

Airbus technical magazine

November 2016

A380 Special edition

FAST

Flight Airworthiness Support Technology





Alain FLOURENS

Head of the A380 Programme

Dear Airbus friends,

With the 200th A380 delivery coming up this year, we wanted to give you an update on this unique aircraft and its evolution, in a special edition of FAST.

A380 operations are certainly extending. Since January this year, we have seen 15 new routes, 8 new destinations and the world's longest-ever direct flight between Dubai and Auckland.

We at Airbus firmly believe the A380 is a cost-effective and versatile solution for customers and for increasingly congested hubs, such as Heathrow and Hong Kong.

We have therefore been continuously working to improve operations, facilitate maintenance and increase profitability of the aircraft, in particular with an optimised cabin space. We are now offering improved cabin layouts that allow for the best class segmentation so airlines can optimise revenues. This increased cabin flexibility also meets market needs, in line with new travelling trends and the growing traffic in regions such as Asia and the Middle East.

With its still unbeaten comfort features of quietness, smoothness of flight and seat width, the A380 remains a unique experience and a firm favourite for air travel, with 60% of A380 passengers actually ready to make an extra effort to fly the aircraft again. You can read more in the article on page 28.

To encourage even more passengers to enjoy the experience, Airbus has created an A380 website, iflyA380.com, that gives information about A380 destinations, flights, airline operators and passenger feedback. iflyA380.com also incorporates a tool to facilitate A380 bookings with airlines. This is only a first step and we have other ideas to promote the A380 directly to passengers.

And looking ahead, for those customers interested in the second-hand market, we are ready with support including cabin reconfiguration, training and operations.

The A380 Special edition gives you a 360° view of our iconic aircraft's evolution and our efforts to make it even more profitable and attractive.

Enjoy the tour and discover - or re-discover - the A380!



FAST

Flight Airworthiness Support Technology

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Where you see this icon, a video is available on the FAST magazine app (Apple & Android).

Operational versatility of the **A380**



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The A380 has made a significant impact on the long-haul market since its entry-into-service in October 2007.

For many airlines, it has taken on the flagship role, introducing new levels of passenger comfort and amenities, resulting in widespread passenger praise.

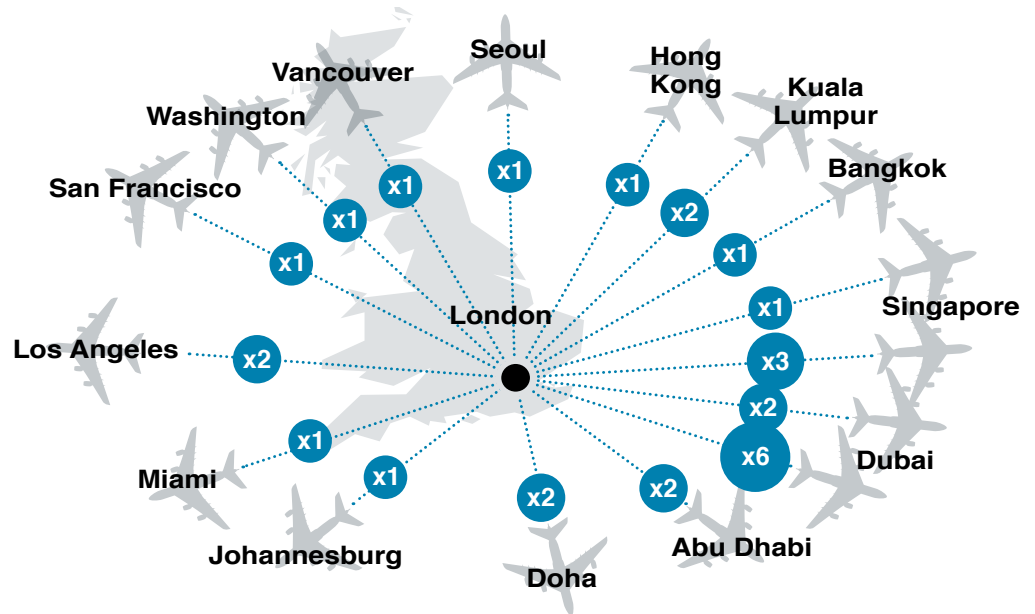
The variety of operations from short to ultra long-haul markets, and from 4-class to 2-class, demonstrates the A380's flexibility, and that it brings solutions to increasing passenger traffic.



Optimised flights

Today, A380 operations span the globe with over 110 routes to 55 destinations. The three major airline alliances are represented. The A380 has a significant presence at the world's biggest hubs such as Dubai, Los Angeles and Hong Kong. It has been a key enabler for slot-constrained airports to maintain their growth.

At London Heathrow, one of the most congested airports in the world, there are now 56 daily A380 flights representing 8% of the airport's passenger traffic.



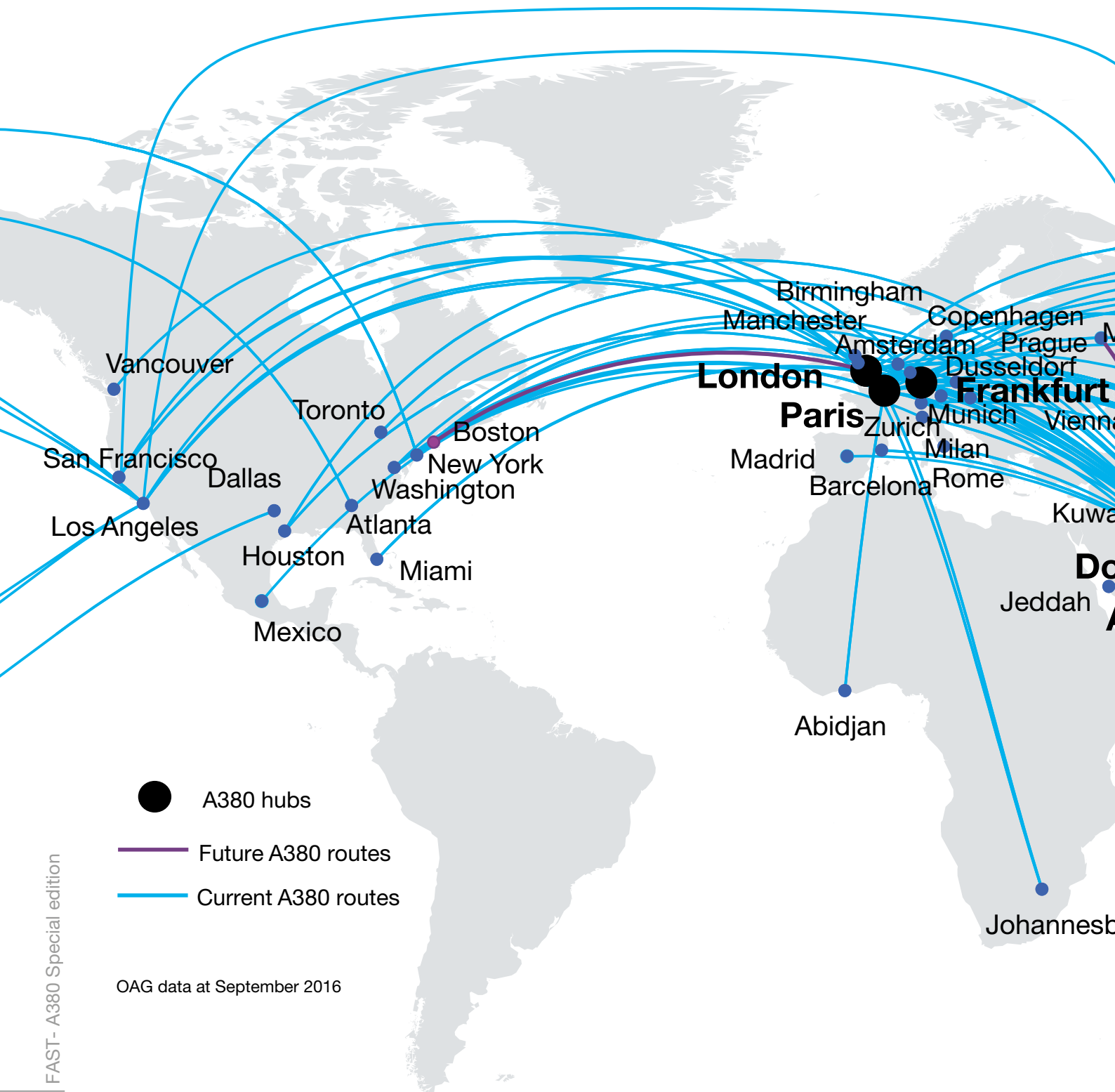
British Airways (BA), London's home carrier, has used the A380 to consolidate frequencies and release valuable slots for new destinations. Up until the summer of 2013, BA operated 3 daily B747 flights on the London to Los Angeles route. This was replaced with a twice-daily A380 service which offered the same seat capacity, but lowered the daily trip operating cost by nearly 20%. This consolidation offers more capacity at the peak time when passengers want to travel. In addition, BA A380s are configured to accommodate 5% more premium passengers, leading to higher overall revenue than on its B747s. Beyond the improvement in efficiency, freeing up a valuable slot for new route development was a key benefit for an airline operating at such a constrained airport.

BA is not alone in using the A380 to consolidate capacity. Thai Airways replaced a 10x weekly B777-300ER service with a daily A380 on the Bangkok to Paris CDG route. There are numerous other cases of operators consolidating a mix of daily and twice-daily services into a daily A380 to optimise the network and focus on peak travel times. Other operators have used the A380 to boost their growth to particular destinations which are either highly constrained, or demonstrate a strong time-of-day preference. In 2008, Singapore Airlines, the first to operate the A380, switched all of its 3 daily B747 frequencies to A380s on the London to Singapore route to capture the high levels of demand.

The A380 has also brought solutions to market seasonality, a phenomenon seen in many markets. Lufthansa deploys the A380 on routes which see high peak season demand such as Frankfurt to San Francisco. By deploying the A380 during the 6 to 8-month summer period, it receives a significant boost in revenue thanks to the 60% capacity increase. Beyond the increase in capacity on the route it flies, the A380 also has a dramatic effect on connecting traffic. Traffic figures show the introduction of the A380 on SFO-FRA increased connecting traffic volume via Frankfurt by nearly 80%. The additional passenger volume and revenue on regional and domestic feeder flights give operators the opportunity to benefit from more competitive unit costs due to the A380's greater economies of scale.

An outstanding payload range performance gives the A380 the ability to fly some of the longest routes in the world. On the Dallas to Sydney route, Qantas previously operated B747-400ERs, which had to make a technical refuelling stop in Brisbane. When Qantas started flying the A380, it was able to fly the route non-stop to Sydney. Similarly, Emirates operates several ultra long-haul routes from Dubai, including Los Angeles and Dallas. Emirates has recently announced the latest addition to its ultra long-haul network, a non-stop A380 flight from Dubai to Auckland.

The 8,600 nautical mile trip (elapsed travel time of 17 hours, 15 minutes) will be one of the longest scheduled flights in the world. The convenience of a non-stop flight is particularly sought after by premium passengers, giving A380 operators the added advantage of attracting higher yields. In addition, the exceptional space and comfort of the A380 is greatly appreciated by passengers who travel on ultra long-haul flights.

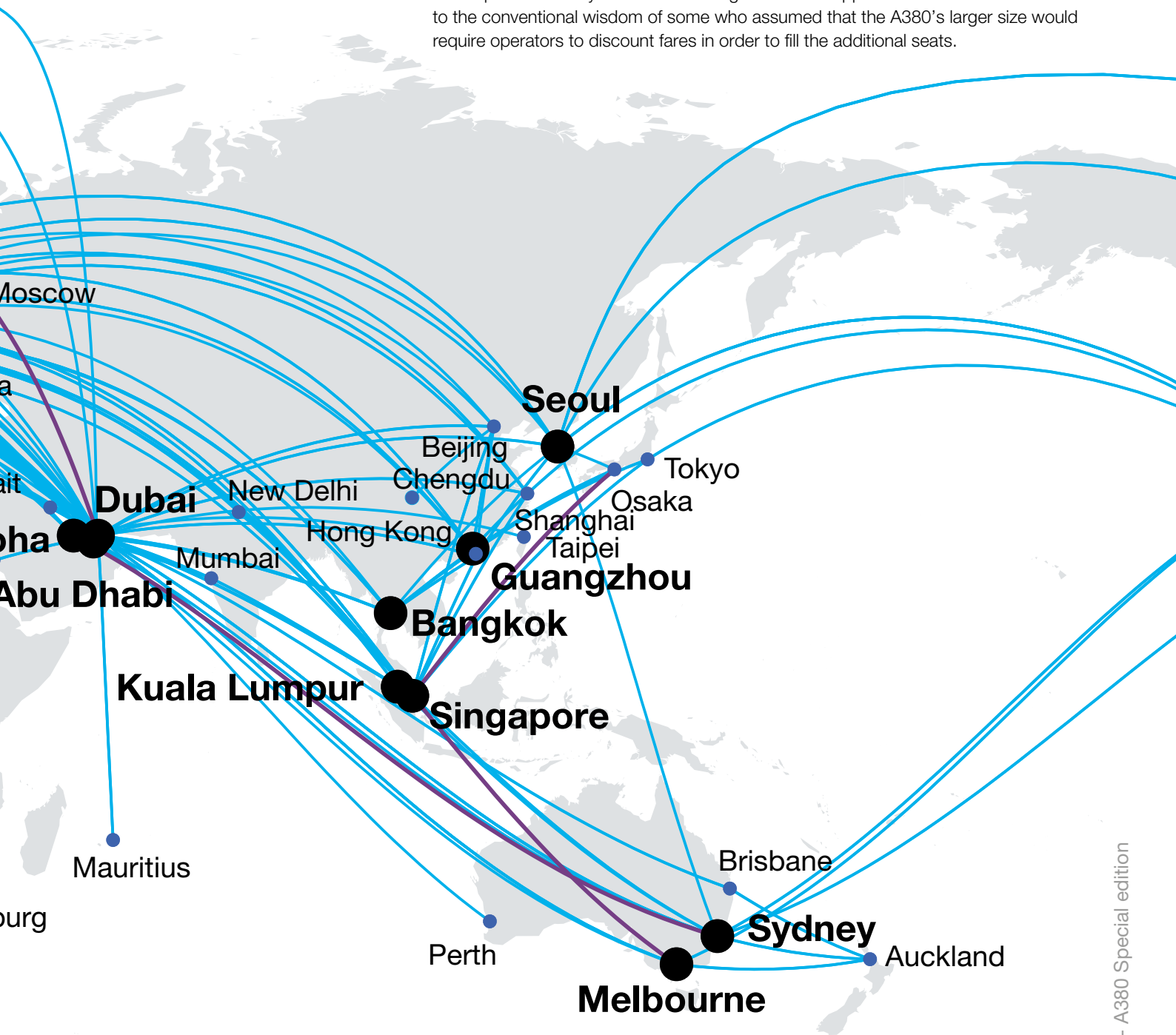


Greater passenger appeal, greater demand

The A380 offers its operators the space to innovate with new passenger amenities such as bars, showers and duty-free shops. Etihad introduced 'The Residence' a class beyond first. With a separate bedroom and seating area, it provides a flying experience close to that offered on a corporate jet. All these amenities serve to increase the level of service beyond the seat and allow A380 operators to further differentiate themselves from the competition. As illustrated by the famous 'flying A380 bar', operators are successfully marketing these amenities to the public. The resulting product awareness influences passengers to seek out A380 flights.

Over the past nine years of A380 operations, passenger feedback regarding the unprecedented space and comfort offered by the A380 has been overwhelmingly positive. Surveys have shown that, given a choice, passengers clearly prefer travelling on the A380 compared to other competing aircraft types – and that many passengers say they are willing to pay a premium to travel on the A380. (Read more in Passenger Experience on page 28.)

These positive survey results and strong anecdotal support for the A380 ran counter to the conventional wisdom of some who assumed that the A380's larger size would require operators to discount fares in order to fill the additional seats.



The Wingtip Study

Airbus designed a scientific ‘apples-to-apples’ real-world comparison, known as the Wingtip Study, to test whether passengers are truly willing to pay more to enjoy the extra space and comfort of the A380. The study took its name directly from airline scheduling terminology; ‘wingtip departures’ occur when an airline schedules two of its aircraft to fly from the same origin to the same destination, departing within a very short time of each other – almost as if the two aircraft are flying wingtip-to-wingtip in formation towards their shared destination.

The Wingtip Study looked for real-world examples of airlines operating both the B777 and the A380 in tandem as wingtip departures. By using this type of head-to-head comparison, all of the variables that might otherwise distort a comparison between aircraft types were eliminated.

Airbus identified two examples of A380s and B777s being operated together to create wingtip departures. In the first case, Air France operated daily B777 and A380 departures from New York to Paris with only 45 minutes between the two flights. In the second example, British Airways scheduled daily A380 and B777 departures from Hong Kong to London with only 15 minutes between the two flights.

Because the wingtip departures were operated by a single airline at nearly the same time, it was possible to determine if a customer preferred a specific aircraft type. Any distorting criteria that might have existed due to the time of departure, choice of airline, on-board product, or potential connections at the hub, were completely eliminated because both flights were nearly identical in all of the above respects. The only real difference between the two wingtip flights was the type of aircraft used to operate them – so any passenger preference for one aircraft over the other would be easily identified.

Following five months of detailed analysis, the study’s findings clearly supported what passengers had been saying all along: that they prefer to travel on the A380, and they are willing to pay a premium to do so. Far from A380 operators having to discount their fares, the above Wingtip Study examples showed that an A380 fare premium already exists in all classes.

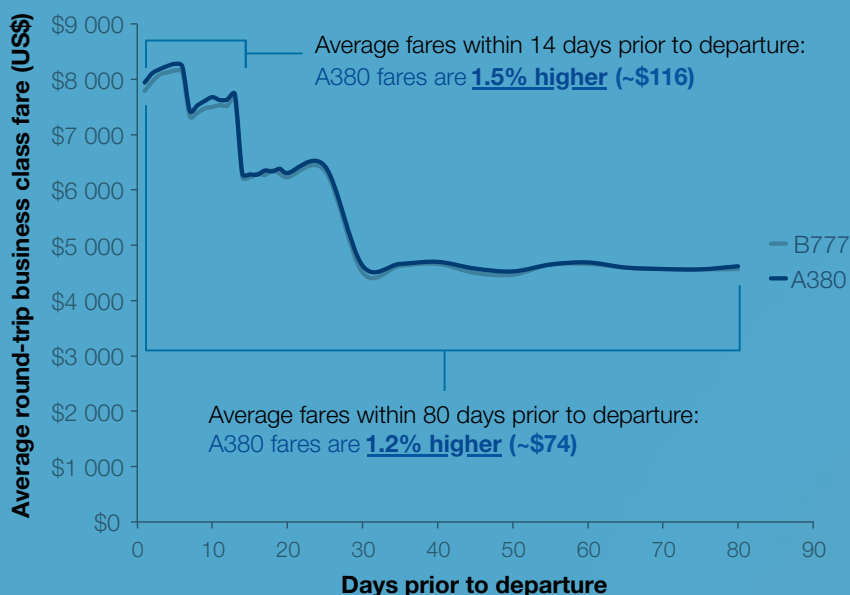
In the case of Air France’s JFK-CDG wingtip departures, average business class fares on the A380 were \$74 higher than those on the corresponding B777 flight, while average A380 economy class tickets cost \$25 more than those on the similarly-timed B777 flight.

The study demonstrates that A380 passengers have been choosing aircraft type ahead of cost, and are already willing to pay a premium to travel aboard the A380.



Business class fare comparison A380 vs B777

JFK to CDG



Future opportunities for the A380

So what is the next step in the way operators fly the A380? The A380 is nearing its first decade of service and, as with all other aircraft programmes, some of the first A380s will move into the second-hand market. Exploring the A380's second-hand market potential reveals new opportunities such as the Hajj/Umrah pilgrimages.

An airline's challenge during the Hajj pilgrimage is to transport the largest possible number of pilgrims over the shortest period of time. They must also minimize the number of days (or weeks) pilgrims must wait in the country before and after the event until they can secure space to return home. No aircraft makes more economic sense than the largest one, the A380. However, how can an airline optimise use of the aircraft during the rest of the year?

The development of Umrah, a pilgrimage made outside of the Hajj period, could be the answer. Umrah traffic is already 4 times the size of Hajj overall. Today, this market is predominantly served by ageing B747s which must be replaced over the next few years. Not only does the A380 offer the right capacity, but it also has a 20-30% reduction in cost per seat vs the B747.



CONCLUSION

How the A380 market will develop in the future can be seen by looking at long-term worldwide traffic forecasts which show a doubling of passenger traffic every 15 years. Furthermore, the proportion of global traffic which will pass through megacities (cities with over 10,000 daily long-haul passengers) will increase from 90% today to 93% by 2024. As a result, the pressure on big hub airports, many of which are congested today, will only increase. Airport upgrades needed to absorb traffic growth, can take many years and may meet objections from local communities. Large aircraft such as the A380 offer an immediate solution to airlines, airports and travellers alike. ■■■

A380

The solution for airlines and airports

The A380's unique high capacity can bring value not only to airlines, but also to airports by helping to solve airport congestion.

