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FAST

Flight Airworthiness Support Technology

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Flight Airworthiness Support Technology

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Tel: +33 (0)5 61 93 43 88
Fax: +33 (0)5 61 93 47 73
e-mail: fast.magazine@airbus.com

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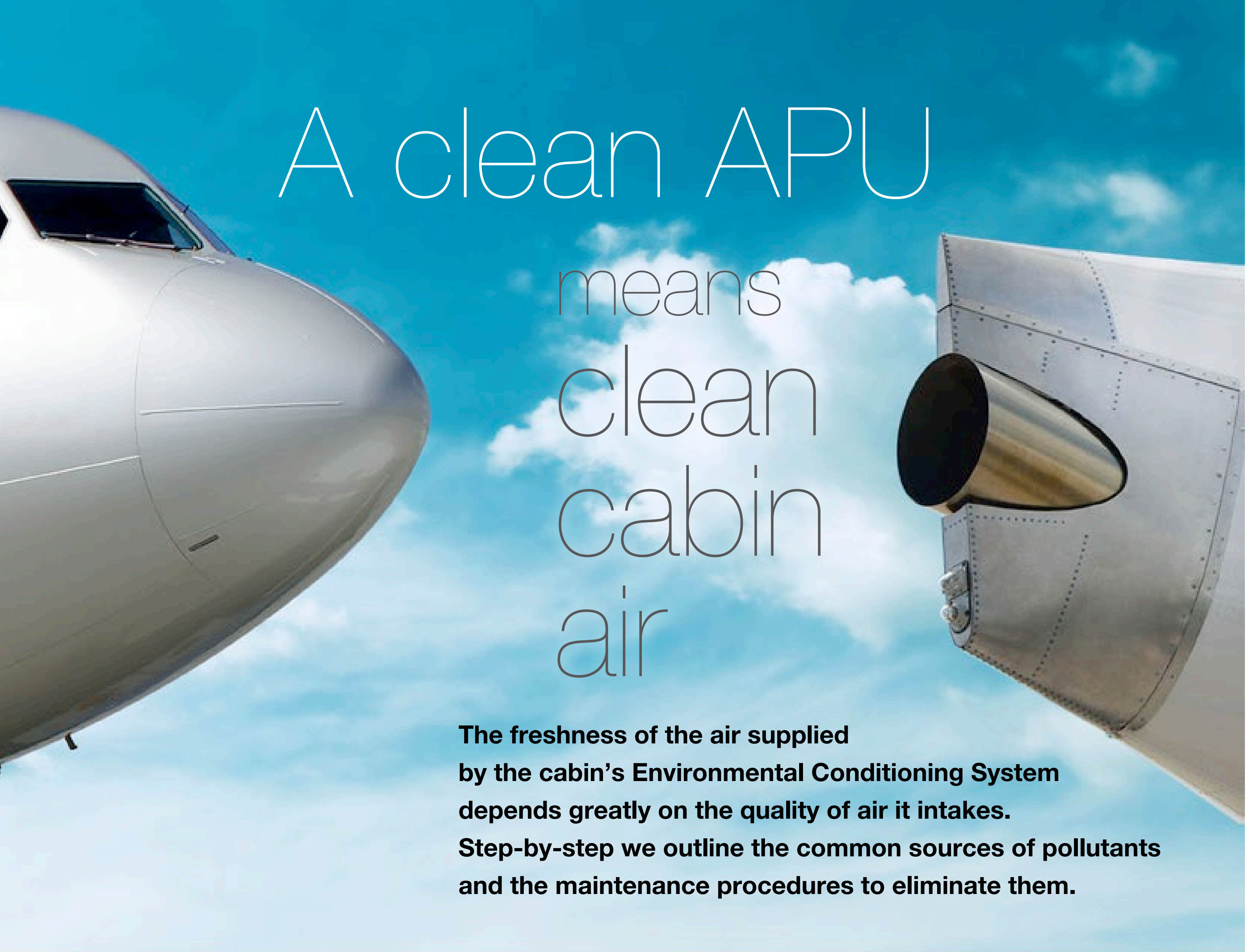
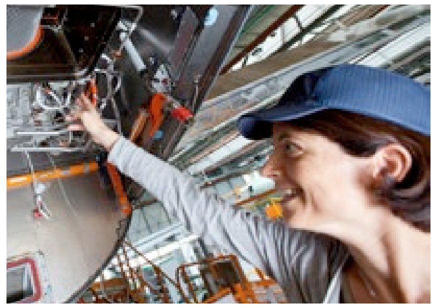


A clean APU means clean cabin air

The freshness of the air supplied by the cabin's Environmental Conditioning System depends greatly on the quality of air it intakes. Step-by-step we outline the common sources of pollutants and the maintenance procedures to eliminate them.

APU maintenance guidelines to avoid smell in cabins



Article by
Laura VERA-BARCELO
Head of APU System
Engineering Support
AIRBUS
laura.vera-barcelo@airbus.com

Air supplied by the Environmental Conditioning System (ECS) can be contaminated by the unavoidable ingestion of environmental pollutants such as industrial pollution as well as engine exhaust pollution from the many vehicles and aircraft operating in the airport environment.

Since the ECS is supplied with air from the Auxiliary Power Unit (APU), engine bleed system or Ground Power Units (GPU), there is also a possibility of contamination from these.

One source of in-service contamination events reported on the A320 Family fleet is the APU. This results from either internal leakage or re-ingestion of oil following external leakage. It is worth noting that a noticeable cabin odour can be generated from ingesting only a very small amount of oil.

This article provides operators with inspection and maintenance recommendations to be followed in case odours of hydraulic and de-icing fluids fuel or oil are experienced in the cabin and the APU is suspected as being the contamination source.

Finding the cause

The first step must be to identify the source of contamination and the path it has followed to reach the aircraft ECS, then to eliminate it.

Once the source has been established and rectified, the task of decontamination should be performed. Failure to eliminate the source of the contamination will lead to repeated occurrences of reporting odour in the cabin, repeated application of the decontamination procedure and a significant duplication of efforts.

Oil smell in the cabin can occur at almost any time as a result of a contaminated ECS. It should be noted that oil smell in the cabin resulting from a contaminated ECS on ground may occur while the APU is not running and can subsequently generate odours in flight.

The most common reports are those of stale odours or oil smells and occasionally visible smoke, or activation of the smoke detection system in conjunction with a 'bleed pack' overheating. From this information alone though, it is not possible to determine whether the APU or the engines contaminated the ECS.

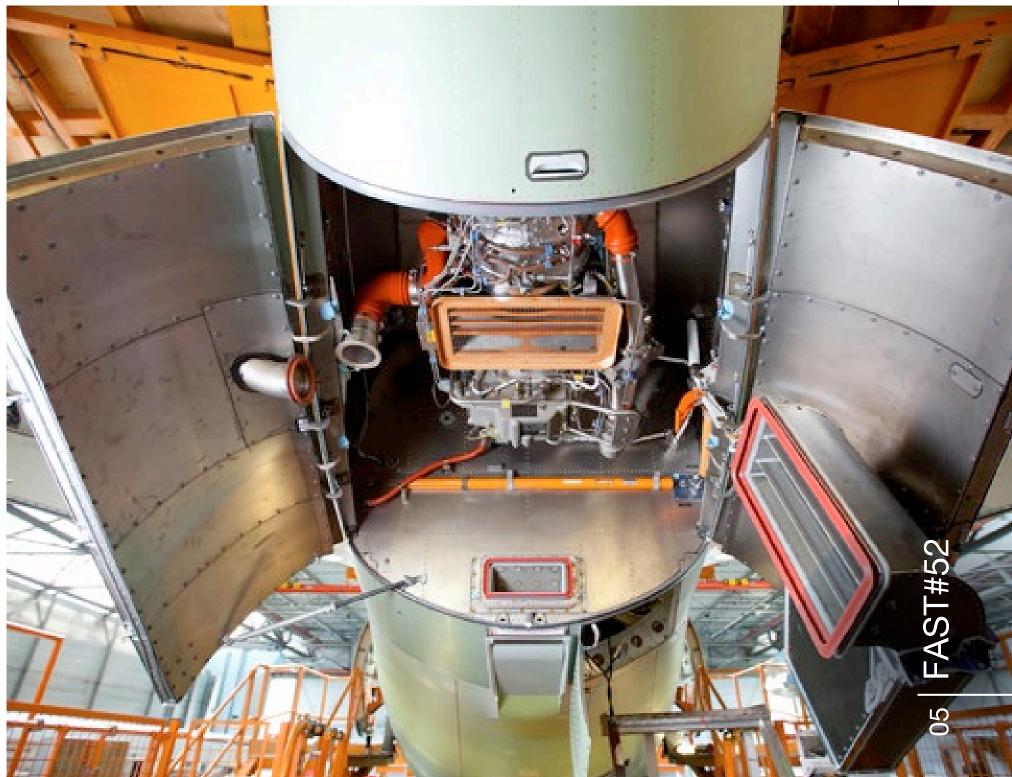
From experience, odours associated with slight APU oil leakage are more often reported shortly after take-off, disappearing in cruise and reoccurring late in the descent. Odours may also be noticeable at the APU start for a few seconds, but quickly disappear.

During the operation of the APU with only a slight leakage, odours may not be detectable. However, the oil will be gradually deposited within the ECS (the packs) in areas of cooler temperatures. Following the engine start-up and transition to engine bleed air, the odours may once again be noticeable due to the higher associated airflow rates and temperatures through the packs.

The odours can disappear after a short time due to changes in the pack configuration (from cooling to heating mode), reoccurring again late during the descent due to the packs returning to the cooling mode.

Operational experience has also shown that intermittent odour reports, as described, can occur after the source of leakage had been identified and rectified. This is due to the residual system contamination and emphasizes the importance of a thorough ECS decontamination.

The APU compartment in the aircraft's tail cone
Photo courtesy of Pratt & Whitney Aeropower



APU contamination source identification and restoration

External fumes ingested by the APU

External fumes present in the vicinity of the APU intake (i.e. exhaust gas fumes from main engines of any aircraft nearby, or ground power units (used during ground operation, etc.) may be ingested, leading to smell in cabin.
The smell will stop when the fumes are no longer ingested.

Under these circumstances, no further inspections will be required on the APU. However, we recommend performing cabin ventilation to eliminate any residual smell before the next revenue flight.

Aircraft external fluid leakages ingested by the APU

It may happen that hydraulic leaks from the main landing gear bay are directed along outside the aircraft fuselage, up to the APU air intake. Hydraulic fluid can then be ingested while the APU is running, causing an ECS contamination and associated smell in the cabin. Under these circumstances, a visual inspection should be carried out on the aircraft fuselage from the nose landing gear up to the APU inlet, and from the vertical stabilizer up to the APU inlet for presence of hydraulic fluid. Also, check for the presence of hydraulic fluid on the APU inlet duct to confirm ingestion by using ultra-violet/black light. Any hydraulic leak identified must be fixed.

