

DECEMBER 2009  
FLIGHT  
AIRWORTHINESS  
SUPPORT  
TECHNOLOGY

# FAST<sup>45</sup>

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**AIRBUS**

# FAST

M A G A Z I N E  
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S U P P O R T

FLIGHT  
AIRWORTHINESS  
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TECHNOLOGY

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on paper produced without using chlorine, to reduce  
waste and help conserve natural resources.  
**Every little helps!**



# Introducing more eco-efficient chemical treatments for aircraft structure Towards a chromate-free Airbus

The future of the aircraft industry's impact on the environment is paramount to Airbus, continuously searching for more eco-efficient values, from the first step of the design and throughout the aircraft's entire life cycle (see figure 1). Airbus integrated eco-efficiency values into its core strategy and was the first aeronautical company to obtain the ISO 14001 environmental certification for all its European Union (EU) manufacturing sites and product related activities. Proactive approach,

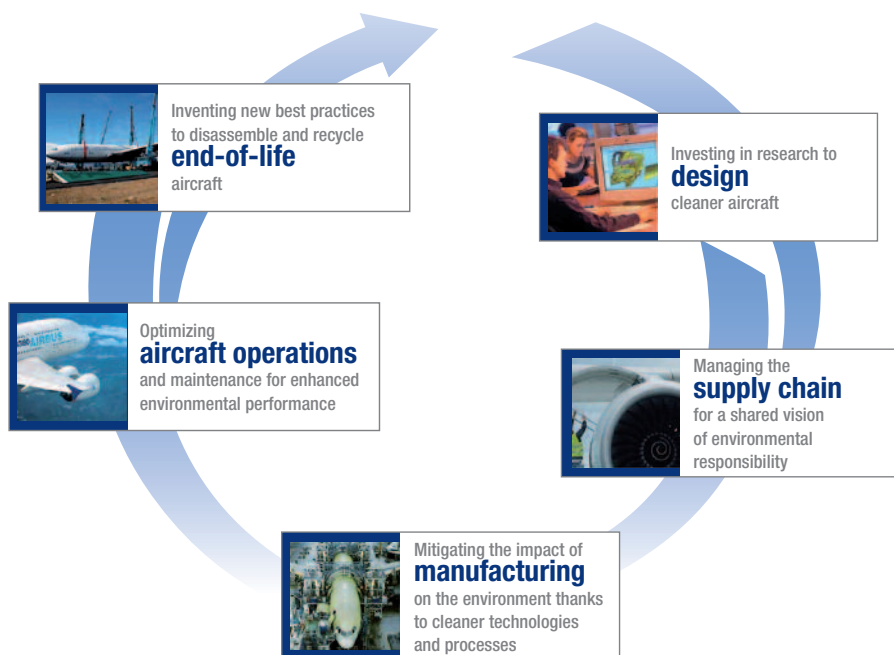
anticipating the future regulatory framework at the earliest possible stage in design, rather than implementing reactive solutions, has proved to be the most appropriate response to the various growing environmental challenges. Therefore, Airbus has launched initiatives to progressively replace the most hazardous substances and processes. This article introduces the Airbus roadmap for replacing chromate containing materials and processes with more environmentally friendly ones.



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Aircraft life cycle

figure 1



notes

**Chromium** is a chemical element that has the symbol Cr and atomic number 24. It is a steely-grey, lustrous, hard metal that takes a high polish and has a high melting point. The name of the element is derived from the Greek word 'chroma' meaning colour; many of its compounds being intensely coloured.

**Hexavalent** chromium refers to chemical compounds that contain the element chromium in the +6 oxidation state. Usually such compounds are chromium trioxide or the chromic acid or dichromic acid. Chromate salts have a yellowish colour, dichromate salts are orange. Chromium VI compounds are a synonym for Chromium Hexavalent: Cr(VI).

## Chromate usage

Among a number of initiatives in that respect, the Airbus Chromate-Free (ACF) project aims to progressively develop new eco-efficient alternatives to all applications and processes using chromates (see figure 2) and offer these new solutions widely, bringing an overall benefit throughout the life cycle of the aircraft, including for maintenance operations.

The ACF project involves all stakeholders and the milestones for elimination of chromates. Comprehensive research studies have been conducted for years. The ACF project was initiated in 2006 to ensure that mature alternative options and technical solutions be available for all Airbus programmes without compromising technical performance and quality.

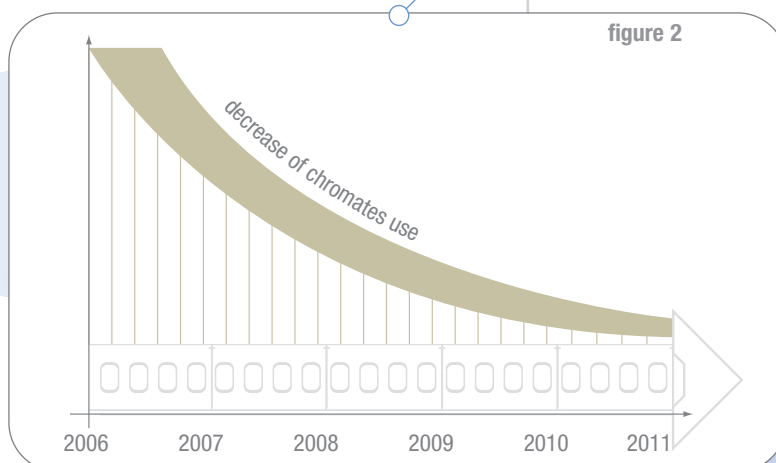
For over 50 years, hexavalent chromium has been used as corrosion-inhibiting compounds with the protection of metallic surfaces as one of its most important applications. Thanks to chromates, the protection was ensured for the 30-year aircraft lifespan without compromising flight safety, even in extremely severe conditions. Chromates (such as strontium chromate,

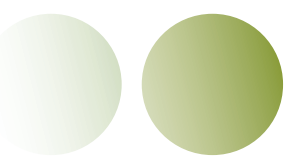
chromium trioxide, zinc and potassium chromate), are often found in numerous processes such as:

- Surface treatment applications:
  - Chromic acid anodising,
  - Acidic etching (pickling),
  - Conversion coatings,
  - Hard chrome plating.
- Painting and bonding processes:
  - External and internal painting,
  - Bonding primer,
  - Sealants.
- And other additional applications:
  - Electrical and electronic applications.

The hazardous properties of these substances and the resultant regulatory pressure for replacement have recently reinforced the need to replace them with less hazardous substances.

ACF roadmap





## The main regulatory framework

Numerous regulations in various countries and regions now strictly restrict the use, production, storage, elimination or marketing of chromates.

In Europe, most of the chromates are considered as highly hazardous, with very high concerns according to the newly adopted REACH\* European regulation (EC n°1907/2006). Chromate compounds will certainly be subject to formal and time limited authorization for further use (sodium chromate has recently been introduced in the REACH\* candidate list by the European Chemicals Agency).

They are already subject to a formal ban under the European Directive 2002/95/EC so called RoHS (Restriction of Hazardous Substances) for electronic and electrical equipment, even if on-board equipment is today excluded from the scope of RoHS. Stringent occupational health and safety requirements also regulate exposure to these chemicals. Chromates are already banned within the automotive sector.

Since 2006, the new Occupational Safety and Health Administration (OSHA\*) regulation introduced in the USA regarding hexavalent chromium, has considerably lowered the Permissible Exposure Limit (PEL) for airborne exposure inducing very strict controls of the exposure to this chemical.



### information

#### \* REACH (Registration, Evaluation, Authorisation and restriction of Chemicals - EC n°1907/2006)

This new regulation aims to improve health and environment protection while maintaining competitiveness, and enhancing the innovative capability of the EU chemicals industry. REACH will furthermore give greater responsibility to industry to manage the risks from chemicals and to provide safety information that will be passed down the supply chain.

REACH web site:

[http://ec.europa.eu/environment/chemicals/reach/reach\\_intro.htm](http://ec.europa.eu/environment/chemicals/reach/reach_intro.htm)

Airbus REACH guidelines:

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

#### \* OSHA (Occupational Safety and Health Administration)

The United States OSHA is an agency of the United States Department of Labor. Its mission is to prevent work-related injuries, illnesses, and deaths by issuing and enforcing rules (called standards) for workplace safety and health.

Cal/OSHA regulation:

<http://www.dir.ca.gov/>

OSHA web site:

<http://www.osha.gov/index.html>

<http://www.osha.gov/SLTC/hexavalentchromium/index.html>

OSHA Hexavalent Chromium:

<http://www.osha.gov/SLTC/hexavalentchromium/index.html>

<http://www.osha.gov/SLTC/hexavalentchromium/index.html>

<http://www.osha.gov/SLTC/hexavalentchromium/index.html>

## Towards elimination of chromates: The Airbus Chromate-Free (ACF) project

Airbus, jointly with all concerned stakeholders, is introducing new chromate-free applications, while maintaining compliance with applicable regulations and implementing the most efficient measures to control emissions and protect against exposure to chromates. Actions are also managing the transition for aircraft maintenance operations to be made during the complete life cycle of all existing fleets in full compliance with regulations.

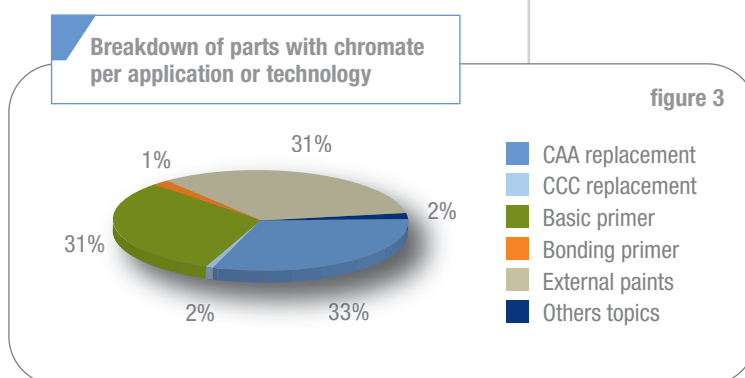
### GENERAL OVERVIEW OF ACF

ACF is organized in several topics for the different fields of technologies (applications or technologies) concerned by the replacement. An overview of the different ACF topics and their current status is given in the right hand side table.

Airbus is covering all the different applications, with a special focus on those with the highest percentage of chromates, which are used in production or applied on the aircraft. The main topics Chromate Acid Anodising (CAA), basic primer and external paints, represent approximately 90% of chromate use within Airbus as shown in figure 3.

The following describes CAA, basic primer and external paints with their current status in details and the effort necessary to develop alternative solutions.

Applications or Technologies	The status is reflecting mainly research and development activities - qualification and industrialization time frames are depending on the subject and are currently under planning.
Pickling of Aluminium Chromic Acid Anodising (CAA)	<b>Chromate-free</b> solution already in use since 2006: <ul style="list-style-type: none"> <li>For corrosion protection <b>Tartaric Sulphuric Acid (TSA)</b> anodising has been <b>already implemented</b> as the new standard in several Airbus plants and is being successfully deployed within the supply chain,</li> <li><b>Phosphoric Sulphuric Acid (PSA)</b> anodising as pre-treatment prior to structural metal bonding is <b>ready for qualification</b> by Airbus.</li> </ul>
Chemical Conversion Coating (CCC)	<b>Chromium trivalent based products</b> have been identified as the most promising technology to replace current chromium-loaded CCC processes. To ensure the integrity of the aircraft, <b>structural primer</b> and <b>bonding primer</b> have challenging requirements for long-term stability. <b>Major improvements have been achieved</b> over the last 2-4 years.
Basic primer Bonding primer	<b>Chromate-free external paint systems</b> were developed for A380 application and are <b>already state-of-the-art</b> for external paint in the aerospace industry.
External paint	<b>Chromate-free pickling process</b> is available to ensure corrosion resistance for austenitic and martensitic steel, including the most sensitive above 0.8% carbon.
Pickling of steel	Several coatings are available to replace <b>hard-chrome</b> . A first batch of parts is close to implementation in production.
Hard-chrome replacement	<b>Chromate-free products</b> are available and currently tested under operational conditions. Airbus qualification is finalized.
Sealants and jointing compounds	A batch of <b>alternative solutions</b> is under screening to identify the best performing solution. Technical maturity (selection of the best candidate) is expected beginning of 2010.
Fastener coatings	Airbus with stakeholders is analysing <b>standard parts</b> and <b>equipment</b> to evaluate possible substitution solutions.
System items	





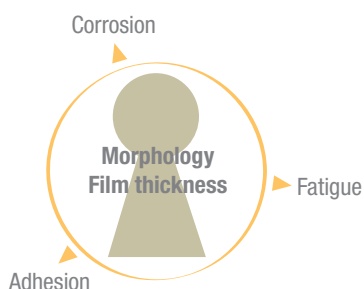
Surface treatment baths - figure 4



TSA treated parts - figure 5

#### Key technical requirements for anodising processes

figure 6



#### CHROMIC ACID ANODISING (CAA) REPLACEMENT

The Chromic Acid Anodising process will result in the electrochemical growth of an aluminium oxide/hydroxide layer by interaction of a clean aluminium surface with a chromic acid based immersion bath and an applied voltage between the parts and a suitable cathode.

