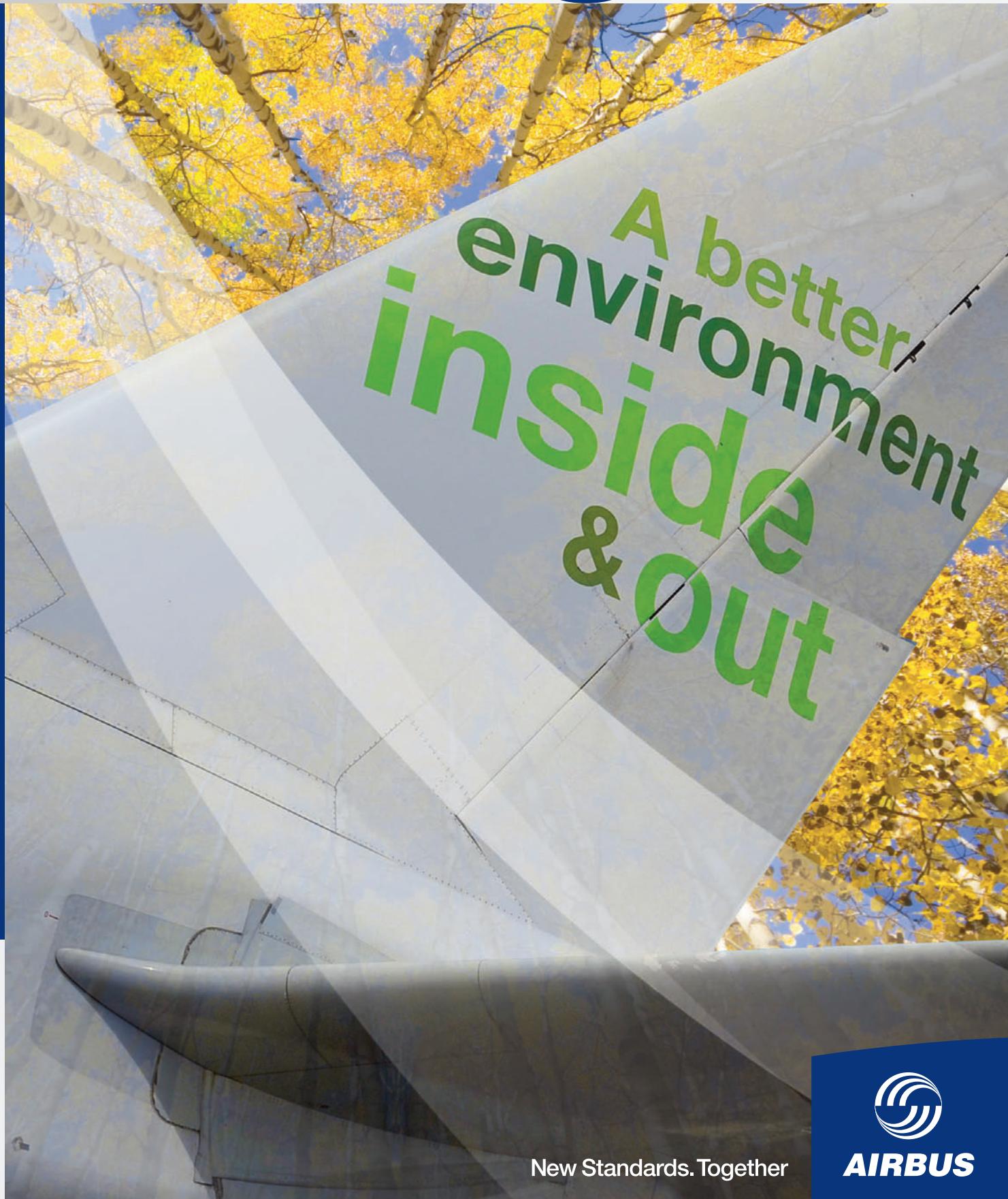


AUGUST 2010  
FLIGHT  
AIRWORTHINESS  
SUPPORT  
TECHNOLOGY

# FAST 46

AIRBUS TECHNICAL MAGAZINE



FAST 46

New Standards. Together



# Customer Services events

## Just happened

### **5<sup>th</sup> Technical Data symposium**

The fifth Technical Data symposium took place with the participation of more than 150 attendees, including 60 different airlines from all around the world.

In line with the theme of the symposium, 'Delivering Innovative Solutions', more than 30 different presentations, demos and workshops, covering solutions for every single key area of technical data, were shown. Airbus customers fully validated Airbus vision for Technical Data and highlighted the exceptional networking opportunity that an event like this represents with strong encouragements to keep up the good work in the future.

### **9<sup>th</sup> A330/A340 Family symposium**

This event, recently held in Berlin, Germany, gathered 177 persons representing airlines, leasing organisations, MRO (Maintenance Repair and Overhaul) organisations and suppliers.

Airbus customers acknowledged the good progress made by Airbus on some major topics since the previous symposium, held in Dubai. Airbus presented six 'Awards for Operational Excellence' to: Korean Air, Asiana Airlines, Swiss, China Airlines, Etihad Airways and Qatar Airways.

Many technical and non-technical subjects were raised during the airline caucus. Airbus set its priorities for the coming months.

### **Upgrade Services' team was at the Aircraft Interiors Expo, Hamburg, Germany**

Airbus Upgrade Services introduced an 'Expo premiere' this year, the 'Product Information Session'. This session gathers a series of presentations on innovative new products such as the enhanced cabin for the A320 Family, mood lighting, the new trend for premium economy and the flexible cabin concept.

Please contact Airbus Customer Services for details on new innovations and products suitable for retrofit to your fleet.

## Coming soon

### **Material, Logistics, Suppliers and Warranty symposium**

This symposium will be held in Paris, France from 25<sup>th</sup> to 27<sup>th</sup> October, 2010.

Airbus will present the latest developments and initiatives in the material, logistics, suppliers and warranty domains, that have been developed based on the close and productive relationship with our customers and suppliers. The new suite of Flight Hour Services solutions will also be presented. These services have been developed to help airlines increase their aircraft availability and reliability, whilst decreasing maintenance risks and investment.

The airline and MRO markets are constantly evolving and thus require innovative and flexible solutions. Innovation is a key driver for Airbus, not only when building aircraft, but also when supporting its customers' operations. Airbus will continue to drive the deployment of new supply and logistics services together with the customer and supplier community, shaping the future together and delivering world-class support to its airline operators. The invitations have been sent out.

### **A380 symposium**

This second A380 symposium will be held in Singapore from 15<sup>th</sup> to 19<sup>th</sup> November 2010. It will review in-service experience and progress since the first symposium, focusing on major open issues, associated support plans and implications for future operators.

The formal invitation letters, as well as the preliminary agenda, have been sent out.

Symposiums are held for each Airbus programme every two years and target airline engineering and maintenance managers. The prime function of these meetings are to enable two-way communication regarding actual in-service issues, as well as topics of more general interest.



# FAST

FLIGHT  
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Customer Services Worldwide  
Around the clock... Around the world

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**Every little helps!**



# Alternative fuels

## A flight path towards sustainable aviation

Global economics' development is dependent upon efficient and worldwide transportation means, to enable the distribution of goods, services and business interaction through people. Aviation is the optimized solution for worldwide cooperation.

Airbus is an eco-efficient organisation and wishes aviation to flourish whilst reducing its impact on the environment. Today, aviation is recognized as a key industry for global economic development and currently contributes to 8% of the global Gross Domestic Product (GDP). Conversely, aviation only contributes to 2% of man-made CO<sub>2</sub> emissions. Over the past 40 years, the industry has improved its fuel efficiency and reduced its related CO<sub>2</sub> emissions by 70%. The industry, as a

whole, has voluntarily committed to tough targets including 'Carbon Neutral Growth' by 2020 and a reduction of CO<sub>2</sub> emissions by 50% in 2050, compared to 2005.

To improve its environmental footprint, Airbus is working innovatively in key areas such as product technology improvements, Air Traffic Management (ATM) and developing solutions for low carbon lifecycle energy sources through alternative fuels for aviation.

To achieve this, Airbus is actively investigating alternative energy sources for aviation and launched its 'Alternative Fuels Roadmap' early 2008, proposing Research and Technology (R&T) activities, flight demonstrations , alternative fuels' approvals and targets for bio-fuel commercialisation.



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Engineering Programme  
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**Nicolas MOUNEY**  
Alternative Fuels and  
Acoustics Senior Engineer  
CoC Power Plant  
Airbus Engineering

# What are alternative fuels?

## THE ALTERNATIVE FUEL SOURCES

There are at least three types of 'drop-in' alternative fuels that meet the performance of non-renewable (fossil) jet fuels - giving a slightly higher energy content (reducing fuel burn), flash point (temperature at which fuel vapours will ignite - critical for safety during ground handling/refuelling) and a lower freezing point (potentially increasing the effective operational envelope of the aircraft). Bio-fuels are a range of fuels which are derived from renewable biomass. The term covers solid biomass, liquid fuels and bio-gases. The bio-fuels and some fossil fuels make synthetic fuels:

- The Fischer-Tropsch (FT) process gives a synthetic fuel, made from natural gas (Gas To Liquid - GTL), coal (Coal To Liquid - CTL) and biomass (Biomass To Liquid - BTL) such as farm waste or woodchip/forestry waste. (GTL, CTL and BTL are collectively known as XTL). This process was developed in the 1920s. It is a set of chemical reactions that convert a mixture of carbon monoxide and hydrogen into liquid hydrocarbons.
- Hydrogenated Biomass Oils (HBO) fuels are made using the animal fats, oils from plants like camelina, jatropha and salicornia, or oils from algae. This process de-oxygenates the biomass oils or fats to produce paraffins which can then be reformed by a hydro-treatment to make aviation kerosene.
- Hydrotreated Cellulosic Fibre (HCF) fuels are made using cellulosic biomass such as forestry and farm waste or switch grass, to name a few. This process converts the cellulosic material into a solution which is then fermented into alcohols and then reformed by a hydro-treatment to make aviation kerosene.

## THE 'WHY'

Considering the likely depletion of petroleum fossil fuels, along with the believed impact of CO<sub>2</sub> on the climate, Airbus is committed to improving its fuel burn / CO<sub>2</sub> emissions' performance. Aviation currently represents approximately 12% of the world transport fuel consumption (or 7 to 8% of the global petroleum consumption). In addition to this, jet fuel price volatility remains a major cause of concern for the airlines, as fuel typically accounts for approximately 40% of their operating costs (in 2008).

## THE 'NEED'

Technically, conventional jet fuel or kerosene (also known as JET A1), has specific characteristics that are necessary and remarkably suitable for flight conditions. It has a good energy content, a low freezing point (below minus 40°C) and it is stable and reliable. Alternative fuels for aviation must meet these characteristics. Therefore, Airbus in the short-to-medium term, is concentrating its efforts on those alternative fuels which are termed 'drop-in'. These types of fuels will enable the existing fleets to benefit by reducing their CO<sub>2</sub> emissions, as well as eliminating the environmental impacts that would be incurred by changes to the supply and airport infrastructures.

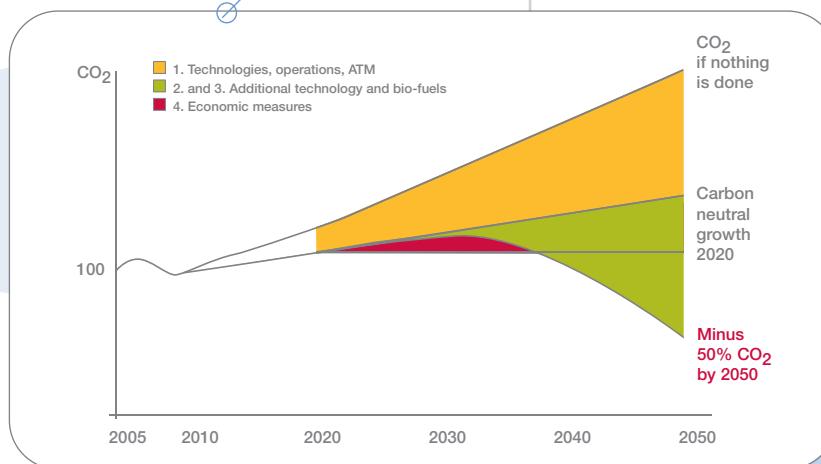


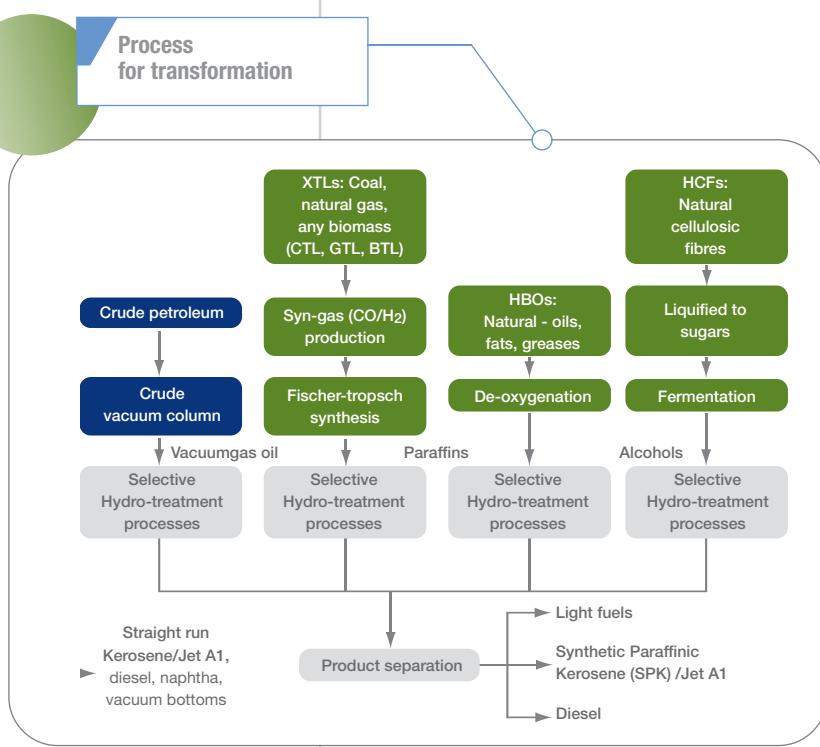
information

### 'Drop-in' fuels

Fuels that can be mixed with existing jet fuels without requiring any change to the supply infrastructure, airframe or engines and provide the same or better performance.

### 4 key strategic approaches to reduce CO<sub>2</sub> emissions





## PROCESS FOR TRANSFORMATION

Other alternative fuel possibilities have been analysed but are currently not seen to be a solution for the aviation, including alcohols which contain 35% lower energy content and Fatty Acid Methyl Esters (FAME) with 10% lower energy content and a freezing point at -5°C (see following article on 'FAME'). Airbus has extensively studied the use of hydrogen and does not see this as a solution in the short-to-medium term, without major changes in the aircraft design, the support of infrastructures and techniques to industrialize its production.



Cellulosic fibres such as forestry waste, wheat stubble or switch grass.



Algae are simple water-based organisms. Algae capture carbon dioxide and use sunlight to convert it into oxygen and biomass which can then be converted into oil for use in bio-fuels.