There have also been reports of odour in the cabin following an aircraft de-icing process. Following this operation, inspect the external surfaces of APU doors for presence of de-icing fluid and then check if there is any on the APU inlet duct.

Note that when using de-icing fluid on aircraft, the APU bleed system should be selected ‘off’. Additionally, we recommend waiting three to four minutes after an aircraft de-icing is completed before selecting the APU bleed ‘on’ again.

Then clean the contaminated surfaces (APU doors, intake duct air flow path, etc.).

De-icing

De-icing fluid residue

APU external fuel or oil leakages ingested by the APU

External oil or fuel leakage from the APU may be re-ingested if the APU inlet seal or APU doors’ seal is degraded, or the air intake diffuser is misaligned. Additionally, misalignment of APU drain mast and bellows’ seals fitted on the right-hand APU compartment door may not allow fluids to be properly drained outside the APU compartment.

If an APU external fluid leakage re-ingestion by the APU is suspected, inspect the APU compartment and the APU external surfaces to identify the source of the leakage by using ultra-violet/black light.

While inspecting the APU external surfaces, we advise to check fuel and oil tubes and fittings, inspect around the APU oil pump, oil cooler, fuel pump and actuators driven by the fuel as the Inlet Guide Vane Actuator (IGVA), Starter Control Valve (SCV) and Bleed Valve (BV).

Inspect around the oil temperature, oil level and oil chip detectors, and the pressure sensors.

Inspect around the circumference of the APU generator to the gearbox mount, around the APU starter motor flange, and around the load compressor housing to the gearbox split-line.

Check the alignment of the drain tube bellows on the door with the drain tubes on the bottom of the APU by closing the right-hand APU door and checking from the open left door. If they are not aligned, adjust the spring adapter assembly on the door.

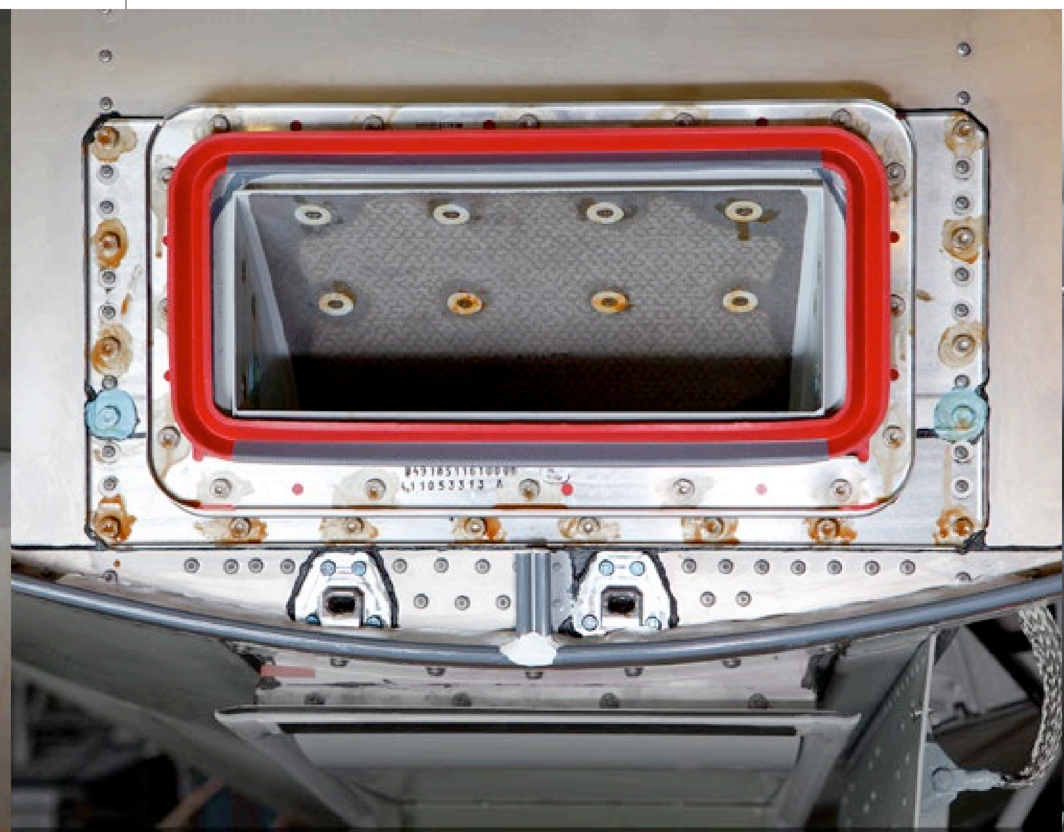
If evidence of contaminants is found, identify the contaminants’ path which led to the APU pneumatic system. Inspect the APU intake duct, APU intake plenum and bleed duct inner walls for the presence of contaminants.

Eliminate the source of contaminants as per Aircraft Maintenance Manual (AMM) instructions and if ingestion is confirmed, inspect the condition of the APU doors’ sealing, intake duct sealing, alignment between the APU intake duct and APU inlet plenum, oil cooler discharge duct and restore them if required.

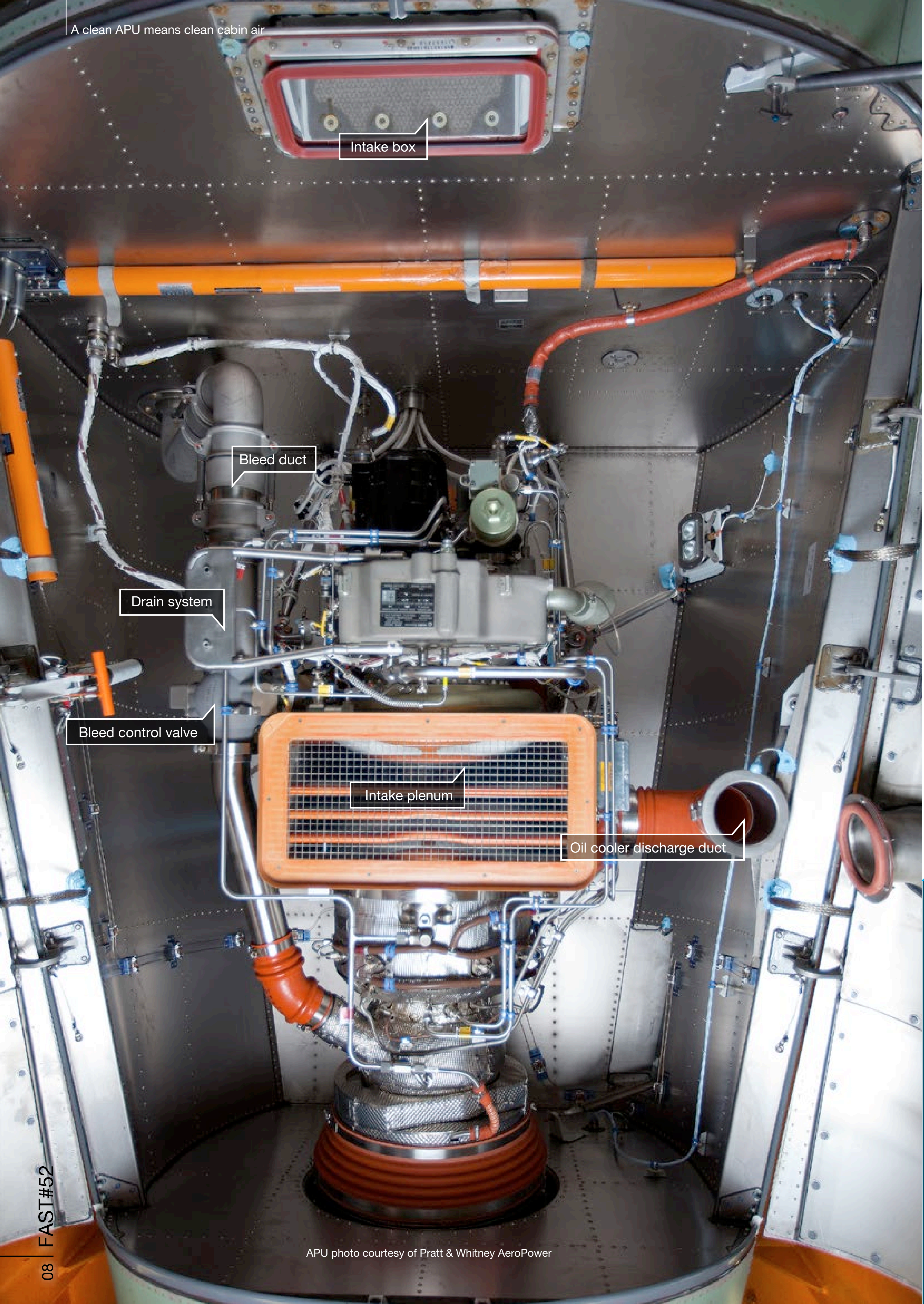
Failure to do so will lead to repeated occurrences of reporting odour in the cabin, whenever an APU external fluid leakage occurs.

APU oil cooler outlet duct

APU intake box

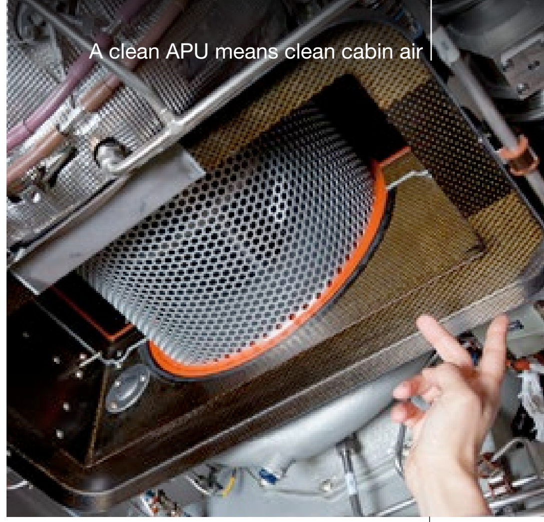


APU intake system



APU photo courtesy of Pratt & Whitney AeroPower

A clean APU means clean cabin air



APU photo courtesy of Honeywell

APU internal oil leakages

If oil ingestion is suspected and no external leak is evident, inspect the bleed duct downstream of the APU bleed valve with ultra violet/ black light for oil contamination. If there is evidence of oil, there is the possibility of an internal APU oil leakage or ingested oil.

Check the APU load compressor witness drain for the presence of oil. The load compressor sealing system breaking down would result in oil being present at the seal cavity witness drain.

Inspect the inside of the cooling fan ducts for evidence of oil. If oil is present and the inside of the plenum is clean, further inspection of the oil cooler and cooling fan is required as there might be a cooling fan/oil cooler internal oil leak.

Check the APU oil level for presence of over-servicing. Note that prior to inspecting the oil level, it should be confirmed that a complete de-oiling during normal APU shutdown has been performed. This can be done by checking that the APU air intake flap is fully closed. If the shutdown circumstances are unknown, operate the APU at 'no-load' for five minutes, followed by a normal shut down.
For a complete APU de-oil, wait at least 15 minutes after the last APU shutdown prior to checking and eventually completing the oil level.