The oxide layer produced by the process has a good corrosion resistance when sealed or primed, providing a good paint and adhesive adhesion in unsealed conditions.

Within Airbus Chromate-Free, Airbus developed two alternative processes of the aluminium surface treatment:

- TSA - Tartaric Sulphuric acid Anodising for corrosion protection,
- PSA - Phosphoric Sulphuric acid Anodising for structural bonding.

TSA and CAA are similar processes. They are an electrochemical process used for both generating an aluminium oxide layer for corrosion protection and

surface treatment prior to application of a corrosion-inhibiting primer.

The PSA process is similar to the CAA and TSA process with a modified morphology specific for bonding applications.

The main managed properties are corrosion resistance, paint adhesion, fatigue, and quality of the coating.

As shown in figure 6, the key technical requirement for the anodising processes of aluminium is a balance between three criteria:

- The adhesion with a homogeneous porosity,
- The corrosion resistance depending on the porosity,
- The fatigue properties.

The morphology of TSA, CAA and PSA surfaces are pointed out on figure 8.

Fatigue properties are a generic requirement for structural aluminium parts. As already known for CAA the anodising and/or relevant pre-treatment processes reduce the fatigue performance in comparison to non-treated aluminium parts.

It is important that replacement processes will have similar or better fatigue performances when tested to compare to today's standard CAA. The fatigue performance of TSA and PSA has been tested and showed equivalence to CAA (see figure 7).

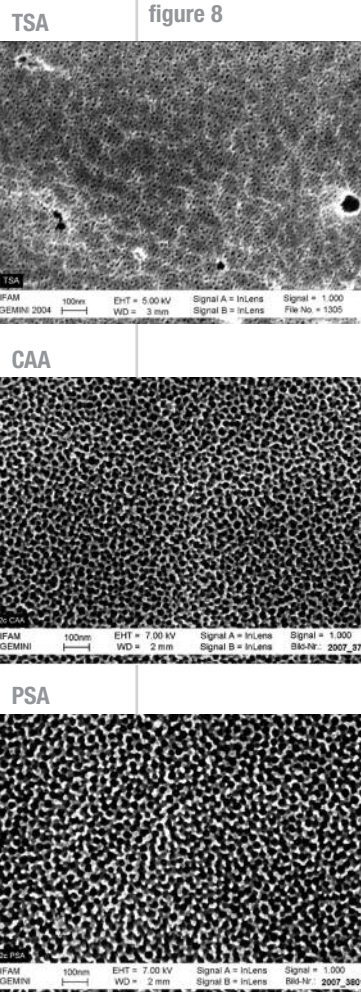
A further requirement was the morphology shown in figure 8. The morphology of both anodic films is a regularly structured open porous aluminium-oxide, which is produced by the process and provides the protection required.

The table below shows the parameters investigated during the process development phase. In comparison to CAA, the TSA or PSA process has a reduced process time and anodising temperature. This leads to an improvement in eco-efficiency by decreasing time and energy consumption and offers a capacity increase. Manufacturing needs for TSA and PSA were also one of the main

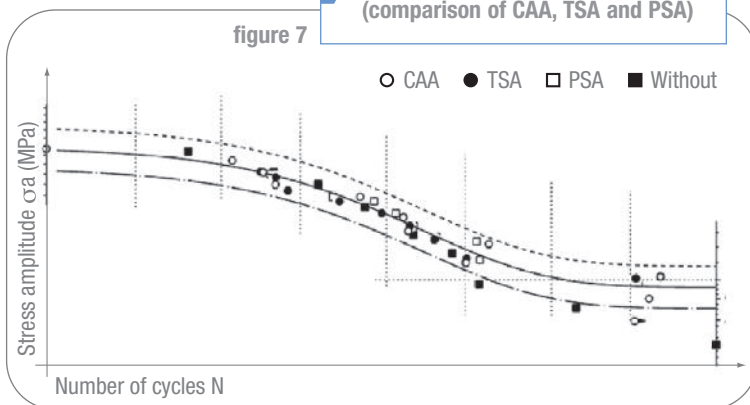
requirements, and their performance compared to CAA are as follows:

- Racking:  
The procedure is equivalent to CAA.
- Tank materials:  
The TSA/PSA process can be run in the same installations as CAA with only minor modifications. Tank and piping materials (including lining) shall be resistant to phosphoric and sulphuric acid (normally the case for CAA baths). Residuals of CAA do not jeopardize TSA/PSA performance.
- Fungal contamination:  
The TSA/PSA electrolytes are less toxic than CAA and fungus growth in the treatment line cannot be excluded. The installation of preventive measures (e.g. filters, UV-lamps) is recommended.

Morphology comparison of TSA, CAA and PSA



Fatigue strength test (comparison of CAA, TSA and PSA)



	CAA	PSA	TSA
Film thickness	3 ... 5 micro millimetre	1 ... 5 micro millimetre	3 ... 5 micro millimetre
Temperature	40°C	28 ... 32°C	37 ... 43°C
Process time	45 min	20 ... 25 min	20 ... 25 min
Voltage	40V or 21V	15 ... 20V	13 ... 15V



#### Structural basic protection system

figure 9



Structural primer + anodising (TSA) = basic protection

- Internal top coat
- Basic primer
- Anodising (TSA)
- Aluminium alloy

#### BASIC PRIMER

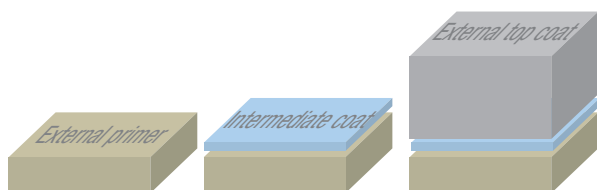
A common effort between Airbus and its paint suppliers has led to significant progress in the structural protection system in the last two years. This topic has the highest priority in the Airbus Chromate-Free project.

To ensure integrity of the aircraft structure, structural primer has challenging requirements for long-term stability. It is planned to have chromate-free basic primer products ready for qualification by the end of 2010.

The structural protection system is divided into basic protection and a topcoat. The basic protection is performed with TSA and a basic primer (figure 9).

#### External paint system on customized area

figure 10



- External top coat
- Intermediate coat (optional)
- External primer

#### EXTERNAL PAINT

The external paint is applied on the basic protection. chromate-free external paint systems were developed and qualified for A380 application and are already state-of-the-art in the aerospace industry.

The new Airbus technique brings additional environmental benefits due to the use of less solvents and fewer coats. This technique which is similar to the one used in the car

industry, requires just two coats with dramatically reduced paint volumes, and drying times down from 12 to two hours.

A colour coat and a clear coat or varnish, are applied onto a chromate-free primer.

The process also reduces the amount of repainting and cleaning required during the lifetime of in-service aircraft

([http://www.airbus.com/en/presscentre/pressreleases/pressreleases\\_items/07\\_12\\_14\\_eco\\_efficient\\_painting.html](http://www.airbus.com/en/presscentre/pressreleases/pressreleases_items/07_12_14_eco_efficient_painting.html)).

Airbus is applying the most modern and best eco-efficient techniques for its aircraft painting process better than the Best available REference Technologies (BREF) defined under the European Integrated Pollution Prevention and Control (IPPC) directive (<http://eippcb.jrc.ec.europa.eu/>).

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## Conclusion

Airbus approach to introduce more eco-efficient chemicals and processes is part of its commitment to environmental protection and sustainability as a responsible leading industry. Airbus believes that research and implementation of more environmentally friendly options are not only better for the environment itself but must be seen as a real opportunity to bring additional values to companies, and additional characteristics for the products we deliver to our customers.

A significant step towards chromate-free has been achieved with the replacement of Chromium VI for surface treatment applications: Using the new developed TSA/PSA processes, Chromium VI could be already reduced by approximately 30%. This solution offers an improvement in eco-efficiency by decreasing time and energy consumption and may offer capacity increase.

Taking into account the results already implemented of another 30% reduction for the external paints, Airbus has reduced the use of hexavalent chromium by approximately 60% (see figure 3). Airbus roadmap to eliminate Chrome VI is on

track either in the production processes or the product involved.

Thanks to major investments and mobilisation of all stakeholders, any relevant actions and necessary efforts to achieve its final goal to deliver a completely Chrome VI free aircraft will be undertaken through this ambitious ACF project.

Airbus will offer all newly developed chromate-free materials and processes to its suppliers, progressively as soon as qualified. Information as well as required support are being considered to help the supply chain to take all actions for a successful implementation within their own facilities.

All decided replacements would be implemented for all aircraft and spares to be delivered. For the A350XWB relevant solutions will be taken into account for the new design as appropriate. As further progress will be made, Airbus will regularly inform the customer community of these through any relevant Customer Services publication and web site (<http://www.airbus.com/en/corporate/ethic/s/environment/eco-news/>).



# Airbus new Auto Pilot/Flight Director TCAS mode Enhancing flight safety during TCAS manoeuvres

The 'Traffic Alert and Collision Avoidance System' - known as 'TCAS' has been introduced in the 90s to reduce the risks associated with mid-air collision threats. Today this safety goal has globally been reached. However, in-service feedback showed that surprise and stress induced by TCAS Resolution Advisories (RA) may lead to non-optimum crew response, resulting in undue aircraft altitude deviations, injuries in the cabin, lack of proper communication with Air Traffic Control

(ATC), therefore jeopardizing the aircraft and its passengers' safety. In a context of continuous increase of traffic, the new proposed Airbus Auto Pilot/Flight Director (AP/FD) TCAS mode aims at significantly enhancing safety by supporting pilots to fly avoidance manoeuvres requested by TCAS. After a short reminder on the TCAS operations before AP/FD TCAS mode deployment, this article will present the AP/FD TCAS mode concept and its numerous expected benefits.



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## Reminder on TCAS operations before AP/FD TCAS mode deployment

### TRAFFIC ADVISORY (TA)

When the TCAS considers an aircraft to be a potential threat, it generates a first level of alert called Traffic Advisory (TA). This advisory aims at alerting pilots on critical intruder's position. TAs are indicated to the crew by:

- An aural message: "Traffic, Traffic",
- Specific amber cues on the Navigation Display, which highlight the critical intruder's position.

No specific action is expected from the crew following a TA.

### RESOLUTION ADVISORY (RA)

If the risk of collision becomes more critical, the TCAS triggers a stronger level of alert called Resolution Advisory (RA), which proposes a vertical avoidance manoeuvre (in most cases a TA will be triggered prior to a RA).

A Resolution Advisory is indicated to the pilots by:

- An aural message specifying the type of vertical manoeuvre to perform ("Climb", "Descent", "Maintain", "Adjust", "Monitor", etc.),
- Green and red zones on the Vertical Speed Indicator (VSI) materializing the 'fly-to' and 'forbidden' vertical speed areas,
- Specific red cues on the Navigation Display materializing the threat aircraft.

In order to fly the avoidance manoeuvre required by the RA, the pilot has to disconnect both the Auto Pilot (AP) and Flight Directors (FD), and to adjust the pitch attitude of the aircraft so as to reach the proper Vertical Speed (V/S) indicated on the VSI.



notes

### TCAS system

The 'Traffic Alert and Collision Avoidance System' (TCAS) is designed to scan for, detect, and interrogate the transponders of other aircraft in the nearby airspace vicinity. When TCAS detects

that an aircraft's distance or closure rate becomes critical, it generates aural and visual annunciations for the pilots. Since 2000, TCAS is mandatory on all aircraft types which carry more than 30 passengers.