Most megacity airports are congested, with slots being a nearly priceless resource. Limited slots mean airlines are unable to accommodate passenger demand at peak times. The A380 is ideally suited to high-volume trunk routes between expanding megacities.

New definitions for wake vortex separations enable the A380 to easily integrate traffic whilst offering greater capacity.

The A380 has proven that it can be integrated into airport operations, showing strong advantages against other very large aircraft. Today, 230 airports can welcome the A380, and this trend is increasing.



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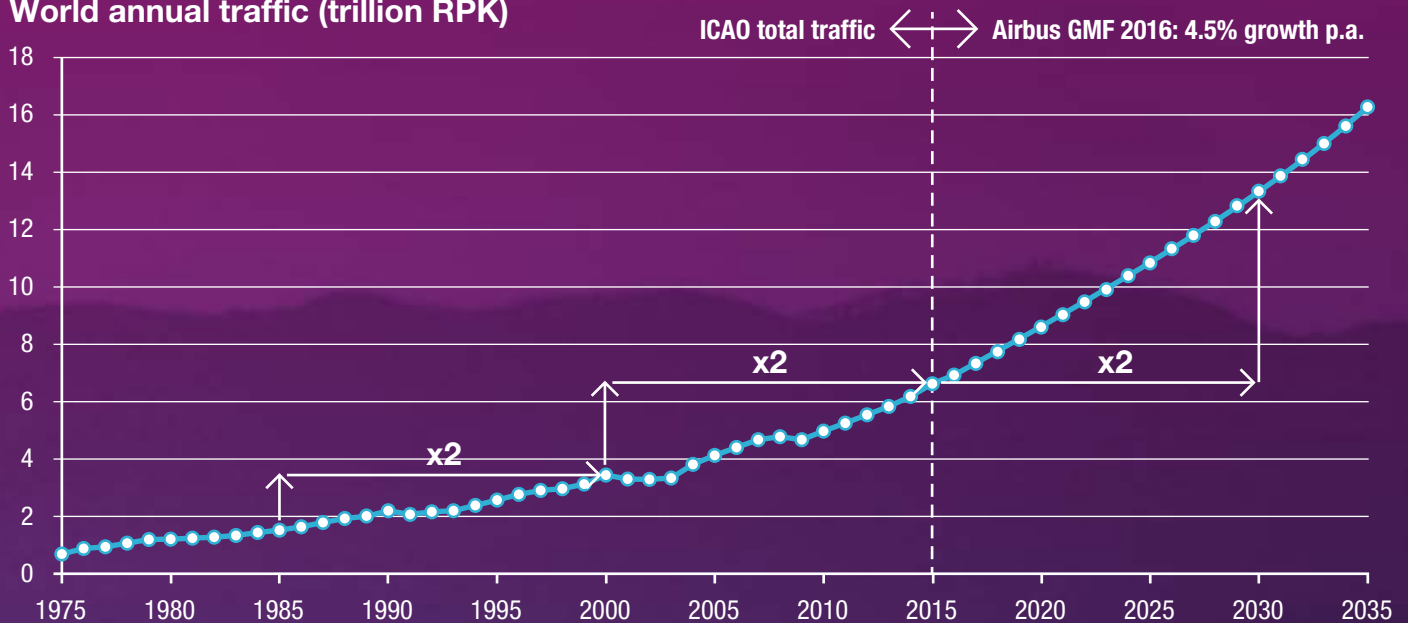
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Airport congestion

More demand, more traffic

Passenger air traffic has doubled every 15 years since the early 1980's. Although the world endured various crises, with difficult periods for the air transport industry, the long-term growth trend was quickly re-established. Today, solid growth drivers for the industry are in place with, at the forefront, the economic dynamism of emerging countries. Demand is set to continue and is even expected to double again in the next 15 years. The Airbus 20-year forecast shows an expected average annual growth rate of 4.5%.

World annual traffic (trillion RPK)



RPK Revenue Passenger-Kilometre
GMF Global Market Forecast

More traffic, bigger megacities

In 2014, another five urban centres became aviation megacities, meaning hubs with more than 10,000 daily long-haul passengers. The largest is currently London, with 120,000 – the only city today handling more than 100,000 daily long-haul passengers. In 2014, there were on average 10,000 landings per month per runway at London Heathrow. Dubai, the main hub of the Middle East, is second largest with 98,000 passengers. However, 20 years from now, all of the 10 largest aviation megacities will have daily traffic of over 100,000 daily long-haul passengers. Together, these 10 cities will transport 1.5 million long-haul passengers each day.

Bigger megacities, bigger aircraft

To support the increase in demand, airlines around the world have responded by developing their networks. Service has been extended to new airport pairs, and more airlines have started flying on existing routes. In parallel to the development of air services, airlines are increasingly using larger aircraft. Over the past ten years, the number of seats per flight has grown by 20% the highest ten-year increase since the 1970's. The trend towards larger aircraft is a result of airline efforts to become more productive through the transportation of passengers at a lower cost per seat, but also a result of airport congestion. Increasingly, airports reach their limits in terms of slot capacity, consequently affecting air traffic management. At these airports, an increase in traffic is only possible by using larger aircraft in the short to medium term.

Hub-and-spoke* concerned by congestion

With the deregulation of the air transport sector, carriers have become free to make strategic choices on fares and network structures, which has led to a concentration of traffic on the spoke routes. The success of hub-and-spoke structures in the years following the deregulation is explained partly by the savings from operating fewer routes and partly by the economies of scale from using larger aircraft to absorb traffic density. However, this concentration of traffic from hub-and-spoke networks has contributed to greater airport congestion. In congested hubs, a high proportion of flights are affected by delays, cancellations and missed connections that end up affecting both air travellers and airlines. Congestion is therefore a major concern and a relevant policy issue.

***Hub-and-spoke:** Aircraft deployment method in which a carrier designates one or more strategically located cities as hubs to which its larger aircraft bring most of its passengers and cargo through many scheduled flights. The passengers and cargo are then taken to their respective destinations by smaller aircraft belonging to the same carrier or smaller (commuter or feeder) airlines under a code-sharing arrangement.

80% of megacities are congested

Congestion occurs when airports cannot fully cope with demand. IATA (International Air Transport Association) has been at the forefront of ensuring a fair, neutral and transparent allocation of airport slots at the world's most congested airports through the application of the Worldwide Slot Guidelines (WSG). Over 170 airports are formally designated as Level 3 (most congested, requiring slots), and this number is expected to grow significantly due to a lack of investment in airport infrastructure to cope with increasing demand.



New airport infrastructures not the fastest and easiest solution

Airport infrastructure projects are not easy to implement. They take time, involve many stakeholders and are frequently delayed. Sometimes, even if infrastructure projects are achieved, they are not always the solution. If there is congestion on the ground, the same applies to the sky. Additional runways do not always solve the airspace congestion, as shown in Guangzhou, China, where despite a new third runway, slots remain limited due to airspace congestion.

In these types of cases, solving congestion becomes much more complex for the airports and airlines.

Secondary airports not covering overflow

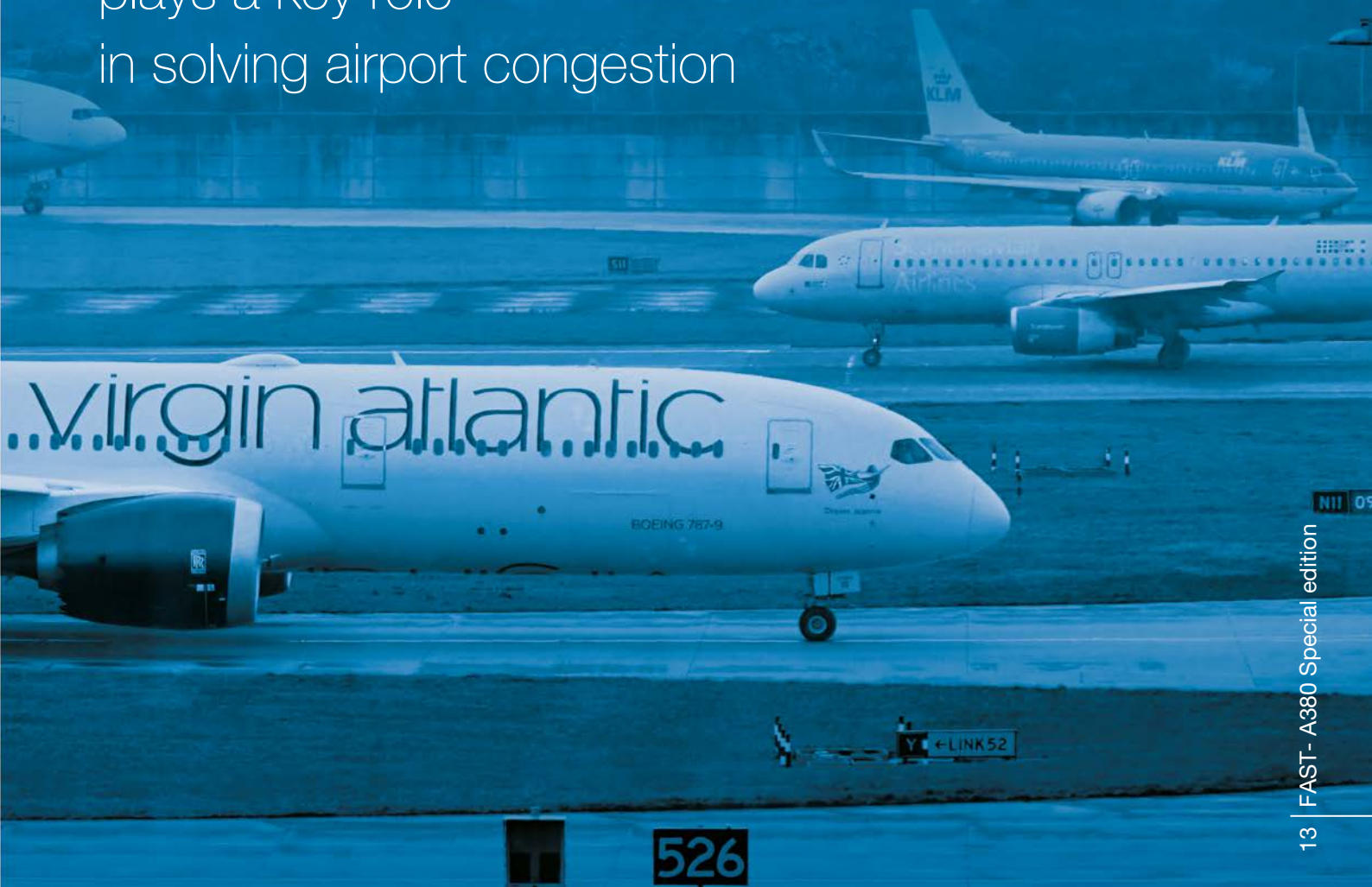
When an airport is constrained, nearby airports do not always capture the entire passenger overflow. Airlines can lose revenue by putting seat capacity at lowest yield at secondary airports, and miss network and hub efficiency. The number of passengers travelling through London Heathrow has grown at less than 1% on average per year since 2000; during this same period, London's other airports have grown at nearly twice that rate. However GDP* indicates that Heathrow should have handled nearly 15 million more passengers than it did in 2013. It would be logical to assume those passengers, squeezed out of Heathrow, would have simply turned to nearby airports. But London's other airports captured only about half of this overflow.

*GDP Gross Domestic Product (strongly correlated to air traffic growth)

A380: capacity to cope with airport congestion

Due to its size and capacity, the A380 is the most efficient way to capture traffic at the most concentrated places and times, maximising revenue for airlines by seizing the strong passenger flow at the highest yield times. The A380 increases capacity on trunk routes, boosts connecting traffic and strengthens hub position. By consolidating routes with the A380, airlines increase seat capacity while creating economies of scale, as well as freeing up airport slots, or using current slots and adding more passengers.

The A380's high capacity
plays a key role
in solving airport congestion



Relieving congestion and freeing up slots

HKG

Hong Kong International Airport is Asia's busiest. A plane lands or takes off every minute; but the airport is built on re-claimed land so expanding isn't simple. The way forward for the local authorities is persuading airlines to bring more passengers in and out on bigger aircraft like the A380.

Eight airlines already fly A380s into Hong Kong; and last year a milestone was reached there with the 5000th flight. The airport had nearly 70 million passengers in 2015 and is keen for that to rise. Fred LAM says many passengers, especially the Chinese, choose this airport because of the A380 option. So he has a winning argument to entice airlines to switch increasingly to bigger aircraft - it will help them save money.



Our two runway situation at the moment can accommodate about 1100 aircraft movements per day. We are almost reaching that size capacity, so we are in the process of building a new runway. But a third runway will not be available for at least another 8 years, so in the meantime we are doing what we can to encourage airlines to switch to bigger aircraft, which will hopefully bring us more passengers to the airport.



Fred LAM
Chief Executive, Hong Kong International Airport



These quotes are extracts from video interviews with airport chief executives, available on the app version of FAST magazine



by airport chief executives

LHR

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London Heathrow Airport is also the biggest on its continent with 75 million passengers and a take-off or landing every 45 seconds, also on just two runways. Again the solution is bigger planes.

Heathrow is one of the great airports of the world and we are also full. When you are at capacity you need to have the largest airplanes operating from your airport to be able to serve more passengers and that is what the A380 does. It's the largest plane in the world, it helps us serve more passengers on very busy routes out of Heathrow and it also frees up slots to serve new routes in North America, South America and Asia that we wouldn't otherwise be able to serve.

...

Over the last 30 years the number of people impacted by aircraft noise at Heathrow has pretty much halved. That's because of new technology such as the A380 and it means we can expand Heathrow and still have fewer people impacted by aircraft noise because of aircraft like the A380. That is why we incite airlines to bring their quietest and cleanest airplanes like the A380 here to Heathrow.

...

We have re-built Heathrow in the last ten years. We have invested £11 billion to create this world class airport but of course we have to be able to pay for that and the more passengers we have coming through, the more affordable we can make it. There is a virtuous circle there - we are actually reducing our landing fees because we are getting more passengers coming through and the A380 has been key to that in helping us to have more passengers for every landing and take-off that we have.

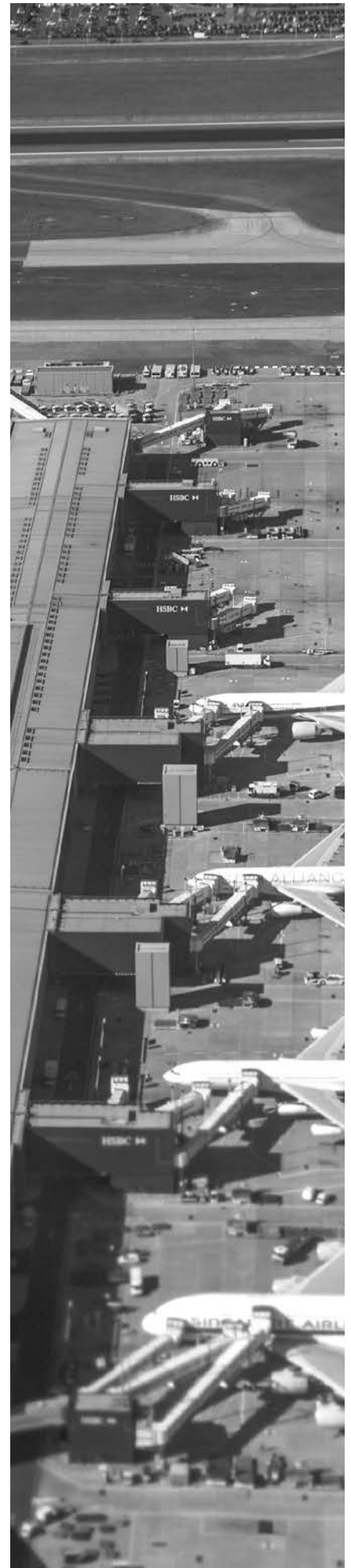


John HOLLAND-KAYE
Chief Executive, Heathrow Airport

”

Both Heathrow and Hong Kong point out that with extra passenger numbers, their retail and restaurant outlets emerge winners too. So keen are the two airports to have A380 traffic, that they have reduced landing fees for those planes.

These quotes are extracts from video interviews with airport chief executives, available on the app version of FAST magazine



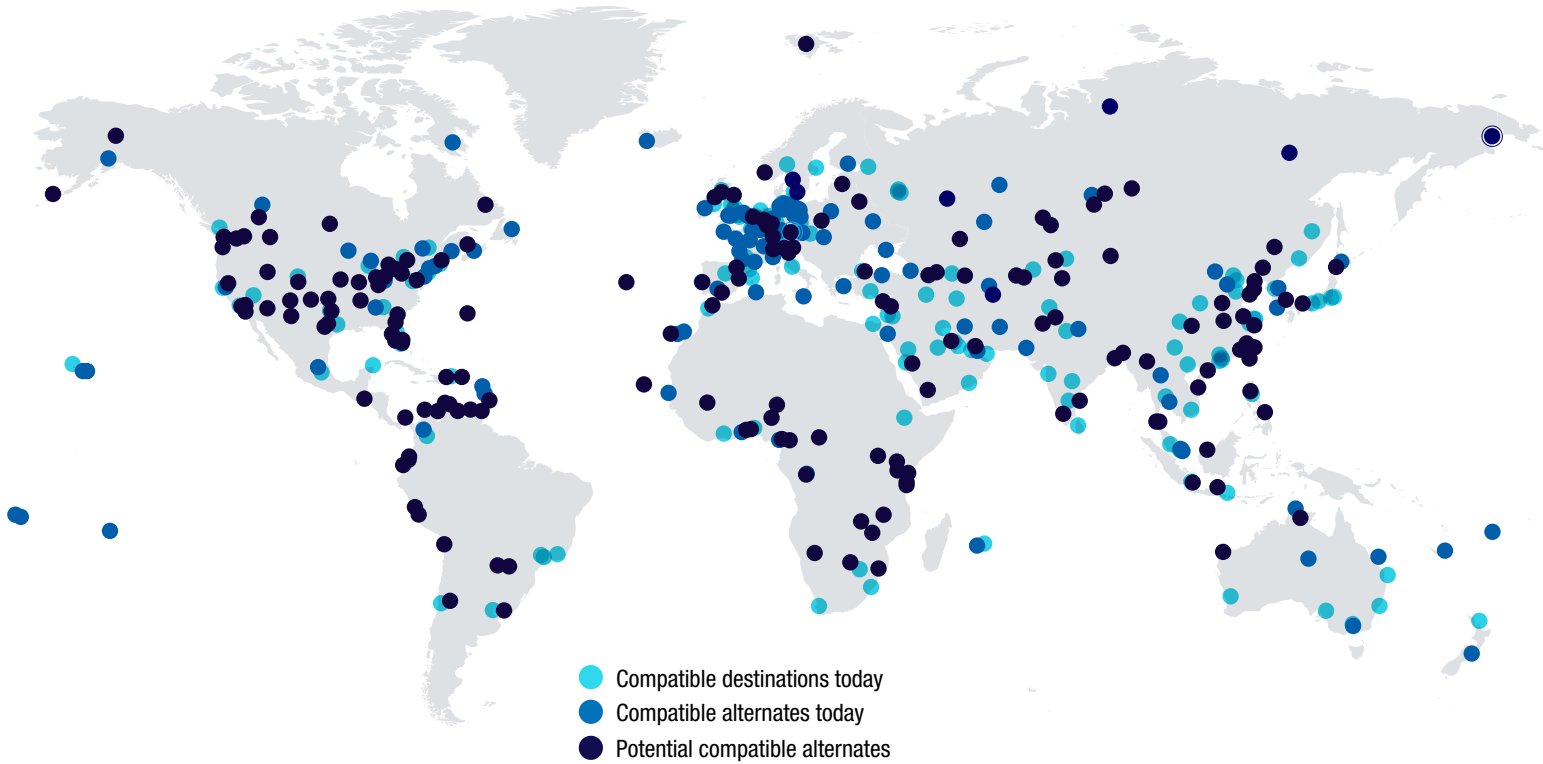
Airport compatibility

The A380 is a very special aircraft, with true benefits for airports and airlines alike. Since the early days of A380 development, Airbus has been working closely with airports to expand the network of compatible airports.

A growing network of A380-compatible airports

230 compatible airports today (destinations + alternates)

400 potential compatible airports



Working together

The ‘working together’ concept is a collaborative approach generally applied to the concept phase of a new aircraft whereby airlines are invited to get involved all along the key milestones of the development programme.

Airbus applied a similar concept with the airports for the A380. Airports took part in the design by providing their specific requirements, which enabled them to anticipate future adaptations. Regulators were included in the early stages, as local rule-making drives airport modifications.

In parallel, the International Industry Working Group (IIWG), a specific group first created for the Entry-Into-Service (EIS) of the B747 in 1970, unites key industry stakeholders including airlines, airports, regulators, manufacturers and service providers. This group enables free flow of information between members, as well as a close relationship between aviation bodies such as the International Coordinating Council of Aerospace Industries Associations (ICCAIA), the International Air Transport Association (IATA) and the Airports Council International (ACI).

