

Chapter 2

Historical Development of Air Transport

Abstract The historical development of air transport starts with a short review of myths and legends, the Dream of flying, which is as old as mankind. The next part covers the physically based approach of flying, starting from Da Vinci and his drawings of flying vehicles, via the Montgolfier's hot air balloon, Sir George Cayley and his principles of flying. The part about the technically based approach covers briefly the different attempts from Clement Ader, Otto Lilienthal up to the Wright brothers, who finally in 1903 managed to fly with a vehicle heavier than air. It follows the beginning of commercial air transport in Europe and US between the two World Wars. In the 1950s, the jet age in civil air transport started with a disaster of Comet, but all lessons learned from these air accidents helped other companies to start successfully these new jet engine types of civil transport aircraft, which are still flying today. The aircraft design parameters of speed, range, size and fuel efficiency and their development of the last century are shortly addressed to extract the standards and the maturity of today's air transport system. A brief review of the airline development follows with the example of KLM. It follows a short airport review, where the airport development of Atlanta—the biggest airport today—is taken as example.

2.1 The Dream of Flying

The dream of flying is as old as mankind. In all civilizations (old and new like Greek, Chinese, Roman, Inca, Celt et alii.) Gods have certain capabilities to fly and pass easily between earth and heaven. Some courageous people tried to copy this capability by intensively watching the flight of birds and adapting certain mechanisms from them. The Greek mythology tells about the genius Daedalus, who was at his time an excellent artist and innovator. As the king of Crete named Minos wanted to keep his capabilities as architect just for his personal and own profit, Daedalus decided to escape by constructing and building a flying vehicle, which

consisted of feathers, “fixed by thread and wax, thus constructing the wings with a certain camber just like the birds.” [1].

In China, Kites were constructed and also played some mystic role as element between heaven and earth. But details about their technical efforts and achievements are not so well documented.

The Christian religion knows also some persons with flying capabilities, angels and devils, who can—with the help of wings—travel between heaven and earth and underworld/hell. An excellent description of these old myths and first attempts of flying is given in [2], where certain myths about flying attempts in nearly all culture have been found. These ideas and legends of flying are part of cultural or religious habits.

Behind the imagination of flying, which can be found in all old cultures and civilizations, there are also the basic emotional elements of mankind about freedom and mobility. Being capable to fly like a bird means to escape from your local area and discover new islands, a better world, finally the paradise.

But the reality of successful flying attempts has not been reported until the beginning of the “Renaissance” and immediately the name of the famous artist Leonardo da Vinci appears also on the engineering/technical scene.

2.2 Physics Based Approach

Leonardo has postulated “that human beings would be capable to depart into the air with the help of machines with large wings, which had to be designed to overcome the air resistance”. A lot of drawings are showing different principles of his flying vehicles: some show a human being, lying horizontally in his apparatus and hands and feet are fixed or controlling some cables or bars; others are showing a person controlling a flapping mechanisms to move the wings up and down; others show a sort of screw, which can be rotated by a filament movement and which will be lifting off vertically when sufficiently accelerated (Fig. 2.1). Also a parachute system can be found in his archive of drawings. So a lot of different flying principles were shown in his drawings and it seems that he had constructed also a lot of models to test his principles. More details can be found in [3, 4].

The next step can be seen with the Montgolfier brothers, who by some chance and luck developed the hot air balloon. They had constructed a balloon and discovered the principle of hot air balloons. The flight of their hot air balloon in front of the King in Versailles in 1783 is reported as a sensation and huge spectacle, having seen the first three passengers being lifted up, a coq, a sheep and a dog (Fig. 2.2).

The principle of hot air balloons was immediately seen as a very good chance to be used for military services. But the disadvantage became also very soon apparent: the balloon was not controllable. He just followed the wind without the possibility to give him a specific direction of flight. So the interest for balloons disappeared quickly.

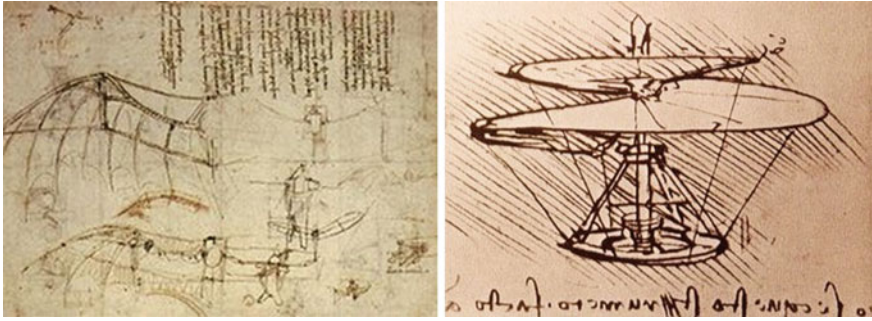
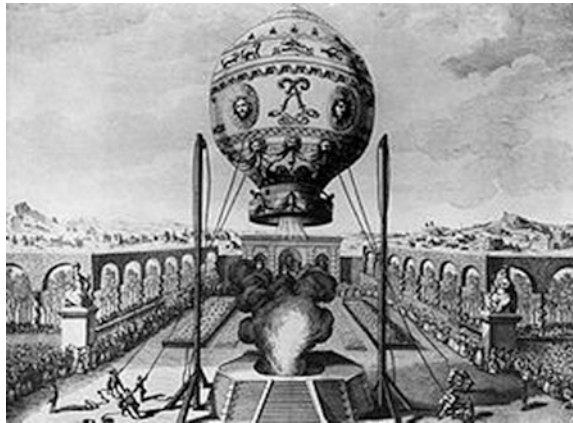


Fig. 2.1 Drawings about flying vehicles from Leonardo da Vinci

Fig. 2.2 The Montgolfiere hot air balloon



It took some further years, before Sir George Cayley (1773–1857) defined and developed some elementary principles fundamentally important for future success of flight vehicles [5].

