

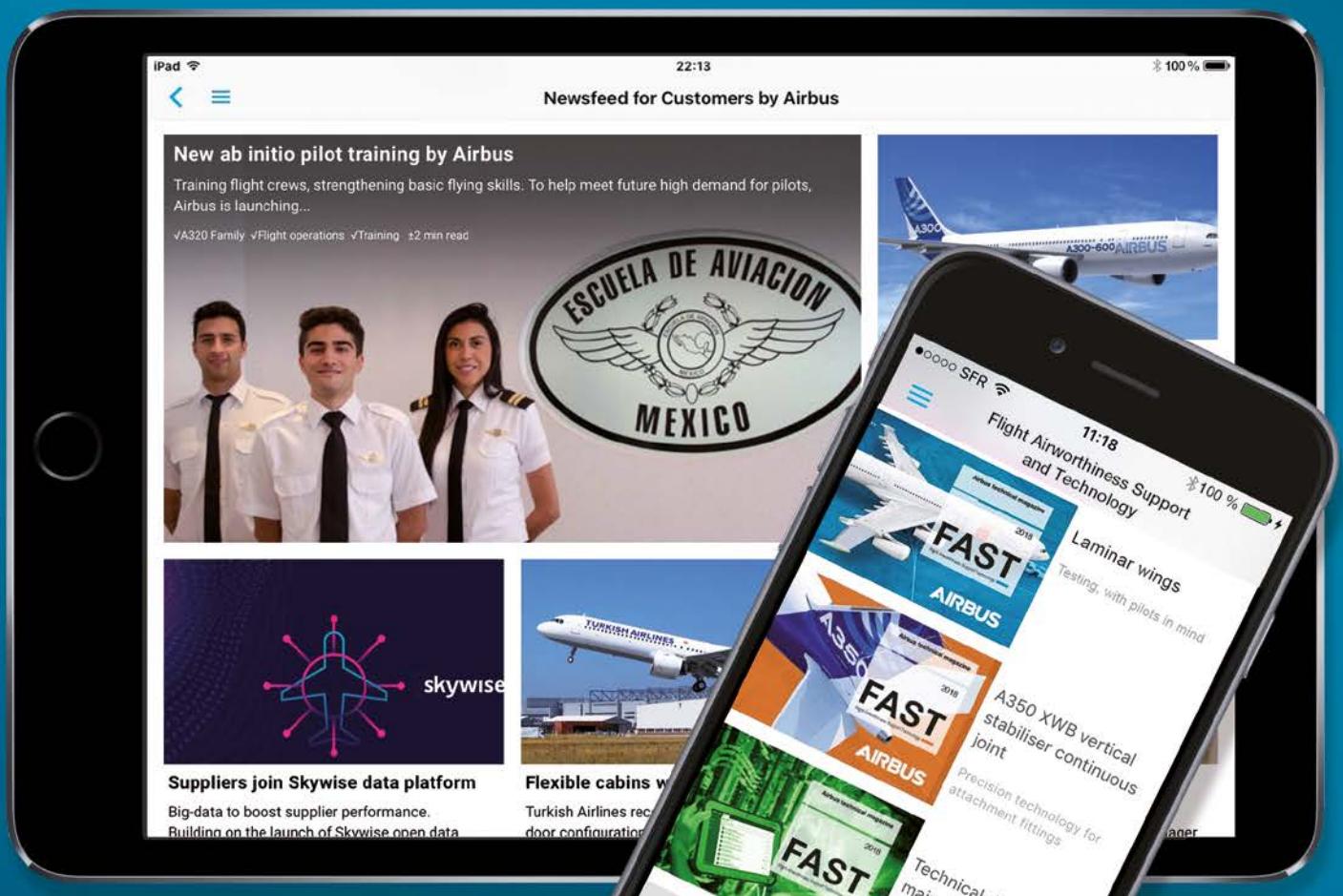
#62

# FAST

Flight Airworthiness Support Technology

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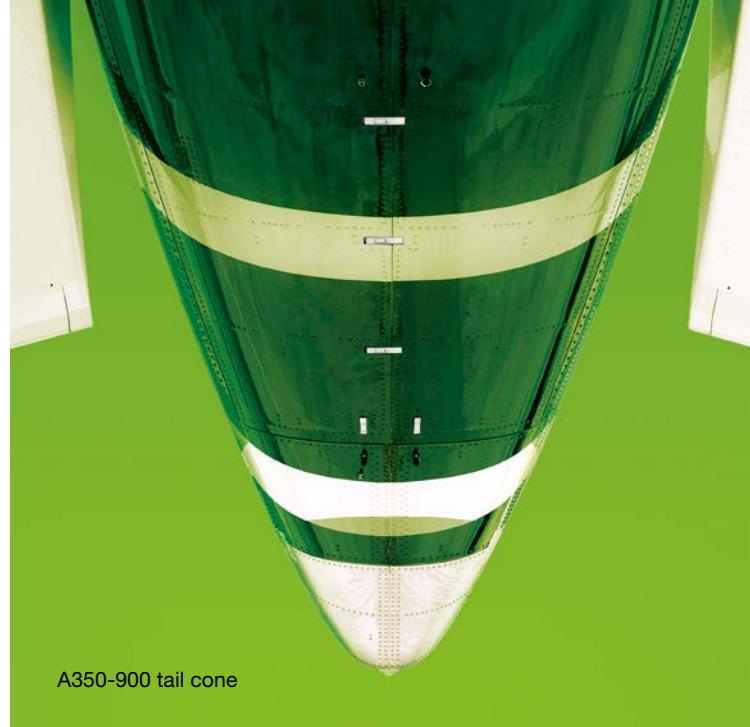


Airbus technical magazine

#62

# FAST

Flight Airworthiness Support Technology



A350-900 tail cone

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# Focus on fuel

**Increasing efficiency and reducing emissions**



*Article by*

**Nicolas DUVAL**

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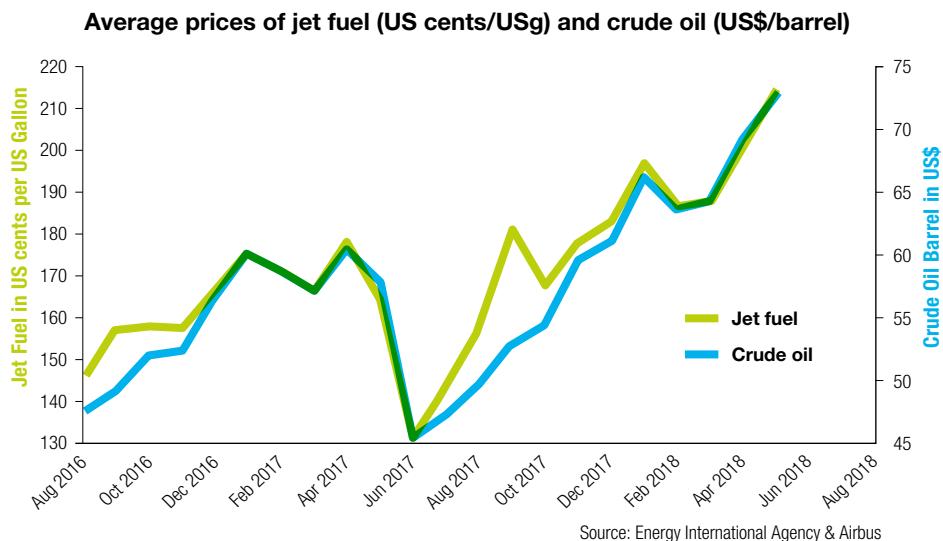
**Emmanuelle AYGAT**

Fuel and Emissions Performance Manager  
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**Fuel represents around 40% of an airline's direct operating costs and is subject to price volatility like few other overheads. Any reduction in consumption not only directly improves an airline's margins but, equally importantly, brings obvious environmental benefits.**  
**What's the latest on emissions regulation and how can operators reduce their carbon intensity?**

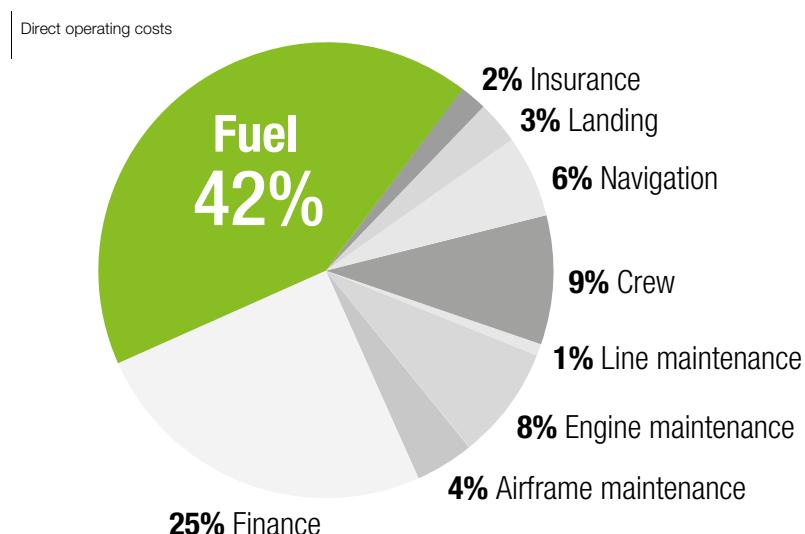


Jet fuel was 52% more expensive in May 2018 than it was a year earlier. That means, according to International Air Transport Association (IATA) data, that airlines will pay about \$40 billion more for fuel this year than in 2017. Indeed, the industry organisation has warned that its members' 2018 profits will be 12% lower than originally forecast, at \$33.8 billion, because of the fuel price spike.



Today's aircraft such as the Airbus A350 XWB, A320neo and A330neo are far more efficient than previous models; the latest generation of engines brings double-digit fuel burn reduction, and incremental aerodynamic improvements such as Sharklets deliver smaller but regular gains.

However, it is an airline's entire operating environment and all the actors involved that contribute most to shaping its efficiency and its fuel consumption. That environment covers the complete flight cycle, from taxi to final approach, landing, ground operations, and maintenance.



# CORSIA and carbon offsetting:

## What you need to know

Aircraft engines produce nitrogen oxide, unburnt hydrocarbons, particulates and noise. Reducing levels of each requires different methods. For example, Airbus has partnered with British Airways to reduce the noise impact of the A380 around London Heathrow. They have worked with the thrust and climb angle to reach higher flight levels sooner on departure, and with the thrust and angle of descent to stay higher for longer on arrival. The project has seen improvements over some communities of up to nine decibels on departure and up to two decibels on arrival. However, this inevitably has an effect on fuel consumption.

As the most well-known of combustion engine emissions, carbon dioxide gets the most attention. A single ton of jet fuel produces just over three tons of CO<sub>2</sub>. To reach civil aviation's self-imposed aim of stabilising carbon emissions at 2020 levels, regulated monitoring and offsetting is acknowledged as compulsory in an industry where, according to IATA, passenger numbers will almost double between 2016 and 2035 at a 3.7% compound annual growth rate.

One pan-national monitoring device is CORSIA – the Carbon Offsetting and Reduction Scheme for International Aviation. It is a global initiative overseen by ICAO, the International Civil Aviation Organisation. CORSIA will make it compulsory for airlines operating international flights to offset their CO<sub>2</sub> production through emission credits on a carbon market fed by sectors seeking to reduce their emissions.