Eliminate the source of contaminants as per AMM instructions.
Note that it may require an APU removal depending on the source identified.

APU compartment, APU intake system and ECS cleaning

Once the inspections have been carried out, the contaminant source has been eliminated and the APU compartment/duct sealing condition has been restored, the next step will be to clean the contaminated APU compartment, APU intake system, APU inlet plenum and APU Load Compressor as per AMM instructions.

Afterwards, decontaminate the aircraft pneumatic system as per AMM 21-00-00 and SIL 21-029. Failure to do so will lead to ineffective or only partial decontamination and therefore, the risk of future reports of odours in the cabin.

CONCLUSION

Correct maintenance of the Auxiliary Power Unit (APU) helps avoid odour in the cabin. The AMM (Aircraft Maintenance Manual) and TSM (Trouble-Shooting Manual) details the actions which should be performed to identify, fix and clean any fluid leakage around the APU. Failure to resolve the cause could lead to future reports of odour in cabin.

Aircraft Maintenance Manual (AMM) task references

- AMM 49-00-00-790-001-A Check APU compartment and air intake duct for oil contamination (GTCP36-300)
- AMM 49-00-00-790-007-A Check APU compartment and air intake duct for oil contamination (APS3200)
- AMM 49-00-00-790-008-A Check APU compartment and air intake duct for oil contamination (131-9A)

Trouble-Shooting Manual (TSM) task references

- TSM 49-00-00-810-846-A Fumes in the cabin (GTCP36-300)
- TSM 49-00-00-810-921-A Fumes in the cabin (APS3200)
- TSM 49-00-81-810-874-A Fumes in the cabin (131-9A)

Electrical hoist kit

to ease engine mounting

With their tons of costly and sophisticated technology, engines need to be moved with the utmost care. Airbus has tailor-made an electrical hoist kit to precisely control load and ease positioning, while improving safety for maintenance staff and the aircraft.

Article by

Mathieu NOEL
GSE & Tool Design Engineer, AIRBUS
mathieu.noel@airbus.com

Eric RIVIERE
GSE Designer, AIRBUS
eric.e.riviere@airbus.com

The choices for lifting engines

If maintenance tasks require the removal of an engine, there are currently three types of equipment available, each with their advantages and disadvantages:

Bootstrap system

Traditionally a system of four manual hoists that lift the engine (or its cradle) off a trolley.

Advantages:
- Accurate and quick engine positioning
- Appropriate to line maintenance
- Inexpensive

Disadvantages:
- Longer installation
- Risk of injury due to a hard physical work
- Slower task for heavy engines (due to manual hoists)

Mobile overhead crane

Lifting the engine and its cradle.

Advantages:
- Quick task
- Good load control
- Man-hour savings compared to bootstrap

Disadvantages:
- Engine cowls, fan and thrust reverser must be removed
- Heavy maintenance means (10 tonnes minimum capacity)
- Not appropriate for line maintenance

Hydraulic or pneumatic engine positioner

Hydraulic or pneumatic lift system on a trolley.

Advantages:
- Good load control
- Man-hour savings compared to bootstrap
- Quick task

Disadvantages:
- Complicated to use by mechanics
- Longer engine alignment
- Not appropriate for line maintenance
- Very expensive (almost no realistic return on investment)

The structure from which the electrical hoists are suspended, is positioned on top of the pylon.

The electrical hoist kit comprises:
- Ground power supply
- Central control unit
- Two rear electrical hoists
- Two front electric hoists
- Two remote control devices

Three operators are required; one at the central control unit and two positioned laterally with remote control devices

Electrical hoist kit

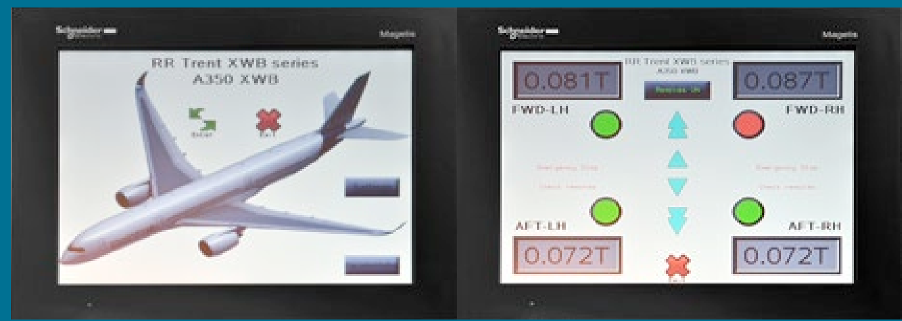
Airbus' electrical hoist kit for a faster and safer engine change

Of the three systems currently used to position engines, the most versatile system for line-maintenance is the bootstrap. The electrical hoist kit replaces the manual hoists used on the bootstrap, adding significant advantages including speed, better load control and man-hour savings.

The system is just as flexible as traditional manual bootstraps, with the electrical hoists cabled to a mobile power unit located in the control box.

One of the clear advantages is that rather than using up to eight engineers, safe engine manoeuvring may be performed by only three; one on the control box at the front of the engine, and one to each side.
The electrical hoists are based on the same principles as the manual ones, so the new kit does not require any additional specific training.

The main operator uses a touch screen to enter the type of aircraft and engine to be installed. The control box is already pre-programmed with precise loads and characteristics for the entire Airbus fleet.

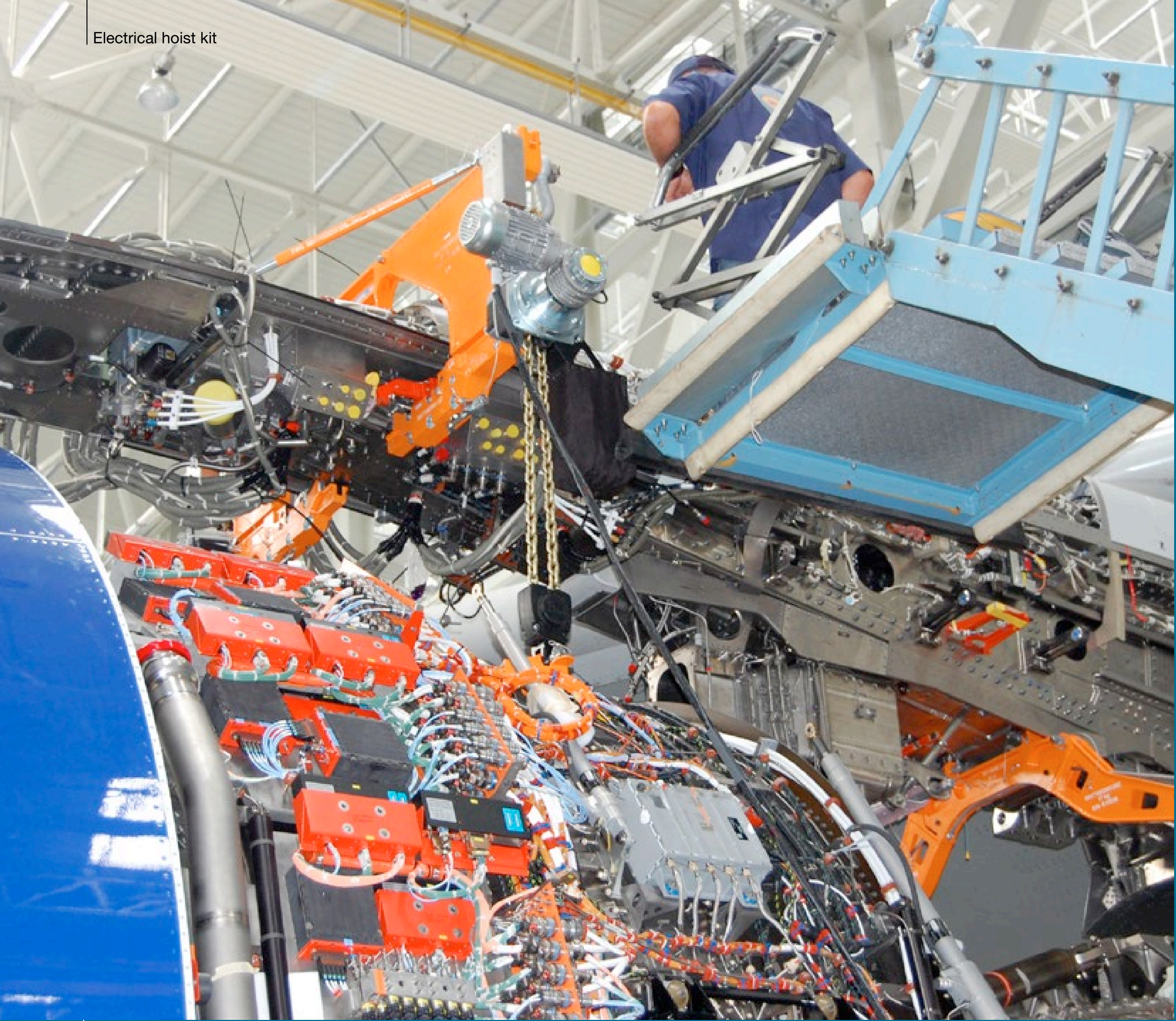


With the hoists securely attached to the engine hooks, the wireless electrical hoists takes up the slack and lift the load of the engine.

The electrical hoists have integrated dynamometers to ensure a correct load distribution. Should overload or imbalance of the engine occur during the lifting phase, an automated audible warning signal is triggered.

The warning signal also stops the lifting or lowering manoeuvre of the engine (the green button turns red) allowing the operator to verify the loads and then to slowly compensate.
This automated supervision keeps the engine's centre of gravity steady, preventing the engine from tipping over.
When balanced again the manoeuvre can resume, either at high or low speed depending on the engine's distance from the pylon (i.e.: the closer the engine is to the pylon, the slower the operation needs to be).

The hoists can be controlled either from the central control box or from either side via the hand-held remote control devices of the two other mechanics.
The hand-held devices are particularly useful for the final approaching phase, incrementally easing the engine into position.



A mechanic is at each side of the engine with a wireless control device, perfectly positioned for the final approach phase

Positioning in two phases

The engine installation procedure with the bootstrap system can be split into two main actions: the **lifting phase** and the **approaching phase**.

The lifting phase is the operation of lifting the engine from the ground to the pylon. This phase stops when the pylon shear pins start to enter the engine mounts.

The approaching phase engages the pylon shear pins in the engine mounts guiding the engine mount into contact with the pylon. This final stage is particularly delicate with mechanics closely monitoring loads on each hoist to ensure the bootstrap is not overloaded.

Torquing correctly

To ensure a proper engine torque phase and apply a safe torque value in the engine bolts, the operator has to ensure a perfect fit between the engine mounts and the pylon bolts (with no gap).
For doing this, when the final approach phase is completed, the operators apply a preload on each mount of approximately 400kgs. Then the operators are sure to torque the mounts at the proper value, and not share the torque value between the bolts and the mounts.

