Most major airports are facing significant passenger growth, growing congestion, and limited potential for expansion.

A380
A solution for airports

Given the unique nature of the A380's size with greater span, height, seating capacity and weights, a team dedicated to the A380 airport compatibility aspects was set up in 1994, 12 years before the planned entry into service. Dialogue with major world airports is now well-established and many are using the A380 as the reference aircraft for master planning. The availability of the A380 Airplane Characteristics for Airport Planning manual, on the Airbus web site since February 2002 has significantly supported this process. In parallel, work with regulatory authorities and on environmental aspects is ongoing. Many aspects of the A380 design have been driven by airport compatibility considerations, thus minimising the amount of adaptation and, hence investment, required by airports to accommodate the aircraft.

Most major airports are planning for operations of large aircraft, mainly because they are facing significant passenger growth, growing congestion, and limited potential for expansion. These airports, therefore, see the A380 as a boost for business: it will enable them to increase revenue for relatively little expenditure within the limits of their existing infrastructure. Dialogue and combined working groups are key elements in defining the A380 and airport master plans.

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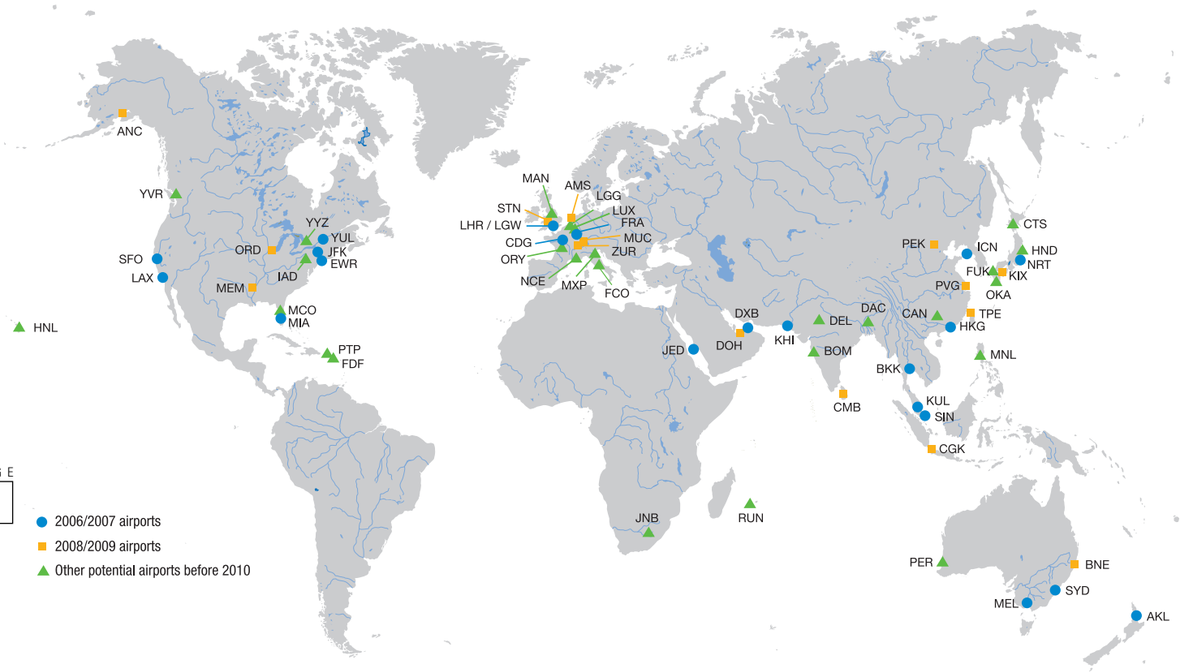
A380 - A SOLUTION FOR AIRPORTS

Airbus is working closely with 60 airports (Figure 1) that are likely to see the A380 before 2010 as indicated by existing and potential customers. Of these airports, many are A380 compatible today and those that do require infrastructure changes have planned and in some cases started work on the relevant upgrades. In addition surveys have been carried out and contacts established with further airports based on carrier interest and Airbus forecasts for future A380 routes.