From 2019, airlines involved in CORSIA will be required to monitor and report their CO<sub>2</sub> emissions. They should begin preparing compliance from 2018. Although the scheme does not fully enter into effect until the end of 2020, thanks to the voluntary participation of numerous nations it is estimated that 80% of international air traffic will be covered by the scheme from 2021. State participation becomes mandatory in 2027.

Airbus supports ICAO and IATA in building awareness and helping deployment of CORSIA among airlines. Through the Sustainable Aviation Engagement Programme, Airbus already offers help to airlines with the monitoring and reporting of emissions to authorities.

As an example, in December 2017 the Indonesian Directorate General of Civil Aviation (DGCA) hosted a CORSIA workshop in Yogyakarta in collaboration with Airbus, Vertis Finance, Garuda Indonesia and with support from ICAO's Technical Cooperation Bureau. Representatives attended from south-east Asian airlines, civil aviation authorities and airline associations. The aim was to deliver a concrete implementation plan to Garuda and DGCA Indonesia to manage and declare the airline's CO<sub>2</sub> emissions and offsetting obligations.



### What is offsetting?

Carbon offsetting is simply a way for individuals or organisations to neutralise their proportion of an aircraft's carbon emissions on a particular journey by buying carbon credits on the market and investing in carbon reduction projects.



### CORSIA key dates for airlines

- 2018** Prepare compliance
- 2019** Monitor, report emissions
- 2021** 80% international traffic covered by scheme
- 2027** Mandatory participation

2010 1.5% fuel efficiency per year	2020 Carbon neutral growth	2050 -50% CO <sub>2</sub> emissions compared to 2005	For more on CORSIA see the ICAO website <a href="http://www.icao.int">www.icao.int</a>
Airbus supports the ATAG* aspirational objective to achieve 1.5% fuel efficiency per year with new technologies and new aircraft <small>*Air Transport Action Group</small>	<b>CORSIA</b> Airbus supports ATAG, ICAO, states and airlines to ensure the successful implementation of the CORSIA scheme - also contributing to capacity building	Airbus supports ATAG in this ambitious and challenging goal towards a 2-degree pathway requiring significant research, investment and policy development	



## Learning to be more fuel efficient

While fuel efficiency recommendations are most effective when tailored to the particularities of an airline's fleet and operations, some tools that help reduce consumption can be universally applied. They are detailed in Airbus' reference guide 'Getting to Grips for Fuel Saving' whose latest, updated version is planned by the end of 2018.

'Getting to Grips' includes best practices on flight and ground operations; maintenance task recommendations; information on CORSIA; the role of air traffic management in fuel saving; sustainable fuels; and details of Airbus' aftermarket and upgrade services that offer 'quick win' improvements. The upcoming version has a simplified structure and in 2018 it will cover the A320neo and A380. The A350 XWB and A330neo will be covered in a subsequent edition.

Quick wins offered by Airbus include single engine taxi without APU, known as SETWA. SETWA enables an A320ceo aircraft to save up to 25% in fuel burn compared to two-engine taxiing, with negligible weight increase. It is available on the A320 Family, A330, A350 XWB and A380.

In addition to the Getting to Grips guide, Airbus hosts yearly fuel savings and emissions reduction seminars to examine and discuss latest developments and technologies. In 2018 the event reached its seventh edition. It was attended by some 160 delegates representing over 50 airlines as well as airports, air navigation service providers, original equipment manufacturers, environmental bodies, and fuel producers from across the world.

The seminar is a useful networking opportunity for the fuel efficiency managers, pilots and flight operations specialists who attend. It emphasises interactivity to explore and respond to airline needs. Subjects for debate and discussion are proposed by participants and presenters coming from diverse backgrounds to share their insight and experience. Areas covered at the 2018 event include using big data to better manage fuel, new technologies and a focus on ground operations.

The seminar is complemented by twice-yearly webinars that delve into more detail on the subjects it raises. It revolves around presentations by Airbus experts and detailed question-and-answer sessions. Participants at the March 2018 webinar discussed potable water uplift. Airbus and Finnair worked to reduce the amount of potable water carried on the airline's fleet, presenting the results during the June seminar.

### Fuel savings & emissions reduction seminar: What the participants say



Operators work with Airbus in a partnership on fuel efficiency. We want the same thing, and can have a frank discussion of what we expect from you. Fuel is clearly an Airbus priority, and we know we can count on support when we make changes to our business.

The networking during the seminar is very valuable for meeting your opposite numbers at other airlines. The participation is very diverse. Swapping tips and hints when operations are comparable is great. I appreciate the Top Five, when we draw up top issues for Airbus to address and press you on how you will tackle them. Of course the following year we can review progress!

**Luigi FOFFA**

*Fuel Efficiency Manager, British Airways Engineering,  
Seminar caucus chairman*

The value of the fuel seminars lies in sharing ideas to overcome obstacles together. Every year the event allows us to step out of the day-to-day, reflect and gain some perspective. This is especially relevant in fostering culture change around the next generation of aircraft that come with new fuel saving innovations, techniques and tools.

Airbus' information sharing is encouragingly consistent, as the yearly seminar is complemented by webinars at regular intervals. The fact that you're listening to operators, that's the key to great customer support.



**Mike PULASKI**

*Senior Manager, Fuel Smart, American Airlines*

# Applying fuel efficiency solutions

Fuel efficiency can be optimised by concentrating on pragmatic continuous improvement in ground operations, flight operations, and maintenance.

## Ground operations

Several options for so-called 'green taxiing' exist, from single engine use to hybrid or fully electric manoeuvring. Ground movements represent about 15 minutes per flight; 'green' taxiing can significantly reduce fuel burn during the phase. Airbus offers three solutions to improve efficiency – SETWA (see above), TaxiBot and eTaxi. They deliver between 25% and 85% fuel savings on the ground compared to standard operations, and reducing emissions.

**TaxiBot** – Single aisle aircraft are towed by a semi-robotic, pilot-controlled vehicle with engines switched off. Modification involves a switch on the cockpit centre pedestal, and taxiing fuel savings of up to 85% can be achieved compared to two-engine operations. TaxiBot is already available for the A320 Family and will be certified for the A330, A350 XWB and A380.

**eTaxi** - Aircraft can taxi without engines or without requiring airport tractors or tugs. A significant modification is needed to install electric motors in the main landing gear that are powered by the APU. But eTaxi brings savings of up to 85% compared to two-engine taxi and removes pushback fees: the weight of the electric motors is compensated by fuel savings. It will be available on the A320 Family from 2021.

## Flight operations

Airbus' Green Operating Procedures highlight how fuel burn can be optimized during all phases of flight. Operators can use them to define their own fuel policy as part of a general cost reduction policy covering maintenance and operating costs, fuel consumption and passenger comfort. Savings can be achieved, for example, by using a Ground Electrical or Pneumatic Unit instead of an Auxiliary Power Unit at the gate, by optimum flight level during cruise, or by optimization of the descent profile.

Air traffic doubles every 15 years, raising challenges to safety, reliability and the sustainability of aviation itself. To respond to these challenges, the Airbus subsidiary NAVBLUE develops digital flight operations and air traffic management solutions which offer major improvements for navigation, enhanced operations and savings. Extra fuel reserves are used to cover potential uncertainties during flight; however, they increase aircraft operating weight and fuel consumption and may reduce payload. Using an MSN or 'tail-centric' approach, NAVBLUE offers a set of innovative applications to save fuel. Its consulting services help airlines implement a fuel and flight efficiency strategy by optimizing activities related to flight preparation and flight operations.

## Maintenance

The airframe is a complex shape and includes many panels, doors and flight control surfaces. In order for the aircraft to perform at its optimum efficiency - i.e. to create the lowest amount of drag - the airframe must be as free from irregularities as possible. This means that surfaces should be as smooth as possible, panels and doors should be flush with surrounding structure and all control surfaces should be rigged to their specified position.

In terms of overall airframe condition (dents, panel gaps, under or over filled panel joints, etc...), particular attention should be paid to areas of the airframe that air impinges on first (e.g. forward portion of the fuselage, the nacelles, wings, fin, etc).

One objective of the maintenance schedule is to preserve the aircraft's operational efficiency by the most economic means possible. This is achieved through inspections, and subsequent repair as necessary, in specified areas at specified intervals. These intervals are the minimum allowable, but the industry is constantly seeking to extend task intervals. Although carrying out any maintenance task more regularly might increase maintenance costs, some tasks can bring significant reductions in fuel consumption.

TaxiBot



eTaxi

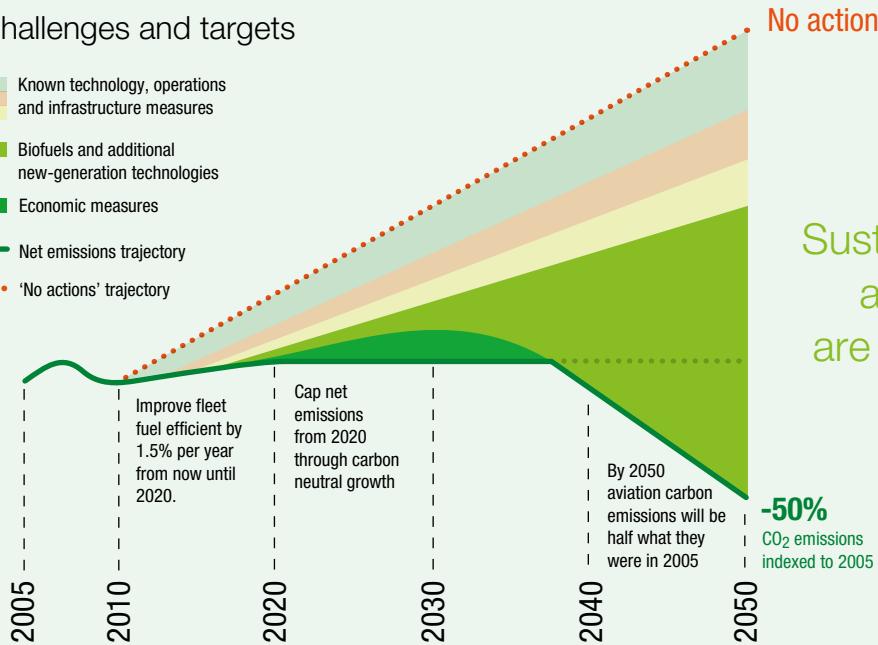


## Sustainable aviation fuels

Sustainable Aviation Fuels (SAF) are a significant pillar to be used by aviation to reach carbon neutral growth. SAF are built by blending alternative and renewable sources of raw materials with conventional fuels. A variety of blends is available on the open market, although the sector is still in its infancy in terms of large-scale use. Compared to conventional jet fuel, SAF can reduce life cycle greenhouse gas emissions by up to 80%.

### Challenges and targets

- Known technology, operations and infrastructure measures
- Biofuels and additional new-generation technologies
- Economic measures
- Net emissions trajectory
- ... 'No actions' trajectory



Sustainable aviation fuels and new technologies are expected to account for more than 50% of CO<sub>2</sub> savings

Around 100,000 flights per year are now operated using SAF, according to IATA data. However that amounts to just 0.5% of the aviation industry's total fuel bill of around \$200 billion a year. IATA says a 'massive uplift' in SAF production and use is necessary to reach a 50% cut in net CO<sub>2</sub> emissions by 2050, compared to 2005 levels.

Airbus offers customer ferry flights from its Toulouse base using a biofuel blend provided by Total. Cathay Pacific uses the facility for each A350 XWB delivery, including its first A350-1000 which left Toulouse in June carrying a 10% blend of sugarcane-based biofuel. Other customers, including China Airlines and Iberia, have also used the facility for their ferry flights. Airbus' delivery centres in Mobile (Alabama) and Finkenwerder (Germany) have been identified as the next targets for SAF facilities.