Camelina is a flowering plant native from Northern Europe and Central Asia, traditionally grown for vegetable oil. It needs little water or fertilizers, so it can be grown on marginal agricultural lands without competing with food crops. It is also used as a rotation crop for wheat to increase the health of the soil.



Oil from jatropha seeds is used to make bio-fuels in tropical regions such as South America, where it grows naturally and in plantations. Jatropha is currently being promoted for bio-fuels across developing countries.



Because salicornia can be grown using saltwater, it can be cultivated on coastal lands unsuitable for conventional crops. Its seeds contain high levels of unsaturated oil, making it ideal for bio-fuel.

## ALTERNATIVE FUELS OPTIONS FOR COMMERCIAL AVIATION

CATEGORY	TYPE					
	Conventional Jet Fuel ("Kerosene")	Alcohols	Bio Esters	Syn. Fuels	Hydrogenated bio-mass	Cryogenic Fuels
Non Renewable Fossil	✓				✓	Liquefied Natural Gas
Renewable		Ethanol NOT drop-in 35% lower energy content Freezes at -5°C	FAME* NOT drop-in 10% lower energy content Freezes at -5°C	CTL & GTL DROP-IN	BTL DROP-IN	HBO & HCF DROP-IN
				✓	✓	FUTURE

\* Not suitable for aviation ✓ Approved suitable for aviation

Courtesy of ABPM -  
Associação Brasileira  
de Produtores  
de Óleo de Jatoba

## Benefits

Plant matter absorbs CO<sub>2</sub> as it grows. When it is converted into fuel and burnt, CO<sub>2</sub> is released. The net result is that the CO<sub>2</sub> absorbed and released can partially cancel each-other out, to achieve near-neutral emissions.

## Challenges

### SUSTAINABILITY

The biggest challenge is producing sustainable feedstock in sufficient quantity, in order to provide the large quantities of fuel required. Airbus believes that solutions for the alternative fuel production must reflect the local flora and habitat, ensuring that the local solutions reflect each region's natural resources and provide local employment.

Airbus is focusing its research from sustainable plants or biomass feedstocks that do not compete with land, food, nor water resources. To ensure this, Airbus is working with the Roundtable on Sustainable Bio-fuels (RSB) to ensure it proposes sustainable solutions.

RSB website:

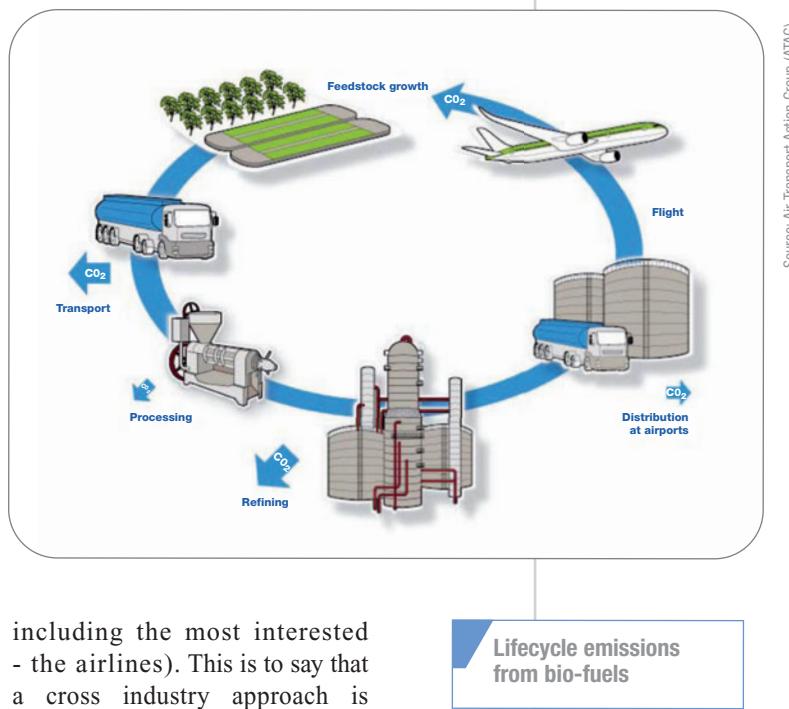
<http://cgse.epfl.ch/page65660.html>

### RESEARCH AND TECHNOLOGY (R&T)

The development of bio-fuels requires an analysis and implementation that will depend on the governments' support through policy (prioritisation of energy types) and incentives. Airbus is working with cross industry groups to speed-up the commercialisation of the bio-fuel production, based on R&T.

### INVESTMENT

Investors finance the commercialisation of bio-fuels across the value chain (farmers, refiners, airports, transportation and distribution,



including the most interested - the airlines). This is to say that a cross industry approach is essential. All these parties have to work hand in hand to reach this common goal.

### PRICE

Last but not least, price plays a pivotal role for the alternative fuels' commercial success. Alternative fuels must be commercially viable and affordable, not only during the production phase but also for the end user. For example, in 2008, approximately 40% of the airline costs were linked to fuel purchases. Alternative fuels must therefore be competitive with fossil based fuels.

## Airbus achievements

On February 1<sup>st</sup>, 2008, Airbus completed the world's first ever flight by a commercial jet (A380) using synthetic liquid jet-fuel made from natural gas (GTL), similar to conventional jet fuel in terms of CO<sub>2</sub> emissions but has virtually no sulphur and is better for local air quality. Thanks to these and later tests, 50% blends of GTL and BTL were officially authorized for passenger flights. Qatar Airways flew the world's first commercial service with GTL in October 2009 on an A340-600.

Source: Air Transport Action Group (ATAG)



#### **Qatar Airways first flight with GTL / Pre-flight London Gatwick reception**

From left to right:

- **Gary WOODWARD**, Shell General Manager Operations Technical & Supply Aviation
- **Dr. Eulian ROBERTS**, Qatar Science & Technology Park Managing Director
- **Akbar AL BAKER**, Qatar Airways Chief Executive Officer
- **Rainer OHLER**, Airbus Head of Public Affairs and Communications
- **Phil HARRIS**, Rolls Royce Civil Aerospace Senior Vice President Customer Business
- **Ali AL SHARSHANI**, Shell Associate Researcher.



#### **United Airlines first flight with GTL on an A319**

**Joe BURNS**, United Airlines Flight Captain and **Mark BOURDEAU**, United Airlines Fuel Technical Services.



Qatar Airways Chief Executive Officer, Akbar AL BAKER, who was on-board the flight, said: "Qatar Airways is proud to be associated with this consortium and to become the world's first airline to use this new fuel technology on a commercial passenger flight."

The second commercial flight using GTL fuel was performed in April 2010 by United Airlines on an A319.

GTL fuels are a good step towards bio-fuels and these demonstrations triggered lots of interest from airlines for bio-fuel use in the near future. Airbus focuses on its implementation.

To carry out engineering, economic analysis and to move into the development of sustainable bio-fuels, Qatar Airways, in collaboration with Airbus, launched in January 2010 the bio-fuel value chain to commercialize bio-fuels. A detailed implementation plan for the bio-fuel production, an investment strategy plan and market analysis are being developed in this project.

In the view of the continuous collaboration with airlines, Airbus and the Brazilian airline 'TAM' announced in April 2010, a bio-fuel flight with an A320 with CFMI engines, using 50% blend of Brazilian jatropha. A letter of intent was also signed to set up the bio-fuel value chain in Brazil to commercialise the bio-fuel production.

#### **The role of Airbus**

Airbus is playing a catalyst role in the alternative fuels' development by continuously working with industrial partners to fully explore the potential value to supply the aviation industry.

Airbus is:

- Working with airlines to implement projects and convince them of the benefits of such a development,
- Providing decision-makers with relevant bio-fuel data,
- Developing research programmes (for example algae, bacteria, etc.) in collaboration with universities,
- Participating in sustainability pilot phases and analysis (involvement in the Roundtable Sustainability on Bio-fuels),
- Supporting the approval process for new bio-fuels within the fuel specification approval bodies ASTM / DEF-STAN (ASTM International Worldwide Standards Organisation/UK Defense Standards body).

Today, Airbus is supporting many national, European and international R&T initiatives including (but not limited to):

- CALIN - Research work which aims to identify and evaluate a number of alternatives to kerosene for the short, medium, and long term.

- ALFA-BIRD - Overview of potential alternative fuels, assessment for suitability for aircraft, technical analysis and future alternative fuel strategies.
- CAER (in preparation) - Establish a French aeronautic alternative fuel programme.
- SWAFEA - Forum for the community (industry, policy, science and research) to meet and discuss state-of-the-art in alternative fuels and energy for aviation.



w e b s i t e

### "Find out more about environment and alternative fuels"

#### Airbus and eco-efficiency

<http://www.airbus.com/en/corporate/ethics/environment>

#### Air Transport Action Group

<http://www.atag.org>

#### Publication

'Beginners guide to aviation to bio-fuels'

<http://www.enviro.aero>

(ATAG sponsored website)

#### Aeronautics Research in Europe

<http://www.acare4europe.org>

#### Clean Sky, a 'Joint Technology Initiative'

<http://www.cleansky.eu>

#### International Civil Aviation Organisation

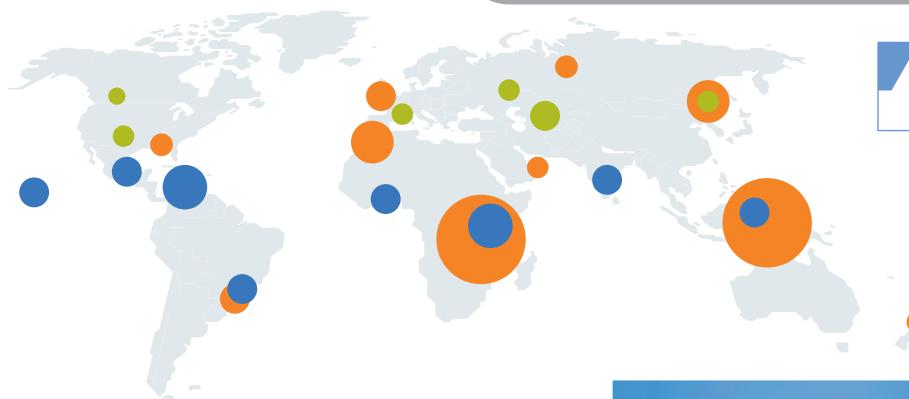
<http://www.icao.int/env>

#### IPCC Report on Aviation and the Global Atmosphere

<http://www.ipcc.ch>

#### Sustainable Aviation Fuel User Group

<http://www.safug.org/>



- Algae
- Jatropha
- Camelina

Source: Air Transport Action Group

#### Optimum land for growing sustainable aviation bio-fuels

Circles indicate potential locations for bio-fuel feedstock growth (indicative estimate)

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## Conclusion

Aviation has a limited spectrum of solutions compared to the other transport industries. Research and test flights have shown that synthetic bio-fuels can replace fossil fuels on today's aircraft, without any modification. The biggest challenge is producing sustainable feedstock in sufficient quantity and at a commercially viable cost, in order to provide a feasible fuel for aviation. Even though the industry has come a long way in understanding alternative fuels, there is some way to go before these different fuels become viable and widely available. Airbus foresees that 30% of all

flights will be powered by sustainable bio-fuels by 2030. The Airbus roadmap has set out a number of steps towards achieving this goal, and already succeeded in demonstrating that use of Biomass To Liquid (BTL) is viable, subject to available and sustainable feedstocks. Airbus is acting as a catalyst to bring together the value chain and to attempt to speed-up the commercialisation and visibility of aviation bio-fuels, as a solution towards "Greener, Cleaner, Quieter and Smarter" skies. Cross industry collaboration, sustainability and price are key!

**AIRBUS**



# Jet fuel contamination with FAME (Fatty Acid Methyl Ester) World jet fuel supply

This article explains the impact of FAME contamination in jet fuel, the on-going studies for aircraft clearance with higher levels of FAME concentration and the operational recommendations. FAME fuels are manufactured from biomass and have properties that are similar to petroleum diesel. This fuel makes a good fuel for road transportation means but is not appropriate for air transport, due to lower energy content and higher freezing point.

For a few years, the awareness of the human impact on climate change and ways to reduce it, have been identified. One of the key areas being

pointed at is the use of fossil fuel-based energy sources. This, added to the global increase of fuel prices and the threat of oil depletion has led a drive to develop and use alternate fuels in the transport industry. Worldwide, governments are regulating the introduction of bio-fuel components in ground transportation fuels. For example, Europe has mandated that automotive diesel must include a 5% bio-fuel component (Directive 2003/30/EC). Similarly, in the U.S.A., bio-diesel use has been increasing (following Energy Policy Act of 2005). The bio-fuel component usually added to diesel fuels are Fatty Acid Methyl Esters (FAME).



**Marie FROMENT**  
Fuel Systems Engineer  
Airbus Customer Services Engineering

## What are the bio-fuel components?

The term ‘bio-fuel’ (read also the previous FAST article - ‘Alternative fuels’) is used for any fuel derived from a biomass source through a conversion process which can be biological, thermal, chemical, or a combination of these, to form one or more products. The most common bio-fuel components currently available in the transport industry are: Bio-ethanol, bio-diesel from transesterification of vegetable oils and fats, and bio-gas from anaerobic digestion.

The bio-fuel component, Fatty Acid Methyl Ester (FAME), is manufactured using a chemical process called transesterification.

This reaction for bio-diesel component production is shown in figure 1. In this reaction, one molecule of oil or fat reacts with three molecules of a low carbon number alcohol in the presence of a base catalyst. Three molecules of fatty acid esters and one molecule of glycerine are produced. The low carbon number alcohol is usually methanol, but can also be ethanol or higher alcohols. The ‘R’ represents the fatty acid carbon chains associated with the natural oil or fat.

Manufacturers have the methanol react with an oil (triglyceride) such as vegetable oil (typically derived from sunflower or rapeseed oil), animal fat or used cooking oil to produce FAME and glycerol. The final properties are similar to petroleum diesel, which makes them good alternate fuels for road transport.

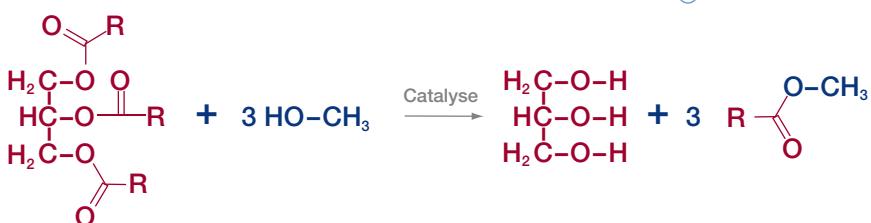


notes

In organic chemistry, **transesterification** is the process of exchanging the organic group R'' of an ester with the organic group R' of an alcohol. These reactions are often catalysed by the addition of an acid or base catalyst.