Airbus' electrical hoist kit added benefits

Health and safety

- Less physical exertion for the mechanics
- Perfect load control
- A warning system informs the operator when the load limit has been reached
- Supervision system prevents any risk of overloading
- Less noise generation (day/night operation)
- Easier engine installation thanks to homogeneous lifting and compact system

Time

- Around 30% less time needed for the removal or installation of outboard engines
- Less man-hours

Use

- Lower maintenance costs
- Optimize aircraft availability
- Easier handling - touch screen display and wireless remote control
- Easier storage
- Wireless remote control devices
- Mixed fleet usage
- Electrical hoist kit adapted to all bootstrap systems

CONCLUSION

Airbus' new electrical hoist kit allows bootstrap system operators to manoeuvre engines in a safe and more efficient manner.

Engine characteristics for all of Airbus' aircraft are pre-programmed, and can be easily selected on the central control unit's touch screen. The engines are lifted in perfect balance to the pylon, then two operators positioned laterally with hand-held devices smoothly position the engine in the final approach to the pylon.

Maintenance costs are greatly reduced as not only does it require three operators instead of eight, but the time needed to remove or install an engine is also reduced by 30%.

For further information please contact Maint.gsetools@airbus.com

Fleet performance online toolbox

The top priorities for any airline are to keep its aircraft flying safely, ensuring that they are well maintained while optimizing operational costs.

These daily challenges mean that there may not always be enough time to step back and consider change:
- How are we doing compared to others?
- What opportunities for improvement do we have?
- What would give us the best return on any investment?

From the technical performance perspective, Airbus provides* free-of-charge, an online virtual box of tools to help airlines find solutions to their fleet performance questions.

Article by
Olaf SCHOLZ
Head of Fleet Performance
AIRBUS
olaf.scholz@airbus.com

* Via secured access on www.airbusworld.com

In-service Data On-Line Services (IDOLS)

Confidentiality and data sharing

In order to ensure data privacy, a unique system of three confidentiality circles are available, providing access to different levels of information:

- Blue circle (sharing of basic information to all users)
- Silver circle (sharing of detailed information in a restricted circle)
- Gold circle (sharing of detailed information between all gold members)

IDOLS for Reliability

This tool enables its users to quickly identify reliability issues and creates a clear status of your fleet performance versus the global Airbus fleet. Using the ATA drill-down feature, you are able to quickly identify your priorities in fleet reliability. Directly from the reports, you can display the event causes (maintenance, flight operation, spares, etc.), the maintenance action codes and the details of each event.

IDOLS for Maintenance Costs

The benchmarks in IDOLS for Maintenance Costs are based on an annual data collection of maintenance costs. This tool allows the airlines to consolidate their maintenance cost data in order to make meaningful comparisons with other Airbus operators, and to identify trends and opportunities for improvement within the operational and economic performance of their fleet.

IDOLS for Maintenance Costs also includes useful features such as fleet ageing and utilization adjustment, viewed in clear graphic diagrams.

IDOLS for Components

This third IDOLS module shows you much more by focusing on the specific reliability of component performance and uses component removal data provided by Airbus' operators. With this tool, it is possible to:
- Monitor component Mean Time Between Unscheduled Removals (MTBUR)
- Compare an operators fleet against Airbus' benchmarks
- Identify priority components for improvement

Once you have entered and compared your data with Airbus' benchmarks, and areas for improvement have been identified, your next step in the fleet performance management process is to analyse the issue and find its solution. In addition to our IDOLS suite, we offer additional tools which focus on identifying the most practical solution.

World In-Service Experience WISE

The WISE online tool helps you analyse the specifics of issues impacting your fleet and identify existing solutions.
WISE is a family of services which bring together pieces of knowledge capitalized and analysed by Airbus from in-service events, operators and suppliers' experience.

The two axis which form the WISE family are:

- **WISE Knowledge base**
  providing information for frequently asked technical questions.

- **WISE Main Adopted Solutions and Tips (MAST)**
  promoting effective and viable modifications and maintenance advice based on in-service experience.

With WISE, it is possible to access:

- Up-to-date technical information
- Highlights on best practices and efficient recommendations
- Means to improve aircraft reliability while reducing operational and maintenance costs

MOD Assessment tool

By using your provided data, the MOD Assessment tool is able to generate business cases reports for the implementation of the appropriate maintenance action or modification. The MOD Assessment tool helps operators evaluate and compare the cost of ownership of a given in-service issue and the cost impact of the modification, acting as a bridge between the technical aspect of an aircraft modification and the finances.

Using daily business figures (number of delays, cancellations, number of removals, spare parts' prices, etc.), the operator is able to quantify the economic impact of a given modification (payback period, net present value, etc.), accompanied by a visual view of the results.

Fully customisable, this tool will provide you results tailored to your airline and will help you identify whether the modification will generate value for you, or not.
In a few minutes, engineers can calculate the return on investment of a given aircraft modification, improving the decision making process by adding an economic rational.

The IDOLS benchmarking tools can identify how the airline is performing compared with the rest of Airbus' fleet, and even with specific operators.

The rich IDOLS environment allows airlines to measure its aircraft performance at every level; from the whole aircraft and its systems, right down to components. Having identified areas for potential improvement, the airline can check the ever growing WISE-MAST database for initiatives that may deliver cost effective performance improvements. These initiatives can then be assessed for suitability in the airline's context using the MOD Assessment Tool.

Together, these free-of-charge tools represent a valuable resource for airlines wishing to optimize the technical performance of their fleet with minimum investment.

Airbus online tools are complemented by

FAIR forums and working groups

The FAIR process allows Airbus to identify the most significant in-service issues and address them efficiently.

The FAIR forums, In-Service Problems (ISP), Ops (Operations) and e-Solutions allow airlines to raise specific issues, share their experiences and identify existing solutions while contributing to the issue prioritisation process.

FAIR working groups allow more generic issues to be assessed and addressed in a pragmatic way through the creation of networks of specialists from airlines and associated suppliers.

In order to better understand these tools and optimise your tool utilisation, we offer WebEx sessions as well as the opportunity to attend a Fleet Performance users club each year. The focus of this event is for you to understand how to get the most from the different Fleet Performance tools, to exchange best practices.

CONCLUSION

Airbus' fleet performance online tools help the airlines optimize their fleet reliability, maintenance and operational costs.
These free-of-charge tools are accessible via AirbusWorld and airlines can compare their performance with Airbus' entire fleet, or even with a specific airline, providing that they have signed the confidentiality and data sharing agreement.

Flying the TCAS trajectory
with AP (Auto-Pilot) or FD (Flight Director)

Retrofit solutions for AP/FD TCAS

Christine VIGIER
Surveillance Design Manager
Upgrade Services
AIRBUS
christine.vigier@airbus.com

Yves MARTIN
Navigation Design Manager
Upgrade Services
AIRBUS
yves.y.martin@airbus.com

One of the most significant advances in terms of flight safety in the 1990s came with the Traffic alert & Collision Avoidance System (TCAS).

As a further enhancement, Airbus now proposes a new function associated with the TCAS which allows the pilot to fly the collision avoidance trajectories, either in an Auto-Pilot (AP) or Flight Director (FD) mode.

Already standard on newly delivered A380s and basic on the A350 XWB, Airbus has been working with its suppliers to encourage operators to upgrade their existing fleets of all ages with packaged solutions.

Currently, when TCAS considers that an aircraft is in a position of potential threat of collision, it emits two types of advisories:

- The **Traffic Advisory** (TA) is the first level of alert, giving information via an aural message, but no action is expected from the pilots.
- The **Resolution Advisory** (RA) is the secondary alert level, demanding an action from the pilots. An aural message indicates the procedure for a vertical avoidance manoeuvre to the pilot (climb, descend, maintain, adjust, monitor, etc.).

An in-depth analysis of the needs expressed by pilots has shown that this unusual situation can increase the level of stress for the flight crew, and can occasionally lead to the pilot's over reaction, leading to undue aircraft deviation.

AP/FD TCAS may be considered as an additional feature of the existing TCAS which provides an enhancement of the current system by assisting the pilot to fly the TCAS trajectory more consistently, either with or without Auto-Pilot thus optimizing the avoidance trajectory (read FAST 45, page 10).

When the Auto-Pilot is "on", the manoeuvre is performed automatically.
When the Auto-Pilot is "off", the avoidance manoeuvre to perform is provided to the pilot through the usual Flight Director (FD) pitch bar guidance.

AP/FD TCAS benefits

The AP/FD function is now proposed as an option on the A320 Family and the A330/A340 Family.

- **Operational benefits**
  - Immediate and accurate response to TCAS alerts
  - Moderate load factor during the avoidance manoeuver
  - TCAS RA manoeuvres easily flown using standard AP/FD flight techniques
  - Reduced pilot workload and stress due to TCAS alert
  - Consistent with Airbus cockpit philosophy
  - Simple procedure
  - Simple training

- **Significant safety benefits**
  - Risk of collision divided by two for fitted aircraft

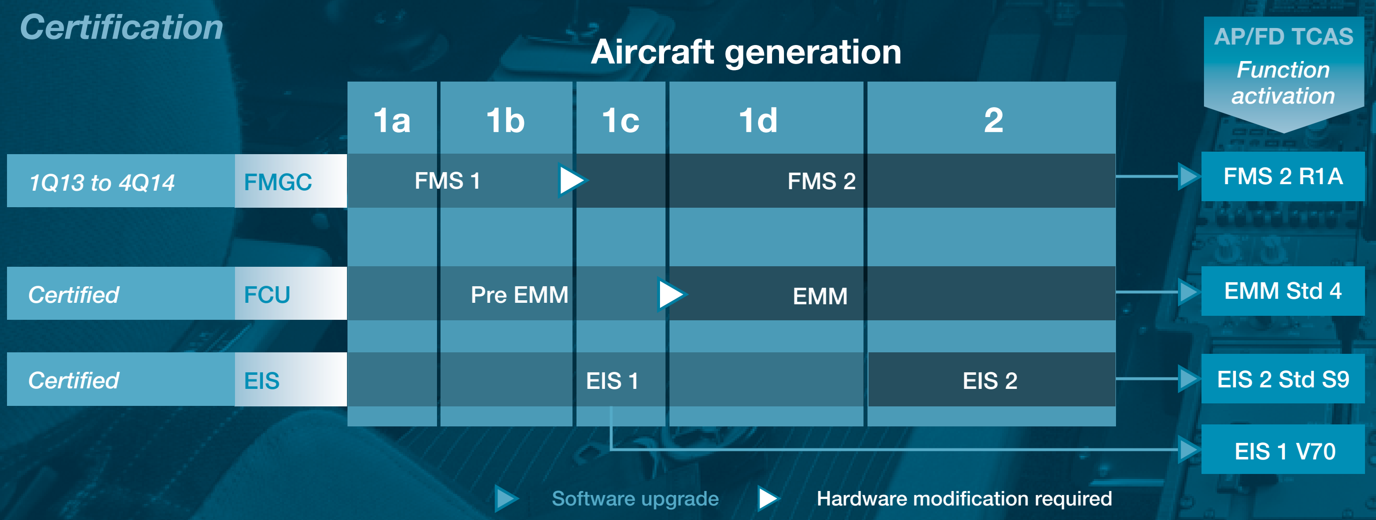
Upgrading to AP/FD TCAS

In order to activate AP/FD TCAS, some pre-requisites have to be installed, particularly for three avionics systems: Flight Management Guidance Computer (FMGC), Flight Control Unit (FCU) and Electronic Instrument System (EIS). A specific commercial package is proposed for each aircraft generation – 1a being the oldest and 3 the youngest.