## CONCLUSION

Effective fuel management is essential to optimising airline operations and reducing aviation's environmental footprint. This is especially true at times of fuel price volatility. While latest-generation engines such as those that power the A320neo, A330neo and A350 XWB offer significant savings, it is important to see the bigger picture. Fuel burn can be truly optimised by implementing performance-boosting retrofits and running efficient ground, flight and maintenance operations.

Fuel efficiency recommendations are subject to continuous improvement and Airbus works closely with its customers to optimise fuel consumption. Airbus is of course fully committed to carbon-neutral aviation through its support for monitoring initiatives such as CORSIA and institutional programmes such as the United Nations' Sustainable Development Goals. ■■■

# Lightning and HIRF effects

**Monitoring aircraft to ensure long-term protection**

*Article by*

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**When lightning strikes an aircraft, the result looks spectacular from the ground and it can also cause alarm for passengers. However, aircraft are designed to cope well with what is actually a fairly common event – on average a passenger jet will be hit by lightning once every 1,000 flight hours. Airbus monitors one of the different means of protection against lightning which also contributes to protecting aircraft against High Intensity Radiated Fields (HIRF).**



# What happens during a lightning strike?

Lightning strikes are most likely to occur during landing and takeoff flight phases when aircraft are passing through cumulonimbus clouds that create high electrical charges. Strikes are less likely during cruise phase, partly because most cruising altitudes are well above the clouds, but also because pilots can navigate around storms once they are well into their journey.

Lightning arrives at the extremities or protuberances of the aircraft, usually a wing tip or the nose; this is known as the entry point. It then leaves from another extremity, or exit point, such as the tail, as it continues on its path to earth. During this process the fuselage acts as a Faraday cage: an enclosure used to block electromagnetic fields and conduct the lightning current safely.

Those onboard might notice some noise, sense what feels like an impact and even experience brief disruption of the cabin lights; however there is usually no cause for concern. On traditionally designed aircraft the aluminium 'skin' does the conducting, while ultra-modern aircraft such as the A350 XWB have a copper layer embedded in their carbon fibre fuselage sections specifically to handle lightning.

The aircraft is designed to ensure aircraft structure electrical continuity. It is capable of distributing lightning current in a highly effective way, thus providing key protection. Nevertheless, there are other means of protection such as: systems architecture (ensuring redundancy and dissimilarity); devices/equipment protection (equipment qualification against electromagnetic hazards); and design and installation rules of the electrical installation.

## Dealing with induced current

When an aircraft is struck by lightning, induced voltages inside the fuselage may occur. These induced voltages are produced between the external surface of the aircraft, where the current is high, and the internal part of the aircraft which acts as ground to the potential reference.

The induced voltages could be enough to disrupt the aircraft systems if harnesses lacked an additional layer of protection. This protection is provided through the use of braided metal conduits which conduct current safely to the aircraft's voltage reference points, ensuring only a minor amount of current reaches the cables inside or metallic raceways protecting cable signals.

The conduits also function as a barrier reducing HIRFs\* such as those generated by radar stations. These could interfere with the functioning of aircraft systems but the braided conduits, combined with Electro-Magnetic Hazards (EMH) qualification equipment, ensure attenuation of HIRF events. All aircraft equipment is qualified against EMH, based on Environmental EUROCAE RTCA-DO160 (environmental conditions and test procedures for airborne equipment).

\*HIRF = High Intensity Radiated Fields



Braided metal conduits



# Checking for damage:

## Lightning/HIRF Assurance Plan

Of course, all this protection relies on the good condition of the conduits and their correct functioning throughout the aircraft's lifecycle. As well as satisfying airworthiness requirements of the conduits at the time of type certification, Airbus monitors them over time through a sampling campaign. This is known as the Lightning/HIRF Assurance Plan and through Airbus expertise, close collaboration with customers and systematic data gathering, it contributes to keeping the current fleet safe as well as to improving future aircraft design.

### How aircraft are selected

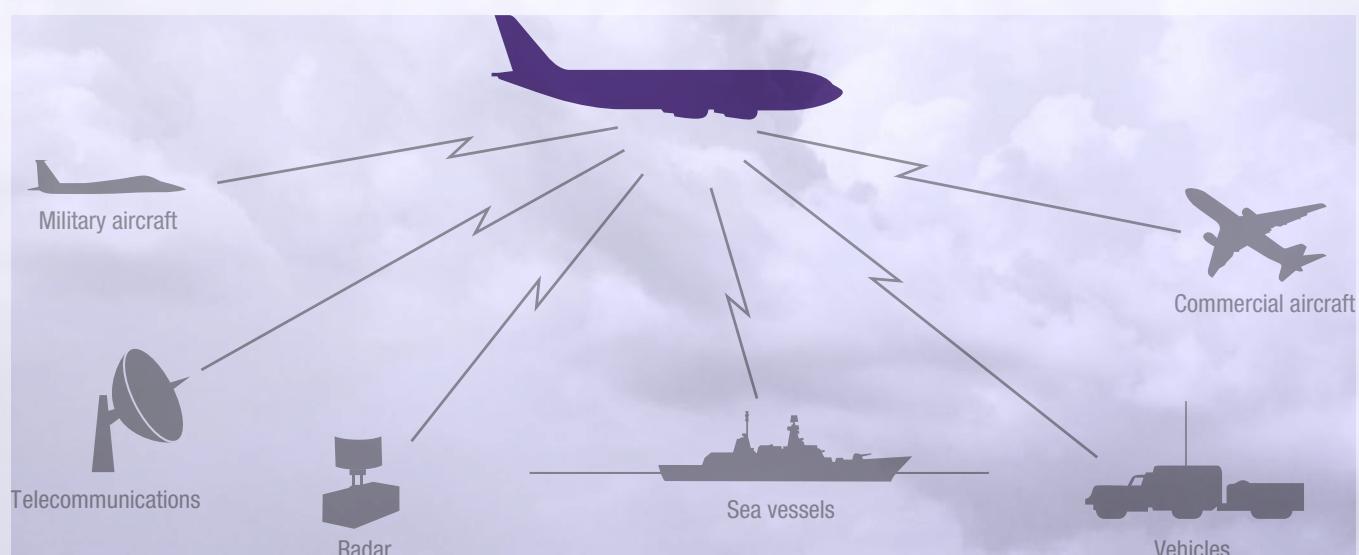
For each campaign, Airbus works on a representative sample of aircraft considering a range of environmental factors such as humidity, heat levels, routes, airports and distances covered. Having identified suitable aircraft for sampling, Airbus invites the corresponding operators to participate in the campaign with one aircraft from each fleet. Lightning/HIRF inspections are then organised to fit around the airline's routine maintenance checks so that there is no disruption to normal MRO scheduled activities.

Sampling campaigns start six years after entry-into-service, with one aircraft per family inspected per year. This sampling is repeated after 12 years (2nd campaign), 18 years (3rd campaign) and so on.

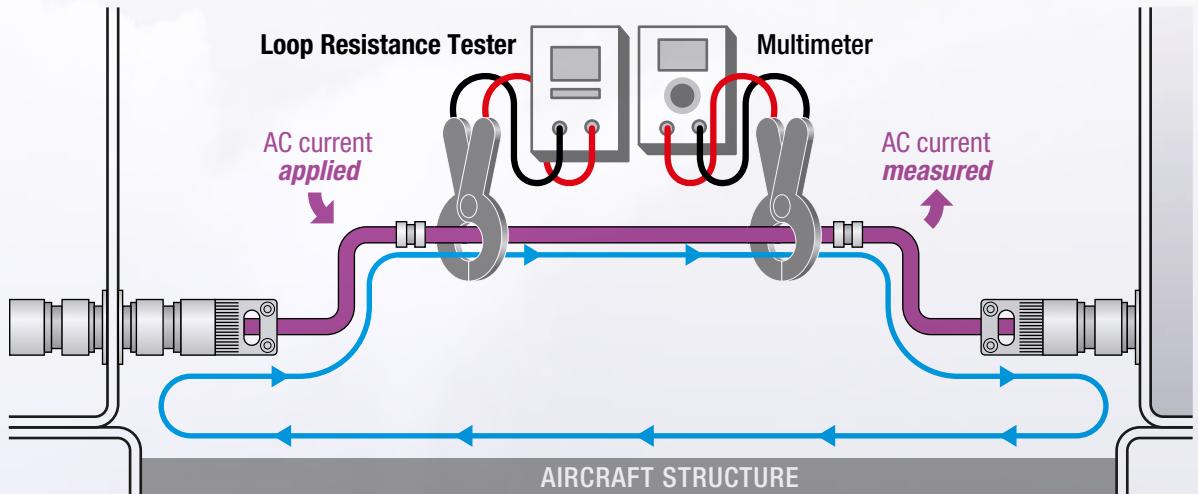
### The inspection: finding and fixing issues

Airlines are already obliged to carry out their own visual inspections. However, Airbus looks for signs which are not visible from the outside. These inspections can take place anywhere in the world and usually involve a small, multi-functional team of experts from Airbus with the full range of engineering and maintenance skills that could be required.

Potential sources of High Intensity Radiated Fields



Most of the work involves a device known as a loop resistance tester (LRT). With all aircraft systems switched off, this is clamped onto a section of the braided conduit and a measured current is applied. The team measures the flow of charge through the conduits. The LRT shows how well the conduit is conducting the current, thus demonstrating the status of the harness protection. If any sign of conductivity reduction is revealed, the LRT pinpoints the cause. The team has a part 145 qualification allowing it to work on the aircraft and repair or rectify as required, free of charge.



This process is repeated on conduits all over the aircraft over a period of several days and all data about different forms of degradation is recorded. Causes of conductivity reduction have included mainly degradation of bonding areas linked to environmental conditions. The team can deal with many issues directly on-site. It tends to find fewer issues on older aircraft as modifications and service bulletins, made following earlier sampling campaigns, have guided constant refinements of the design.

#### **After inspection: bringing long-term solutions**

Once Airbus has inspected all targeted aircraft in a sampling campaign, it presents the findings to the aircraft certification authorities (EASA and FAA). After careful consideration, solutions are agreed for any issues that have been found. They could involve quality improvements, modifications, or changes to scheduled maintenance tasks. Finally, the outcomes may influence the scope and number of aircraft to involve for the following campaign.

The data gathered during campaigns is also extremely valuable in informing the design of aircraft and variants to remove common causes of degradation – an example of highly effective preventative maintenance. The work carried out on aircraft during inspections will influence current and next generations.

## **CONCLUSION**

Although aircraft are very well protected against lightning strike and HIRFs, the use of braided metal conduits to add an extra layer of protection to the aircraft's systems is essential for airworthiness certification. Through regular sampling campaigns, the Lightning/HIRF Assurance Plan helps to ensure that these standards are maintained throughout the lifecycle. Findings from inspections are shared with the certification authorities and the Airbus design office also uses them to refine their future use of conduits.

# Laminar wings

## Testing, with pilots in mind

Airbus is working at the heart of European research into the feasibility of natural laminar flow within an industrial environment. Known as BLADE (Breakthrough Laminar Aircraft Demonstrator in Europe), the project involves 21 partners and around 500 contributors working closely together as part of the Clean Sky\* European project. All of them depend on the data gathered by an Airbus flight test team to push the research further.