Figure 1 - Likely first A380 airports



AIRPORT COMPATIBILITY

Many recommendations that Airbus received during it's extensive consultations with airports and regulatory authorities have directly shaped the design of the A380. The main characteristics that have been optimised for better airport integration are summarised in Figure 2. The landing gear width and 20-wheel design will allow the aircraft to use 23m wide taxiways and have a comparable pavement loading to existing aircraft. Furthermore the A380 will be certificated for unrestricted operations on 45m wide runways. In the context of terminal operations, the door locations and cabin layout allow comparable turn around times to the 747-400 with 35% more passengers boarded. Ground servicing points are located in similar positions to other widebody aircraft allowing the use of existing ground servicing equipment. As well as the physical characteristics, the field performance of the aircraft has been optimised to allow the A380 to operate from any airport that the 747 does today.

Figure 2 - Designed for airport integration

Recommendations	A380 Status
• ICAO Code F/FAA group VI - less than 80m span	79.8m span (262ft)
• Airports Council International (ACI) recommendation - less than 80m aircraft length	72.7m length (238ft)
• Minimum obstacle free zone (OFZ) - less than 80ft (24.4m) height	height (79ft)
• Use of 45m (150ft) wide runway, 23m (75ft) taxiway widths - close to group V / code E	14.3m (47ft) landing gear width lower cockpit height, cameras
• Reduced taxiway/object separation (Wing tip height to be considered)	5.3m vertical tip clearance Outboard 3m of wing is dry
• Pavement loading - comparable to existing aircraft	20 main wheels, large bogies and wheels
• Ground manoeuvres comparable to existing aircraft	14.3m landing gear width, 28.5m wheel base
• Minimize need for new ground support equipment	Comparable with most existing vehicles Location of servicing points comparable with existing aircraft Sill heights comparable to 747
• 90 minutes turn around-time	16 large doors, 2 decks, 2 aisles each, 2 stairs, 2 catering lifts, potential upper deck access with passenger flow improvements
• Low noise and emissions	Meet latest ICAO standards with margins
• Jet blast comparable to existing jets	Four Engines, with similar thrust to A330

There are a number of factors that relate to the wingspan, weight and capacity of the aircraft that airports will have to take into consideration however. With a wingspan of 79.8m(262ft) and fin height of 24m(79.6ft) the main area that airports will need to address are runway and taxiway separation distances. These vary from one airport to another with many newer airports already being fully A380 compliant. Although the pavement loading of the A380 is comparable to existing aircraft, the weight-bearing limit of tunnels and bridges will need to be verified to ensure they are capable of supporting the 562t Maximum Ramp Weight of the aircraft. Parking stands will need to be upgraded to cater for the greater wingspan, alternatively the size of aircraft on the stands either side of an A380 could be limited. With a seating capacity approximately 35% higher than the 747-400, terminal facilities directly related to aircraft capacity such as gate holding rooms, may require modification. The amount of modification required at airports will vary considerably dependant on the compatibility of existing infrastructure.

THE SMART INVESTMENT FOR AIRPORTS

Many airports are already congested today, accommodating future growth with the existing aircraft mix would require additional infrastructure to provide the extra stands and slots. This would require the construction of new runways, taxiways, parking areas, terminals and gates with costs in the region of several billion dollars. As aircraft capacity has hardly changed for three decades there is an urgent need to prepare for the future. The A380 carries 35% more passengers than a 747, thus allowing airports to accommodate growth within their current infrastructure, therefore mitigating the need for such massive infrastructure investment. Adaptation of airports to accommodate larger aircraft is cheaper, simpler and more space efficient than the duplication of runways and gates. For those airports that are land constrained and/or movement limited by local environmental legislation, large aircraft are the only solution to cater for growth. The costs related to the integration of the A380 are incremental and relate only to airside, apron and terminal upgrades ($100 million - Airports Council International – North America average). They are dependent on a variety of factors including the level and layout of existing infrastructure, frequency of A380 operation and adoption of operational recommendations. This level of investment is small in comparison to total airport expenditure and much less than that required for new airports, which are also subject to very long planning and construction periods.

