AIRBUS A380

the 21st century jetliner

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content

[1] Introduction

The A380 is the most advanced and spacious airliner yet developed. With this documentation we are going to inform about this masterpiece of engineering, but on the other hand we will show also disadvantages and problems of this superjumbo. In addition to this the reader will find some short descriptions of technologies and principles which offer an insight into the exciting science of aeronautics. The A 380 which Airbus sees as the "flagship of the 21st century"[2] was designed in close collaboration with major airlines and airworthiness authorities. This plane combines the very latest technologies for materials and industrial processes. It also stands for the economical competition between America and Europe as the latest discussions revolving about subsidies for Boing and Airbus show. The A380 will meet the most stringent international certification requirements. It will be able to carry 35 per cent more passengers than its closest rival, the Boing 747. There will be much more comfort for the passengers of the A 380 because of much more floor space available. Because of the application of new technologies, which result in a high rate of efficiency there will be 15-20 percent lower seat-per-mile costs and the range will be 10 per cent greater than that of its closest rivals. For instance on long-distance routes like Frankfurt-Los-Angeles passengers will experience a more relaxing way of traveling. A380 will help to avoid aircraft jams by transporting people without additional aircraft movements which seems to be important in a century of growing air travel. The first version of A380 can transport up to 555 passengers in a standard three-class configuration. Airbus made big efforts to develop an environmentally friendly aircraft. So the plane has a significantly reduced noise level and lower emissions. For example the A 380 produces half the noise than other aircraft of comparable size on take-off. This is on the one hand an effect of the new engines Rolls-Royce Trent 900 or Engine Alliance GP7200, which were designed especially for A380 but on the other hand it is also a consequence of an advanced wing and landing gear design. Because of this the A380 will be quieter than todays and future noise limits. But if you talk about A380 as an environmental friendly aircraft you will have to consider not only noise reductions. Lightweight materials like composites are used extensively within the body and wings, which results in a remarkable reduction of the plane's weight. Therefore A380 burns 12 % less fuel than Boing 747, which makes it a "highly efficient aircraft".[2] An effect of this are significantly reduced exhaust emissions. Indeed, the A380 will be the

first long-distance aircraft to consume less than three liters of cerosine per passenger over 100 km.[7] This fuel consumption is comparable to a family car. It is also important, that pilots who have flown other Airbus aircraft will be able to operate the superjumbo with minimal additional training, because A380 uses the same cockpit layout, procedures, handling characteristics and a steering system called "fly-by-wire"[2] like other Airbus planes. Airbus designed the A380 in collaboration with the world's biggest airports, ensuring airport compatibility and an easy entry into service. So the A380 provides a very responsible solution to growing air traffic and airport congestion. The alternative would be a further increase in aircraft movements.[2] But this might require billions of dollars of investment by airports in new runways, terminals and facilities and would also contribute to jams at airports and on the flight routes and a significantly increase of influences of air travel on the environment. Another consequence would be a raised risk of accidents because of necessary cuts in security distances. The concept has been confirmed, through worldwide participation in the program from its roots on and through the already remarkable number of planes sold. At the end of July 2005, 16 customers had announced firm orders and commitments for a total of 159 planes.[2]

At the beginning the A 380 family consists of a passenger aircraft with a range of up to 15,000 km and the freight version. This A380F, will enable airlines to transport about 150 tons over 10,400 km.[7] Stretched or extended range variants will become available as and when the market requires them. We hope you will enjoy our short publication about the realization of this European dream.

Aircraft Dimensions		
	ft	m
overall length	239ft 3in	73
cabin length	166ft 3in	50.68
fuselage diameter	23ft 5in	7.14
height (to top of horizontal tail)	79ft 7in	24.1
wing span (geometric)	261ft 8in	79.8
Design Weights		
	lb X 1000	tonnes
max. take-off weight	1 235	560
max. landing weight	851	386
max. zero fuel weight	796	361
typical operating weight empty	608.4	276.8
Basic Operation Data		
engines	Trent 900/GP 7 000	
engine thrust range	70 000 lb slst	
range (max. pax)	8 000nm / 15 000km	

according to www.eads.com

[2] Development

[2.1] Design phase

Airbus first began studies on a very large 500 seat passenger aircraft in the early 1990s. The company wanted to develop a competitor and successor to the Boeing 747 as a strategic play to end Boeing's dominance of the very large airliner market. At first Boeing and Airbus launched a cooperative research project, later on it became obvious that there is no market for two superjumbos.