\***Clean Sky** is a European research programme developing innovative, cutting-edge technology aimed at reducing CO<sub>2</sub>, gas emissions and noise levels produced by aircraft. Funded by the EU's Horizon 2020 programme, Clean Sky is a joint undertaking that contributes to strengthening European aero-industry collaboration, global leadership and competitiveness.

FAST talked to (*left to right*)

**Julien Moreau** - flight test specialist engineer,  
**José Corugedo-Bermejo** - flight test engineer,  
**Thierry Fol** - flight lab leader,  
**Karl-Heinz Mai** - experimental test pilot,  
 to find out more about their role in the project,  
 how they keep airlines in mind and exactly how  
 they gather the data.



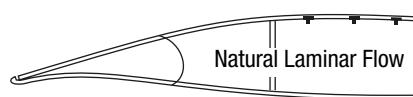
## FAST: What are you hoping to achieve with BLADE?

**Karl-Heinz:** The simplest way to put it is fuel efficiency. Natural laminarity is essentially super smooth air flow close to the wing skin and the resulting reduction in drag allows aircraft to fly using less power. In concrete terms, the use of laminar wings on short and medium range commercial aircraft could mean a 5% fuel burn saving, by modifying the shape and the surface finish. This would create many financial benefits, as well as a consequent drop in emissions. However, it has to be achieved without adding complexity in aircraft operation for pilots and airlines, and without having too much impact on cruising speed.

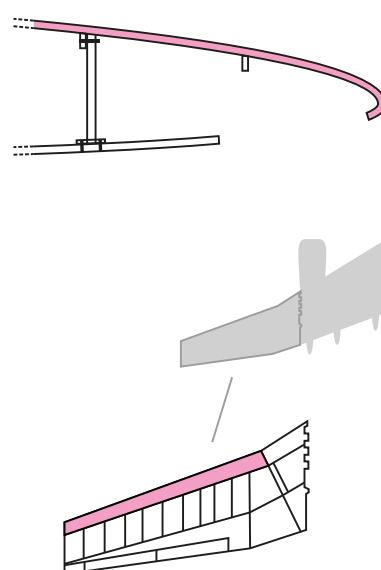
**Thierry:** We already know that laminarity works – gliders are usually laminar aircraft – but it has long been assumed that it is unsuitable for larger, more robust commercial aircraft with their need for much greater speeds and power. The argument has been that, although a laminar commercial aircraft is technically possible, it couldn't be produced at a cost that made it practical.

**Karl-Heinz:** That practicality is a recurring theme in the project. Laminarity's full benefits are probably best achieved at slightly lower speeds than airlines currently favour, so we have to consider the possible consequences for air traffic control. Flight controls and flight parameters have to be adapted to ensure that aircraft handling remains normal. The flight envelope might change a little and the physics might shift slightly but, for pilots converting to a laminar winged aircraft, there has to be no change.

Examples of two



Laminar wing structure concept  
with continuous surface



“5% fuel burn saving without adding complexity in aircraft operation for pilots and airlines, and without having too much impact on cruising speed”

## FAST: So are you flying with root-to-tip laminar wings now?

**Julien:** No, but that's quite a common misconception so it's best to be clear about what we do. We needed a scale-1 demonstrator to test the laminar surfaces that some of the BLADE partner companies have developed. This was firstly because we want to fly these laminar surfaces in representative aerodynamic conditions, in terms of Mach\* and Reynolds\*\* numbers.

And secondly, wings flex and distort in flight and that can disrupt laminar flow. We aren't flying around with a futuristic A340 wing. The experimental zone refers only to the panels of laminar materials in place of some of the outer wing panels of an A340 test aircraft. We're then monitoring what happens to those panels during real flights and sharing that data with the rest of the project.

**José:** You'd never see an aircraft in flight with different coloured panels; but we're not after cosmetic perfection, we just need results. Being able to use the first A340 ever built was fantastic because its big wings give us a natural zone to experiment: the 2/3 span of a typical transonic short-range aircraft wing of the type most likely to benefit from natural laminarity.

**Thierry:** That's one of the great benefits of being involved in this project – it's a genuinely experimental test flight campaign. If we need to check results or fly differently, we can. The partners tell us what they'd like to know, but we decide how to gather the data. This can be challenging but it's also fun being pushed to find solutions. Knowing about the transition from laminar to turbulent flow on a surface in a lab is essential. Knowing how much the distortion caused by the aircraft movement can trigger the transition is a whole new area.

## FAST: How do you gather the data?

**Julien:** A full list of techniques would be very long but I think the most unusual compared to standard flight test equipment probably involve infrared cameras, reflectometry, the waviness beam and pressure taps. Getting the first infrared images showing exactly where the transition line from laminar to turbulent air flow was on the test panel was a thrill for us all. Infrared isn't new technology but it was the first time anybody had mounted cameras on an aircraft tail and used it to measure laminarity on such a wide wing surface.

## FAST: How well is BLADE going and can customers buy aircraft with laminar wings in the near future?

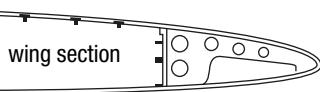
**José:** We can't answer the second part – we're working to establish how well the laminar panels supplied by our industrial partners will work in real flight conditions. We can say that, from a flight test point of view, they seem to be working well enough so far for us to be optimistic about the future.

**Karl-Heinz:** The other aspect is to emphasise what Julien said earlier – BLADE isn't about trialing a new type of wing. We're trying to establish whether laminarity can be a practical option for designers of future aircraft. At this stage we can't be certain that the potential fuel savings can become a reality while avoiding disruption and excessive expense, and we're in no position to guess at manufacturing costs. However, at Airbus we're commercial aircraft-minded people and we wouldn't be pressing ahead with a project like BLADE if we didn't think the signs were suggesting that this could be good for us and our customers.

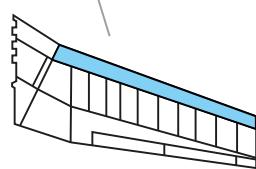
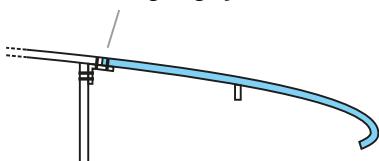
\* Mach: Ratio between speed of aircraft and sound of aircraft

\*\* Reynolds: Ratio between inertia forces and viscous forces inside the fluid

upper cover options



Laminar wing structure  
with leading edge joined to box



## Re-thinking testing methods

A great deal of the data gathered during the BLADE flights is gathered on all test flights and standard flight test installation equipment fulfils this function. However, the data relating to laminar flow required new equipment and new thinking.

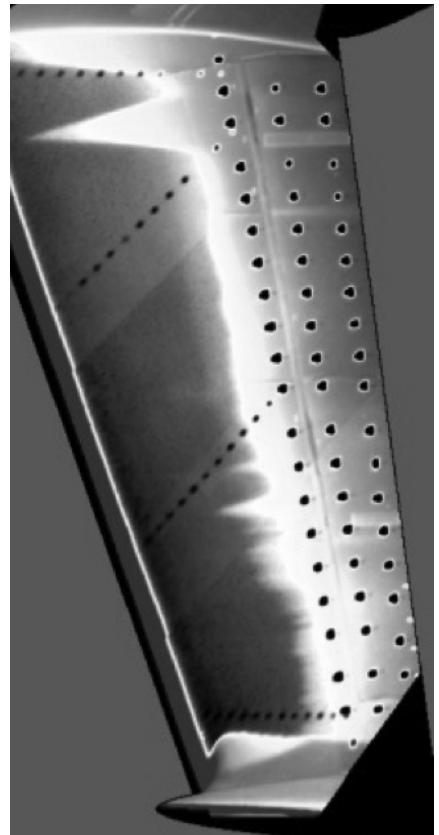
### Infra-red

To provide data that will help partners decide if a laminar wing will be a practical option for future serial production aircraft, the team needed to record changes in laminarity levels on the test panels in real time. The changes to the wing surface caused by adjustments in angle of attack or speed influence the air flow over the wing. To measure these changes, they used existing infra-red technology and skin temperature change at transition point.

As shown in the diagram below, laminarity involves a thin layer of smooth air flowing over the wing skin. When this flow ceases to be smooth and becomes turbulent, it has reached the line of transition and laminar flow has ended. The exact point at which this happens changes according to the materials and shape used to make the test panel and all the other variables that occur during flight.

The BLADE test team mounted infra-red cameras on the vertical tailplane of the A340 and these provide a stream of images showing the thermal patterns on the wing as shown in image to the right.

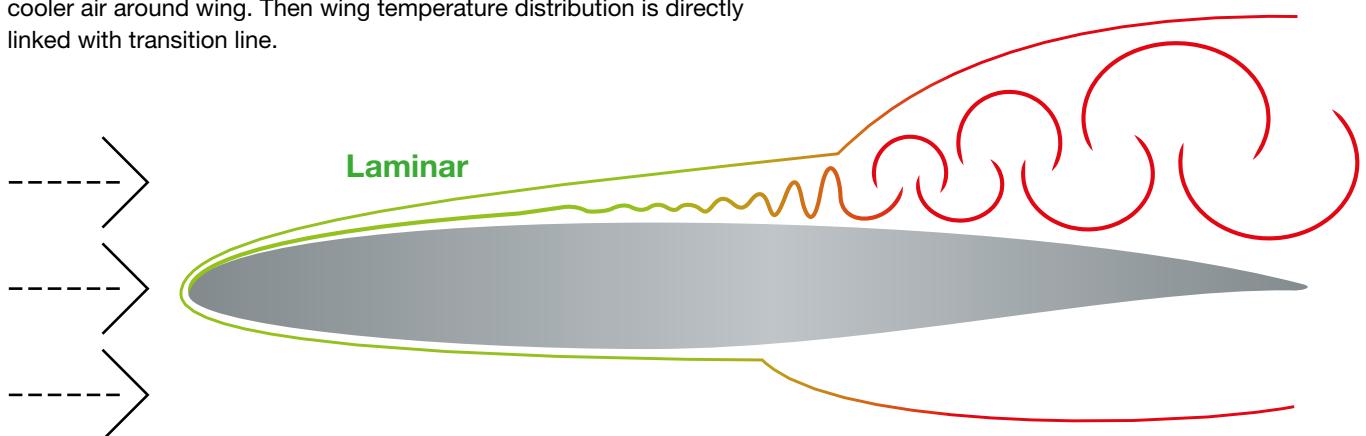
The areas where air flow is turbulent appear white and light grey in the infra-red images and the areas of laminar flow show as dark grey. Looking at these images alongside flight data allows an accurate account to be established of how the laminarity of the panels being tested changed in the course of any flight. This is crucial information for the wider BLADE project but whenever a change is detected a question is raised: Why did that change in laminarity occur?



Infra-red airflow

### Laminar flow

Turbulent air flow disperses wing heat by increasing mixing with cooler air around wing. Then wing temperature distribution is directly linked with transition line.