The charts underneath help determine which retrofit corresponds with a given generation of aircraft.

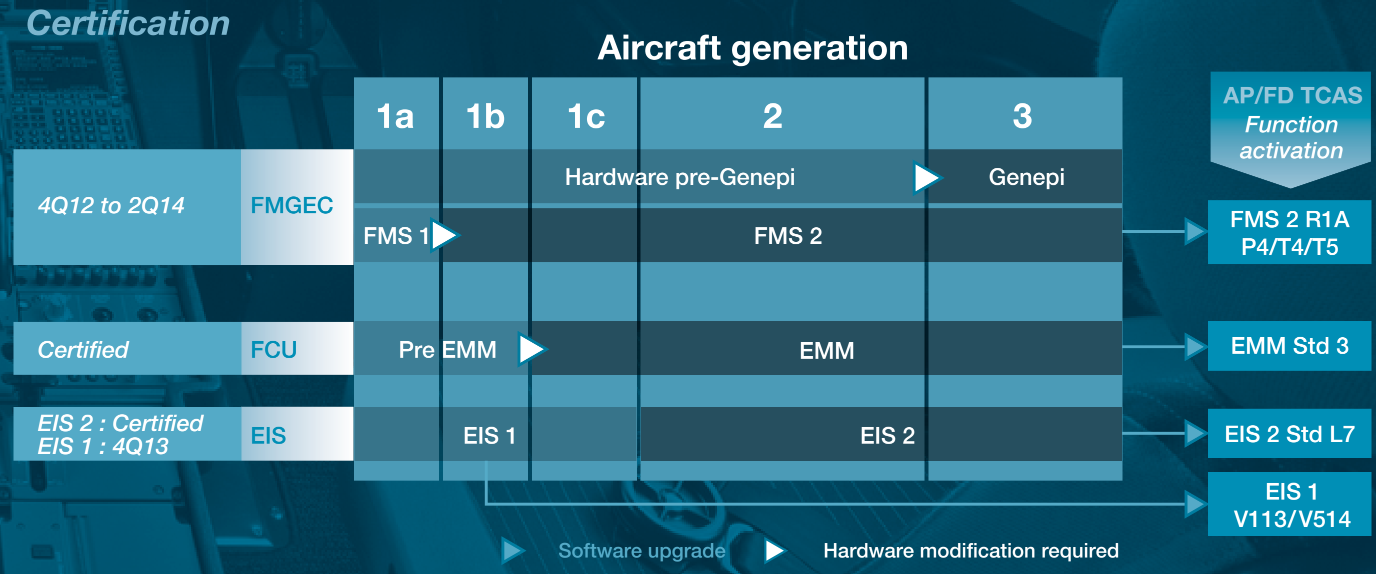
A320 Family:

For AP/FD TCAS activation, the requirements are: FMS2 R1A for FMGC and EMM at standard 4 for FCU. There are two solutions for EIS: EIS1 V70 (with Cathode Ray Tube technology) or EIS 2 standard S9 (with Liquid Crystal Display technology) – benefits being higher for the second solution.



A330/A340 Family:

For AP/FD TCAS activation, the requirements are: FMS2 R1A for FMGEC and EMM at standard 3 for FCU. There are two solutions for EIS: EIS 1 V113/V514 (with Cathode Ray Tube technology) or EIS 2 standard L7 (with Liquid Crystal Display technology) – benefits being higher for the second solution.



GLOSSARY

AP/FD - Auto-Pilot/Flight Director
EIS - Electronic Information System
EMM - Enhanced Maintainability and Manufacturing
FCU - Flight Control Unit
FMGEC - Flight Management Guidance flight Envelope Computer
FMGC - Flight Management Guidance Computer
FMS - Flight Management System
Genepi - new hardware generation for flight guidance
Std - Standard

	1a	1b	1c	1d	2
For FMGC	From FMS 1 std B398, a hardware/software modification is required to install FMS 2 R1A.	From FMS 1 std B546, a hardware/software modification is required to install FMS 2 R1A.	A software upgrade is performed to go to FMS 2 R1A.	A software upgrade is performed to go to FMS 2 R1A.	A software upgrade is performed to go to FMS 2 R1A.
For FCU	A hardware/software modification is required to go to EMM Std 4.	A hardware/software modification is required to go to EMM Std 4.	A hardware/software modification is required to go to EMM Std 4.	A software upgrade is performed to go to Standard 4.	A software upgrade is performed to go to Standard 4.
For EIS	A software upgrade is performed to go from EIS 1 to EIS 1 V70	A software upgrade is performed to go from EIS 1 to EIS 1 V70	A software upgrade is performed to go from EIS 1 to EIS 1 V70	A software upgrade is performed to go from EIS 1 to EIS 1 V70	A software upgrade is performed to go to the Standard S9.

	1a	1b	1c	2	3
For FMGEC	Two hardware/software modifications are performed to install Genepi and FMS 2 R1A.	A hardware/software modification is performed to install Genep.	A hardware/software modification is performed to install Genepi.	A hardware/software modification is performed to install Genepi.	A software upgrade is performed to install FMS 2 R1A.
For FCU	A hardware/software modification is required to go to EMM Std 3.	A hardware/software modification is required to go to EMM Std 3.	A software upgrade is performed to go to Standard 3.	A software upgrade is performed to go to Standard 3.	A software upgrade is performed to go to Standard 3.
For EIS	A software upgrade is performed to go from EIS 1 to EIS 1 V113/V514	A software upgrade is performed to go from EIS 1 to EIS 1 V113/V514	A software upgrade is performed to go from EIS 1 to EIS 1 V113/V514	A software upgrade is performed to go to Standard L7.	A software upgrade is performed to go to Standard L7.

Note : for some software modifications a shop visit may be necessary dependent on the existing standard.

Pre-requisites for retrofit

There are a number of pre-requisites required before the activation of AP/FD TCAS.
Recognising the importance of fleet harmonisation, Airbus has worked with its suppliers to offer an attractive packaged solution with the objective of enhancing the standards of the entire Airbus fleet, no matter in which aircraft configuration.

Avionics systems	A320 Family	A330/A340 Family
EIS Primary Flight Display *Electronic Instrument System*	**EIS 1 V70** *or* **EIS 2 S9 (minimum)**	**EIS 1 V514 (A330)** *or* **EIS 1 V113 (A340)** *or* **EIS 2 L7**
FMGC / FMGEC *Flight Management and Guidance Computer* / *Flight Management Guidance and Envelope Computer*	**S6C13** *or* **S6I12** **H2C13** *or* **H2I12**	**T4HJ1** *or* **P4HJ1 (A330 - PW/RR)** **T5GIA** *or* **P4GIA (A330 - GE)** **T5F1** *or* **P4F1 (A340 - CFM)** **T5K2** *or* **P4K2 (A340/500-600 - RR)**
FCU *Flight Control Unit*	**Standard 4**	**Standard 3**
FWC *Flight Warning Computer*	**H2F5 (minimum)**	**L12** *or* **13**
TCAS *Traffic alert & Collision Avoidance System*	**TCAS 7.0 (minimum)**	**TCAS 7.0 (minimum)**

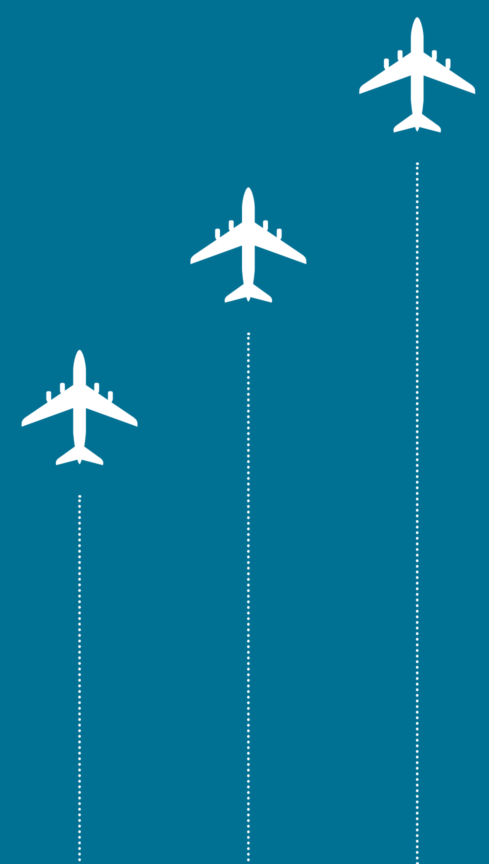
Additional benefits associated with the pre-requisites

Installing AP/FD TCAS will provide the pre-requisites to install state-of-the-art functions in your in-service aircraft, such as:

- **ADS-B out RAD** (Automatic Dependent Surveillance - Broadcast out Radar) for non-radar and radar airspace which will be mandated in Europe and North America by 2017
- **ROPS** (Runway Overrun Prevention System)
- **RNP-AR** (Required Navigation Performance - Authorisation Required)
- **BUSS** (Back Up Speed Scale)

The pre-requisites for AP/FD TCAS are also pre-requisites for additional functions such as the examples below:

Avionics system	ADS B out RAD	ROPS	RNP AR	BUSS
FMS2 R1A	✓	✓	✓	
EIS upgrade		✓	✓	✓
FWC	✓	✓		✓



AP/FD TCAS retrofit solution

To ease the retrofit solution on older aircraft, the AP/FD TCAS upgrade is offered as a package, including the pre-requisite avionics' equipment to allow a full fleet harmonization.

The harmonization will be from FMGC/FMGEC (Flight Management and Guidance Computer/Flight Management Guidance and Envelope Computer) and FCU (Flight Control Unit) levels, to the latest certified standards.

The packaged AP/FD TCAS installation provides:

- The foundation for upcoming regulatory requirements and functions associated with air traffic management's evolutions, as developed in programmes such as SESAR (Single European Sky Air Traffic Management Research) and NEXTGEN (Next Generation Air Transportation System), or through other initiatives around the world.
- Deployment of upcoming operational enhancements such as ROPS (Runway Overrun Prevention System) and TCAP (TCAS Alert Prevention) reducing level-off RA occurrences.

Practical impacts of TCAS retrofits

Provided that the pre-requisites are already embodied, the modification consists of:

- Wiring provisions' installation
- Activation by pin programming

The average time for the installation of this retrofit is approximately one day (two shifts).

CONCLUSION

The AP/FD TCAS solution has already proven its efficiency on Airbus' latest aircraft and it will be offered as standard on the A350 XWB. Currently, more than 95% of A380s in service are equipped with this system.