Navigation Display in case of TCAS TA

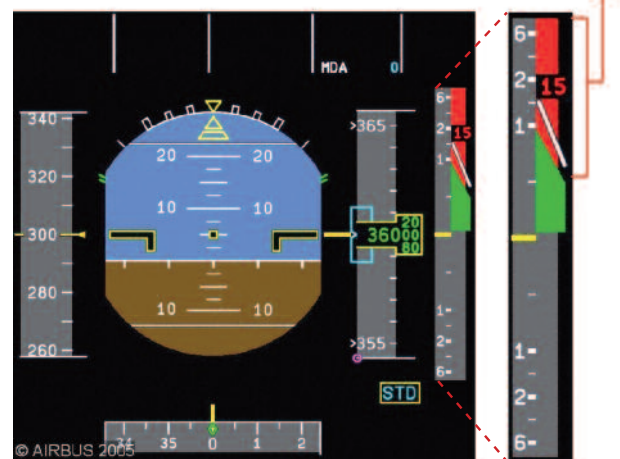


TCAS RA Primary Flight Display (PFD) without AP/FD TCAS mode



"Adjust V/S, adjust"

Red area indicating the forbidden vertical speed domain



This unfamiliar flying technique increases the stress level already induced by the triggering of the Resolution Advisory.

## AP/FD TCAS mode concept

The AP/FD TCAS mode concept was born following an in-depth analysis of needs expressed by airline pilots, human factor studies linked to the TCAS system and recommendations given by airworthiness authorities, which highlighted the relevance of a new means to support pilots flying TCAS RA.

The new AP/FD TCAS mode completes the existing TCAS functionality by implementing a TCAS vertical guidance feature into the Auto Flight computer. This new mode controls the Vertical Speed (V/S) of the aircraft on a vertical speed target - acquired from TCAS - adapted to each RA.

- With the Auto Pilot (AP) engaged, it allows the pilot to fly the TCAS RA manoeuvre automatically,
- With the AP disengaged, the pilot can manually fly the TCAS RA manoeuvre by following the Flight Director (FD) pitch bar guidance.

It has to be considered as an addition to the existing TCAS features (traffic on Navigation Display, aural alerts, vertical speed green/red zones materializing the RA on the Vertical Speed Indicator).

In case of a TCAS RA, the AP/FD TCAS mode will automatically trigger:

- If both AP and FD are engaged, the AP/FD vertical mode reverts to TCAS mode, which provides the necessary guidance for the AP to automatically fly the TCAS manoeuvre,
- If the AP is disengaged and FD are engaged, the TCAS mode automatically engages as the new FD guidance. The FD pitch bar provides an unambiguous order to the pilot, who simply has to centre the pitch bar, to bring the V/S of the aircraft on the V/S target (green zone),

- If both AP and FD are OFF, the FD bars will automatically reappear with TCAS mode guiding as above.

Depending on the kind of alert triggered by the TCAS, the AP/FD TCAS mode will have the following behaviour:

- In case of Traffic Advisory (TA), the AP/FD TCAS mode is automatically armed, in order to bring crew awareness on the TCAS mode engagement if the TA would turn into an RA.
- In case of corrective RA ("CLIMB", "DESCEND", "ADJUST", etc. aural alerts), the aircraft vertical speed is initially within the red VSI zone. The requirement is then to fly out of this red zone to reach the boundary of the red/green V/S zone. Consequently:
  - The TCAS vertical mode engages. It ensures a vertical guidance to a vertical speed target equal to the red/green boundary value on VSI (to minimize altitude deviation)  $\pm 200$  ft/min within the green vertical speed zone, with a pitch authority increased up to 0.3g load factor,
  - All previously armed vertical modes are automatically disarmed, except the altitude capture mode (ALT\*) when the altitude capture is compliant with the RA (i.e. when 0 ft/mn is not within the red VSI zone, as for 'ADJUST V/S' RA). In those cases, if the altitude capture conditions are met while in TCAS mode, it will allow safely capturing the targeted flight level (see figure page 14 - Safe altitude capture with AP/FD TCAS mode),
  - The Auto Thrust engages in speed control mode (SPEED/MACH) to ensure a safe speed during the manoeuvre,
  - The current lateral trajectory is maintained.



### notes

At any time, the crew keeps the capability to disconnect the AP and the FD, to respond manually to the RA by flying according to the 'conventional' TCAS procedure (i.e. manually controlling the vertical speed by referring to TCAS indications on the vertical speed scale).

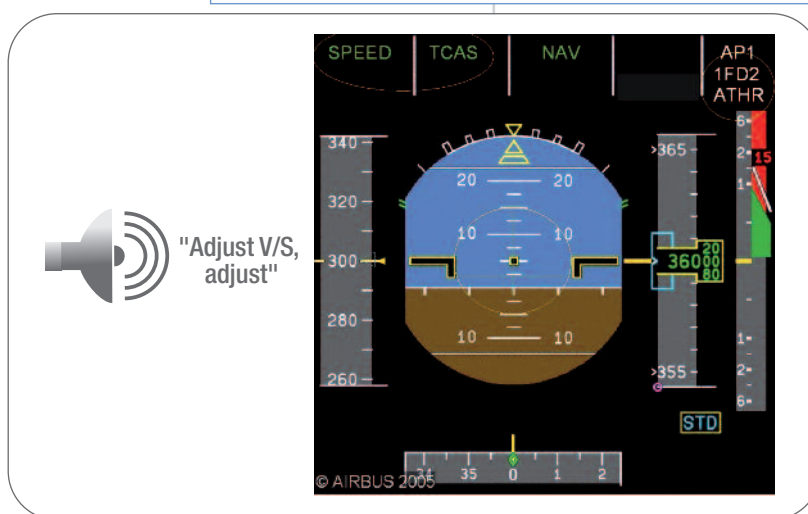
- In case of preventive RA (e.g. "MONITOR V/S" aural alert), the aircraft vertical speed is initially out of the red VSI zone. The requirement is then to maintain the current vertical speed.

Consequently:

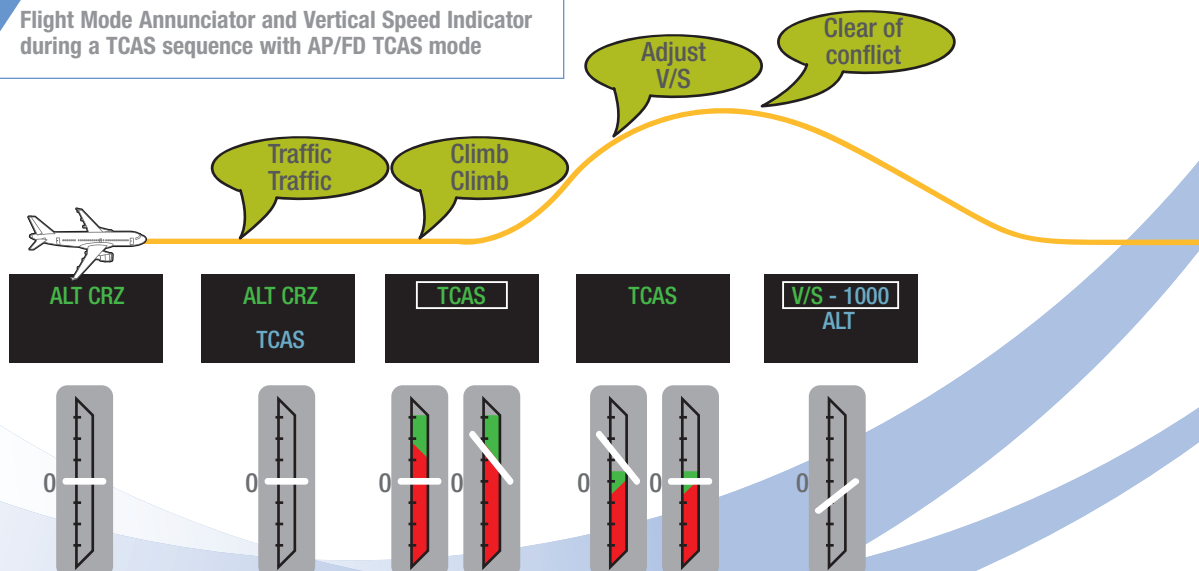
- The TCAS vertical mode engages to maintain the safe current aircraft vertical speed target,
  - All previously armed vertical modes are automatically disarmed, except the altitude capture mode (ALT\*).
- Indeed, levelling-off during a preventive RA will always maintain the vertical speed outside of the red VSI area. So, if the altitude capture conditions are met while the TCAS mode is engaged, it will allow to safely capture the targeted level, thus preventing an undue altitude excursion,
- The Auto Thrust engages in speed control mode (SPEED/MACH) to ensure a safe speed during the manoeuvre,
  - The current lateral trajectory is maintained.

- Once clear of conflict, vertical navigation is resumed as follows:
  - The AP/FD vertical mode reverts to the vertical speed (V/S) mode, with a smooth vertical speed target towards the Flight Control Unit (FCU) target altitude. The ALT (altitude) mode is armed to reach the FCU target altitude (Air Traffic Control cleared altitude),
  - If an altitude capture occurred in the course of a TCAS RA event, once 'clear of conflict', the AP/FD vertical mode reverts to the altitude capture mode (ALT\*) or to the altitude hold mode (ALT),
  - the current lateral trajectory is maintained.

PFD upon a corrective TCAS RA with AP/FD TCAS mode



Flight Mode Annunciator and Vertical Speed Indicator during a TCAS sequence with AP/FD TCAS mode



## Operational and safety benefits

### OPERATIONAL BENEFITS

The operational benefits of the AP/FD TCAS mode solution are numerous. The system addresses most of the concerns raised by in-line experience feedback such as:

- It provides an unambiguous flying order to the pilot,
- The flying order is adjusted to the severity of the RA; it thus reduces the risks of overreaction by the crew, minimizes the deviations from trajectories initially cleared by Air Traffic Control (ATC) - preventing the risk of a new RA triggered with another aircraft and adapts the load factor of the manoeuvre,
- It prevents undue altitude crossing when altitude capture is compliant with the RA (see figure below),
- The availability of the AP/FD TCAS mode makes it possible to define simple procedures for the aircrews, eliminating any disruption in their flying

technique when a RA is received. Indeed the pilot no longer needs to disengage the Auto Pilot or Flight Directors before conducting the TCAS manoeuvres.

When the TCAS mode engages, the procedure simply consists in letting the Auto Pilot conduct the avoidance manoeuvre (if Auto Pilot engaged) or in manual flying the FD bars, which smoothly guides on the proper vertical speed target. The VSI becoming in both cases a 'monitoring' device, it allows checking that the proposed TCAS guidance properly leads or maintains the aircraft's vertical speed outside the red VSI zone.

By reducing the crew's workload and stress level, the AP/FD TCAS mode should therefore significantly reduce:

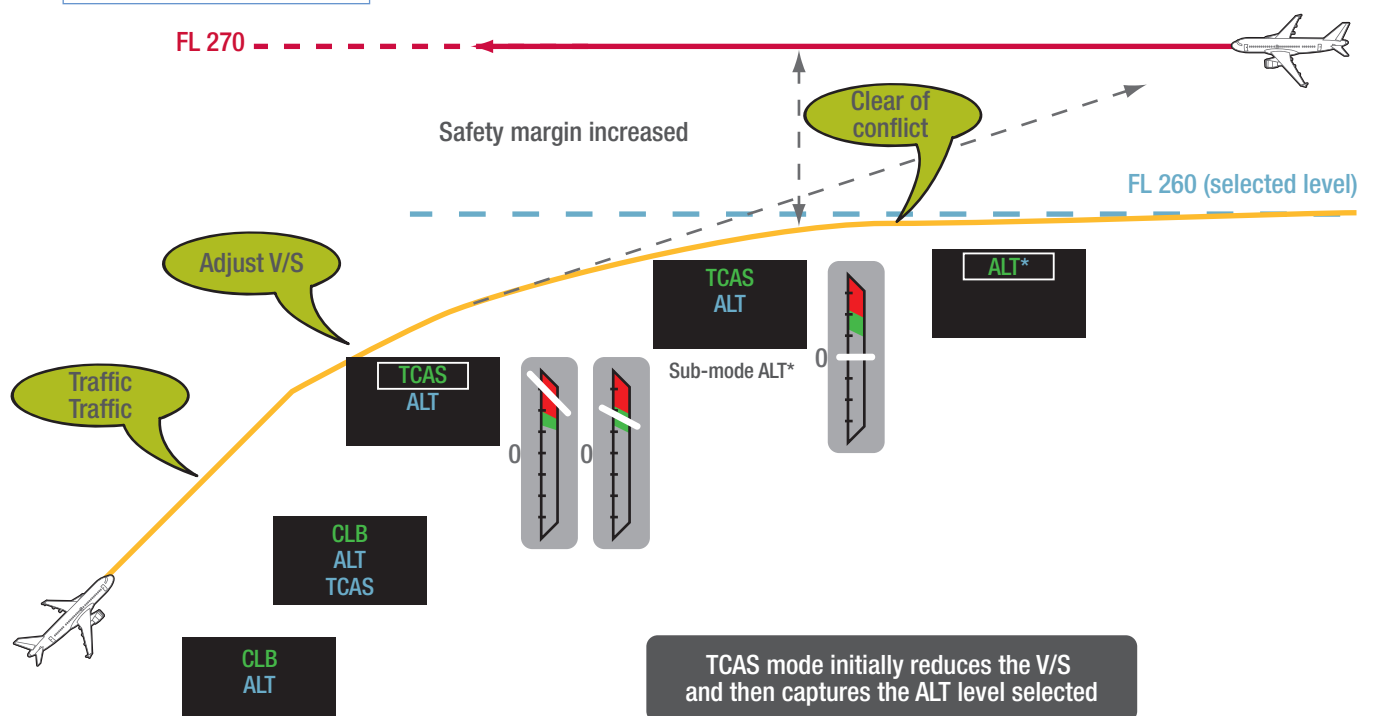
- Inappropriate reactions in case of RA (late, over, or opposite reactions),
- Misbehaviours when 'clear of conflict',
- Lack of adequate communications with ATC.