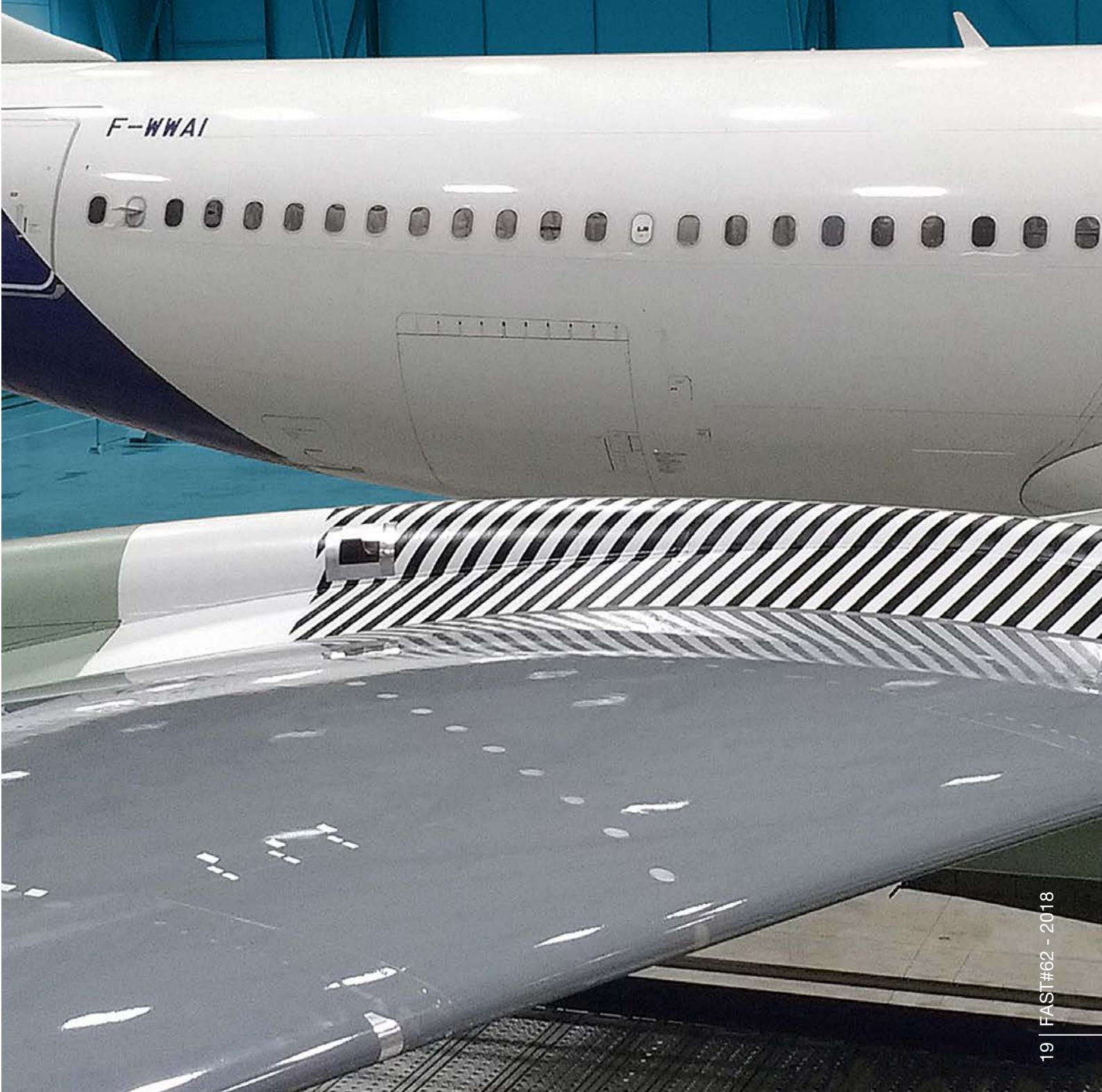


## Reflectometry

The answer is frequently to do with changes in the wing surface caused by pressure changes during flight. To measure these pressure changes, and the distortion they cause, the BLADE team combines a brand new technique with some well-established, pressure-measuring ones.

The new technique is known as reflectometry and relies on the basic concept that, to get a perfect reflection, a completely flawless reflective surface is needed. The further that surface moves away from perfection, the more distorted the reflected image becomes, as demonstrated by mirrors at fairgrounds.

This is the first time that reflectometry has been used during flight tests so, although the BLADE team are pleased with its performance, they are cautious and run a simultaneous test using other means to ensure that the results are accurate.





## The waviness beam

Rather than trying to replicate the ‘whole wing’ approach of reflectometry, the team take a clear, highly accurate linear measurement of any skin waviness caused by pressure changes. A beam supporting a line of highly sensitive, tiny position sensors is placed under the skin of the wing and this generates a mass of data showing exactly what is happening to the wing skin across a single narrow section of the wing. If this data confirms the wider picture being given by the reflectometry equipment, the team can be confident that they have an accurate way of recording the effects.

## Flight deformation data

In-flight deformation data is a crucial support in tackling industrial constraints because it allows researchers working on different laminar materials to predict the impact that different manufacturing techniques will have on the laminar flow levels of a future wing. If creating the most laminar wing possible makes it too expensive to manufacture, a wing that offers a certain amount of laminarity could be economically viable. To decide this, the designers of tomorrow’s wings need to understand the distortion levels and performance of the different laminar options.



## CONCLUSION

The Airbus flight test team are playing a key role in the BLADE partnership. By taking a flexible and genuinely experimental approach to how they use the A340 test aircraft, the team is generating data that will allow Airbus and its partners to come to a careful assessment of the commercial potential of laminar wings.

That assessment’s accuracy will depend on having data that demonstrates how the experimental wing surface behaves during real flight. Testing panels which are integrated into a bigger and well-established wing is a long way from flying any fully laminar wing that might be designed in future. However, gaining real-world insights into laminar flow could now allow that design process and the consequent fuel burn and emission savings to become reality sooner than was previously thought likely. BLADE is accelerating industrial laminarity. ■■■

# Be cool, be efficient

Article by



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**Making passengers feel comfortable, even as they are boarding their plane, gives a good first impression. In hot climates, this means the cabin temperature is cool and the step from boarding gate to cabin is seamless. The challenge for airlines is to keep their passengers comfortable whilst at the same time reducing fuel consumption in line with airport environmental requirements; they also need to keep their own costs down.**

Although on-board auxiliary power units (APUs) can provide effective cabin air-conditioning, they are increasingly restricted by legislation and may not be the preferred option for environmentally friendly and cost-conscious airlines.

Whether a solution involves conventional ground carts or subfreezing operations\*, best practices can improve air-conditioning operations on the ground. There are 'quick wins' and more complex procedures, but it is worthwhile carefully considering how to combine them to best effect to obtain maximum efficiency at minimum cost.

\*Subfreezing operations: the temperature at the aircraft inlet is below 2°C

# Quick wins on the apron

Efficient air-conditioning operations are in everybody's best interests and Airbus provides data and guidance. However, if air-conditioning on the ground seems too costly or is not meeting the expected standards, checking some basic measures may help.

## Choosing the right cart

Airbus does not recommend one particular cart because every airline operates in its own way, flying different destinations and times. Add the variations in cabin layouts and passenger numbers and there simply isn't a 'right air cooling unit' for everybody. However, there are some aspects of the aircraft characteristics that are worth emphasising:

The air flow rates and temperature requirements for the ground cart, provided in sections 5.6 and 5.7 of the aircraft characteristics documents, are needed at the point where the aircraft is connected to the ground equipment.

The manufacturers of the equipment publish a cooling capacity in kilo-watts or tons in the US. However, this is only indicative and will not necessarily ensure the temperature and flow rate combinations at the point of aircraft connection that translate into good performance.

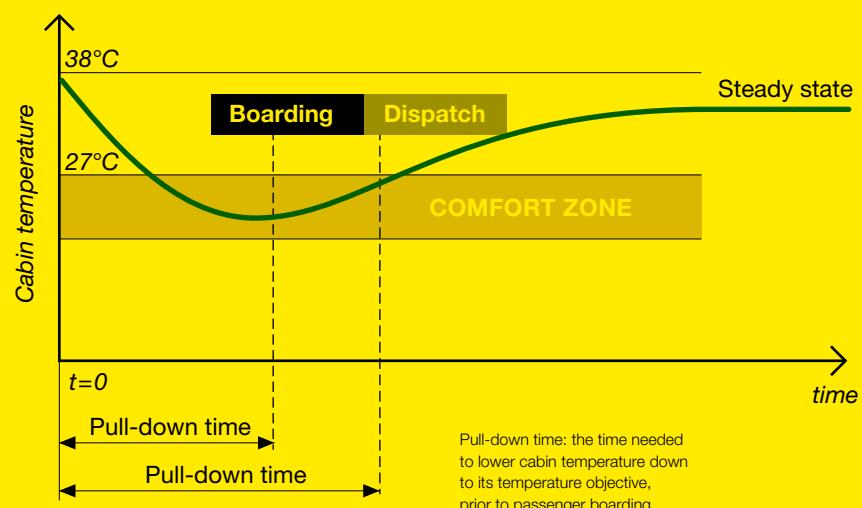
## Steady state data – a false friend?

Airlines choosing a cart might also look at the steady state\* data, but this actually refers to a theoretical state of a settled temperature that is never reached in normal operations. Once an aircraft is ready to take off, the job of the ground equipment is over and the on-board systems run the air-conditioning. This usually occurs long before the steady state is reached which means that, although the figure is very useful for ground air-conditioning designers, it is of limited use to airlines.

The example below shows a cart which might be rejected because it has a steady state above the desired comfort zone. Nevertheless, it might actually do an efficient job of pulling down the cabin temperature to below the 27°C objective in plenty of time for boarding. Equipment with a steady state figure within the comfort zone might be more powerful and expensive than is really needed.

\*Steady state is reached when the temperature distribution of the cabin does not change with respect to time.

## Air-conditioning at turnaround



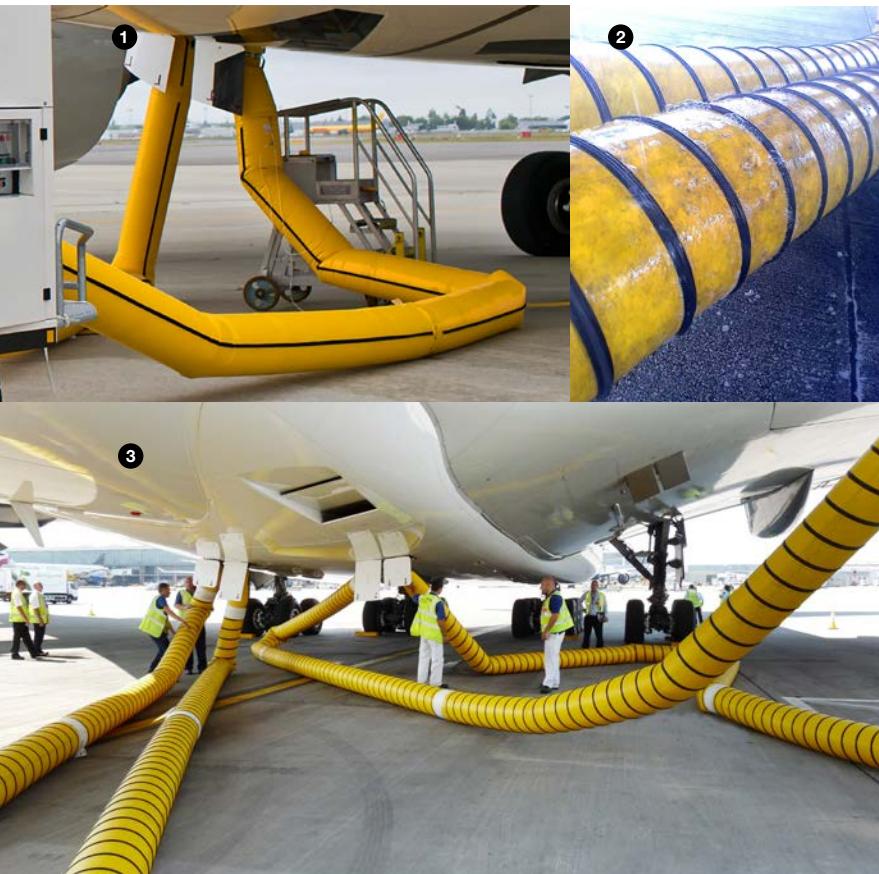
## Common mistakes – and best practices

When it comes to using the cart, there is still more to do than simply switching it on or off, even when the unit performances appear to match with aircraft demand. Three of the photographs below show a number of common mistakes that can combine to make a cart 50% less effective in cooling performance than it should be. Severe bends, or ‘elbows’, in hoses cause a loss of pressure which leads to a drop in cooling power. The same is true of undetected leakages, while overly-long hoses dragging on the ground can lead to the cooled air becoming warmer than it should be by the time it reaches the aircraft.

