Air transportation, French Revolution, Industrial Revolution, Open source.*

INTRODUCTION

The rise of cooperation

The present paper was concerned with the analysis of Aviation development in the early 20th century. The main focus of the analysis was the different working ambiences that were established in the United States and in Europe, noticeably in France. These ambiences had a crucial impact on the outcome of the airplane performance and Aviation milestones in both continents. The work of individuals and the industrial development in regard to Aviation were analyzed to fundament the hypothesis that the French and Industrial Revolutions played a major role in the development of Aviation.

Initially, we can consider the masterpiece of Alberto Santos-Dumont, a Brazilian aviation pioneer who spent most of his adult life in France. He designed and flew airships and airplanes in the early 20th century. Most Brazilians believe Santos-Dumont was a single good soul because he gave anyone his designs and inventions for free. On the other hand, most Brazilians are not aware that Santos-Dumont utilized in his aircraft ideas and even components from other people. In fact, not only Santos-Dumont took this approach, but the majority of Aviation pioneers in France at that time as well. They were enlightened by the ideas from the French

Received: 05/02/12 Accepted: 24/05/12
*author for correspondence: bmattos@ita.br
Pç Eduardo Gomes, 50- Vila das Acácias
CEP 12.228-901-São José dos Campos/SP-Brazil

Revolution. The development of the airship number 3 from Santos-Dumont is a good example, because it was based on an earlier design from the Tissandier brothers.

In 1881, the French brothers Albert and Gaston Tissandier demonstrated the world's first electric-powered flight at an electricity exposition by attaching an electric motor to an airship. They built a larger model that performed its first flight on October 8, in 1883, the first one of an electric aircraft (Santos-Dumont, 1904). The same brothers also made a second attempt on September 26, 1884, which performed as they had expected for. In the late 14th century, Santos-Dumont built, among other designs, two cigar-shaped airships. Figure 1 shows his number 2 concept, which went through an accident when its gas container doubled up (Santos-Dumont, 1904). From this point on, Santos-Dumont (Santos-Dumont, 1904) opted to reshape his future airships. He adopted the configuration from his friend Tissandier for the number 3 airship, which was the first practical airship in history (Lins de Barros, 2003). Although Santos-Dumont did not mention that he took over the Tissandier design in the books he wrote, the similarities between both designs are obvious (Fig. 2).

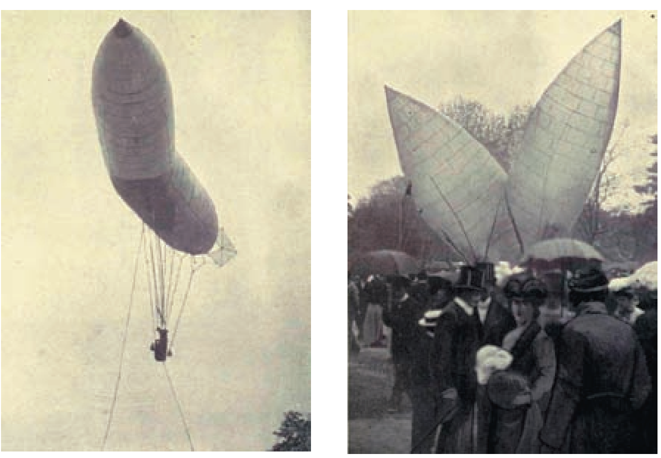


Figure 1. The cigar-shaped Santos-Dumont number 2 recorded some accidents.

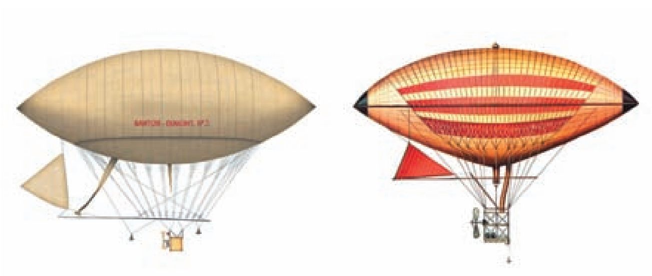


Figure 2. Santos-Dumont number 3 (left) was very similar in shape when compared to one of its predecessors, the electric-powered Tissandier's airship (Library of Congress, 2011).

Contrary to what happened in France, a very competitive atmosphere was established in the United States, with almost no collaborative work among the aviation pioneers being registered. To exemplify this, we address the work carried out by Samuel Langley on Aeronautics. Samuel Pierpont Langley was an American astronomer, physicist, inventor of the bolometer and pioneer of Aviation. He attempted to make a working piloted heavier-than-air aircraft. He began experimenting with rubber-band powered models and gliders in 1887 (Schmitt, 1990). Among other things, Langley built a rotating arm (functioning similar to a wind tunnel) and made larger flying models powered by miniature steam engines. His first success came on May 6, in 1896, when his number 5 unmanned air model flew nearly 3/4 of a mile after a catapult launch from a boat on the Potomac River. The distance was ten times longer than any previous experiment with a heavier-than-air stable flying machine. On November 11 in that year, his number 6 model flew more than 1,500 m. In 1898, based on the success of his models, Langley received a War Department grant of US$ 50,000 and US$ 20,000 from the Smithsonian to develop a piloted airplane, which was christened Aerodrome (Schmitt, 1990). Langley engaged Charles M. Manly as the engineer and test pilot. When Langley was informed by his friend Octave Chanute about the Wright brothers' success with their 1902 glider, he attempted to meet them, but they politely evaded his request.

While the full-scale Aerodrome was being designed and built, the internal combustion engine was contracted out to manufacturer Stephen Balzer. When he failed to produce an engine to the power and weight specifications, Manly finished the design. This engine was able to deliver 50 hp, far more power than the 12 hp (Wright, 1988) output by the engine of Wright brothers' first airplane (Schmitt, 1990). The engine that was fitted into Aerodrome weighted 95 kg. Mostly the technical work of men other than Langley, the engine was probably the main contribution to aviation in the United States. The piloted machine had wire-braced tandem wings. It had a Pénaud tail for pitch and yaw control, but no roll control, depending instead on the dihedral angle of the wings, as did the models, for maintaining roughly level flight.

Contrary to the unstable Wright brothers' flyer airplane, which could land on solid ground (Culick, 2001) and Santos-Dumont 14-bis, Langley sought safety by practicing in calm air over the Potomac River. This required a catapult for launching the vehicle, with no landing gear. Langley envisaged a 'ditching' after the level flight, which if successful would entail a partial, if not total, rebuilding of the machine. Langley gave up the project after two crashes on take-off on October 7 and December 8, both in 1903.

If the Wright brothers had established a collaborative work with Langley, they probably would have had access to the impressive 50-hp engine that was developed for the Aerodrome airplane. This would have provided the United States with a giant leap in Aviation at that time.

Concerning the Aerodrome, it was rebuilt by the American aviation pioneer Glenn Curtiss, who struggled in court against the Wright brothers. After Curtiss introduced some structural reinforcements to aerodrome, he performed successful flights with the airplane (Schmitt, 1990). Afterwards, the Smithsonian Institute initiated a campaign to credit Langley the first flight of a heavier-than-air vehicle. The dispute was terminated in 1942 after the Institute withdrew its request (Schmitt, 1990). The aerodrome was restored to its original configuration and is currently on display in the Smithsonian Museum.

These examples from Europe and the United States are reinforced by others along the present paper, in order to sustain the thesis that Europe was more successful in the development of aviation in the early 20th century because an open source philosophy was established there. In addition, an overview of Aviation in both continents is provided for the same purpose.

Progress report of open source philosophy

The concept of open source and the free sharing of technological information existed long before computers became present in our everyday life. For example, cooking recipes have been shared since the beginning of human culture. Open source can be present in business, software, and any kind of technological knowledge.

The advent of the Internet has reshaped the way people communicate and work. More specifically, after broadband Internet connections have been made available to ordinary people, the Internet found its path to generalized business and grew exponentially. In an opposite direction to the business side, a lot of open source projects, encompassing the world online community, emerged. Most of those ventures are highly and undoubtedly successful. Linux, a Unix-like operating system, is the most prominent example of such initiative. Linux is largely driven by its developers and user communities. Some vendors develop and fund their distributions on a voluntary basis, Debian is a well-known example of this. Others maintain a community version of their commercial distributions, as Red Hat does with Fedora. Even the International Business Machine Corporation (IBM) surrendered to its appeals and replaced its in-house AIX operating system by the Linux one.

Wikipedia is another mainstream example of open source effort to make things happen. Wikipedia co-founder Jimmy Wales has described it as "an effort to create and distribute a multilingual free encyclopedia of the highest quality to every single person on the planet in his or her own language." Such website exists to bring knowledge to everyone who seeks it. Wikipedia is an online free-content encyclopedia that anyone can edit. Who owns the encyclopedia? The articles hosted on this site are released by their authors under the GNU Free Documentation License (or a free license), so the articles are free content and may be reproduced freely, under the same license.

A generalized initiative for the development of open source projects is the SourceForge one (SourceForge, 2012). SourceForge.net is the world's largest open source software development website. It hosts more than 324,000 projects (status from January 2012) and over 1 million registered users with a centralized resource for managing projects, issues, communications, and codes. SourceForge.net has the largest repository of open source code and applications available on the Internet and hosts more open source development products than any other site or network worldwide. It also provides a wide variety of services to projects they host, and to the Open Source community.

Another project that seeks help from the online community is the SETI@home, which is a scientific experiment that uses Internet-connected computers in the search for extraterrestrial intelligence (SETI). Anyone can participate by running a free program that downloads and analyzes radio telescope data. Radio telescope signals consist primarily of noise (from celestial sources and receiver's electronics) and man-made signals, such as TV stations, radar, and satellites. The modern radio SETI projects analyze the data digitally. More computing power enables searches to cover greater frequency ranges with more sensitivity. Radio SETI, therefore, has an insatiable appetite for computing power. Previous radio SETI projects have used special-purpose supercomputers, located at the telescope, to do the bulk of data analysis.

In 1995, David Gedye proposed doing radio SETI using a virtual supercomputer composed of large numbers of Internet-connected computers, and he organized the SETI@home project to explore this idea, which was originally launched in May 1999. The reason for asking the online community for helping to process radio telescope signals is caused because the researchers are limited by the amount of computer power available for data analysis. To tease out the weakest signals, a great amount of computer power is necessary. It would take a monstrous supercomputer to get the job done. SETI programs could never afford to build or buy such computing power. SETI@home involved more than five million people, whose combined machines provided more than the equivalent to two million years of computing time looking for faint signs of intelligent life beyond earth.

There are uncountable initiatives for the development of open source engineering software packages. Indeed, it can register such initiatives on all fronts of engineering subjects like structural analysis, computational fluid dynamics, vehicle system simulation, for naming just a few of them. It is worthy of mention Scilab (Scilab, 2012), which is a scientific software package for numerical computations that provides a powerful open computing environment for engineering and scientific applications. Since 1994 it has been distributed freely along with the source code via the Internet. It is currently used in educational and industrial environments around the world.

The French and English Revolutions

The French Revolution in 1789, which caused the fall of the monarchy in France, is one of the most important facts of history. Louis the 16th received from his predecessor a country economically ruined, with dissatisfied and oppressed population, which faced a high load of taxes. France still kept its mediaeval social structure, counting three classes: nobility, clergy, and the so-called ‘third state’. A farmer had to allocate approximately two-thirds of its production for the payment of taxes (Maior, 1966).

The liberal ideas of Locke, Voltaire, Montesquieu, and Rousseau contributed to the goals of revolution. In addition to these philosophers, the economists Quesnay and Adam Smith contributed ideologically to the great transformation of 1789 (Maior, 1966).

In general, four causes can be enumerated to explain the French Revolution (Darnton, 1982). Firstly, the Enlightenment contributed to an environment in which revolution was possible by its insistence on reforming institutions to comply with standards of reason and utility. Furthermore, it coincided with public opinion rise, which undermined the absolutist notion that political decisions required no consultation or tolerated no opposition. Secondly, the French state faced bankruptcy due to a regressive and inefficient tax system, as well as the participation in the Seven Years War (from 1756 to 1763) and the War of American Independence (from 1775 to 1783). Thirdly, France witnessed endemic political strife in the 18th century. Technically, absolutist monarchs ruled by divine right and exercised sovereignty without the interference of representative institutions. French kings in reality met with opposition to their policies from the noble magistrates of the highest law courts (Parlements), who resisted fiscal reforms in the name of protecting traditional rights from arbitrary authority. Finally, while class conflict did not cause revolution, there were stress zones in French society, as a growing population threatened many people with destitution and as talented commoners chafed at their exclusion from high offices in the church, state, and military. Economic problems intensified after bad weather doubled the price of bread in 1789.

Enlightenment was a movement which stated that science could explain everything in nature. Until then, most people believed that God controlled the universe in a ‘metaphysical’ manner. Metaphysical means beyond physical, and suggests that it is impossible for humans to comprehend things that happen in our environment. Since it was developed more or less simultaneously in Germany, France, Great Britain, the Netherlands, Italy, Spain, and Portugal, the movement spread through much of Europe, Russia and Scandinavia as well as the United States and Latin America. It has been argued that the signatories of the American Declaration of Independence, the United States Bill of Rights, and the French Declaration of the Rights of Man and of the Citizen, were motivated by Enlightenment principles (Israel, 2001).