He postulated the principles of flight in his paper “The art of flying, or Aerial Navigation”.

- Separation of forces acting on the wing in lift and drag (vertically lifting and horizontally drag forces)
- Stability and controllability as basic principles for a flying vehicle
- Lift to compensate the mass; leading to light weight structures
- Independent thrust to compensate the aerodynamic drag.

He constructed a lot of models, which were quite successfully demonstrating these postulated principles. Some historians are seeing in Cayley the father of modern aircraft. But it has to be stated, he was just constructing models and he had not yet the final idea about the right propulsive force.

The beginning of the nineteenth century saw a lot of efforts to try to develop the steam engine as a propulsive system, but all efforts, to use steam engines for the flying vehicles failed. This was a false direction with no successful design layouts [6].

The physical scientific community, looking at and commenting the efforts for human flying were also not helpful. Their clear statement was, it would be physically impossible to have flying organisms/vehicles, which are bigger than eagles and vulture. The German physicist Hermann Helmholtz stated 1873 [7]:

... in developing the large vultures, nature has found the limits, where with muscles operating organisms and by best conditions of alimentation have achieved the maximum size, which by its own wings and for longer time can stay in the air and keep flying. Under these circumstances it is rarely probable, that a man - even with the most sophisticated wing mechanisms - can be in a position to lift up his own body mass and keep it there by just using the force of his muscles.

So no hope and encouragement could be expected from the scientific community.

Nevertheless there were still continuous efforts and a lot of passion to develop a real flying vehicle, which was controllable. The demand from the Emperors, kings and rulers of the world for such sort of vehicle for military and surveillance purposes were still obvious, providing—as we would say today—“the market demand”.

2.3 The Technically Based Approach

At the second half of the nineteenth century, a lot of efforts were still underway to overcome all the pessimistic view from the scientists about the “dream of flying”. There can be seen two different and competing philosophies in the nineteenth century: Flying following the principle “Lighter than air” and flying following the principle “Heavier than air”.

The flying concept “Lighter than air” ended in the development of airships, which had a propulsive unit and could be controlled. This principle, first being successfully tested by the Montgolfier brothers, culminated later on in the development of big airships by Graf Zeppelin. His Zeppelins finally managed to cross the Atlantic between 1931 and 1937 with quite an impressive passenger load of ~50 persons. However, with the disaster of the Zeppelin ZL 129 on 7 May 1937 in Lakehurst, the commercial transport with airships ended immediately.

The principle of flying “Heavier than air” was seen as more problematic. The scientific community classified this principle as impossible for mankind and was providing no support and help. All persons, who still were convinced that flying with machines “heavier than air” was possible, were seen as “fools” and hopeless utopists. The enthusiasts working on the concept of “heavier than air” were following two different principles:

- a sort of flapping wing like the flight of birds or
- a fixed wing but with a strong propulsive unit to accelerate the vehicle.

Some encouragement was seen, when the big steam motors appeared, developed for the railway and the big steamships. But the steam engines were too heavy to be used in the flying vehicle.

In France, two engineers have to be mentioned, who contributed significantly to the development of flying machines with fixed wings, Alphonse Penaud and Clement Ader. In 1876, Penaud patented a design for a large amphibious aircraft with such innovative features as retractable wheels, a glass-enclosed cockpit, a single-lever control for both the rudders and the elevators, and twin propellers driven by an engine concealed in the fuselage. The design was amazingly ahead of its time, but no engine existed that was light enough and could make such an aircraft fly.

Clément Ader (1841–1926) focused on the problem of heavier-than-air flying machines and in 1890 built a steam-powered, bat-winged monoplane, which he named the *Eole*. It is reported that he flew it a distance of 50 m. The steam engine was unsuitable for sustained and controlled flight, which required the gasoline engine; nevertheless, Between 1894 and 1897 Clément Ader built a larger but still ‘Eole-like’ twin screw machine which he named the *Avion*. Interrupted after an accident in 1897, the work was not continued due to a lack of financial resources.

During this time period between 1850 and 1900, a lot of important developments have been made, not only in France but also all over the world, in Brazil, Australia, UK and USA. However, it is not the place here to be exhaustive about the historical details, but [4–6, 10, 11] are giving further details.

A major breakthrough started with Otto Lilienthal. He and his brother Gustav were fascinated from storks. They discovered that young storks—when trying to take off—were always starting against the wind, a very important lesson learnt which we are still using today in our daily air operations.

Otto Lilienthal discovered the importance of forward speed, being similar necessary for lift like the flapping mechanism. He developed a circular rotating device named “Rundlauf”, where he tested the wing shapes, first flat plates, than by copying the wing profiles of storks, wing profiles with camber and with incidence and finally complete wings.

All his systematic approach and research about wing profiles was finally published by him in a book in 1891 with the title “Der Vogelflug als Grundlage der Fliegekunst” [8]. It is the first time, that an inventor published his own knowledge openly, which was financed privately and therefore, helped other inventors and competitors in the race for the first successful flight.

In 1890, Otto Lilienthal started to develop his first “gliding vehicle”, with cambered wings. The practical gliding tests started 1891 from a hill close to Berlin (see Fig. 2.3). Fortunately, Otto Lilienthal was a successful engineer and entrepreneur, who earned his living with his own company, producing boilers and heating machines, and could therefore finance all his private flights, his technical research and necessary tests by himself! There was at this time no military or research program available, to ask for a research budget!