REGULATORY ASPECTS

The costs of adapting an airport to handle the A380 can be minimized by applying current accepted airport operational recommendations rather than design recommendations (Figure 3), which are applicable to new airports and new areas of existing airports. The A380 Airport Compatibility Group (AACG) was the first group dedicated to airport operational recommendations and they now work jointly with the FAA and ICAO on A380 operations. The AACG Common Agreement Document was completed at the end of 2002. Four European civil aviation authorities have signed a letter, stating that the AACG document constitutes a sound basis for any adaptation of their respective regulations, to facilitate the introduction of the A380 for safe and harmonised operations into existing airports. A CD-ROM containing the complete AACG documentation was officially released to ICAO on January 31st, 2003.

Dissemination of AACG work to ICAO, FAA, A380' airlines and airports, international and working groups dealing with new large aircraft operations was conducted through presentations at ICAO Europe (October 2002), ICAO Montreal (November 2003) and FAA (November 2002).

Following the dissemination of the AACG work Airbus is currently assisting in the definition of operational recommendations in conjunction with both ICAO (circular on new large aircraft operations, including A380 specifics discussed at Airport Design Study Group meetings in July and October 2003 - planned to be issued by year end) and the FAA (modification of standards requested by major US airports - expected FAA answers by early 2004).

GROUND OPERATIONS

The main driver for ground operations of the A380 was to be as compatible as possible to existing wide-body aircraft in all key areas, these include manoeuvrability on ramp and taxiway systems and terminal operations. To facilitate this aim, Airbus has and continues to work closely with airlines, airports, ground handling companies, ground servicing equipment (GSE) manufacturers to ensure the all aspects of ground operations will be ready for the A380 when it enters service.

MANOEUVRABILITY

Recent modifications to corners of taxiways to suit the greater turning circles of the A340-600 and 777-300 will allow the A380 to manoeuvre without restriction (Figure 4). Although the track of the A380 landing gear is slightly wider than those aircraft its wheelbase is shorter. This means that the effective clearance between the main wheels of the A380 and the edge of the taxiway is greater. Visibility from the cockpit also directly influences the accuracy of ground manoeuvring and in this respect the A380's mid-deck cockpit position offers a better field of vision than the 747. It also makes the transition from other Airbus wide-body types to the A380 easier for pilots.

Current Regulatory situation

- Operational recommendations for existing aircraft
  - Operational standards are aircraft specific and used worldwide for 747 operations with no reduction in safety levels
  - Based on **Risk Analysis** and **Aeronautical Study**
  - A380 Airport Compatibility Group (AACG) – Industry consensus on A380 operational standards for **existing airports** between Aviation Authorities and airports' experts
- Design recommendations for future developments
  - Values for generic large aircraft published:
    - ICAO Annex 14 Code F
    - FAA AC 150/5300 Group VI
  - Applicable to **new airports** and **new areas** of existing airports