Galileo was one of the first thinkers of the Enlightenment. Galileo used a refracting telescope to search the skies, some Jupiter moons were discovered and he became the first person to observe Saturn’s rings, though he could not see them well enough to discern their true nature. Based on his observations, he confirmed the Copernicus’ theory that the earth traveled around the sun.

Enlightenment thinkers encouraged people to use science to explore nature and to question what they had always accepted without questioning. The Enlightenment stimulated people to participate in the government and to rethink old ideas, such as feudalism and primogeniture. The American Revolution and the French Republic are seen by many as huge achievements for the Enlightenment.

No moment in history stands alone, but each builds surely from the moments before it. The French Revolution and its aftermath were no exceptions, being recorded as a period of political and social upheaval in the history of France. In many ways it sprang from the undeniable and unswayable forces of modernization, toppling a system that was dying under its own weight and intrinsically unable to adapt and survive in the new economic and philosophical reality. The French governmental structure, which was previously an absolute monarchy with feudal privileges for the aristocracy and Catholic clergy, underwent radical change to forms based on Enlightenment principles of nationalism, citizenship, and inalienable rights. These changes were accompanied by violent turmoil, including executions and repression during the Reign of Terror, and warfare involving every other major European power. Subsequent events that can be traced to the Revolution include the Napoleonic Wars, two separate restorations of the monarchy, and two additional revolutions as modern France took shape. The ideals brought by the French Revolution for a more equal society rapidly spread along the entire Western world. Although Karl Marx had written "The Poverty of Philosophy" in 1847, a response to Pierre-Joseph Proudhon's "The Philosophy of Poverty", and a critique of French socialist thoughts, he was certainly influenced by the ideals of the French Revolution.

The Industrial Revolution was a period in the late 18th and early 19th centuries when major changes in agriculture, manufacturing, and transportation with a profound effect on the socioeconomic and cultural conditions in Britain happened. The Industrial or English Revolution crystallized some principles that were contrary in many ways to the ideals of the French Revolution. Under the umbrella of the English Revolution, the human being was not the center of matters. Money, or more exactly the capitalist, was the gravity center of the system with few or no regard to workers' life. The changes brought by the Industrial Revolution subsequently spread throughout Europe and North America and, later, the world, a process that continued as industrialization. The onset of the Industrial Revolution marked a major turning point in human society; almost every aspect of daily life was eventually influenced in some way.

In the later part of the 1700s, there was a transition in parts of Great Britain's previously manual-labor-based economy towards machine-based manufacturing. It started with the mechanization of the textile industries, the development of iron-making techniques, and the increased use of refined coal. Trade expansion was enabled by the introduction of canals, improved roads, and railways. The introduction of steam power (fuelled primarily by coal) and powered machinery (mainly in textile manufacturing) underpinned the dramatic increases in production capacity. The development of all-metal machine tools in the first two decades of the 19th century facilitated the manufacture of more production machines in other industries. The effects spread throughout Western Europe and North America during the 19th century, eventually affecting most of the world. The impact of this change on society was enormous.

EUROPEAN AVIATION BEFORE WORLD War I

Experiments with balloons

Compared to the civilization history and naval warfare, the history of Aviation is very recent, only about a century old. The camera film was created in 1825. Seventy years later, a motion picture was shown for the first time before an audience in Berlin. Likewise, early developments in Aviation are well-recorded. Because the history of the aerostat started long before that of the airplane, it is less known.

Ancient inscriptions and texts indicate that the Chinese used hot air balloons and gigantic kites before the Christian era in order to keep the battlefield under surveillance. The Mongols used illuminated kites to communicate during the Battle of Legnica against the Poles and Germans in 1241 A.D.

Much later after the Legnica Battle, Portugal became one of the most powerful nations in the world, which came about thanks to the Knights Templar, one of the most famous Christian military orders. Under the influence of the French King Philip, le Beau, the Pope Clement V declared an internal crusade against them. On Friday, October 13, 1307 (a date possibly linked to the origin of the Friday the 13th legend), Philip had all French Templars simultaneously arrested, charged with numerous heresies, and tortured by French authorities nominally under the Inquisition, until they allegedly confessed. This action released Philip from his obligation to repay huge loans from the Templars and justified his looting of Templar treasuries. In 1312, due to public opinion and scandal, and under pressure from King Philip (who had been responsible for maneuvering Pope Clement V into the Vatican), Clement officially disbanded the order at the Council of Vienna. Even though all lands were supposed to be turned over to the Hospitallers, Phillip retained a great deal of the Templar assets in France. Some other European leaders followed suit in an effort to reduce the amount of Church-owned lands and property.

In 1314, three Templar leaders, including Grand Master Jacques De Molay, Hugh De Perault, and Godfrey De Goneville were burned alive at the stake by French authorities after publicly renouncing any guilt. Remaining Templars around Europe, having been arrested and tried under the

Papal investigation, were either absorbed into other military orders such as the Order of Christ and the Knights Hospitaller or contemplative Benedictine or Augustinian ones. In Portugal, they found refuge under the Order of Christ. The Templars brought to Portugal treasures, knowledge of ancient civilizations, and naval technology from the Arabians, which triggered the naval navigation era, making Portugal one of the most powerful nations in the world.

Under the European expansion brought by the navigation era, Brazil was discovered by Portugal in 1500. Brazilian Jesuit Bartolomeu de Gusmão, born in Brazil to Portuguese parents, adopted a religious career and moved to Portugal when he was 15 years-old. By reading antique writings possibly brought to Portugal by Templars, he rediscovered the principle of the hot-air balloon. In August 1709, Gusmão built a small and unmanned balloon and performed a demonstration at the court of King Dom João V. There are reports that Gusmão built an unmanned larger balloon that freely ascended outdoors some time later. Bartolomeu de Gusmão proceeded with his experiments with larger balloons and legend has it that eventually he himself flew a balloon, which was launched from Saint Jorge Castle, on the top of one of Lisbon's seven hills, covered 1 km, and crashed in Terreiro do Paço. However, there is no evidence that this actually happened. Later, Gusmão was pursued by the Inquisition and left Portugal. Before leaving the country, he gave his brother several drawings of his balloons. After some time, his brother worked at Portugal's Embassy in Paris and established some contacts to José de Barros, a scientist close to the Montgolfier brothers, the first people to construct a balloon that performed a recorded manned flight in history.

Short before the French Revolution, the brothers Joseph-Michael and Jacques-Étienne Montgolfier built a globe-shaped balloon of sackcloth with three thin layers of paper inside. The envelope could have nearly 790 m^3 of air and weighed 225 kg. It was constructed of four pieces (dome and three lateral bands), and held together by 1,800 buttons. A reinforcing fishnet of cord covered outside the envelope.

In June 4^{th}, 1783, Montgolfier's aircraft performed its first public demonstration at Annonay in front of a group of dignitaries from the Etats particulars. The related flight covered 2 km, lasted ten minutes, and had an estimated altitude of 1,600 to 2,000 m. Word of its success quickly reached Paris. Etienne went to the capital to make further demonstrations and to solidify the brothers' claim to the invention of flight. Joseph, given his unkempt appearance and shyness, remained with the family.

From the flights with Montgolfiers' balloons on, ballooning became largely widespread. In 1785, Jean-Pierre Blanchard and John Jeffries departed from England on a balloon and crossed the English Channel. In 1794, France opened a ballooning school. It also used two balloon corps in the battles of Maubeuge and Fleurus and in the Mainz siege in the following year. In July of 1849, Austrian troops used balloons for the first time to drop bombs on Venice.

English aeronaut Charles Green (1785-1870) used a coal gas-filled balloon, formerly known as the Royal Vauxhall, for his most famous flight from London to Nassau in Germany, in 1836. It was on this voyage, along with passengers Robert Holland and Thomas Monck Mason that Green successfully completed the world's longest flight, covering an estimated 770 km in 18 hours. After achieving this feat, Green had an endless supply of sponsors, who were eager to ascent in the famous balloon.

Towards controlled flight with airships

In 1852, Frenchman Henri Giffard was the first to fly an airship (Torenbeek, 2009), which was fitted with steam engines and propellers (Fig. 2). Santos-Dumont commented on Giffard's experimentation with airships (Santos-Dumont, 1904): "Giffard's primitive steam-engine, weak in proportion to its weight, spitting red-hot sparks from its coal fuel, had afforded that courageous innovator no fair chance, I argued. I did not dally a single moment with the idea of an electric motor, which promises little danger, it is true, but which has the capital ballooning defect of being the heaviest known engine, counting the weight of its battery. Indeed, I have so little patience with the idea that I shall say no more about it except to repeat what Mr. Edison said to me on this head in April 1902: 'you have done well,' he said, 'to choose the petroleum motor'."

From Giffard's steam-powered airship on, numerous vehicles were developed, including that belonging to Paul Hälein, in 1872 (Fig. 3), and the one of Charles Ritchel, in 1878. Paul Hälein from Germany was the first to use internal combustion engines on an airship. Hydrogen was used as the fuel to lift the airship, stored in a single tank. In the United States, Charles Ritchel made demonstrations of a lighter-than-aircraft built with impermeable fabric and tubular structure with room for the pilot and an engine, and he managed to sell five units of his flying machine. Several other airships produced significant innovations before the turn of the century.

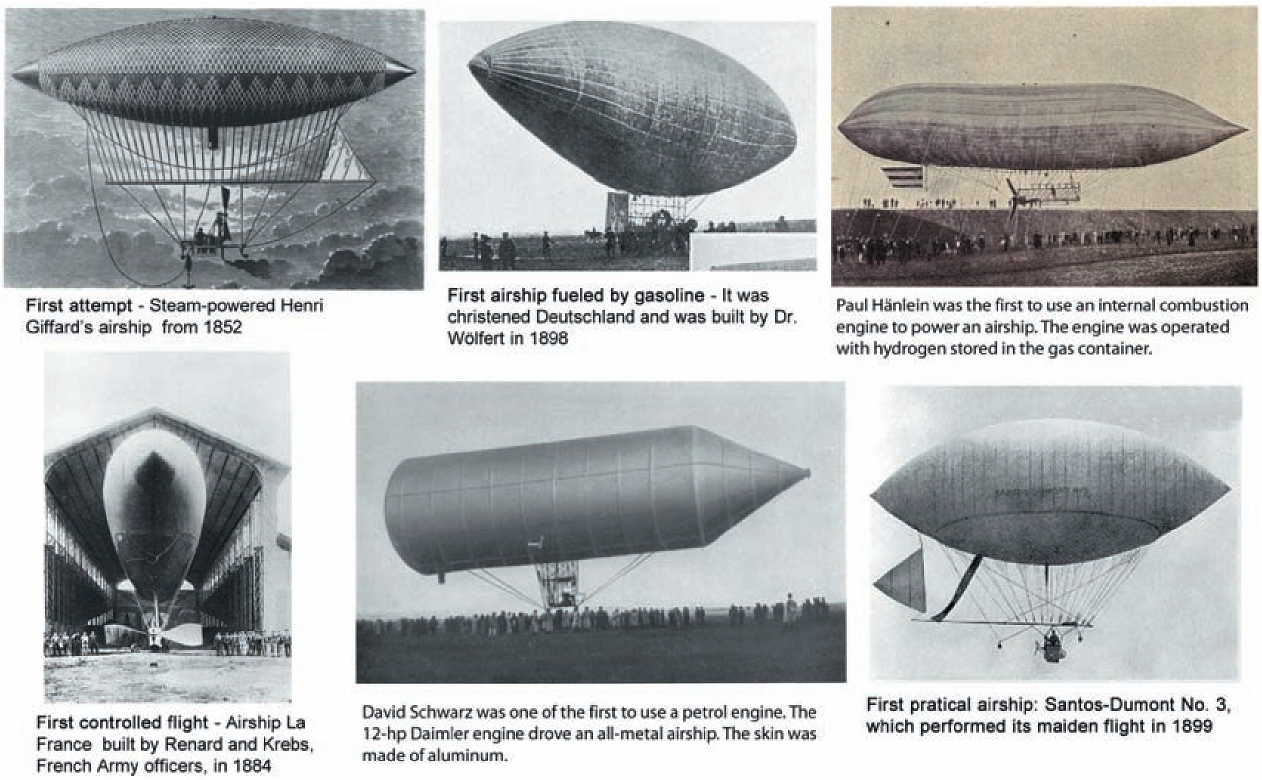


Figure 3. Some airships built in the second half of the 18th century.

In 1883, the brothers Albert and Gaston Tissandier from France designed and constructed the first airship powered by electricity. The current was supplied by 24 potash cells to a Siemens 1.5 hp (1.1 kW) engine running at 180 revolutions per minute. The engine drove a large two-bladed pusher propeller, through a reduction gearbox. The speed achieved at no wind conditions was still only 4.8 km/h, since the ratio of power to weight was no better than that of Giffard's airship (Santos-Dumont, 1904).