#### notes

For Air Traffic Controllers (ATC) the AP/FD TCAS mode is totally transparent in terms of expected aircraft reactions.

#### Safe altitude capture with AP/FD TCAS mode



## SAFETY BENEFITS

To assess the safety benefits carried by the AP/FD TCAS mode, Airbus requested Egis-Avia/Sofreavia specialists (experts in charge of safety performance assessment of Airborne Collision Avoidance System - ACAS) to perform a safety performance analysis using the same methods and tools that supported previous ACAS studies in Europe.

Based on the encounter model methodology, the goal of this study was to assess the effects of the introduction of the AP/FD TCAS mode function in the European airspace, both from a global airspace perspective and from a fitted aircraft perspective.

The conclusions of this safety study are that AP/FD TCAS mode will significantly improve the safety in the European airspace:

- From a global airspace perspective, with an assumption of 7% of aircraft equipped with the AP/FD TCAS function only, the expected benefits are equivalent to the benefits expected with the full deployment of the future improved TCAS II version 7.1 (the target is to have every equipment certified by 2012

for forward fit) on every aircraft of the European airspace.

- From an aircraft perspective, conclusions are that aircraft equipped with the AP/FD TCAS mode function will have a much lesser risk of collision than aircraft not equipped with the AP/FD TCAS mode: Their safety will be increased by more than a factor '2'.

## Certification schedule

The new AP/FD TCAS mode was approved and certified by the European Aviation Safety Agency (EASA) for operations on the A380 in August 2009.

The discussion with the Federal Aviation Authority (FAA) is in progress.

The AP/FD TCAS mode will also become available for retrofit on other Airbus Fly-By-Wire aircraft in the coming months. Airbus fleet certification of the AP/FD TCAS mode function is expected:

- On the A320 Family from end 2010 to end 2011, depending on the aircraft type,
- On the A330/A340 Family from September 2010 to end 2011, depending on the aircraft type.



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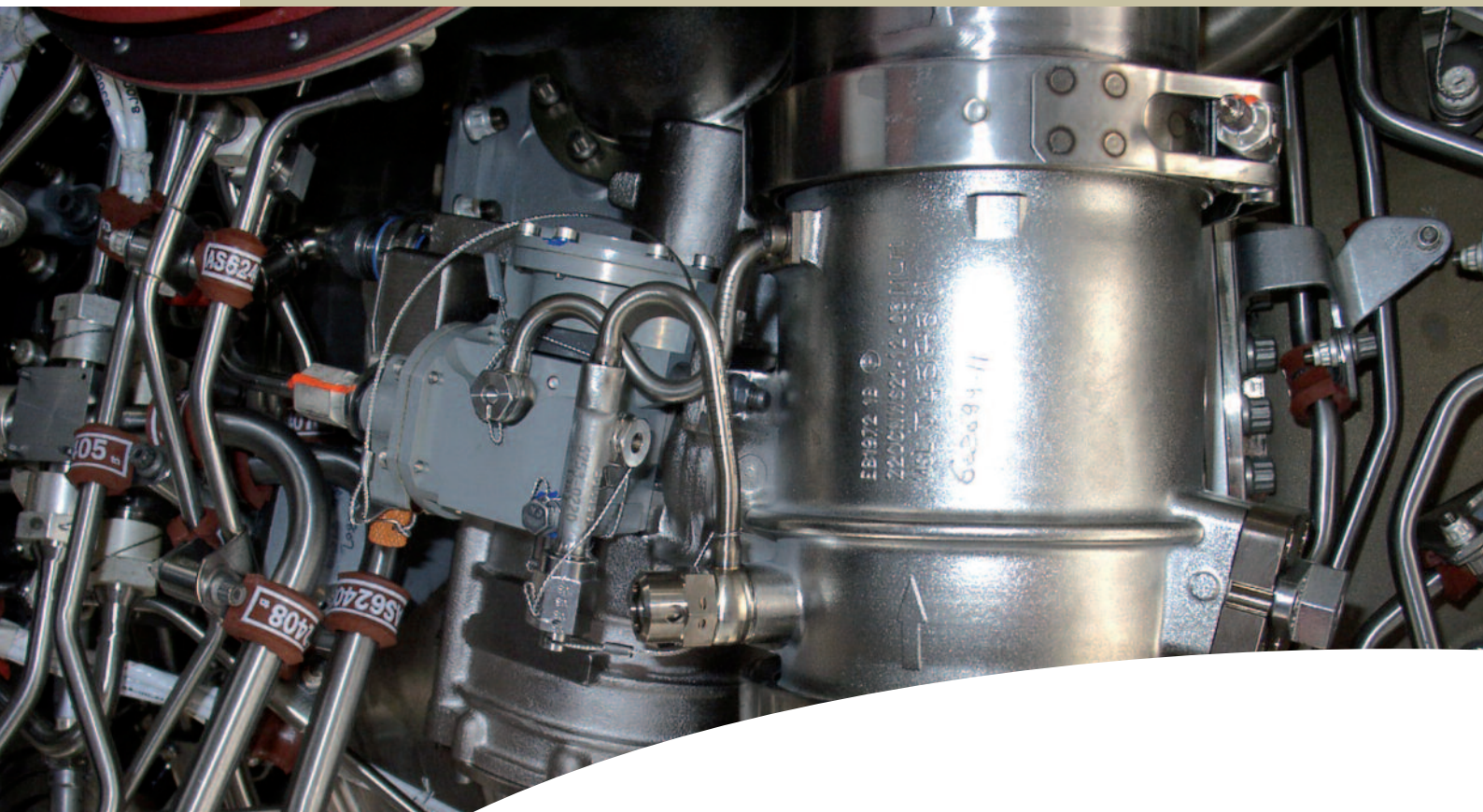
## Conclusion

With the AP/FD TCAS mode, Airbus has reached a new step improving flight safety. By providing prompt and accurate responses to TCAS alert situations, thanks to the Auto Pilot or to the Flight Director, this new system will allow significant safety benefits to the aircraft and its passengers. Numerous airline pilots were offered the opportunity to test this new Airbus

functionality during the development phase: It was perceived as a very simple and intuitive solution, fully consistent with the Airbus cockpit and Auto Flight system philosophy, and definitively deemed as a major safety improvement.

The first of a long list of aircraft equipped with AP/FD TCAS mode has just taken off last November 2009.

**AIRBUS**



# A320 Family Air & Bleed working group activities From engineering to airline culture

The bleed air and the air conditioning systems are among the drivers of Operational Interruptions (OI). Improving their respective reliability performances was the A320 Family main issue priority set by the operators to Airbus. This objective was achieved thanks to the 3D concept “Discuss, Decide, Deliver” and to the associated “work together” which involved suppliers, Airbus and the aircraft operators (including aircraft maintenance). The discussion was expected to only be technical but it quickly appeared that the paramount need of the airlines was the ability to

quantify the returns on their investments, and above all, the ability to assess the impacts. Thanks to these working groups, the airlines are now able to use economic assessments from Airbus based on rates of OI as a decision tool for solution selections. This clearly shows the Airbus move from an engineering culture to an airline culture. The following article describes the work achieved to select the best solutions and describes what has been learnt from this very pragmatic, innovative and collaborative approach praised by Airbus operators.



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## Air Conditioning System description



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glossary

## Bleed air system description

The bleed air system gets air from the pneumatic air sources (aircraft engines, Auxiliary Power Unit APU and ground air source) and supplies the air regulated in pressure and temperature through ducts to the user systems (wing ice protection, air conditioning, engine starting, hydraulic reservoir pressurization and pressurized water). The bleed air system is installed in the nacelle and pylon of each engine as described in figure 1.

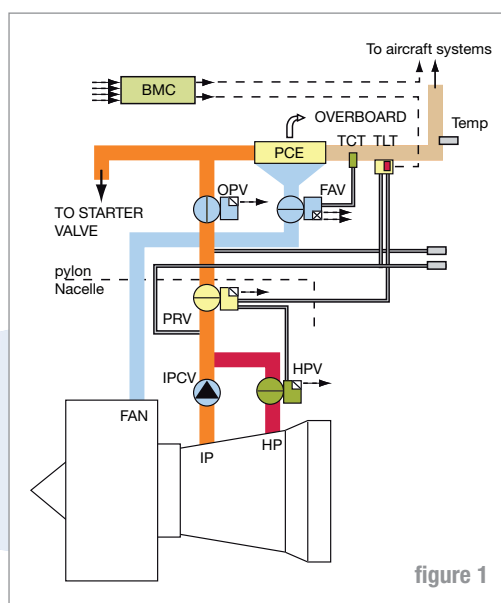


figure 1

## For the pressure regulation:

IPCV: Intermediate Pressure bleed Check Valve (IPCV)

HPV: High Pressure bleed Valve

OPV: Over Pressure Valve

PRV: Pressure Regulator bleed Valve commanded by a TLT (Temperature Limitation Thermostat)

## For the temperature regulation:

PCE: Pre-Cooler Exchanger

FAV: Fan Air Valve

commanded by a TCT (Temperature Control Thermostat)

## For the system monitoring:

BMC: Bleed Monitoring Computer

## The reason for these working group activities

The air conditioning system (ATA21) and the bleed air system (ATA36) are subject to a high number of Operational Interruptions (OI).

An OI is a technical delay that is greater than 15 minutes. It includes flight diversions, in-flight turn backs and aborted take-offs.

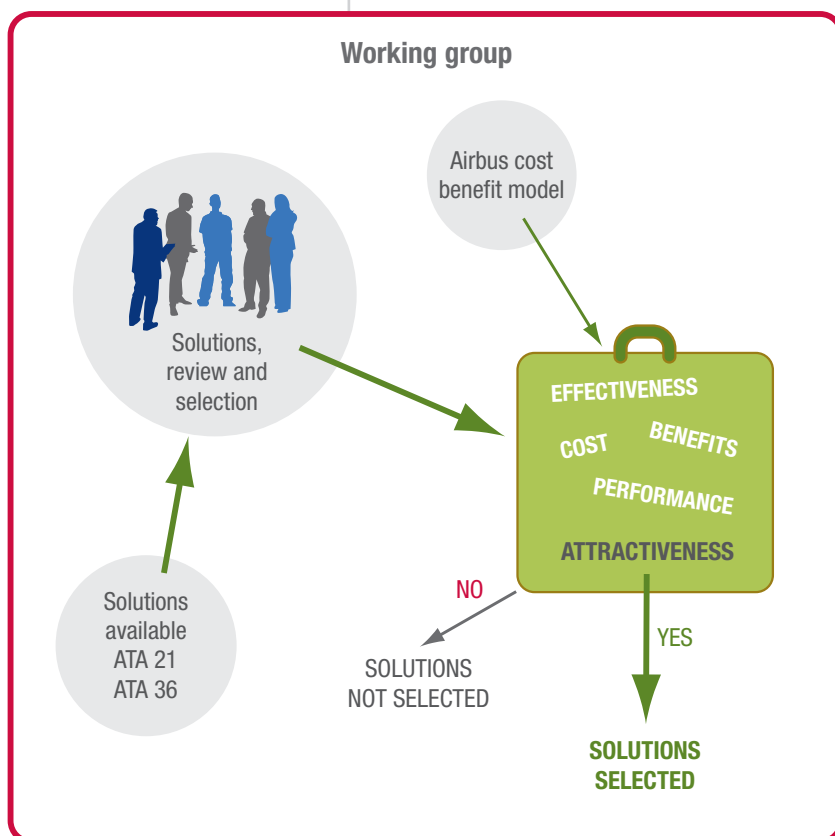
Since the A320 Family Entry-Into-Service in 1988, many efforts have been made and the benefits of new technologies have been taken into consideration to design more robust and simplified systems. This is reflected in the positive OI trend at aircraft level, but can still be improved at some systems' level which was the purpose of the working group.