Boeing decided to focussed on a different strategy with the "Dreamliner 787" – a medium sized, cost-effective and modern aircraft, whereas Airbus designers introduced the superjumbo project in June 1994. Airbus began engineering development studied numerous design configurations of the plane, then known as the A3XX. E.g. a single deck aircraft was taken into consideration, which would have seated 12 abreast and twin vertical tails. However Airbus decided on a twin deck configuration where a much lighter structure is possible. The key aims of the design are lower operating costs per seat than Boeing 747-400 with at the same time increased seating comfort, the use of advanced technologies and materials to ensure a wider range and fewer emissions.

Two different versions of the A380 are planned: A freighter and a passenger version with 555 seats which can either be stretched to 656 seats or shortened to 480 seats[3].

[2.2] First Orders

Airbus decided to collect 50 orders before launching the program. In July 2000 Emirates Airlines became the first A380 customer by saying it wants to buy seven. Air France, International Lease Finance Corporation (ILFC), Singapore Airlines, Qantas and Virgin Atlantic followed and completed the 50 orders[2]. Airbus was in the position to officially approve the project and its name "A380".

FedEx became the first customer for the freighter version of the A380 by placing their order on January 16, 2001. FedEx will take delivery of three aircraft each in 2008, 2009 and 2010, as well as one in 2011.

Singapore Airlines will be the first airline to operate the 555-seat A380. The delivery of the first aircraft is planned for the first quarter of 2006. The A380 will be used on routes to London, Los Angeles, San Francisco, New York, Tokyo, Hong Kong and Sydney.

[2.3] Test phase

On May 17, 2004 Airbus started A380 engine flight trials. The first engine destined to power the A380, the Rolls-Royce Trent 900, made a successful first flight lasting three hours and 40 min. It is the largest and most powerful engine to fly on any Airbus aircraft.

In order to test the completely assem-

bled A380 Airbus worked out an extensive flight test programme that is currently running and lasting 15 month. Four prototypes are altogether 2200 hours in the air.

[2.4] Production

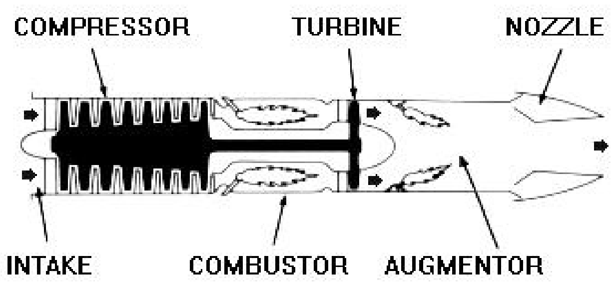
Airbus owns not less than 16 manufacturing sites all across Europe. About 6000 employees work for the production of parts for the new A380 airliner there [8]. The front and rear sections of the fuselage are produced in Hamburg. They are loaded on an Airbus Roll-on-and-roll-off-ship (RORO), Ville de Bordeaux, and shipped to United Kingdom. In Bristol and Broughton in north Wales the huge wings are manufactured and shipped by a barge to Mostyn docks, where the RORO-ship adds them to its cargo. After that it proceeds to Saint-Nazaire, western France where it unloads its cargo from Hamburg and loads further assembled sections instad. The ship completely unloads in Bordeaux. Having done that, the ship picks up the horizontal tailplane in Cadiz, southern Spain, and delivers them to Bordeaux as well. From there, the A380 parts are transported by barge and by road to the final assembly hall in Toulouse. To deliver such huge components, a completely new infrastructure had to be created, including special river and seagoing vessels, wider roads and extra canal systems. When the final assembly is completed, the aircraft are flown to Hamburg were our journey began. They are now furnished and painted according to the preferences of the customer. In early 2001 first components for the A380 were manufactured, final assembly began in 2004. The first Airbus A380 was revealed during a huge ceremony with presence of the French, German, British and Spanish president and prime ministers in Toulouse on January 18, 2005.