Charles Renard and Arthur Krebs, military officers in the French Army Corps of Engineers, built an elongated airship, La France (Fig. 3), which was a vast improvement over earlier models in 1884. La France was the first airship that could return to its starting point in a light wind. It was 50.3 m long, its maximum diameter was 8.2 m, and it had a capacity of 1,869 m^3. Like the Tissandiers' airship, a 7.5-hp (5.6 kW) electric, battery-powered motor propelled La France. This motor was later replaced with another one that delivered 8.5 hp (6.3 kW). A long and slender car consisting of a silk-covered bamboo framework, lined with canvas hung below the balloon. The structure that accommodated the batteries and engine was 33 m long, 1.4 m wide, and 1.8 m deep. The engine drove a four-bladed wooden tractor propeller that was 7 m in diameter, but which could be inclined upwards when landing to avoid damages to the blades. Renard also provided rudder and elevator, ballonets (to keep the shape of the gas container), sliding weight to compensate for any shift in the gravity center, and a heavy guide rope to assist in landing, all this would become standard equipment for the next generations of airships to come.

The first flight of La France took place on August 9, 1884. Renard and Krebs landed successfully at the spot where they had begun – a flight of only 8 km and 23 minutes, however one during which they had been in control throughout. In 1884 and 1885, La France made seven flights. Although its batteries limited its flying range, it was demonstrated that controlled flight was possible if the airship had a sufficiently powerful lightweight engine.

The first airship equipped with a petrol engine was built by Karl Wölfert, in Germany (Fig. 3). In 1896, he constructed an airship pointedly named Deutschland. The gondola was directly connected to the hull and an 8-hp Daimler engine powered the aircraft, which flew for the first time on August 10, 1898 in Cannstatt, close to the city of Stuttgart. In 1897, the airship caught fire during a flight in Tempelhof, in Germany. Wölfert and his mechanic died in the accident. Escaping hydrogen from the envelope had probably come into contact with the hot exhaust gases from the engine. They were the first victims of power-driven Aviation. Future designers would avoid placing the petrol engine so near the flammable hydrogen balloon.

Austrian engineer David Schwarz was also attempting to harness the petrol engine to an airship, which was highly unusual and ahead of its time in being made of sheet aluminum, an eight thousandth of an inch thick, which was supported internally by an aluminum frame braced with wires (Fig. 3). The airship was 47.5 m long and had a capacity of 3,700 m^3. Power was provided by a 12-hp Daimler engine, driving four propellers, two of which were for steering and the remaining other two for propulsion. Schwarz's mechanic had the dubious honor of testing his employer's novel brainchild. The airship made its maiden voyage from Tempelhof, Berlin, on November 3, 1897. It did several successful circles, but then started to descend rapidly before it struck the ground and broke up. This time, the pilot was able to walk away, without any bruises.

Practical airships

The Balloon Brésil was the first aircraft designed and built by Santos-Dumont and was ahead of its time. Instead of Chinese silk, he employed in its construction the Japanese one (Santos-Dumont, 1904). This resulted in a much smaller and lighter balloon compared to the existing ones with the same payload. The common sense at that time advised the use of Chinese silk, but Santos-Dumont correctly calculated that Japanese silk would enable a lighter balloon.

After his brief experiments with balloons, Alberto Santos-Dumont released his first dirigible in 1898, one year after David Schwarz's crash. He christened it Santos-Dumont number1 (Fig. 4). It was made of lightweight Japanese silk, had a capacity of 186 m^3, and was powered by a 3.5-hp internal combustion engine. Similar to many other Santos-Dumont designs, the number 1 was no bigger than was strictly necessary to lift its pilot. Santos-Dumont did not even have room to sit down in the tiny wicker basket. After a takeoff attempt, Dumont's number 1 crashed on September 18, 1898 (Santos-Dumont, 1904). The airship hit the trees of Jardin D'Acclimatation in Bois de Boulogne and was extensively damaged. Santos-Dumont repaired it and took off again a couple of days later. Using the incidence-changing mechanism he had designed, he was able to reach a 400 m height. At the highest altitude attained by Santos-Dumont, the pressure drop accounted by hydrogen leakage, which was caused by the porosity of the hull, could not be compensated by Dumont's mechanism anymore. The graceful dirigible was out of control and began to fall. With serenity and self-control, Dumont shouted out for some boys below to catch the hanging rope and maneuvered the airship against the wind (Santos-Dumont, 1904). The landing was then almost perfect.

In May 1889, number 2 (Fig. 4) was ready to flight. Santos-Dumont's second airship was strongly based on the number 1 configuration. Despite the rain, windy weather and low temperature, he decided to fly. Short after takeoff the airship hit some trees and broke into two pieces. Winds then threw the airship against the trees.

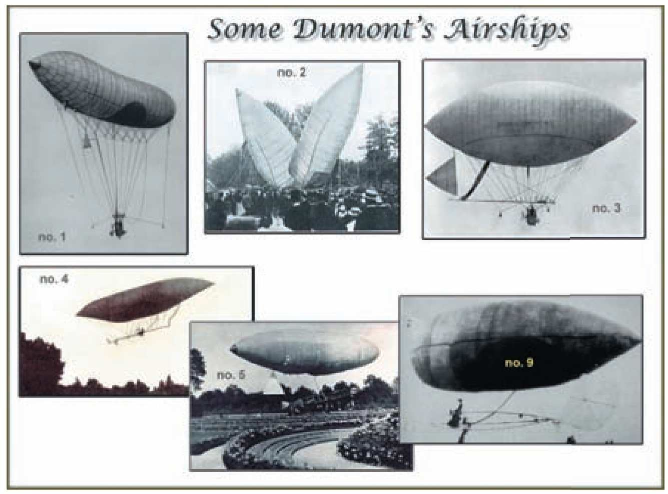


Figure 4. Some airships designed and built by Santos-Dumont.

On November 13, 1889, Santos-Dumont finally performed a controlled flight with the number 3 airship (Fig. 4), which was lifted by hydrogen and powered by an internal combustion engine. The determined Brazilian modified his design to prevent envelope failure. In this time, a long sausage shape was rejected in favor of an elliptical envelope, similar to the one Giffard and his friend Tissandier (Fig. 4) had used long before. Since it was thicker in the middle of its length, it was unable to fold up on itself. The number 3 was the first successful aircraft to be propelled by an internal combustion engine. Besides hydrogen, Santos-Dumont also considered to employ illumination gas for lifting the number 3 airship. The main idea behind this was to design a low-cost aircraft, which could be easily manufactured to be employed as a general transportation.

Henri Deutsch de la Meurthe established the Deutsch de la Meurthe Prize of 100 000 francs (US$ 20 000, in 1901 dollar) in 1900 to grant the first person to fly around the Eiffel Tower, leaving from and returning to the Saint Cloud field within 30 minutes. The entire city of Paris watched as Santos-Dumont performed his aviation milestone in October 1901, piloting his airship number 6 (Fig. 5).

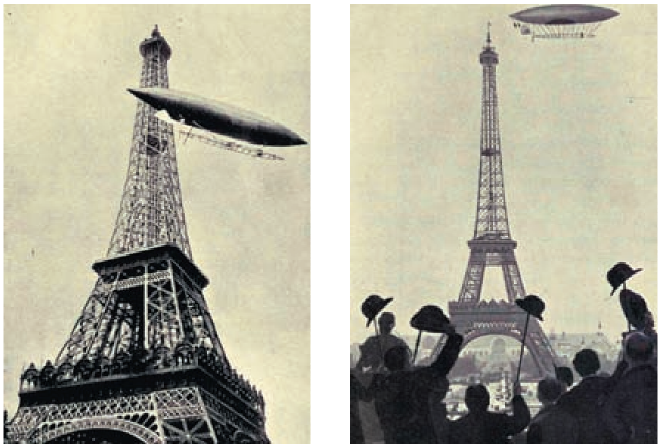


Figure 5. A milestone for aeronautical engineering: Dumont's airships around the Eiffel Tower. Left – number 5 suffered from gas leakage after turning the Eiffel Tower. This picture is erroneously misinterpreted by many historians – they refer that the airship in the picture is the number 6. Right – the number 6 in the path to win the Deutsch de la Meurthe Prize.

Santos-Dumont envisioned a future in which air transportation would have an important role. Number 16 Omnibus, Dumont's largest design, was conceived with passenger transportation in mind (Lins de Barros, 2003). Although number 10 was unsuccessful, Dumont's dream came true as early as 1910 with regular airship flights by German DELAG, the first airline in the world. Later on, the Zeppelin Company became famous for using airships to carry passengers overseas.

On July 2, 1900, LZ 1, the first Zeppelin airship, performed its maiden flight over Constance Lake, Germany. It was only 18 minutes in the air and carried five passengers. The cloth-covered dirigible, which was the prototype of many subsequent models, had 1 aluminum structure, 17 hydrogen containers for lifting gas storage, and 2 15-hp Daimler internal combustion engines, each turning two propellers. After two further flights, which took place on October 17, and 21, 1900, it was scrapped. In 1905, Zeppelin built his second airship, the LZ 2, which incorporated three major improvements: lighter and more powerful engines; more accurate commands; and stronger structure. However, by the second test flight in 1906, one of the engines malfunctioned and the airship proceeded to an emergency landing. Afterwards, a thunderstorm caught the aircraft and destroyed it. After the Zeppelin LZ 4 airship was also destroyed by a thunderstorm in 1908, the Germans collected money to enable Graf von Zeppelin to continue building airships. Zeppelins were employed during World War I in raids to bomb London and Italian cities.

Santos-Dumont meets Thomas Edison

After his flights around the Eiffel Tower, Santos-Dumont became worldwide famous. He was cartooned, biographies about him were written, postcards featured him, suits and shoes were sold remembering his way of dressing, and even Carnival costumes in Brazil imitated his airships (Jorge, 1977). Santos-Dumont eccentricities and adventurous life have also inspired lots and lots of adventurers and writers. Right after his trip to the United States in 1902 and his return to Paris, great number of toys and publications appeared. Probably, Tom Swift was the most expressive character ever created based on Santos-Dumont real life (Pagano, 2012). Most of the inventions in the Tom Swift series are enhancements of the real inventor's creation, the combined airplane-airship was perfectly inspired in Santos-Dumont number 14 (Fig. 6).

Figure 6. Fictional characters were inspired in Santos-Dumont.

Santos-Dumont received a greeting card from Thomas Edison with congratulations for his achievements with airships (Pagano, 2012). The aviation pioneer was touched by Edison's card, therefore both inventors met during Dumont's trip to the United States, in 1902.

One of the purposes of their conversation was the aeronautical use of batteries that had been developed by Edison (New York Times, 1902). This encounter was published by some newspaper at that time (Pagano, 2012). Emmanuel Aimé, ex-secretary of the Aéro-Club de France, took part in the meeting.

In the beginning of the meeting, Edison declared that mankind ought to be ashamed of themselves because the problem of aerial navigation by human beings had not been solved. He also made clear that while Santos-Dumont performed a great job in steering airships through the air, it would take a long time before Aviation was due to become commercially possible. The reasons were due to the fact that no inventor was able to secure any reward for his labor under the patent laws at that time. He called for a sort of protective institute of invention, which should have rewarded the successful inventor of the commercial airship (Pagano, 2012).

The next contents of the talk between Santos-Dumont and Thomas Edison were extracted from a newspaper report available at Pagano's blog (Pagano, 2012).

Edison was much interested in the young man who had wondered Paris and the world by steering an airship over the city, not once but several times: "You are the only man who has done such a thing," he exclaimed. "I am sure you have never worked on the problem of aerial navigation," replied Santos-Dumont, "or you would have accomplished years ago more than I have done now." The aeronaut was not trying to be complimentary; he had the biggest admiration for Thomas Edison and his inventive genius. At this point, Edison affirmed that he had built a very light motor to be operated by exploding gunpowder. He experienced a lot in lifting weights with it, but worked with a small model and did not attempt to fly. The man also stated that he gave it all up because had a number of other things to do which were far more profitable. Like the Wright brothers, Edison was caught by the spirit of the English Revolution.

The talk continued and Edison addressed that the aircraft would become even lighter than those already developed by Dumont. Mr. Edison believed that the problem of aerial navigation should be solved by means of the flying machine, and not by the airship. Only with the machine can air navigation ever be made either safe or commercially profitable, he said during the conversation. The term flying machine referred to a contrivance heavier than the air, it is intended to navigate. At rest such an apparatus would not float at all, due to the higher speed at which it moves. In Edison's mind, then, aerial navigation was simply a question of sufficient power, properly applied, to overcome the lack of buoyancy necessary to make the machine rise and to keep it in sufficient motion in order to hold it in position at a certain altitude. He constantly referred to the figure of the bird that anyone could see rise and fly at will.