## Engineering culture versus airline culture for a better OI trend

With an engineering approach, each time an in-service issue arises and requires an improvement, the necessary engineering work aims at proposing the best technical solution. Some of the key questions such as "What is the cost?", "What are the real benefits?" that an airline will have are not fully answered. Many solutions which would help to improve the systems' reliability performances are then not selected by the airlines. Time and money are spent by Airbus and the suppliers for poor benefits.

A 'working together' approach which encompasses all aspects (technical, economical, etc.) has been required to satisfy all of the involved parties and it is presently what this working group has highlighted.

### Working group activities

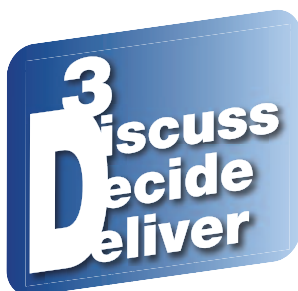


## Working process

The first innovation consisted in involving aircraft operators, more than ever, in the setting of the working group objectives, as well as defining and validating the performance objectives.

An important step was the acknowledgement that improving the systems' performance was not only a matter of upgrading the system components, under the suppliers' responsibility, but also improving the system integration in the aircraft, under Airbus leadership, in the manner the system is operated and maintained by the aircraft operators. It was soon understood that sharing experience and combining efforts of the three main stakeholders (airlines, suppliers and Airbus) was a key condition of success.

The working group approach:  
The three main steps



## Discuss

### (or scoping phase):

It consists in identifying the key issues to be resolved and the performance improvement objectives. This was done with the use of a questionnaire and the validation of the scope in the initial face-to-face workshop held in Toulouse in April 2008. Two additional workshops were conducted with the participation of more than 30 worldwide operators, with the main system supplier (Liebherr), as well as teleconference/web-exchange sessions including up to 10 operators per call.

## Decide

### (or resolution phase):

It consists in detailed discussions and in the sharing of experience leading to the identification of the improvement solutions.

- Which solutions?

To answer the concerns, several solutions have been proposed such as an Airbus modification, a preventive maintenance task, a trouble-shooting task, an operational procedure, etc.

- How were the solutions validated?

To validate the solutions, it was required to have the answer to the following questions:

- 1 - "Is it effective?"
- 2 - "Does it reduce the number of OI and what are the benefits?"
- 3 - "What is the cost?"

By answering these questions, the working group participants were then able to rate the solutions and only the best rated ones have been selected, taking also into account the solutions which brought significant reduction in OI.

## Deliver

### (or implementation phase):

It consists in progressive embodiment of the solutions in the fleet and the report of early benefits. This phase involved Airbus and/or Liebherr visits to individual operators and allowed sharing results via the A320 FAIR-ISP (Forum for Airline Issues Resolution - In-Service Problems) web forum, accessible on-line to all the A320 Family operators (all deliverables of the working group can also be consulted in the FAIR-ISP forum on AirbusWorld).



information

### Typical bleed failure scenario

The dual bleed loss events usually happen when one bleed fails, resulting in the remaining bleed on the other engine to compensate for it. The augmented flow of warm air from the engine core leads to a corresponding increase in the flow of cold air from the Fan to the Pre-Cooler Exchanger (PCE). In case of one engine bleed loss, the remaining bleed fails when the Fan Air Valve (FAV) does not let enough cold air reach the PCE. This causes the temperature downstream of the PCE to reach the 260°C (500°F) over-temperature threshold, which induces the automatic closure of the bleed system. This excessive rise in temperature is caused mainly by either:

- Leakage of the Temperature Control Thermostat (TCT) to FAV sense line,
- TCT drift/failure,
- Or FAV leakage/failure.

Note: In-service experience has shown that the root cause of over-temperature is often linked to a combination of the above factors. Other possible causes are:

- Temperature sensor failure,
- Wiring failure.



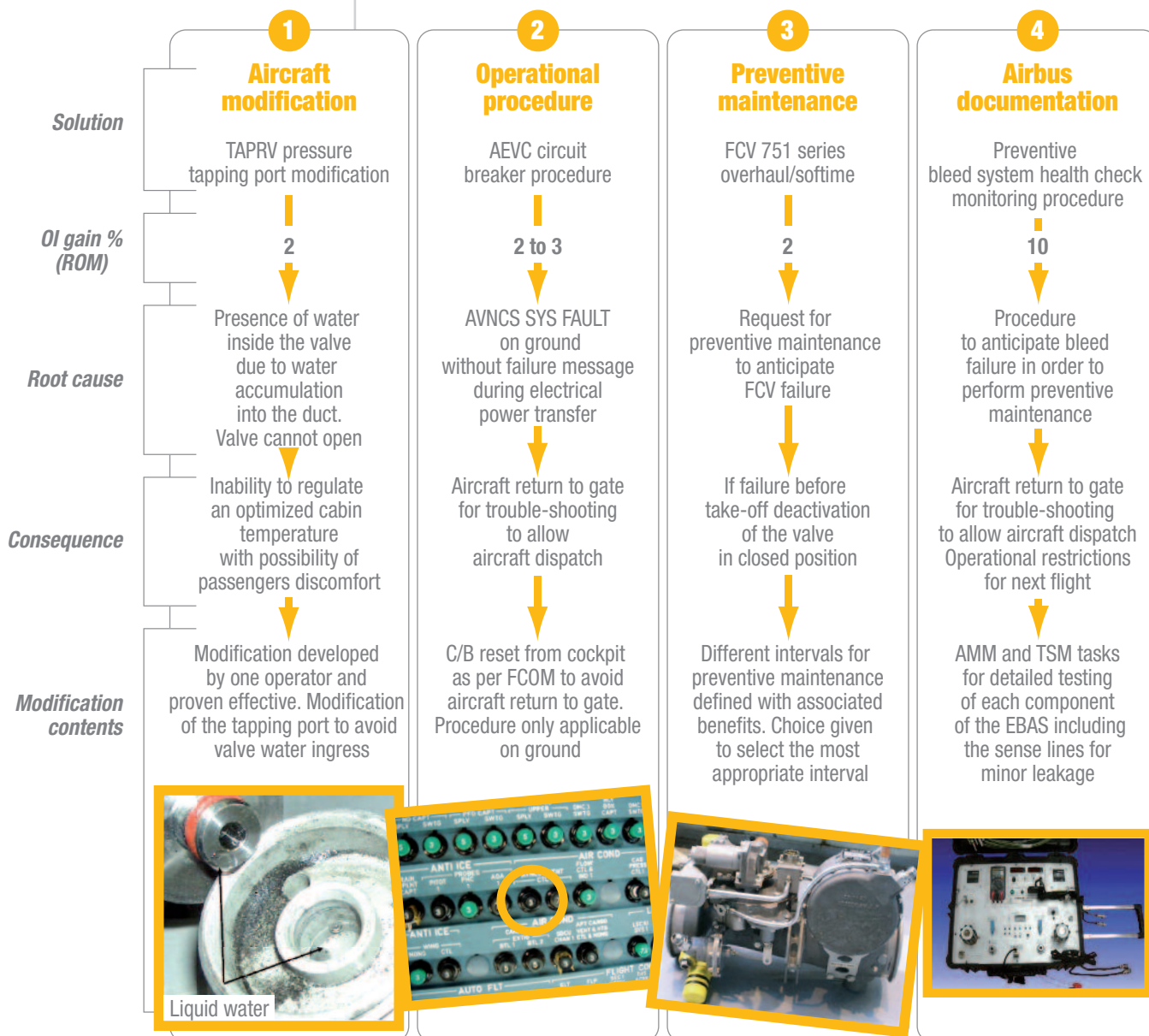
## Solutions selected

The solutions selected by the working group fall into four main categories:

- Airbus modification,
- Components preventive maintenance,

- Airbus documentation,
- Operational procedure.

### SOME EXAMPLES OF SELECTED SOLUTIONS:



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### glossary

**AEVC:** Avionics Equipment Ventilation Controller  
**AVNCS SYS FAULT:** Avionics System Fault  
**AMM:** Aircraft Maintenance Manual  
**C/B:** Circuit Breaker  
**EBAS:** Engine Bleed Air System  
**FCOM:** Flight Crew Operation Manual

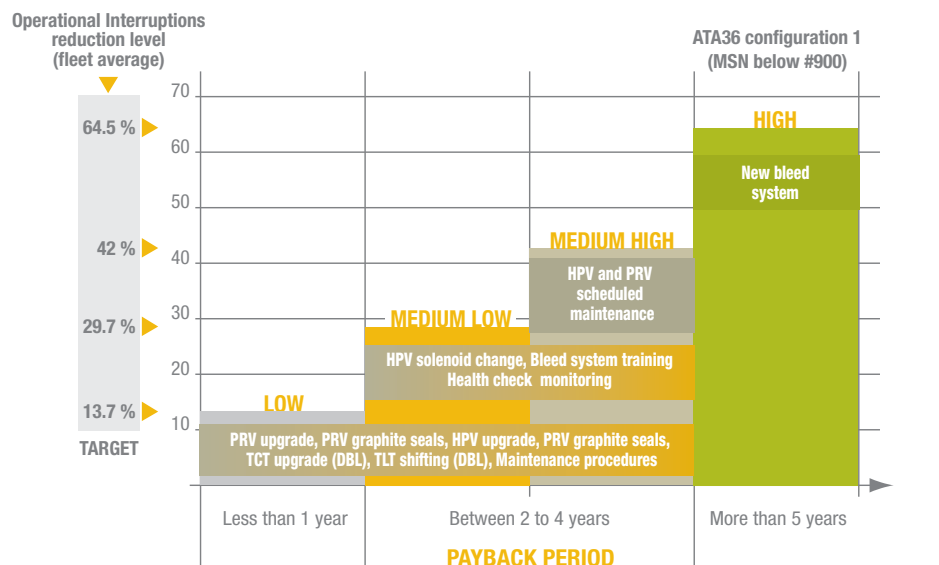
**FCV:** Flow Control Valve  
**OI:** Operational Interruption  
**ROM:** Rough Order of Magnitude  
**TAPRV:** Trim Air Pressure Regulating Valve  
**TSM:** Trouble-Shooting Manual

## Achievements and deliverables

Third significant innovation was the idea of packaging the solutions. This was done for two reasons. The first reason is technical: Some solutions complement each other and embodying them all at once provides more benefits than with the simple sum of each solution. The second reason is all about decision making: The 'Air & Bleed Working Group' packages are defined in such way that operators can decide for a small effort and can hope a reasonable performance improvement with a short payback period, or they can go for a larger effort and expect a greater performance improvement with a longer 'payback' period (see packages in chart).

## Lessons learnt and added value

Before the launch of the working group, activities were already running between airlines and Airbus to find the proper means to inform about the cost and the benefits of a given solution. 'WISE Main Adopted Solutions and Tips', also called MASTER, has been developed and is now available to the airlines through AirbusWorld.



MASTER provides 'Top Fleet Solutions' that increase aircraft availability and reduce operating costs. These MASTER solutions are:

- Technically proven: Demonstrated by actual in-service experience,
- Economically efficient: Demonstrated through a cost benefit model with a payback period of less than five years,
- Widely applicable: Embodiment possible on a large number of aircraft.

PRV: Pressure Regulating Valve  
HPV: High Pressure Valve  
TCT: Temperature Control Thermostat  
TLT: Temperature Limitation Thermostat  
DBL: Dual Bleed Loss

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## Conclusion

To reduce the number of Operational Interruptions (OI) caused by bleed air and air conditioning systems, solution packages are proposed taking into account technical and economic embodiment decision data. This has been achieved thanks to the combination of an innovative way of working altogether with airlines, suppliers and Airbus, while implementing an innovative approach to in-service issues. The working group packages allow individual customization

of solutions for a given operator. All individual solutions are documented (SIL 21-152 and SIL 36-057) and Airbus has the capability to perform customized computation of the cost/benefit results for each individual situation, upon request. These positive results have led customers to request Airbus to launch similar initiatives in other aircraft areas. Working groups on ATA 27 (Flight Controls) and ATA 29 (Hydraulics) were such as launched in December 2009.