On April 27, 2005 Airbus A380 successfully completed its first flight that lasted three hours and 54 minutes, reaching the height of 4.2 km near south of France. The A380 took off and landed at Blagnac international airport, Toulouse [5].

[3] Technology

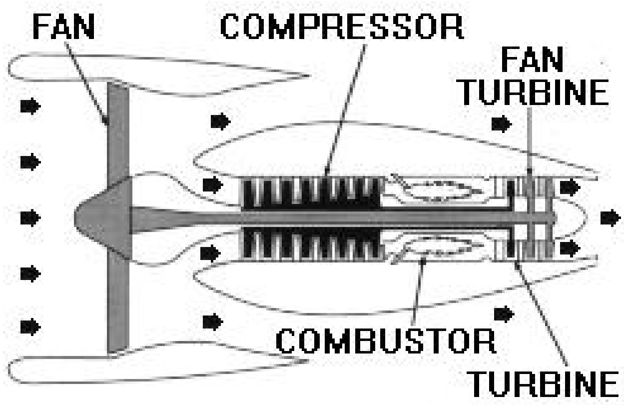
[3.1] Turbo fan

Depending on the preferences of the customers either the Rolls-Royce Trent 900 or Engine Alliance GP7200 turbofan engines may power the A380. Both are adopted from the turbofans installed in the Boeing 777. Let us use this occasion to have a closer look on the function of a turbofan. A fan engine is any engine that takes in, accelerates and discharges a fast moving jet of air to generate thrust in accordance with Newton's third law of motion. Unlike military turbofans those used in civil airplanes have to be optimized with respect to the noise level[2].



The turbojet is the basic engine of the jet age. Air is drawn into the engine through the front intake or inlet. The compressor squeezes the air to many times normal atmospheric pressure and forces it into the combustor. Here, fuel is sprayed into the compressed air, is ignited and burned continuously like a blowtorch. The burning gases expand rapidly rearward and pass through the turbine. The turbine extracts energy from the expanding gases to drive the compressor, which intakes more air. After leaving the turbine, the hot gases exit at the rear of the engine, giving the aircraft its forward push.[8]

For additional thrust or power, an afterburner or augmentor can be added. Additional fuel is introduced into the hot exhaust and burned with a resultant increase of up to 50 percent in engine thrust by way of even higher velocity and more push.[8]



A turbofan engine is basically a turbojet to which a fan has been added. Large fans are placed at the front of the engine to create high bypass ratios for subsonic flight. This additional amount of incoming air air passes through the fan and bypasses, or goes around the engine, just like the air through a propeller. This produces greater thrust and reduces fuel consumption. The fan is driven by a second turbine, located behind the primary turbine that drives the main compressor. So a turbofan gets some of its thrust from the engine and some from the fan. The ratio of the air that goes around the engine to the air that goes through the core is called the bypass ratio. Because the fan is enclosed by the inlet and is composed of many blades, it can operate efficiently at higher speeds than a propeller. That is why turbofans are used on high speed planes and propellers are used on low speed planes. Low bypass turbofans are more fuel efficient than basic turbojets.

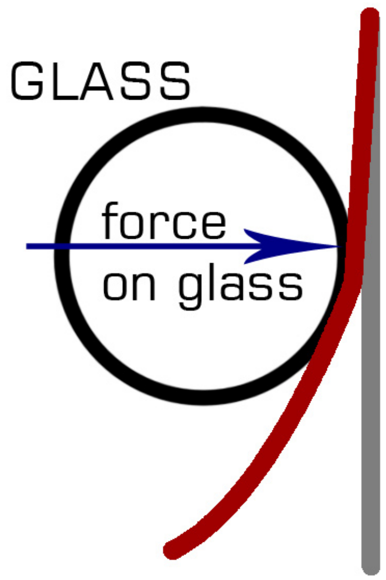
[3.2] Physics of flight/lift

The question, what makes an airplane fly, can not be answered easily. As you know an airplane flies because of lift, but what causes lift? There are three different explanations. At first there is the Mathematical aerodynamics description of lift, which uses complex mathematics and computer simulations for calculating lift. It mainly relates to the difficult mathematical concept of rotation, which is a measure of apparent rotation of air around the wing. Though this enables engineers to calculate lift exactly it does not provide understanding of lift. On the