In the first half of 2016, the A380 was approved for commercial operations at:

MEX (Mexico)

GIG (Rio de Janeiro)

GRU (Sao Paulo)

BHX (Birmingham)

TPE (Taipei)

VIE (Vienna)

ORD (Chicago)

BOS (Boston)

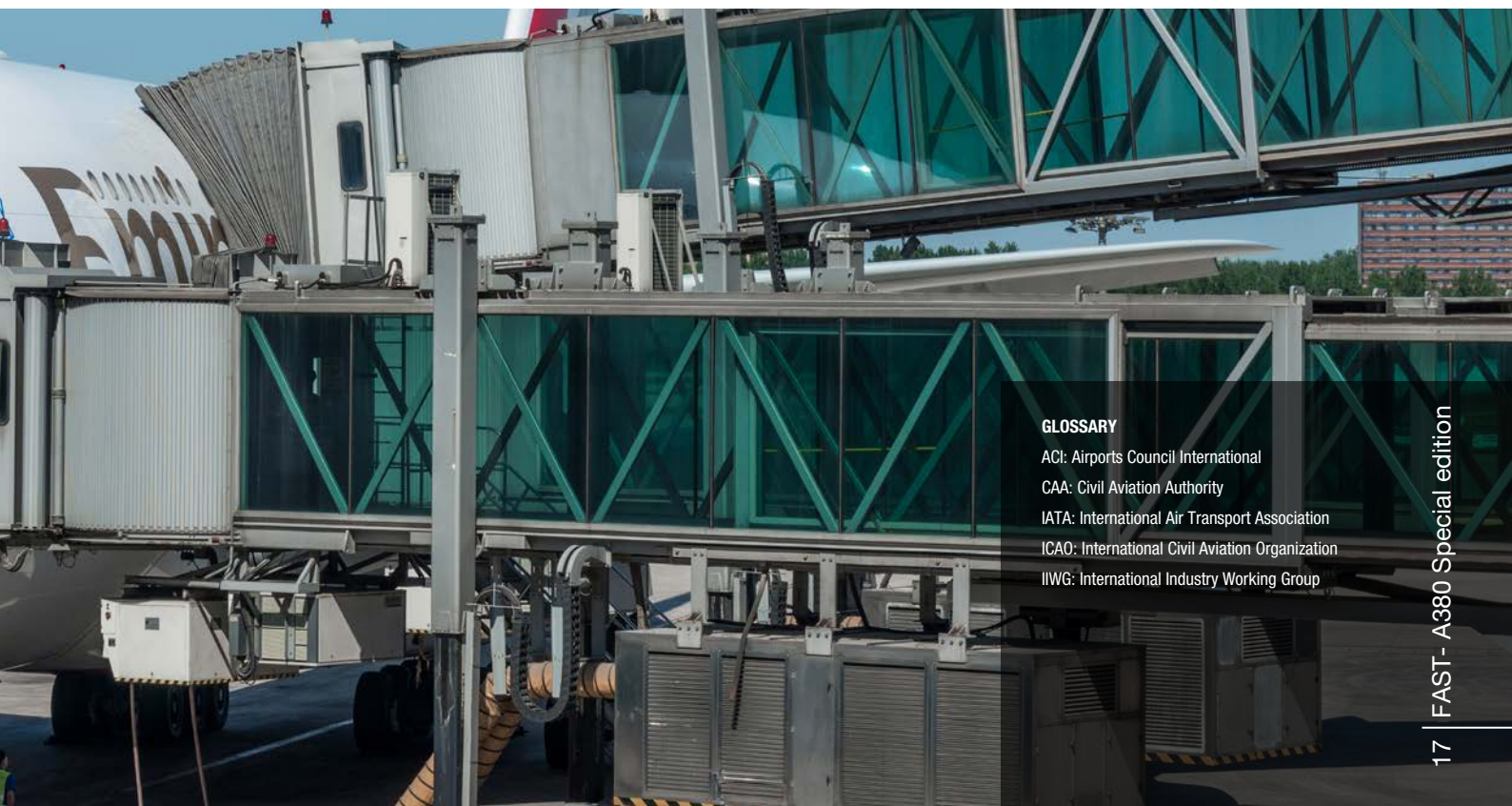


Latest approved airports

Another crucial criterion for airport compatibility is timeframe. Compatibility mitigation can solve any issues that may appear in only a few months through operational measures, short term investments, etc. For longer-term planned operations or significant traffic increase forecast, early dialogue with airports is the most efficient way to prepare the compatibility through master planning. Organisations (ACI, IATA, IIWG...) allow a sound and mutually beneficial dialogue with world airports.

It is important to identify the airport’s type of operation, as the requirements will be different if the airport is the destination, the primary alternate, the diversion, the en-route or the emergency airport.

Preparing an airport for the A380 can be quite simple, with a short lead time. BHX (Birmingham) built an operational plan approved by the CAA UK, identified an A380 gate and upgraded it with a third Passenger Boarding Bridge (PBB) in less than a year. It also bought already-used equipment from LHR (London Heathrow), which was key in reducing the lead time.



GLOSSARY

ACI: Airports Council International

CAA: Civil Aviation Authority

IATA: International Air Transport Association

ICAO: International Civil Aviation Organization

IIWG: International Industry Working Group

Smooth integration into airport operations

For an airport to become A380 compatible, a number of regulations must be taken into account. The International Civil Aviation Organization (ICAO) is the global aviation rule-maker.

When studying an airport's compatibility, these main areas are covered: airside, pavement, Turnaround Time (TAT) and Ground Support Equipment (GSE).

Airside

The airside refers to the area of the airport where the aircraft is in movement. Different points are checked:

- Runway and taxiway compatibility is interfacing with the aircraft which includes performance on a given runway length
- Main landing gear width vs runway or taxiway widths
- Engine position vs runway or taxiway shoulder widths
- Wing span vs runway or taxiway separations
- Landing gear span and base vs runway turn pads and taxiway turns

Pavement (weight & landing gear)

The airport pavement loading characterisation is driven by the well-established ICAO ACN/PCN* method, which will be updated by 2020. The new method will be based on the Cumulative Damage Factor concept and Equivalent Single Wheel Loading, supported with significant testing achieved in the USA (National Airport Pavement Test Programme) and in France (A380 Pavement Experimental Programme), since the 1990's.

Due to its main landing gear layout, the A380 is unique in terms of cumulative pavement loading. Body gear stresses are cumulated with single-aisle aircraft main gear tracks and wing gear stresses are further outboard of widebody main gear tracks.

A380 ACN values on flexible and rigid pavements are comparable to those of smaller widebodies despite the A380's higher Maximum Take Off Weight. They are also below ACN values of the B777-300ER, which is the pavement sizing aircraft.

*ACN Aircraft Classification Number
PCN Pavement Classification Number

Turnaround Time & Ground Support Equipment (Aircraft cabin & door distribution)

The aircraft performance on ground (time and costs) is dependent on the aircraft's size, door and service panel distribution, cabin layout, GSE availability and local specifics. The A380 is capable of a Turnaround Time of less than 90 minutes, as the cabin configuration and GSE staging and sequencing (catering vehicles and passenger boarding bridges in particular) allows for optimum ground handling and servicing. It is the only aircraft where the two cabin levels can be treated separately.



ROPS

Runway Overrun Prevention System (ROPS) is a safety feature which alerts the pilots to the risk of runway overrun, and if necessary, provides active protection. ROPS, an innovation introduced with the A380, continuously monitors an aircraft's position and calculates the distance needed to safely stop on the runway in dry and wet conditions. If the determined stopping distance is longer than the available runway length, ROPS triggers visual and oral alerts.

BTV

Brake to Vacate (BTV) has been designed to optimise braking efficiency and runway turn-around time, thereby improving traffic flow and congestion. BTV technology allows pilots to select the appropriate runway exit during the approach to landing. It also regulates the aircraft's deceleration after touchdown, enabling it to reach any chosen exit at the correct speed under the optimum conditions, regardless of the weather and visibility.

Aircraft parameters to consider for airport compatibility:

- Aircraft span vs runway and taxiway separations
- Aircraft length vs runway turn pads and taxiway turns and stand lengths
- Tail height vs hangars and Obstacle Limitation Surfaces (OLS)
- Aircraft Classification Number (ACN) vs Pavement Classification Number (PCN)
- Available Ground Support Equipment vs aircraft servicing requirements (electricity, air, water fuel, passenger and cargo handling, towing...)
- Rescue and Fire Fighting (RFF) capability
- Shortage of contact stands vs remote stands
- Local environmental pressure vs aircraft noise and emission performance

Excellent noise performance

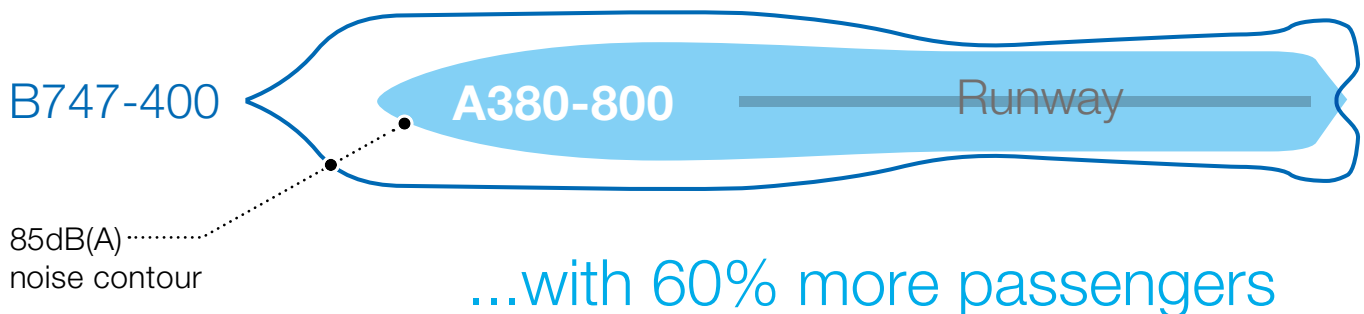
Noise performance is an important factor for airports which need to take into consideration local populations. Airports and their neighbours have welcomed the outstanding low noise performance of the A380.

The high-lift system, helped by very large wingspan and state-of-the-art engines, allows the A380 to quickly gain altitude thereby reducing perceived noise at ground level. The A380 was the first aircraft to be certified at a Maximum Take-Off Weight (MTOW) of more than 400 tonnes with a cumulative noise level of 27 EPNdB* below ICAO Chapter 3.

The Noise Abatement Departure Procedure (NADP) enables the reduction of flyover noise over sensitive areas. The diagram below illustrates the noise footprint of the A380-800 as recorded by local noise abatement associations during the first A380 demo flight, compared to the B747-400.

*EPNdB: Effective Perceived Noise level in decibels

A380: half the noise...



Optimising wake vortex separations at airports

ICAO separations

The A380 stands in its own category in ICAO recommendations for wake vortex separations. It is important for airports to be aware that, despite the A380's size, the wake vortex separation is no more than 1 NM additional separation distance compared to other widebodies. Often the perception is that the A380 is adding 2 NM of separation distance compared to other widebodies.

However, this is only looking at the separation to a follower of the A380; in actual fact there is a positive effect of the A380 on separations to aircraft flying in front of it. In the ICAO separations standard set in 2008, the A380 is put in a new 'Super Heavy' category which imposes an extra 2 NM separation to any follower compared to if the A380 had remained in the 'Heavy' category (B767, B777-300ER or B747-8).

As the A380's traffic share increases, some airports feel that their capacity (in terms of passengers and/or aircraft movements) is penalised. However, this perception can be counterbalanced by two facts as illustrated below:

- **The A380 can fly +1 NM closer to any 'Heavy' category aircraft flying ahead.**

This means that the overall string length of 2 'Heavy' aircraft with an A380 in the middle is only +1 NM longer than a string of three 'Heavy' aircraft. This is illustrated in the ICAO table to the right.

- **The A380 has a higher capacity than other aircraft.**

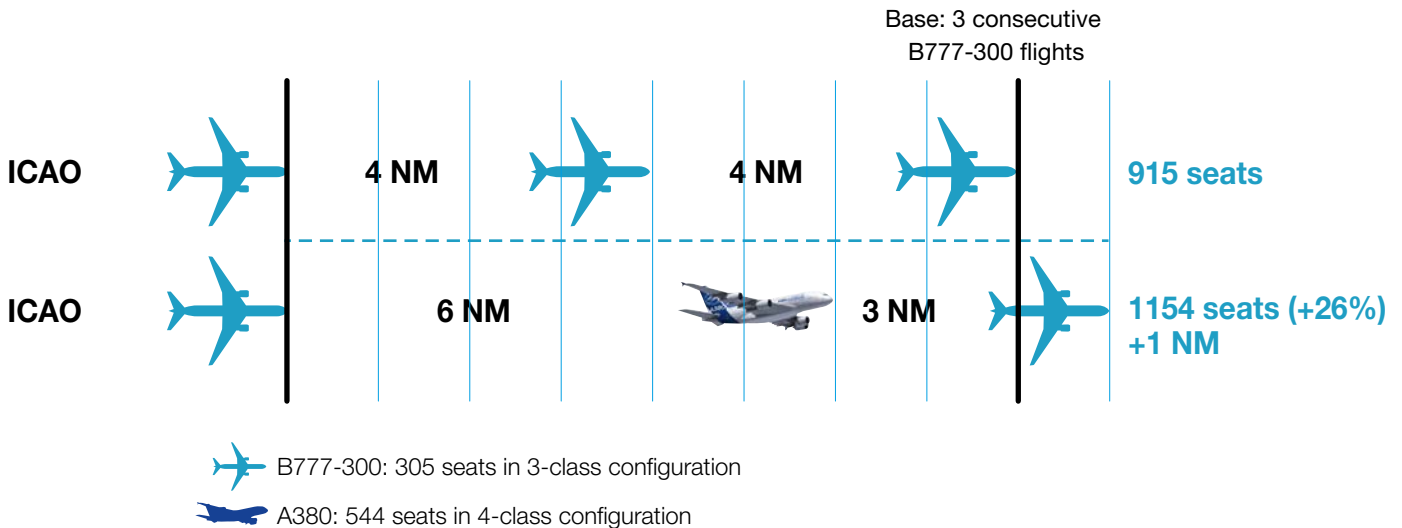
It offers over 70% more seats than a B777-300ER. In a sequence of three B777-300ERs, for example, the middle one could be replaced by an A380. While the overall string separation distance would only increase by 1 NM, the overall capacity of the string would increase by 26%.

The four ICAO categories and the wake vortex separations

Follower > Leader ∇	A380-800	Heavy	Medium	Light
A380-800		6 NM	7 NM	8 NM
Heavy MTOM ≥ 136 tonnes		4 NM	5 NM	6 NM
Medium MTOM <136 tonnes ≥ 7 tonnes				5 NM
Light MTOM < 7 tonnes				

An empty cell means 'Minimum Radar Separation' which can be as little as 3 NM.

MTOM: Maximum Take-Off Mass
NM: Nautical Miles



London Heathrow Airport, while following the ICAO separation rules, declared to Bloomberg on 13 January 2014 that, 'the airport added 2.4 million passengers in 2013 as airlines eked out seats by operating bigger planes including the Airbus A380'.

RECAT-EU* separations

While most airports follow ICAO recommendations published in 2008, other separation standards have since been approved by regional airworthiness authorities which offer reduced separations. In 2014, EASA certified the RECAT-EU standard which is more advantageous for the A380 as well as other aircraft types. Airlines are encouraged to promote this concept to airports and to their national authorities. The EASA-approved Eurocontrol safety case can be used to approve RECAT-EU locally in any country.

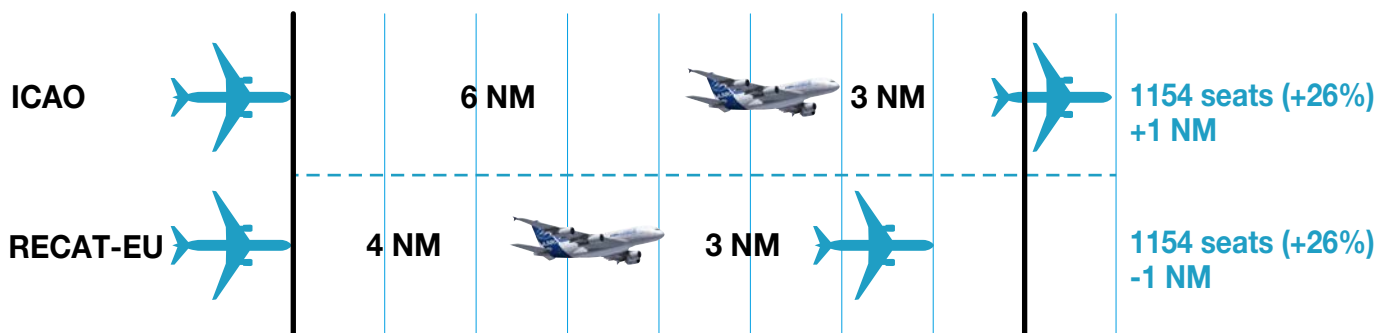
Eurocontrol obtained RECAT-EU certification after additional wake vortex in-flight measurements helped demonstrate that the A380 could reduce its wake vortex separations. With its 6 aircraft categories, RECAT-EU offers a more optimum set of separation rules compared to the 4 ICAO categories. For example, an aircraft in the RECAT-EU 'Upper Heavy' category such as the B777-300ER or B747-8 will be able to get as much as 2 NM closer to the A380 compared to the ICAO rules. When an A380 is put in between two B777-300ERs, the overall string length is actually 1 NM shorter than three B777-300ERs behind one another in the ICAO rules, while still offering 26% more seats. This is illustrated below.

Another illustration of a RECAT-EU benefit is the A380's seamless integration into A320/B737 traffic which offers 38% more capacity to the overall string of aircraft. Many airports are converting or are considering converting to the RECAT-EU separation standards. Paris Charles De Gaulle implemented RECAT-EU at the end of 2015. London Heathrow has started working on implementing RECAT-EU separation rules for the A380 in its 'Time Based Separation'. Other airports interested in evaluating RECAT-EU implementation include Dubai, Frankfurt, Sydney and Singapore.

*RECAT-EU: re-categorisation by Eurocontrol of ICAO wake turbulence longitudinal separation minima on approach and departure

The future at ICAO level

ICAO recommendations are expected to be revised, taking into account any reduced separations which have been certified since 2008 such as RECAT-EU and RECAT-US which both offer reduced separations. Common values need to be identified, in particular for the A380. It is in the interest of all stakeholders, airlines, airports and civil aviation authorities that ICAO recommendations allow for more capacity at airports in the future.



RECAT-EU allows A380 insertion with shorter separation by 1 NM while bringing 26% more seats

CONCLUSION

Air traffic is growing every year and becoming more and more concentrated at megacities, 80% of which are already congested today. Airport congestion and slot limitations are a global constraint recognised by all in the industry, and with its bigger capacity, the A380 is clearly part of the solution.

With over 300 flights per day and 3 million passengers per month, the A380 has become a fixture at airports around the world. Specially designed to capture the growing passenger market and to be easily integrated in the airport operation process, the A380 is continuously opening new airport doors, and expanding its network. More than 110 routes are operating everyday with the A380, with a regular network expansion all year long. This is the result of the 'working together' concept with airports and taking into account regulations and aircraft parameters. Adopting reduced separation standards such as RECAT-EU is key in further improving A380 capacity benefits to airports in the future.

Today an A380 takes off or lands every 3 minutes, helping with airport capacity limitation, supporting airlines to maximize their hub efficiency and revenue, and offering passengers the best comfort in the sky. ■■■

Pilots at the controls of the **A380**

Article by
Jean-Michel ROY
Test Pilot
AIRBUS



The A380 is seen by pilots around the globe as *the* airliner, creating envy anytime they see one taxiing ahead.

FAST magazine opens the A380's cockpit door to find out what the pilots actually think of this aircraft.

A chance to discover how innovation and commonality with the existing Airbus fly-by-wire family are the pillars of its design.

Fly (F)

F1: The side sticks deliver the pilot commands to the Flight Control Computers, part of the Fly-By-Wire (FBW) architecture, in manual flight. In line with flight control laws, surfaces respond to the pilots' commands.

F2: The flap lever controls the aircraft configuration for take-off and landing.

F3: The pitch trim control switch. The A380, like all other FBW aircraft, is a stable platform. In normal law, an automatic trim function reduces pilot workload during speed and configuration changes. On the A380, pitch trim is fully electrical including back-up (no more mechanical trim wheels). At engine start, the trim is automatically set according to where the aircraft's centre of gravity is located.

F4: The Primary Flight Display (PFD) monitors the aircraft's attitude (pitch and roll) as well as air data (altitude and airspeed) and flight mode annunciator (displays automation mode information). On the A380's screens, which are larger compared to older aircraft, the aircraft configuration indicator (slats/flaps/landing gear) is also displayed.

F5: The engine thrust levers control thrust on all four engines. As on all FBW aircraft, they are normally set in a notch defining the maximum thrust available and the autothrust will regulate according to the flight phase (climb thrust in climb, speed control in cruise, idle in descent). If the pilot wishes, they can take the levers out of the notch and fly the thrust manually. On landing, two reversers are available on the inner engines.

F6: The Auto Flight System control panel allows the crew to provide short-term commands to the Auto Flight System (Flight Director, Autopilot, Autothrust) like heading change, altitude change or speed change.