At a certain point, someone asked Mr. Edison whether his new storage battery would be useful in solving the problem of aerial navigation. "Oh, no, of course not," he replied. "It would be too heavy. We must get the lightest possible motive power. Thus, the greatest factor of this problem is to get a very light motor, which will be powerful enough to operate the flying machine properly." The inventor believed that the gasoline or gunpowder engines were the best suited for the task. He affirmed that Santos-Dumont was on the right track in this regard, but he should turn his efforts towards a flying machine not airships. Afterwards, Santos-Dumont asked Mr. Edison to join the race to develop a proper flying machine and Edison replied: "No, I will not go into anything which cannot be protected from the pirates who live off the work of inventions, and I do not believe it would be possible to secure a patent on other flying machine or an airship or any part of one that would stand the test of the courts. If someone should make a commercially successful flying machine, dozens would at once copy the models and take away the fruits of the original inventor's labor. There is not a judge in the country who would holds that there was really any invention in such an apparatus, because so much has been done and written about it that the only difference between the successful machine, which have been, will be very alight. I doubt whether any new principle will be discovered on which even a claim for a patent may be made."

The aviator believed that there was no big barrier to overcome the issue of building a successful flying machine. According to him, light and compact structures as well as powerful engines enough to sustain flight would be easily available in a near future. The successful test with unmanned flying machines carried out by Samuel Langley was also addressed by him and he manifested again his disregard for airships for solving the problem of aerial navigation.

During the first years of the 20th century, Santos-Dumont was the single person in the world who was able to fly in a controlled fashion. Emmanuel Aimé, who was present in such meeting, once declared (Musa *et al.*, 2001): "Among all airship designs, openly or secretly studied in the last few years, the one by Santos-Dumont is the only one capable of flying in the free atmosphere. Say what you may, but there are no airships in the world, there is only one and you have to come to Paris in order to see it."

No happiness with steam

Since a long time, experimental development in Fluid Mechanics was performed side-by-side with theoretical work carried out by scientists and researchers. In 1738, Daniel Bernoulli published his findings on the relationship between pressure and gas velocity. His assistant, Leonard Euler, published some articles in 1750 with his famous equations on the behavior of compressible fluids. Italian mathematician Joseph Lagrange and French mathematician Pierre-Simon Laplace studied Euler's findings and tried to solve his equations. In 1788, Lagrange introduced a new model for fluid flow, as well as new equations for calculating speed and pressure.

In 1789, Laplace developed an equation that would help solve Euler's equations. It is still used in Modern Aerodynamics and Physics. He also successfully calculated the speed of sound. In addition to these theoretical advancements, experiments in Aerodynamics were also producing more practical results. In 1732, the French chemist Henri Pitot invented the pitot tube, a device that enables the speed calculation at a point in a flowing fluid. This would help explain the behavior of fluid flow. The English engineer Benjamin Robins performed experiments in 1746 using a whirling arm device and a pendulum to measure drag at low and high speeds.

In 1759, English engineer John Smeaton also used a whirling arm device to measure the drag exerted on a surface by moving air. He proposed the equation $D = kSV^2$, where D is the drag, S is the surface area, V is the air speed, and k is a constant, which Smeaton claimed was necessary for it. This constant became known as Smeaton's coefficient, and the value of this constant was debated for years. Those making the first attempts at flight, including the Wright brothers, used such coefficient. French scientist Jean-Charles Borda published the results of his own whirling arm experiments in 1763, and verified and proposed modifications to current Aerodynamic theories, being able to show the effect that the movement of one object had on another nearby one. The Navier-Stokes equations, which are considered the most complete mathematical model of fluid flow, were written in the beginning of the 19^{th} century. However, this system of equations was solved only halfway through the 20^{th} century. Therefore, Aviation pioneers largely used experimentation and employed less complex theoretical models in order to achieve their goals. As of the middle of 19^{th} century, two new trends emerged based on the steam engine: the race to fly a lighter-than-air airship with engines and directional control, and the development of fixed-wing aircraft. Over time, the airplane began to take on a familiar shape.

In 1799, 26-year-old George Cayley sketched what it is now recognized as the familiar conventional configuration of an airplane: a cambered wing having dihedral; an aft vertical tail; and an aft horizontal tail. Cayley's choice for the airfoil was based on their Aerodynamic characteristics tested by him and his predecessors using a whirling arm apparatus. He himself invented dihedral as a means for maintaining equilibrium in roll. The vertical tail provided directional stability, like the feathers on an arrow, and in Cayley's view, would also be used for steering, as a boat's rudder serves. By analogy, the horizontal tail gave stability in pitch. It turned out that Cayley was half right on both counts. He did not formally apply Newton's laws for translational and rotational motions to the airplane. No mathematical descriptions for the motions of an aircraft were produced and, therefore, it has no quantitative basis for designing his flying machines. But he had things right at the level he worked. Already with his first efforts, he established the principle that was explained thoroughly in a series of papers: the means of producing lift to compensate weight must be distinct from the ones for generating thrust; a revolutionary idea at that time (Grant and Fliegen, 2003). He properly shifted attention to artificial flight from the simple imitation of birds to development of fixed-wing aircraft.

As of 1891, the German Otto Lilienthal performed about 2,000 glider flights (Grant and Fliegen, 2003). Both Lilienthal and Cayley wrote books and articles about light theory, which influenced the work of other pioneers. Santos-Dumont and the Wright brothers count among the readers.

Born in 1812, William Samuel Henson was, like his father, a successful industrialist in the lacemaking business in Somerset, England. In 1840, under the influence of Cayley's early writings, Henson and an engineer who also worked in the lacemaking industry, John Stringfellow, designed a steam-driven airplane called an aerial steam carriage. Samuel Henson, John Stringfellow, Frederick Marriott, and D.E. Colombine incorporated as the Aerial Transit Company in 1843 in England, with the intention of raising money to construct the flying machine. The company planned "to convey letters, goods and passengers from place to place through the air," according to the patent issued on March 28, 1843 for its flying vehicle, which was christened Ariel and was also known as Aerial Steam Carriage (Schmitt, 1990).

The patent obtained by Henson was the first one issued for an airplane in history. Henson's airplane configuration was comprised of a landing gear, tail surfaces, and engines mounted behind the wing; passengers would be transported in an enclosed fuselage. Two counter-rotating six-bladed propellers would drive the airplane. However, the Aerial Carriage was never built and flown. The Aerial Transit Company was financed by D.E. Columbine; John Marriott, a journalist whose value was that he knew a Member of Parliament; and Mr. Roebuck, who was expected to promote a bill in Parliament for a shareholders company to operate an Aerial Steam Carriage. Henson and Stringfellow engaged in model testing in order to make their airplane become true. In 1843, they obtained the help of Joe Chapman, a mathematician, who also had a whirling arm device. Chapman made more than 2,000 recorded aerodynamic experiments on the whirling arm for Henson and Stringfellow. This led to an airplane with a span wing of 6 m and an area of 5.84 m^2, powered by a small steam engine designed primarily by Henson but improved by Stringfellow. Some unsuccessful flight attempts were made with this type. The machine was not able to get airborne after being launched by a catapult system. Lack of suitable power and techniques for the construction of lightweight structures were the reasons for the Aerial Steam Carriage failure.

Due to the failure of his proposed enterprise, in 1848, William Henson and his wife, Sarah, left England and moved to the United States, settling in Newark, New Jersey, where he spent the last 40 years of his life. Henson had apparently ceased his aerial research for good, and never again took up the matter. Stringfellow stayed on and in 1848 tried once more to fly a model with an improved steam engine. The results were disappointing, nothing more than a short, uncontrolled hop. At this point, Stringfellow also gave up, and the entire episode was forgotten. However, the Ariel had some positive effects: its design prompted Cayley to rethink wing configuration and come up with the multiple-wing design, a feature of nearly all the early successful aircraft. The plane itself was logically designed and inspired many builders. Ariel configuration certainly influenced the Demoiselle from Santos-Dumont. Both planes presented a monoplane configuration featuring cambered airfoils. The materials were to be spars of bamboo and hollow wood, with diagonal wire bracing.

Other many flight attempts happened with aircraft powered by steam- and electric-engines. These flights were unsuccessful since such engines presented high-weight-to-power ratio at that time. Only after the internal combustion engine was improved, flying with a heavier-than-air aircraft became possible.

Putting an airplane airborne

In France, an Aviation community was established in the turn of 19th to 20th century. Most of people were friends, including Louis Blériot, Henri Farman, Gabriel and Charles Voisin, and Santos-Dumont. The latter was not a theoretician or a scientist, but he superbly integrated the technologies at his disposal at that time, in other words a technology integrator. In addition, he improved existing technology in many aspects, for example, lubrication of opposed-cylinders engines. He also invented devices and mechanisms to improve airship stability and maneuverability.

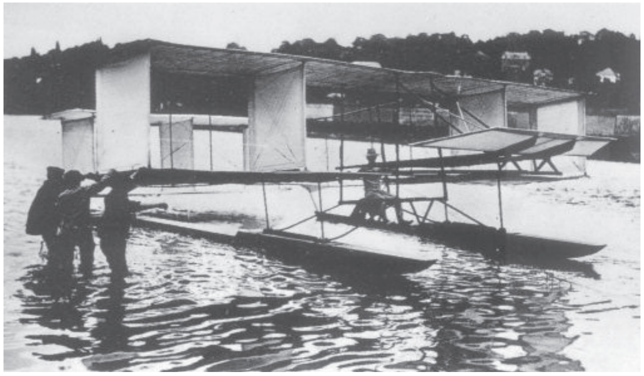
Santos-Dumont had been thinking about a heavier-than-air aircraft for a long time (Santos-Dumont, 1904). He initially considered a huge airplane based on Cayley's ideas (Lins de Barros, 2003). A counter-rotating dual rotor helicopter was also constructed, but soon he was aware of the difficulties posed by a vertical takeoff concerning the required higher power-to-weight ratio, therefore he abandoned the concept. He tried some different concepts that simply did not work.

Years before the work to the construction of the monoplane began, Dumont was convinced by the Voisin brothers to switch to a biplane configuration, which should be shaped like a square kite called Hargrave box. On November 12, 1894, Lawrence Hargrave, the Australian inventor of the box kite, linked four of his kites together, added a sling seat, and flew 4.88 m. By demonstrating to a skeptical public that it was possible to build a safe and stable flying machine, Hargrave opened the door to other inventors and pioneers. The Hargrave-designed box kite, with its improved lift-to-drag ratio, was to provide the theoretical wing model that allowed the development of the first generation of European and American airplanes.

In 1905, the Voisin brothers ran a glider manufacturing business in partnership with Louis Blériot, in Paris. The box-kite configuration had been successfully employed in their glider designs (Fig. 7). During some trials on the Seine River, Santos-Dumont perceived that the Antoinette boat engine, which was employed to bring the glider airborne, could be fitted in a heavier-than-air machine (Fig. 7). On this way, the 14-bis was conceived. Again, we testify that there was an exchange of information, ideas, and even designs among the members of the aviation community in France.

Santos-Dumont properly did not follow entirely the Hargrave-box kite concept. He transformed a pair of wings incorporating a control surfaces box in a canard configuration. The 14-bis aircraft was constructed at Neuilly-Saint James on the outskirts of Paris and was exhaustively tested (Fig. 8). At first, the airship number 14 served as a support platform for evaluating the stability of the airplane and, for this reason, it was called 14bis (Encore). Thus, Dumont also invented the flight test. Finally, he performed a few flights with his biplane and in France certified by Aéro-Club de France commission, who attended for the occasion.

Some months earlier, on August 21, 1906, Santos-Dumont made his first attempt to fly. He did not succeed because the 14bis airplane was underpowered at this time. His next move, it was the re-engine of his aircraft with a 50-hp (37.3 kW) power plant, which he obtained through Louis Bréguet. He was ready for a new flight attempt. On September 13, Santos-Dumont



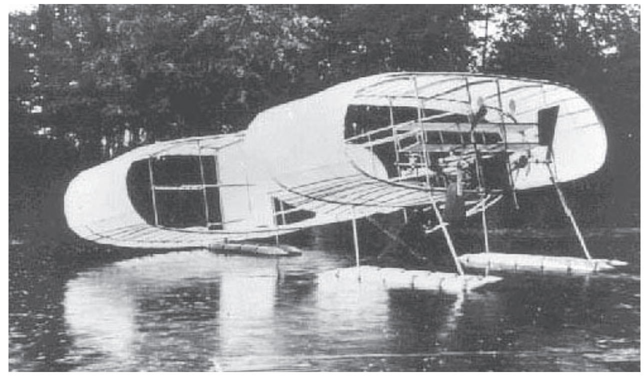
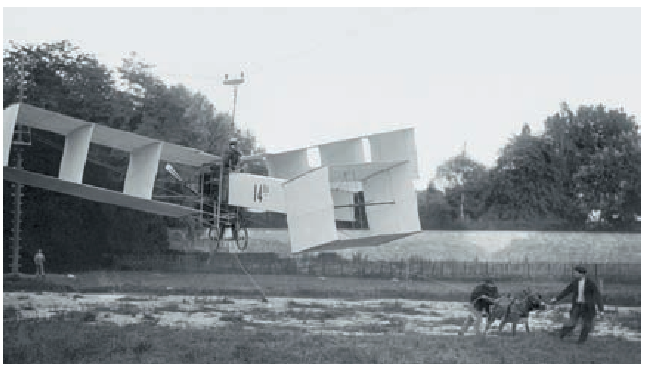


Figure 7. Left – Voisin-Blériot glider based on Hargrave-box configuration (1905). Santos-Dumont is sitting in the middle of the aircraft. Right – this machine was built by Gabriel Voisin for Louis Blériot from Blériot's designs in 1906. It began as a glider and was later fitted with an engine and propellers. When Voisin test flew it, it sank in the Seine River.