other hand there is the so called popular description, based on the Bernoulli principle. This principle says that when a fluid is speeded up the pressure is lowered. This explanation mainly focuses on the shape of the wing and relies on the principle of equal transit times, which says, that the parts of air separated at the leading edge of the wing have to converge at the trailing edge[9]. The distance of travel in equal times is directly related to speed. As the air has to go farther over the top of the wing because the bended wing profile it must have a higher velocity than the air under the wing. According to the Bernoulli principle the air creates a region of lower pressure over the wing. So there is a resulting upward force to the wing, which causes lift. We will now show some problems about this description by an example calculation. We will refer to a Cessna 172, a four seated airplane of 1050 kg weight. At this plane the path over the top of wing is about 5% longer than under the wing. So the wing would only produce 2% of needed lift at low speed flight at 100 km/h and the minimum speed for sufficient lift would be at 640 km/h or the length of the top side had to be 50 % longer than the bottom. Another problem about this description is, that it ignores, that lift requires power and the dependence of lift on the angle of attack. According to this explanation inverted flight would be impossible because the planes for acrobatic flights have a symmetric profile of wing[12].

Not so common but very evident is the Physical description of lift. It is based on Newton's three laws and the so called coanda effect. As you will see this concept is very useful for understanding

flight phenomena and it all in all provides an intuitive understanding of lift and rough estimates of lift. Newton's first law says that a body at rest will remain in rest or a body in motion will continue in straight line motion unless subjected by an external force. So you can say, if there is a bend in flow of the air there must be a force acting on it. The third law says that for every action, there is an equal opposite reaction. The wing exerts a force on the air and lift is the reaction. The air is bent down, so there is a force on air and an equal and opposite force up on the wing. The wing must divert lots of air down because lift is equal to the change in momentum of air. You can say that lift is proportional to the amount of air diverted down times the vertical velocity of that air. For more lift you either can speed up air or divert more air. Therefore the vertical component of the so called downwash causes lift. To the pilot the air seems to leave wing with the horizontal speed of the plane and roughly at the angle of attack but to an observer on the ground, if he would be able to see the air the air, it would be coming of the wing almost vertically. We will now do a back of the envelope calculation for Cessna 172 at 220 km/h. For example we choose an angle of attack of 5 degrees. The vertical velocity of air would have an amount of 18 km/h. If we now assume the average vertical velocity is half this amount we calculate from Newton's first law, that the amount of air diverted is in the order of 5 ton/s.[12] So the wing diverts air of five times the plane's weight. Regarding this we learn, that lift is not only surface effect because the wing has to accelerate al the air 7.3 m above the wing[12]. Another conclusion from the physical description is that when air is bent around the top of the wing, the wing pulls on the air above. This pulling causes the pressure getting lower and so air is speeded up, not the other way round. All in all it is the acceleration of air above wing to the downward direction that gives lift. Another conclusion is, that top surface does much more contribute to the lift than the bottom and therefore is the more critical surface. Because of this external stores like tanks and fans are under the wing and not on the top of it. In the next step we will explain, why the wing bends air by using the Coanda effect. When fluid comes in contact with



a curved surface it will follow it, for example a small stream of water wraps to a glass (red line) instead of flowing vertically down (grey line). This tendency of fluids to follow a curved surface is called the Coanda effect. The viscosity causes, that next to the surface the relative speed between fluid molecules and surface is nearly zero and raises above the surface. The fluid flow towards surface is caused by shearing forces. The volume of air that seems to rest is called the boundary layer and it has a thickness of about 2,5 cm at a Boing 747. One can say that forces on wing and air are proportional to the tightness of bend. Another important fact is the angle of attack to the oncoming air. If you use an effective angle of attack lift is proportional to the angle of attack. An interesting effect, called stall is, that lift decreases at an angle of about 15 degrees.[12] At this angle the forces necessary for the bend of air are higher than the viscosity of air supports and therefore air separates from the wing. Now we will describe the connection between lift and power. When airplane leaves the air has a vertical velocity and is left in motion. The necessary power for giving air this velocity is created by the engines. The energy given to air is proportional to amount of air diverted times its vertical velocity squared. So induced power is proportional to load times vertical velocity[9]. But power is also needed to overcome the parasitic drag, which is caused by molecules impacting on the surface of the plane. This power increases at speed to the power of three. So at low speed induced and at high speed parasitic power is dominating.[8] Last but not least we will look at the wing vortices. The distribution of downwash along the wing is related to the load distribution along wing. It changes from root to the tip. The wing next to the root scoops up most air and there is highest velocity of downwash. So the downwash curls out around itself because of change in velocity of air. The tightness of curling of wing vortex is proportional to the change of downwash speed along wing and so at tip the tip there is the tightest curl because of lift becoming zero. A visualization of this effect can be seen in the next picture.