Navigate (N)

N1: The Navigation Display (ND) is the extra large screen that not only displays the aircraft's position on a map, but also displays its altitude, improving pilots' situational awareness relative to terrain and weather. On the ground, it is possible to display aircraft position on the airport map, increasing pilot situational awareness at big airports especially in poor weather conditions.

N2: The Flight Management System (FMS) used for overall flight strategy is now controlled on a large screen, identical to the PFD and ND, allowing increased readability as well as improved reconfiguration capability. Pilots may interact with the FMS (along with the ND and mailbox) via a keyboard and track ball.

N3: Brake to Vacate (BTV) is a new auto-brake function allowing runway occupancy time to be optimised while reducing brake wear and improving passenger comfort. This function is associated with runway overrun protections, offering enhanced safety and efficiency for landing (see ROPS article FAST #55).





Communicate (C)

C1: The integrated radio management panel allows easier management of voice communications.

C2: The mailbox allows interactive management of the datalink between the aircraft and the ground Air Traffic Control.

Manage systems (S)

S1: The overhead panel brings together the aircraft system control panels for air conditioning, electrical, fuel and hydraulic systems, for example. The dark cockpit environment allows easy checking that the aircraft is ready to fly (no white lights).

S2: The warning display shows the different checklists, both in normal operation and in abnormal or emergency situations.

S3: The system display offers schematic views of systems relevant to the current flight phase. For example, in normal operation, it displays the door page at the gate, the engine page during engine start and the wheel page during taxiing. In the event of a system failure, it presents the relevant page. Cameras relay real-time video of parts of the aircraft (e.g. cockpit door).

Manage mission (M)

M1: The Onboard Information System (OIS) eases access to operational information, reducing pilot workload and the quantity of paper in the cockpit. It replaces paper documents with electronic ones, quickening information searches and updates to the operations manuals, navigation charts, performance computations for take-off, en route and landing, etc.



A380 versatility

by Abbas SHABAN

Captain with Emirates



The A380 is a versatile aircraft which provides Emirates with an opportunity to deliver a unique customer experience. The aircraft's real estate allows us to offer features such as our onboard spa and lounge which tend to be very well received by our customers and are also key revenue drivers.

The Emirates A380s provide a strong revenue potential on trunk routes with strong demand for premium classes and the large economy cabin in the aircraft helps lower commercial risk by covering operational and fixed costs.

One of the other important factors about the A380 that improves the overall customer experience is the reduced noise levels inside the cabin when compared to other widebody aircraft.

Despite being a large aircraft, the A380 has outstanding performance capabilities requiring a shorter runway length for take-off and landing compared to other widebody aircraft. It can take off with an overall weight of 575,000 kg and at temperatures up to 45°C. This gives us the flexibility to schedule A380 departures at any time of the day including baking afternoon missions in peak summer! The A380 is also very importantly one of the most environmentally-friendly aircraft with excellent noise and emission characteristics.

Accomplishing business targets

In terms of customer engagement the A380 helps Emirates offer a superior product that works like a crowd-puller.

Operationally, the large widebody capacity offered by the A380 is a critical part of Emirates' strategy to optimise operations to congested airports. The A380's payload range means that it is capable of the longest hauls on the Emirates network. For example, Emirates will soon be operating non-stop flights from Dubai to Auckland - a flight time of almost 18 hours!

Adaptability to different route types

The versatility of the A380 allows Emirates to operate different combinations of payload and range to meet the diverse route requirements on the Emirates network. For example, Emirates uses the A380 on short flights from Dubai to Jeddah, Kuwait, on medium-range flights to various destinations in Europe and on ultra long range flights to destinations in the USA, Australasia and so on. Emirates' strategy primarily revolves around using the A380 for trunk demand on mature routes which could be short, medium or long-haul and it works best in our network when trunk routes feed other trunk routes.

However, there are certain factors especially related to airport infrastructure that make the deployment of the A380 on certain routes fairly difficult. These include the limited number of new airports that are compatible to operating an A380 and the challenges around development of airport compatibility for secondary airports.



A380 technologies

by Jacques VERRIERE

Captain with Air France



Air France's pilots were already familiar with technologies such as Flight Management System (FMS) and fly-by-wire, but in the A380 cockpit, we found improved human-machine interfaces (FMS is one example) as well as several new technologies. The most visible feature in our cockpits is the dual Head-Up Display (HUD) installation. Some other technologies are less visible but still important for safety. For the first time, we flew an aircraft equipped with Brake To Vacate (BTV) and Runway Overrun Prevention System (ROPS), as well as auto TCAS (Traffic Collision Avoidance System). The A380 entry-into-service was also an opportunity to switch from paper manuals to electronic FCOM (Flight Crew Operating Manual), MEL (Minimum Equipment List), and to get rid of some older technologies such as ADF (Automatic Direction Finder) despite some regulatory hurdles that we had to overcome. As pilots, we consider the A380 is the first aircraft of the 21st century.

HUD rationale

Since the 1970's, HUD installation on civil aircraft had been the subject of heated debate among airline pilots: some considered HUD as the ultimate tool, others considered it as useless. When Airbus offered single or dual HUD as an option on A380s, we took this opportunity to assess its advantages. For an aircraft such as the A380, as well as all other Airbus aircraft, HUD does not improve the operational capabilities in terms of minima, so the only factor to consider was safety. We examined the causes of a string of several approach and landing incidents and accidents and found that a large percentage were caused by destabilization in short final (wind shears, wind shifts in direction) sometimes associated with poor visibility. We considered that one of the advantages of HUD is the enhanced detections of such destabilizing factors and its installation would improve safety.

Two-HUD advantage

Air Alaska introduced HUDs on its B727 fleet after a season marked by many flight cancellations at its Seattle base due to foggy weather. At this time, it was the only practical way to improve minima on aircraft using older technology. Several earlier generation civil aircraft, as well as some business and regional jets, are equipped with HUDs to allow CAT3B operations with autoflight systems that are not certified as fail operative. In CAT3 operations, with specific task-sharing (captain flying head-up and first officer monitoring head-down), a single HUD in captain position, is a logical choice. Our goal was to use HUD for enhanced situation awareness in order to improve safety mainly in approach and landing. We now know that this task-sharing known as Pilot Monitoring (formerly Pilot Not Flying) is safest when both pilots have access to the same information via dual HUDs. Our position seemed to be quite isolated a decade ago (FEDEX was also a noticeable exception), but now we feel comforted by the fact that both main airplane manufacturers offer dual HUDs as the only option (or as basic configuration) on their newer aircraft.





Moving to an A380

by Alan CHAN

Divisional Vice President Training Singapore Airlines



Prior to the Entry-Into-Service (EIS) of the A380, SIA detached two senior instructor pilots for two years with Airbus to help define some of the human-machine interface and technical aspects of the flight deck. We gained much in the area of technical co-operation with the Airbus project team, which assisted us tremendously in our EIS.

Transitioning pilots to the A380

One of our considerations was whether there was a need for the initial pilots on the A380 to have Airbus fly-by-wire experience, as we had a mix from the B747-400, B777 and A340-500, with the majority from the B747-400. We concluded that there was no necessity.

Our B747-400 pilots had coped well with the technical complexity of the A380 flight deck, albeit with a little help in the way of technical briefings along the way. There were some issues initially with regard to negative operational transfers from the B747-400: undesired outcomes resulting from uncalled for fuel-balancing, misunderstanding of the lower severity level of hydraulic system failures compared to the B747-400, and lack of appreciation of the effects of normal and flare law during landing phase. These were quickly overcome with technical briefings conducted early into our EIS. Pilots from the A340-500 had their fair share of issues, albeit different from those encountered by the B747-400 pilots.

Operating the A380

A process to dispatch the aircraft with less redundancy than that approved by the MMEL was set up. It was not easy initially since it involved regulatory approvals, but close cooperation between SIA and Airbus in working with our local authorities ensured that we were able to minimise instances of AOG. There were other technical issues that necessitated long-term rectifications, some of which are still on-going. One of the more challenging aspects of the A380 is the availability of alternates that will permit an A380 to land and be dispatched, both en-route and destination alternates. Various restrictions in the airport manoeuvring area add to the complexity for pilots.



For example, in an airport in China, the only available runway for low visibility operations is not approved for A380 operations, and this results in delays and dispatch difficulties.

One of the beauties of the performance capability of the A380 is its ability to cruise at a higher initial altitude than the B747-400, even at maximum take-off weight. This has given us a tremendous advantage in securing an appropriate initial altitude on our long-haul flights from Singapore to Europe. The A380 also has the advantage of not being limited by routes over high terrain when compared to a twin.

Feeling the difference

Transition to the A380 from other Airbus families was relatively easy and seamless. It is certainly not difficult, nor can one say that it is easy to fly an A380. The A380 feels very much like the other fly-by-wire aircraft in the Airbus families, yet it is also quite different. It appears to be slower than the A330, but faster than the A340-500. Nevertheless, the A380 is a beauty to fly. I love its handling quality. It is gracious in flight and rides well in turbulent conditions. For all its size and slowness, it flies well and is a joy to manoeuvre. One is amazed at the approach speed, wondering if it is at all a big jet.

I had flown the A330 and A340-500. To me, the A330 is very responsive and sporty with a unique landing profile. The A340-500 is slower and not quite as sporty as its smaller sibling. My colleagues tell me the A350 handles well.

The A380 is like none of the above. It is the only one of its kind and now rules the skies.



M MEL: Master Minimum Equipment List
AOG: Aircraft On Ground

CONCLUSION

Versatility, innovation and commonality are key features that pilots appreciate about the A380.

Indeed, the A380 adapts to different route requirements in terms of payload and range, offers new or improved technologies which facilitate flying and contribute to safety and integrates the existing Airbus fly-by-wire family. ■



A380

Passenger experience

Passengers love the A380. Over 120 million passengers have already enjoyed the unique experience of flying aboard this aircraft.

What is new today is that passenger experience is becoming a criterion for choice. Passengers are increasingly informed about the details of their upcoming flight via the websites where they book. People are becoming more aware that passenger experience and comfort might differ from one aircraft type to another.

What was initially a simple characteristic of the A380 is turning into a major and distinct advantage over the competition.

Article by

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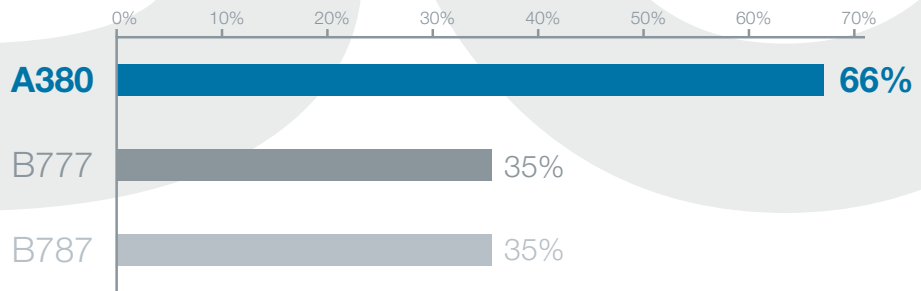


A unique flight

The A380 has become part of world aviation history. Passengers recognise the A380 with its unique shape and size. And they also recognise it when they fly it.

According to a recent survey by the independent agency Epinion, almost twice as many passengers (66%) recognise the aircraft type when they fly on an A380, compared to passengers flying on another aircraft.

Passengers recognising the aircraft type after the flight



The A380's differentiation is a real competitive advantage for an airline compared to other aircraft, as an enjoyable flight will not only be attributed to the A380 but also to the airline itself.

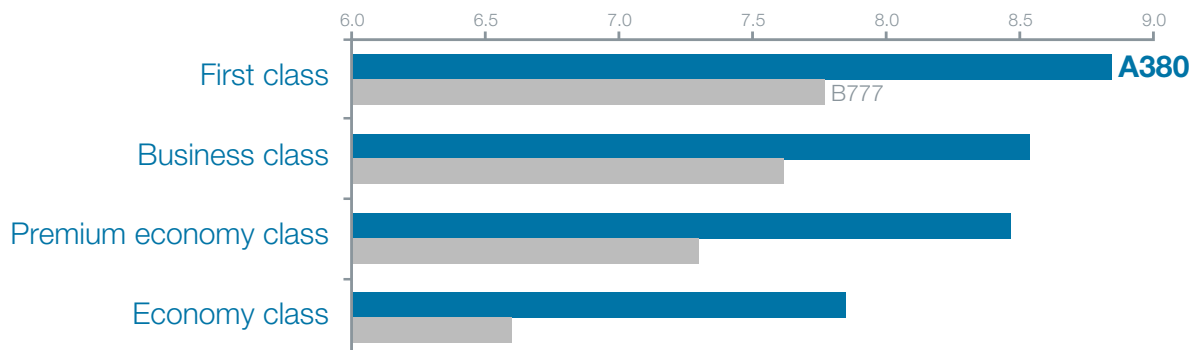
The A380 is highly popular among the general public. This is most visible on the web and social media where the A380 is the most mentioned aircraft. Being popular on the web is a key advantage for the A380 and its operators, given that 85% of passengers today book their flights online (source: Epinion).

High passenger satisfaction

Flying aboard the A380 is not only different, but is also very satisfying.

In the Epinion survey, passengers rated their experience on a scale from 1 to 10.

The result is quite clear: the A380 is rated better than any other aircraft type, in all classes, including economy. Results are similar even when comparing aircraft within the same airline or aircraft on the same routes.



This high satisfaction rate can be explained by the high-end experience offered by the A380, being more spacious, more comfortable and quieter than other aircraft; but also by the airlines' on-board offer. Airlines have understood this marketing potential and use the A380's image to market their own brand.



Advertising stimulates demand and there is a huge demand from passengers to fly on the A380. The Epinion survey identified that 60% of passengers who have already experienced the A380 are ready to make an extra effort to fly on an A380 for their next long-haul flight.

What does making an effort mean?

- 20% of the passengers said they are ready to pay a bit more – 100 USD on average - for a return trip on the A380
- The remaining 40% of passengers would take a less convenient flight: additional connection, less convenient time of the day, longer connecting time, or even an airline they don't know – only to make sure they fly on an A380

Overall, this extra effort means more revenue for the A380 operators.

60%
of passengers are ready to make an extra effort to fly the A380

Increasing customer awareness

According to the Epinion survey, 24% of A380 passengers specifically selected this aircraft type when they were looking for their flight tickets.

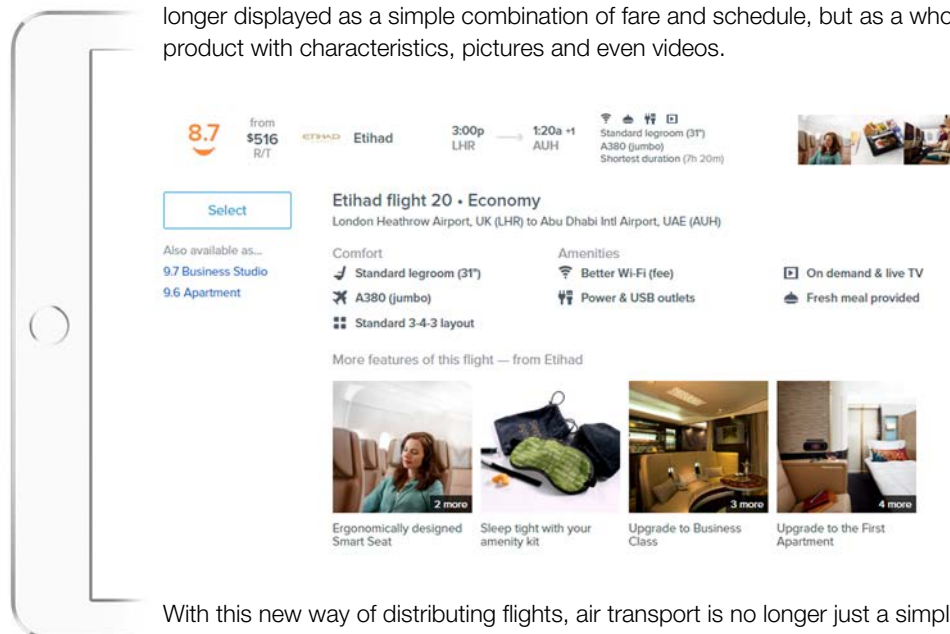
As travellers become more aware of aircraft type, the number of 'A380-friendly' passengers is growing and is stimulating demand for A380 flights.

Airbus has introduced the first ever A380-specific booking assistant, so passengers can easily find A380 flights (see overleaf).

Customer awareness has been growing in all industries, as more and more information on the product is now available to the consumer. People are looking increasingly at product characteristics and satisfaction, and not just at the price.

The trend towards more consumer awareness, that started in the hotel and restaurant industries with websites such as booking.com or tripadvisor, is now happening in the world of flight retailers.

Some websites are pioneering this area such as Routehappy. A flight ticket is no longer displayed as a simple combination of fare and schedule, but as a whole product with characteristics, pictures and even videos.



With this new way of distributing flights, air transport is no longer just a simple commodity, and this can actually turn into an opportunity for airlines.

Websites are giving more and more details about flights, such as seat comfort, air quality, connectivity and entertainment systems. More awareness on these topics means more opportunities for airlines to value the passenger experience they offer.

Consumers are now able to look at the level of the passenger experience when they choose a flight. This new environment will stimulate more and more the demand for A380 flights that offer unrivalled passenger experience.

CONCLUSION

Independent surveys show that the A380 is the passengers' preferred aircraft.

Passengers now have the choice to fly on an A380 or on another aircraft type thanks to websites such as iflyA380.com. The A380's key assets, its differentiation and its unrivalled positive customer feedback, are giving the A380 operators a clear advantage over the competition. ■■■■

Promoting and booking via iflyA380.com

To respond to increasing demand from consumers to fly the A380 and to spread even more awareness about this unique aircraft, Airbus has developed the first ever A380 booking assistant, iflyA380.com. In this website, travellers can discover all A380 destinations, all A380 airline offers, read feedback posted by A380 passengers and find and book A380 flights.

The aim of iflyA380.com is to help A380 passengers find their next A380 flight. It also aims to create more awareness amongst a wider audience, to help consumers learn about the aircraft type and its associated benefits. These potential passengers go through phases of inspiration and research before they book. Given that 70% of them do not actually know where they want to go when first looking for a trip, (*Google/Ipsos MediaCT), iflyA380.com aims at inspiring them.



The website includes details about the A380, about the airlines operating it and the destinations.

The A380 becomes an integral part of the journey, offering a unique travelling experience, unbeatable levels of comfort and distinctive on-board services and all before travellers even reach their destination. In addition to displaying A380 characteristics and destinations, the website enables each airline to showcase its cabin and on-board services. A380 passenger comments from social media provide convincing feedback to encourage travellers to try the experience for themselves.

80.com

ifyA380.com is a real means to attract travellers. The website not only highlights how the A380 contributes to the passengers' flight experience, it can also influence booking decisions by triggering positive emotions and it has already started to prove efficient with some first bookings that have come directly through ifyA380.com.



Ensuring the best **A380** cabins



The cabin experience has increasingly become a major differentiator for travellers. The A380 cabin frequently leaves a favourable impression on those who have flown in it. This positive level of passenger satisfaction has been achieved by working hand-in-hand with airlines to create the most comfortable travel experience, that satisfies their expectations and at the same time respects airworthiness regulations as well as operational, technical and industrial constraints.

Article by (left to right)

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Tailoring the A380 cabin to customer needs

Airbus explains the A380 baseline offer and reviews it with the customer. Proven, in-service solutions may be integrated, which comply with the required lead time. To facilitate the complex task, Airbus supports the customer definition team in a close and robust partnership providing knowledge and skills built up on customisation experience.

The optimum cabin arrangement is very specific to an airline and usually the result of several iterations. The type of classes (first - business - premium economy - economy) with the required number of seats per class and spacing between seats are an essential input as a first step. Secondly, the airline defines cabin service needs such as galley space, the number of lavatories and required space for stowage.

The current trend is for operators to place the first, business and premium economy classes on the upper deck, while configuring the main deck for an all-economy layout in a 10-abreast (3-4-3) or 11-abreast (3-5-3) seating configuration, thereby keeping Airbus' standard 18-inch width between armrests. However, to maximise versatility, the main deck's seating in constant cross-section can be configured in a 4, 6, 7, 8, 10 and 11-abreast (9 also possible by adding a seat rail) and the upper deck's seating in a 4, 6, 7 and 8-abreast.

Based on the above, the cabin takes into account technical feasible solutions, lead time for development of specific arrangements and airworthiness regulations. The remaining fine-tuning is about balancing those key factors while meeting cost and weight targets.

Following the cabin arrangement, cabin systems are determined such as integrated In-Flight Entertainment (IFE) and/or connectivity to access internet, live TV and phone services. Customers can customise lighting by choosing from a variety of colour and intensity options provided by Cabin LED Units (CLEDU), and can decide on visual projections such as logos and patterns.

Standard A380 cabin

- 544 passengers
- 4 classes
- Front and rear staircase
- 1 trolley lift
- 18 lavatories
- 20 galleys
- 19 cabin attendant seats

3D designs and virtual reality

New technologies, implemented by Airbus throughout the cabin definition process, facilitate the customer's decisions and speed up the process.