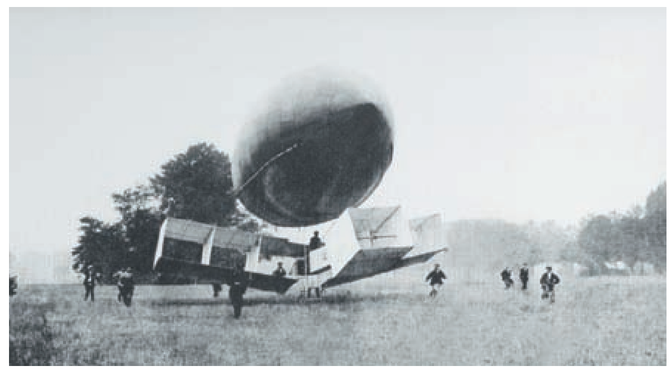
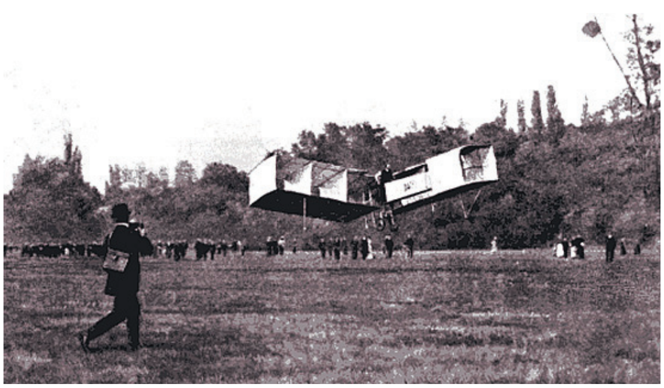


Figure 8. Dumont's ingenious trials with 14-bis before the first flight.

made the first flight of 7 or 13 m (according to different accounts) above the ground, which ended with a violent landing, damaging the propeller and landing gear. On 23 October 1906, 14^{bis} biplane flew a 50 m distance at a height of 2 to 3 m during a seven-sec-long flight (Fig. 9).

Santos-Dumont won the 3,000 Francs Prize Archdeacon, instituted in July 1906 by the American Ernest Archdeacon, to honor the first flyer to achieve a level flight of at least 25 m. Before his next flight, Santos-Dumont modified the 14^{bis} by the addition of large octagonal ailerons to provide some roll control. Although ailerons had been used in sailplanes before, Dumont pioneered the application for airplanes. Since he already had his hands busy with the rudder and elevator controls (and could not use peddles as he was standing), he operated the commands via a harness attached to his chest. If he wanted to roll right, he would lean to his right, and vice-versa. With the modified aircraft, he was back again on trials on 12 November. This time the Brazilian was not alone.



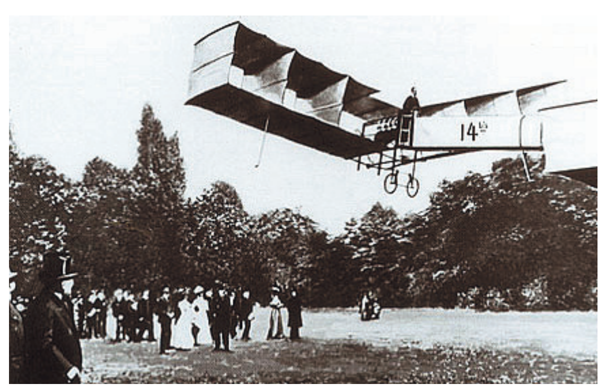


Figure 9. Left – first flight with 14-bis on October 23, 1906. Right – second flight with the type took place on November 12.

Blériot and Gabriel Voisin had built a flying machine aiming at winning the prize. Their machine presented an elliptical wing and a pair of trapezoidal ones. After some takeoff attempts, their flying machine was damaged. Dumont then initiated the takeoff run but damaged the landing gear. After repairing the 14bis, Dumont made six increasingly successful flights. One of these flights was 21.4-s long within a 220 m path at a height of 6 m, attained after taking off against the wind (Fig. 9).

Long-range flights

Santos-Dumont had shown the world that the dream of a long-range powered flight could be a reality. In 1907 many aviation enthusiasts and experimenters tried to build on his achievement. Few of them, however, met with much success. Among them were Adolf de Pischof, Louis Blériot, and Romanian Trajan Vuia. Meanwhile, Paul Cornu and the Breguet brothers experimented with helicopter designs. In Britain, Horatio Philips got (briefly) airborne in a machine with four sets of wings, Samuel Cody began the construction of a biplane for the Army, and John Dunne was commissioned by the Government to design an airplane in secrecy. The most successful aircraft of 1907 was one made by the brothers Charles and Gabriel Voisin, now running a plant for airplane manufacturing. The FlightGlobal (1909a) stated: "The Voisin brothers and their engineer and works manager M. Colliex make no secret of the fact that they have based their work on that of pioneers such as Lilienthal, Langley, and others, and in fact they say that they never miss an opportunity of utilizing an information or data on which that can lay hands."

A biplane elevator at the front was based on the Hargrave boxkite construction, and it carried a huge square tail assembly at the rear. Power was provided by the 50-hp Antoinette engine. It was a crude and heavy machine with no control in roll at all, but it was capable of staying in the air for several seconds at a time, and on this basis the brothers set up a workshop to its manufacture. In the summer of 1907, their third production machine was ordered by Henry Farman.

Henry Farman was born in 1873. Henry trained as a painter at the École des Beaux Artes, but quickly become obsessed with the new mechanical inventions that were rapidly appearing at the end of the 19th century. Since the Farmans were well-off, he was able to pursue this interest as an amateur sportsman. Farman had a natural flair for getting the feeling of a piece of machinery, and enjoyed considerable success. In the 1890s, he became a championship cyclist, and at the turn of the century he discovered motor racing. Driving Panhard cars he came fifth in the Paris-Berlin road race of 1901, and won the Paris-Vienna in 1902. With his mechanic, he covered the 615 miles (990 km) to the Austrian capital in just 16 hours along unmade roads. Farman himself became a casualty of the sport when he was involved in a serious accident. He fully recovered, but the experience destroyed his enthusiasm for cars. Nevertheless, his fascination with machinery endured. He was aware of the Voisin float-glider experiments on the Seine during 1905/06, and he had flown in balloons before with his brother, Richard. When the Voisins began to produce a powered airplane for sale in 1907, he was one of their first customers. He made his first flight at the end of September and, displaying his usual sure feel for machines, was soon able to stay in the air longer than anyone else. On October 26, he flew for 771 m at Issy. For this flight, he won a cup sponsored by Ernest Archdeacon of the Aéro-Club. By early November, Farman was coaxing turns out of the Voisin, despite it being built without any roll control. This meant that all turns were a delicate skid round on rudder alone. If the outside wing picked up too much airspeed, it would rise, and if the turn was persisted in, the plane would be in danger of side-slipping into the ground lower wing first. Farman incorporated a number of modifications of his own to the Voisin during the autumn, including a reduction in the size of the tail surfaces, removing one of the forward elevators, and rigging a slight dihedral angle into the wings. Thus, the Voisin-Farman I became the Voisin-Farman I-bis. It was clear to members of the Aéro-Club that Farman would soon attempt to win the last and largest Archdeacon prize, the so-called Grand Prix of Aviation. This comprised a purse of 50,000 francs (of which half had been contributed by oil magnate Henri Deutsch de la Meurthe), for the first aviator who could fly to a marker 1,000 m.

After several successful flights of a kilometer in a closed circle made during the last few days of 1907, in which Farman managed to cover this distance, though not without the wheels of his machine lightly touching the ground at one or two places, M. Henri Farman finally, on January 11, at last made two unofficial flights without touching the ground except at the take-off and landing. Two days later (on Monday, January 13) before the officials of the Aéro-Club de France, he repeated this performance for a third time, and won the Deutsch-Archdeacon prize of 50,000 francs (US$10,000) for the first flight by a heavier-than-air machine of one kilometer in a closed circuit. The weather was perfect, there being practically no wind and the air was clear and mild. The flight was made above the parade ground at Issy-les-Moulineaux, some five miles out from Paris, at 10:12 AM. At that time, the airplane was started and ran along the ground for 90 or 120 m and attained its usual speed of about 30 miles an hour, and quickly ascended into the air to a height of 3.6 or 4.5 m. It passed between the two posts that formed the goal for the start and finish, and flew in a straight line towards the 500-m post. When about half way to this post, Farman operated his horizontal rudder, and caused the machine to rise to a height of about 7.5 m. The airplane swept around the halfway post almost on an even keel, and then took a straight course back to the goal, which it passed through at about the same height as before, descending 30 m or so beyond in practically the same place from which it started. The time of this flight was 1 minute and 28 seconds, which corresponds with an average speed of about 25 ½ miles an hour.

Not content with winning the 10,000 Francs prize, Farman once more flew his machine on January 15, for the purpose of ascertaining how much it would lift. He at first loaded it with 66 pounds dead weight, but he found that only a slight lift could be obtained with this weight. With 20 kg dead weight, the machine rose and flew for a few hundred yards, but it was unable to make a sustained flight. With 15 pounds weight added, the machine flew from one end of the field to the other, and made a sharp turn when struck by a sudden strong gust of wind, which caused it to wheel around almost at right angles, and also to incline inward very sharply. After making the turn, however, it finished its flight on an even keel and at a height of 1.2 or 1.5 m above the ground.

In a final test, Farman flew from one end of the field to the other, and skirted along the fortifications at this point in a large circle, covering in all more than 2 km in a flight that lasted nearly three minutes. This final flight was the longest which had thus far been made. Farman expressed himself as quite satisfied that his machine was being pushed to the limit as far as its lifting power is concerned. In all probability his next step will be to equip it with a more powerful and lighter motor. By Farman's recent successful flights in a circle, the record of the Wright brothers made in this country over two years ago has in this respect been duplicated; however there are many other points to be considered when one reviews the practicability of airplane flight. Firstly, Farman has found that his machine in that condition was incapable of long-distance flight, because of its inability to lift any perceptible quantity of fuel; secondly, he has not demonstrated its capability of flying with safety against a wind having a velocity of 32 km/h – a feat which the Wright brothers accomplished with their first motor-driven machine in 1903. While Farman's airplane had approximately the same weight as that of the Wright brothers, it was fitted with a motor of three times the horse-power, and of about one-quarter the weight per horse-power developed. In spite of their handicap in the shape of less horse-power and a much weightier motor, the Wright brothers' airplane made a speed of 64 km/h, as against 52 km/h shown by Farman's. Therefore, the American inventors, by constructing a slightly larger machine and fitting it with an up-to-date, lightweight, and aeronautical motor, should have been readily able to carry two men and sufficient fuel for a flight of 200 km, which are among the requirements specified by the War Department for a heavier-than-air flying machine.

In March 1908, Farman recovered the machine in rubberized fabric and changed the engine for a 50-hp Renault. The Voisin-Farman I-bis became the Henri Farman I-bis. The new engine did not last long and he installed back the Antoinette one. However, Farman's constant tinkering with his plane showed how confidently he had grasped the essentials of Aeronautics. During the Summer, he added side-curtains to the wings, to make them true box kites, and importantly put in ailerons of his own design so that the machine could be banked. On May 28, 1908, Farman took the first passenger in Europe into the air. Appropriately enough it was Ernest Archdeacon, the man who had been doing so much to encourage Aviation in France since 1903.

The only other prominent aviator during this period was Léon Delagrange, who, like Farman, had purchased a standard Voisin in 1907. However, he was less technically-minded than Henry and had made only a few modifications to the basic design (Fig. 10). Gabriel Voisin remarked that, in contrast to Farman, Delagrange 'was not the sporting type and knew nothing about running an engine'. Nevertheless, a sporting rivalry seems to have been developed between

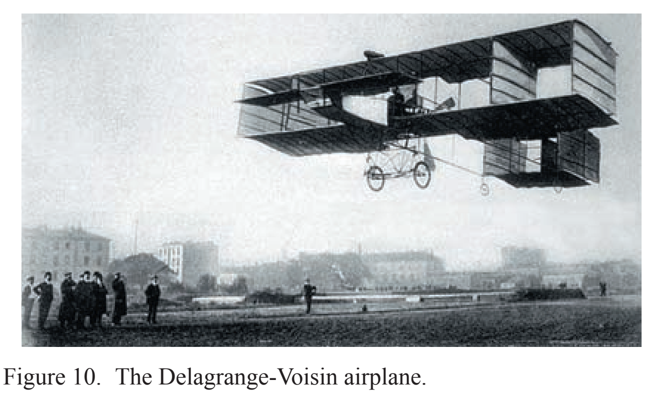


Figure 10. The Delagrange-Voisin airplane.

the two fliers. In the Summer of 1908, Delagrange went South to Italy in order to demonstrate the art of flying while Farman went North to Belgium. On June 22nd, Delagrange set an endurance record of 18 minutes, 30 seconds at Milan: Farman retaliated with 20 minutes, 20 seconds at Ghent, on July 6th. On September 6th, he flew for 25 km at Issy: Farman bested that with 40 km at Champ de Chalons on October 2nd. Finally, Farman made the logical next step of flying between two places, rather than simply making measured circuits over the safety of an aerodrome. On 1908 October 30, he flew the 27 km from his camp at Bouy to the cavalry ground at Rheims in just under 20 minutes.