[3.3] New technologies

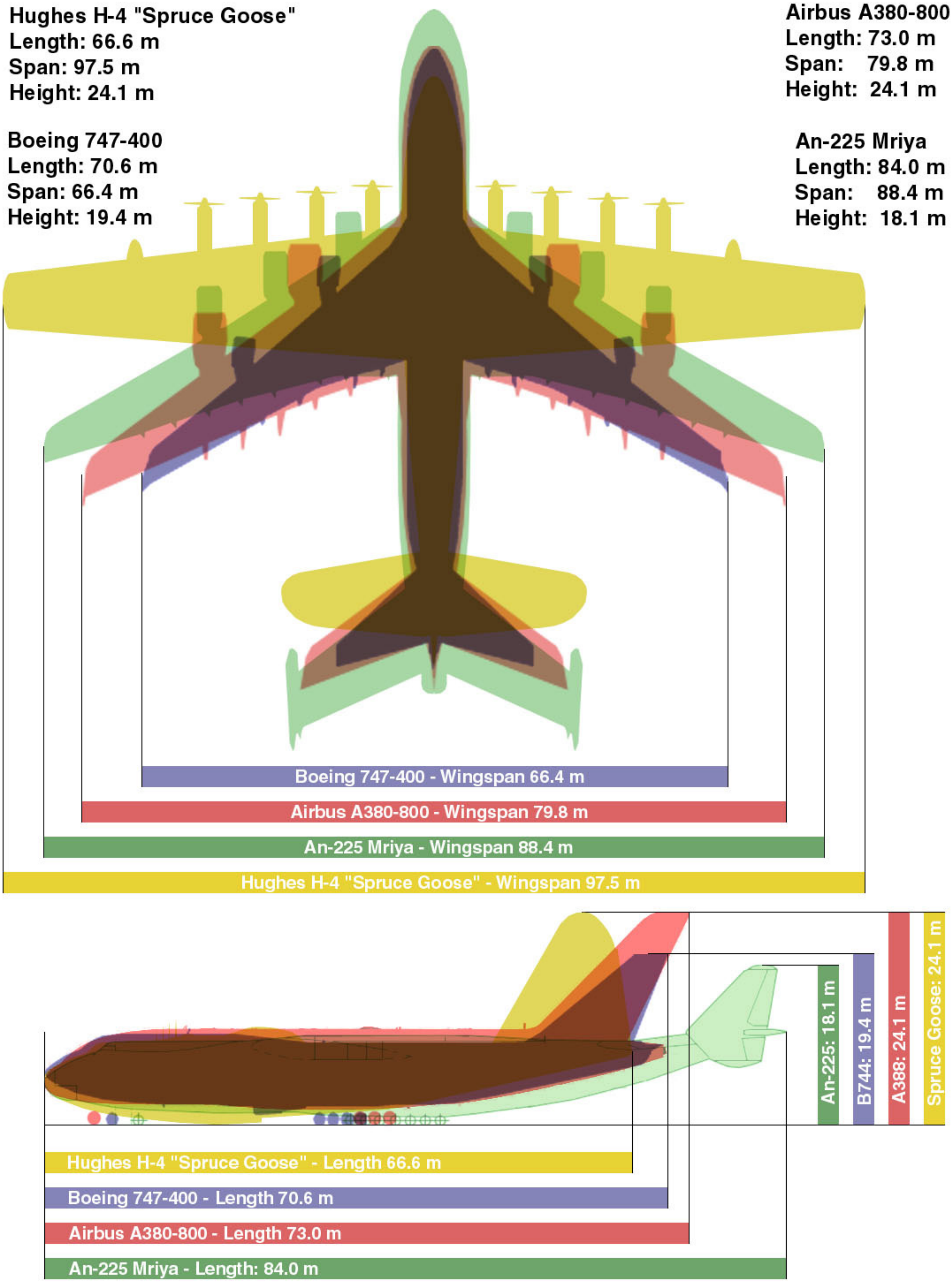
The A380 is an innovative airliner using the latest technology. From the material sed up to the complex electronic network – many components were newly developed to build this worlds largest passenger airliner. With respect to the materials the percentage of composite used increased tremendously. An aluminium-glass-fibre laminate called GLARE is used for the first time on a civil airliner. It is lighter than conventional aluminium, that are used in aviation and has better corrosion and impact resistance. Moreover GLARE is easier to repair than other aluminium-composites. Due to it is a weldable aluminium airbus could use laser welding techniques extensively. So called carbon-fibre reinforced plastics (CFRP), glassfibre reinforced plastic (GFRP) and quartz-fibre reinforced plastic (QFRP) are used for the structural components of the airliner in many places, e.g. for the wings, fuselage sections and on doors[5]. Consequently a crucial primary structure, the center wing box is made of composite.