Example of the FAME manufacturing process by transesterification

Figure 1



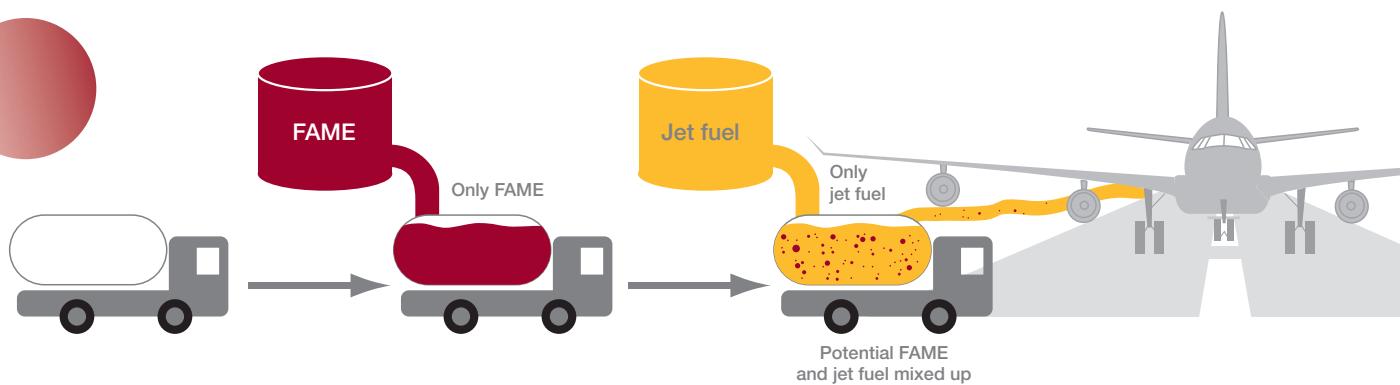
H=Hydrogen  
O=Oxygen  
HO-CH<sub>3</sub>=Methanol  
C=Carbon chains  
R=Fatty Acid Carbon chains



Rapeseed



Sunflower



Multi-product transportation

Figure 2

The blends (mixture) are commonly referred to as 'Bx' where 'x' designates the volume percentage of FAME. As an example, B5 contains 5% FAME and B10 contains 10% FAME.

Worldwide, multi-product supply systems such as pipelines, trucks, trains and ships often transport different grades of fuels and fluids, using protective measures that are designed to minimize cross-contamination. However, as FAME has the property to 'stick' to surfaces, small traces of FAME can be found in jet fuel; this contamination having been picked up by the jet fuel when following a batch of fuel containing FAME in the same transport system. There is also the possibility of carry-over of bio-blended-diesel (containing FAME) at the product interfaces, which occur in multi-product pipelines (refer to figure 2) which can then lead to jet fuel (JET A1) contaminated with FAME.

The most common bio-fuel types, currently in use in road transport, are not suitable for use as aviation fuels because they do not meet jet fuel specification requirements (e.g. freezing point, thermal stability, etc.)

## The current situation for air transport

In response to concerns about FAME contamination of jet fuel

and the possibility of airport supplies becoming contaminated, both, EASA (SIB N°2009-1) and FAA (SAIB NE-09-25) have issued information bulletins on this issue. Operators have been informed about the potential issue of jet aviation fuel being contaminated by FAME and that limited FAME contamination of airport fuel supplies has occurred.

FAME (from bio-blended-diesels) in jet fuel can have the following issues which are of concern for aircraft operations:

- Corrosion - formic and acetic acids, glycerine, water and methanol can be present,
- Cracking or softening of Elastomer seals,
- Presence of alkaline earth metals with an effect on engine components,
- High freezing point (freezing at -5C),
- Thermal stability - polymerisation can occur, leading to a filter blockage.

To minimize the potential impact of FAME contamination on jet fuel supply, the global jet fuel specification Defstan 91-91 was amended to permit up to 5mg/kg (5ppm - parts per million) of FAME content, being the lowest detection limit of current measurement methods (refer to the 'FAME current existing measurement methods' paragraph). For example, one litre of B5 in 10,000 litres of jet fuel renders the jet fuel 'unfit for use'.

As the use of bio-fuel components increases, the current level of 5ppm will be difficult to manage. Consequently, if contaminated fuel (above 5ppm) is detected on an aircraft, then at the present time operators have to defuel, then re-fuel the aircraft, to ensure no FAME contamination of aircraft systems. As a result of this risk, engine, APU (Auxiliary Power Unit) and aircraft manufacturers, have agreed that up to 30ppm, FAME contamination may be permitted, subject to stringent limitations. There is a limitation allowing two subsequent fuel uplifts reaching up to 30ppm (operation with two refuels allowed at airframe level). After these two fuel uplifts, then the fuel on-board will have to be below 5ppm of FAME.

## Current testing with FAME in aviation jet fuels

A specific programme has been put in place in order to provide emergency clearance of 100ppm contamination of FAME in jet fuel. This programme is led by the Energy Institute and is sponsored by airframe, engine manufacturers, oil companies, pipeline companies, government ministries, bio-fuel producers and military agencies. The aim is to perform and analyze all the testing requirements in order to confirm the compatibility in terms of the specification of jet fuel with FAME contamination up to 100ppm.

For example, an engine endurance test has started at the beginning of September 2009 and has completed several hundred cycles. It is expected that the testing will be analysed by the middle of 2010. No significant differences at 100 and 400ppm levels have been noticed in the fuel freezing point with either the manual freezing point method (ASTM D2386) or any of

the automatic methods. Similar results have been noted regarding the effect on the water solubility properties.

The testing showed no incompatibility problems between FAME and approved biocides or additives (such as anti-icing).

The influence of FAME on microbiological contamination development (refer to FAST 38) has also been studied. The impact linked to concentration (increased up to 400ppm) have been tested and preliminary conclusions show it does not have a significant impact to any additional microbiological development.

The programme includes the FAME material compatibility with an exhaustive list of materials. The results of this testing will determine the clearance of 100ppm due to the impact of FAME on aircraft systems. If any results are not suitable, maintenance plans would need to be introduced, or other contingency measures taken, on a material by material basis.

Testing results should be available by the end of 2010.



notes

Due to effects on exposure of the engines and APUs to high FAME concentration, further recommendations, as provided by the appropriate engine and APU manufacturer, will also need to be applied to allow the aircraft operation.



notes

ASTM International is the industry organisation that defines the consensus on fuels. ASTM standards are the minimum accepted values for properties of the fuel.

### AIRBUS RECOMMENDATIONS IN CASE OF JET FUEL CONTAMINATION WHEN FAME IS DETECTED

In the event of a fuel uplift of jet fuel, where FAME contamination with a concentration higher than 5ppm is detected (refer to paragraph 'Current testing with FAME in aviation jet fuels'), then it is advised that Airbus be contacted for further dispatch.

The dispatch limitations detailed below and the test requirements are still being refined and reviewed as further data becomes available from industry testing.

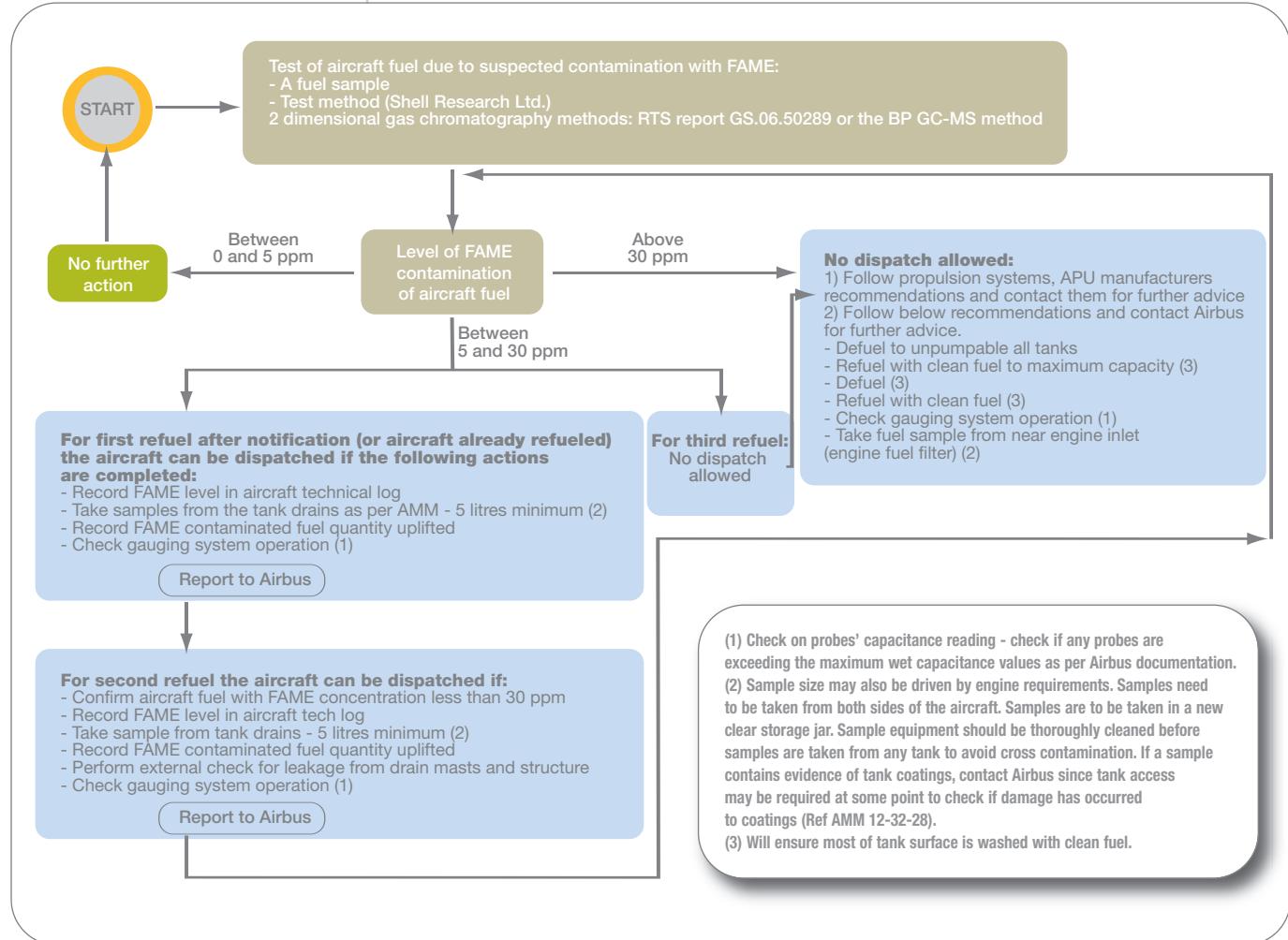
Operation with aircraft fuel contamination levels up to 30ppm is allowed at airframe level for up to two refuels but would require:

- Samples of fuel to be taken in the aircraft tanks (sample volume in the order of 5 litres),
- Confirmation of gauging system operation (due to potential deposits on the probes) by verifying the max wet capacitance values (confirmation of correct gauging),
- Lack of external fuel leaks.

After the two refuels, if the aircraft fuel is contaminated with FAME above 5ppm, the aircraft would then have to be defueled down to 'unpumpable' before refuelling.

If uplifted fuel still contains more than 30ppm FAME, then no dispatch will be accepted and the tanks must be flushed by defuel/refuel operations. This may involve more than one defuel/refuel cycle, before the dispatch will be allowed (refer to figure 3).

Figure 3



## FAME current existing measurement methods

One of the current difficulties encountered, linked to the 5ppm limitation, is the ability to test for the presence of FAME at this level. Since 5ppm is barely detectable, only very sophisticated laboratory instruments are able to detect such levels.

A specially configured gas chromatograph (GC-MS method) is currently used as one of the industry accepted methods for detection. The development of this test method was coordinated by the

Energy Institute, however, it is a difficult and expensive process and there are only a few laboratories in the world which are able to run this analysis.

One part of the programme, being led by the Energy Institute, is to develop a rapid detection method that can be used in the field. One method, under study, is based upon the Fourier Transform Infra-Red (FTIR) technology and might become an adapted method which could be adopted if a higher FAME limit is introduced.

Globally, there are four means of testing under development (GC-MS, SPE-FTIR, SPE-NMR and HPLC) to meet the objective to have rapid and portable means of testing.



information

### Laboratories carrying out the GC-MS method (IP PM-DY/09 test) for FAME down to 5ppm level

- Intertek - Sunbury (UK)
- Intertek - Thurrock (UK)
- Intertek - Antwerp (Belgium)
- Intertek - Le Havre (France)
- Intertek - Sydney (Australia)
- Intertek - Singapore (Singapore)
- SGS - Rotterdam (Netherlands)
- SGS - Le Havre (France)
- SGS - Lavera (France)
- Petrolab - Speyer (Germany)



information

### Test methods under development

- GC-MS method IP PM-DY/09: selective ion monitoring/scan detection method - precision at 5 mg/kg (5ppm)
- Flow analysis-FTIR rapid screening method IP PM-DT/09: Flow analysis by Fourier Transform Infra-Red
- spectroscopy method - precision down to 20 mg/kg (20ppm)
- HPLC-ELSD method IP PM-DV/09: HPLC Evaporative light scattering detector method
- SPE-GC method IP PM-EC/09: Solid phase extraction and gas chromatography method

### CONTACT DETAILS

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## Conclusion

Due to the increase in the potential of FAME contamination occurring in jet fuel, above the currently allowable limit of 5ppm, Airbus is actively supporting the industry work on several aspects to minimize the potential impact of higher levels of FAME contamination. Areas of research include the increase of the clearance levels up to 100ppm, the development of a quick means of field

testing to determine the levels of FAME contamination and operational recommendations in the event of uplift of jet fuel contaminated with FAME. Updates and findings of the research are documented (Airbus SIL 28-091) and it is expected that additional recommendations will be available by the beginning of 2011.

**AIRBUS**



# Repair Design Approval

## Structure damage assessment using Repair Manager

Damage to aircraft structure causes severe operational interruptions and the restoration to an airworthy condition needs to be shown before the next flight. It can also be difficult to assess damage, find and collect relevant information from a wide variety of data sources, while complying with the regulatory record keeping requirements. This article will explain the regulatory requirements to report such damages (Part 1) and will guide you through an overview of a damage case using the new on-line service developed by

Airbus, Repair Manager (Part 2). This software provides airlines a simple and efficient method to view, locate concessions and in-service damage and repairs, on a 3D (three-dimensional) simplified model of the aircraft, enabling them to record and safely store the details. Repair Manager allows the operator to build a comprehensive database of all of the structural damages on an aircraft and maintain it together with the associated approval documentation.



**Alain BALEIX**  
Head of Repair Approval  
Airbus Customer Services



**Colin SMART**  
Structure Engineer /  
SRM development  
Airbus Customer Services

## Part 1: Repair Design Approval

### BACKGROUND

Since the early 1990s, Airbus supports the approval of repairs' actions or damage allowance with a 'Repair design Approval Sheet' (RAS) form (See Structure Repair Manual chapter 51-11-14).

From 1996, Airbus has been granted by the French DGAC (Direction Générale de l'Aviation Civile) with the privilege to approve minor repair designs within its Design Organisation Approval (DOA). This privilege was extended to the major repair design in 2003. In 2004, the DOA was transferred from the DGAC to the EASA (European Aviation Safety Agency), so the approvals are now issued under an EASA DOA. This article will only describe the Repair Design Approval process within the EASA regulatory framework.

The equivalence of the regulatory frame can be found in each country having signed the Convention on International Civil Aviation (also known as the Chicago Convention).