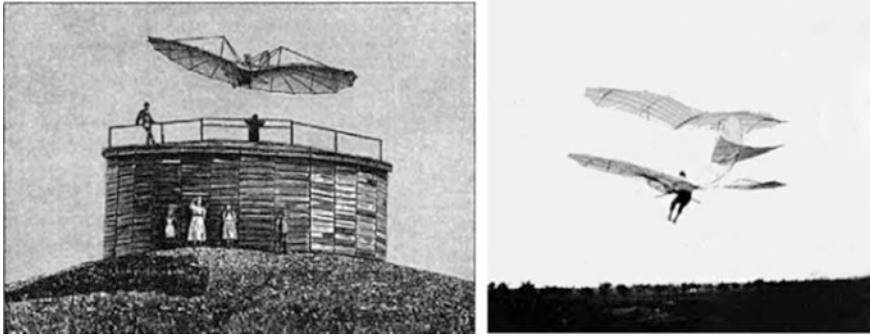


Fig. 2.3 Lilienthal's "Sturmhügel" Flying base 1894 and a gliding flight

In total Lilienthal developed 18 different gliding vehicles, did close to 300 gliding flights, the longest flight was more than 250 m. He also tried to integrate a light engine, but the right engine did not exist for him. His sudden death after a flight accident stopped his approach. But all his knowledge and discussion with important persons like Langley, Joukowski and others inspired other inventors like Ader and the Wright Brothers to continue and use the experience, developed by Otto Lilienthal. Important to mention is also the fact, that Otto Lilienthal was the first real pilot of his gliding vehicles. He took the risk to enter as a pilot and get the feeling for the lift and wind forces and also experienced the basic principles of flight control including stability.

With his openness of publishing and communicating his experience, with the role as pilot of a gliding vehicle and with his enthusiasm, to finance all his research and test efforts, Otto Lilienthal can be seen as one of the central engineers, who had prepared the flight of man.

Successful were then the Wright brothers in Virginia, who managed to develop a flying vehicle, capable to lift off and land with a pilot onboard.

The **Wright brothers**, **Orville** (1871–1948) and **Wilbur** (1867–1912), were two Americans who were inventing and building the world's first successful airplane and making the first controlled, powered and sustained heavier-than-air human flight, on December 17th, 1903. In the two following years, the brothers developed their flying machine into the first practical fixed wing aircraft (Fig. 2.4).

The brothers' fundamental breakthrough was their further development of three-axis control, which enabled the pilot to steer the aircraft effectively and to maintain its equilibrium.

Their first U.S. patent, 821,393, did not claim invention of a flying machine, but rather, the invention of a system of aerodynamic control that manipulated a flying machine's surfaces [9, 12].

With the news, that the Wright brothers had demonstrated the first autonomous flight with a machine heavier than air, a new impulse was given to all enthusiasts in all countries.



Fig. 2.4 The Wright brothers—Orville and Wilbur and their Kitty Hawk

In 1909, Louis Bleriot, a French aviator, made the first airplane crossing of the English Channel.

Within only 10 years, a lot of new flying machines were developed, very different concepts, different tail configurations, multiple wings, different propulsive engines and engine integrations.

Also the national bodies/governments started to get interest in these flying vehicles. National research started and national military sponsors appeared on the scene.

Figure 2.5 is showing the timeline with the major milestones of bringing the flying vehicles to real flight.

During World War I (1914–1918), it is reported that over 80 000 flying vehicles have been constructed and have been used [6, 9]. However it is also agreed by all specialists, that the flying vehicles have not been a decisive element during this war despite this enormous investment in air vehicles and despite the big progress within 15 years from the first flight in 1903 to the end of the 1st World war. Some examples are shown in Fig. 2.6. In 1918, the biggest bomber aircraft of WWI (Gotha bomber and Handley Page bomber) had a takeoff mass of more than 5 tons [13, 14].

2.4 The Beginning of Civil Air Transportation

The civil air transport started after WW I parallel in different areas.

The Junkers F 13 was the world's first all-metal transport aircraft, developed in Germany by Hugo Junkers at the end of World War I. It was an advanced cantilever-wing monoplane, which could accommodate four passengers as shown in Fig. 2.7.

The Junkers F 13 is one attempt to use the experience of all the military vehicles and develop out of this knowledge a commercial transport. Hugo Junkers, the creator of F 13, had the vision that there is a big chance to use the aircraft as