The Voisins had built an airplane for Henry Kapferer and then one for Léon Delegrange, in which Gabriel Voisin achieved flight in 1907; they then built an airplane for Henry Farman, which was the first to fly a kilometer circuit; then they built another for Farman, but they sold it to J.T.C Moore-Brabazon. This infuriated Farman so much that he established his own company to compete with Voisin. The first aircraft Farman produced was the Type III of 1909. Later, Farman formed the Farman Airlines, which operated the legendary Farman Goliath airliner in the decade of 1920. In 1910, the Voisin company needed a replacement for their famous, but now obsolete, box kite-like standard construction. The box kite was modernized, fitted with ailerons and a simplified tail-unit, and the front elevator was discarded. This model then became the direct progenitor of the Voisin's World War I bombers. Besides this evolution, one also experienced new types. One of these, which became quite successful, was the Voisin Canard. The first plane of this class was tested in late 1910, and it had been put together from existing parts, the fuselage reportedly coming from an old triplane. It was powered by a 50 hp Rossel-Peugeot rotary engine.

After the World War I, the demand for airplanes plunged. Thus, Gabriel Voisin turned his attention to the automotive world. His brother Charles died in a car accident in 1912. Gabriel had a great deal of technical and engineering expertise but lacked sufficient knowledge of automobile techniques. He started by buying rights to Citroën models, using designs that had undergone testing, rather than starting from scratch. His expertise acquired in the Aviation world helped to design ground vehicles, which are aerodynamic but also light. The only downfall to this formula is that the vehicles were not always visually appealing, which led to poor sales. Most featured aluminum bodies and were scrapped during World War II. In 1929, Gabriel developed the first anti-lock braking systems (ABS).

The first practical airplane

In 1907, Santos-Dumont's was working in a revolutionary airplane, back to the monoplane configuration as he had dreamed before the flights with 14-bis. It was the airplane that shaped things that would come. The single-engine Demoiselle aircraft (Fig. 11) was Dumont's final design. The aviator performed a large number of experimentation with Demoiselle, which received successive designations – numbers 19 to 22. The Demoiselle was a groundbreaking experience in terms of construction and configuration. It was produced in different countries, including Germany, France, Holland, and the United States (Schmitt, 1990). This aircraft was employed as Dumont's personal transportation and he willingly let others make use of his design. The fuselage consisted of a specially reinforced bamboo boom, and the pilot sat beneath between the main wheels of a tricycle landing gear. The Demoiselle was controlled in flight partially by a tail unit, which functioned as both elevator and rudder and by wing warping (number 20).

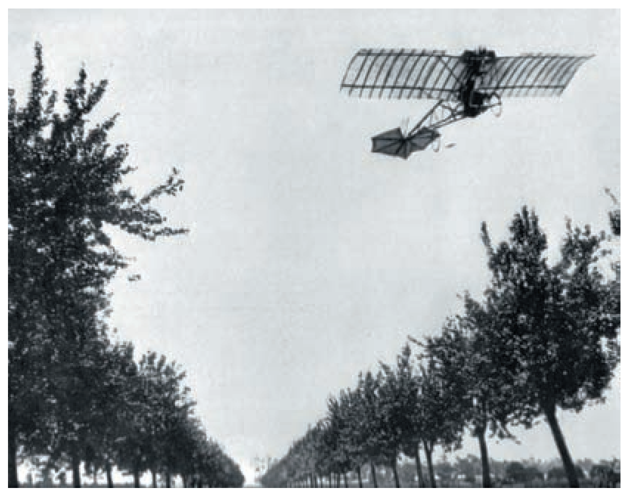


Figure 11. Demoiselle monoplane flying over a boulevard.

It presented a wingspan of 5.10 m and an overall length of 8 m. Its weight was little more than 110 kg with Santos-Dumont at the controls. The pilot was seated below the fuselage-wing junction, just behind the wheels, and commanded the tail surfaces using a steering wheel. The sustentation cables of the wing were made of piano ropes. Demoiselle featured airfoils with considerable camber at the wing leading edge. Initially, Santos-Dumont employed a liquid-cooled Dutheil & Chalmers engine with 20 hp. Later, the great inventor repositioned the engine to a lower location, placing it in front of the pilot. He also replaced the former 20-hp engine by a 24-hp Antoniette and carried out some wing reinforcements. This version received the designation number 20.

Due to structural problems and continuing lack of power, Santos-Dumont introduced additional modifications into the Demoiselle's design: a triangular and shortened fuselage made of bamboo; the engine was moved back to its original position, in front of the wing; and increased wingspan. Thus, number 21 was born. The design of number 22 was basically similar to number 21. Santos-Dumont tested opposed-cylinder (he patented a solution for cooling this kind of engine) and cooled-water engines, with power settings ranging from 20 to 40 hp, in both variants. An interesting feature of the water-cooled variant was the liquid-coolant pipeline that followed the wing lower side lofting to improve the aircraft aerodynamics.

Dumont's monoplane could be constructed in only 15 days. Possessing outstanding performance, easily covering 200 m of ground during the initial flights and flying at speeds of more than 100 km/h, the Demoiselle was the last aircraft built by Santos-Dumont. He used to perform flights with the airplane in Paris and some small trips to nearby places. Flights were continued at various times through 1909, including the first cross-country one with steps of about 8 km, from Saint Cyr to Buc on September 13, returning the following day, and another on the 17th, of 18 km in 16 minutes. The Demoiselle that was fitted with two-cylinder engine became rather popular. Santos-Dumont was so enthusiastic about Aviation that he released the drawings of Demoiselle for free, believing that aviation would be the mainstream of a new prosperous era for mankind (Fig. 12). Clément Bayard, an automotive and bicycle maker, constructed several units of Demoiselles, which was sold for 50,000 Francs. The design of Demoiselle clearly influenced that of the Blériot 6th airplane, which was used by his friend Louis Blériot for the British Channel crossing, in 1909.

The French World War I ace Roland Garros flew it at the Belmont Park, New York, in 1910. The June 1910 edition of the Popular Mechanics magazine published drawings of the Demoiselle and affirmed that Santos-Dumont's plane was better than any other that had been built up to that date, for those who wish to reach results with the least possible expenses and with minimum of experimenting. American companies sold drawings and parts of Demoiselle for several years thereafter.

The World War I greatly stepped up Aviation growth. In 1911, Blériot's company released the first transport aircraft with enclosed cabin, which was christened Aèrobus. In November

Figure 12. Advertisement in "Popular Mechanics" about the purchase of Demoiselle drawings.

1909, Igo Etrich made the first flight in Austria in an Austrian designed and built airplane, at Wiener-Neustadt. It was called the Taube (pigeon) and was a monoplane with bird-like wings. Subsequently, it was produced in refined form as single, two- or three-seaters. The maiden flight of the so-called Etrich's Luftlimousine took place on May 7, in 1912, only six days after the Avro Type F (Fig. 13), the latter has been considered as the first aircraft with a fully enclosed cabin to fly (Schmitt, 1990).

The top speed of the Etrich aircraft with three passengers on board was 106 km/h. Shortly after the World War I, the first airlines were founded and started operating with retrofitted bomber planes. German manufacturer, Junkers, designed and produced the world's first all-metal planes, as some were used in combat in the later stages of the World War I. The Junkers F.13 was the first airplane intended for passenger transportation, and its first flight was in 1919. It was the world's first all-metal transport airplane.

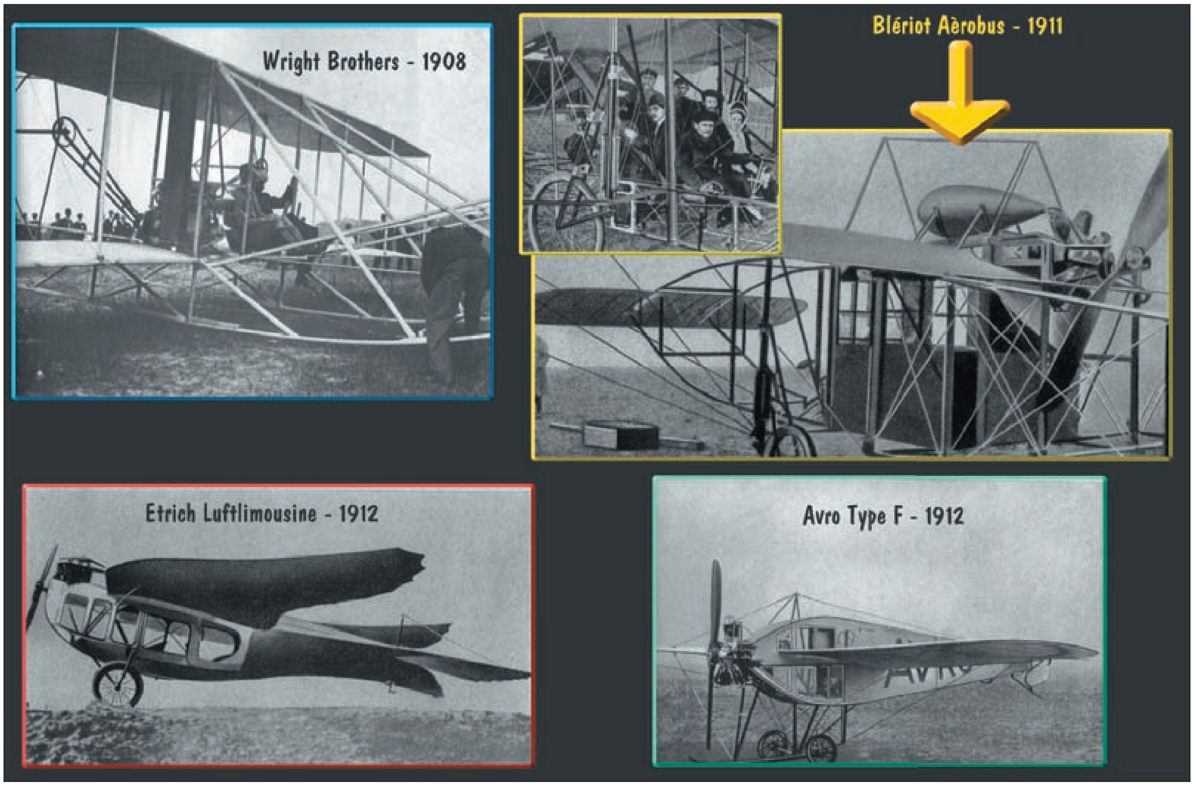


Figure 13. The first airplanes used for people transportation.

CRUSADE FOR THE FIRST FLIGHT IN THE UNITED STATES

Langley flight attempts

Samuel Pierpont Langley was born in Massachusetts, in 1834. He was affined with scientific and technological matters. He attended Boston Latin School, graduated from The English High School, and then he was an assistant in the Harvard College Observatory. Later on, he became chair of mathematics at the United States Naval Academy. In 1867, he was nominated director of the Allegheny Observatory and professor of astronomy at the Western University of Pennsylvania, which is now known as the University of Pittsburgh, a position he kept until 1891, even while he became the third Secretary of the Smithsonian Institution in 1887. Langley was the founder of the Smithsonian Astrophysical Observatory.

Langley attempted to make a working piloted heavier-than-air aircraft but his two attempts with manned aircraft were not successful. Therefore, he began experimenting with rubber-band powered models and gliders in 1887. He built a rotating arm (functioning similar to a wind tunnel) and made larger flying models powered by miniature steam engines.

His first success came on May 6 1896, when his number 5 unpiloted model flew 1,000 m after a catapult launch from a boat on the Potomac River. The distance was ten times longer than any previous experiment with a heavier-than-air flying machine, demonstrating that stability and sufficient lift could be achieved in such craft. On November 11, in the same year, his number 6 model flew approximately 700 m. On both occasions, the Aerodrome number 5 landed in the water, as planned, because, in order to save weight, it was not equipped with landing gear.

In 1898, based on the success of his models, Langley received a War Department grant of US$ 50.000 and US$ 20.000 from the Smithsonian to develop a piloted airplane, which he called an “Aerodrome” (coined from Greek words roughly translated as “air runner”). Langley hired Charles Manly as the engineer and test pilot. When Langley received word from his friend Octave Chanute of the Wright brothers’ success with their 1902 glider, he attempted to meet such brothers, but they politely evaded his request.

While the full-scale Aerodrome was being designed and built, the internal combustion engine was contracted out to manufacturer Stephen Balzer. When he failed to produce an engine to the power and weight specifications, Manly finished the design. This engine had far more power than did the engine for the Wright brothers' first airplane – 50 hp compared to 12 hp. The engine, mostly the technical work of men other than Langley, was probably the main contribution of the project to Aviation. However, the American aerospace community did not benefit from this advanced engine since there was almost no information exchanging among the aviation pioneers.