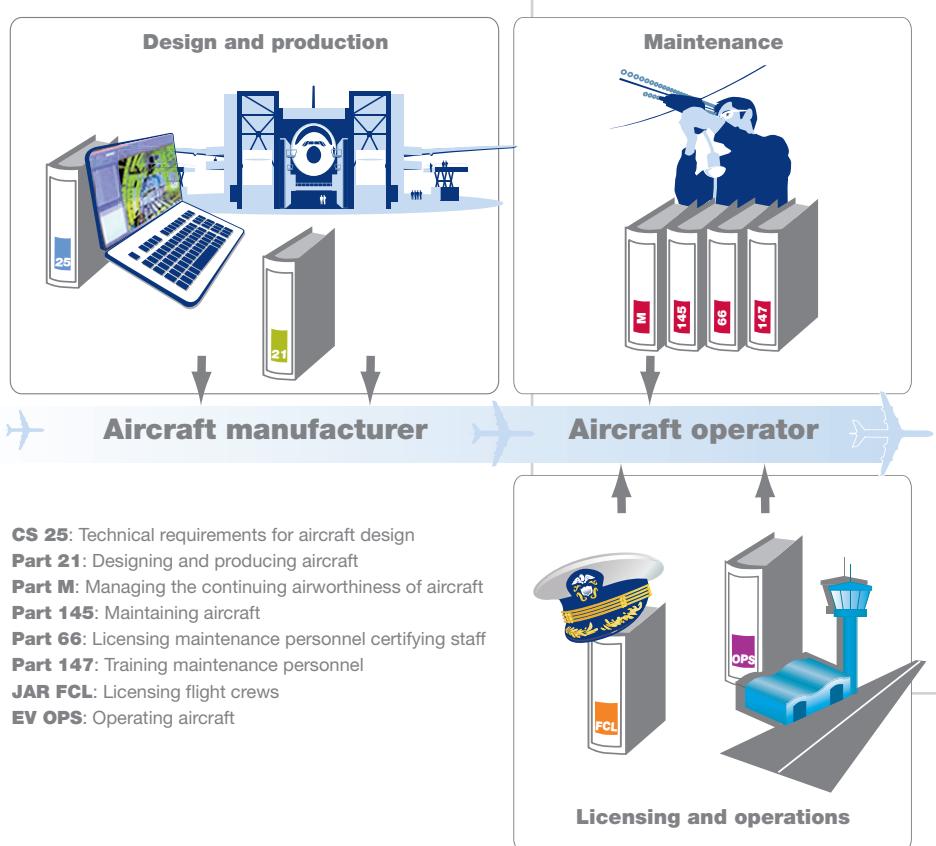
### THE AIRWORTHINESS OF AN AIRCRAFT

The airworthiness aims to obtain an acceptable level of safety for civil flights. An airworthy aircraft is:

- Designed and built according to applicable requirements,
- Operated within its intended environment and within its quantified and declared limitations,
- Maintained in accordance with procedures acceptable to the responsible authority.

The first responsible of the airworthiness of an aircraft is its owner. Airbus is involved as being the designer and manufacturer in this chain of responsibility.

Airbus is a Type Certificate (TC) holder to design large transport aircraft and relative activities with a Design Organisation Approval (DOA). Airbus aircraft are certified in compliance to the certification basis issued from the airworthiness codes for large aircraft (JAR 25 / FAR 25).



**Structural issue**

Figure 1

With an optimized design of light structure, modern aircraft are susceptible to fatigue damage. Their structural strength is slowly entailed by potential cracks under cyclic loadings of the aircraft. It shall be maintained at an acceptable level through a monitoring.

**Regulations take into account this phenomena and rule it through CS25 and Part 21**

Compliance to CS25.571 by test and analysis determines these areas and their damage tolerance capability. The resulting monitoring is published as a maintenance task in accordance to CS25.1529 and CS25 appendix H, so in the Airworthiness Limitation Section (ALS) for the more critical areas

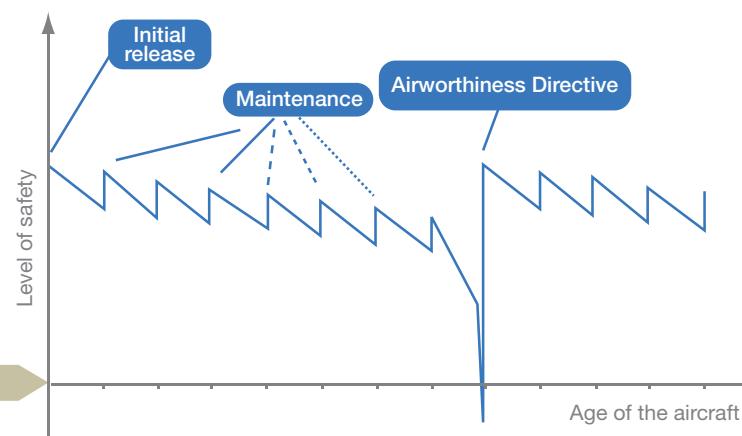
**Instructions for Continued Airworthiness (ICA)  
(Part 21.A61 or Part 21.A107 including ALS, attached to type design Part 21.A31)**

The maintenance programme is established and approved according to Part M.A.302, including ICA.

**The maintenance programme is performed to comply with Part M.A.201 a) 4).**

**Safety level**

Figure 2

**INSTRUCTIONS FOR CONTINUED AIRWORTHINESS (ICA)**

ICA result from the certification exercise, issued and linked to the Type Certificate (TC) and its modifications. All are compulsory according to the airworthiness codes; ones largely depend on the aircraft usage and may be customized when the Airworthiness Limitation Section (ALS) has to be strictly observed. The structural issue illustrates the process (see figure 1).

**THE CONTINUED AIRWORTHINESS**

Ages of service may reveal unexpected defects not contemplated at the issuance of the TC, either by the airworthiness code or the designer. The regulation prevents the decrease of the level of safety by ruling reports of unsafe conditions:

- The operator of the aircraft according to EU-OPS 1.420,
- The responsible of the maintenance according to Part M.A.202,
- The maintenance station according to Part 145.A.60,
- The design or production organisation according to Part 21A.3.

Additional duties of Airbus, as a TC holder, are:

- To investigate and to analyze failures, malfunctions and defects linked to its products.
- When an Airworthiness Directive (AD) is issued against the unsafe condition:
  - To propose the appropriate corrective action,
  - To make them available to all known operators' accomplishment instructions.

ICA and ADs contribute to maintain a high level of safety as per figure 2.

## RESTORING THE CONTINUED AIRWORTHINESS WITH THE REPAIR DESIGN

A damaged aircraft shall be assessed also from an airworthiness standpoint before the return to service and to show evidence of an acceptable level of safety.

This assessment requires the organisations to inspect the damaged aircraft, design and approve the repair, embody the repair and inspect the repair according to the repair approval.

Basically, the tasks of an organisation designing a repair are similar to a modification to a TC, such as to draw/design the repair, show compliance to the requirements and obtain, or to approve, the repair design.

## SOME HIGHLIGHTS ON THE PART 21

The scope of the Part 21 subpart M (21A.431) is the approval of the repair. This means the elimination of damage and/or restoration to an airworthy condition of in-service aircraft. In Airbus DOA, a RAS is the issuance of the Repair Design Approval as per Part 21A.437, its design certificate.

Some repair data do not need this specific approval such as:

- A replacement without a design activity,
- Explicitly approved data, such as the Structure Repair Manual (SRM), Service Bulletins or Production Concessions as part of the Aircraft Individual Certificate (AIC).

A Repair design Approval Sheet (RAS) is dedicated to structural damage, mainly ATA structure chapters (52 to 57) and interface with systems like flight controls of ATA 27. The Airbus process for system damages is called a Technical Adaptation (TA).

A RAS cannot be used for a modification to TC. Airbus does not update its documentation (Illustrated Part Catalog - IPC, Aircraft Maintenance Manual - AMM, Structure Repair Manual - SRM, etc.) for a repair.

The classification of the repair design (Part 21A.435) into minor or major follow the same criteria than for a modification to TC (Part 21A.91), having the same means which are to report (see figure 3) the relevant information to the authorities.



notes

The operator needs to meet the airworthiness requirements for ageing aircraft (FAA Part 26):

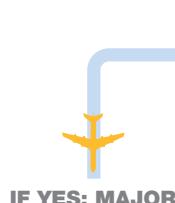
- To demonstrate damage tolerance of repairs to Fatigue Critical Structure (FCS),
- To include inspections associated with these repairs in the Maintenance Programme,

These requirements are being implemented by EASA through the Part M (see Acceptable Means of Compliance AMC20-20).

REPAIR DESIGN APPROVAL SHEET	
Ref. RAS/DOA/AMC20-20/001	Issue: A
AVC Type (A20-274-01)	MBW-001
PN: 00000000000000000000	ATA: 50-01-11
	S/N: _____
Title: Rear Cone Fuselage Skin - lightning strike / burned fastener head	
Page 1 of 1 PC 2104 PM 1-9227	
<b>DAMAGE / REPAIR DETAILS:</b> Lightning strike on a bond on fastener head on rear cone fuselage skin at F0171 and D10127 LH. - Perform affected fastener as per GRM 51-43-01-00. - Perform cold expansion on nose fairing at 51-44-00. - Perform cold expansion on nose fairing at 51-44-11. - Restore surface finish as per GRM 51-75-10-000-00. <b>Damage/Repair Ref. LTR-Ref. T9-1791-10-000-00</b>	
<b>REPAIR CLASSIFICATION:</b> REGULATIONS INVOLVED: 14 CFR - TO CERTIFICATION BASIS: JUSTIFICATION DOCUMENT: SAS/42/23/194/2010/A DEFINITIVE APPROVAL LIMIT:	
<b>INTERIM AUTHORIZATION FROM STRESS AND/OR DESIGN OFFICES:</b> Name: _____ Signature: _____ Date: _____	
<b>INTERIM APPROVAL:</b> Name: _____ Signature: _____ Date: _____	
<b>PATRIOTIC TOL. AVIAT. DOC. SAS/R/92/31640-2010/A</b> <b>REPAIR CATEGORY:</b> A <input checked="" type="checkbox"/> An additional requirement B <input type="checkbox"/> Inspection required C <input type="checkbox"/> Temporary repair	
<b>SPECIFIC MAINTENANCE REQUIREMENTS:</b> Method of inspection: Interval: Emergency repair as per: Repair structure: Heatshrink tube (SHPT)	
<b>DEFINITIVE AUTHORIZATION FROM STRESS AND/OR DESIGN OFFICES</b> Name: A. Peters A. Zonkay Signature: Date: 04 Jun 2010 04 Jun 2010	
<b>DEFINITIVE APPROVAL:</b> Name: Kenneth WARDLE Signature: APPROVED UNDER EASA REGULATIONS AND APPROVAL NUMBER: 00000000000000000000 Date: 07 Jun 2010	

### Questions for reporting

Figure 3



Does the repair design permanently affect:

- The maintenance programme to ensure the continued airworthiness of the aircraft?
- The airworthiness approved limitations in the Aircraft Flight Manual (AFM), Master Minimum Equipment List (MMEL), Weight & Balance Manual (WBM)?

IF NO: MINOR

Does the repair design:

- Need extensive justification, testing or development of new methods, techniques or practices?
- Require a re-evaluation of the original certification substantiation data?
- Affect functions where the failure effect is classified catastrophic?

# STRUCTURE DAMAGE ASSESSMENT

## REPAIR DESIGN APPROVAL

**LIMITATIONS AND INSTRUCTIONS FOR CONTINUED AIRWORTHINESS FROM REPAIRS' DESIGN**

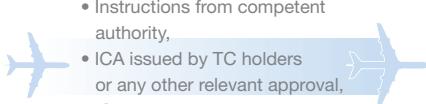
As for a Type Certificate (TC), structural repairs on light optimized structures (a fortiori allowable damages) are susceptible to fatigue and as for the TC, they require inspection leading to ICA and limitations.

The Airbus Repair design Approval Sheet (RAS) form supports compliance in areas dedicated to maintenance requirements to Parts:

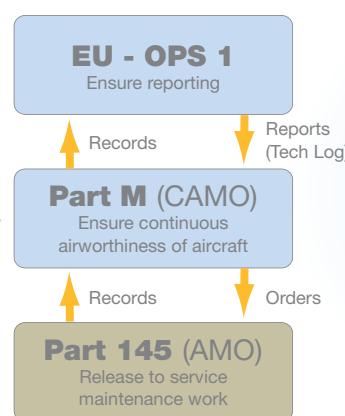
- 21A.449 (unrepaired damage),
- 21A.443 (limitations),
- 21A.449 (ICA).

<b>Areas dedicated to repair maintenance requirements</b>	
<b>REPAIR CATEGORY:</b> <ul style="list-style-type: none"> <li>A <input type="checkbox"/> No additional requirements to zonal inspection programme</li> <li>B <input type="checkbox"/> Inspection required</li> <li>C <input type="checkbox"/> Temporary repair</li> </ul>	
<b>SPECIFIC MAINTENANCE REQUIREMENTS:</b> <p>Threshold*: _____</p> <p>Interval: _____</p> <p>Method of inspection: _____</p> <p>If temporary, repair life limitation*: _____</p> <p>Repair Structural Modification Point (SMP)*: _____</p>	
<small>* If not otherwise specified; Threshold, repair life limitation or SMP are from time of embodiment</small>	
<input type="checkbox"/> ALI (Airworthiness Limitation Item) limitations to apply (life limited parts only)	

### AOC - Operator EU-OPS 1


**Part M.A.302:**

- Instructions from competent authority,
- ICA issued by TC holders or any other relevant approval,
- ICA issued by major repair approval holder.

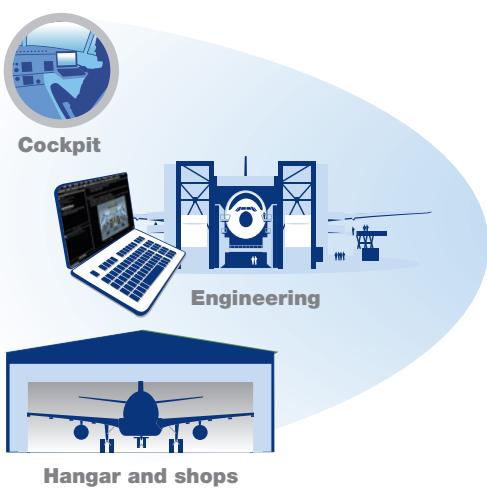


### LIMITATIONS

When the limitations affect a life limited part, the RAS indicates the life of the damaged area and not the life of the entire part, itself being dictated by the Airworthiness Limitation Section (ALS) Part 1:

- When the RAS limit is lower than the ALS limit, the new part life is that of the RAS.
- When the RAS limit is higher than the ALS limit, this is still applicable and the Continuing Airworthiness Maintenance Organisation (CAMO) needs to observe the ALS limitation.
- The ALS limitation can vary through time and the CAMO is required to update the life limited parts' maintenance accordingly, including the repaired ones.

Some limitations can result when the structural (damage or its repair) affects the performances of the aircraft, like the aerodynamics. They may decrease the maximum weight of the aircraft, the One Engine Inoperative (OEI) ceiling or other performance penalties. These limitations have to be recorded and communicated to the flight operations of the company. All these limitations comply with the applicable requirements.



## INSTRUCTIONS FOR CONTINUED AIRWORTHINESS

The compliance to CS25.571 for the repair results in an ICA like for TC. Then, the task is compared with the actual maintenance programme of the aircraft, as established by Airbus.