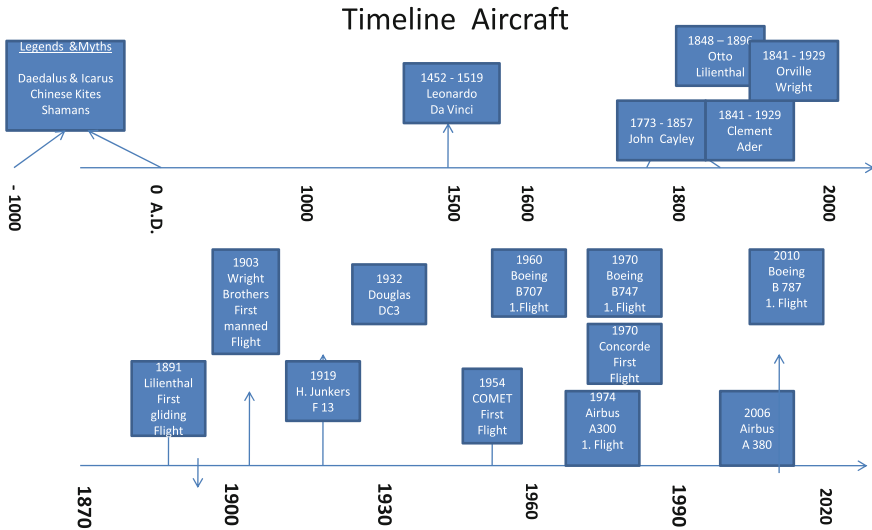


Fig. 2.5 Time horizon with milestones of major flying achievements

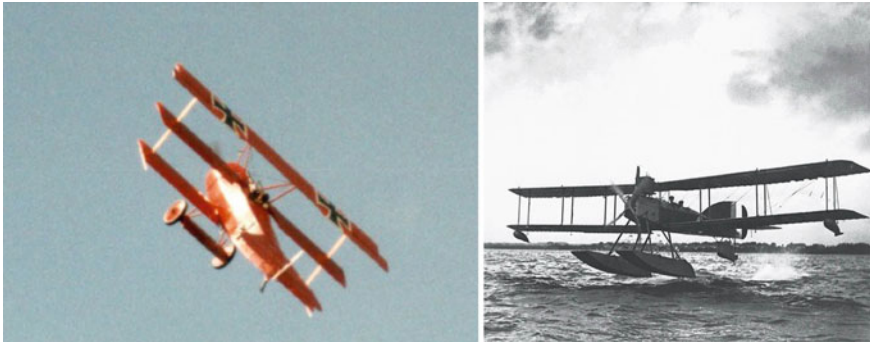


Fig. 2.6 Examples of World War 1 aircraft, a Fokker triplane and a Shorts waterplane

transportation means. Surprisingly, the F 13 has all the typical characteristics of today's aircraft. It has already a single cantilever wing, a classical tail, two engines with propellers, and a reasonable fuselage cabin. So only 16 years after the first flight by the Wright brothers, a nearly perfect configuration for air transport has already been developed with all the typical characteristics of a transport aircraft, as we know them today:

- an unobstructed cabin,
- a front cockpit,
- a fuselage to accommodate the payload (not yet pressurized!)



Fig. 2.7 Junkers F13

- a classical tailplane for control and stability,
- one engine mounted in front of the fuselage (certification rules were not yet invented!)

The F13 has been only slightly successful, as the market was not yet ready and the acceptance and infrastructure for air transport had still to be developed. Nevertheless 360 units from the F13 were built. Other aircraft constructors like Anthony Fokker [15] also started to develop commercial aircraft (Fokker F.VII trimotor), but were also not very successful.

The real push for a commercial air transport did not yet start. Reliability and safety have been still a very difficult subject and not yet satisfactorily solved. The infrastructure with airfields well positioned over the continents was not available. Passengers did not really believe on the reliability of the air vehicles and the demand from the public for commercial air transport was not strong enough.

Statistics show, that pilots in general in this time had only a lifetime in average \sim of less than 10 years.

In the world and specifically in the US, the aircraft was primarily used for mail transport.

A big push for air transport started in 1925 in the US where the government withdraw the air mail from the official “post office” and outsourced it to private competitors in order to reduce cost. This was a first push to reduce mail travel time. A next step followed in 1926, with the US “Air Commerce Act”, which put air navigation, licensing of pilots and air vehicles as well as the investigation of air accidents under governmental control. This was a first step in pushing a “safety system” in place.

Aircraft had not yet enough range to travel between Europe and US. Charles A. Lindbergh opened the new transatlantic area with his direct solo flight in 1927 from New York to Paris. This spectacular flight got a lot of public interest and also helped a lot to show the new capabilities of modern aircraft and make flying more popular for ordinary people.

The Australian Charles Kingsford Smith was the first to fly across the larger Pacific Ocean in the Southern Cross. His crew left Oakland, California to make the first trans-Pacific flight to Australia in three stages to Brisbane in 20 h, where they landed on 9 June 1928 after approximately 7,400 miles total flight.

Direct mail routes from Europe to Africa and South America were opened in 1930. In 1930 appeared the Boeing “Monomail” model, which had already a retractable undercarriage and was aerodynamically a very proper design, reducing fuel consumption considerably.

The next step was expected from the “high altitude aircraft”, which should fly above the normal clouds (thus improving travel comfort) and also increasing air speed without major fuel burn increase. New engine concepts (air charger for piston engines) and better and more reliable instrumentation to fly through clouds were developed and helped this purpose.

Around 1935 the first long range aircraft appeared on the market.

A statistic from all German airports in 1938 shows that 315 000 passengers, 9725 mail and 7165 t of freight have been transported, giving a percentage of air transport of 72,1 % for passenger, 16,1 % for mail and 11,8 % for freight transport [16].

In 1939, World War II started in Europe and all engineering efforts were related to military air vehicles. Speed and range increase and better maneuverability were the dominating factors for aircraft development. The first jet engines appeared in Germany with the ME 262,

The first swept wing concepts for high speed flights were developed in 1937 by DVFLR (A. Busemann), allowing higher speeds up to Mach Numbers of 1, the speed of sound! [17, 18].

The military aircraft became the dominant factor in the superiority of World War II, with speed and maneuverability as dominating performance characteristics.

After WW II, the military efforts first seemed to be reduced, but with the road blockage for West Berlin in June 1948 by Russia, the Cold War started between West and East and military aircraft development was still very high. However, the blockage of road transport from West Germany to Berlin gave a push to civil air transport and the Western Allies managed successfully an 11 months support for the city of Berlin only by an outstanding continuous air transport between Western Germany and the isolated City of Berlin (“Luftbrücke Berlin”!).

On the civil side, the recovery from the difficult and poor years of war took some time, as first a new economic push was needed to develop long-term stability in the economic area and secondly political stability was mandatory before confidence in a longer period of peace between the major countries could be established. This started in the Western world in the beginning of the fifties. The economic growth asked for more travel in the western world and air travel used its chance of drastic

time savings between US and Europe, the new Western block. The new demand asked for new air transport vehicles. All the technologies, developed before and during the World War II were now also available for the civil air transport and a lot of new aircraft concepts appeared on the growing market. The biggest push came from the engine side, where the jet engines allowed flying faster and also higher. Compared to the propeller driven aircraft, the jet aircraft increased the speed by nearly a factor of 2, leading to considerable time reductions in the intercontinental routes.