As customers can visualise their cabin and requested customisations via 3D designs, the level of feasibility and accuracy of the customised cabin is greatly increased.

Virtual cabin reviews mean that customers can start planning on-board and cabin crew activities.

Thanks to these technologies, Airbus can take earlier corrective actions to help reduce costs and lead time.



Meeting regulatory, operational and comfort requirements

Airbus carries out investigations, based on requirements, so that the cabin is compliant with airworthiness and operational regulations. These investigations cover a wide variety of subjects.

Evacuation

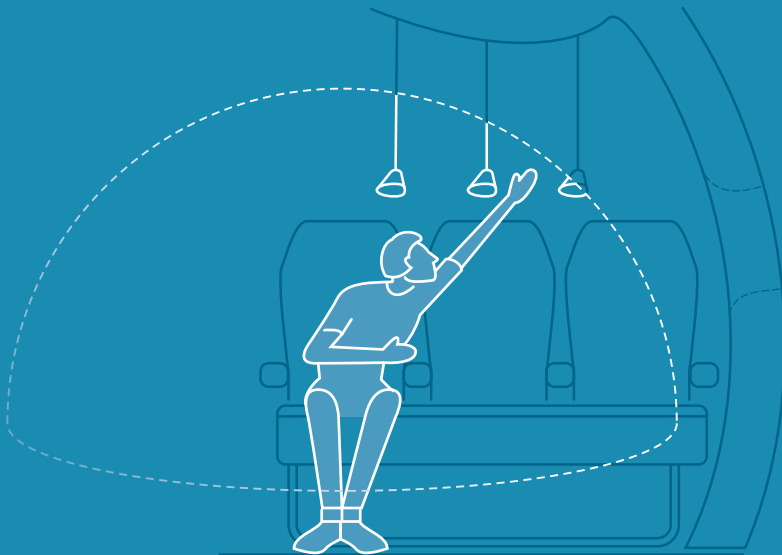
The A380's flexibility means that many cabin configurations can be installed, although they must all strictly respect airworthiness authorities' requirements and safety measures. Airbus ensures that the customised cabin complies with these criteria.

Passengers must be uniformly distributed in each zone so as to comply with the evacuation plan. Currently the maximum number of passengers in an A380 is 853 as agreed with the airworthiness authorities. To comply with the emergency evacuation requirements, all passengers and crew must be able to leave the aircraft cabin within 90 seconds.

Oxygen masks

All cabin occupants must be able to see and reach their oxygen mask in case of emergency depressurisation of the cabin. In this investigation, Airbus must demonstrate that all occupants can reach an oxygen mask when seated in any position, with the seat belt fastened or not.

The quantity of masks must exceed the maximum allowable occupants in the dedicated area by at least 10%. Mask drop lengths and reachability are studied by using anthropometrical human models and 3D geometry in compliance with airworthiness authorities' rules.





Quieter cabins

The A380 is renowned for its quiet cabin. However, Airbus offers support to customers who wish to further reduce the noise levels in specific areas.

In complex cases, Airbus offers a cabin mock-up acoustic lab to simulate cabin noise scenarios so that customers can perceive the impact of certain modifications and decide if it is worth the investment in the cabin change.

One example of how Airbus and an airline worked together on an acoustic investigation was the project to install a quiet passenger bedroom in the front of the upper deck. The chosen location was particularly challenging as the head wall of the bedroom was planned to be against the avionic system compartment and close to the main front staircase. In a standard cabin configuration, this space is usually occupied by a lavatory, which requires much less noise reduction.



The Airbus design office and the supplier worked in close cooperation to provide a design to the Airbus interior noise department for analysis. Different insulation scenarios were tested via the lab, the final recommendation being to implement an optimised balance of secondary insulation and wall-panel performance.

After more studies to prevent noise leakage through the doors, as well as service and rapid decompression flaps, Airbus validated the final design in flight test. The objective of having a reduced background noise level between the first class and the bedroom was achieved with a noticeable decrease of the sound pressure level.

AIRBUS

A380

Cabin ventilation

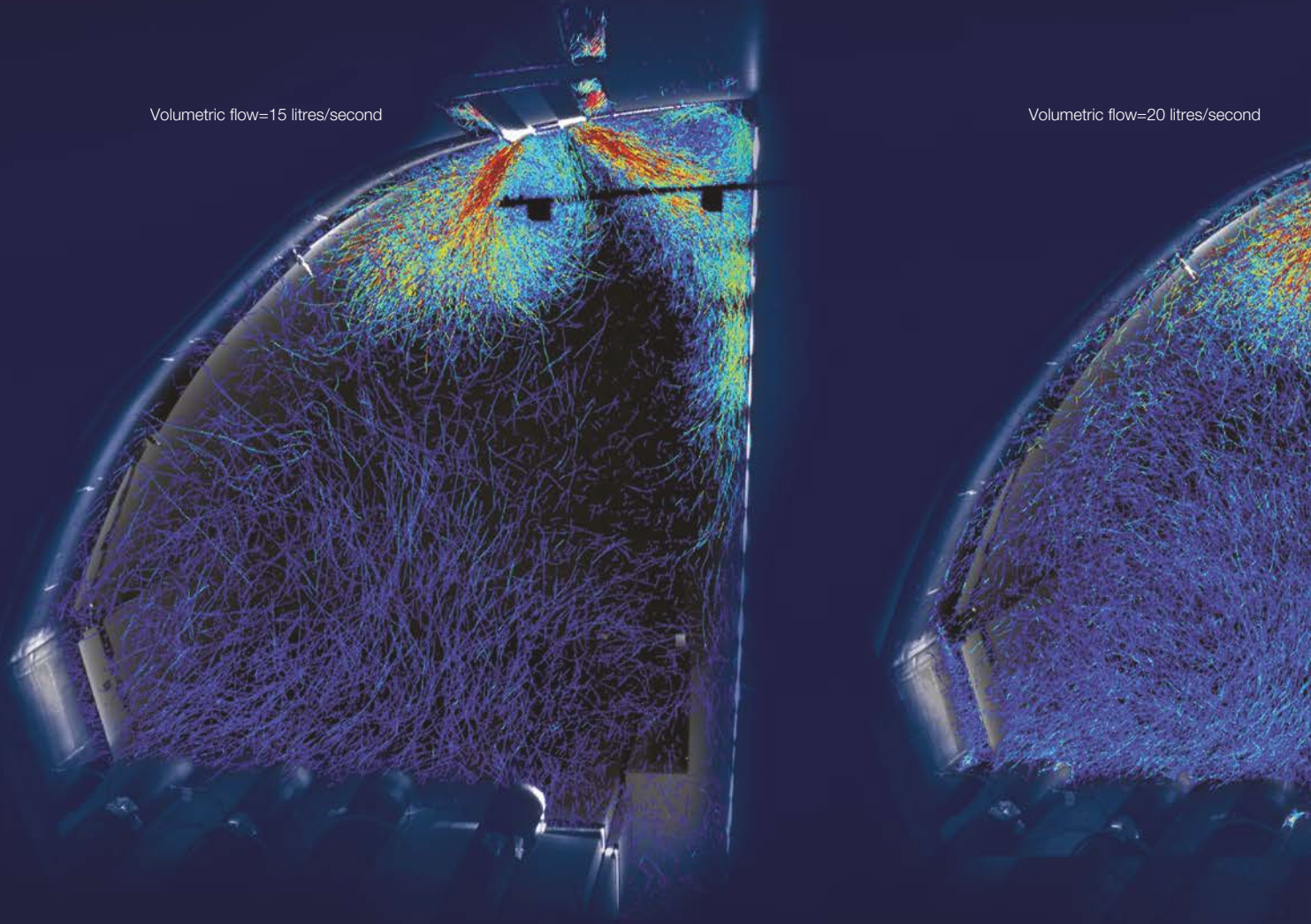
Optimal cabin ventilation must be ensured for passenger comfort, but also to ensure that the cabin complies with regulations. The thermal condition within an aircraft cabin is affected by external factors such as the outside temperature and solar radiation, and by internal factors such as passenger density, heat emission from in-flight entertainment, lights or galley equipment. Regulations also impact thermal condition as they require a certain amount of fresh outside air to ensure adequate oxygen levels.

To reach this goal in view of varying aircraft configurations, many particular adaptations are implemented into a new cabin design, taking the original cabin layout from the customer as definition basis. The A380 passenger cabin is divided into 15 temperature zones, 8 for the main deck and 7 for the upper deck. Every new seat class arrangement within these zones is analysed to determine whether modifications are required to obtain optimal thermal comfort for passengers. Further determining factors, for example the overhead stowage concept and monument installations, have an impact on the type of air outlets chosen for every position within the cabin. For an A380 cabin, up to 270 air outlets are installed, for which the airflow is regulated by up to 425 restrictors that are installed inside the air supply ducting and need to be calculated for each customised cabin.

In addition to the ventilation system and representing the biggest effort in the ventilation customisation process is the cabin air extraction system (CAX), which extracts heat and odours from galley and lavatory areas. Another key element is the passenger individual air distribution system with adjustable air nozzles above the passenger's head to regulate individual air supply.

In complex cabin configurations, further studies may also be needed. In these cases, CFD (Computational Fluid Dynamics) calculations are performed to analyse the behaviour of the air flow and the ventilation performance. The main advantage of CFD simulation is that design changes can be implemented much faster into a virtual model than in a mock-up. Each area can be analysed in detail by cutting the model in different planes and directions.

In some cases though, a combination of CFD analysis and mock-ups can be used to confirm results. To study cabin airflow velocity, helium bubbles are injected into the air supply that can be visualised using specific filming techniques.



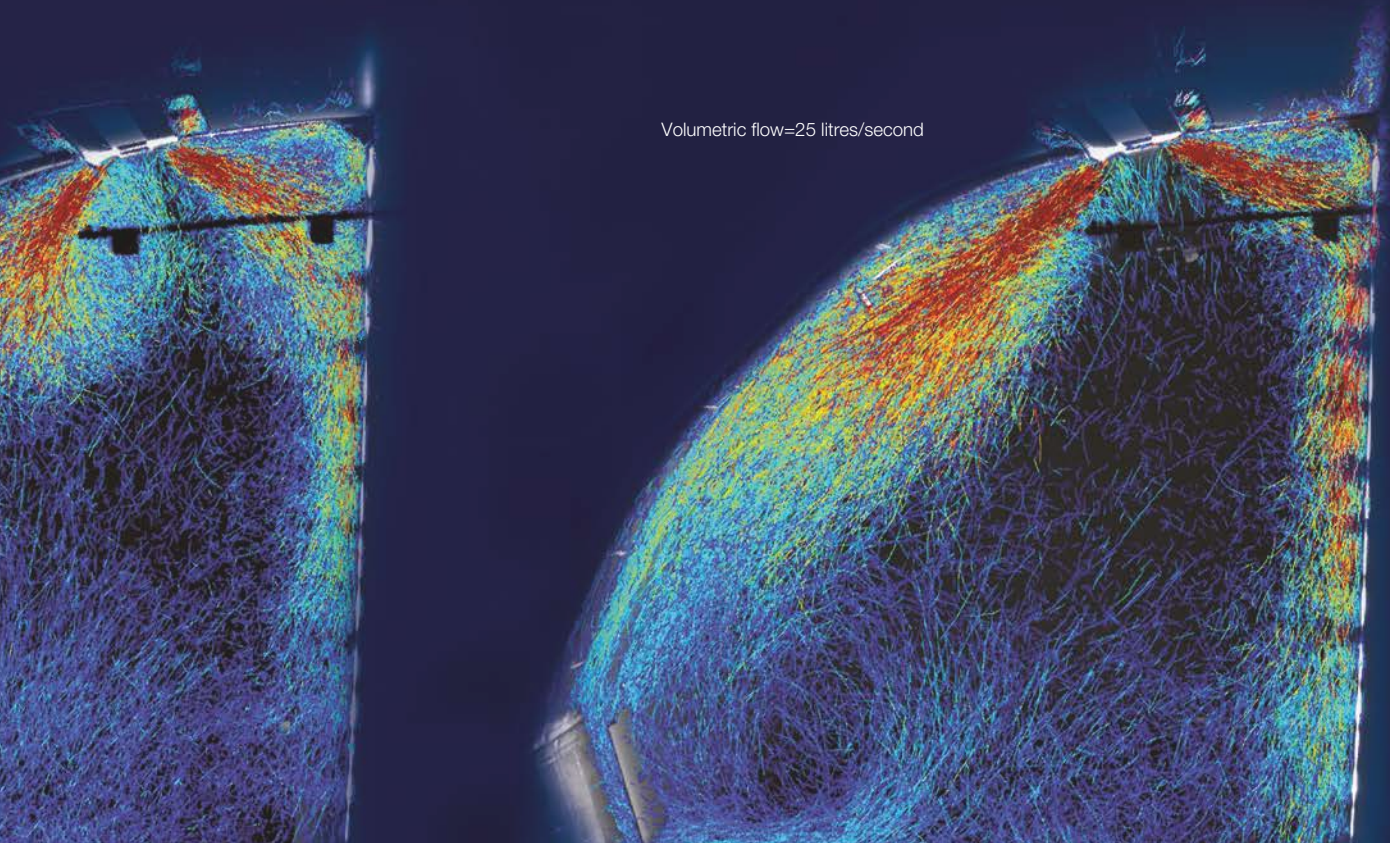
Helium bubble test showing direction and velocity of airstream in the cabin

Maintainability of equipment

Airbus applies a basic rule of 15 minutes maximum to replace a Line Replaceable Unit (LRU). Specific investigations are launched when a cabin element physically covers an LRU.

An example of this is the cabin air recirculation filters, located in the aircraft sidewall on the upper deck. For maintenance purposes, these units must have sufficient replacement accessibility. However, commodities such as personal storage areas in first or business class seats may be placed partially or totally in front of such units. When access to units is not feasible via the commodities, specific split air filters may be recommended during customer guidance phase.

Investigations can either take place via virtual reality or by creating a mock-up, for more complicated setups.



CONCLUSION

Interpreting the customer's vision requires close collaboration between the customer, Airbus and equipment suppliers. Key steps include optimising the design and ensuring compliance with certification requirements, while respecting cost and lead time targets.

The whole process is supported by 3D design, virtual reality and full-scale mock-ups to achieve one of the quietest and most spacious cabins in civil aviation. ■■■

A380

Innovative systems and aircraft design



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Designed to ensure the highest technical and commercial performances, the A380 entered into service with the most efficient technologies of the moment. In many cases, Airbus developed new technology, proving the A380 as an innovation driver that cleared systems for aircraft such as the A350 XWB.

A programme plane however, always remains in evolution and innovations continue to be implemented long after its entry-into-service, strengthening its position as the world's largest and most technologically advanced passenger aircraft.

This continuous improvement cycle is not about to stop.



Setting the highest safety standards

Innovation evolutions

Monitoring of vertical load factor and Angle of Attack (AoA)

In order to improve AoA monitoring in case of multiple icing, a specific function makes a correlation between load factor increase and AoA increase. Load factor is representative of the aircraft's dynamic behaviour and should be coherent with AoA evolution. If AoA behaviour is not in line with the load factor, it is disregarded, as icing is suspected.

Runway Overrun Protection System (ROPS) and Brake to Vacate (BTV)

Available since 2009 for both dry and wet runway states, ROPS is an Airbus developed response to the growing occurrence of runway overrun incidents, which remain the main cause of aircraft accidents. Associated to it, BTV assists pilots in easing airport congestion and improves runway turnaround time. Improvement is ongoing to take into account contaminated runway states. Both systems are optional and can be retrofitted.

TCAS (Traffic Collision Avoidance System)

Autopilot/Flight Director TCAS (AP/FD TCAS) mode combines the Autopilot (automatic mode), Flight Director (manual mode) and the TCAS to provide a vertical speed guidance based on optimum avoidance manoeuvre in case of conflicting air traffic (TCAS Resolution Advisory (RA)). It avoids or reduces pilot overreaction, enhances safety and increases pilot comfort.

The aim of the TCAS Alert Prevention (TCAP) is to reduce the number of undesired TCAS RA occurring during level off manoeuvre, by adapting the altitude capture law. It improves passenger comfort, without fuel penalty for a normal operation. These systems are basic for new aircraft and can be retrofitted for the others.

Future innovations

Manual protections for autopilot operation

Current flight control practice is to disconnect autopilot when entering too deep into flight control protection domain. To improve safety and help pilots during severe events, autopilot will be kept engaged and continue working, taking into account the same protections as manual flight.

New Air and Inertia Automatic Data Switching (NAIADS)

This solution automatically displays best air and inertial data. It also provides backup airspeed and altitude from independent engine probes. These improvements will be available by end of 2018.

Flight data recovery improvements

To anticipate future regulation evolutions, some solutions are currently proposed or will be proposed by end of 2019 on top of the existing recorders.

- Aircraft tracking relying on the periodic transmission of key parameters through ACARS network, by using Aircraft Operational Communication (AOC).
- The 'deployable recorder' will combine recorders that can float on water and Emergency Locator Transmitters (ELT) to improve flight data recovery for investigations. Availability is expected for end of 2019.



Designing and evolving for high performance

Structure

Innovation at EIS

The A380 already integrated new technology at EIS. Its structure was based on R&T innovative designs and benefitted from new materials such as Carbon Fibre Reinforced Polymer (CFRP) with Intermediate Modulus fibres (Centre wing box and Section 19, UD beams), fuselage shells in Glare, 6xxx Alloys in conjunction with laser beam welding.

New R&T developments are continuously being investigated for performance enhancement.

Future innovations

One of the most promising technologies for increased durability is the application of Laser Shock Peening. Laser peening induces exceptionally deep residual compressive stresses to enhance the fatigue strength of critical metallic components. This treatment, applied locally, limits fatigue and crack growth. Another technology under development is the application of cold working in hybrid joints (Aluminium-Titanium, Aluminium-CFRP).

Other developments are being studied via the "design-to-cost" technique. One innovative technology is related to the application of Isogrid structures. The hexagonal topology is especially good for structures that are dominantly loaded by shear forces, e.g. the pylon. Although implemented for the A350 XWB on the wing rib 1, the application foreseen for the A380 would be for the pylon lateral panel. This technology enables weight reduction as well as reduced recurring costs by using thinner raw material plates compared to conventional stiffened structures.

Another design-to-cost application concerns Additive Layer Manufacturing (ALM), or 3D printing.

A first example of this technology used on the A380 is the mounting device for iPads for the captain and first officer. This retrofittable option will be implemented in 2017 on the A380.

The application of riblets, a new generation of coating, enables a reduction in fuel consumption. The riblet profile can be engraved in the external coat. This technology applied on the upper skin of the wing as well as on the upper and lower horizontal tail plane skin would enable 0.3 % Block Fuel saving.

Systems

Innovation at EIS

Electrical system – Variable frequency

To simplify the electrical equipment, the heavy IDGs (Integrated Drive Generators), which provided fixed frequency power to the electrical network, were removed and replaced by Variable Frequency Generators (VFGs). These new generators are lighter and have been proven more reliable.

Hydraulic generation at 5000 PSI (Pounds per Square Inch)

Increased pressure from 3000 to 5000 PSI has enabled smaller pipes, manifolds and reservoir while still providing the same mechanical power. This modification has also enabled the downsizing of all actuators (flight controls, high lift, landing gear, doors, etc.). In addition, the downsized hydraulic distribution creates a significant weight benefit.

Fuel transfer load alleviation

Wing bending load management is a key driver of aircraft weight reduction. But the optimum is unfortunately opposite between ground and flight. To take benefit from both, fuel transfers are automatically managed just after liftoff to create more inboard fuel loading on ground and more outboard fuel loading in flight.

Relaxed stability

Specific longitudinal control laws have been developed to allow flying with a more aft center of gravity and therefore reduce Horizontal Tail Plane size. Redundancies have been added in particular by having a longitudinal gyrometer in the Backup Control Module. Even further relaxed stability is being considered for the future.

Y* lateral law

Expanding “control per objective” philosophy to yaw axis, pedals now control sideslip instead of directly controlling the rudder deflection. Specific sideslip probes have also been added. More accurate sideslip control reduces lateral loads and therefore aircraft weight.

Load alleviation functions

On top of the classical Manoeuvre Load Alleviation function, short period wing structural modes are controlled or damped by control law specific functions using dedicated accelerometers. These functions act in case of turbulence (Active/Passive Turbulence Alleviation) or in case of manoeuvre (Ailerons/Rudder Waltzes). It provides passenger comfort as well as a significant weight reduction.

2H2E architecture

Four totally segregated power sources are used: two hydraulic circuits and two electrical circuits. It allows dissimilarity in technologies, increases redundancy and therefore safety. Furthermore, it also eases installation to avoid engine burst consequences as electric cables can be installed on the fuselage ceiling, whereas hydraulic pipes need to run below lowest floor.

EHA/EBHA

Together with 2H2E architecture, flight control actuators include electrical actuators (EHA) and electro-hydraulic actuators (EBHA). These electrical actuators are a backup for the hydraulic actuators in case of failure or MEL (Minimum Equipment List) dispatch.