The piloted machine had wire-braced tandem wings (one behind the other), a Pénaud tail for pitch and yaw control but no roll control, depending instead on the dihedral angle of the wings, as did the models, for maintaining roughly level flight.

In contrast to the Wright brothers' design of a controllable airplane that could fly against a strong wind and land on solid ground, Langley sought safety by practicing in calm air over the Potomac River. This required a catapult for launching (Fig. 14). The craft had no landing gear, and the plan was to descend into the water after demonstrating flight. Langley gave up the project after two crashes on take-off on October 7 and December 8, both in 1903.

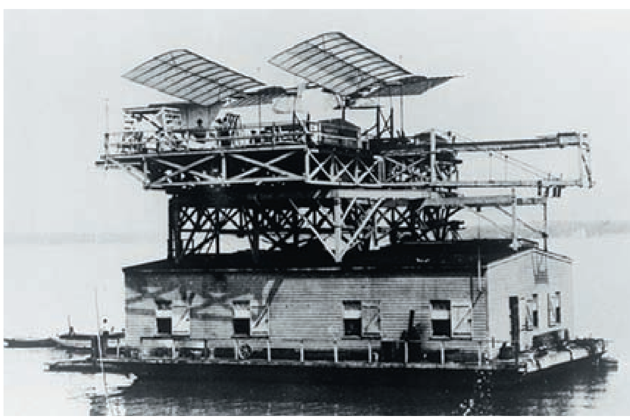


Figure 14. The Langley Aerodrome was designed and built by a group led by Samuel Langley. Shortly after this photo was taken, on December 8 1903, manned tests of the Aerodrome ended abruptly in failure, as it fell into the Potomac River. Photo from NASA Langley Research Center (NASA Langley, 2012).

United Brothers of America

According to their own report, on December 17th, 1903, the Wright brothers flew on flyer I biplane (Wright, 1988). This machine was equipped with two counter-rotating propellers, which were driven by a single 12-hp four-cylinder reciprocating engine. Many historians recognize this flight as the first manned one. The following flyer II was fitted with a 16-hp engine and had a takeoff weight of 408 kg, which resulted in a weight-to-power ratio of 25.5 kg/hp. About 30 reporters showed up at Huffman Prairie on May 23rd, 1904. However, the Wrights could not get the flyer II motor to run properly, and everyone went home disappointed. A handful came back on May 26, but the Wrights were only able to manage a flight of about 8 m. Indeed, flyer II was not able to takeoff if strong wind conditions were not present. However, there are some photographs of alleged flights with flyer III at Huffman Prairie, in 1905. Flyer III was fitted with a 20-hp water-cooled engine and presented a takeoff weight of 388 kg. Even flights that covered a distance of astonishing 12 miles were said to be performed (Fig. 15) with this type. Surprisingly, the Wright brothers did not fly in 1906 and 1907, and many air enthusiasts said that they were all the time busy applying for patents.

In 1901, the Frenchman Ferdinand Ferber heard of the Wright brothers' work from Octave Chanute, therefore he began to correspond with them. Two years later, Ferber built a copy of a Wright glider and fitted an engine to it. He attempted to fly the machine tethered to a crane but without success. In December 1905, Ferber published the letters he had received from the Wright brothers. They had some allegations that the two Americans had performed 18-miles flights in a closed circuit. Ferber had a special interest in disclosing such kind of information: he intended to convince the French Army to purchase the brothers' creation. Most French people interested in Aviation did not believe that the Americans had obtained success in flying a powered machine. Archadecon challenged the Wright brothers to come to France to display their aircraft. He even offered cash for that. However, he got a single replay form the Americans.

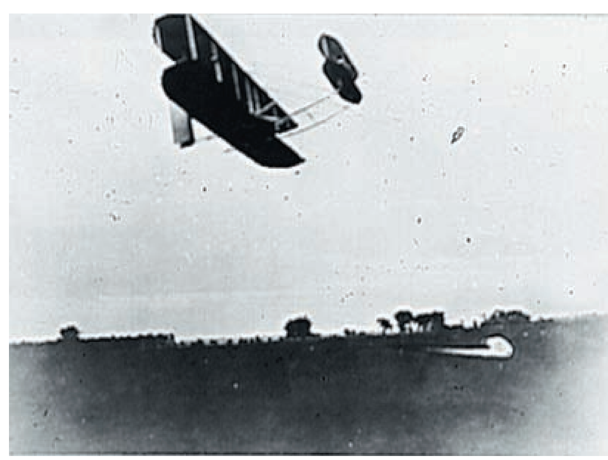


Figure 15. Photograph of an alleged 12-mile flight on September 29, 1905 with Flyer III. It is thought that this and other similar pictures suffered from water contamination during a flood that reached Wrights' house (Source: Library of Congress, USA).

The Wright brothers were unable to convince the US Army to purchase the flyer because no convincing flight demonstration was performed. Thus, Wilbur went to Europe where Aviation was very famous after the flight of Santos-Dumont. Orville remained in the United States to continue the pursuit of a contract to sell Armed Forces planes. They intended to improve their plane and secure European investors to open an assembly line. In France, Wilbur Wright set up a shop in a field near Le Mans that the French automobile manufacturer Leon Bollée provided. Wilbur began working on the planes they had shipped to France at the end of 1907. They were in terrible shape – French Customs had repacked them poorly. It took him six weeks to assemble an airplane, even with the help of the mechanics provided by Bollée. When it was completed, it became flyer A, incorporating a series of modifications, among them a new 30-hp engine. The new airplane weighed 544 kg, characterized by a weight-to-power ratio of 17.7 kg/hp. The first flight was delayed due to bad weather. Finally, on August 8, 1908, the weather cleared. In front of a small crowd, which included the aviators Louis Blériot, Ernest Archdeacon, Henry Farman, and Hubert Latham. At that time, Wilbur made a brief but perfect flight that astounded his audience. He followed-up with several more flights – each longer than the previous one. The flightworthiness of his airplane and his skill as a pilot were impressive. By October 15, he had taken up 30 passengers. These flights took place at a landing ground at Auvours.

On December 8 1908, Wilbur established a world record flying at a height of 115 m. In the same month he performed a flight covering impressive 124.7 km. In France, an agreement was made between the Société Ariel and in Britain with Short Brothers of Eastchurch. Both companies produced the passenger carrying machine that Wilbur had demonstrated at Le Mans. The design was a biplane in every sense for it had double elevators, main plains, and rudders. The rudders were placed further aft than in the brothers' 1905 design for better controllability. The pilot sat on the wing edge with the elevator control on his left. On his right, there was another stick that controlled both the rudders and wing-warping (independently). As with previous Wright's designs, there were no wheels, and so takeoffs continued to be from a wooden rail, assisted by a weight and derrick mechanism. After landing, the machine had to be carried back to the rail on a wheeled trolley. During the demonstration flights in Europe in 1909, the Wright brothers also met the wealthy businessman J.P. Morgan. Later that year, Morgan introduced the Wrights to a group of New York financiers who were interested in backing the fledgling aviation industry. They helped the Wright brothers establishing the Wright Company, which was founded in November, in 1909. In January, 1910, the Wright Company set up a factory in Dayton, Ohio. They also established a flying field and a flight school at Huffman Prairie, site of the Wrights' flights after their history-making Kitty Hawk flight. Orville Wright and Charlie Taylor, their longtime mechanic, also set up a flying school in Montgomery, Alabama, in March 1910, where Maxwell Air Force Base would later be located. Orville immediately began the instruction of the first five men who became members of the Wright exhibition team.

Meanwhile in the United States, on December 23, 1907, the U.S. War Department issued Specification number 486 for a "Heavier-than-air Flying Machine." It stated that the aircraft should be able to carry two men for a distance of 201 km at a minimum speed of 64 km/h. It should be able to stay aloft for one hour between refueling, land without damage, be transportable on an Army wagon, easily steerable in all directions, and at all times be under perfect control and equilibrium. These were, in fact, the specifications that the Wrights had earlier told the War Department they could meet. On January 27, 1908, the Wrights submitted their formal bid to the War Department for one aircraft that would cost US$ 25,000. This was considerably less than the US$ 200,000 they had wanted to charge the French government the year before. Only one other bid would be considered, the one from Octave Chanute's old partner and their acquaintance, Augustus Herring. Back in Dayton, Orville was busily working on the plane for the Signal Corps with his two helpers – Charlie Taylor and Charlie Furnas. He was also writing letters and articles for the Scientific American, Aeronautics, Century magazine, and other journals. On May 14, 1908, the mechanic Charlie Furnas became the Wrights' first airplane passenger in history. Orville and Furnas made several flights that day, but in a solo one, Orville made an error with the elevator lever, and the plane dove into the ground at 64 km/h. He was unhurt, but the plane was wrecked. Some months later Orville demonstrated a Model A to the US Army at Fort Myer. From September 3, 1908, he made ten flights, but on September 17 he crashed after the starboard propeller blade broke. His passenger, Lt Thomas Selfridge was fatally injured and Orville suffered a broken hip. Military trials were postponed until the following year, when a replacement aircraft would be available. The 1909 Signal Corps Flyer successfully completed the Army's acceptance trials and in July it became the world's first military airplane accepted into military service.

The Patent war

In 1908, the brothers warned Glenn Curtiss not to infringe their patent by profiting from flying or selling aircraft that used ailerons (Santos-Dumont had already employed ailerons in its 14-bis configuration that flew in November 1906). Curtiss refused to pay license fees to the Wrights and sold a plane to the Aeronautic Society of New York, in 1909. The Wrights filed a lawsuit, beginning years of long legal conflict. They also sued foreign aviators who flew at the United States exhibitions. The brothers' licensed European companies, which owned foreign patents the Wrights had received, sued manufacturers in their countries. The European lawsuits were only partly successful. Despite a pro-Wright ruling in France, legal maneuvering dragged on until the patent expired in 1917. A German court ruled the patent invalid due to prior disclosure in speeches by Wilbur Wright in 1901 and Octave Chanute in 1903. The Wrights made agreements with some U.S. groups that sponsored air shows and collected license fees from them. They won their initial case against Curtiss in February 1913, but the decision was appealed.

From 1910 until his death from typhoid fever in 1912, Wilbur took the leading role in the patent struggle, traveling incessantly to consult with lawyers and to testify in what he felt was a moral cause, particularly against Curtiss, who was creating a large company to manufacture aircraft. The Wrights' worry with the legal issue hindered their development of new aircraft designs, and by 1911 Wright aircrafts were considered inferior to those made by other companies in Europe. Orville and Katharine Wright believed Curtiss was partially responsible for Wilbur's premature death, which occurred in the wake of his exhausting travels and the stress of the legal battle.

The lawsuits against Americans companies that were trying to manufacture airplanes caused a huge setback to the North American aerospace industry. In the beginning of World War I the production of aircraft in Europe largely surpassed that in America; the American pilots in the battlefield of that period were sitting in more advanced European fighters.

In January 1914, a U.S. Circuit Court of Appeals upheld the verdict in favor of the Wrights against Curtiss, whose company continued to avoid penalties through legal tactics and because Orville was planning to sell the Wright company and did not follow-up the legal victory. In 1917, with World War I underway, the U.S. government stepped in to supervise a cross-licensing organization in which member companies paid a blanket fee for using Aviation patents, including the original and subsequent from Wright. The Wright-Martin (successor to the Wright Company) and the Curtiss Companies (which held a number of its own patents) each received a US$ 2 million payment. The patent war ended, although side issues lingered in the courts until the 1920s. In a twist of irony, the Wright Aeronautical company (another successor) and the Curtiss Airplane Company merged in 1929 to form the Curtiss-Wright corporation, which remains in business today producing high-technology components for the aerospace industry.

The lawsuits damaged the public image of the Wright brothers, who were generally regarded as heroes. Critics said the brothers were greedy and unfair. Supporters said the brothers were protecting their interests and were justified in expecting fair compensation for secrets of their invention. The brothers long friendship with Octave Chanute collapsed after he publicly criticized their actions.

Demoiselle and Farman airplanes in the United States

The Demoiselle took part in some air shows in the United States (Fig. 16) in early 1910s. Most of the planes displayed in those events were French. They contributed to the development of the North American Aviation. When William Boeing witnessed an air show in 1910, where Farman airplanes played

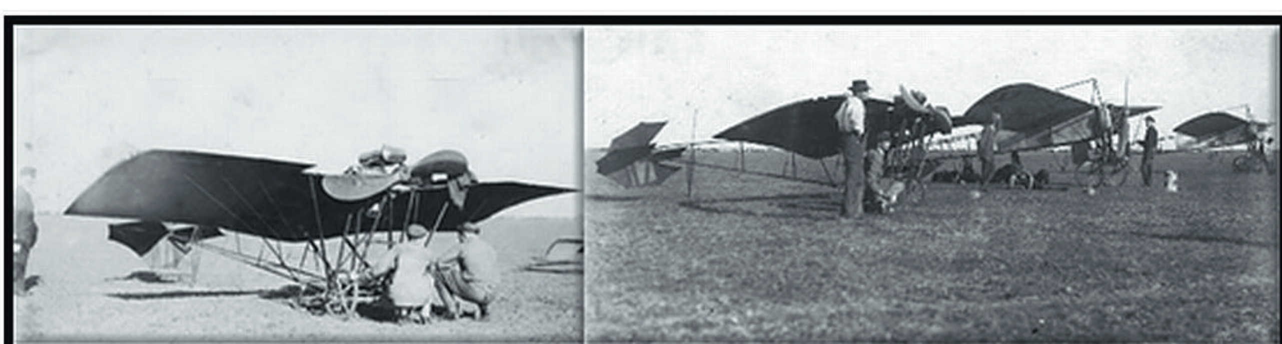


Figure 16. Demoiselle and Blériots airplanes taking part in an air show in Texas, United States, January 1910.

a major role, Aviation became an instant obsession. The show was a catalyst that would lead him to build his own plane and start his own airplane company, Pacific Aero Products, in 1916. This company evolved into the worldwide known Boeing Co.