**AIRBUS**



# A300-600

## Extended Service Goal

### Enabling longer lasting operation

Commercial aircraft design is defined such that with proper maintenance, the operational service life of the aircraft is not limited. For design and certification, a Design Service Goal (DSG) is defined in Flight Cycles (FC) and Flight Hours (FH) such as it will reflect the expected average utilization of the aircraft model over 20 years of normal airline service. The DSG is not a life limit but only a reference for design and certification. It is Airbus policy to limit the validity of the initial Maintenance Programme to the DSG. Since the aircraft is only allowed to operate with an approved Maintenance Programme, this Limit Of

Validity (LOV) represents the only limitation for aircraft operations. In the late 1990s, it became obvious that A300 - B2 and B4, A300-600 and A310 aircraft were going to reach the original DSG within the following years. Consequently, Airbus launched the Extended Service Goal (ESG) study which aimed at extending the initially defined LOV of the Maintenance Programme to cover the evolution of the A300/A310 Family fleet.

This article describes how Airbus has integrated the ESG study results for the A300-600 passenger version, covering both structures and systems.



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Part 2: Systems  
Deputy Head of Systems  
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## Part 1: Structures

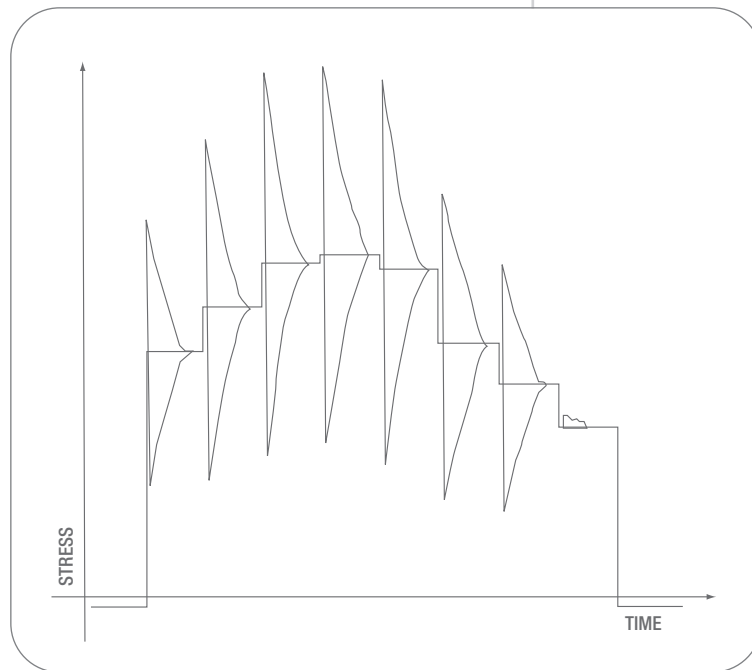
### BASIC AIRCRAFT STRUCTURE DESIGN AND CERTIFICATION

For certification, extensive Fatigue and Damage Tolerance (F&DT) analysis supported by testing are performed to substantiate the structure. The F&DT analysis consists in demonstrating that the design objectives are met including on adequate scatter factors.

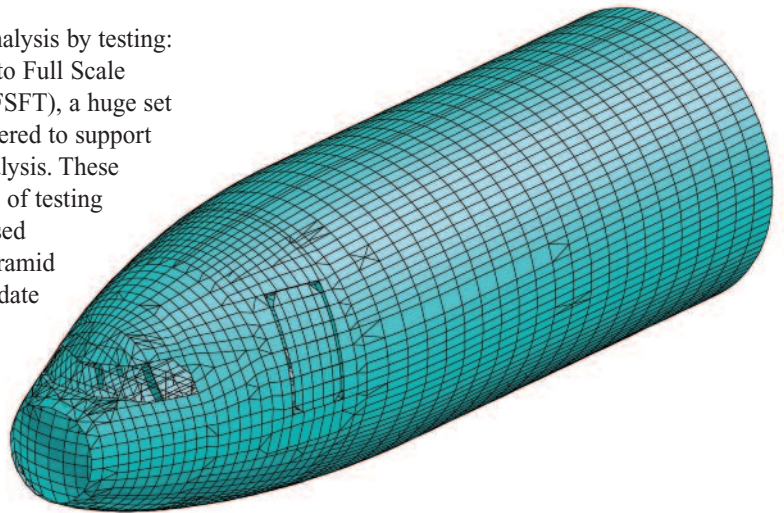
This requires to:

- Define a goal, called by Airbus the Design Service Goal (DSG),
- Determine the flight-by-flight spectra: Fatigue loads and spectra for occurrence distributions are prescribed in terms of flight and ground manoeuvres, and atmospheric gusts and turbulences. A number of flight profiles are determined to represent the various spectra expected in-service combined with different flight lengths. Those loads, combined with the cabin pressure, reflect a realistic loading of the airframe for several types of ground/air/ground cycles. From those profiles, a typical spectra expected in-service is used to establish the basis of the analysis conducted for certification,
- Evaluate the damaging effect of those fatigue loads and spectra, calculated through the F&DT analysis: The internal stress distributions due to the fatigue loads and typical spectra are calculated using Finite Element Models (FEM) analysis methods. From the FEM outputs, detailed F&DT analyses are performed for the complete aircraft structure justification. To be able to consider variation of those loads and spectra, comparatively to the typical spectra, a set of parametric studies is conducted for the various significant parameters (range, centre of gravity, payload, fuel at landing, etc.),

Initial spectra



- Support the analysis by testing: From coupon to Full Scale Fatigue Test (FSFT), a huge set of data is gathered to support the F&DT analysis. These different types of testing can be expressed in terms of pyramid of tests to validate main design principles and to validate the internal stress distribution. Residual strength tests are also performed by introducing different types of realistic damages, either at the end of the fatigue tests, or mainly in the static test specimen,
- Define the appropriate FSFT loading sequences by using the set of flight profiles representing the various fatigue loads and spectra expected in service combined with internal pressure.



A300 Finite Element Models

Fatigue and Damage Tolerance (F&DT) tests' objectives are to:

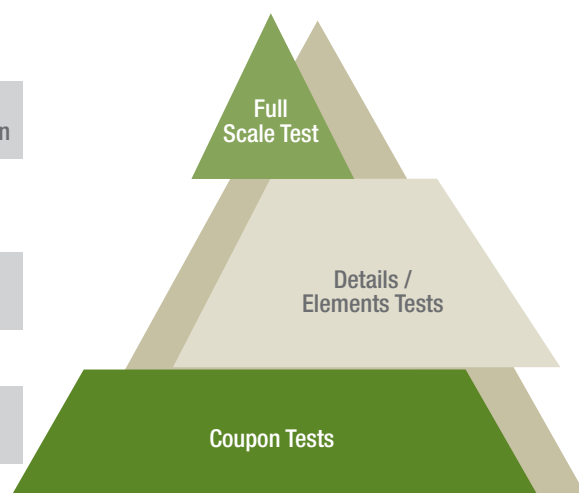
- Validate the F&DT analysis conducted,
- Show that the design objectives are met based on adequate scatter factors,
- Early identify weak points in the primary structure, hence determine as soon as possible corrective actions on production and in-service aircraft, before they appear in service,
- Validate inspection methods that are proposed in the Maintenance Programme,
- Validate repair solutions.

#### Pyramid of tests

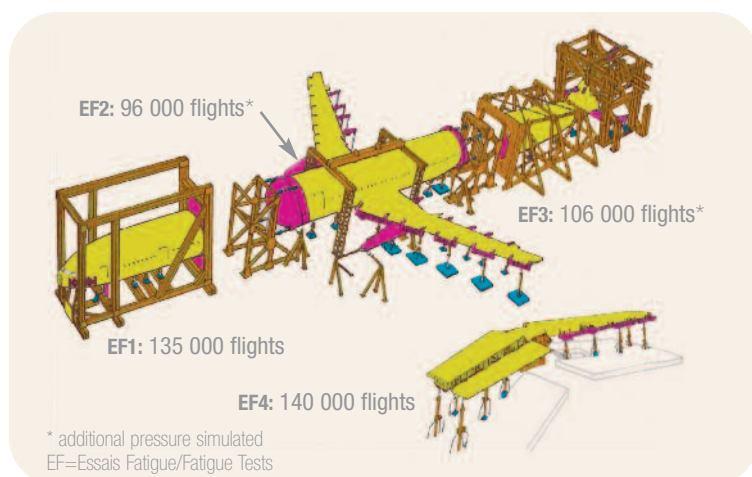
Full Scale Tests  
To validate internal stress distribution

Details / Elements - Tests  
To validate main design principles

Coupon Tests  
To determine material allowables and properties



#### A300 Full Scale Fatigue Tests. Simulated flights



F&DT analysis ensures that the anticipated service life can reasonably be attained, and that the structure has a good level of damage tolerance in terms of damage propagation and residual strength. The above approach, supporting the initial F&DT analysis with a complete set of Full Scale Fatigue Tests (FSFT) on a representative 'structure' under realistic flight-by-flight loading, allows implementing a reliable structure Maintenance Programme.

#### INITIAL MAINTENANCE PROGRAMME DEFINITION

##### 1/ FATIGUE AND ACCIDENTAL DAMAGE

Based on the above analysis supported by tests, appropriate maintenance actions are defined in the initial Maintenance Programme, approved by Airworthiness Authorities, to ensure that any type of damage initiated in the airframe due to whatever reasons are detected and repaired before they become critical.

All the items that need an action before the Design Service Goal (DSG), or that are life limited (safe life items like landing gears) - and in that case that have a limit beyond which the part must be replaced - are listed in the Airworthiness Limitation Sections (ALS).

It is Airbus policy to limit the validity of the initial Maintenance Programme to the DSG (LOV=DSG).

##### 2/ CORROSION

Corrosion is monitored by scheduled maintenance actions. Those actions are recorded in the Corrosion Prevention and Control Programme (CPCP). On the contrary of the fatigue tasks which are driven by the number of FC/FH, the corrosion related tasks are time dependant. The aim of the CPCP is to control the level of corrosion in the fleet to not exceed

an 'acceptable level'. The CPCP is thus regularly adapted to the fleet's needs and findings, using regular in-service surveys. In case of significant corrosion findings, appropriate instructions are defined:

- Repairs - aimed at resuming the structure original strength level,
- Modifications - to improve the corrosion resistance in order to reduce the risk of future findings.

#### THE EXTENDED SERVICE GOAL (ESG)

As the Airbus fleet grows in age, Airbus prepares ageing aircraft activities to ensure that the respective Maintenance Programmes are validated beyond DSG before the lead aircraft reaches it.

ESG study does not impact on the F&DT certification, but ESG study consists in re-validating and updating the approved Maintenance Programme, and when necessary, defining additional maintenance actions taking into account in-service and test experiences, to ensure its validity beyond the DSG.

Such actions are typical inspections that became applicable after the initial 'LOV=DSG' or are terminating maintenance actions (modifications) to reduce the inspection burden. This covers the F&DT and Accidental Damages inspections. The CPCP does not need to be reviewed in the frame of the ESG, because it is time dependant and already regularly adapted to the fleet's needs and findings.

To ensure that the fatigue mission assumptions are conservatively covering real fleet usage, fleet surveys (on a flight-by-flight basis) are necessary to gather possible usage evolution for the whole fleet. The aim of this regular exercise is to check, and if necessary, update the considered 'typical loading spectra expected in service'.

Typical parameters considered are: flight time, payload, fuel quantities, Take-Off Weight (TOW), Landing



#### information

### Regulation requirements (Fatigue & Damage Tolerance - F&DT)

The JAR/FAR 25.571 Amendment 54 that introduced the damage tolerance principles, was not applicable for the A300 certification. However, the design and the definition of the Maintenance Programme have been based on the damage tolerance principles since the beginning. Due to this, Airbus obtained from Airworthiness Authorities the validation of this amendment's compliance for A300-600 aircraft.

Following the issue of F&DT requirements, several initiatives were launched by the rulemaking authorities to review and update the requirements, in order to properly incorporate available experience (in-service events, incidents or accidents) into the applicable F&DT approach.

One typical example is the AAWG (Airworthiness Assurance Working Group). A major structural accident triggered the industry working group to review the Widespread Fatigue Damage (WFD) and crack turning phenomena.

The recommendations coming out of these activities were integrated in Airbus approach as soon as available, even before becoming mandatory. More recently, the FAA (Federal Aviation Authority) requested 'Damage Tolerance Data for Repairs and Alterations', effective since 11 January 2008, to enforce manufacturers supporting operators in showing compliance to the AASR (Ageing Aircraft Safety Rule).

Weight (LW), centre of gravity positions, etc. The review of the utilization may also lead to the update of the Maintenance Programme. For efficiency reasons, both, fleet surveys inputs and the extension of LOV study, are done concurrently.