Innovation evolutions

Aluminium wiring

Targeting weight savings, the A380 was the first programme to introduce aluminium wiring for approximately 60% of the total wiring length of the aircraft (close to 500 kilometres) instead of the conventional copper as current conductor. Knowing that aluminium weighs one third of the weight of copper, 40 percent of the conventional wiring weight has been saved.

The aluminium wiring technology was already used for thick cables (cross-section of 5mm² or more). However, the A380 was the first aircraft to use the technology for thinner cables, under 5mm², and for the connections. The new wire's conductors are made of nickel-plated, copper-clad aluminium strands and a special protection has been developed for contact design to provide a specific sealing barrier to prevent from any corrosion risks.

The outer insulation is made of improved polytetrafluoroethylene (PTFE) tape. A new specification was also worked out for the aluminium connectors.

Introduction of GLA (Gust Load Alleviation)

In case of gust, the Angle of Attack (AoA) probes can measure the flow change at the nose of the aircraft 200 ms before it reaches the wing. Ailerons are quickly deflected upwards and wing bending loads are decreased when the gust finally hits the wing. This allows a weight reduction of the wing

Future innovations

Automatic Take-Off Compensation (ATOC)

In potential future developments, a reduction of fin size is being considered, introducing an ATOC function which will reduce opposite engine thrust during the take-off run if an outer engine failure occurs. This allows recovering similar take-off performance with a smaller fin by reducing the yaw effect of the engine failure.

Optimising maintenance to improve availability

Maintenance programme

An aircraft on ground for planned and unplanned maintenance is not available for operation and thereby is not generating revenue.

Airbus worked with several airlines, defining the Operational Availability (OA) of an aircraft as the number of days per year the aircraft is not available for operation due to technical reasons. Airbus is also contributing to an IATA working group to publish the definition of the OA.

To improve A380 OA and maintenance costs, Airbus launched a project to optimise scheduled maintenance programme intervals, with the following targets:

- An extension of A-check intervals from 750FH (Flight Hours) to 1000FH
- An increase of C-check intervals from 2 to 3 years, to avoid one aircraft grounding over a 6-year period

The A-check optimisation results are expected to be approved by the authorities by the end of 2016 through the Maintenance Review Board Report (MRBR) Revision 8, whereas the C-check optimisation results will be included in the MRBR Revision 9 foreseen for March 2018.

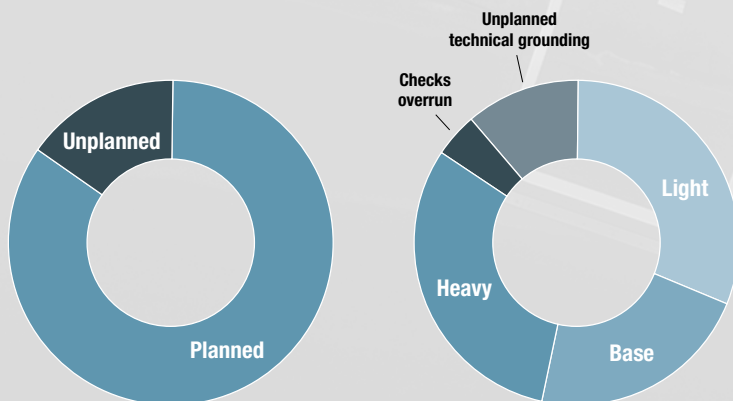
This maintenance programme optimisation covers systems, powerplant and zonal inspection tasks as per the Maintenance Review Board (MRB) process, including some Certification Maintenance Requirements (CMR) tasks. It also targets structure inspection task alleviation (Airworthiness Limitation Item).

The extension is possible thanks to:

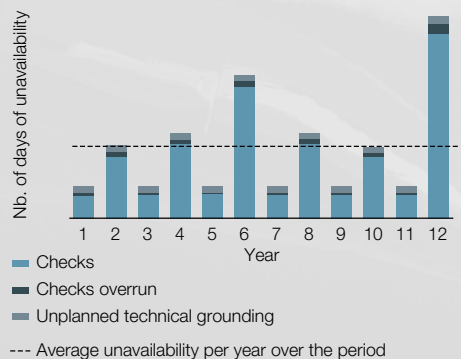
- Identification of some margins, to be validated by tests or in-service monitoring
- A detailed assessment of in-service feedback (finding/nil-finding, but also some specific requests to capture in-service experience on filter clogging, drain bottle liquid levels, etc.)
- A correlation of Full-Scale Fatigue Test findings versus aircraft configuration and actual loads
- The use of NDT (Non Destructive Techniques) instead of visual inspection, in some areas limited in size to increase inspection intervals
- The introduction of some structural modifications to improve design and remove the ALI (Airworthiness Limitation Item) or escalation TH/II (Threshold Interval Inspection). Not all the modifications will be retrofittable, but as an example, section 19 will be free of inspection in forward fit.

The active contribution of operators to the scheduled maintenance optimisation process by providing actual data is a key element for the success of the project.

Unavailability breakdown



OA results: Unavailability per year - 1st cycle



Systems

Innovation at EIS

Easing and improving maintenance was a driver and a requirement during the design phase of the A380. On previous Airbus aircraft, maintenance functions were undertaken by independent applications in various Line-Replaceable Units (LRUs), such as the Central Maintenance Computer or the Aircraft Condition Monitoring System. For the A380, the focus was on integration.

Onboard Maintenance System (OMS)

This is designed as a fully integrated component:

- Access to Aircraft Full Duplex internet network via a secured gateway
- Multiple interface access points through Portable Multi-Access Terminal (PMAT) and a dedicated Onboard Maintenance Terminal (OMT)
- Other supporting functions such as data loading and aircraft monitoring hosted by the same hardware
- Data transmission capability enhanced for both in-flight and on-ground phases through High Frequency, Very High Frequency and SATCOM (Satellite Communication) but also gatelink

Innovation evolutions

F/CTL – SLATS (FLAPS) WING TIP BRAKE TEST REQUIRED

Previously, a test was required in the case of failures of wing tip brakes (system preventing a runaway of slats/flaps in case of dissymmetry/disconnection of slats/flaps shaft).

No dispatch was allowed if the test was not passed. Since April 2014, dispatch for 3 flights is possible without performing the test, enabling airlines to fix the failure at main base.

COND - SECONDARY CABIN FANS FAULT

At EIS, depending on number of Low Pressure (LP) fans failed, dispatch could be forbidden. Since July 2015, up to the total number of LP fans (9) can be inoperative without preventing the dispatch, as long as aft cabin air extraction is operating (galleys, lavatories and aft avionics bay).

F/CTL - SLAT SYST 1 (CTL) FAULT

At EIS, failure of slat channel 1 (electrical one) prevented any dispatch. Thanks to a modification of Flight Control computer PRIM and Fault Warning system together with an amendment of Go-Around operational procedure, dispatch with slat channel 1 inoperative is accepted for 3 flights since June 2015, allowing the airline to fix the failure at main base.

MMEL optimisation

Providing the right tool and means to line maintenance is key; however it is essential to be able to dispatch out of the main base an aircraft which has only minor issues ('go' or 'go if' faults). Since EIS, many studies have been launched to optimise and simplify MMEL procedures (Master Minimum Equipment List).

FUEL – L(R) OTR TK PMP FAULT

At EIS, failure of one of the outer pumps required checking that the emergency transfer was operative: this check means partially defuelling the aircraft to provide some volume in feed tanks 1 and 4 to be able to receive fuel from outer tanks during the check.

Since January 2014, dispatch without this check is authorised, preventing delays in case of pump failures.

Trimtable Horizontal Stabiliser (THS) Tail cone – LP5 fan

In order to prevent fire, section 19 has been fitted with a fan for better ventilation on ground. At EIS, dispatch with this fan inoperative was possible providing an inspection for leaks was performed before the flight, which is time-consuming, at least for the access. Since July 2016, the need for inspection of section 19 is conditioned by a combination of Turnaround Time (TAT) with Outside Air Temperature (OAT), avoiding delays when right conditions of TAT and OAT are met.

Future innovations

High Slip Induction Motor (HSIM) fuel pumps (FS)

Pump reliability and maintenance costs improved by switching to A350-like technology of HSIM having almost no electronic parts. A beneficial side effect is a reduction of pump fairing size and therefore fuel consumption.

Updating cockpit and communication systems

Since entry-into-service, A380 aircraft have been fitted with the most advanced integrated cockpit with 8 identical large displays (6" x 8"), proposing the current A320 and A330 Family formats (Primary Flight Display, Navigation Display, Engine Warning Display, Secure Digital) and additional formats such as Vertical Displays (VD) and Multi-Functional Displays (MFD).

New functions have been implemented to the existing ones on Airbus families, via a new avionic network using Avionics Full-Duplex Switched Ethernet (AFDX). These include:

- FLS (Flight Management System based Landing System) function: an Instrument Landing System (ILS) look-alike way of flying a non-precision approach computed by the FMS
- GLS (GPS Landing System) CAT I approach
- NADP (Noise Abatement Departure Procedure) for a better noise abatement during departure phase
- FANS (Future Air Navigation System) A+B function, allowing datalink communication for oceanic area and remote areas through ACARS (FANS A) and for continental areas through ATN (Aeronautical Telecommunication Network - FANS B)

To control these new functions, interactivity through two Keyboard and Cursor Control Units (KCCU) is proposed.

In terms of connectivity, IP SATCOM (Swift BroadBand - SBB) was proposed from entry-into-service to manage both flight operations applications and passenger applications.

New IP SATCOM (such as Ka Band SATCOM) are now proposed as well to answer a very demanding high bandwidth market.

FlySmart with Airbus

The target of the Airbus Electronic Flight Bag (EFB), called FlySmart with Airbus, is to improve operational performance by providing information in the cockpit and to reduce the use of paper documentation.

FlySmart with Airbus started as an aircraft-installed EFB (class 3) with integrated cockpit displays (Onboard Information Terminal - OIT) on each side of the captain and first officer.

For operators preferring portable and installed EFB (class 2), Airbus will soon propose new options based on WiFi links in the cockpit which enable pilots' electronic devices (tablets) to connect to the aircraft.



Reducing impact on the environment

The European REACH regulation (Registration, Evaluation, Authorisation and Restriction of CHemicals) came into force on 1 June 2007, with a gradual introduction of the obligations. Its purpose is to control and progressively eliminate the most hazardous chemicals from the market. It impacts all companies in the European Union, and therefore Airbus.

Protection of health, safety and the environment is a global priority for Airbus.

Management of hazardous substances

REACH is generating unprecedented changes in the way information on substances is exchanged and responsibilities are distributed along the supply chain. Airbus and its supply chain have to identify, control and eliminate the various possible hazardous substances used in the company, in design and throughout the lifecycle of Airbus products.

Airbus has to anticipate the evolution of environmental regulations to avoid material obsolescence. On the A380, a lifecycle assessment is systematically performed before the launch of any modification in order to better evaluate the environmental footprint.

Removal of chromates

At entry-into-service, the A380 was a forerunner in the application of more environmentally-friendly substances. For its painting system, external chromate free primer and low volatile compound paint were introduced. Since then, a tremendous effort has been concentrated in the eradication of compounds containing chromium VI.

This has been one of the biggest challenges for over a decade. The complexity is mainly due to the fact that chromium VI is found in numerous applications. No single alternative exists as chromates are widely applied for corrosion prevention (anodising process, primer and chemical conversion coatings).

A non-negligible task is the replacement of the hard chrome used on parts such as bearings, bushes, axles, etc. Although hard chrome on its own is not prohibited, its deposition process that heavily uses chromates is.

Many areas still exist where alternative coating is being researched. The main research focuses on the replacement of chromated basic primer. In the coming years, REACH will evolve with the replacement of cadmium plating and borate compounds. Although no official date has yet been announced, Airbus has started research in these fields.

Halon replacement

The second main challenge in the frame of REACH is halon replacement.

Halogenated hydrocarbons, also known as halons, primarily halon 1301 (CBrF3), halon 1211 (CBrClF2) and halon 2402 (CBrF2CBrF2), have proved to be very effective gaseous fire extinguishers and explosion suppressants, but with very high ozone layer depleting potential.

At entry-into-service of the A380, this agent was used in four different applications: Auxiliary Power Unit (APU) / engine, cargo zone, lavatory waste bin and portable extinguisher. In order to comply with ICAO Standard 6 production cut-off dates, Airbus identified new agents, validated their performance and introduced them on the production line.

This is the case for lavatory waste bin application where agent FE26 (an organofluoride gas) is used on every single aircraft produced since 2011.

For portable extinguishers, the agent 2BTP has been selected as the most efficient substitute for halon. Starting January 2017, depending on local authorities' directives, operators can request the halon-free fire extinguisher (called HAFEX) to be installed in the cabin.

On APU/engine and cargo, important R&T efforts are made to identify the best chemical agent for the new type certificate. Up to now, no production cut-off date has been defined by the International Civil Aviation Organization (ICAO) and European Commission.

CONCLUSION

The A380 programme will continue to scan innovations on the market and will integrate them in future evolutions, taking into consideration quickly evolving techniques as well as the needs of increasingly demanding airlines and passengers. ■■■

A380

Capability and profitability enhancements

Ensuring that an aircraft is capable of satisfying the diverse requirements of customers is essential to the success of the whole programme. Each airline has its own strategy, targeting a particular market segment and operating a particular network. These factors determine the airline's choice of aircraft and how it operates them.

The A380 was designed with flexibility in mind to ensure that it can respond to the needs of a wide customer base. This flexibility has been enhanced through a number of changes since its entry-into-service and will continue to be enhanced by other modifications in the next few years, bringing value to customers.

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A customer seeks best operational value by maximising revenue and minimising costs on its aircraft. This value can be affected by many factors.

Fuel cost

On long range aircraft, fuel accounts for about half of total operating costs and is an important cost reduction lever for airlines. The A380 entered into service with unbeatable fuel per passenger per kilometre and its fuel burn performance has since been improved by working on a number of complementary axes.

Cabin revenue

The A380 offers unprecedented options to provide exceptional levels of comfort across all classes, enabling operators to adapt the cabin layout to suit their objectives. A number of enhancements are in development to improve the revenue potential while ensuring that the A380 retains its level of comfort and unique passenger experience.

Range capability

With its 8200 nautical miles (NM) typical maximum passenger range capability, the A380 has already demonstrated its capability to economically operate even longer routes such as Dallas-Sydney and Dubai-Auckland. Increases in range capability can be used to increase payload during the most demanding months of the year when the payload may be limited by take-off weight or to enable even longer routes to be envisaged.

Payload capability

Some airlines choose not to operate the A380 at its maximum range capability. However, payload capability may be important to ensure economic operations with the selected cabin layout. For example, the passenger payload of high density one-class layout needs to be accommodated by the aircraft structure.

Airport constraints

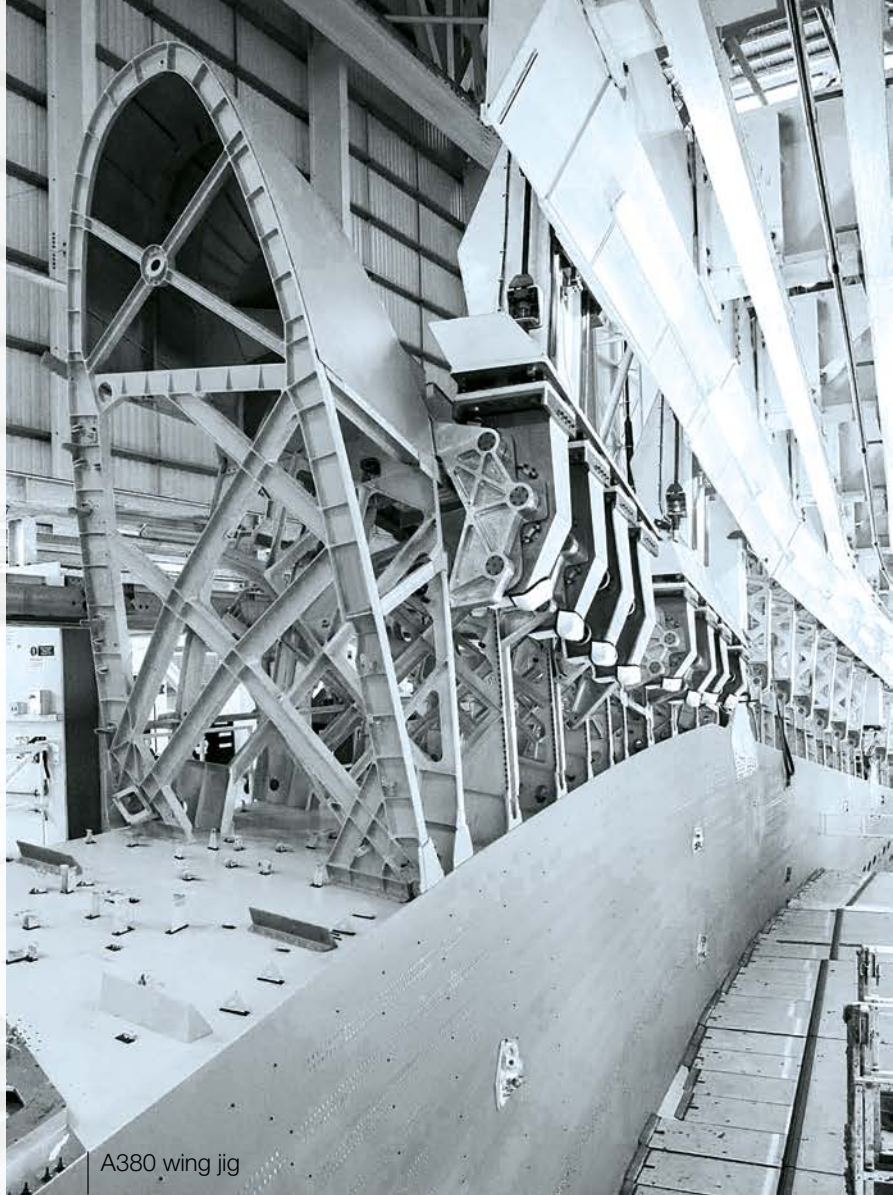
Airlines often operate under numerous airport constraints depending on their network. The frequency of operations may be limited by external noise quotas, aircraft separation distances or runway occupancy time, among others. (Read more in A380 - The solution for airlines and airports on page 10).

These factors affecting the operational value of airlines can be addressed by different levers.

Reducing aircraft drag

Drag reductions lead to cost savings thanks to reduced fuel consumption and can also lead to significant revenue increases. Greater revenue can come from increased payload on demanding routes, or from new routes that require increased range capability.

A better understanding of the physical phenomena or modelling tool capabilities enables improvements to aircraft designs. An example of this on the A380 was the modification of the wing pressure distribution in 2013. This was achieved by adapting the spanwise wing twist distribution, resulting in significant drag reduction. This modification was obtained by adjusting the manufacturing jigs within the limits of their initial capabilities.



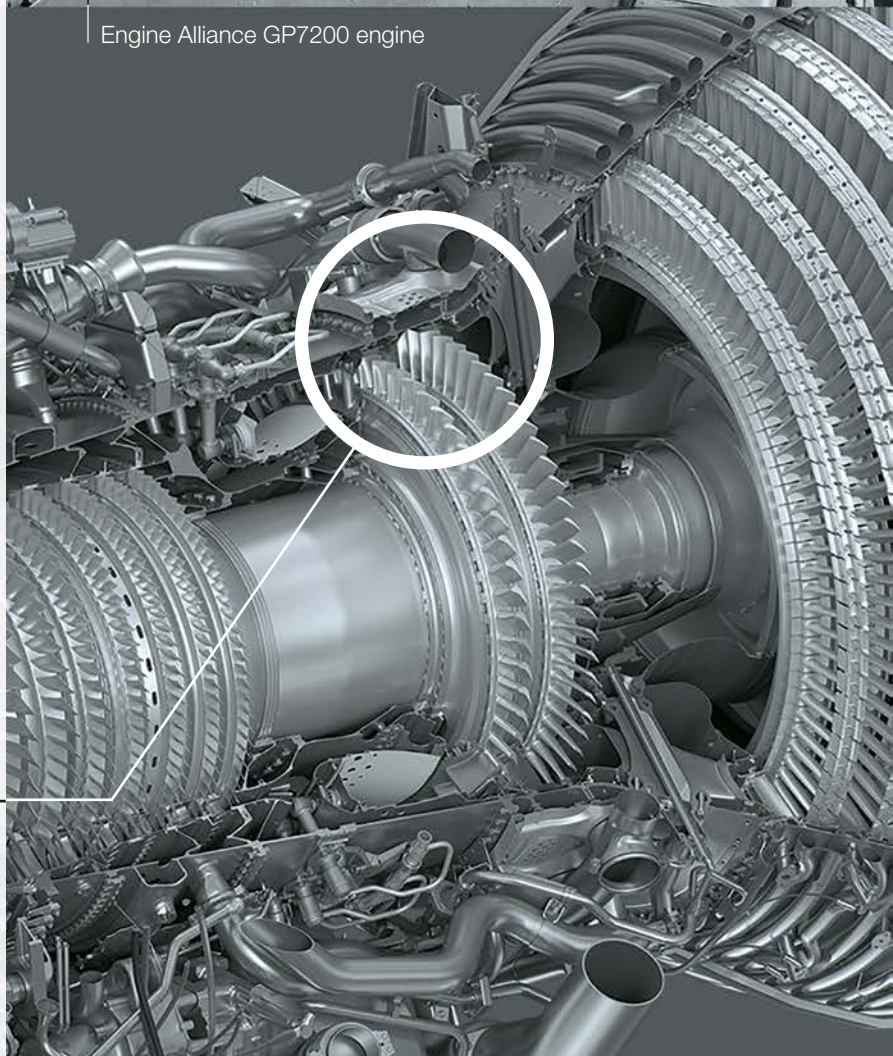
A380 wing jig

Improving engine fuel burn

Engine fuel burn improvements can bring cost savings and revenue increases. The fuel burn of the A380 (equipped with Rolls-Royce Trent 900 and Engine Alliance GP7200 engines) has been improved since its entry-into-service thanks to a combination of production tolerance control and packages of engine modifications.