- When a ‘zonal’ task is adequate, no inspection is indicated in the RAS,
- When another maintenance task is adequate, it is repeated as a ‘method’ in the RAS without threshold and interval,
- When a maintenance task is to be adapted locally for the repair inspection, the maintenance task and its adaptation are indicated in the RAS,
- When there is no maintenance task, the RAS supports all details for the inspection and it is classified as major.

All the ICA for major repairs shall be incorporated by the CAMO into the maintenance programme of the aircraft, according to the Part M 302 requirement.

## Part 2: Repair Manager

### OBJECTIVE AND OPERATIONAL BENEFITS

Repair Manager on-line software provides airlines with a simple method to view and locate non-conformities and in-service damage and repairs on a 3D simplified model of the aircraft, to record and safely store the details. Its objective is to ease line maintenance’s structural damage reporting, to reduce elapsed time to assess damage and authorize the aircraft’s return to service. In addition, the tool allows the operator to build a comprehensive database of all the structural damages on an aircraft and maintain it together with the associated approval documentation.

### KEY FUNCTIONS

Repair Manager mainly serves the following areas of activity within an airline:

- Line and heavy maintenance for damage reporting, assessment and follow up,
- Engineering services for assessment and data analysis,
- Ease aircraft dispatch by direct access and compilation of the aircraft status reports (also known as a Dent and Buckle Chart).

At any time, a user can directly access to:

- The structural status of the entire fleet or a specific MSN (Manufacturer Serial Number),
- The structural damage and repair history of any MSN by accessing all its repair files including approval documentation,
- The aircraft status report of each MSN.

When damage is found, a user is able to report it through a series of process based steps to compile a full and comprehensive damage report, with just a laptop connected to AirbusWorld, the Airbus customer portal.

This guidance provides the required information for the damage evaluation and reporting back the necessary data to the airline Maintenance Control Centre (MCC), Airbus, or a non-Airbus OEM (Original Equipment Manufacturer). Repair Manager also allows the operator to delegate access to the tool for third party maintenance organisations, so they can use the tool for the operator’s fleet during maintenance checks.

### STRUCTURAL DAMAGE REPORT CREATION

This guides the user through the different steps of the compilation of a report: Location, description and assessment. It also helps the user to fill in repair and approval data in the relevant tab of the Structure Damage Report (SDR).





Damage on fuselage skin

## SPECIFIC TOOL FOR ACCURATE DAMAGE LOCATION - 3D SIMPLIFIED MODELS

The 3D simplified models are used to locate the damage/repair on a 3D digital mock-up of the aircraft structure. Using the 3D models, a user can directly locate a structural damage on the aircraft. The 3D simplified models use a defined set of damage shapes and colours depending on the damage status (draft, opened, closed, deferred and obsolete). A summary of the damage details, (including the damage type, approval documents, inspection information, etc.) are displayed on screen when the mouse is moved over the damage point.

## SEARCH FUNCTION

Two types of search functions are available:

- A 3D search allowing the user to display all of the damages and repairs on a particular Manufacturer Serial Number (MSN) that meet the criteria entered in the search fields,
- A tabular search allowing the user to list all the damages and repairs for MSNs that meet the criteria entered in the search fields. This feature also provides a work list of items awaiting validation by the engineering or maintenance control departments.

Using search criteria, users can get quick access to all the information stored for a given, or multiple MSNs (open and deferred actions, additional maintenance requirements, etc.), or damage (status, dimensions, allowable damage, repair and approval documents, etc.) and can then launch the relevant actions, if required.

## AIRCRAFT STATUS REPORT (DENT AND BUCKLE CHART)

An Aircraft Status Report (ASR) can be generated automatically showing the location of all of the damages and repairs loaded on the

3D simplified models together with a list of all the recorded damage classified by ATA chapter and repair category (Category A for ‘no additional maintenance’, B for ‘specific maintenance requirement’ and C for ‘temporary repair’).

## LINK TO AIRBUS TECHNICAL DOCUMENTATION

The part damage and location detail pages give direct access to AirN@v/Repair, AirN@v/Maintenance and engineering drawings, through AirbusWorld. These provide direct access to the approved documentation data for structural maintenance, such as the Structure Repair Manual (SRM), Non-destructive Testing Manual (NTM), Aircraft Maintenance Manual (AMM), Illustrated Parts Catalog (IPC) and the mechanical drawings for convenient and practical guidance.

## WORKFLOW STEPS

The workflow, when damage is discovered, is as follows (the Repair Manager home page gives direct access to the functions available):

- **Report:** For creating and continuing damage reports,
- **Find, access, consult, get reports:** For accessing the search functions and to export the results, for users with an ‘administrator’ profile, it also allows the export of selected Structure Damage Reports (SDR).
- **Get an aircraft status report:** For providing access view and creating an aircraft status report using the 3D models and the tabular listings.
- **Advanced functions:** Allowing the mass import of data.

The import and export functions allow the users to re-assign SDRs for removable parts from one MSN to another, in a semi-automated process.

## Repair Manager overview of the process for a repair requiring a Repair Design Approval

**1**

**AIRBUS | Repair Manager**

Welcome to Repair Manager Application

RM (Repair Manager) is an on-line application which allows Customers to report on Aircraft Structural Damage. It also allows access to several other main functions : Consult and create SDR (Structure Damage Report), generate the "Aircraft Status Report", import concession and legacy damage reports; export report for further re-use and other functions.

You can select below the action to execute.

- Report**
  - You have identified a structure damage and you want to create a new SDR (Structure Damage Report)
  - A SDR is already created and you need to continue editing it
  - Resume edition of an existing report
- Find, Access, Consult, Get reports**
  - You have the need to find a SDR, consult a SDR, get reports from the Data Base content or visualize filtered SDR in 3D.
  - Access to Damage Database content
- Get an Aircraft Status Report**
  - You need to get the Aircraft Status Report from an Aircraft
  - Access to Aircraft Status Report service
- Advanced functions**
  - You need to use advanced functionalities
  - If you have to import "concessions" or "legacy SDR"
  - Access to import service

### Step 1 - Aircraft

The user selects the aircraft type and selects the relevant aircraft from the list. The list contains all the aircraft of this type operated by the airline. MROs will see the aircraft list for the airline when access delegation has been given by the operator. The user checks if the aircraft Weight Variant (WV) information is up to date and updates the flight cycles and flight hours' information.

The system will automatically list all the damage reports created within the last 15 days to reduce the possibility of the user entering a duplicate damage report. The location and details of these reports can be accessed directly from the list.

**2**

**AIRBUS | Repair Manager**

Please fill in main aircraft information of the SDR.

A/C KAD code	QFA	Aircraft type	Aircraft model	Registration or tail no.	LEASER
VH-EZK					
0007	VH-EZG	330-200	QFA	022	10015 5082
0002	VH-EMH	330-200	QFA		
0015	VH-EMI	330-200	QFA		
0040	VH-EMJ	330-200	QFA		
0076	VH-EML	330-200	QFA		
0043	VH-EMM	330-200	QFA		
0054	VH-EMN	330-200	QFA		
0014	VH-EMO	330-200	QFA	9	0
0015	VH-EMP	330-200	QFA		
0050	VH-EMQ	330-200	QFA		
0052	VH-EMR	330-200	QFA		
0022	VH-EMT	330-200	QFA		

A/C MN: 0007 A/C model: 330-200  
Weights variant: 002 A/C flight hours: 10015 A/C flight cycles: 5082

**AIRBUS | Repair Manager**

Please fill in SDR aircraft identification

SDR MN: \* Input with asterisk  
Airline ref: ABC-AIR1234567890  
Responsible: Pierre Dubois  
Origin: In Service

Damager event: Ground vehicle  
Date of event: 28/05/2010  
Airport: TLS

General comments: Few small dings seen painted by艸tler

**AIRBUS | Repair Manager**

List of existing damage for selected aircraft

There are 4 records created or modified in the last 15 days that match with the aircraft selection criteria.  
Check on "CREATE SDR" to carry on to the next step.  
Check on "REVIEW" to review damage entries.  
Check on "PRINT" to print the damage entries.

### Step 2 - SDR Identification

A damage report title is entered to easily identify the damage report in the future, (the only mandatory field on this page). The operator has the ability to enter their own damage report reference in addition to the unique damage report reference created by the system. The damage event fields are used to link several damage reports together following a major event and make them easier to find.

### Step 3 - Part identification

The user sees the whole aircraft 3D model on screen and then selects the aircraft section that has been damaged.

**3**

**AIRBUS | Repair Manager**

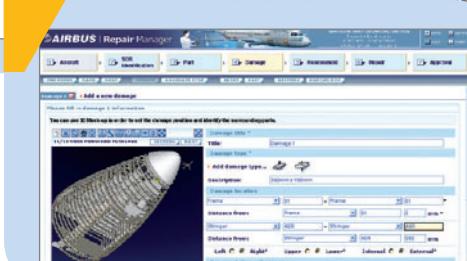
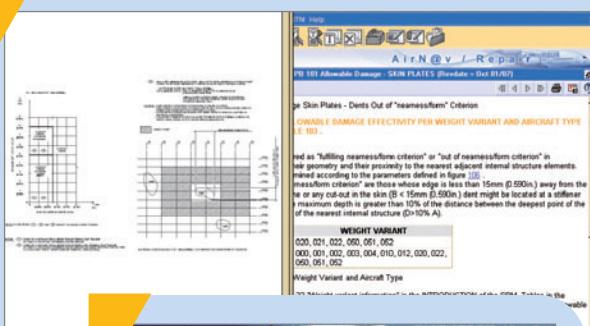
Please fill in part information.

You can click 3D model up in order to select the affected part. Then go to SDR in order to enter the PIM information.

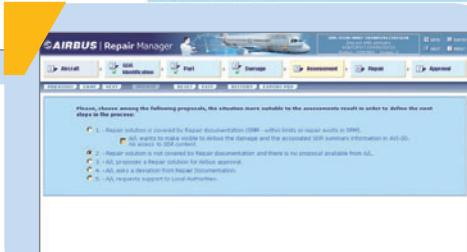
3D Navigation references	
A/C section:	
Part type:	
Part name:	
C.B. ID:	
Part details:	
Assy Ref.:	
Assy description:	
Assy P/M:	
Assy S/M:	
Assy P/PC:	

**AIRBUS | Repair Manager**

3D view of the aircraft showing the damaged section highlighted in orange.

**4**

Photographs of the damage including dimensions can also be loaded.

**5**

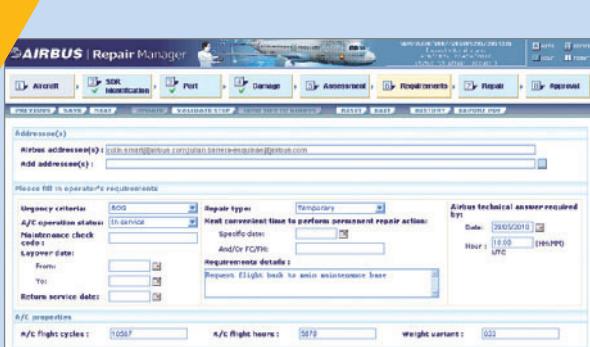
## Step 5 - Assessment

The assessment is performed according to the instructions provided in the aircraft manuals, SRM, AMM, CMM, etc. If the damage is within the limits of the approved documentation or the repair solution is covered by the SRM, then the line mechanics can validate the damage description and finalize the approved process. If the damage is outside the approved document limits, then the next steps need to be performed by the engineering or maintenance control departments. They can then decide whether a damage report needs to be sent to Airbus and/or the Original Equipment Manufacturer (OEM) for approval, or whether they can approve the damage or repair themselves.

**SRM:** Structure Repair Manual

**AMM:** Aircraft Maintenance Manual

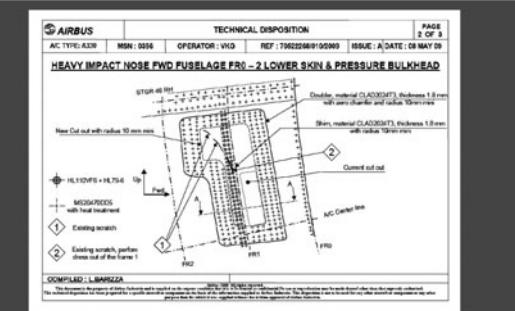
**CMM:** Component Maintenance Manual

**6**

## Step 6 - Requirements

If the damage is outside the SRM limits, the user then fills out the details of their request for assistance, describing the current status of the aircraft and the date the answer is required.

7



## Step 7 - Repair

Once the technical statement is available (from Airbus, non-Airbus OEM or from the SRM), the user completes the repair page to record/load the repair proposal into the tool, the date that the repair has been performed may also be completed, if different from the date the damage was discovered. More than one repair can be added so that the repair history is retained (temporary repair followed by a permanent repair).

8

## Step 8 - Approval

Once the technical statement is available (from Airbus, non-Airbus OEM or from the SRM), the user (the same or a different one with the necessary rights) fills the approval page. The approval page includes all the required information depending on the damage category. It also allows specifying the type of repair (Temporary or Permanent) and the existence of additional maintenance requirements and inspections.

In this section, you can attach the Repair design Approval Sheet (RAS) or other approval documents associated with the repair. These can also include documents such as a 'Permit to Fly', 'Alternative Means Of Compliance' (AMOC), etc., as described in the Repair Design Approval (Part 1). Any approval documents can be attached to a damage report whether they are internal to the operator or from a non-Airbus OEM.

As with the repairs page, multiple approvals can be attached on separate tabs keeping the history of the repair approvals available.

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## Conclusion

An accurate damage assessment and its relevant reporting are fundamental for expediting the repair design. A complete and precise report is the first requirement for an efficient repair design. The observance of the Instructions for Continued Airworthiness (ICA) is key for safety. This encompasses the ICA issued, not only by an Airworthiness Directive, a Type Certificate or a modification, but also from a Repair design Approval Sheet which you may find in AirbusWorld.

In that context, Repair Manager is a decision tool for speeding up and easing structural damage report compilations during the assessment phase. Its easy-to-use interface with simplified 3D models will guide you, step by step, towards a more accurate and effective reporting and to be in compliance with airworthiness authorities' regulations for damage record keeping. Repair Manager is available for all the Airbus aircraft families from mid July 2010.

AIRBUS



# Head-Up Display system

## Enhanced operations' situational awareness

Innovation is at the heart of activities and Airbus ensures that its aircraft benefit from the most advanced technology available.

During the end of 2002, Airbus decided to provide the HUD (Head-Up Display) as an option on its commercial aircraft (and as the basic instrument to operate the Airbus A400M military transport aircraft). A new generation HUD, called MPP

(Multi-Programme Project) HUD, has been developed and proposed on the A320, A330/A340 aircraft families, as well as on the A380. This MPP HUD, based on proven technologies already available on all aircraft within the Airbus Fly-By-Wire family, is being further optimized for the A350 XWB and will be proposed as an option at its Entry-Into-Service.



**Eric ALBERT**  
HUD Project Leader  
Airbus Cockpit Engineering

# The Head-Up Display (HUD) system

The fundamental element of the HUD system is a conformal head-up display that presents essential flight information and guidance to the pilot in his forward field of view for all flight phases.