Another improvement about the A380 is the shift in the hydraulic system from typically used 207 bar to 350 bar. Under the higher pressure the gas takes less volume and as a result the size of pipelines, actuators and other hydraulic components could be reduced, which ends up in a significant weight reduction. In order to resist the increased pressure pipelines are made from titanium. To generate the power the A380 uses four 150kVA variable-frequency generators. They are more reliable than the common constant speed drives. A computer operates and supervises the complex electrical power system. Where former aircrafts used contactors and breakers with moving parts solid-state devices have been installed for better performance and longer service life. Additional weight saving effects come from aluminium power cables that are used instead of copper.

More obvious than the efforts being made to optimize the structural components will the advantages of the advanced avionics architecture of the A380 be. The A380 features an advanced cockpit with the latest interactive displays and extended integrated modular avionics (IMA). IMA was first used in military aircrafts such as F/A-22 Raptor and Eurofighter. It reduces the number of parts as well as providing increased flexibility. The data networks are switched full-duplexed star-topology and based on 100baseTX fast-Ethernet. This reduces wires required as well as eliminating latency. Another great step forward is the Network Systems Server, which is the heart of the paperless cockpit. It provides electronic documentation, such as an equipment list, navigation charts, performance calculations, and an aircraft logbook[5]. The interfaces to the pilots are two additional displays, each equipped with a keyboard and control cursor device like laptops have.

The passengers will benefit from the latest entertainment system built in the A380. The illumination system of the innovative airliner is completely bulbless. LEDs with a much longer service life are used in the cabin, cockpit, cargo and other fuselage areas. The cabin lighting features programmable multi-spectral LEDs to vary the ambience illumination “from daylight to night and various shades in between”[5].

[3.4] Comparison of giant airplanes



[4] Versions

[4.1] Passenger version

Amazing about the passenger version of the A380 is the space and comfort that can be provided. The designers have plans for relaxation areas, bars, duty free shops and the like. The double deck cabin will offer 50 per cent more floor space than former aircrafts.[2] Photos of proposed interior are altogether very impressive and we will have a closer look at some details:

There are suggestions to use the extra space to make a "luxury jet" out of the A380 featuring casinos and bedrooms. That would of cause "drive up the cost for business and firstclass travellers"[2].

First class stretched seats can fold down into beds.

In the three-class-configuration the especially the first class passengers will profit from "levels of luxury more typical of cruise liners than airliners"[6].

First class seats. Virgin Atlantic is seriously planning to have private double beds as well as gymnasiums on board of their A380.

The lower deck will house shops, bars, restaurants and casinos like this.

A stairway on Airbus A380. The twin decks of the plane will be connected by two staircases, one at the front and one at the rear of the cabin.

Another view of first class luxury sleeping compartments. In the typical three class configuration with 555 seats only 22 of them will have the sort of luxury shown in this mock-up[8].

Even for economy class passengers A380 offers more comfort than the standard cabins they are used to. The seats are about one inch wider, providing more space as well as individual armrests and extra legroom does.