An example of this is the Trent 900 Enhanced Performance package suite developed by Rolls-Royce. This package notably features improved compressor blade aerodynamics (elliptical leading edges), which reduce the flow separation behind the leading edge thus improving turbomachinery efficiency.

Another example from Engine Alliance (a Joint Venture of General Electric and Pratt & Whitney) is the enhanced engine control software that modifies the turbine case cooling to optimise turbine blade tip clearance through the different phases of the mission delivering an improved mission fuel burn.

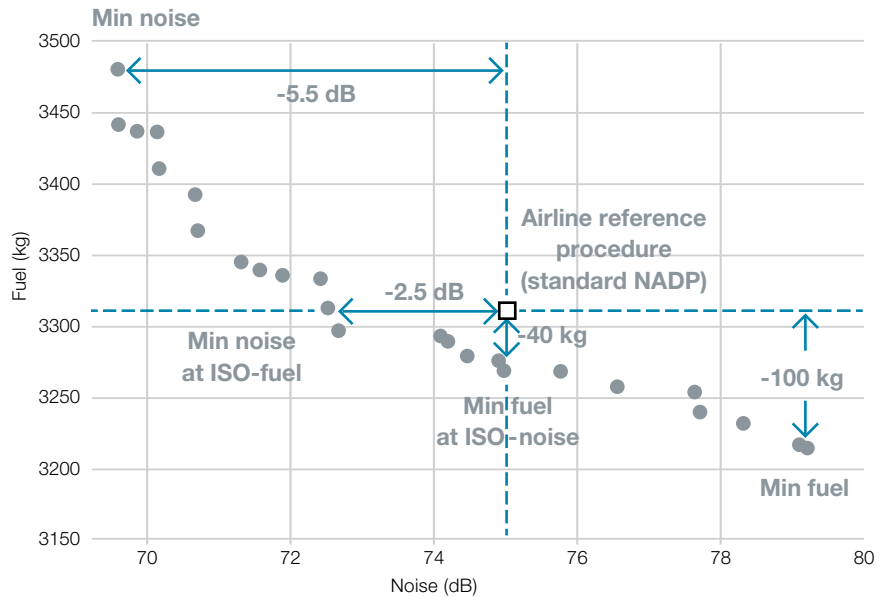


Engine Alliance GP7200 engine

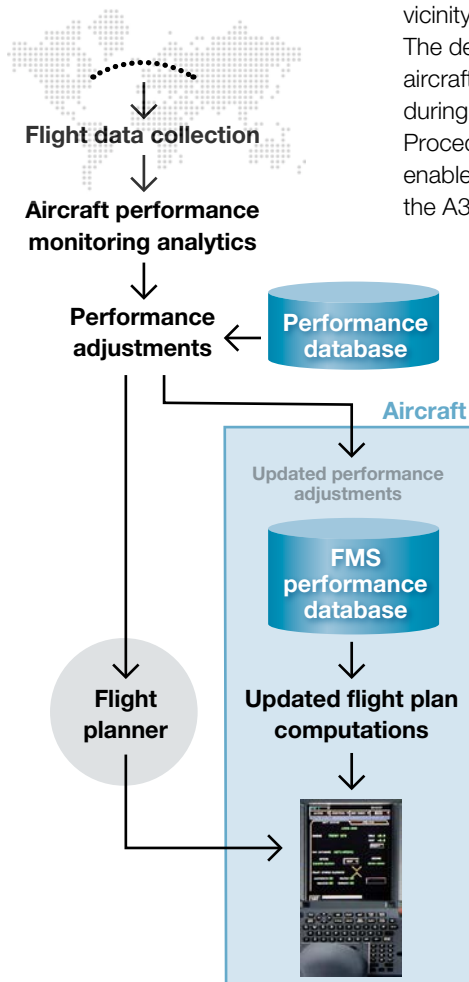
Optimising aircraft operations

Aircraft operations can be made more efficient either by flying the aircraft differently to optimise its trajectory, or by a reduction of the fuel reserves enabled by a better understanding of the actual aircraft performance.

Fuel and external noise benefits from departure optimisation



The Multi-Criteria Departure Procedure (MCDP) optimisation capability offers flexibility enabling airline flight operations to define their own strategy for optimising external noise and fuel burn. It also offers a unique possibility to target specific areas in the vicinity of the airport where noise exposure on the ground is to be minimised. The dedicated A380 Flight Management System (FMS) functionality enables the aircraft to take full advantage of the MCDP concept without increasing pilot workload during the departure phase, compared to the NADP (Noise Abatement Departure Procedure) Standard Operating Procedures that are in common usage. This capability enables variations up to -200kg of fuel and -10dB external noise to be achieved on the A380 depending on the airline operational reference.



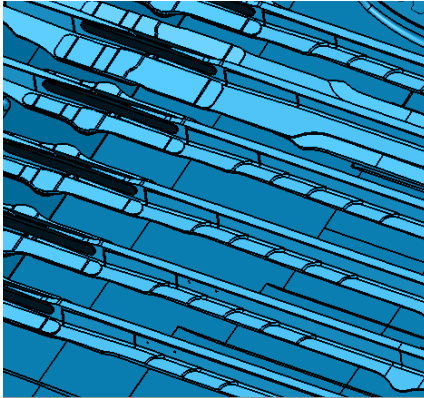
Performance modelling improvements

The FMS contributes to operational efficiency by providing flight plan predictions and optimised speeds for trajectories. The accuracy of the predictions and precision of the identified optimum is dependent on the representativeness of the aircraft physics embedded within the models and of the forecasted atmospheric conditions.

New generation aircraft performance monitoring analytics developed by Airbus will enable the performance model to closely follow the ageing of the aircraft across the various flight phases in service for flight planning purposes.

The associated gain in computational rates of these analytics will also enable real-time trajectory re-optimisation, taking into account evolutions in the forecasted weather during the flight.

An FMS upgrade containing these functions is currently being studied.



Structural optimisation included improvements to stringer grow out radii, pocketing and thickness tailoring of wing covers enabled by the change of material.

Reducing aircraft weight

Weight reductions are an important part of aircraft improvement because every kilo of weight saved equates to a kilo of additional payload capability. For this reason, the A380 underwent an extensive weight-saving programme that reduced aircraft weight by 1.8 tonnes after the introduction of more composites and light-weight metal alloys, structural optimisation and system simplification.

An example of this was the replacement of 2026/2027 Aluminium by third generation Al-Li (Aluminium-Lithium) on the lower wing skin. A total weight-saving of 740 kg was achieved thanks to the reduced density and improved material properties of Al-Li that allowed the detailed design of the wing covers (re-pocketing, thickness, grow-out radii) to be re-optimised.

Increasing design weights capability

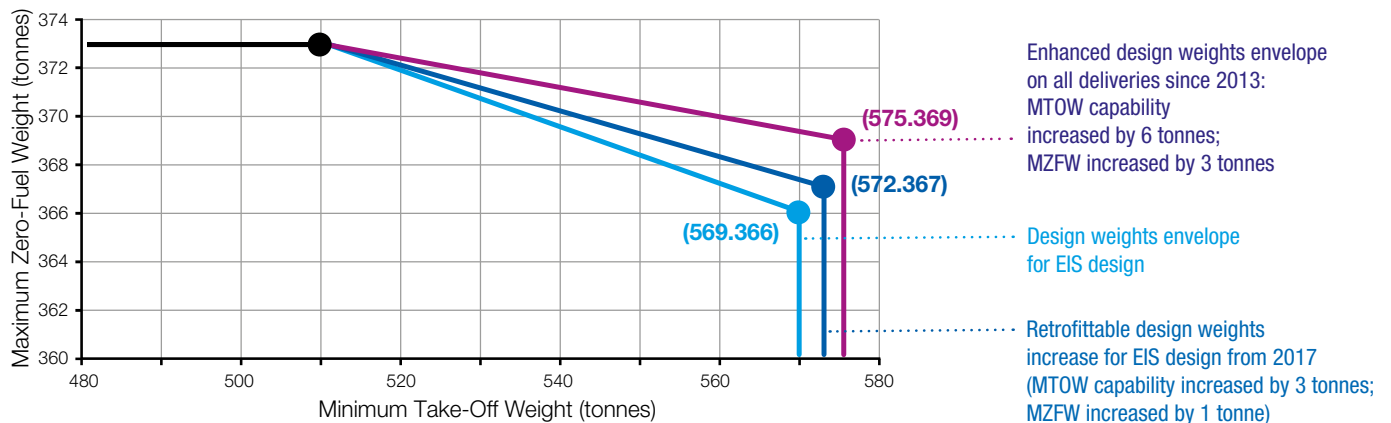
Increasing design weights delivers improved capabilities. Increasing Maximum Take-Off Weight (MTOW) improves the range capability or allows payload to be increased on the most demanding routes. Increasing Maximum Zero Fuel Weight (MZFW) enables more payload to be carried on shorter routes. Increasing Maximum Landing Weight (MLW) is necessary to maintain fuel reserves at landing when MZFW is increased or to allow fuel reserves to be increased to enable operations to airports with distant alternate airports.

In 2013, the design weights were increased at the same time as the modification to the twist of the wing (+6 tonnes of MTOW and +3 tonnes of MZFW & MLW). This was achieved with limited structural reinforcement thanks to the development of a more effective Load Alleviation Function that was enabled by the implementation of more rapid gust sensors in the multi-function probe and by the identification of optimum design weight increases taking into account existing structural margins.



The increased rapidity of the sensors in the Multi-Function Probe enabled the Load Alleviation Function to be enhanced to facilitate increased design weights.

Payload-range capability enhanced in 2013 by introduction of increased design weights



To enhance the payload-range capability of the entry-into-service standard of aircraft (aircraft delivered prior to the 2013 design weights increase), existing structural margins have been used to enable the MTOW & MZFW of the range mode weight variant to be increased by 3 tonnes and 1 tonne respectively, with no modifications to the aircraft structure. This improves the maximum range capability of the aircraft by 90 NM and improves payload capability by 1.8 tonnes on critical routes.

Cabin efficiency and revenue potential

Airbus and airlines are always seeking to maximise cabin efficiency and consequently the revenue potential of the aircraft. To support this, new cabin features can be implemented, depending on cabin design.

New cabin improvement package

The cabin package has been launched to deliver short-term improvements. It consists of several cabin modifications, in a continued effort to optimise the cabin and make it more efficient, with the same high level of comfort.

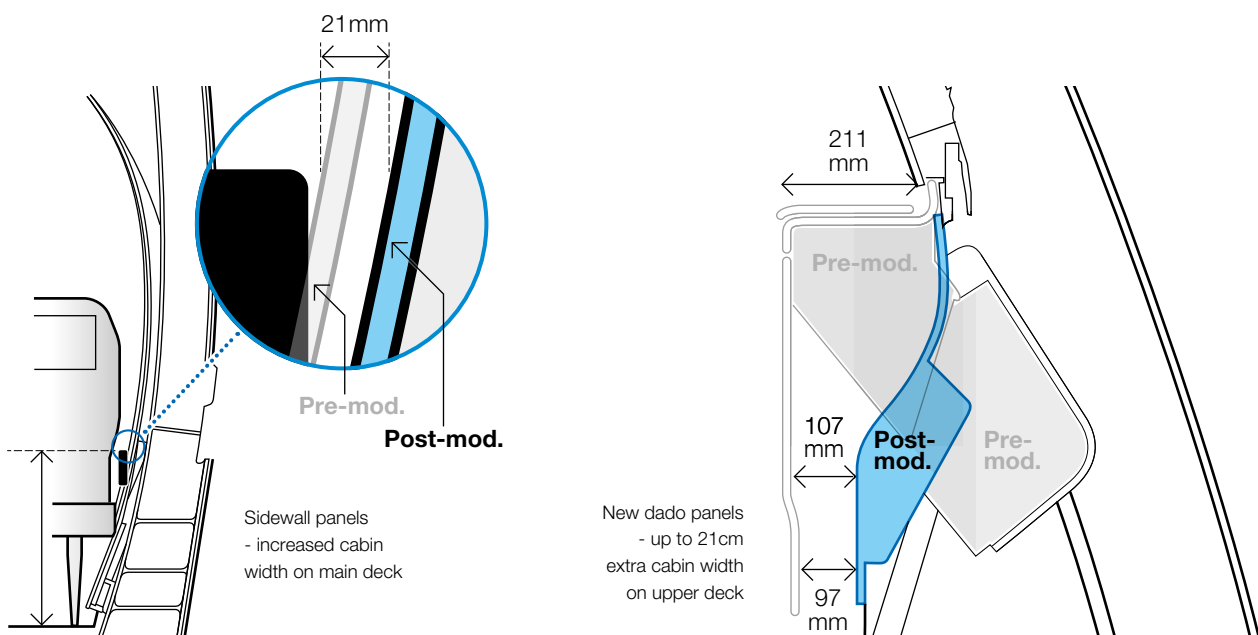
The sidewall panel position has been modified to deliver increased cabin width for the main deck 11-abreast economy class seating configuration. This configuration already enables 20 to 30 economy class seats to be added to the cabin compared to the 10-abreast configuration.

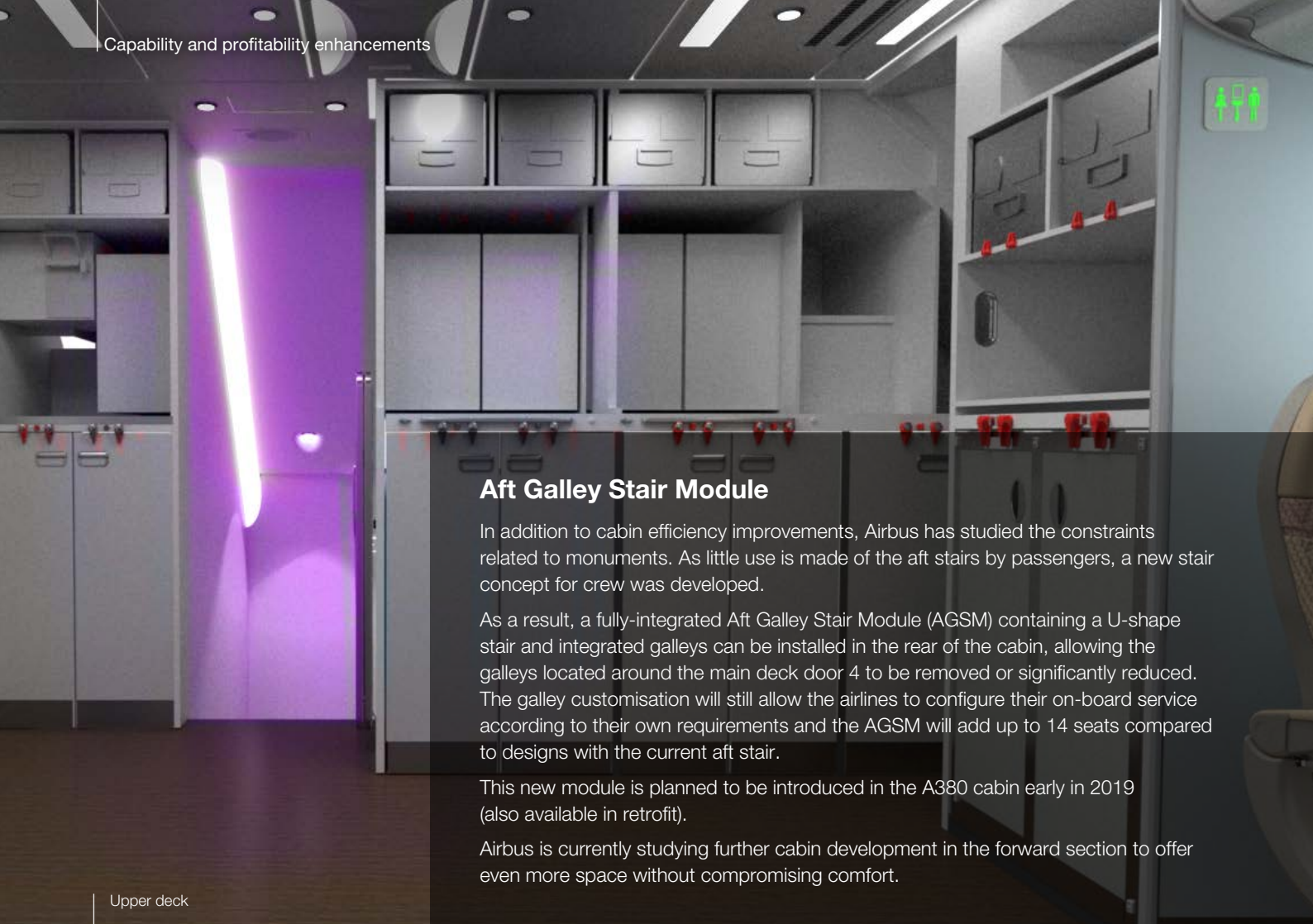
This 11-abreast configuration is already proposed with the same level of comfort as for the 10-abreast thanks to its 18" seat width. The sidewall rotation modification will provide 0.83 additional inches (21mm) on each side of the cabin, by a modification of the lower sidewall attachment to make it more vertical thereby giving more lateral legroom to the passenger.

A 9-abreast premium economy class seating configuration is now proposed for the main deck. In order to have the most efficient cabin layout, the current trend is to introduce a 4-class layout with a premium economy class. The best location for the 9-abreast premium economy class is forward of main deck door 2. This 3-3-3 seating arrangement requires the installation of an additional seat rail and is offered in linefit and retrofit.

The upper deck cabin width has been increased enabling extra seats or comfort level to be improved in the business class zone. This modification consists of removing the current sidewall stowage and of introducing a new air recirculation system enabling new lower sidewall dado panels to be installed, adding up to 21cm to cabin width.

The modification is a major contributor to space gain in the upper deck. As an example, when combined with a herringbone business class configuration, up to 10 additional seats can be added. This cabin improvement will become the new A380 standard from 2017.





Aft Galley Stair Module

In addition to cabin efficiency improvements, Airbus has studied the constraints related to monuments. As little use is made of the aft stairs by passengers, a new stair concept for crew was developed.

As a result, a fully-integrated Aft Galley Stair Module (AGSM) containing a U-shape stair and integrated galleys can be installed in the rear of the cabin, allowing the galleys located around the main deck door 4 to be removed or significantly reduced. The galley customisation will still allow the airlines to configure their on-board service according to their own requirements and the AGSM will add up to 14 seats compared to designs with the current aft stair.

This new module is planned to be introduced in the A380 cabin early in 2019 (also available in retrofit).

Airbus is currently studying further cabin development in the forward section to offer even more space without compromising comfort.

Upper deck

Main deck

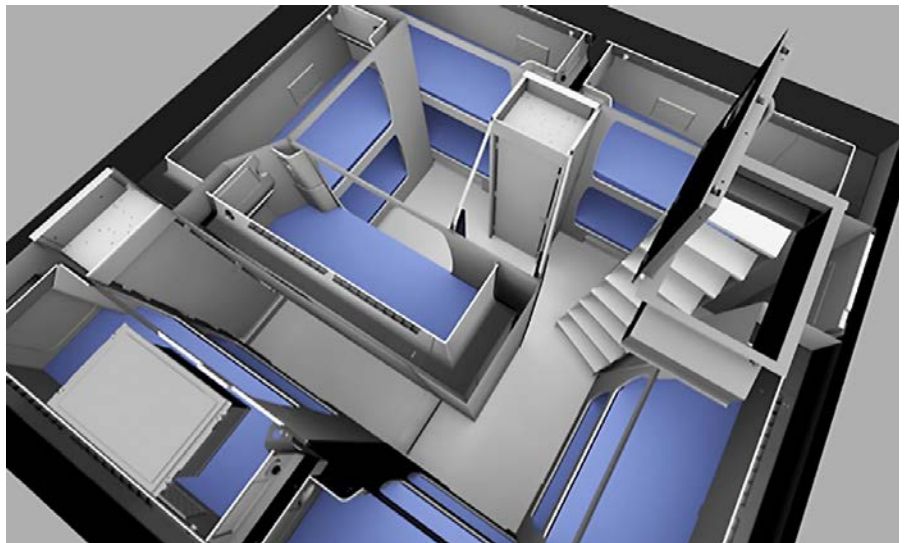


Optimised crew rest areas

As part of the space optimisation strategy, Airbus is now introducing a combined flight and cabin crew rest area in the catalogue of options for 2017. This new area includes two additional bunks for the flight crew, installed in the lower deck cabin crew rest area, bringing the total number of bunks to 14. The flight crew rest area may be separated from the cabin crew rest area by an optional partition.