Recognising the need for fleet harmonisation and the broad appeal of the AP/FD TCAS solution, Airbus has designed an attractive commercial package solution which can encompass the full in-service Airbus fleet. The package includes pre-requisite upgrades of avionics' equipment and provides the foundation for other upcoming operational enhancements.

Airbus aims to support each airline on a customised basis and will pro-actively approach customers to discuss this innovative new offering.

The retrofit package is available as of now for most configurations and will be customized for your specific fleet.

Stopping the drops

Repairing wing fuel tank access panels on A330/A340

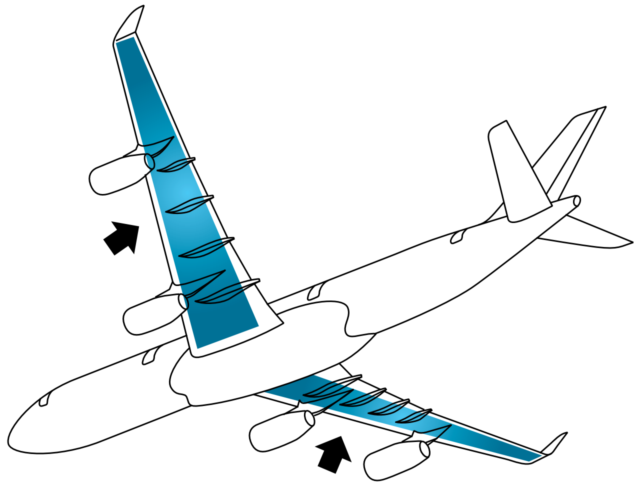
Nicolas RIBIERE
Pylon/Wing
Structure engineer
AIRBUS
nicolas.ribiere
@airbus.com

Claude HEMADOU
Pylon/Wing
Structure engineer
AIRBUS
claude.hemadou
@airbus.com

Fuel leakage of any kind is not an issue to be taken lightly. It is one of the systematic checks performed during the walk-around inspection before every flight.
The most frequent area that fuel leaks occur is from the fuel tank access panels situated under the wing, and experience has shown that with the A330/A340, leakage will be from the panels between rib 1 and 27.

If a slight leak is left unchecked it will, eventually, become running leakage, grounding the aircraft until the problem has been resolved.

Airbus has made comprehensive improvements to these panels, their seals and the way they are installed.



Any fuel leakage from the under wing access panels requires immediate attention.
(AMM 28-11-00-280-803 paragraph 3B)

The tell-tale streaks of leakage around fuel tank access panels

Example of seal fatigue

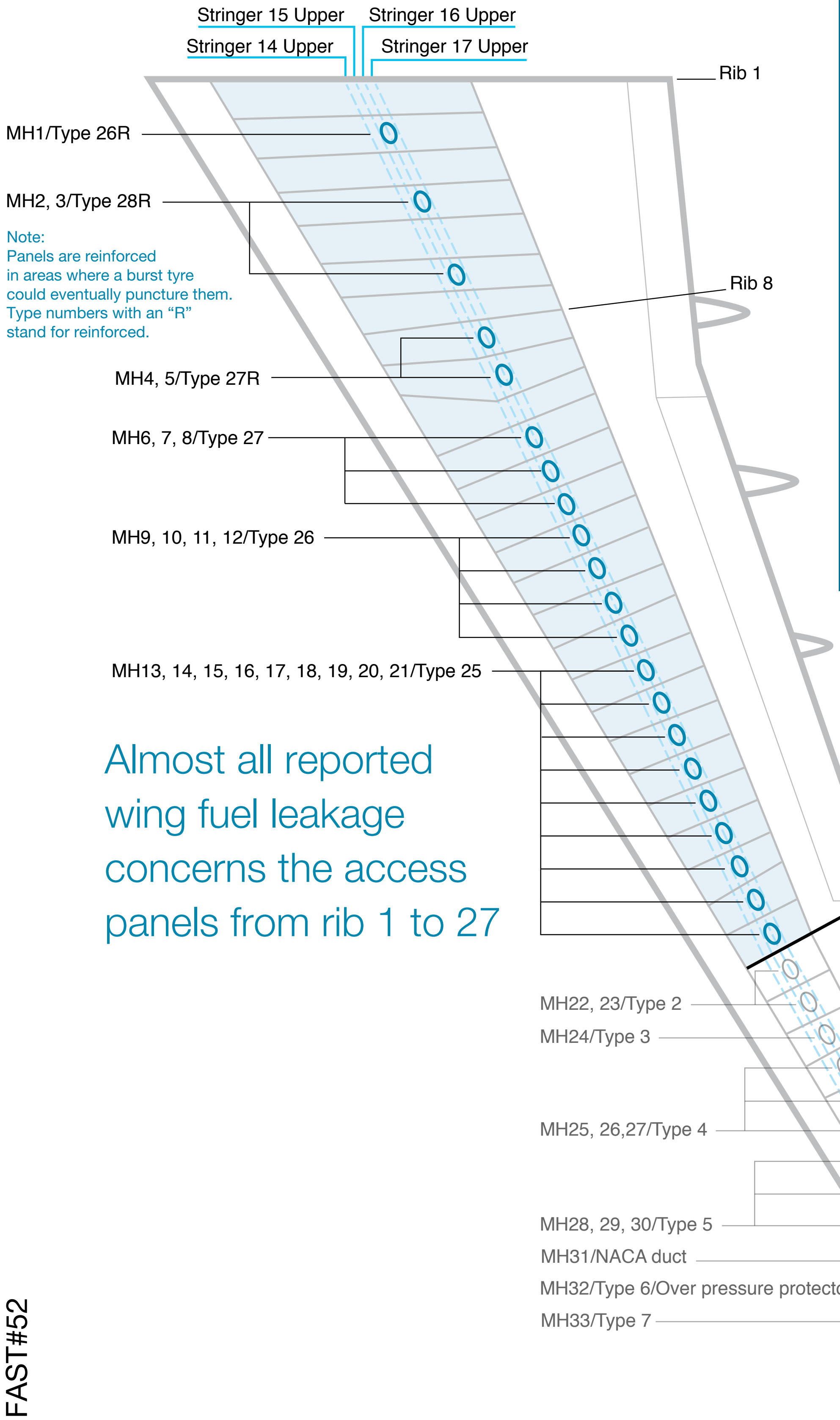
Most of the time leakage around fuel tank access panels is due to a damaged seal.

Seal replacement requires emptying the fuel tank and completely removing the panel as described in AMM 57-27-11.

Several documents, TFUs (Technical Follow-Up) and a WISE (World In-Service Experience) solution have been published to provide maintenance rules to be applied.

Under wing tank access panels on A330/A340 aircraft
(skeleton view from top)

The A330/A340 Family aircraft wing is divided in two fuel tanks areas which are equipped with different types of panels:
- The inner wing tank (from rib 1 to 27) is equipped with non-loaded access panels,
- The outer wing tank (from rib 27 to 39) is equipped with loaded access panels.



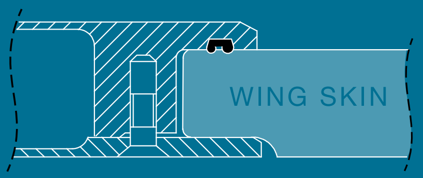
Almost all reported wing fuel leakage concerns the access panels from rib 1 to 27

Inner Tank
Non-loaded access panels between ribs 1 to 27

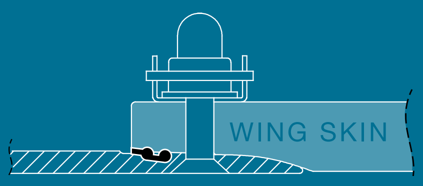
Outer Tank
Loaded access panels between ribs 27 to 39

The difference between loaded and non-loaded access panels

On the inner wing (between rib 1 and 27) where the wing skin is thicker, the access panels do not need to contribute to the stiffness of the structure. Panels are in two parts that clamp around the wing skin and are referred to as non-loaded.



On the outer wing (between rib 27 and 39) where the wing skin is thinner the access panels need to contribute to the structure's stiffness.
These one-part panels are fastened directly into the wing skin and are referred to as loaded panels.



Improved access panel design

Before the modification 47583 (prior to MSN 370), the fuel tank accesses from rib 1 to 27 were fitted as standard with Super Plastic Forming (SPF) panels made in a light titanium structure filled with foam, and held in place by a clamp ring.
A drawback to this design is that fuel sometimes entered the hollow structure.
The modification 47583 introduced a new machined aluminium panel composed of an inner and outer door that clamp together against the wing skin, sealing the hole. These are now installed as standard on A330/A340 assembly lines.

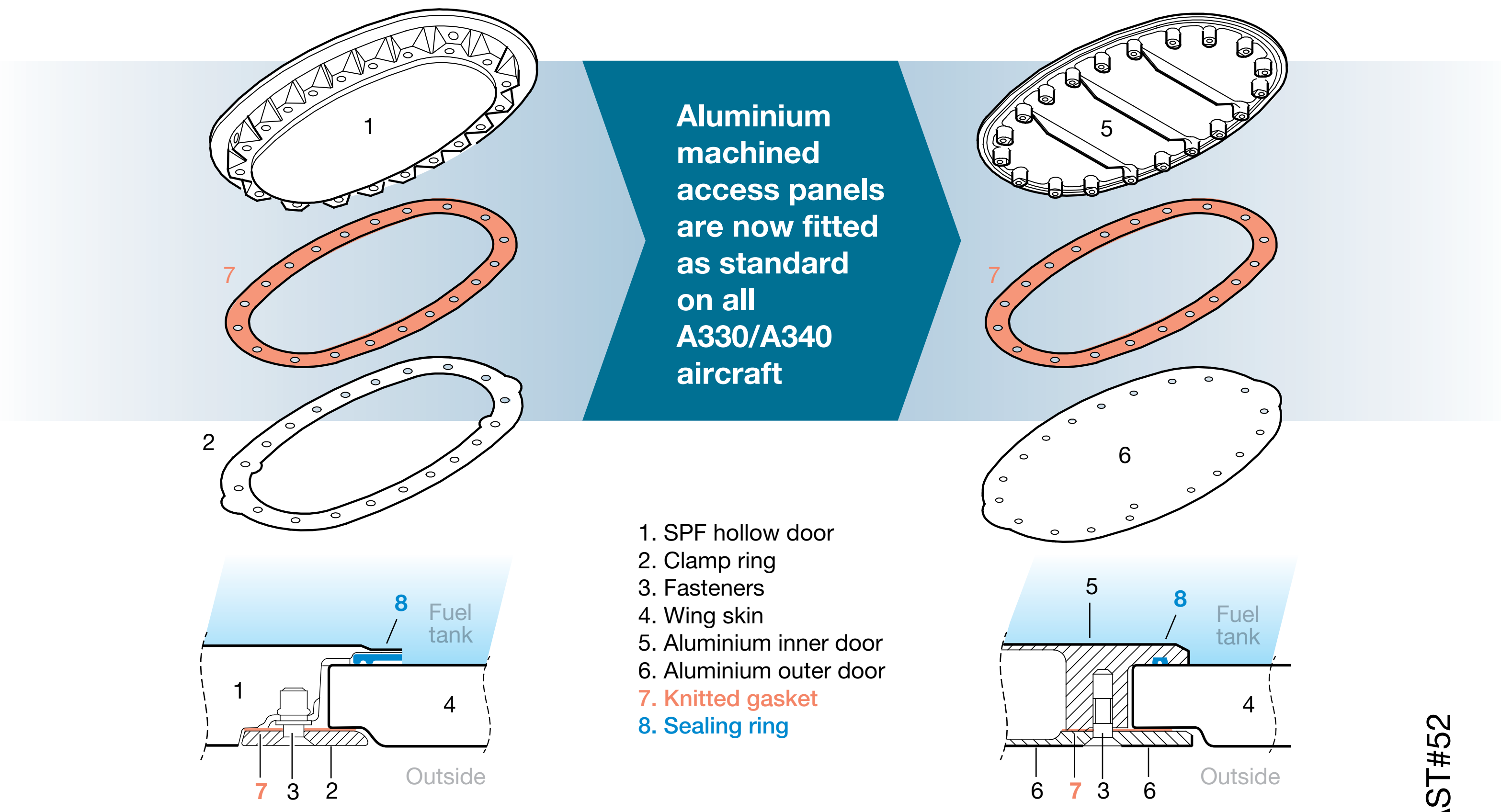
As SPF panels are no longer manufactured, a leaking SPF panel needs to be completely replaced by the new machined aluminium version, composed of inner and outer door, and corresponding knitted gasket.