The jet engines consume more fuel per thrust and hour, as shown later in Fig. 2.11 and explained in Chap. 6. But this disadvantage of higher fuel consumption was compensated by the higher speed ($Ma = 0.8$, compared to $Ma = 0.5$) and the higher altitude capability, allowing flights over the clouds and avoiding thus critical weather conditions.

The big change in civil air transport—jet age—started with the COMET, developed from the British company de Havilland. This new transport aircraft allowed a better way of flying, especially the time reduction for long range routes, were very quickly accepted from the passenger side. However, some completely unexpected aircraft accidents during the cruise phase of Comet I led to a very critical situation for air transport. British authorities did the utmost to clarify the root cause of these accidents and were building a big hangar which could simulate the external cruise flight conditions! Finally, it was discovered that fatigue characteristics of the fuselage material were a main reason for these air disasters. The lessons learnt revealed that the windows in the fuselage, designed as rectangular elements, were one major cause, where after several air cycles some cracks started to develop, leading to fuselage disintegration and a total aircraft loss during cruise phase.

A new discipline was born in aircraft design: material fatigue as a major design element for the fuselages of aircraft. As all tests and examination were discussed very openly, the other manufacturers profited from these lessons learnt and especially the American companies Boeing and McDonald-Douglas were profiting from these lessons learnt. The company de Havilland constructing Comet aircraft and having the merit to have built the first civil jet transport aircraft, has even in the updated design as Comet IV not taken any profit for their courage and innovative design. The future business of developing good civil jet aircraft was taken by the American companies Boeing and Douglas.

But it also has to be mentioned, that the fast development of always new and improved aircraft concepts was only possible, as there was a large community of international scientists and engineers who were intensively involved in important research programs, developing new aerodynamic profiles and wing design concepts, new materials and structural design methodologies and also developing the control systems in a way to drastically reduce the pilots work load. Some important names should be mentioned here like Ludwig Prandtl, Theodore von Karman, Dietrich Küchemann, William Boeing and Wolfgang Wagner amongst others.

2.5 The Jet Age

The civil air transport with jet engines started with a big failure, the Comet disaster!

The courage of European/British excellent engineering talents was not rewarded by a successful market acceptance.

After the failure from Comet, the American manufacturers Boeing and McDonald-Douglas developed their jet engine powered aircraft, the B-707 and the DC-8 about in parallel and both became fairly successful on the market. Both were designed for about 175 passengers, thus increasing the payload by roughly 75 % compared to the older long range aircraft like DC-7 and Lockheed L-1049, better known as “Super constellation”. Jet aircraft were however more noisy during takeoff and landing. But this was not seen as a major drawback as this was also representing the new dynamic optimism and new positive economic push after WW II.

With the bigger cabin, direct operating cost went down by about 15 % in comparison to the older aircraft like DC-7 and DC-6.

The air transport across the Atlantic Ocean became faster and within 6-8 h east coast of US and west coast of Europe (London, Paris) could be reached which meant a travel between North America and Europe could be done within one day!

Already in 1956 the American airlines transported more passengers than the railway. But it has also to be reminded, that the railway in US was not so well established compared to Europe. But air transport offered more flexibility and it was easier to install some new airports instead of investing in heavy infrastructure for railway tracks. In 1957 more passengers travelled across the North Atlantic by air than by ship. The large fleet of cruise ships suffered considerably.

The next development steps came quite naturally. The bigger cabin pushed for bigger aircraft and the larger aircraft needed bigger wings, which allowed having larger fuel volumes, leading to more range for aircraft and thus offering more direct routes over water like South America routes to Africa and Europe similar like the Trans-pacific routes (see Fig. 2.9). The further development of the jet engines to provide more thrust and parallel having a higher bypass ratio with less fuel consumption allowed to further reduce fuel consumption and offered the possibility for even larger aircraft. The B-747—originally a military design for a large military transport aircraft—gave a big boost for air transport capacity and improved travel cost. Most airports were not really prepared to accommodate these new big “Jumbo-Jets”. New air terminals had to be provided at the airports. New procedures for air traffic control, aircraft separation procedures, etc. had to be developed to ensure a safe and regular air transport system. Air transport became a more international business and ICAO, the International Civil Aviation Organization was becoming more powerful to establish international rules for the ever increasing air transport worldwide and defining international standards for all participants and shareholders of air transport.

Figures 2.8, 2.9 and 2.10 are showing the history of the main aircraft design parameters like speed, range and size from the 30s till the year 2020.

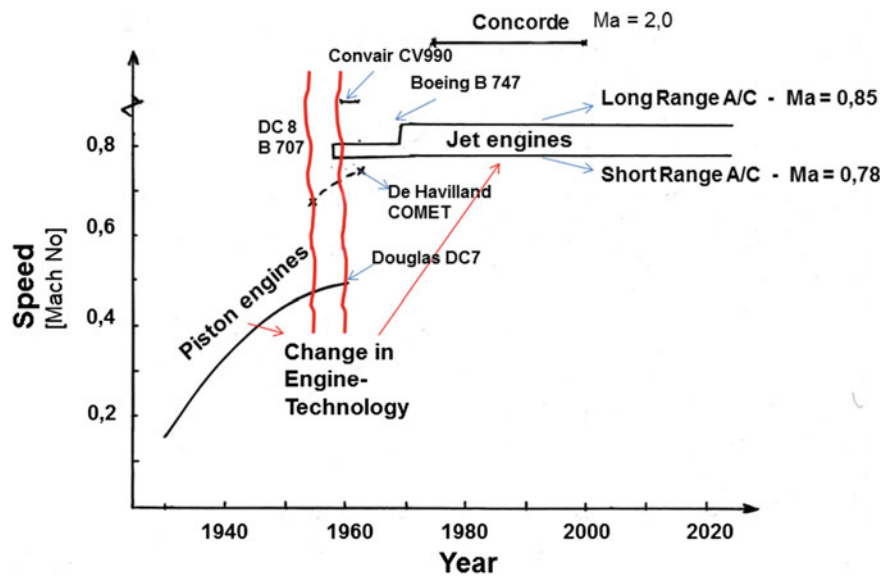


Fig. 2.8 Development of the aircraft design driver “Speed”

It becomes obvious from Fig. 2.8 that **speed** seems to have reached a certain stable standard (which is $Ma = 0.74 - 0.78$ for Short range aircraft and $Ma = 0.82 - 0.86$ for Long-range aircraft. (More reasons and details will be given in Chap. 4).