The HUD is a see-through device which helps the pilots to fly more accurately, displaying collimated flying symbols overlaying the real outside world view.

The new generation HUD systems are from a single source SFE (Supplier Furnishing Equipment).

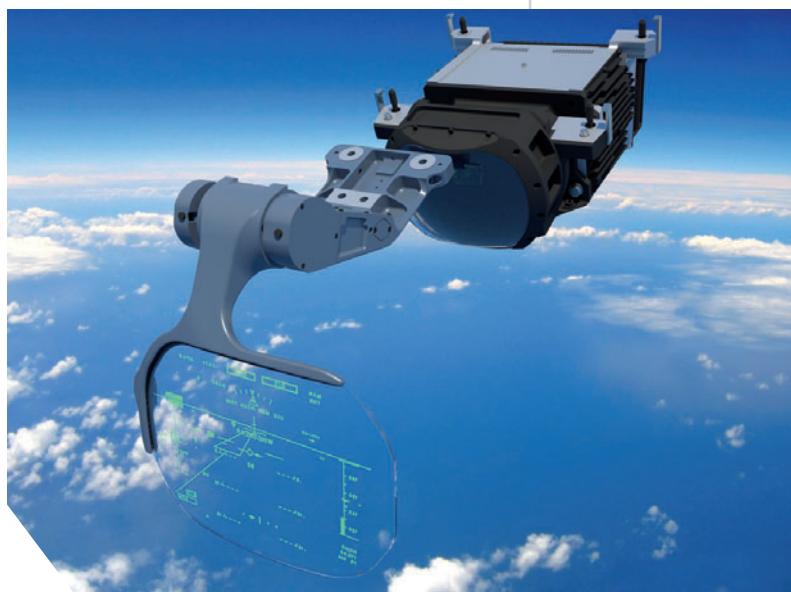
## System overview

### COCKPIT INTEGRATION

The HUD System is fully integrated into the existing cockpits. Either single or dual installation configurations for the MPP HUD (on A320, A330/A340 aircraft families and the A380) are available as a forward fit. Only the dual installation configuration is currently proposed for the A350XWB.

The HUD system comprises a:

- Head-Up Display Computer (HUDC): For data collection, display management, graphics generation and BITE (Built-In Test Equipment) management on A320, A330/A340 aircraft families and A380 , or a Display Unit (DU) on A350XWB (basically installed),
- Head-up Projection Unit (HPU): Display device, drive electronics and projection optics,
- Head-up Combiner Unit (HCU): Optical element (glass plate), mounted behind the windshield which reflects the projected image towards the pilot,
- Personalization Memory Module (PMM): For memorization of the electronic bore-sighting parameters.



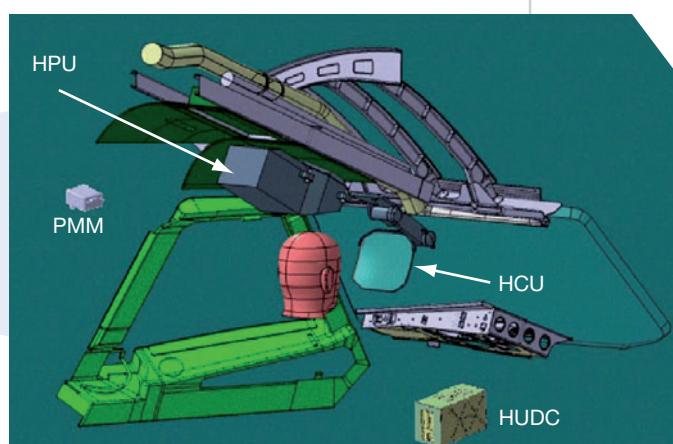
Courtesy of Thales Avionics

The HUDEC receives data from the aircraft's sensors and generates the display symbology. The HPU includes a LCD (Liquid Crystal Display) imager that projects the image onto the HCU. The HCU is an optical element (a glass plate), mounted between the pilot's head and the windshield which reflects the projected image towards the pilot. Whilst the superimposed image (to infinity) provides flight information to the pilot, he can continue to see external scenes in a completely normal way (through the HCU's glass plate). The PMM allows the memorization of the electronic bore-sighting parameters. This electronic process consists in aligning the optical references of the HUD cockpit equipment with those of the aircraft.



**The certifications** of the new MPP HUD system were achieved on the following dates:  
 • A318 (PW): 23<sup>rd</sup> Nov 2007,  
 • A320 & A318 (CFM): 17<sup>th</sup> Dec 2007,  
 • A319 (CFM): 18<sup>th</sup> March 2008,  
 • A380 dual HUD (EA): 31<sup>st</sup> July 2009.

The certifications on A319 and A320 aircraft with IAE engines are forecasted by the end of 2010. The certification on other aircraft models (e.g. A330/A340 Family and A321) will depend on the customers' requests.

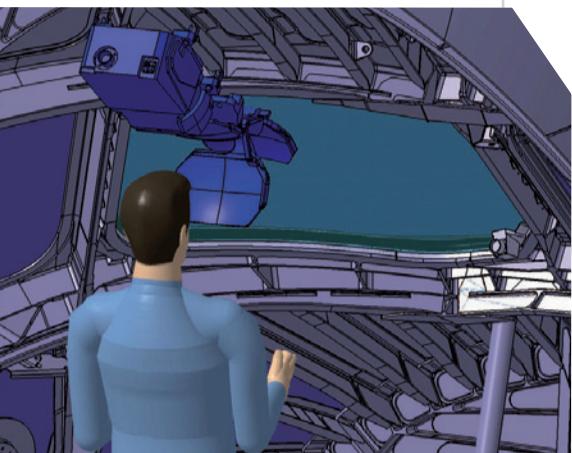


MPP HUD components in the cockpit (A320, A330/A340 aircraft families and A380)



## notes

The Display Global Work Package is a system platform integrating and regrouping the functions of the Cockpit Display System (CDS), the Head-Up Display and the Airport Navigation.



New A350 XWB HUD components integrated in the cockpit

### MPP HUD (MULTI-PROGRAMME PROJECT HEAD-UP DISPLAY)

The single installation configuration is composed of one HUD set (HUDC+HPU+HCU+PMM) installed on the Captain's side. For the dual installation, one HUD set installed on the First Officer's side completes the single installation.

In accordance with the MPP HUD development policy, one of the most ambitious challenges was that one same HUD be installed in the A320, A330/A340 aircraft families and A380 aircraft cockpits, despite their different architectures. This target has been achieved since the HUD part numbers remain the same, whatever the Airbus aircraft. This offers the benefit of having the Airbus cockpit commonality and brings cost savings to the operators in terms of maintenance and spares.

### A350XWB HUD

The dual installation configuration (upon the A350XWB basic configuration) is composed of two HUD cockpit equipment sets (HPU, HCU and PMM).

The HUD part numbers for the A350XWB are specific to this aircraft because the HUDC is no longer needed, as the software is hosted in the Head Down Display as part of the Display Global Work Package (see A350XWB HUD overall system architecture), therefore saving space and weight.

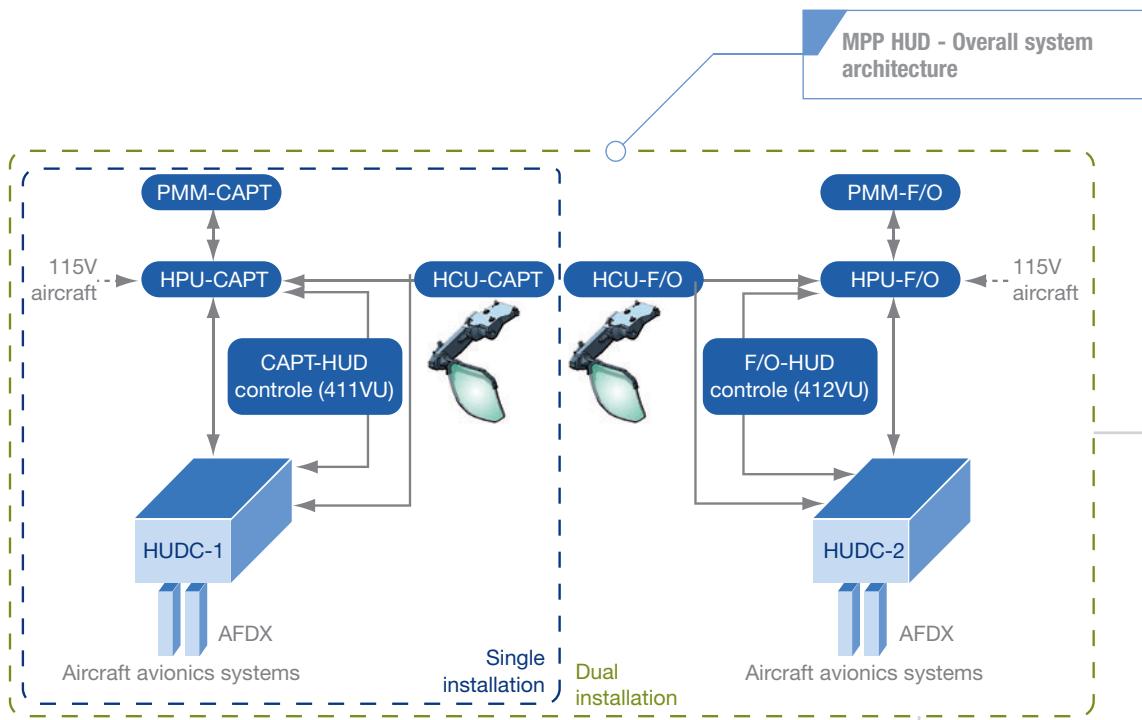
The MPP HUD system was the first fully digital HUD certified on a civil aircraft. Indeed, it is the first HUD based on the LCD (Liquid Crystal Display) technology and not on the commonly used CRT (Cathode Ray Tube) technology. For the HUD, the LCD technology provides an increased reliability and a great image luminosity. It also provides advantages in volume, weight and consumption savings that greatly reduces the operational costs when the aircraft is equipped with such a system. The LCD technology offers additional graphic capabilities without time disruptions (reverse video, haloing effect, priorities, line thickness, grey level, etc.) and a good quality and legibility of the symbols.



HUD Projection and Combiner Units in the cockpit



HUD Computer in the avionics bay



The main benefits introduced by the new A350 HUD compared to the MPP product are:

- Weight savings and volume linked to the integrated architecture as part of the Display Global Work Package (no additional HUDC),
- More integrated solutions in the cockpit layout (linings, etc.),
- Better reliability based on LED backlighting (instead of lamps) for the LCD display,
- Better head clearance,
- Better optical performances (e.g. with regards to the eyes' motion box defining the three dimensional area in space in which the centre of the HUD virtual display can be viewed with at least one eye).

## HUD core function (symbology)

The primary aim of the HUD symbology is to provide essential flight data and information needed for the safe and effective control of the aircraft. It is necessary for the symbology to accurately represent the outside (conformal) view, while not obstructing this outside view.

The following items are unique to HUD symbology:

- Conformal display elements:  
Some HUD symbols are designed to overlay the real world as seen by the pilot through the HUD Combiner,
- Viewing position:  
The HUD is designed to be viewed from the cockpit Eye Reference Point and a head movement area around that point, called the "Eye Motion Box",
- Viewing into the sun:  
The HUD is designed to be able to project symbology that can be seen against a very bright background (34000 Cd/m<sup>2</sup>). The pilots can use the dedicated sun-visor to reduce the intensity of the sun and can set the brightness of the symbology so that it can be seen (or use an automatic brightness feature).



notes

The HUD is not a substitute but an additional instrument to the existing avionics and needs to be integrated.

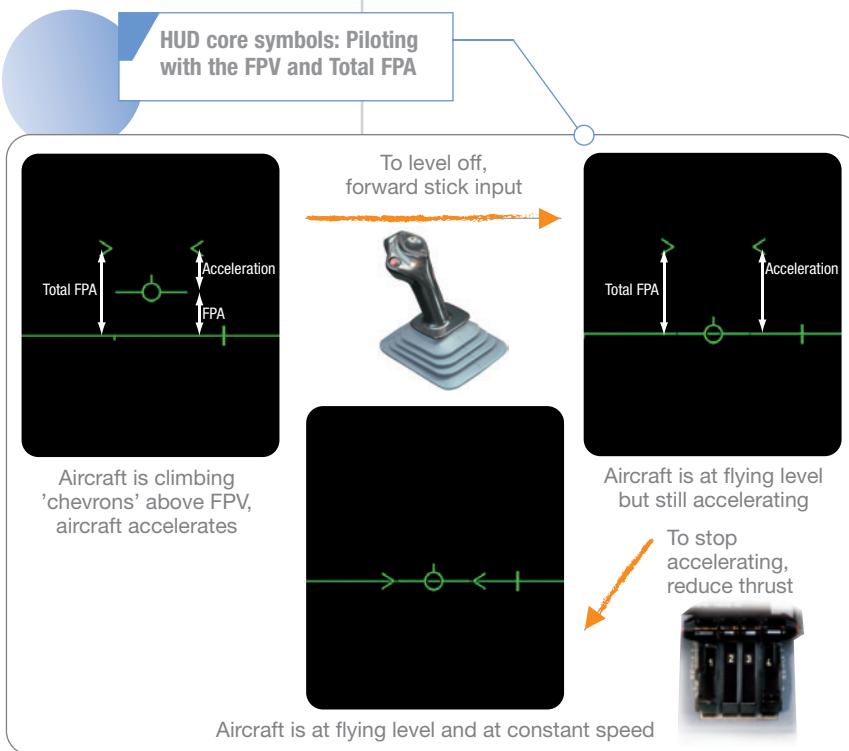
The HUD integration in the cockpit is one of the key factors to achieve the operational objectives with a high consistency and efficient use.

### HUD in-flight symbology



### The FPV (Flight Path Vector)





The core symbols of the HUD is the attitude/energy box, mainly composed of the:

- Aircraft attitude (pitch, roll, side-slip and heading),
- The FPV (Flight Path Vector) also commonly named 'bird',
- The Total FPA (Flight Path Angle),
- The speed delta (on the left side of the FPV).

The Flight Path Vector (FPV) indicates the actual aircraft's trajectory through the aircraft Flight Path Angle (FPA) as the longitudinal component and the aircraft drift angle as the lateral component.

The Total FPA (or total energy 'chevrons') indicates the actual total energy of the aircraft (potential and kinetic). On top, it provides the acceleration/deceleration status of the aircraft.

The velocity vector FPV associated to the total energy (Total FPA) assist the pilot to control the speed and path stability during the approach.

One of the other fundamental elements of the HUD is the conformal approach symbology which allows enhancement of the pilots' situational awareness, by showing conformal trajectory related symbols superimposed to the external scene.

The angle between the LOC (Localizer) axis and the horizon indicates the lateral deviation of the aircraft's position with the runway centre line.

The position of the Approach Reference Flight Path symbol versus the touchdown point, indicates the aircraft's vertical position versus its ideal approach path.

The symbology set described on the left, including the Primary Flight Display-like symbology (altitude, speed scale, Flight Mode Annunciator, etc.) is the primary display mode of the HUD.