Compatible with existing taxiway systems

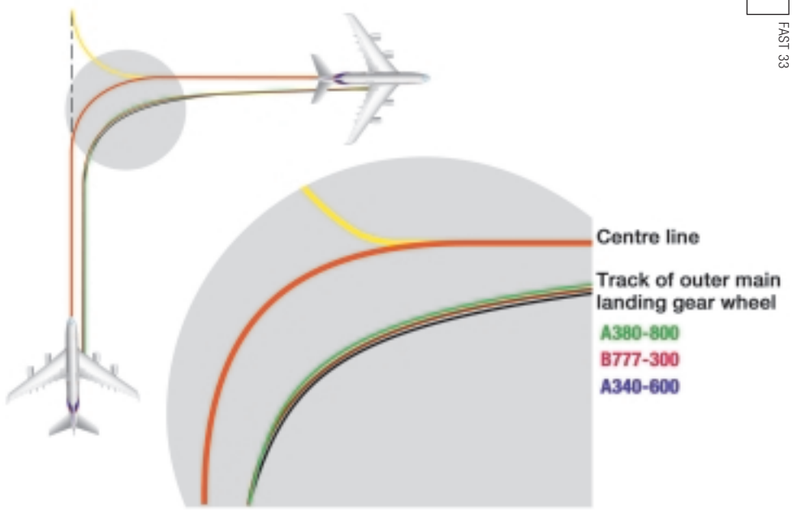
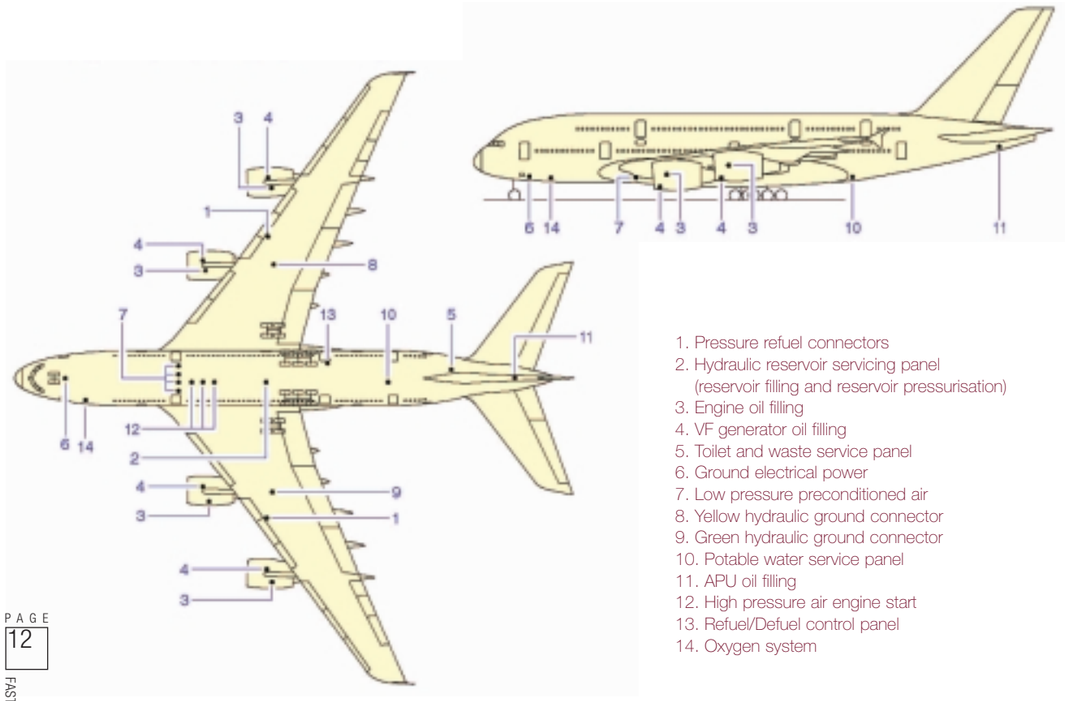


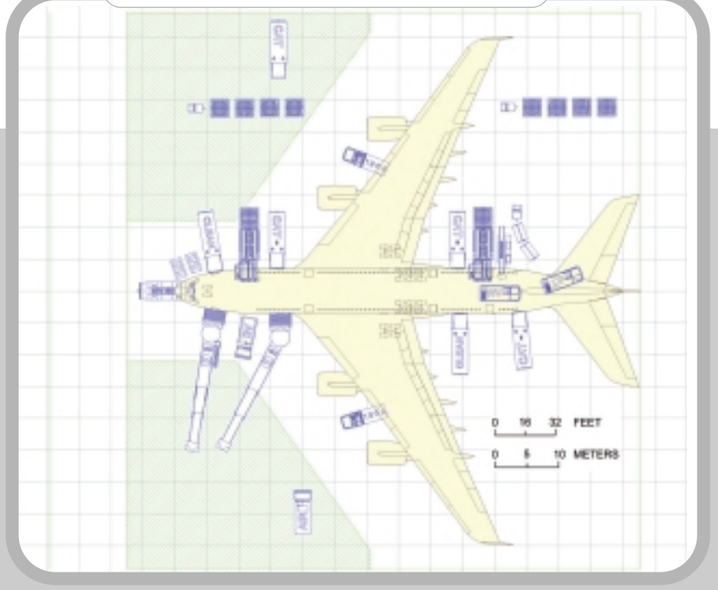
Figure 4 - Turning Radii of the A380 compared to existing wide-body aircraft