This combined crew rest area frees up space at the current flight crew rest area just behind the cockpit, which will be used to relocate three lavatories. This in turn enables additional seats to be installed in the main deck cabin.

The lower deck crew rest area can also be relocated in the forward cargo area with an entrance door next to the forward trolley lift. This new location gives additional flexibility in the design of the seating zone between main deck door 2 and 3 thanks to the removal of the fixed point related to the aft crew rest access. The forward lower deck crew rest location also enables one more pallet to be installed in the hold.



Combined flight and cabin crew rest area, including two additional bunks, installed in the lower deck

Flexible cabin changes

Airlines can now adapt their cabin configuration to seasonal constraints by changing the class split within the cabin. They can define alternative cabin layouts within two zones: main deck between door 1 and 2 and upper deck aft of door 1.

The structure, cabin equipment and systems are adapted to enable these layouts to be installed by the airline in under 4 days, depending on the magnitude of the changes.

Economic gains from A380 enhancements

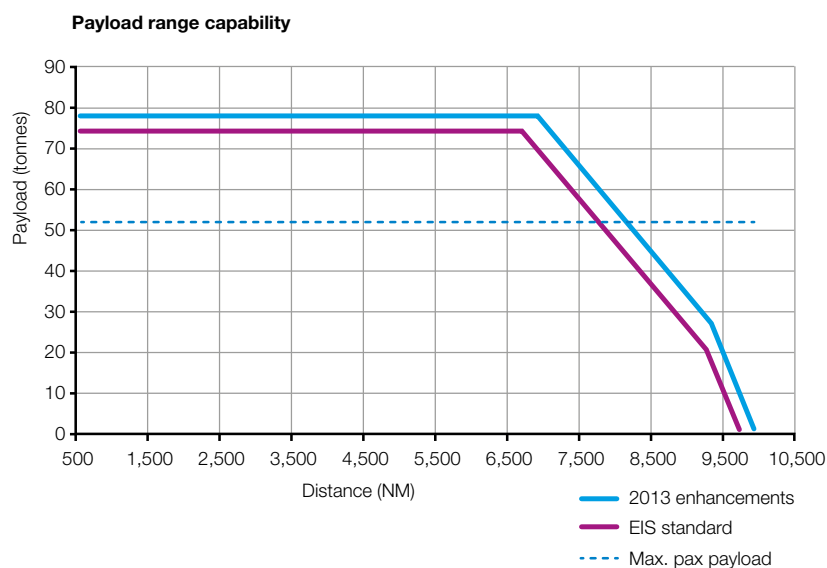
A380 operational capability and economics have been significantly enhanced since entry-into-service (EIS) in 2007.

Lower fuel consumption

Fuel consumption savings from airframe drag reductions, engine efficiency improvements and weight savings described previously have led to a reduction of the block fuel consumed for a 4000 NM mission of 2.3% relative to the EIS standard of the aircraft. Further operational fuel consumption improvements can be achieved thanks to Multi-Criteria Departure Procedure optimisation capability.

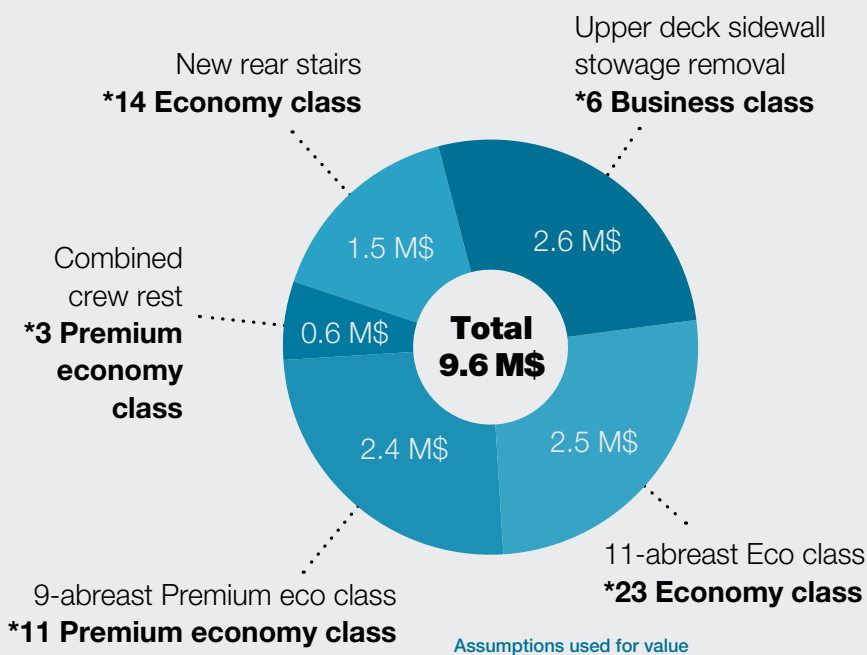
Increased range and payload

This efficiency improvement, combined with the increased Maximum Take-Off Weight introduced in 2013, leads to an increase in range capability of 375 NM compared to the EIS standard of the aircraft. Increasing the range capability has been key in enabling new routes such as Dubai–Auckland and in developing revenue capability on demanding routes thanks to the additional 7.8 tonne payload offered at iso-range. This additional payload capability facilitates the implementation of cabin improvements for increased revenue.



More cabin revenue

This cabin revenue enhancement can be illustrated using a 4-class cabin configuration. This configuration shows how the airlines can benefit from several cabin efficiency developments including the main deck 11-abreast economy class seating, the 9-abreast premium economy class seating, the upper deck new dado panel for business class optimisation and the new aft galley stair module. The combination of these new developments could bring an annual airline revenue increase of up to \$9 million per aircraft, while maintaining the exceptional levels of A380 comfort. The relative contributions of the different developments to this revenue enhancement are shown in the chart to the right.



Assumptions used for value

Mission: 4000 NM

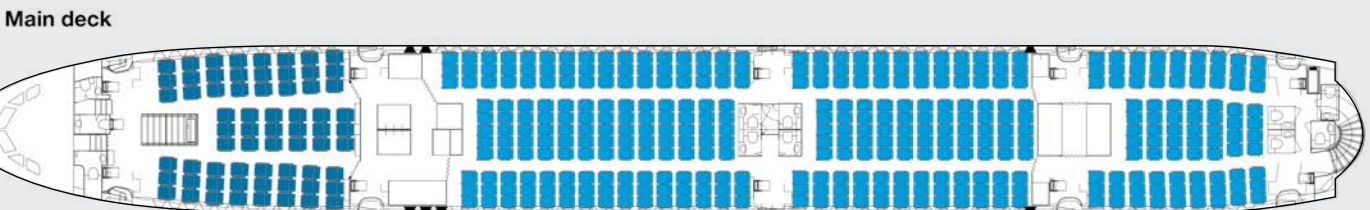
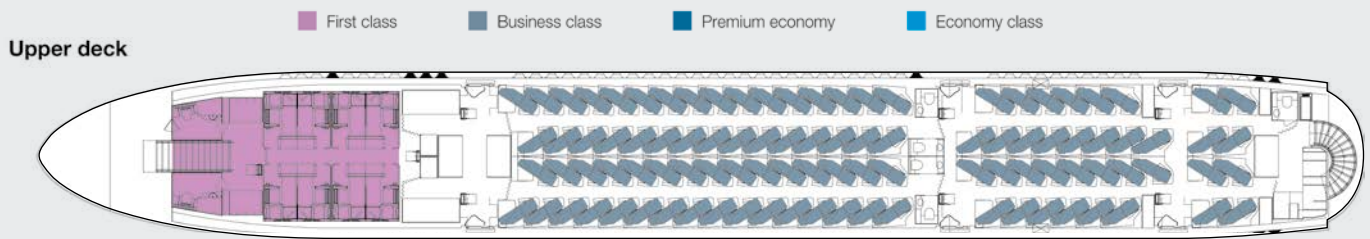
Flights per year: 584

Load factor for additional seats: 50% in all classes

Yields: same yields

*Estimated additional seats

This standard layout of 544 seats that includes the above enhancements, except for the Aft Galley Stair Module (AGSM), can deliver a significant overall benefit without having to introduce a stretched fuselage version. If the AGSM is installed, it can enable an additional 14 seats.



Some airlines seek to maximise cabin revenue with high density layout such as the example given below. This layout with 855 passengers shows how the A380 cabin can be adapted for large numbers, while maintaining the A380 economy class comfort standard including 18-inch seat width.



The combination of the above features of the A380 cabin design can also be adapted to maximise revenue for airlines focusing on ultra long range operations, over 15-16 hours of flight.

CONCLUSION

To respond to customer expectations, fuel burn performance, mission capability and revenue potential of the A380 have been improved since entry-into-service in 2007 by the implementation of cost-effective modifications. New cabin enhancements, available between 2017 and 2019, will further improve the revenue potential of the A380 cabin. ■■■■

Service packages to optimise operations

Current and future A380 customers are increasingly focused on securing operational performance excellence at a competitive cost. Airlines can choose a customised turnkey service package from Airbus. It provides an efficient solution for airline operations by maximising on-time fleet dispatch, minimising upfront investment and securing maintenance and entry-into-service costs.

Services for operators introducing second-hand A380s into their fleets, include pilot and maintenance training, and upgrades such as cabin reconfiguration.



Tailored Support Package

Airbus offers a suite of services, packaged and customised to meet customer needs. The cornerstone of every offer is the Flight Hour Services - Tailored Support Package (FHS-TSP).

The core module systematically included in the service is FHS-Components which guarantees spare parts availability from an inventory pool, as well as an exclusive on-site stock at the customer's main base, and component repair by-the-hour.

Airlines may then add the following optional modules:

- Engineering services, providing Airbus expertise for advanced fleet technical management (maintenance programme and planning, reliability programme, engineering support, airworthiness review, etc.)
- Airframe maintenance, dealing with the execution of scheduled maintenance (line, base and heavy maintenance)

A full TSP solution can provide a guarantee of aircraft availability On-Time Performance (OTP) covering technical, logistics and maintenance delays.

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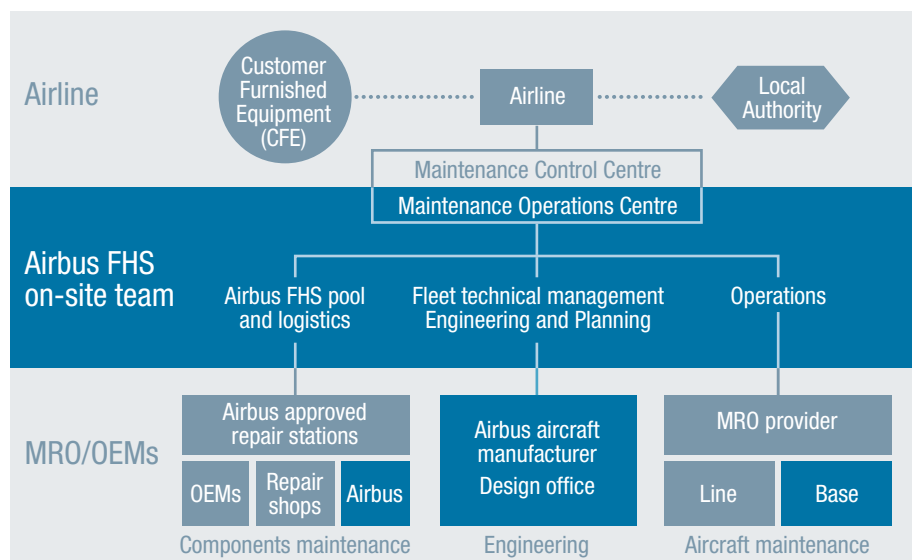
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Example of a contractual and industrial set-up between FHS-TSP stakeholders



With this modular service, airlines select what best suits their maintenance strategy, ranging from Airbus assistance up to full outsourcing of engineering activities.

For airframe maintenance (line, base, heavy check) with Airbus FHS-TSP, airlines can integrate their affiliated Maintenance, Repair and Overhaul (MRO) centre when they have developed their own capabilities, or use a 'best in class' MRO provider as per the Airbus standard.



Airbus FHS now covers over 313 aircraft of all Airbus types, and is currently supporting five A380 operators.

Singapore Airlines (SIA) has recently opted to extend its existing A380 FHS-Components support agreement to a full 'Flight Hour Services - Tailored Support Package' (FHS-TSP) contract to integrate and provide full component support, line and base airframe maintenance, as well as fleet technical management services for its A380 fleet.

Under this 10-year agreement, Singapore Airlines will benefit from Airbus experience and expertise in maintenance, engineering, reliability and supply chain management, partnering together with its affiliated MRO SIA Engineering Company (SIAEC).

Support for second-hand A380s

For operators acquiring second-hand A380s, Airbus is proposing a package of services in addition to FHS-TSP, to support the Entry-Into-Service (EIS) and daily operations. The package includes specific A380 training for flight and cabin crews, mechanics and performance engineers, as well as technical data and software required to maintain and operate A380 aircraft. An Airbus Field Service Representative is available at the airline main base to ensure smooth EIS. The A380 Health Monitoring service (AiRTHM) is also available to improve dispatch and operations. The scope and duration of this package is fully customised to complement the FHS-TSP offer and to match the airline's operations.

Aircraft lessors and potential customers can also benefit from Airbus services to support aircraft transition, with a particular focus on cabin reconfiguration.

The choice of cabin layout options for reconfiguration of A380 aircraft has been carefully studied to fit market needs, and is based on modularity and ease of reconfiguration. As a result, transition costs are reduced to the minimum while leaving much autonomy to lessors and operators to choose a cabin that fits their operations, all this with the unmatched seating capacity and comfort of the award-winning A380 cabin.

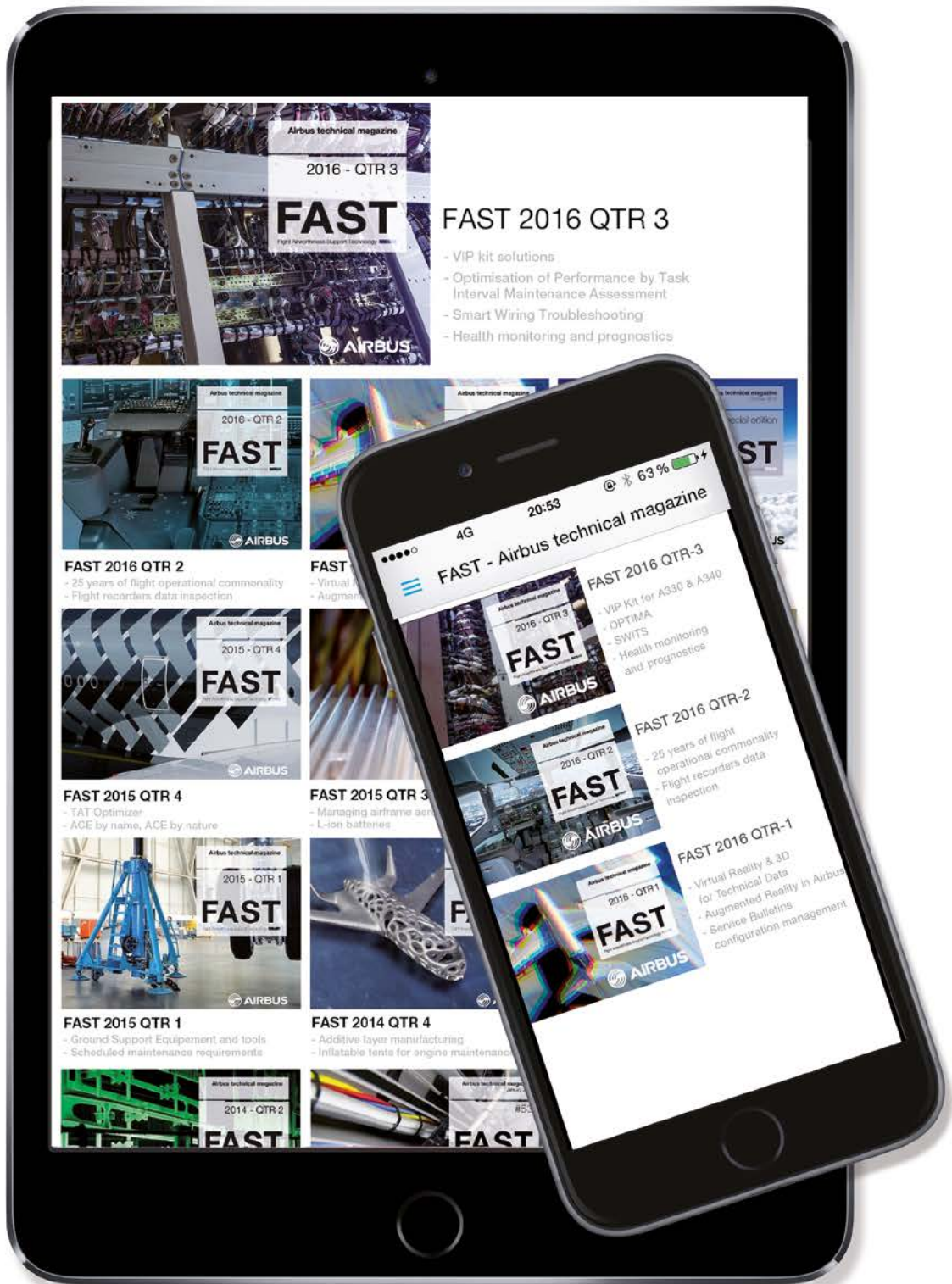
Upgrade engineering is performed by highly skilled Airbus teams that use design methods, tools and specifications equivalent to production quality standards, including the management of the aircraft configuration and aircraft document update. The resulting Service Bulletin (SB), allows the airline-selected MRO teams to perform and certify the modifications on the aircraft, thanks also to the pre-consolidated and certified upgrade kits.

For the upgrade embodiment phase, Airbus can offer a complete solution or support the customer's MRO with services such as tool leasing, shipment consolidation and follow-up, job card preparation, needed to ensure a successful start to an A380's second life.

CONCLUSION

The Airbus turnkey service package offers modular solutions to airlines to help them reach high performance levels, adapted to their individual needs. This enables operators to achieve a smooth entry-into-service and cost-effective operations when adding new or second-hand A380s to their fleet. ■■■

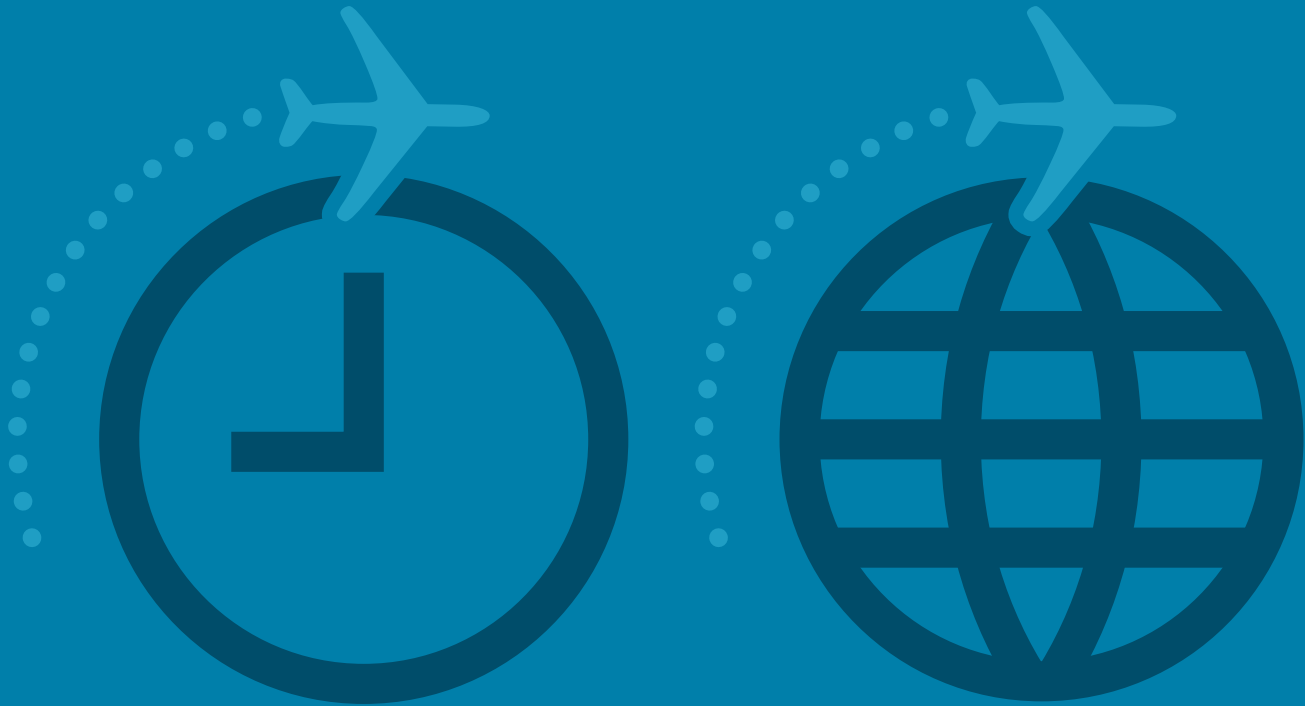
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