FACTS AND FIGURES

Table 1 displays the impressive progress of the solution of the heavier-than-air flight issue (FlightGlobal, 1909b). All achievements were recorded by Aéro-Club de France. Although Wilbur Wright had settled down in France in 1907, he was only able to deliver a remarkable performance in late 1908, after he incorporated the European technology. The brothers did not take part in the trophy organized by the Scientific American in the U.S for a 1-km flight journey. Curtiss won the competition with its "June Bug" biplane.

Figure 17 is a diagram illustrating the relationship between weight-to-wing area and weight-to-power ratio for several single-engine airplanes. The Wright brothers continuously improved the weight-to-power ratio of their machines. However, the graphic shows that the Flyer figures are higher than any single-engine piston-powered aircraft of all time. This explains the need for a catapult-launching system or suitable wind conditions to takeoff for the later versions; the first two ones can be considered an underpowered glider. Even considering the PIK-20E motor-glider, fitted with a retractable Rotax 505 engine, we have obtained values quite different for that from a flyer. For this aircraft, weight-to-wing area and weight-to power ratios are 47 and 10.9, respectively (Wikipedia, 2011).

France, the pioneer of world Aviation, led the way for the Allied aviation in World War I. In 1914, the French Aviation industry was the most advanced in the world, and its contribution was crucial to the establishment and maintenance of air power to confront that of the Central Powers. In the early years of the war, France supplied aircraft and engines to her allies. French as forerunner of the quest for technology can be credited to the open-source ambience, which prevailed in the aeronautical community before the Great War. The increase in aircraft production is naturally due to the shadow of the war to come.

In 1911, the tradition of military air shows was started, and not only was this idea taken up by other nations, but it proved a great stimulus for the Aviation industry. The industrial aircraft production surges and the figures are really impressive: 1,350 aircraft in 1911, 1,425 in 1912 and 1,294 in 1913 (Angelucci, 2001).

Germany's achievements in setting up and developing the framework needed for aerial warfare can be considered as impressive. At the beginning of the war, German airplanes were slow and unarmed, intended only to be used for aerial observation and reconnaissance of ground forces. After changing the way aircraft could be usefulness in a war scenario, the armed forces were reorganized to efficiently incorporate the new weapon. The aircraft production in 1912 topped 136 units, which is a considerable increase from just 24 built in 1911. In 1913, Germany aircraft production rose to 446. A huge

Table 1. Progressive records (FlightGlobal, 1909b).

Aviator	Place	Date	Distance/Time
Santos-Dumont	Bagatelle	August 22, 1906	Few seconds
Santos-Dumont	Bagatelle	September 14, 1906	7-8 m
Santos-Dumont	Bagatelle	October 23, 1906	50 m
Santos-Dumont	Bagatelle	November 12, 1906	220 m
Henry Farman	Issy	October 26, 1907	771 m
Henry Farman	Issy	January 13, 1908	1,500 m
Henry Farman	Issy	March 21, 1908	2,004 m
Delagrange	Issy	April 10, 1908	2,500 m
Delagrange	Issy	April 11,1908	3,925 m
Delagrange	Rome	May 27, 1908	5 km
Delagrange	Rome	May 27, 1908	9 km
Delagrange	Rome	May 30, 1908	12,5 km
Delagrange	Milan	June 22, 1908	17 km
Henry Farman	Gand	July 6, 1908	19,7 km
Delagrange	Issy	September 6, 1908	24,727 km
Orville Wright	Fort Meyer	September 9, 1908	1 h 2 min 30 s
Orville Wright	Fort Meyer	September 10, 1908	1 h 5 min 57 s
Orville Wright	Fort Meyer	September 11, 1908	1h 10 min 50 s
Orville Wright	Fort Meyer	September 12, 1908	1h 15 min 20 s
Wilbur Wright	Auvours	September 21, 1908	1 h 31 min 25 s
Wilbur Wright	Le Mans	December 18, 1908	1 h 54 min 22 s

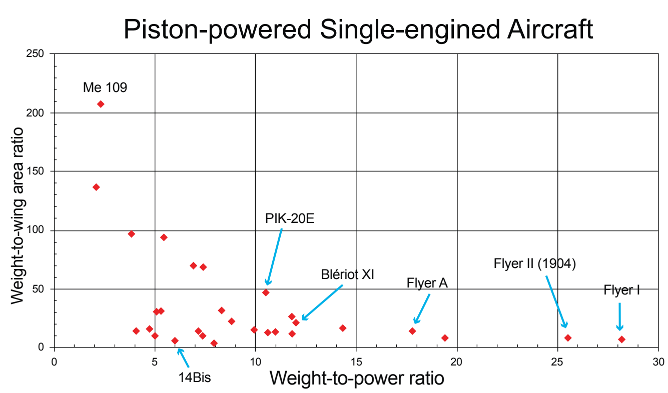


Figure 17. Comparing graph containing two important parameters for single-engine piston-powered airplanes.

increase was seen in 1914: 1,348 airplanes were produced. Germany mastered the design of large airships, which saw combat in the World War I. Between wars, airships were the sole air vehicle able to nonstop transoceanic flights.

Russia played a minor role in the Aviation development during World War I. Inferior products were trademark in Russia in the pre-war period. The internal turmoil caused by the revolution of 1917 hampered the development of the Aviation in the former Soviet Union.

The United States felt the consequences of the delay in implementing organization and development plans in military Aviation. Until 1911 the only airplane was the Flyer A that Orville and Wilbur Wright had managed to sell to the Army in August, 1909. On July 18, 1914, military aviation moved forward with the creation of the Aviation Section of the Signal Corps. When the United States entered the War In April 1917, its Air Force counted less than 250 airplanes, most of them unsuitable for combat. Only in 1918, the American Expeditionary Force's air arm could be organized in a proper manner under the command of Gen. William Mitchell used only French equipment. At the end of the war, there were 45 squadrons, including 740 airplanes, 800 pilots, and 500 observers.

Table 2 summarizes the number of military airplanes that each country put into service in 1914 and 1918. The strongest nation was Germany, and the United States recorded a very small old-fashioned fleet, most of airplanes being derivatives of the flyer A from 1909.

After World War I the United States produced a large number of British designed aircraft and engines. Among them was the mass-produced Airco DH.4 (Fig. 18). The type was a British two-seat biplane day-bomber and was designed by Geoffrey de Havilland for Airco. It was the first British two-seat light day-bomber to have an effective defensive armament. It performed its first flight flew in August 1916 and entered service with the Royal Flying Corps in March, 1917. The majority of DH.4s was actually built as general purpose two-seaters in the USA, for service with the American forces in France. The DH.4 was tried with several engines, of which the best was the 380 hp (280 kW) Rolls-Royce Eagle engine. Due to the chronic shortage of Rolls-Royce aero engines in general, and Eagles in particular, alternative engines were also evaluated, with the BHP (230 hp/170 kW), the Royal Aircraft Factory RAF3A (200 hp/150 kW), the Siddeley Puma (230 hp/170 kW), and the 260 hp (190 kW) Fiat, all being used in production aircraft. None of these engines could match the Rolls-Royce Eagle in performance and reliability. However, there were simply not enough Eagles available. In the USA, the new American-built Liberty L-12engine was suitable to be fitted into DH.4, although the engine produced a slightly inferior performance to that provided by the Eagle.

After the war, a number of firms, most significantly Boeing, were contracted by the US Army to re-manufacture surplus DH-4s to DH-4B standard. Known by Boeing as Model 16, deliveries of 111 aircrafts from this manufacturer took place between March and July 1920, with 50 of them being returned for further refurbishments three years later.

Table 2. Frontline combat aircraft in the World War I period (Angelucci, 2001).

Country	Aircraft in service in 1914	Aircraft in service in 1918
France	138	4,500
Great Britain	113	3,300
Germany	232	2,390
Italy	150	1,200
USA	55	740
Former Soviet Union	244	-
Austro-Hungarian Empire	86	-
Belgium	24	-

Figure 18. Some English World War I bombers that were manufactured in the United States.

CONCLUDING REMARKS

The evolution of the airplane since the first flight of Santos-Dumont in 1906 rests on technological advances in many fields of Engineering. The airplane is more a product of Engineering than of Science. For instance, the Navier-Stokes equations that model the behavior of a body in relative motion to a fluid were derived in early 19th century. However, these equations could only be properly solved with the advent of the digital computer.

In the beginning, Aviation development was in many ways a technology of the elite – most elite exhibition fliers, military aviators, and wealthy hobbyists. Their exploits may have thrilled the masses, but for most Aviation was a spectator activity, not a part of everyday life. Exception was made for Santos-Dumont, Farman, Voisin brothers, Blériot, and Wright brothers. All these extraordinary men and other not enlisted here envisaged the Aviation taking an important role in mankind life. Santos-Dumont was the only one who did not look at Aviation as a personal commercial enterprise. Although the rich Dumont himself did not take part in any commercial enterprise, he was aware of the commercial impact of Aviation on the world's economy and of its potential as warfare.

Therefore, it is easy to recognize that the Internet has enabled a large amount of collaborative projects on a global scale. However, collaborative work in an open source fashion is not new. Indeed, it already took place in Europe at the dawn of Aviation, namely in France. That kind of ambience at that time can be credited to the ideals of the French Revolution. Contrary to this, in the United States, the development of the Aviation encompassed the spirit of the English Revolution. It was business-oriented with people working in secrecy with no or few exchanging of ideas and information. That is the reason why Europe was ahead of America concerning aircraft technology before World War I broke out and a patent war started in the United States among their Aviation pioneers. The meeting between Santos-Dumont and Thomas Edison can be considered confront by English versus French revolutions. Although resulting inconclusive, the meeting revealed the working ambiences prevailing in both continents, North America and Europe. Probably, this talk had exercised some influence on Dumont moving towards airplanes instead remaining in the airship battlefield.

Although a cooperative atmosphere in Europe in the dawn of Aviation was established and widespread, no collective decision concerning the design of airplanes was made. Most of aviation pioneers freely shared their concepts and even entire designs but acted someway independently. A combination of open-source philosophy and collective decision really did not take place in Europe.

Octave Chanute had warned the Wrights that the Aviation world was catching up, especially in France. Thus, Wilbur Wright went to Europe in 1907 and established a workshop to continue improving the flyer concept. His brother remained in the United States to establish business with the American armed forces. Orville Wright carried out the first successful public demonstration of flyer in May 1908, when he registered the first passenger aboard a flight machine. However, Europeans went a step ahead of this: in January 1908, Henri Farman was recognized by Aéro-Club de France as the first aviator to perform a kilometer-long flight. In June 1908, Glenn Curtiss was acclaimed the winner of prize established by the Scientific American magazine for the first 1-km flight in straight line in the United States. The Wright brothers did not take part in the competition. Concerning the happenings in Europe, Wilbur was only able to get the flyer airborne in August 1908. These flights did not impress the European aeronautical community and their machine, and they did not deliver the performance the brothers had promised. After incorporating European technology, outstanding flights took place in late 1908 (FlightGlobal, 1909b) and the brothers' European flyer was the basic airplane they were able to sell to the US armed forces in 1909. In addition, American pilots were at controls of French and British airplanes in World War I. The Americans also mass-produced British airplanes under license in the United States during and immediately after World War I. A good example of this is the British bomber DeHavilland DH 4, of which 4,346 exemplars left assembly lines in the United States.

How was the spirit of French Revolution put into practice by the Aviation pioneers? Part of the answer is related to the coming on the scene of the Aéro-Club de France (French Air Club). The Aéro-Club de France was founded in 1898 to organize, support, and regulate all efforts to make Aviation an everyday reality. There were already several claims and flight attempts concerning a heavier-than-air machine, balloons flights had become a fad, and there were people and enterprises building and manufacturing airships. Then, people that founded the Aéro-Club de France promptly elaborated rules to testify the first man to fly an airplane. The men behind this initiative were E. Archdeacon, L. Serpollet, J. Verners, M. de Dion, H. de La Vaulx, and Santos-Dumont. The Aéro-Club de France was a basic concept that all other similar air clubs followed suit. Henry Deutsch de La Meurthe (1846-1919) was a tycoon of the petroleum sector and became a sponsor of the Aviation, closing interacting with Aéro-Club de France founders. Although there was a competition for glory among its members, truly information exchange was part of everyday life. Workshops were part of Aéro-Club's everyday life. Progress in Aviation and Aeronautical Engineering were reported, analyzed and discussed in that place.

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