The voluntary consideration of Widespread Fatigue Damage (WFD) recommended methods may also lead to revise and add maintenance requirements. As for the initial Type Certification (TC), the revised F&DT analysis is supported by the extensive experimental information resulting from the A300/A310 Family test pyramid (FSFT A300 and A310). It is supplemented by additional information on:

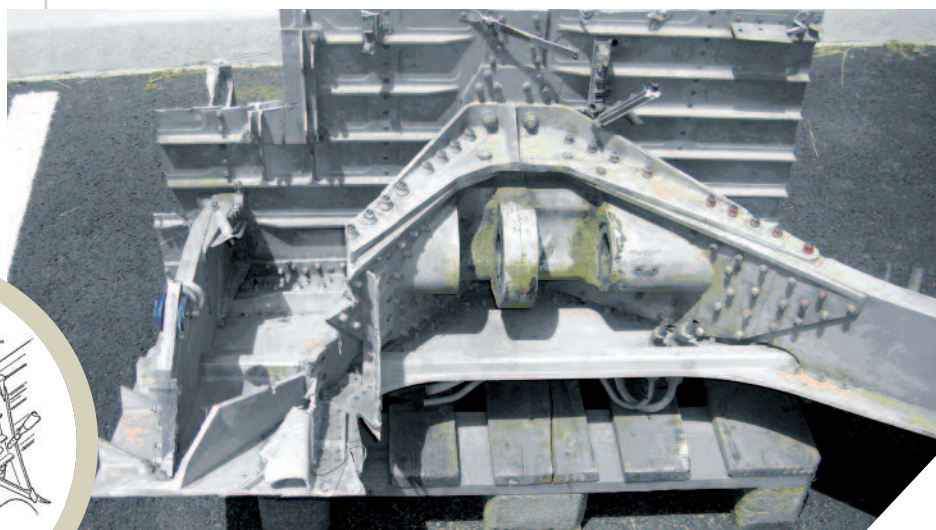
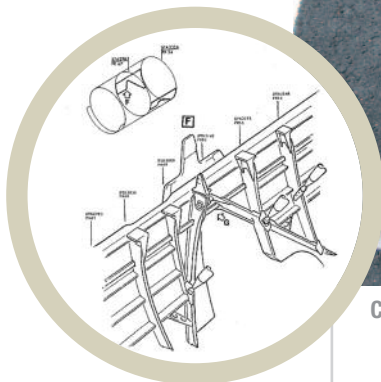
- In-service events,
- More accurate tear down of the initial Full Scale Fatigue Test,
- Additional testing.

On top, alternate means may also be necessary to support or refine the analysis in specific areas like:

- Tear down of an aged aircraft (or parts of it),
- Additional one-time inspections of aircraft reaching the LOV,
- Detailed Finite Element Models.



**Tear down programme for A300 MSN 008**



Centre section tear down - example: Landing gear attachment

For operations beyond the Design Service Goal (DSG), Airbus committed to demonstrate:

- The continuous validity of the Maintenance Programme,
- That Widespread Fatigue Damage (WFD) is not expected to occur, following the recommendations of the Airworthiness Assurance Working Group (AAWG) and draft NPA20-10/AC91-56B, and in anticipation of regulatory texts.

The first Extended Service Goal (ESG1) study was launched in the late 1990s, with the aim to protect the A300 and A300-600 fleet beyond 2002. Results of this study were presented to the operators in 2002. A310 ESG has been developed, and presented to the operators in 2005.

All these life extension activities conducted on the various A300/A310 Family models allowed to increase the Limit of Validity (LOV) of the certified Maintenance Programmes beyond the initial DSG.

ESG2 activity has been launched for the A300-600 passenger model to preserve fleet operations beyond 2011. It aims at extending the current LOV to 1000FC/89000FH. Existing F&DT analysis, FSFT tear down findings, additional testing and tear down of retired aircraft parts, refined Finite Element Models, together with in-service experience, were used to support the refined analysis conducted to validate and update the Maintenance Programme demonstration up to the new LOV= ESG2.

Current approved LOV based on F&DT analysis and testing

Aircraft type series		DSG	Limit of Validity (LOV)
A300	B2	48,000FC / 51,840FH	60,000FC / 65,000FH*
	B4-100	40,000FC / 53,200FH	57,000FC / 76,000FH*
	B4-200	34,000FC / 70,720FH	57,000FC / 118,000FH*
A310	-200	30,000FC / 67,500FH	45,000FC / 105,000FH*
	-300	40,000FC / 60,000FH	40,000FC / 116,000FH
A300B4-600/B4-600 R (passenger aircraft)		35,000FC / 60,000FH	42,500FC / 89,000FH*
A300-600 pax + C4-600, C4-600R variant F, F4-605R Pre mod 12699 (FDX1)		30,000FC / 67,500FH	42,500FC / 89,000FH*
A300F4-600R EIS > 2000 (UPS, GF & FDX2)		30,000FC / 67,500FH	30,000FC / 67,500FH*

UPS: United Parcel Services - FDX: Federal Express - GF: General Freight

\* ESG

## REVISED LOADS AND REFINED SPECTRA

New fleet surveys have been carried out resulting in particular in an increase of fuel at landing of 2.5 tons on passenger aircraft. An improved spectra has been defined, with the aim to refine Fatigue and Damage Tolerance (F&DT) analysis of ground perturbations, lateral gust and dynamic landings, especially on Centre Wing Box, considering experience from recent other programmes.

## ADDITIONAL TESTING AND STRUCTURAL PARTS TEAR DOWN

ESG2 study takes obviously benefit of the ESG1 analyses, which are complemented by means of:

- Additional stress analyses taking into account new in-service data and an improved fatigue spectra,
- Coupon tests,
- Tear down inspection of an old aircraft, following parts' recoveries of MSN 341.

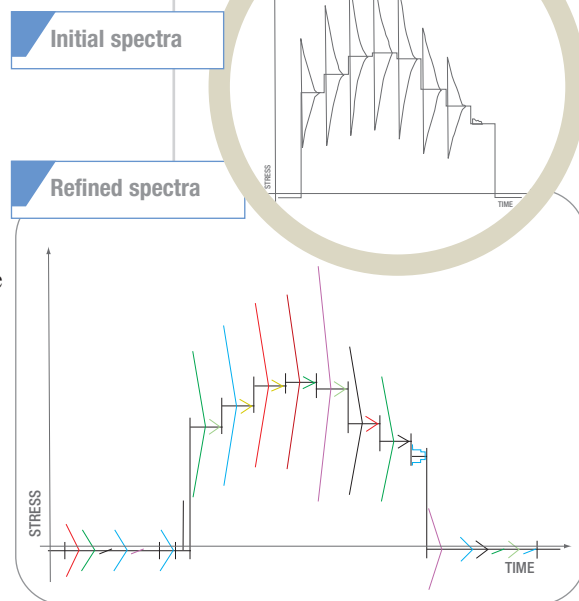
## THE MSN 341 TEAR DOWN AIMS

ESG2 F&DT analysis covers the whole structure but the dedicated approach may differ in function of the areas:

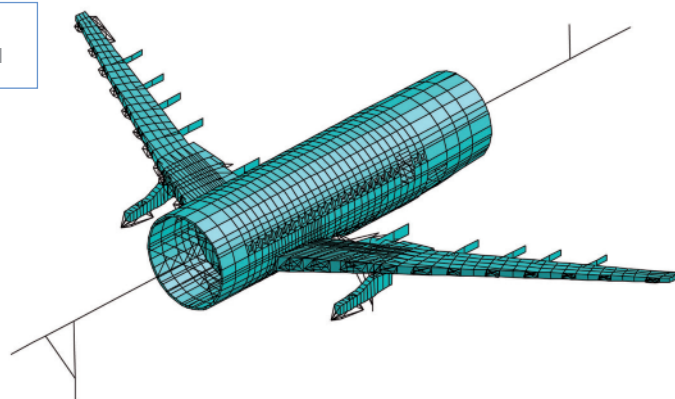
1) Areas well known because of existing FSFT or in-service crack/deep stress analysis and detailed inspection programmes. Data are sufficient to extend the analysis in the frame of ESG2.

2) Areas with no experience of crack initiation, neither in the FSFT (even post tear down), nor in-service and not yet a dedicated/detailed inspection item in the Maintenance Programme.

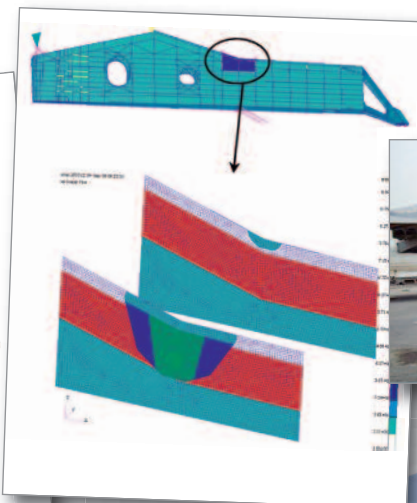
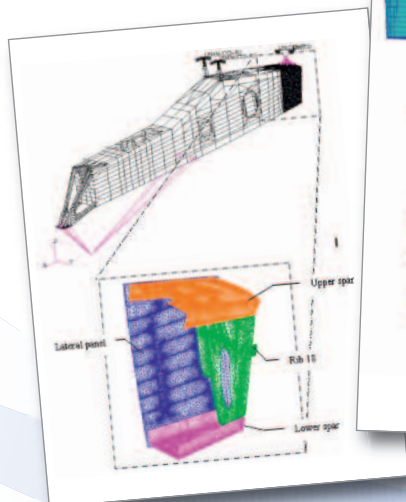
For some second category areas, detailed inspections of a high time in-service aircraft are performed in order to better validate and consolidate the stress analysis. MSN 341 tear down is used as complementary data to the theoretical stress analysis.



A300/A310 Family wing and center fuselage FEM



Additional tear down and refined Finite Element Analysis



## Part 2: Systems

### DESIGN SERVICE GOAL EXTENSION

For the system's certification, extensive analyses and testing were performed to substantiate the Design Service Goal (DSG) at two different levels:

- Firstly, during the qualification of the components or the system at supplier level,
- Secondly, during the integration of those components within the system at aircraft level.

For the qualification of the component, endurance and fatigue tests are performed to support the theoretical analyses which have been used at the beginning of the design phase to develop the component.

At aircraft level, all these components are integrated within the system and are tested. Endurance tests are performed on the Iron Bird (aircraft zero) in order to check the good behaviour of all the systems working together. This Iron Bird is fully representative of the aircraft and includes also all the components fitted within the engines and the landing gears.

At Entry-Into-Service, all the systems are qualified for a DSG of 20 years according to the Maintenance Programme. Appropriate maintenance actions are defined within the Maintenance Planning Document (MPD) in order to guaranty the safety and reliability objectives. All the components which are life limited are defined in the Airworthiness Limitation Sections (ALS) and must be replaced in that case.

For operation beyond DSG, Airbus committed:

- To ensure that operating beyond the original certified Limit Of Validity (LOV) does not impact on the compliance with the requirements as defined by the Type Certification (TC) basis (JAR/FAR 25.1309 and JAR/FAR 25.1529 mainly),
- To provide a policy for the establishment of the systems' justification for the ageing aircraft to maintain compliance with applicable requirements.

The goal of this ESG study is to demonstrate, for the systems, close to twice the original DSG in terms of Flight Hours (FH) and Flight Cycles (FC). A summary is given in the systems DSG/ESG chart below.

### SYSTEM POLICY DESCRIPTION

This system policy has been defined in 1990, at the beginning of the ESG for the A300/A310 Family programme and is also used to extend the DSG to all other Airbus programmes.

An agreement has been found with the European airworthiness authorities on three ageing parameters to be addressed as part of the ESG study for mechanical and for hydraulic-mechanical components:

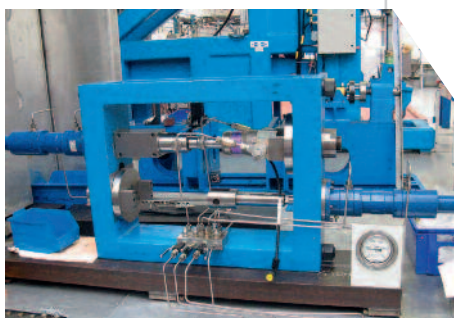
- Corrosion,
- Wear or erosion,
- Fatigue.

The two first ones (corrosion, wear and erosion) can be adequately monitored by scheduled maintenance actions like Maintenance Review Board (MRB) tasks, Time Between Overhaul (TBO) items, zone inspections or functional tests. These maintenance actions are regularly performed and when corrosion or wear is detected, the component is replaced. In the opposite, fatigue damages cannot be monitored. Therefore, a specific study has been performed in order to select the equipment which are sensitive to fatigue.