The other two photos show some popular best practices. One is the use of stainless steel telescopic tubes which is a low maintenance, highly effective alternative to traditional hoses. The other shows a pit system that protects hoses and pre-conditioned air units from heat and contamination by keeping them underground. This is being installed in the Middle East at Bahrain and Dubai, and in Europe at Barcelona and Hamburg.

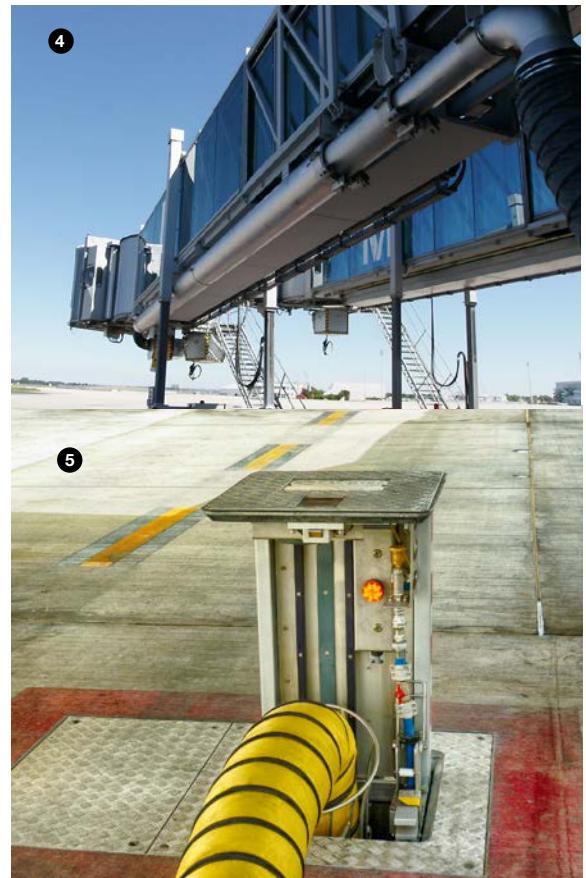
### Examples of mishandling / misuse

- 1) Elbows on hoses when deployed
- 2) Leaks/bad condition (wearing) of the hose
- 3) Too much hose on ground



### Examples of good operation

- 4) Stainless steel telescopic (IST solution) beneath the PBB
- 5) PCA pits (Cavotec solution in Bahrain), shortening hose length and reducing contamination



# Quick wins in the aircraft

Airlines continue to request solutions for an APU alternative at the gate. In addition to subfreezing, other initiatives have been launched to explore solutions.

## Cabin fans on or off?

The AMM tasks related to air-conditioning used to require cabin fans to be ON; this was a default position. It was associated with a CAUTION, the rationale being the possibility of damage to avionics. Nevertheless, some airlines did practice 'FANS OFF' on their aircraft as they experienced better air-conditioning for the cabin. After analysis of the impact on avionics, Airbus' recommendation for 'FANS ON' eventually turned out to have been conservative, except for the A330/A340 Family for which the recommendation 'FANS ON' is maintained.

'Cabin FANS OFF' operation is now permitted on all Airbus products except the A330/A340 Family, when supplying air at the aircraft inlet above +2°C. This allows an increase in the maximum flow rate entering the aircraft.

For example, for the A320 Family, the maximum flow rate goes from 1.0 kg/s – limitation with 'Cabin FANS ON', up to 1.3 kg/s – limitation with 'Cabin FANS OFF'. This increased flow rate can help to achieve faster cooling and is an improvement even if not combined with the best practices described here.

A/C type	AMM simplified	Cautions *See detailed description in the AMM	AMM reference
<b>A320</b>	> CAB FANS ON/OFF > PCA ON	<i>1 door opened or alternative free area*</i>	TASK 12-33-21-618-001-A Pre-conditioning through the LP Ground Connection
<b>A320</b>	> Subfreezing PCA > CAB FANS ON	<i>1 door opened or alternative free area*</i> <i>FANS ON mandatory</i>	TASK 12-33-21-618-002-A Pre-conditioning through the Low Pressure SUBFREEZING PCA GROUND-AIR SUPPLY
<b>A380</b>	> Subfreezing PCA > CAB FANS ON	<i>1 door opened or alternative free area*</i> <i>FANS ON mandatory</i>	TASK 21-00-00-618-805-A Pre-Conditioning through the Low-Pressure SUBFREEZING PCA GROUND-AIR SUPPLY
<b>A380</b>	> APU ON > PCA ON > CAB FANS OFF	<i>1 door opened or alternative free area*</i> <i>CAX to be checked</i>	TASK 21-00-00-618-808-A Pre-conditioning through the Low-Pressure Ground Connection together with the APU
<b>A380</b>	> APU OFF > PCA ON > CAB FANS OFF/ON	<i>1 door opened or alternative free area*</i> <i>CAX to be checked for CAB Fans OFF</i>	TASK 21-00-00-618-801-A Pre-Conditioning through the Low-Pressure Ground Connection with Electrical Power On
<b>A350</b>	> Subfreezing PCA > CAB FANS ON	<i>1 door opened or alternative free area*</i> <i>Fans ON mandatory</i>	TASK A350-A-21-XX-XX-03001-398A-A Pre-Conditioning with Subfreezing Air through the Low Pressure (LP) Ground Connection
<b>A350</b>	> APU OFF > PCA ON > CAB FANS OFF/ON	<i>1 door opened or alternative free area*</i>	TASK A350-A-21-XX-XX-00001-398A-A Pre-Conditioning through the Low Pressure (LP) Ground Connection
<b>A330</b>	> Subfreezing PCA/LPG > CAB FANS ON	<i>1 door opened or alternative free area*</i> <i>FANS ON mandatory</i>	TASK 12-33-21-618-801-A03 Pre-conditioning with a Low-Pressure SUBFREEZING PCA ground-air supply unit
<b>A330</b>	> APU OFF > CAB FANS ON > PCA ON	<i>1 door opened or alternative free area*</i> <i>FANS ON mandatory for Avionic Ventilation</i>	TASK 12-33-21-618-801-A Pre-conditioning through the Low-Pressure Ground Connection
<b>A340</b>	> Subfreezing PCA > CAB FANS ON	<i>1 door opened or alternative free area*</i> <i>FANS ON mandatory</i>	TASK 12-33-21-618-801-A03 Pre-conditioning with a Low-Pressure SUBFREEZING PCA ground-air supply unit
<b>A340</b>	> APU OFF > CAB FANS ON > PCA ON	<i>1 door opened or alternative free area*</i> <i>FANS ON mandatory for Avionic Ventilation</i>	TASK 12-33-21-618-801-A Pre-conditioning through the Low-Pressure Ground Connection

### Why Does FANS ON/OFF vary according to avionics architecture?

For the A330 and A340 programmes, CAB FANS are integrated into the avionic ventilation system as blowing fans and supply some of the necessary air to the avionic compartments. Switching them off directly impacts the avionic ventilation system which is why Airbus does not recommend switching CAB FANS OFF for A330 and A340.

For the A380, to decide if CAB FANS can be switched to OFF, operators should refer to the dedicated AMM task. Part of the ventilation system (the low pressure fans system) supplies some air required by the rear avionic compartments so, if CAB FANS are switched to OFF, there is a need to check the extraction operates properly.

Also, all Airbus aircraft should have FANS ON during subfreezing operations: this is to prevent risk of icing in the mixing chamber.

### Deployment of subfreezing units

Airbus already issued a list of design requirements for the subfreezing unit suppliers. These requirements are provided in the document 'Subfreezing PCA carts: compliance document for suppliers' (ref: X21RP1146224, issue 06, dated 02 February 2015).

As explained in the article on subfreezing in FAST #52:

Replacing the need for APU use at the gate, ground units may now provide -25°C Pre-Conditioned Air (PCA) directly to the aircraft's interface, without any aircraft modification.

This new subfreezing PCA considerably reduces the 'pull-down' phase, even in extremely hot and humid conditions, and allows airlines to keep the aircraft cool more efficiently during turnaround time. The reduced use of the Auxiliary Power Unit leads to economy of fuel and reduction of direct maintenance costs. Furthermore the 'pack off' operation increases the time between cleaning the pack heat exchangers and contributes to reducing bleed leak overheat occurrences in hot regions.

A resulting advantage is the decrease of noise pollution and emissions at the gate.

Five risks, resulting in limitations for ground air conditioning operations, have been identified:

Risk	Limitation	Low pressure air-con operations
Cabin overpressure	Max. flow rate at A/C inlet in kg/sec	All
Duct overpressure	Max. pressure at A/C inlet in mbars-g	All
Icing in the mixing chamber	Min. temperature at A/C inlet in °C	Subfreezing
Duct over-temperature	Max. temperature at A/C inlet in °C	All
Icing in the mixer chamber	Max. humidity at A/C inlet in g water/1 kg air and distribution ducting	Subfreezing

All these limits are defined based on current Airbus Environmental Control System architecture and differ from one programme to another.

Manufacturers have developed three families of products:

- **Air systems** (cold production by expansion throughout an air cycle machine)
- **Vapour cycle systems** (evaporation/compression of cooling fluid)
- **Other solutions based on liquid nitrogen evaporation** (air/nitrogen exchanger)

The three solutions above are compliant with Airbus requirements, so the choice will be made according to airport development plans and airline needs according to the air cooling unit performances and the characteristics of the turnaround. Following discussions with the manufacturers, the compliance document (issue 06) has reached a certain maturity level, the main topic of discussion being on the

*Systems can be centralised or 'on post' as mobile equipment or equipment fixed under the passenger bridge.*

defrost cycle with manufacturers requesting a reduction of the cycle period. In agreement with customers, each proposal features a particular setting, ranging from soft subfreezing (down to -10°C at the aircraft inlet) to deep subfreezing (down to -25°C at the aircraft inlet), according to the ambient conditions, from extreme hot areas to continental ambience.

#### APU restrictions and fuel savings:

Today, roughly one third of airports restrict the use of the APU, mainly to reduce noise and emissions. The Aeronautical Information Publication mentions that '*the use of the fixed energy system has saved 12,170 tonnes (t) of fuel, 38,500t of carbon dioxide (CO<sub>2</sub>) and 75t of nitrogen oxides (NOx)*'. Extract from Unique (Flughafen Zürich AG), Zurich, 2004.

Another study was made by an air cooling unit manufacturer in 2005 demonstrating the benefits of current air-conditioning ground cart units. It concluded that airlines could save 15M USD per year and an airport could obtain a net revenue of 2.5M USD with a return on investment in three years, just by using PCA.

This shows that in terms of economy, it is preferable to use a ground-based PCA instead of the APU.