The business class interior. As well as in the first class the seat can be extended into a bed. Passengers will have access to the Internet at every seat in the aircraft using their laptop.

All the facilities named – gyms, showers, bars and so on – may become reality on board of the A380. Nevertheless one should not be blinded by those amazing plans. So far airlines have always decided on lower ticket costs and a maximum of seats. The only A380 customer likely to use this configuration is Virgin Atlantic, which has a bar in Business

Class on most of its newer airliners and announced plans to include casinos on their A380s[5].

According to the history of the airline industry, the A380 will further develop the improvements of the Boeing 747, wich are more seats at lower seat-distance costs. With 555 passengers A380 furthermore has 50% more cabin volume but only 35% more seats than the 747 [8], meaning much more space per passenger and allowing room for passenger amenities.

[4.2] Freight version

Apart from the passenger Version the A380 will also be available as a freighter. Carrying about 150 tonnes over 10,400 km on three decks it will bring a new level of efficiency on the cargo market. The advantage in range will help to simplify operations due to elimination of intermediate stops and allows express carriers to add new city pairs to their "next day" delivery lists.

The ground operators will have optimal access to the three decks of standard containers through five doors. Entry into service for the A380F is planned for 2008. FedEx will be the launch customer for this version.

[5] Problems

[5.1] Wake turbulence

A general problem of all big aircraft is vortices that stir up on the wingtips. The resulting wake turbulences are most powerful under "high thrust, high angles of attack, and clean configurations"[5]. Problems get obvious on the runway during departures were turbulences are dangerous to following aircraft. Therefore the extent of wingtip vortices is always a big issue when a new large airliner is developed.

The strength of these wake turbulences depends on numerous aerodynamic parameters like the speed of the plain, its weight and wingspan, or flap and gear deployment. The heavier the aircraft and the shorter its wing span the stronger will the wake turbulence be. The A380, at 560,000 kg, will due to its big wing desing produce weaker vortices than the Boeing 747-500. However, at maximum take-off weight, the turbulence will be stronger[5]. Flight testing will show how powerful the vortices created by the A380 really are; if they are larger than existing aircraft vortices (e.g. those of the Boeing 747), it may require greater aircraft separation on approach, reducing the frequency of aircraft landings, which would reduce the efficiency of the aircraft.

[5.2] Ground operation

In order to stay ahead of competition big airports are forced to get their facilities ready for the superjumbo. These works cause additional costs for runway enlargements and structural changes in loading and unloading sections as well as changes on the taxiways. In Hamburg for example a necessary runway extension caused costs of some 80 million Euros instead of an originally planned amount of 50 million Euros. Conservationists claimed that the plans thread the life of a rare species living next to the runway. Consequently a couple of trees could not be cleared and a video surveillance system had to be installed.

The first wave of criticism claimed that as a result of its high weight the A380 would cause a lot of extra stress on runways, taxiways and other airport surfaces. However the A380 uses more landing wheels than e.g. a Boeing 747 (A380: 22 wheels; 747: 18 wheels)[5] resulting in a lower pressure or less weight per wheel. To ensure that point Airbus extensively tested the A380's effect on runways using a special ballasted rig of 540 tons which the same wheel configuration as the A380 would use. Towing it up and down at Airbus' facilities in Toulouse they showed that the ground was not critically effected by the weight.

With respect to the large number of passengers on board of the A380 logistical problems of airports seem to be a bigger issue than changes on runways. Some airports have announced plans for terminal reconfigurations in order to cope with the increasing number of passengers and in particular to manage loading and unloading from the A380's double-decker design.