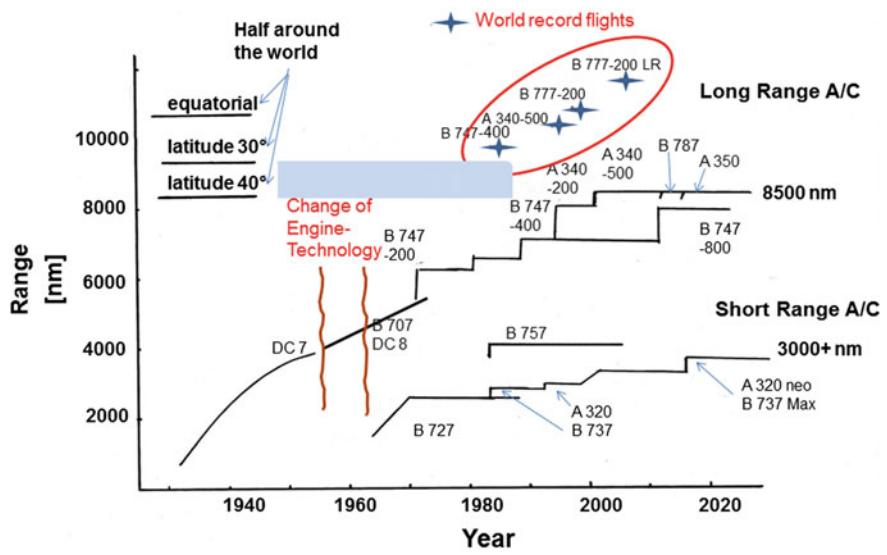


Fig. 2.9 Development of aircraft design driver “Range”

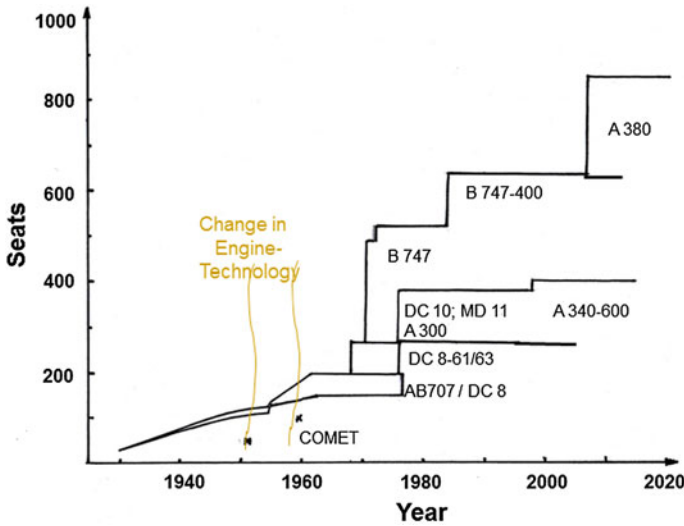


Fig. 2.10 Development of design driver “Seats versus Time”

As can also be seen from Fig. 2.9 **range** has been consistently increased, starting with 4000 nm with the introduction of the jet aircraft to provide today ranges of 8500 nm. Some nice competitive battles between Boeing and Airbus started at the beginning of the twenty-first century, establishing always new world records for the ultimate long range travel. (A340-500 and B777-300 ER have claimed several world records, but all this is and was of no real market interest, more an interesting marketing gag!). There are very few destinations, which are really located opposite on our earth (Singapore to New York, London to Sydney) and where it would be reasonable to install a direct flight route. But these routes are exceptions and it does not make sense to design an aircraft just for this very long range routes. In [21] the longest flown routes are given and in 2013 Singapore airlines is operating a flight from Singapore to New York, taking around 19 h. Are the passengers really using or demanding for such long direct flights? Independent from the passengers demand, it can be stated that range as design parameter and design driver has also come to a natural limit.

Figure 2.10 shows a design parameter, which has not yet reached its technical limits, the **aircraft size**. The A380 with a certified passenger capacity of 852 passengers is the biggest civil aircraft today. A fuselage stretch of nearly 6 m increase in fuselage length is still possible, leading to a capacity of approximately 1000 passengers. There is today no technical limit to design even bigger aircraft. The more important question is, whether there is still a market interest for such big machines and whether the passengers and the operators are interested to use such big planes? In this point opinions are quite different and dependent on the stake holders' interest. (Some comments are given in the Chaps. 3, 8 and 11).

Figure 2.11 is showing the most important parameter for aircraft design, the relative seat mile cost and how this parameter has been constantly improved over time.

The introduction of jet engine have increased the seat mile cost by about 22 % compared to the former piston engine aircraft, however, the advantage of increased speed, altitude and allowing bigger aircraft size were the overwhelming arguments. Today seat mile cost (smc) is the only real driver for all new aircraft designs. Partly, a decrease in SMC can be obtained by designing bigger aircraft, allowing a cost decrease due to size effects. The other part is coming from new technology elements, as they are just been introduced in the new aircraft designs from Boeing and Airbus (B787 and A350), which then have to lead to a real benefit in seat mile-cost (smc). The smc improvement should be at least in the order of 10 %; so that the airline has a clear advantage in the operation and can cover all cost which are dependent on the introduction of a new airplane in the existing own fleet (see Chap. 7).