However, for air cooling units lacking in performance, the APU still has to be operated during boarding or disembarking in hot regions.

Deployment of subfreezing solutions is actually slower than hoped previously and the introduction of this new operating procedure for air-conditioning in AMM tasks is not yet widespread. At new airports in extremely hot areas, it appears to be a prerequisite, the trend being for these new hubs to have a centralised system delivering subfreezing air at each gate.

With these notable exceptions, there does seem to be a reluctance to embrace the new technologies: this may be due to lack of awareness, unfavourable economics, or both. Either way, use of the APU at the gate remains quite common.

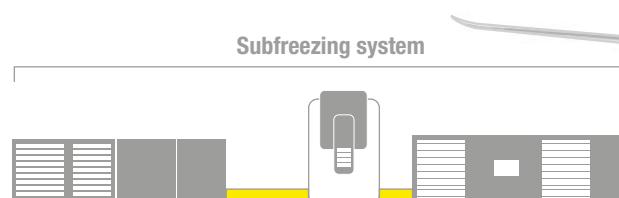
## Alternatives to subfreezing

Airbus has developed for the A380 only, a specific procedure for extreme hot day operation on ground with APU ON, CAB FANS OFF and air cooling unit operative. This new procedure allows operation of the APU at a lower regime with air cooling unit operative.

The new procedure exists under reference AMM TASK 21-00-00-618-808-A, Pre-Conditioning through the Low-Pressure Ground Connection together with the APU.

A trend for the airport of the future is automation at the ramp with use of extensive ground units connected and one single man-machine interface. Smart GSE wireless connectivity for ground cooling function has been successfully tested on one A350 XWB test aircraft, allowing a closed loop in temperature between the aircraft and the ground and making the air-conditioning operation a simple one (ON/OFF unit after selection of the aircraft) and both more efficient and safer (flow rate and temperature control).

Air cooling unit – wireless connectivity



**Compressor**  
Provide compressed air

**Driver**  
Suppress humidity

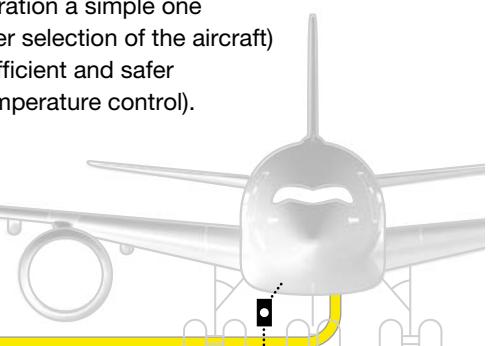
**PCA**  
Control air flow

**Decoding unit**

- Connect to the broadcaster wifi network
- Decode the received A/C parameters
- Provide representative analog signals to PCA control unit

**Data broadcaster**

- Provide wifi access point
- Connected to P-MAT plug
- Select / down-sample A/C parameters
- Broadcast live parameters



# Achieving the comfort objective

The most effective approach to achieving the correct cabin temperature varies massively according to the airline, the destination and the time of day. Taking careful account of all the variables to make a series of correct decisions is essential. Subfreezing is one solution, especially in hot and humid environments such as the Gulf nations, but it is not always available. New air-conditioning procedures are also an option and are further alternatives to using the APU, although they are probably not sufficient in very hot and humid environments.

Referring to the air-conditioning charts in the AMM, airlines can pick the best solution that fits the comfort temperature objective for one specific aircraft on a particular mission.

As an example, let's consider an A320 aircraft. The aircraft is hot-soaked (45°C outside average temperature) in Doha, Qatar, and has to be prepared to fly in the morning (pull-down) to Amman, Jordan.



## ***First flight of the day***

Preparation of the aircraft (pull-down phase):

APU OFF

OAT (Outside Average Temperature) 45°C

Aircraft is soaked up (cabin at 45°C)

T0: Start air-conditioning

Air-conditioning (COOLING) settings (conditions at aircraft inlet): 1.3 kg/s at 2°C (not exceeding 40 mbar-g at the aircraft interface) FANS OFF operation

**Objective:** pull the cabin temperature down to 27°C (comfort objective) in less than one hour. T0+49 minutes: aircraft cabin = 27°C; T0+65 minutes: aircraft cabin = 25°C

---

## ***Turnaround at departure from Doha, Qatar with OAT 45°C:***

IFE: ON

Blinds: OFF

Lights: ON

Galleys: ON

Air conditioning (COOLING) settings (conditions at aircraft inlet): 1.0 kg/s at 2°C (not exceeding 40 mbar-g at the aircraft interface) FANS ON operation.

**Objective:** maintain cabin temperature at 25°C

T0: Start boarding

T0+45 min. dispatch (APU ON)

---

## ***Two-hour flight - turnaround at destination (Amman)***

OAT 30°C

Aircraft cabin at 25°C

Air-conditioning (COOLING) settings (conditions at aircraft inlet): 1.3 kg/s at 2°C (not exceed 40 mbar-g at the aircraft interface) FANS ON operation.

**Objective:** maintain cabin temperature at 25°C

T0: Start de-boarding

T0+45 minutes: dispatch (APU ON)

---

## ***Two-hour flight - turnaround at destination (Doha)***

OAT 45°C

Aircraft cabin at 25°C

Same objective and settings as above



This target has to be met after pull-down of the hot-soaked aircraft and is to be maintained during the turnaround of the aircraft (de-boarding/boarding of passengers until dispatch).

With a 45°C outside average temperature (OAT), for the A320 the following target temperatures can be met (with max. 40 mbars-g pressure at Aircraft Interface):

Aircon ground ops	Cabin Fans status	Flow rate at aircraft inlet (kg/sec)	Temp at A/C inlet	Achieved cabin temperature at the end of pull-down	Pull-down duration
Subfreezing unit	ON ( <i>mandatory</i> )	1.0	-10°C	22°C	85 min
				25°C	59 min
				27°C	46 min
Conventional	ON	1.0	+2°C	22°C	>2 hrs
				25°C	>2 hrs
				27°C	139 min
Conventional	OFF	1.3	+2°C	22°C	103 min
				25°C	65 min
				27°C	49 min

## CONCLUSION

Environmental legislation, coupled with the determination of airlines and airports to become 'greener', means that the drive to find alternatives to APUs on the ground is set to continue and intensify. Alternatives certainly exist thanks to subfreezing technology and new procedures. Depending on their cooling power and the ambient conditions, they can achieve cabin target temperatures in many circumstances.

Nevertheless, a simple established truth that applies to all air-conditioning options remains pertinent. All solutions rely on careful application of all the basic procedures and without this, they will be rendered ineffective. Poor hose quality or a lack of care about deployment can undermine the merits of any system.

A similar level of care is also essential in choosing the right options for a specific aircraft in particular circumstances. This can make as much difference to energy consumption and effective cooling as the selection of air-conditioning technology.

In the near future, the growing automation trend for ground operations will make air-conditioning procedures even more efficient. We should see reductions in pull-down time for aircraft preparation, improved safety with automatic shut-down in case of over pressure, excessive flow rate or too low a temperature, and simpler control of units. This automation will rely on e-connecting the air-conditioning unit to the aircraft, closing a temperature control loop between the aircraft and the unit, and drawing the best performance out of the unit to reach and maintain the cabin temperature comfort target.

As these changes take place, Airbus is ready to support airlines and airports that want to improve their ground operations, whether they are implementing subfreezing technology, tailoring procedures or introducing connectivity to air cooling units. ■■■

# The structural fuel leak challenge

Detecting and preventing



**Fuel leaks are a fact of life for aircraft operators and when they are discovered during walk-around inspections, they can prove particularly disruptive and costly. Airbus receives frequent requests from customers seeking support in detecting and managing these incidents. In response, it offers guidance based on decades of experience with its global fleet. The dual aim is always to help operators reduce the time any aircraft spends on the ground and to prevent recurrences by ensuring that repairs are carried out correctly.**

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### Where and why do fuel leaks happen?

The most common areas for fuel leaks are the wing dry bay and the wing to centre wing box RIB 01, but other areas may include the wing front spar, wing bottom skin and wing tank access panel. Leaks can be challenging because they can occur in many different places, and for a variety of different reasons.

Wing to centre wing box junction



Incorrect sealant application



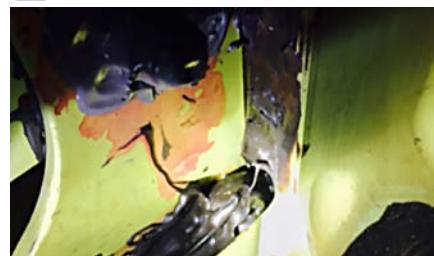
Current sealant cracked due to bolt rotation



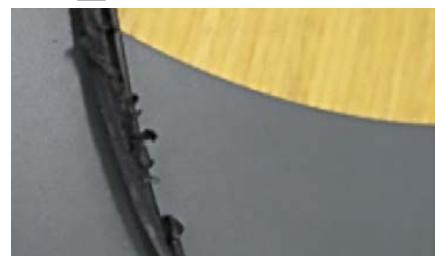
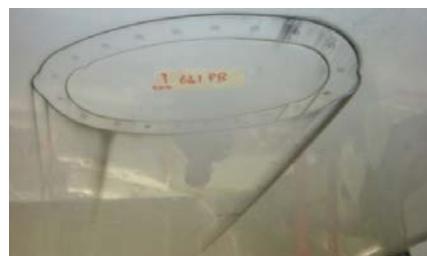
Damage on sealant bead



Cavity not sealed



Seal degradation



Wing spar junction

### Detecting external and internal leak points

The simplest form of external leak point detection can be carried out with fuel remaining in the tanks and a basic product. The likely area of the leak source is cleaned and then covered with a dusting of talcum powder. The powder's absorbent qualities allow it to soak up any fuel and the point at which a dribble, or drops, of fuel emerge becomes visible. This method may not help to identify the internal leak point but it can prove to be an efficient first step that yields quick results.

To determine the origin of the leak, the internal leak point must be identified. One efficient method is to drain the section of the fuel system where the leak is present and introduce a pressurised mixture of 90% air and 10% helium. This creates a detectable flow of gas out of the leak which exposes the exact location of the problem.

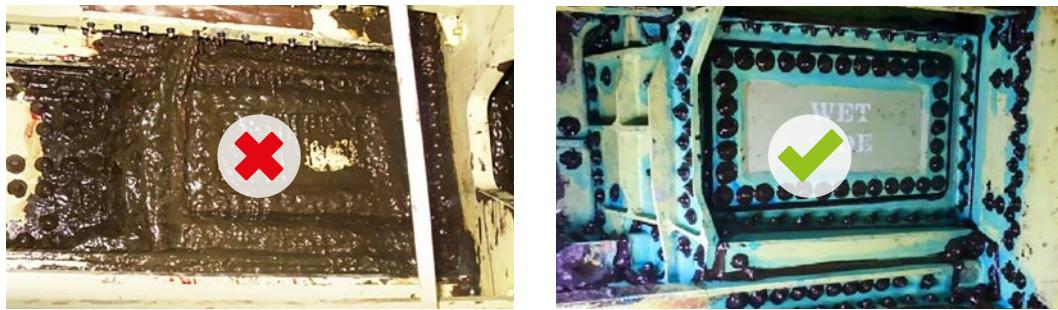
Alternatively, a thin coat of liquid soap can be applied to potential leak sites, then pressurised air introduced from the external leak point. The air finds the fault in the system and makes the soap bubble up as it leaves – a clear visible sign of the leak's location. Using dye can also make spotting the location relatively easy.