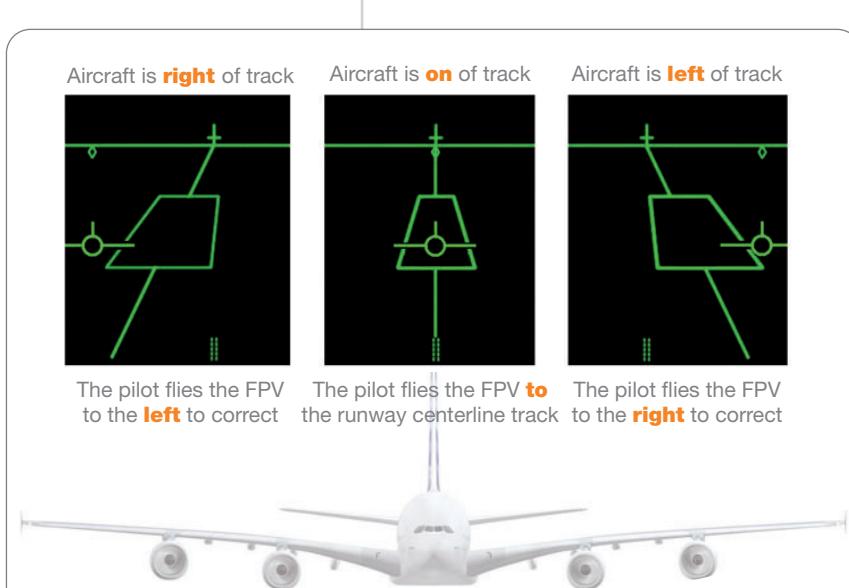
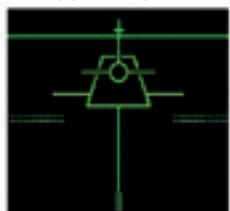


Figure A

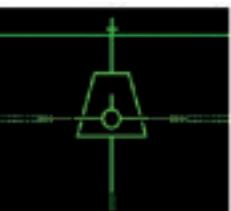
Aircraft is **below** approach path



The pilot flies the FPV **beyond** the touchdown point to correct

Figure B

Aircraft is **on** approach path



The pilot flies the FPV **to** the touchdown point

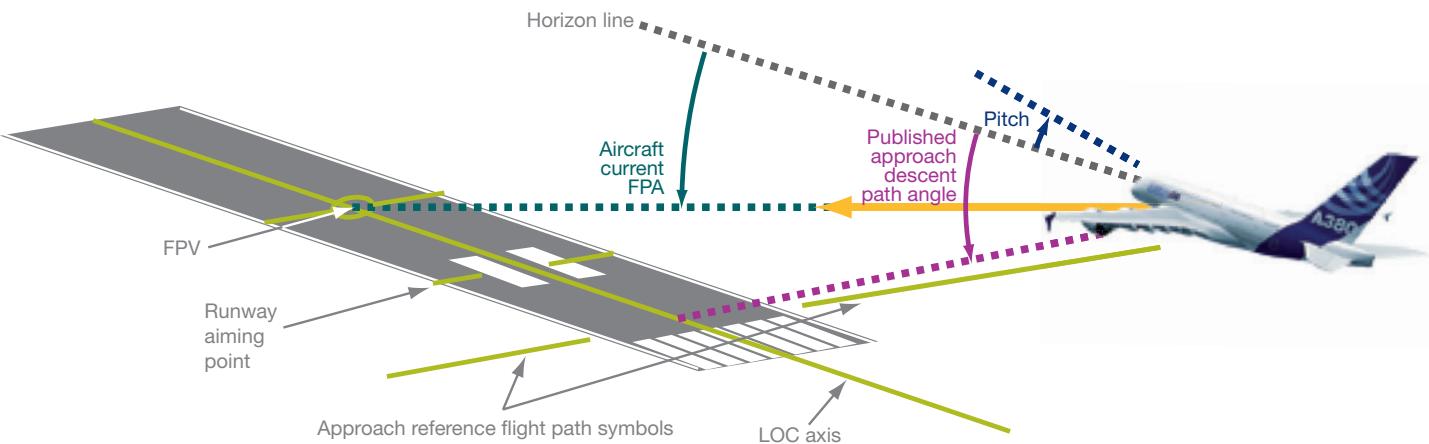
Figure C

Aircraft is **above** approach path



The pilot flies the FPV **before** the touchdown point to correct

For all these figures, natural perspective rules apply.



Some special symbology sets have been developed and are optimized so as the HUD adapts itself to the current flight phase and provides the associated display modes:

- Taxi (ground speed, acceleration cue, etc.),
- Take-Off (lateral raw data and guidance, tail strike limit for A380, etc.),
- Climb, cruise, descent for mainly weather avoidance ‘windshear warning, TCAS RA (Traffic Alert and Collision Avoidance System Resolution Advisory) warning, etc.,
- Approach (mainly composed of the here-above described symbology),
- Roll-Out (ground deceleration scale, etc.).

Each display mode has various ‘de-cluttered’ level functions of the flight phases, in order to favour see-through capability of the HUD.

## Operational benefits

The HUD system improves the crews' situational awareness (therefore contributing to safety) in providing:

- Situational information for the manual visual approaches and landings. With the display of the approach reference path marks, the HUD can replace airport aids such as the VASIS (Visual Approach Slope Indicator System) or PAPI

(Precision Approach Path Indicator), enabling the pilot to precisely calibrate and follow a desired approach path without external aids.

- Enhanced stability of manually flown approaches (instrument and visual approaches) and the accuracy of the landing touchdown, by providing the velocity vector associated to the total energy in the HUD; this facilitates the pilots' control of speed and path stability during the approach.
- An enhancement in flying seamlessly Instrument Meteorological Condition (IMC) to Visual Meteorological Condition (VMC), flying head-up.
- Enhanced pilot situational awareness when close to the ground by showing conformal trajectory related symbols superimposed to the external scene (aircraft trajectory in poor visibility as seen on the previous HUDs),
- Situational information for the monitoring of automatic approaches with Autoland (CAT II & CAT III approaches with ‘Autoland’ and roll-out).
- Reversionary means for roll-out in the event of an untimely ‘Autopilot’ disconnection or a failure of a system affecting automatic roll-out, following an automatic approach and landing,
- A wider field of view ( $35^\circ \times 26^\circ$ ) in high crosswind conditions.

**Interpretation of the Approach Reference Flight Path symbols (corresponding to the figure A opposite page)**



Retrofit installation on an A340-600 flight test aircraft



Pitch/roll adjustment tool for HUD installation

In addition to these improvements, the HUD system also brings some operational credits, such as:

- The lateral guidance information for take-off roll, in low visibility (certified on the A320 Family, on-going development for the A380). As with the Para-Visual Indicator (PVI), the lower take-off minima can be reduced from a 125m Runway Visual Range (RVR) for EASA (500ft. for FAA) to a 75 meters RVR for EASA (300ft. for FAA), thanks to this lateral guidance information.
- The HUD is eligible in approach, for reduction of CAT 1 Approach minima, down to CAT II Approach minima (conducted with Auto-Pilot engaged) on Type 1 airport installations as per FAA Order 8400.13B or EASA NPA OPS-41. This operational benefit requires an operational approval from the operator's airworthiness authority.

In regards to the operational feedback (Entry-Into-Service in 2009), the customers with aircraft equipped with HUD highlighted the following:

- Final approach trajectory (through the control system with the HUD approach symbols) very clear and appreciated (exact flight path of the aircraft),
- Reference mark of the runway slope (conformal approach symbols) very helpful,
- Ground deceleration scale to monitor 'Autobrake' action or control manual braking during roll-out done with ease,
- During taxi, the indication of the ground speed and the energy 'chevrons' (Total FPA), highly appreciated.

The HUD installation is retrofittable. The retrofit conditions have to be defined and agreed by the involved aircraft programme.

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## Conclusion

The Head-Up Display (HUD) contributes significantly to increasing the pilot situational awareness, particularly during the approach and landing phases by showing trajectory related symbols superimposed on the pilot's actual external view. The experience in service confirmed that the HUD is a very good means to stabilize the aircraft during the approach phase, assuming that the flight crews follow a dedicated HUD training. The HUD system also offers enhancement with a video image support. Indeed, the fully digital processing allows the HUD to

display the video image as well as the symbols without any constraints (particularly on graphic capability and flexibility which are not time constraining). The HUD is designed to support future technologies such as the EVS (Enhanced Video System), SVS (Synthetic Vision System) or SGS (Surface Guidance System) that will enhance surface operations and obstacle awareness. Thanks to HUD capabilities, these future growing evolutions will reinforce the enhancement of flight safety on all Airbus aircraft models.

**AIRBUS**



# SPICE

## The future galleys

Ever since the first generation of large passenger aircraft were introduced in the late 1960s, galley architectures have been constructed around the omnipresent trolley. It is hard to imagine the airline world today without these trolleys, but an increasing number of Airbus customers have been voicing the question of whether the time has come, after 40 years, for the air transport industry to look into new architectures for galleys.

To study this question, Airbus spent nine intensive months on-site, with three leading airlines. This work generated a large body of knowledge concerning the issues experienced with today's galleys, as well as the types of solutions that are required. To make use of the knowledge, Airbus initiated a project called SPICE (SPace Innovative Catering Equipment) which promises to make significant progress in improving galley designs.



**Daniel PERCY**  
Airbus Marketing Manager  
Aircraft Interiors Marketing

**1** Chilled upper compartments

**2** Transfer table

**3** Storage galley

**4** Flexible stowage

**5** Service box

**6** Half-size meal box

**7** Meal box

## Modernising galley architecture without disturbing today's processes

The SPICE project found that the main hurdle to achieving true innovation in galley architecture and therefore, to bringing significant benefits, was the trolley itself. Thinking out of the box, or out of the trolley in this case, revealed that the true building blocks of airline catering are the trays or drawers which are put into the trolleys.

SPICE galleys are therefore based around the dimensions of the trays used in today's most popular galley standard, ATLAS. However, SPICE makes three key changes to the storage architecture.

The first architectural change is to store trays and drawers in light-weight boxes, instead of trolleys. The boxes are then moved around the cabin by Folding Service Carts (FSC), which stay on-board the aircraft and remain in a suitable condition for presentation to customers. A typical widebody aircraft will need 8 to 10 FSCs.

The second architectural change is to satisfy airworthiness requirements using the galley instead of the trolley. Today, trolleys are certificated to withstand '9g' loads and to be flameproof.

With SPICE, these requirements are satisfied by the doors on the galley itself.

The third architectural change is to create a system of modular sizes between the different elements which go into the galley. The boxes used in SPICE galleys come in three sizes which relate to each other in the same way, as paper sizes such as A4-A3-A2, each being twice the size of the previous one. In addition, the Galley Inserts (GAIN) such as ovens and beverage makers, also use the same modular sizes.

## Architectural efficiency

These architectural changes make it possible to bring about significant efficiency improvements.

Using boxes and FSCs, stored behind '9g' doors on the galley, helps to reduce weight from the aircraft catering equipment. The boxes themselves no longer need wheels or brakes and the lack of '9g' structure means that any material can be used in the box construction. Boxes made of metal, plastic and even cardboard, have been designed for use with the SPICE galley. A typical SPICE Meal Box can weigh as little as 6kg when made from plastic. This, compared to today's trolleys which have traditionally weighed anything in the range from 21 to 30kg, leads to significant fuel savings.



SPICE saves space as well as weight. When thinking about one of today's galleys, it is evident that above the trolleys there is a lack of geometrical optimisation caused by the various different shapes of equipment. In contrast, the modularity of the boxes and equipment which go into the SPICE galley design ensures that no space is wasted.

Additionally, space is won in SPICE galleys through making ergonomic improvements. With today's galleys, cabin crew have to perform all lifting and carrying tasks manually. Therefore, in order to control the ergonomic impact on the cabin crew, limitations are required on the number and weight of the boxes which can be stored in the galley. SPICE introduces a device called a Transfer Table, which saves the need for cabin crew to lift or carry and therefore allows more boxes to be stored in the galley since they can be stacked higher up.

To quantify these efficiency gains, Airbus has completed numerous assessments of SPICE galleys versus delivered airline galley configurations, using airline galley loading plans for routes which have the highest catering content loaded onboard. These assessments show that the typical weight savings on an A330/A340 Family aircraft is in the range of 600kg. For aircraft as big as the A380, these weight savings can reach more than one ton. The space savings usually allow to have one less galley monument, creating enough space to win two or three economy seats.

## New galley features

The architectural changes which bring efficiency improvements also allow to create a galley system which has a range of new features not available on today's galleys. Full Plug & Play exchangeability of equipment is facilitated by the modularity of GAINs and boxes. The galley and GAIN arrangements will be pre-certified, allowing significant flexibility in configuring and reconfiguring the galley arrangement, with an equipment swap taking only five minutes.

Chilled upper compartments are possible due to the '9g' galley doors being installed at both levels. This gives much more flexibility in galley packing, allowing the meal and drink items to be placed in the upper part of the galley without the need for dedicated 3-mode-chillers, as used today.

Customisable service items can be created to be used directly in the service. Because SPICE boxes don't need to be certified and that the SPICE Service Box (similar to today's Standard Unit) is tall enough to stand bottles upright, boxes can be designed ergonomically optimised for in-flight service which can even be prepared by the caterer. This ensures that preparation times are reduced, allowing the passengers to benefit from a quicker service.

**8** Folding Service Cart (FSC)

**9** Meal service

**10** Drinks service

**11** Waste collection

**12** Plug & Play equipment

**13** Preparation galley

**14** Sliding doors





## Testing the concept with airlines and caterers

Clearly, making all these changes to galleys creates a need to learn how to use the new features, design ways to use the galley efficiently and to validate the processes on ground and in the cabin. For this purpose, Airbus has built prototype SPICE equipment and has been working together with industry partners.

In cooperation with airline cabin crew, who spent over one month in planning and executing cabin trials, the usability of the new galley features, such as the Foldable Service Cart (FSC) and the Transfer Table have been successfully tested and SPICE service routines developed.

These tests revealed a fast learning curve for cabin crew in adapting from today's world to SPICE. The crew confirmed that SPICE's design improved ergonomics, and that the use of pre-prepared service items enables to reduce service times.

Airbus has also been working with the top airline caterers to ensure that SPICE can be integrated into their existing facilities and processes. The first step has been to design the ground equipment the caterer will use to transport SPICE Meal Boxes. Testing of this device has shown that SPICE Meal Boxes can be transported in the same way as trolleys.

Tests in the caterers' facilities identified that it was fully possible to integrate SPICE with minimal or no adaptation, to existing equipment such as trolley conveyor systems, and washing streets. Finally, testing of the galley loading with the caterers revealed that SPICE galleys can be expected to be loaded in equivalent times to today's galleys.

## The challenge of changing galley standards

Changing a system which has been in place for over 40 years naturally introduces, not only major benefits, but also a major challenge due to the impact of dispatch operations. Ultimately, it is a question of whether the benefits outweigh the temporary additional cost, created by operating dual standards over the changeover period.

The main changeover cost is caused when an aircraft with one galley type is swapped for an aircraft with another galley type, after the catering has already been prepared. This causes a dispatch delay as the new aircraft is re-catered.

The other significant cost for airlines may be slightly higher prices from the caterers, since they will need to purchase the SPICE ground equipment. Additionally, the caterer will need to store equipment for both today's galleys and for SPICE galleys which increases the amount of floor space rented.