Access panel components

As with the pre-mod version the post-mod panel has 20 fasteners.
A knitted gasket made of metallic mesh wrapped with rubber is necessary to ensure the electrical conductivity between the outer door and the wing, in case of a lightning strike or the discharge of static electricity.
There is also a sealing ring fixed in a groove in the inner door for fuel tightness/waterproofing.

Pre-mod titanium SPF panels

Post-mod aluminium machined panels



1. SPF hollow door
2. Clamp ring
3. Fasteners
4. Wing skin
5. Aluminium inner door
6. Aluminium outer door
7. Knitted gasket
8. Sealing ring

The final fix – Mod 57909 (January 2009)

New sealing ring material

Despite the AMM and TFU recommendations, fuel leakage was still observed, including on recently delivered aircraft.
Airbus' Design Office launched an investigation campaign on an A330, removing all the under wing fuel tank access panels for a complete analysis.
Results revealed that the rubber seals on many non-loaded access panels were damaged and some of them even broken, leading to immediate fuel leakage.
It was then demonstrated that the rubber, even if in line with Airbus' specifications was susceptible to brittle fracture at low temperature.

The material for the non-loaded access panel sealing rings was modified (Mod. 57909) in January 2009.
The previous acrylonitine butadiene rubber was replaced by a newly developed polychloroprene rubber which performs better at low temperature and resists known contaminants.

It is possible to identify the difference between the pre-mod and post-mod 57909 sealing rings by their different colours: the black seal is the older standard, the new seal is either light blue or grey.

The new material can be installed on both SPF and machined aluminium non-loaded access panels as a retrofit, covering all A330/A340 Family aircraft.
The new seals are used as standard in production and are available as spares. (see TFU 57-27-11-003 and WISE solution).

No aircraft that have been fitted with the new light blue or grey sealing rings have shown signs of fuel leakage.

New seal for titanium SPF panel:
P/N F572-50091-200-00

New seal for aluminium machined panel
P/N F572-50090-200-00

The access panel installation procedure

as provided in TFU 57-27-11-002, TFU 57-27-11-003 and WISE solution (engsup-13461)

1) Bond the sealing ring to the inner door of the access panel:

- Ensure that the sealing ring groove in the access panel is carefully cleaned.
- Ensure that the sealing ring is bonded correctly (tack free) on the access panel.

Bonding agents:

	In the AMM	New CML references
Pre-mod 57909 (black seals)	CML 09-007	CML 06HAA1
Post-mod 57909 (light blue or grey seals)	CML 08-018	CML 05JBC9

2) Lubricate the sealing ring

CML 04-012 (mineral oil based grease, Vaseline or Petrolatum) shouldn't be used on seals inboard of rib 27 as they swell the rubbers (risk of leakage) and are not fuel soluble (potential fuel contaminant). Airbus advises using CML 05-004.

Lubricants:

	In the AMM	New CML references
Panels inboard of rib 27 (in contact with fuel)	CML 05-004	CML 14CCB6
Panels from rib 27 to 39	CML 04-012	CML 03FAB1

3) Lubricate the knitted gasket

In order to improve the lifetime of the knitted gaskets from 2 to 5 years, a new rubber has been used to wrap the metallic mesh. This new rubber is soaked in lithium grease and needs to be lubricated with the dedicated grease: Aeroshell 33 - CML 04-037. Whereas the old rubber was soaked in a clay base and required grease referenced CML 04-013.

Lubricants:

	Gasket	In the AMM	New CML references
SPF panels	P/N A573-50076-200-00 P/N A573-50118-200-00	CML 04-013	CML 03FDG1
SPF panels	*New rubber gaskets* P/N A573-50076-202-00	CML 04-037	CML 03GBC1
Machined panels	P/N A572-54039-004-00	CML 04-013	CML 03FDG1
Machined panels	*New rubber gaskets* P/N A572-54089-002-00	CML 04-037	CML 03GBC1

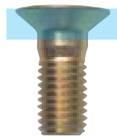
These two different lubricants must not be mixed (SIL 12-008)

4) Lubricate the fasteners

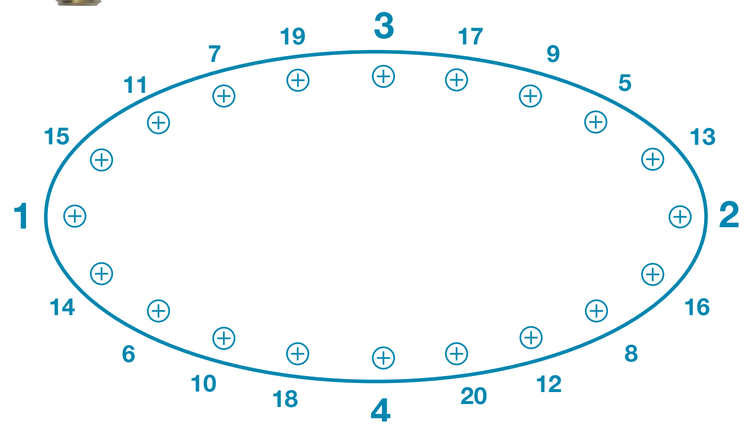
To prevent corrosion, fasteners' material has been changed from steel to CRES (Corrosion REsistant Steel) as mentioned in the Service Information Letter (SIL 57-113). Grease CA1000 without chromates is requested since the AMM revision April 2012, to prevent fasteners from seizing during removal.

Lubricant:

	In the AMM	New CML references
	CML 05-002	CML 06LCG9



Important: Only lubricate the underside of the chamfered edge of the fastener head (refer to SRM 51-76-12).



5) Observe the cross diagonal torquing sequence as illustrated in the AMM 57-27-11.

Torque the bolts in three increments from hand tightening up to the final torque value, using the diagonal torquing sequence.

Note: Never over-torque the fasteners to attempt to stop fuel leakage.

CONCLUSION

Most reported wing fuel leakages come from access panels on the inner tank section under the wing.
If leakage is noticed during the walk-around inspection of the aircraft, Airbus recommends that the access panel be immediately replaced, with its associated knitted gasket and sealing ring. The installation process, including lubrication and the torque sequence are clearly detailed for resolving this issue.

Keeping cool on the ground

Sub-freezing Pre-Conditioned Air
the APU alternative at the gate

As pressure increases on airports to reduce noise pollution, Airbus is coordinating efforts to use sub-freezing air from ground units instead of the APU to cool cabin air.

As well as supplying quieter air, this low pressure pre-conditioned air also saves airlines money while creating revenue for airports.

Joël AUDOUARD-MONTEILS
Manager Electro-mechanical Systems, AIRBUS
joel.audouard-monteils@airbus.com

Dariusz KRAKOWSKI
Air Systems Functional Architect, AIRBUS
dariusz.krakowski@airbus.com

Didier GENDRE
Ground Operations Engineer, AIRBUS
didier.gendre@airbus.com

Airbus is working with ground unit suppliers, airports and airlines to put in place an efficient Pre-Conditioned Air (PCA) system able to maintain the cabin temperature below +27°C during Turn Around Time (TAT) - even in extremely hot weather.

This new sub-freezing Pre-Conditioned Air (PCA) unit significantly improves the current PCA's performance by providing air conditioning from -25°C to 70°C, measured directly at the aircraft's interface, representing a valuable alternative for the use of the APU while the aircraft is at the gate.

As a consequence, the maintenance costs of the APU are directly reduced and the aircraft dispatch is not affected in case of APU unavailability. In addition, as the air conditioning packs are not running, maintenance costs for the cleaning of the heat exchangers are also diminished.

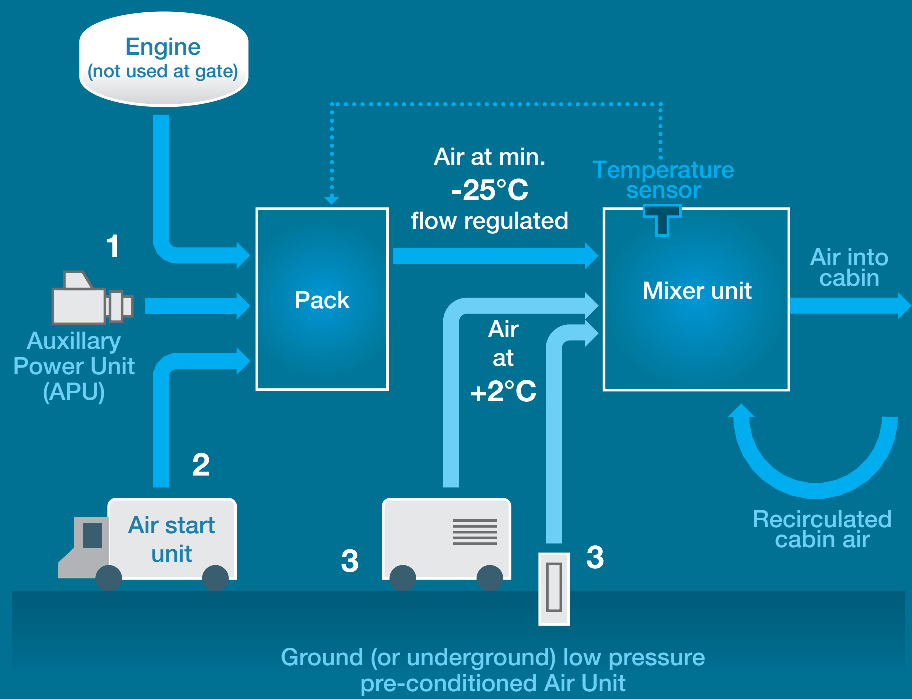
Ways to regulate the cabin air temperature

At the gate, the cabin must be kept to an acceptable temperature for the passengers' and maintenance personnel's comfort.
To ensure this, there are three possible ways.