## Making the repair

Temporary repairs can be carried out on external leak points and only require enough defueling to enable work on the specific area. After thorough cleaning, sealant can be applied and, as long as tests confirm that the leak is fixed, the aircraft can return to normal service. Nevertheless, it should be kept in mind that this solution is only temporary and the problem will return unless a definitive repair is carried out.

A definitive repair involves defueling, draining and venting of the tanks. The internal leak point is then detected using the methods outlined above. All old sealant in the affected area should be removed using appropriate tools. The area is then inspected for damage, and a torque check included if necessary. A bolt removal/installation may also be required, especially in the case of bolt rotation or migration evidence. Finally, after thorough cleaning, the new sealant can be applied.

In the case of a definitive repair, the aircraft should return to service with a very low probability of leak recurrence, although it will depend on the quality of the repair. Inappropriate tools, sub-standard materials or incorrect methods will affect the durability of the repair.



## Taking action to prevent recurring leaks

One key to preventing fuel leaks is to check that repairs are carried out properly.

If any part of the process is flawed, then recurrence is very likely and inspections do often reveal simple causes such as incorrect sealant application and damage to sealant caused by bolt rotation.

In the case of fuel leaks around the fuel tank access panels, tell-tale streaking around the panel is a clear sign that the seal is degraded and a leak will follow within a few months. Replacing the seal at the next MRO opportunity, as described in a dedicated article in FAST 52, will avoid an aircraft on ground situation following a walk-around inspection.

Preventive action also means general fuel leak mapping of the aircraft before it enters the hangar.

Helium testing - image courtesy of Sunaero, equipment supplier.

### Sharing know-how and experience

Detailed knowledge of the aircraft's design is essential for effective fuel leak trouble-shooting so Airbus has a dedicated team available to help customers. They use their design knowledge and experience gathered across the global fleet to evaluate fuel leak paths as quickly and accurately as possible.

Fuel leak path troubleshooting is done based on the analysis of the different assembly steps at the Airbus FAL.

In the case of complex fuel leaks, Airbus strongly encourages customers to complete the STRUCTURAL FUEL LEAK REPORTING FORM (SFLRF) mentioned in the AMM 28-11-00. This form is required for Airbus analysis and support but also for reporting fuel leak data for Airbus records only.

Meanwhile, customer requests for help with developing their own capacity to deal with fuel leaks effectively have led to the launch of a new, tailored workshop at the customer premises. After detailed discussions with the customer about its fleet and experience of fuel leaks, the Airbus workshop leader prepares the workshop to focus on the most relevant areas of trouble-shooting. For instance, an airline might find it can deal with most leaks on most types of aircraft very effectively, but that recurrence is a problem in a specific area. Or they might repeatedly experience a specific type of leak right across their fleet. In either case, the benefits of solving or minimizing the impact of a recurrent issue can be substantial.

Whatever the focus, the workshop team combines classroom-based sessions with time spent on an actual aircraft, guiding the mechanics through the processes and techniques that will help to further refine their skills.

## CONCLUSION

Dealing with fuel leaks effectively is a challenge because there are many potential sources. Understanding the design of the aircraft and having a good grounding in detection techniques is essential, as is the experience needed to carry out repairs to a high standard. Airbus supports customers with fuel leak trouble-shooting and is now also offering workshops for individual airlines. ■■■

# Ultra Long Range A350 XWB

**Extra distance, extra comfort**

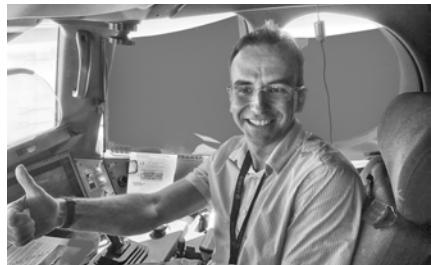
**The first Airbus A350-900 Ultra Long Range (ULR) enters into service in October 2018 with Singapore Airlines (SIA). SIA will use the aircraft to resume the world's longest commercial flight, from Singapore to New York. How does the A350-900ULR differ from the standard A350-900, and what makes it an efficient and competitive option?**

## **The case for ultra-long-range flights**

Today, airlines are flying further non-stop with the new generation A350 XWB, with only the very longest routes requiring technical stops. Yet there is increasing demand for non-stop, ultra-long-haul missions. The convenience of them is especially attractive to business passengers, but they appeal as much to anyone looking for a direct flight over very long distances. Customers keen to open ultra-long-haul routes have long lacked the right aircraft to perform them.

Through consultation with interested airlines, Airbus established the basic technical characteristics that such an aircraft would require: a range of up to 9,700 nautical miles, representing a flight duration of around 20 hours, and without ETOPS\* constraints. High comfort standards for both passengers and crew, the latest entertainment system and a quiet cabin environment were natural pre-requisites.

\*ETOPS (Extended Twin Operations): acronym created by ICAO (International Civil Aviation Organisation) to describe the operation of twin-engined aircraft over a route that contains a point further than one hour's flying time from an adequate airport at the approved one-engine inoperative cruise speed.



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## Technical differences between A350-900ULR and standard A350-900

From 2018 onwards, the A350-900 comes with an improved baseline which further improves the competitiveness of the product. It consists of an aerodynamic performance improvement package including extended winglets, enhanced flap support fairings, wing re-twist and modified over-wing fairings; and an increased Maximum Take Off Weight (MTOW) option of 280 tonnes. All improvements contribute to a greater payload/range capability.

The challenge was to offer these improvements while avoiding any weight impact on the aircraft, and to deliver a mature design. Both have been made possible by revising the loads model with knowledge acquired during flight testing, design allowable improvement and some weight-saving modifications based on deploying technology from the A350-1000. Finally, extensive flight tests in 2017 using Airbus test aircraft secured a mature design for the A350-900ULR's entry into service.

The major differences between the A350-900ULR and the standard version are:

### **Increased fuel capacity**

The A350-900ULR offers a fuel-carrying capacity of up to 165,000 litres (+ 24,000 litres compared to the standard A350-900).

Adding this capacity requires adaptation of the fuel system, including the centre tank venting architecture and fuel quantity management system. Thanks to the A350-900's scalable platform, the capacity is provided with existing tanks.

### **Reduced Weight**

The A350-900ULR is one tonne lighter than the standard airframe, thanks to three adaptations:

- The A350-900's large aft cargo area means the forward cargo hold can be deactivated for ULR operations.
- Removal of one of the two tanks for potable and waste water.
- Single lane slide at door two (instead of dual lane slide).

From an industrial standpoint, manufacturing an A350-900ULR does not disrupt production lead time when compared to a standard -900.



## The A350 XWB Family

The A350-900ULR is the latest addition to Airbus' ultra-modern A350 XWB widebody Family. The Family comprises the baseline A350-900 and its larger sister aircraft the A350-1000.

Based on a clean-sheet design, the A350 XWB is by essence a very flexible platform. It is designed to offer full operational flexibility with unrivalled levels of efficiency and comfort however it is operated, be it on domestic, regional, long haul or ultra-long-haul services.

A350 XWB Family aircraft contain 53% carbon composites, supporting easier maintenance and increased resistance to corrosion. They offer 25% lower operating costs, fuel burn and CO<sub>2</sub> emissions when compared to previous-generation aircraft.

The A350-900 is the cornerstone member of the A350 XWB Family. It accommodates 325 passengers in a standard three-class configuration.

Measuring nearly 74 metres from nose-to-tail, the A350-1000 is the longest-fuselage version of the A350 XWB Family. In a typical three-class configuration, the A350-1000 seats a total of 366 passengers. The aircraft entered into service in February 2018.



## Why the A350-900 suits ultra-long-haul operations

### Comfort

The A350-900's Airspace cabin (see right) offers the quietest widebody cabin flying today. Its effective temperature management system, lower cabin altitude compared to previous-generation aircraft, and full-LED ambient lighting all contribute to passengers' well-being. This helps them to arrive at their destinations feeling rested and refreshed even after the longest flights. Furthermore, cabin air is renewed every two to three minutes, a shorter cycle than the older aircraft it replaces.

The A350-900 can accommodate a broad range of cabin configurations from economy-led three-class arrangements to a more premium-orientated layout, with a level of comfort perfect for ultra-long-range operations. Singapore Airlines' A350-900ULR configuration is tailored for high-comfort, ultra-long-haul flights with a large number of business class berths.

### Flexibility

The A350 XWB Family is designed to provide airlines with high flexibility in operations. It can be operated efficiently whatever the sector length, from regional up to ultra-long-range.

This flexibility means the A350-900ULR can easily be returned to a standard -900 configuration.

Building the ULR from the A350-900 was made possible thanks to extensive design and upstream industrial studies, avoiding complex modifications. Part of the engineering development, for example, involved the relocation of sensors in the fuel system enabling existing tanks to carry the maximum fuel load for the ULR. This dispensed of the need for additional fuel tanks.

### Economics

The A350-900 is a clean sheet design bringing a step change in efficiency, with 25% lower fuel burn and cash operating costs compared to the competitor aircraft it replaces. Additionally, with its mature design the A350-900 reaches high levels of operational reliability.

## CONCLUSION

The entry into service of the A350-900ULR opens a new way of travelling. It responds to growing demand for point-to-point ultra-long haul travel and creates a sustainable, efficient business model for airlines that offer that product.

Thanks to the versatility and efficiency of the A350 XWB Family, Singapore Airlines is resuming the world's longest commercial route, from Singapore to New York, operated until 2013 by the A340-500.

Airbus is convinced there will be a growing demand for a category of travellers who want to travel as far as possible in a non-stop flight. The answer is the Ultra Long Range A350 XWB. ■■■



## A350-900 Ultra Long Range

Dimensions		Capacity			Performance	
Overall length	66.80 m	Pax	Customisable		Range	18 000 Km / 9700 nm
Cabin length	51.04 m				Typical cruise speed	M0.85
Fuselage width	5.96 m	Freight	Max LD3 capacity underfloor	16	Max ramp weight	280.90 tonnes
Max cabin width	5.61 m		Max pallet capacity underfloor	5	Max take-off weight	280.00 tonnes
Wing span (geometric)	64.75 m		Bulk hold volume	11.3 m³	Max landing weight	205.00 tonnes
Height	17.05 m		Total volume (bulk loading)	82.9 m³	Max zero fuel weight	192.00 tonnes
Track	10.60 m				Max fuel capacity	165 000 litres
Wheelbase	28.66 m					

### What is Airspace?

Airspace is Airbus' cabin brand. The A350-900ULR features an Airspace cabin for maximum comfort.

Airlines have to differentiate the experience they offer from that of their competitors in the age of instant and far-reaching passenger reviews on social media. Hundreds of details come together to make one airline cabin superior to another but space, comfort and ambience are probably the biggest contributors to overall in-flight well-being.

These are Airspace's biggest attributes. It takes the best of the ultramodern A350 XWB cabin already flying today to create a unique experience.

At the heart of the Airspace cabin 'DNA' are the advanced technologies developed for the A350 XWB Family. Key enablers include more spacious lavatories, larger storage bins, adaptable full-LED lighting and unique entrance features. Airspace also offers excellent cabin crew and galley facilities that lead directly to better service.



# FAST

from the past

There wouldn't be any future  
without the experience of the past.

Many years ago, passengers already enjoyed comfortable seats and overhead lighting.

Today, however, the Airspace by Airbus concept takes passengers to infinitely higher levels of comfort (see page 37), contributing to their overall well-being during flight.



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