Figure 5 - A380 conventional ground servicing points



1. Pressure refuel connectors
2. Hydraulic reservoir servicing panel (reservoir filling and reservoir pressurisation)
3. Engine oil filling
4. VF generator oil filling
5. Toilet and waste service panel
6. Ground electrical power
7. Low pressure preconditioned air
8. Yellow hydraulic ground connector
9. Green hydraulic ground connector
10. Potable water service panel
11. APU oil filling
12. High pressure air engine start
13. Refuel/Defuel control panel
14. Oxygen system

Figure 6 - A380 ramp layout with main deck servicing



TERMINAL OPERATIONS

Essentially from the main deck to ground level the A380 offers the same accessibility as existing wide-body aircraft. Ground servicing locations have been agreed with airlines to ensure compatibility with existing ground servicing vehicles (Figure 5 & 6). The size of the A380 cabin will drive specific ground servicing requirements, in particular for the amount of electrical power and preconditioned air. Additional ports for ground electrical power and a higher flow rate for the preconditioned air cater for the increased demand, which existing servicing equipment can provide.
The cabin architecture of the A380 allows turn-around times similar to the 747-400. This has largely been achieved by the optimal positioning of the A380's wide dual lane stairs in the cross aisle between Doors 1 left and right on the main deck. This allows the same two bridge arrangement to be used as the 747 but results in separate and simultaneous boarding flows onto the upper and main decks (Figure 7). This considerably improves passenger boarding and de-boarding times, a critical component in the turn around time of a large aircraft.

In those cases where airlines or airports wish to offer an increased level of passenger service or faster turn-around times, specialised equipment such as upper deck boarding bridges and upper deck catering vehicles are required. In those applications which necessitate new equipment with direct upper deck access capability, Airbus has taken a proactive approach in facilitating the communication between the airlines, airports and GSE manufacturers. This primarily includes the organisation of working groups and open forums where manufacturers can present their design concepts and receive feedback from airlines and ground handling companies. As well as the organisation of these meetings, Airbus provides A380 technical data and has set up e-rooms which greatly aid the interchange of information between working group members.

Instigated in February 2001, the upper deck catering vehicle working group is the longest running of these forums. Several manufacturers have shown detailed design solutions for such a vehicle whose main requirement is to service the 8m high upper deck directly. As part of its commitment to ensuring the availability and safe operation of such vehicles by A380 entry into service, Airbus has recently completed a full scale partial mock-up of the A380 in Toulouse (Figure 8) which will be used for operational testing. These tests will initially use existing 5m main deck capable catering vehicles to validate positioning concepts and the interaction with other GSE. When prototype upper deck catering vehicles are available, the mock-up will be offered for full scale operational testing and possibly familiarisation training.

Figure 7 - Balanced boarding flows

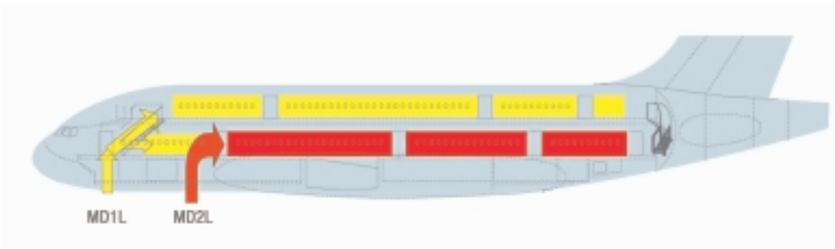


Figure 8 - Initial positioning tests conducted at the full scale A380 upper deck catering vehicle mock-up

PAVEMENT LOADING

Full scale pavement testing to optimize and validate A380 landing gear design was started in 1998 at Toulouse Blagnac airport (Figure 9) with two phases (flexible and rigid pavement tests). New test-validated methodologies are under development, using a software called ALIZE to supplement and eventually replace the current Aircraft/Pavement Classification Number (ACN/PCN) method which although widely used has limited theoretical basis. The development process will see ALIZE calibrated against results from full-scale static and fatigue tests using real aircraft on both flexible and rigid pavements. A380 landing gear configurations as well as those for some competing aircraft were reproduced using a landing gear configuration test vehicle. The results obtained from the test vehicle were also validated against production aircraft.