Steiner [19] is describing the important step of Boeing in the sixties and seventieth, which led to the domination of Boeing as civil aircraft manufacturers. In [10] is the European answer described with all the existing engineering capabilities but the lack of cooperation and the willingness to overcome national egoisms, which have led to the establishing of Airbus as a competent aircraft manufacturer in competition to Boeing.

Schmitt [20] is defining the new challenges of future transport aircraft, which are no longer size, range and speed, but will be cost, low emission and green features to keep the positive mood and acceptance of the travelling public.

The duopoly of today between Boeing and Airbus seems to be a well-established market situation, where it will be difficult for new entrants, to challenge these 2 big aircraft manufacturers. There are, however, several new possible entrants (Embraer in Brazil, Bombardier in Canada, AVIC in China with the COMAC 91, Mitsubishi

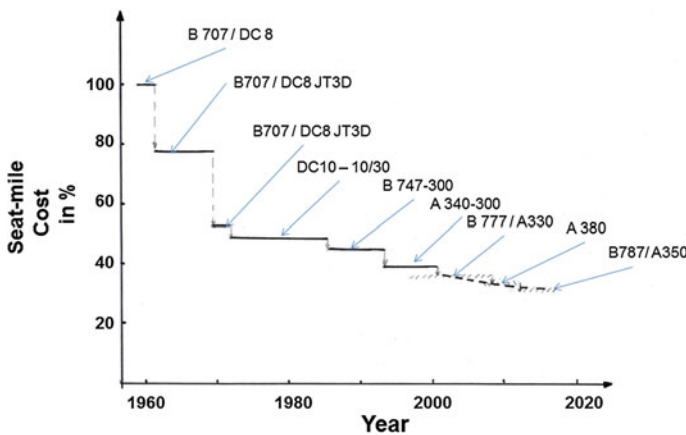


Fig. 2.11 Development of Seat Mile Cost “smc” over time

with the M21 and Russia with the “Superjet” from Sukhoi) which are preparing new designs for civil transport aircraft in the Regional class (90–140 passengers). All these new players are expecting to participate in this multi-billion dollar market and will become major challengers for the two big established players Boeing and Airbus. It will be very interesting to see, how these new aircraft manufacturers will manage their market entrance and market acceptance. But the airlines will for sure support the new aircraft manufacturers, as they will bring new ideas to the market. As we can see from today’s situation where Airbus had major problems with the industrialization of their latest A380 aircraft, where the airlines had to accept major delivery delays of more than 2 years. A similar situation was happening with the latest Boeing design, B787 aircraft, which was also about 3 years late and had to be grounded for 2 months in 2013. In this respect, the airlines will highly welcome some new aircraft manufacturers in the market to increase competition [24, 25].

2.6 Development of Civil Transport Operation (Airlines and Airports)

2.6.1 Airlines

At the beginning of air transport, the airship was used for civil transport operation. The first company, who started with regular air transport was DELAG (*Deutsche Luftschiffahrts-Aktiengesellschaft*). It was founded in 1909 with government assistance, and operated airships, manufactured by the Zeppelin Corporation. Its headquarters were in Frankfurt. The idea was to establish regular air transport between major cities in Germany. In 1914—before the beginning of the 1st World War—DELAG operated seven airships on roughly ~ 1500 routes with a total range of 175,000 km and transported 18,500 passengers without major fatalities [10, 16].

Transportation of Mail stands at the beginning of the fixed wing commercial aircraft operation. In the US the Post-office started the first regular post transport between Philadelphia and New York. Also in Europe transport of mail started the commercial operation after WW 1. In 1920, the first transcontinental airmail service began and the first night flights started a year later. However, accident rates were still high and normal passengers did not yet rely on and believe in air transport.

The four oldest airlines that still exist but using fixed wing aircraft are Netherlands’ KLM, Colombia’s Avianca, Australia’s Qantas, and the Czech Republic’s Czech Airlines. KLM first flew in May 1920, while Qantas (which stands for *Queensland and Northern Territory Aerial Services Limited*) was founded in Queensland, Australia, in late 1920 [22, 23].

The real intercontinental and international air transport started at the end of the 1930ies. New aircraft designs like the DC4, B307, He 111, FW 200 and Ju 90 had increased considerably their speed and range capability, making air transport more attractive for the passenger and the airlines. World War II stopped a lot of these

KLM - development of a typical European airline

- **Oct 7, 1919** Dutch Royal Airlines for the Netherlands and its Colonies (KLM) was founded.
- **Oct 21, 1919** The first KLM office opened on Heerengracht in The Hague.
- **Apr 4, 1921** KLM resumed service with its own pilots and aircraft: the Fokker F-II and F-III
- **Oct 1, 1924** KLM initiated its first intercontinental flight, from Amsterdam to Batavia (Colonial Jakarta) in a Fokker F-VII.
- **Dec 1933** KLM flew Christmas and New Year's cards from Amsterdam to Batavia in a record time of just over four days in a Fokker F-XVIII Pelikaan.
- **Dec 1934** KLM made its first transatlantic flight, from Amsterdam to Curacao in a Fokker F-XVIII Snip.
- **Sep 1945** KLM resumed service following the Second World War, starting with domestic flights.
- **May 21, 1946** KLM initiated scheduled service between Amsterdam and New York using the Douglas DC-4 Rotterdam.
- **Nov 1, 1958** KLM opened its Amsterdam-Tokyo service, flying over the North Pole using the Douglas DC-7 "Caraïbische Zee".
- **Mar 1960** The Jet Age began with the introduction of the Douglas DC-8.