Hydraulic test bench  
endurance tests at system level



Spoiler Actuator fatigue test



Systems DSG/ESG

Aircraft			DSG	ESG
A300	B2/B4	FC	26,000	57,000
		FH	40,000	118,000
A310		FC	26,000	45,000
		FH	40,000	116,000
A300-600		FC	26,000	51,000
		FH	40,000	89,000

Electronic and avionic equipment are not considered in the analysis. In-service experience and repair analyses have not shown any increase of components' failure rates on the oldest computers.

### EQUIPMENT SELECTION

The list is built by selecting components which failures are involved in Failure Conditions (FC) classified 'hazardous' or 'catastrophic' in the existing System Safety Assessment (SSA). Only 'significant' contributing components to a FC are to be considered. For example, if a component experiences a degradation of its failure rate such that this rate should be equal or above  $1E^{-2}/FH$  to impair the global safety objectives, then it is considered that the normal continued airworthiness process will detect the failure rate degradation, well before it could lead to safety issues.

### LIFE EXTENSION ANALYSIS

For equipment which have been selected as sensitive to fatigue and having Declaration of Design and Performances (DDP) indicating a life limit lower than the one expected for the extension, life extension activities have to be conducted.

The life extension demonstration can be performed by using the following methods:

- Engineering analysis:  
Taking into account for example failure mode characteristics, existing design precautions and maintenance tasks as well as detection means and in-service experience,
- Static stress analysis:  
Identification of margins between design loads and normal operational loads.  
In case of a high margin, fatigue is not considered relevant like, for example, mechanical control linkages or elastic components,

- Test:  
DDP updates can be performed by reviewing the existing fatigue analysis or through new extended fatigue tests.  
If identical equipment is used on other programmes with a justified higher DSG, this could be used to justify the extension clearance,
- Statistical analysis:  
Based on in-service experience and use of statistical adequate laws as 'Weibull' (see note) laws, failure rate extrapolation can be performed - the new extrapolated failure rates being then used for the SSA review.

### SYSTEM SAFETY ASSESSMENT REVIEWS AND UPDATES IF NECESSARY

All SSAs have to be reviewed and updated to take into account the new in-service goal for failures that are hidden for the aircraft life, as well as updated failure rates, if any (extrapolated failure rates by 'Weibull' law, or updated further in-service experience reviews).

Additional maintenance tasks could be needed to comply with the safety objectives.

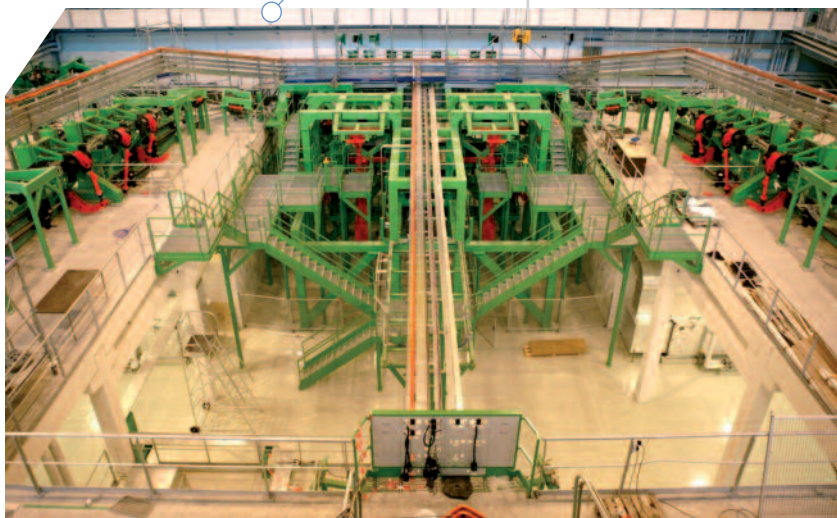


notes

### Weibull

Reliability theory allowing to predict the age-related failure kinetics for a system of given architecture - reliability structure - and given reliability of its components.

Iron Bird - systems integration test endurance test at aircraft level

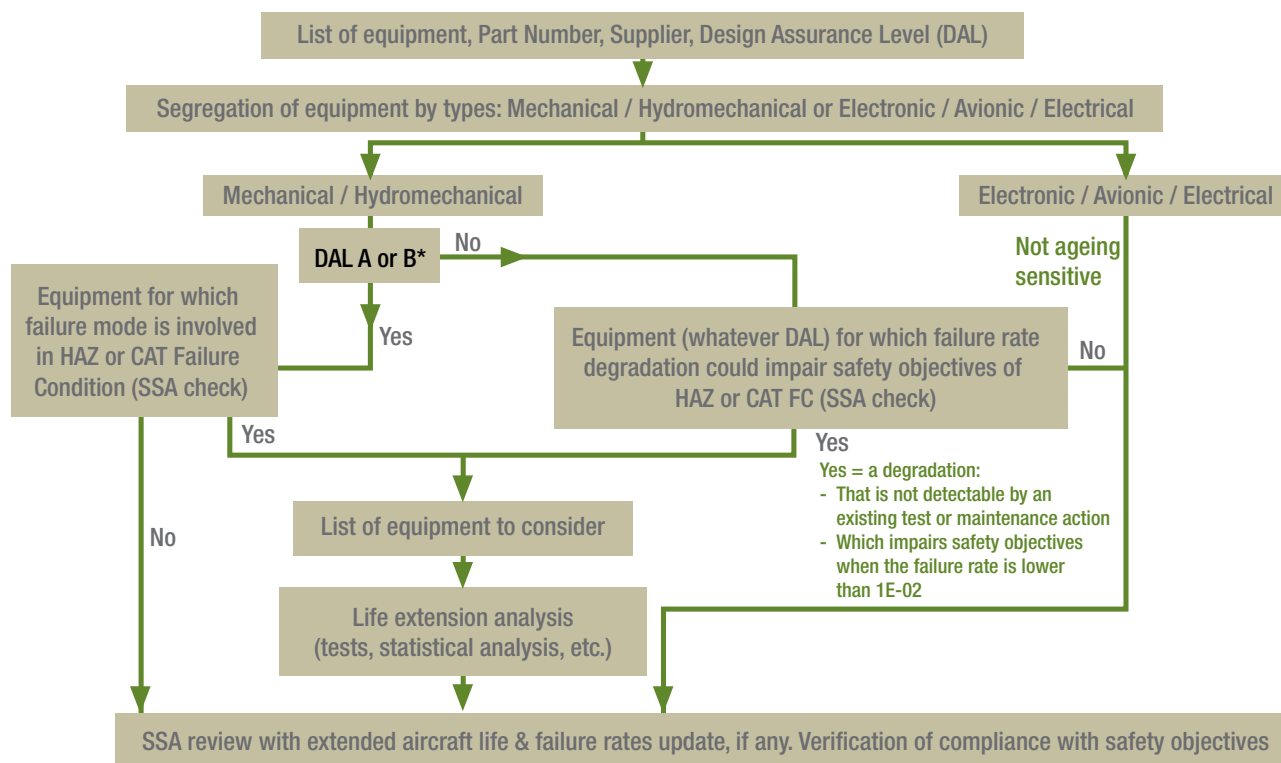


## OUTCOME OF THE LIFE EXTENSION ANALYSIS

If the analysis exercise points out that some equipment are affected by a life limit at aircraft level, or if additional maintenance tasks are

found necessary to be added to ensure safety objectives, this will be introduced in Airworthiness Limitation Sections (ALS) Part 4.

The analysis could be summarized as follows:



**SSA:** System Safety Assessment

**DAL:** Development Assurance Level

- The Development Assurance Level defines the required activities to give adequate confidence that the design will satisfy the purchaser requirements.

- The Development Assurance Level of the equipment is determined only by the aircraft manufacturer.

The chosen level is based on safety classification.

Classification applicable to the relevant system or equipment:

**DAL A** if failure condition classification = Catastrophic (CAT)

**DAL B** if failure condition classification = Hazardous (HAZ) / Severe Major

**DAL C** if failure condition classification = Major (MAJ)

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## Conclusion

Considerable efforts have been spent in terms of analysis/testing and evaluation of the in-service experience to define and incorporate the results of the Extended Service Goal 2 study into the Maintenance Programme of the A300-600. The incorporation of latest available usage information, together with the review of the Full Scale Fatigue Test, additional tear down, in-service findings were used as inputs for the ESG2 study. Thanks to Airbus continuous involvement to improve its products, our customers

will be able to continue operating their A300B4-600/B4-600R aircraft beyond the first Extended Service Goal, enabling them to take benefit from the additional revenue that can be generated from ESG1 to ESG2. The Structure Task Group (STG) is working as an active forum for ageing aircraft activities. The results of ESG2 analyses and their consequences on the Maintenance Programme will be presented to the operators during the STG meeting which will be held in April 2010.

**AIRBUS**



# Customer Services events

## Just happened

### **Outcome of the A300/A310 Family symposium**

The A300/A310 Family symposium took place in Bangkok mid-November with 30 different airlines, 18 MRO (Maintenance Repair & Overhaul) organizations and suppliers. Altogether, 138 participants were gathered allowing productive and fruitful discussions, either during the main meeting sessions or during networking breaks. The prime goals of the A300/A310 Family symposium were as always, two-way communication leading to an ever more safe and efficient fleet management but also to clearly focus on economic long-term operation. Therefore, the symposium agenda was built on the three main themes being long-term support initiatives, main fleet issues review and services proposed by Airbus to allow aircraft operation at the lowest possible maintenance cost.

Charles CHAMPION (Executive Vice President Airbus Customer Services) awarded five operators for their 2008-2009 Operational Excellence, namely MNG Cargo Airlines for A300B2/B4, Air Transat for A310, Korean Air for A300-600, Air Hong Kong for freighter fleet and finally, a special award was given to Thai Airways as a mark of recognition for their kind hospitality in Bangkok.

Last but not least, the 2009 operator caucus session, co-chaired by Mr. Supanit CHANTARASIRI (Thai Airways Director Engineering) and Mr. Cem AKIN (ULS Airline Cargo, Technical Manager) was run efficiently. After a one-hour discussion, the operators ended up with a clear prioritized roadmap that will be used as a valuable baseline for the coming years.

### **The 6<sup>th</sup> Leasing Support conference**

Airbus 6<sup>th</sup> Leasing Support conference, recently held in Dublin, was a great success gathering 38 leasing companies coming from all over the world, despite the actual difficult

market conditions. Airbus received very positive feedback by the customers and participants. The main outcome from the caucus was concerning the specific needs and requirements from the lessors.

## Coming soon

### **Airbus Corporate Jetliner Forum**

The next Airbus Corporate Jetliner forum will take place in Dubai, United Arab Emirates, from 8 to 10 March 2010. This yearly event is a valuable opportunity for our customers and operators to be updated on the latest developments in Airbus Corporate Jets and to meet and network with each other.

### **The 6<sup>th</sup> Technical Data symposium**

The sixth Technical Data Symposium will be organized from 5 to 8 April 2010 in Bangkok, Thailand. This event will gather persons from airlines, MRO (Maintenance Repair Overhaul) organizations and suppliers.

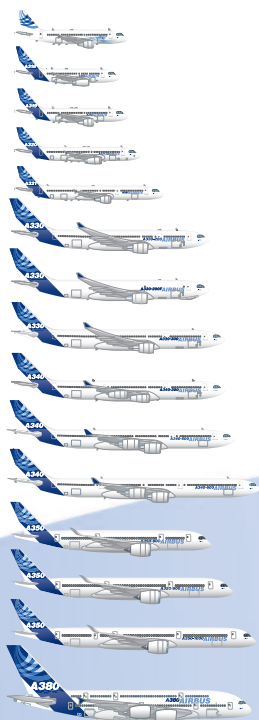
The theme selected will be: "Deliver innovative solutions". Our symposium will encompass presentations such as the Technical Data vision and strategy, products, future changes, innovation, A350 aircraft, as well as product demonstrations and interactive workshops with the customers on specific subjects.

### **A330/A340 Family symposium**

The next A330/A340 Family symposium will be held from 31 May to 3 June 2010 in Berlin, Germany. Airbus will propose a basic agenda in February that may be augmented with your suggestions. As usual, adequate facilities will be available for side meetings and break-out sessions.

Formal invitations will be sent in February.

The prime function of this meeting is to enable two-way communication regarding actual in-service issues affecting A330/A340 Family operations, as well as topics of more general interest (forthcoming regulatory requirements, industry initiatives, maintenance costs, etc.).



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