Figure 9 - Location of Pavement Experimental Programme (PEP) sites

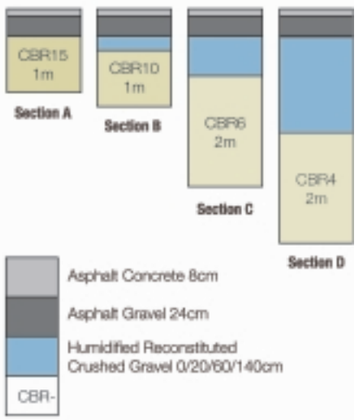
In both of the tests four 30m x 35m segments of pavement were prepared, each separated by 5m of neutral pavement. (Figure 10). Each segment represented a pavement laid on a different quality of natural foundation called subgrade and measured on the CBR (California Bearing Ratio) scale. The three weaker subgrades CBR10, 6 and 4 were covered first with a layer of humidified reconstituted crushed gravel then a layer of asphalted gravel and finally with a layer of either asphalt for the flexible surface or concrete for the rigid surface. Dozens of strain gauges were placed in the surface to measure the effect of different weights of aircraft on the pavement.

Figure 10 - Pavement tests

Flexible Experimentation: tests facilities and means

Experimental test runway structures:

Lengthening of a taxiway
4 Sections: CBR15, 10, 6, 4
each 30m width, 35m long
Neutral separation zones each 5m long



SPECIMEN PAVEMENT DESIGN :
ACCORDING TO THE CBR METHOD, WITH B747-400 AS SIZING AIRCRAFT, VALIDATED BY ALIZE SOFTWARE

The landing gear configuration test vehicle was built to simulate different full scale landing gear layouts and different weights of aircraft (Figure 11). A340 wheels and tyres were used with tyre pressure being varied to simulate the tyres of different aircraft types. A load per wheel of up to 32 tonnes was made possible by the addition of ballast to the vehicle. Both Airbus and other aircraft were used to validate the results obtained from the vehicle tests.

Airbus can now simulate any landing gear configuration with the associated aircraft weight and load transferred through each wheel. The strain gauges on the eight pavement and subgrade samples show the actual load on the surface. Results obtained from the pavement tests have been in line with the outputs from the ALIZE model and validate the comparable pavement loading of the A380 to existing aircraft.

- Modular assembly (2 to 5 bogies)
- Full-scale landing gear
- Variable track and tandem
- Wheel load up to 32 tons
- A340 tyres (pressure adjustment to simulate other aircraft tyres)
- Auto-powered (2 to 4km)