Fig. 2.12 Development of a typical national airline (KLM)

civil transport developments as all engineering skills went into military aircraft design.

After WW II all the aeronautical engineering Knowhow was transferred back to the civil air transport. The jet engine was introduced for civil air transport. At the end of the sixties, the aircraft Boeing B-707, Douglas DC-8, Sud Aviation—Caravelle, Tupolev Tu-104, appeared on the market and established the dominance of jet aircraft in short and long range flights and the newly established national airlines were interested to buy and operate them and develop their international network (see Figs. 2.8, 2.9, 2.10, 2.11). But international agreements had to be developed to build confidence for the travelling persons (see Chap. 4).

A typical development of a classical “flag carrier” or national airline can be seen in Fig. 2.12 with the development of KLM, starting in 1919. Common elements are, to use national aircraft design (Fokker), national pilots and start to connect with the own empire (colonies, when still existing). Here the air transport gave a new dimension to better connect these colonies with the homeland.

2.6.2 Development of Airports

The development of airports followed the need, that some operators wanted to offer transport services between two points and therefore needed the necessary infrastructure. This started with a green plane field, some hangars or light buildings to prepare the formalities for the flight. Most of these fields had not a dedicated runway, but provided a large round circle field, where aircraft could start and land in whatever was the preferred direction related to the wind conditions at the airfield.

Paved areas were created first at those positions, where the passengers were embarking and disembarking. Later on paved runways were installed to allow landings and takeoffs in nearly all weather conditions and during day and night.

The following short history of airport development is based on data from [16, 26–28].

The title of “world’s oldest airport” is disputed, but College Park Airport in Maryland, US, established in 1909 by Wilbur Wright, is generally agreed to be the world’s oldest continually operating airfield, although it serves today only general aviation traffic. Pearson Field Airport in Vancouver, Washington had a dirigible land in 1905 and planes in 1911 and is still in use. Bremen Airport opened in 1913 and remains in operation till today. Amsterdam Airport Schiphol opened on September 16, 1916 as a military airfield, but only accepted civil aircraft from December 17, 1920, allowing Sydney Airport in Australia—which started operations in January 1920—to claim to be one of the world’s oldest continually operating commercial airports. Rome Ciampino Airport, opened 1916, is also a contender. Increased aircraft traffic during World War I led to the construction of several new landing fields. Aircraft had to approach these from certain directions and this led to the development of aids for directing the approach and landing slope. Following the war, some of these military airfields added civil facilities for handling passenger traffic. One of the earliest such fields was Paris—Le Bourget Airport in France. The first airport to operate scheduled international commercial services was Hounslow Heath Aerodrome in August 1919, but it was closed and supplanted by Croydon Airport (UK) in March 1920. In 1922, the first permanent airport and commercial terminal solely for commercial aviation was opened at Flughafen Devau near what was then Königsberg, East Prussia, Germany. The airports of this era used a paved “apron”, which permitted night flying as well as landing heavier aircraft.

The first lighting used on an airport started during the latter part of the 1920s; in the 1930s approach lighting came into use. These indicated the proper direction and angle of descent. The colors and flash intervals of these lights became standardized under the International Civil Aviation Organization (ICAO, see Chap. 4). In the 1940s, the slope-line approach system was introduced. This consisted of two rows of lights that formed a funnel indicating an aircraft’s position on the glideslope. Additional lights indicated incorrect altitude and direction.

Following World War II, airport design became more sophisticated. Passenger buildings were being grouped together in a central unit, with runways arranged in groups around the terminal and taxiways to connect the runway and the terminal area. This arrangement permitted expansion of the facilities. But it also meant that passengers had to move further to reach their plane (see also Chap. 9).

Airport construction boomed during the 1960s with the introduction of jet aircraft traffic. Runways had to be extended out to 3000 m (9800 ft). The fields were constructed out of reinforced concrete using a slip-form machine that produces a continual slab with no disruptions along the length. The early 1960s also saw the introduction of jet bridge systems to modern airport terminals, an innovation which eliminated outdoor passenger boarding.

Brief History of Atlanta Airport (US)

- April 16, 1925 Mayor Walter A. Sims signs a five-year lease on an abandoned auto racetrack and commits the City to developing it into an airfield.
- April 1929 The City pays \$94,400 for the land and changes the name to Atlanta Municipal Airport.
- December 1930 Eastern Air Transport inaugurates passenger service from Atlanta to New York.
- March 1939 The Airport opens its first control tower.
- 1957 Atlanta is the busiest airport in the country with more than 2 million passengers.
- May 1961 Atlanta Municipal Airport is entering into the “Jet Age”, parallel with the opening of the largest single terminal.
- June 1978 Sabena - Belgian Airlines - becomes Atlanta’s first foreign international carrier.
- September 1980 Atlanta International Airport opens the world’s largest air passenger terminal complex, accommodating up to 55 million passengers /year.
- December 1984 A fourth parallel runway was completed. An expansion of an 12,000-foot runway started, capable of handling the largest commercial airplane in development.
- 1988 MARTA’s Airport station linked the Airport to Atlanta’s rapid transit system.
- June 1996 The new Master Plan -- Hartsfield - 2000 + Beyond was proposed.
- March 2000 Hartsfield is the World’s Busiest Airport, accommodating more than 78 million passengers and more than 900,000 landings and takeoffs for 1999.
- July 2005 Hartsfield-Jackson celebrates its 80th birthday

Fig. 2.13 Development of Atlanta airport in USA

Figure 2.13 shows a short summary of a big airport (Atlanta US), which is given to illustrate the constant development and increase in runways, terminal buildings, access to city and all the new technological improvements, necessary to follow the constant increase in passenger demand and societal expectations.

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Schmitt, D.; Gollnick, V.

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