Fortunately, these extra costs are more than offset by the benefits of SPICE. Even in a conservative assessment of a mixed fleet scenario, where SPICE equipped aircraft are operating alongside non-SPICE equipped aircraft, it can be shown that on average each SPICE large passenger aircraft generates an additional US \$1.5 million NPV (Net Present Value) over its life.

This significant finding means that the transition to SPICE does not require retrofits. However, if the airline wished to retrofit existing fleets with SPICE, a business case analysis has shown a payback period as low as three years. This is a significant improvement on business cases for retrofitting today's galleys.

## The vision for SPICE and the programme in 2010

Airbus' vision for SPICE is that it should become a new industry standard, open to all, for use on aircraft produced by all the airframers.

To this end, Airbus is working with industry organisations to ensure that the standard for SPICE equipment and its interfaces is set at the start.

Industrially speaking, the goal is to be able to deliver the first passenger aircraft with SPICE galleys installed in the second half of 2013. However, this is contingent upon the readiness of the market. Under consultation, participating airlines have provided extensive

feedback on what is required to move forward. As a result of this dialogue, Airbus will complete a number of additional trials and development activities.

To allow airlines to validate weight and space savings and prove their individual business cases, a full A330 economy cabin demonstrator is currently under construction.

This facility will also be used to complete trials, benchmarked against today's operation, for the aircraft turn-around-time and for in-flight service.

In conjunction with known galley and equipment suppliers, the development activity will continue. This work will focus on maturity and reliability, and on establishing detailed technical performance of the galley system. Also, an A320 Family version of the SPICE concept will be created.



## Conclusion

The architecture of galleys has not changed in over 40 years, since the introduction of the first large passenger aircraft. Several airlines which recognized this asked Airbus to take the lead in introducing innovation in this area. After considerable research, Airbus conceived a new type of galley system, called SPICE (SPace Innovative Catering Equipment). SPICE makes a number of architectural changes compared to today's galleys, including introducing a system of modular boxes which are moved by Folding Service Carts.

Key benefits of SPICE for airlines include weight savings of 600kg and space savings, enabling 2 or 3 extra economy seats to be installed. Several ergonomic advantages for cabin crew are also introduced, including lifting assistance using a device called a Transfer Table.

'Plug & Play' modularity of galley inserts, chilled upper compartments and reduced service times are additional interesting features.

Airbus has already completed testing of SPICE prototype equipment. This includes testing of cabin service, where actual airline cabin crew served seated passengers. It has also been tested with caterers, making sure they can cope with SPICE in their facilities and during aircraft loading. All tests have shown positive and encouraging results. Following consultation with the airlines about the conditions for launching SPICE and the final validation testing is underway.

The vision for SPICE is that it will become a new global galley standard, available for the whole industry.

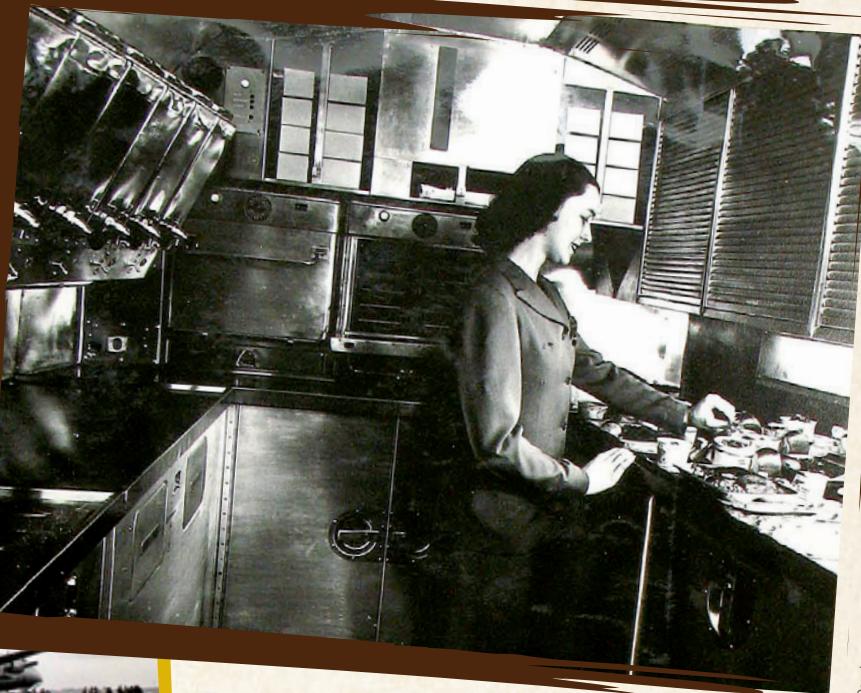
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*Improving  
over 40 years'  
old gallery  
design*



S.E.2010 Armagnac



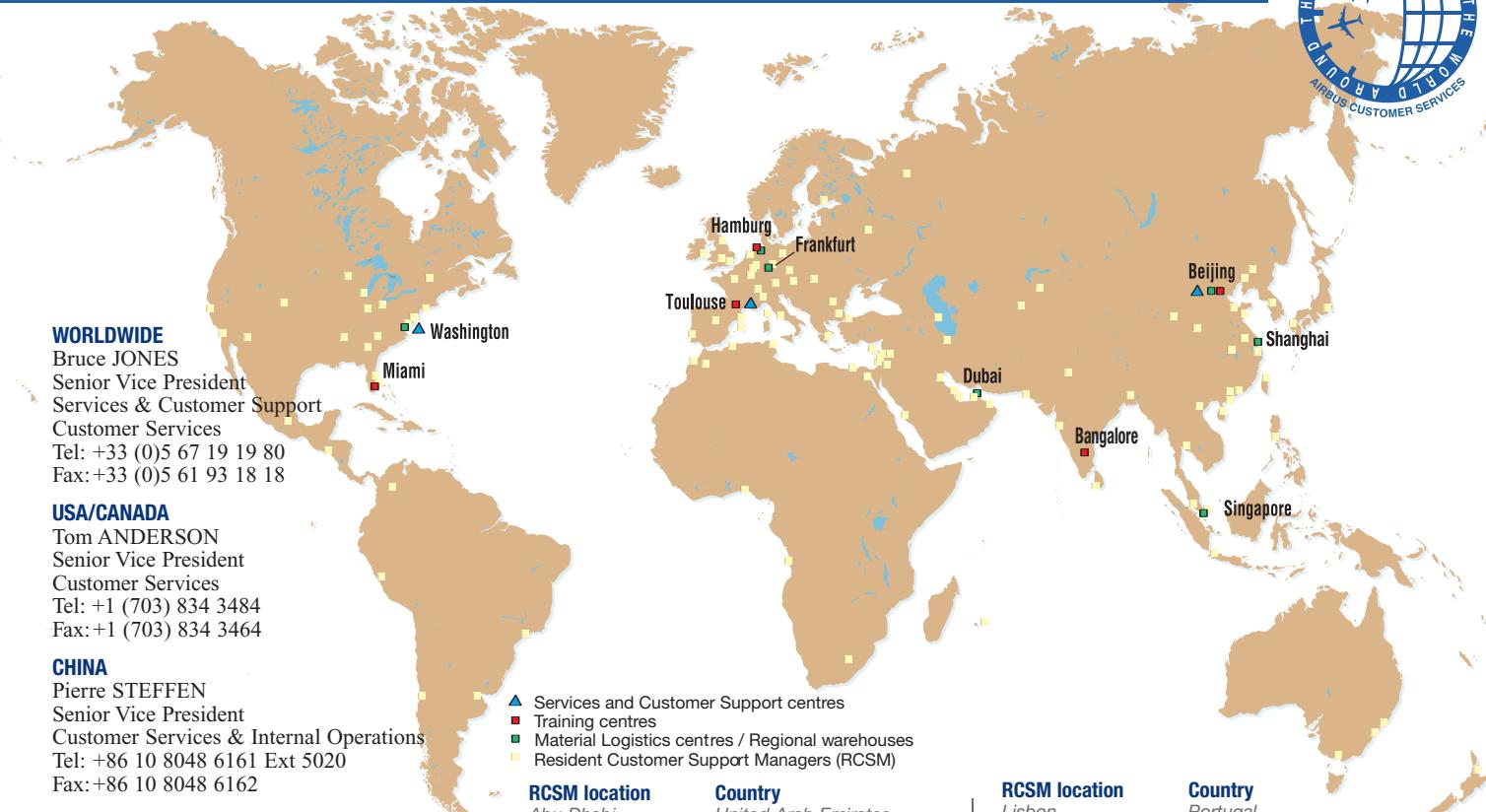
Flight attendant in the galley

Courtesy of Airbus Flight Test Photo Lab

> Galleys on commercial airlines typically include facilities to serve and store food and beverages. Aircraft in operation today mainly use the familiar trolley system. This system was introduced in the late 1960s at the same time the new generation of large aircraft were entering into service with the airlines. The significantly larger number of passengers on these aircraft meant that meals could no longer be efficiently delivered by hand, as they had been up until that point.

Over the current 40 years of old trolley technology, there are two main sizes of trolley in use with the airlines around the world, called the 'ATLAS' (most common) and 'KSSU' sizes. Airbus has developed a new galley concept called 'SPICE' (SPace Innovative Catering Equipment) - read article in this FAST magazine edition, which is a potential new worldwide standard with significant advantages for the cabin crew, the operators and the caterers.

Here, the flight attendant is meticulously preparing the meals for the passengers (maybe with a touch of spice) on a S.E.2010 Armagnac, an aircraft of the late 1940s. The Armagnac was a cantilever mid-wing monoplane designed for a transatlantic service with a retractable tricycle landing gear. A number of versions of this long range aircraft were planned, from a 60 passenger 'sleeping compartment' version to 84, 108 and 160 passengers.

**WORLDWIDE**

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**RESIDENT CUSTOMER SUPPORT ADMINISTRATION**

Jean-Bernard GALY  
Head of Field Service  
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**TECHNICAL, MATERIAL LOGISTICS & TRAINING SUPPORT**

Airbus has its main Material Logistics centre in Hamburg, and regional warehouses in Frankfurt, Washington D.C., Dubai, Beijing, Shanghai and Singapore.

Airbus operates around the world,  
24 hours a day, every day.

Airbus Technical AOG Centre (AIRTAC)  
Tel: +33 (0)5 61 93 34 00  
Fax: +33 (0)5 61 93 35 00  
airtac@airbus.com

Spares AOGs in North America should be addressed to:  
Tel: +1 (703) 729 9000  
Fax: +1 (703) 729 4373

Spares AOGs outside North America should be addressed to:  
Tel: +49 (40) 50 76 4001  
Fax: +49 (40) 50 76 4011  
aog.spares@airbus.com

Spares related HMV issues outside North America should be addressed to:  
Tel: +49 (40) 50 76 4003  
Fax: +49 (40) 50 76 4013  
hmv.spares@airbus.com

Airbus Training Centre Toulouse, France  
Tel: +33 (0)5 61 93 33 33  
Fax: +33 (0)5 61 93 20 94

Airbus Maintenance Training Centre  
Hamburg, Germany  
Tel: +49 (40) 74 38 8288  
Fax: +49 (40) 74 38 8588

Airbus Training subsidiaries  
Miami, Florida - U.S.A.  
Tel: +1 (305) 871 36 55  
Fax: +1 (305) 871 46 49

Beijing, China  
Tel: +86 10 80 48 63 40  
Fax: +86 10 80 48 65 76

Bangalore, India (Maintenance training)  
Tel: +33 (0)5 61 93 33 33  
Fax: +33 (0)5 61 93 20 94

- ▲ Services and Customer Support centres
- Training centres
- Material Logistics centres / Regional warehouses
- Resident Customer Support Managers (RCSM)

**RCSM location**

Abu Dhabi  
Alexandria  
Algiers  
Al-Manamah  
Almaty  
Amman  
Amsterdam  
Astana  
Athens  
Atlanta  
Auckland  
Bangkok  
Barcelona  
Beijing  
Beirut  
Berlin  
Bogota  
Bucharest  
Budapest  
Buenos Aires  
Cairo  
Calcutta  
Casablanca  
Charlotte  
Chengdu  
Chicago  
Cologne  
Colombo  
Damascus  
Delhi  
Denver  
Dhaka  
Doha  
Dubai  
Dublin  
Dusseldorf  
Fort Lauderdale  
Frankfurt  
Guangzhou  
Haikou  
Hamburg  
Hangzhou  
Hanoi  
Hefei  
Helsinki  
Hong Kong  
Honolulu  
Indianapolis  
Istanbul  
Jakarta  
Jeddah  
Jinan  
Johannesburg  
Karachi  
Kita-Kyushu  
Kuala Lumpur  
Kuwait City  
Lagos  
Lanzhou  
Lima

**Country**

United Arab Emirates  
Egypt  
Algeria  
Bahrain  
Kazakhstan  
Jordan  
Netherlands  
Kazakhstan  
Greece  
United States of America  
New Zealand  
Thailand  
Spain  
China  
Lebanon  
Germany  
Colombia  
Romania  
Hungary  
Argentina  
Egypt  
India  
Morocco  
United States of America  
China  
United States of America  
Germany  
Sri Lanka  
Syria  
India  
United States of America  
Bangladesh  
Qatar  
United Arab Emirates  
Ireland  
Germany  
United States of America  
Germany  
China  
China  
China  
China  
P.R. China  
Finland  
S.A.R. China  
United States of America  
United States of America  
Turkey  
Indonesia  
Saudi Arabia  
P.R. China  
South Africa  
Pakistan  
Japan  
Malaysia  
Kuwait  
Nigeria  
China  
Peru

**RCSM location**

Lisbon  
London  
Los Angeles  
Louisville  
Luton  
Luxembourg  
Madrid  
Manchester  
Manilla  
Marrakech  
Mauritius  
Melbourne  
Memphis  
Mexico City  
Miami  
Milan  
Minneapolis  
Montreal  
Moscow  
Mumbai  
Muscat  
Nanchang  
Nanjing  
Newcastle  
New York  
Ningbo  
Palma de Mallorca  
Paris  
Philadelphia  
Phoenix  
Prague  
Qingdao  
Riyadh  
Roma  
San Francisco  
San Salvador  
Santiago  
Sao Paulo  
Seoul  
Shanghai  
Sharjah  
Shenyang  
Shenzhen  
Singapore  
Sofia  
Sydney  
Taipei  
Tashkent  
Tehran  
Tel Aviv  
Tokyo  
Toluca  
Tripoli  
Tunis  
Vienna  
Washington  
Wuhan  
Xi'an  
Zurich

**Country**

Portugal  
United Kingdom  
United States of America  
United States of America  
United Kingdom  
Luxembourg  
Spain  
United Kingdom  
Philippines  
Morocco  
Mauritius  
Australia  
United States of America  
Mexico  
United States of America  
Italy  
United States of America  
Canada  
Russia  
India  
Oman  
P.R. China  
China  
Australia  
United States of America  
P.R. China  
Spain  
France  
United States of America  
United States of America  
Czech Republic  
P.R. China  
Saudi Arabia  
Italy  
United States of America  
El Salvador  
Chile  
Brazil  
South Korea  
China  
United Arab Emirates  
China  
China  
Singapore  
Bulgaria  
Australia  
Taiwan  
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Iran  
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