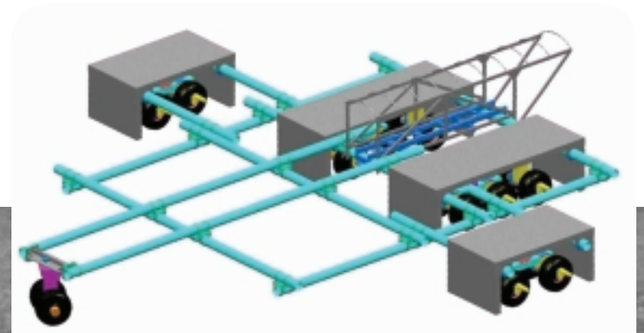


Figure 11 - Modular landing gear test vehicle

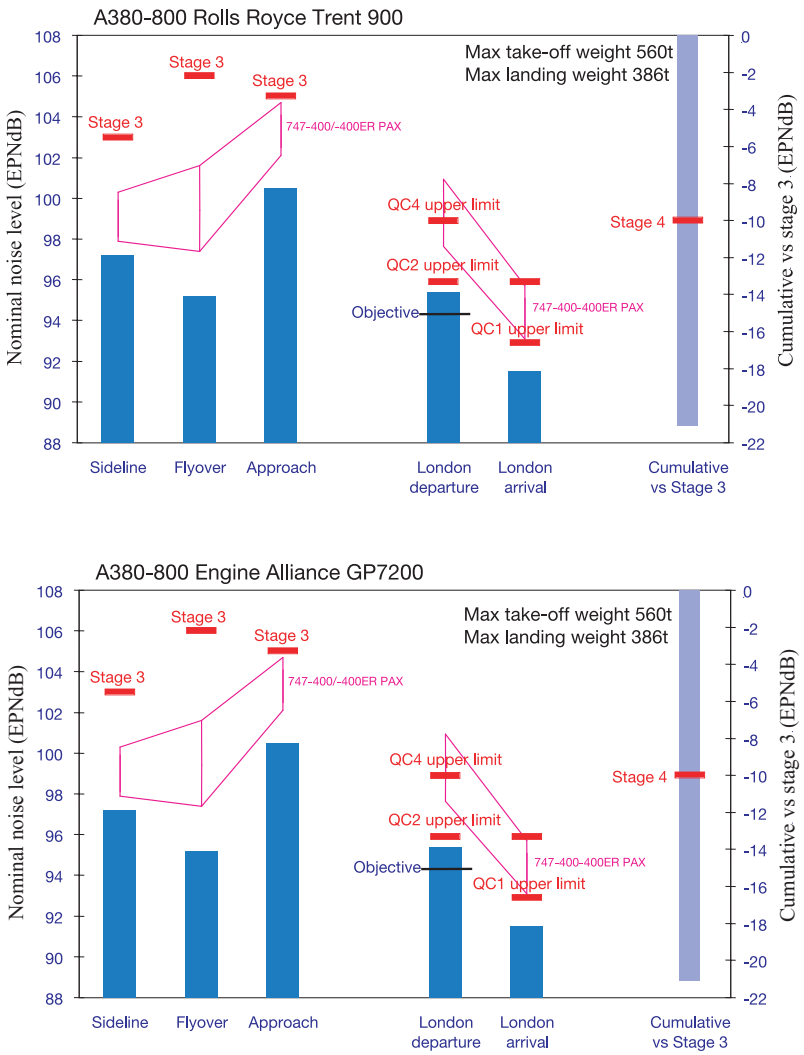


Figure 12 - A380 noise levels in comparison to international and local limits

ENVIRONMENTAL ASPECT NOISE

Low noise characteristics have been a major design driver and as a result the A380 will be significantly quieter than current large aircraft and have substantial margins in relation to today's (ICAO stage 3) and future (ICAO stage 4) noise limits. As well as international regulation, the A380 also has a significant advantage over existing large aircraft based on the very stringent local noise regulation such as the Quota Count (QC) system at the London airports of Heathrow, Gatwick and Stansted (Figure 12).

These noise levels have been achieved through the optimisation of the engines, nacelles and airframe. In addition to the physical optimisation, the A380 will be equipped with a novel function that will see the Flight Management System (FMS) programmed with optimal noise trajectories. These will allow the aircraft to reliably and continuously follow the Noise Abatement Departure Procedure (NAPD) while taking into account actual aircraft parameters and ambient conditions.

Conclusion

The A380 offers airports an immediate solution to cope with the forecast ongoing growth in air traffic. With its larger capacity it offers the most efficient use of terminal stands and runway slots thereby mitigating the requirement for complex and costly infrastructure development. Through a process of consultation from a very early stage, many aspects of the A380 have been optimised for airport compatibility resulting in an aircraft that can be integrated into existing airports with a minimum of change and hence investment. Airbus continues to work with all parties concerned to ensure that airports will be ready for the A380 when it enters into service in 2006.

From an environmental perspective the application of new technology and intensive research has enabled the A380 to combine the intrinsic advantages of its larger capacity with much lower noise compared to existing large aircraft.

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This web edition updates the paper version reflecting the evolution of the programme.