As a result of the longer wingspan of A380, not only an extension but also a broadening of runways and a repositioning of taxiways may be required. There

are fixed safety distances between aircraft that have to be maintained.
Another criticism is that the jet blast from the A380's engines may damage facilities on the ground. There are concerns that they could be dangerous to buildings and to ground vehicles. Wall Street Journal stated that "The debate is supposed to be entirely about safety, but industry officials and even some participants acknowledge that, at the very least, an overlay of diplomatic and trade tensions complicates matters."[13] This assessment seems to be true not only for the particular criticism but for all issues discussed in this chapter.
according to 5, 6

[5.3] Evacuation/emergency

Before the new Airbus A380 can be certified to carry passengers, Airbus must demonstrate to authorities in the United States and Europe that the maximum number of passengers the plane will carry can be evacuated within 90 seconds. For the demonstration Airbus is expected to have more than 850 seats on the two decks of the A380. Never so many people had to get off an airplane in this time - and never from two full-length decks at the same time. In a darkened hangar, Airbus will have 90 seconds to get all 850 passengers and crew members off its new flagship. The volunteers will have to step over and around luggage, pillows and blankets scattered in the aisles. They'll have to find their way through a dark cabin with flight attendants barking orders and only the jet's emergency internal lighting to show the way. There are 16 emergency slides on the A380, eight on each side of the airplane. All of them are 14 feet wide and can accommodate two people sliding at once. The six upper deck slides - three on each side - are 26 feet above the ground. The slides will have gone through more than 2,500 functional tests by the time the A380 is certified. In average about 1.2 people per second must be able to leave the plane through each doorway.
Some aviation safety experts, as well as flight attendants and their union, are concerned about the double-deck design and what could happen in a real-life evacuation, in conditions that a test cannot simulate. Passengers can refuse to jump on a slide, creating bottlenecks and confusion. On the A380, some upper-deck passengers might decide to flee down the two sets of stairs at the front and rear of the plane that connect the main deck or if there were smoke and fire on the main deck, some passengers there might suddenly take the stairs to the upper deck. Another problem is the risk of injury of passengers during the evacuation by falling down or being hurt by running passengers.
Emergency evacuations of modern jetliners occur more often than many people who fly may realize. So the US National Transportation Safety Board found that on average, an emergency evacuation is occurring every 11 days. The consequences of not being able to get out of a jetliner quickly in an emergency can be deadly.
For emergency training Airbus also installed the world's largest cabin trainer in Toulouse. Measuring 25 metres long and 10 metres high, the A380 cabin emergency evacuation trainer is de-

signed for cabin and flight crew safety training. The A380 trainer features a full-scale cabin section with a main and upper deck. It includes facilities such as the cockpit, cabin crew stations, lavatories and the lower deck crew rest area. It is also equipped with two A380 doors, cabin communication systems, and one main and one upper deck escape slide. Cabin and flight crews will be trained on topics such as the cabin and cockpit oxygen systems and the operation of the reinforced cockpit door. Airbus is counting on this state-of-the-art trainer, which features the double-deck design of the actual aircraft, to provide a realistic environment for A380 crews coming to familiarise themselves with the two-deck concept and to be trained on all the cabin systems in optimum conditions.

according to 7, 5, 2

[6] Appendix

[6.1] Orders

Airline	A380-800	A380-800F
Air France	10	
China Southern Airline	5	
Emirates	41	2
Etihad Airways	4	
FedEX		10
ILFC	5	5
Kingfisher Airlines	5	
Korean Air	5	
Lufthansa	15	
Malaysia Airlines	6	
Quantas	12	
Qatar Airways	2	
Singapore Airlines	10	
Thai Airways	6	
UPS		10
Virgin Atlantic	6	
	132	27
	Total	159

according to 2

[6.2] Competitors

	B 747-400	A340-600	A380-800
length	70,7 m	75,3 m	72,7 m
wingspan	64,6 m	63,5 m	79,8 m
height	19,4 m	17,3 m	24,1 m
wing surface	520 m^2	439 m^2	845 m^2
passengers in Lufthansa configuration	390	380	555
range	12 200 km	14 300 km	14 800 km
fuel consumption per passenger and 100 km	4,3 l	3,4 l	3,3 l
tank capacity	216 000 l	bis 204 000 l	310 000 l
speed	0,855 ca. 907 km/h	Mach 0,83 ca. 881 km/h	Mach 0,85 ca. 902 km/h
max. speed	939 km/h	913 km/h	944 km/h
max. take off weight	395 t	bis 380 t	560 t
thrust	267 kN	bis 267 kN	311 kN
cabin area	331,91 m^2	335, m^2	511,27 m^2
fuselage diameter	6,13 m	5,28 m	6,58 m
price	200 Mio. US$	190 Mio. US$	280 Mio. US$

according to www.lufthansa.com

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