1. The 'bleed air' from the aircraft powered by the APU compressor (high pressure), provides a high cooling capability. The bleed air is cooled by the air conditioning packs, mixed to the cabin air thanks to recirculation fans, and then supplied to the various compartments. This air is then mostly discharged overboard through the outflow valves, or recirculated through the mixer unit. This is today's most common way of cooling down aircraft.

2. Another way to get cool air is via a high pressure ground cart supply. This is usually only used to start the engines and is not economical. Nevertheless, the air conditioning packs are active and the environmental temperature control of the cabin air is available in the two modes (1 & 2).

3. The last way is by providing low pressure Pre-Conditioning Air (PCA) from a ground (or underground) based unit to the mixer unit, through a low pressure ground connection. The temperature control system cannot be regulated with this unit (+2° from cart outlet) and the packs are not active. The number of connectors depends on the size of the aircraft. If the recirculation fans are running, the air from the cabin and PCA unit are mixed and supplied to the various cabin zones, cockpit and avionics' compartments. Once again, with no temperature control.



APU restrictions and fuel savings

Today 140 airports restrict the use of the APU, mainly to reduce noise and emissions.
The Aeronautical Information Publication (AIP) mentions that **'the use of the fixed energy system has saved 12,170 tonnes (t) of fuel, 38,500t of carbon dioxide (CO_2) and 75t of nitrogen oxides (NOx)'.** Extract from Unique (Flughafen Zürich AG), Zurich, 2004.

Another study was made by a ground cart manufacturer in 2005 demonstrating the benefits of current air conditioning ground cart units.

It concluded that airlines could save 15M USD per year and an airport could obtain a net revenue of 2.5M USD with a return on investment in three years, just by using the PCA.

This shows that in terms of economy, it is preferable to use a ground-based PCA instead of the APU.
However, for performance reasons and passenger comfort in hot regions, the APU still has to be operated during boarding or disembarking with current PCA systems.

Note: The 'pack off' operation increases the maintenance time between cleaning the pack heat exchangers and can contribute to reducing the occurrence of bleed leak overheat events in hot regions.

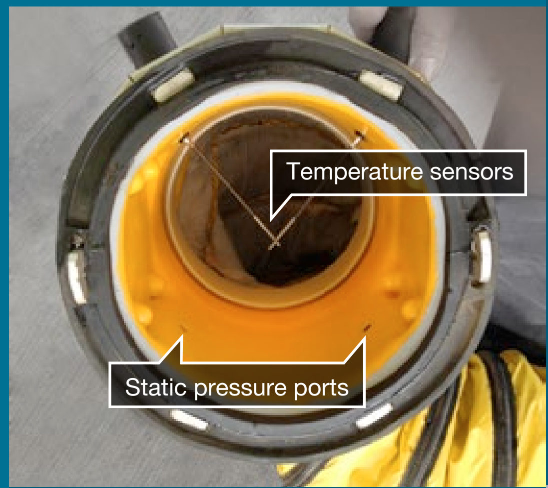
Shortfall in performance of existing PCAs

The performance of the ground based air conditioner units is limited. This is especially noticeable at airports in extremely hot and humid regions such as the Middle East and Asia. Following the IATA (International Air Transport Association) Aircraft Handling Manual (AHM), the air temperature at the aircraft interface is at the recommended minimum temperature of +2°C. Due to the heat loss in the distribution hoses running from the PCA unit to the aircraft connector, temperature at the aircraft's interface is higher than expected. In comparison, when operating the APU or engines, the aircraft air conditioning packs can supply air at very low temperatures to the mixer unit (around -25°C for an A380).

Improving the current system with 'sub-freezing' PCA

Airbus is coordinating and supporting environmentally-friendly PCA unit suppliers which are introducing units able to generate an airflow at a very low temperature (down to -25°C), measured at the aircraft's interface.
Referred to as a 'sub-freezing' PCA, it supplies a very low temperature to the aircraft's mixer unit allowing, optimizing the cooling performance.
The objective is to maintain the cabin temperature under +27°C during the TAT and to significantly reduce the cooling down time, even in extreme weather conditions, to reach a performance comparable with the aircraft's air conditioning packs powered by the APU.

However, to prevent ice build-up in the mixer unit that eventually will damage the aircraft, the mixer unit should be kept at a positive temperature.
This constraint has led Airbus to issue a list of design requirements for the PCA suppliers and specific recommendations.
These requirements, provided in the document 'Sub-freezing PCA carts: compliance document for suppliers' (ref: X21RP1146224) come in addition to the functional specifications included in the IATA AHM 997 (Aircraft Handling Manual).
Sub-freezing PCA units must include a regular defrost cycle during the cooling phase, generating warm air to melt ice in the duct.
Another additional precaution is to control and monitor the humidity, pressure and temperature of the air delivered to the aircraft.



Airlines must only use PCA units that are compliant with Airbus' requirements and strictly apply the procedures available in the Aircraft Maintenance Manual (AMM) that correspond with the Airbus aircraft type.

These procedures are valid for all cabin layouts and they have been validated by test and/or simulation.

The sub-freezing PCA can be used on all Airbus in-service aircraft without adaptation.

PCA control differences

	Current PCA	Sub-freezing PCA
CONTROL & MONITORING		
	• On/Off switch • Cooling (+2°) • Flow and temerature are manually controlled	• On/Off switch • Variable temperature control *(-25° to +70°)* • The pressure is monitored and controlled • The humidity is monitored *(dry air)* • Defrost cycle
PERFORMANCE		
	One level of performance: • Cooling power 'On'	Three levels of performance: • Pull down phase *(cooling the cabin down, aircraft empty)* • Maintaining temperature *(before boarding, aircraft empty)* • Maintaining temperature during boarding

AMM references

REVISIONS

Aircraft	Current PCA operation AMM task	Sub-freezing PCA operation AMM task
A380	21-00-00-618-801-A	21-00-00-618-805-A *May 1, 2013*
A330/A340-200,300	12-33-21-618-801-A	12-33-21-618-801-A03 *April 1, 2013*
A318/A319/A320/A321	12-33-21-618-001-A	12-33-21-618-002-A *May 1, 2013*

Photos courtesy of Cavotec

Benefits for both airlines and airports

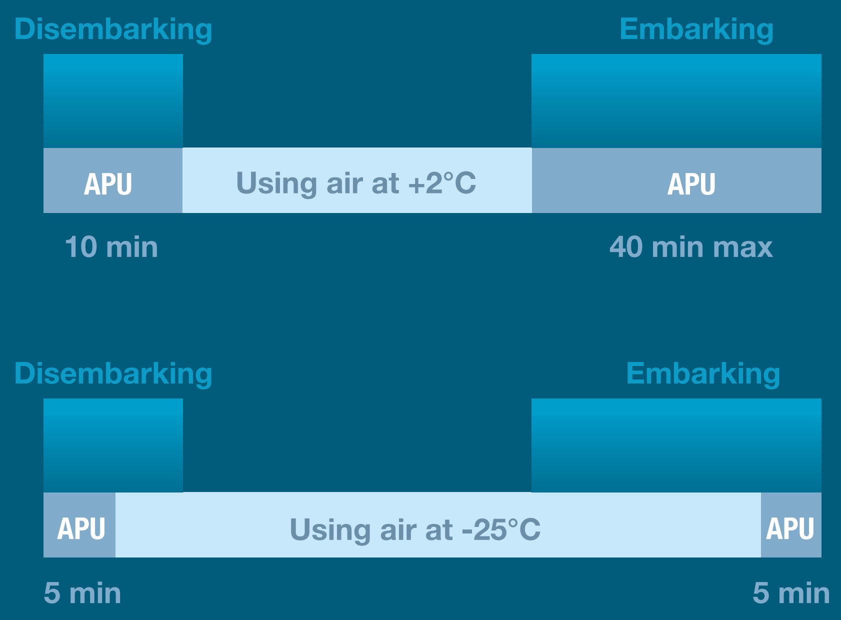
The benefits of this new level of cooling performance go beyond saving fuel by reducing the use of the APU; they also reduce cabin cooling time, speeding up the dispatch of the aircraft, even if the APU is unavailable.

The diagrams to the right illustrate the possible additional fuel savings between an airport with APU restrictions, and an airport equipped with a sub-freezing PCA unit considering hot weather conditions (OAT> 20°C). In practice, the use of the APU could be limited to only 10 minutes.

This duration corresponds to the connection/disconnection time of the sub-freezing PCA unit to the aircraft. The sub-freezing PCA unit is able to supply air in all weather conditions to maintain the passengers' comfort.

Air conditioning during Turn Around Time

at airports with APU restrictions



The time to bring the cabin temperature down to 27°C for an empty aircraft in hot sunny weather conditions (called the 'pull down' phase) is also significantly improved.

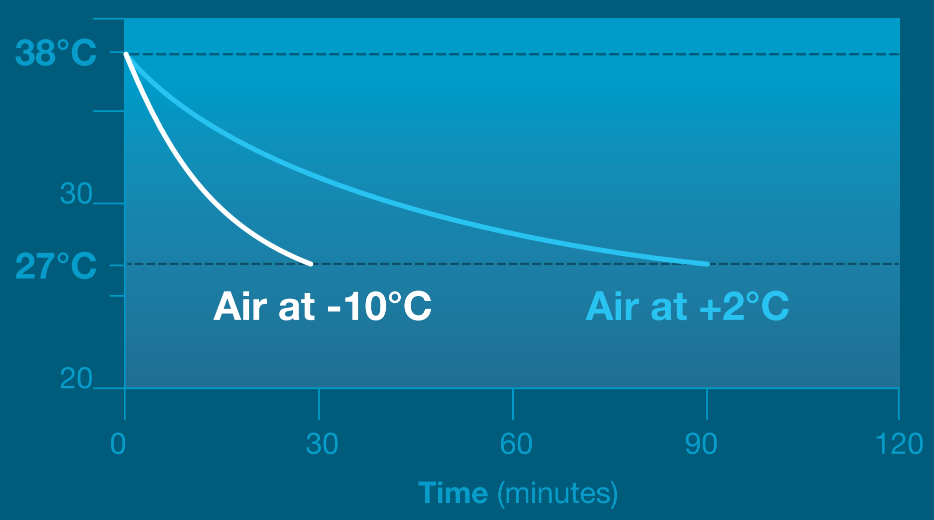
The diagram to the right compares the pull down performance of a classic PCA operation and a sub-freezing PCA operation.

For an A330, with a sub-freezing PCA unit delivering 1.9kg/s at -10°C at the connection of the aircraft, only 30 minutes are necessary to achieve +27°C in the cabin, in a +38°C Outside Air Temperature (OAT) condition. A current PCA unit delivering the 1.9kg/s at +2°C needs 90 minutes.

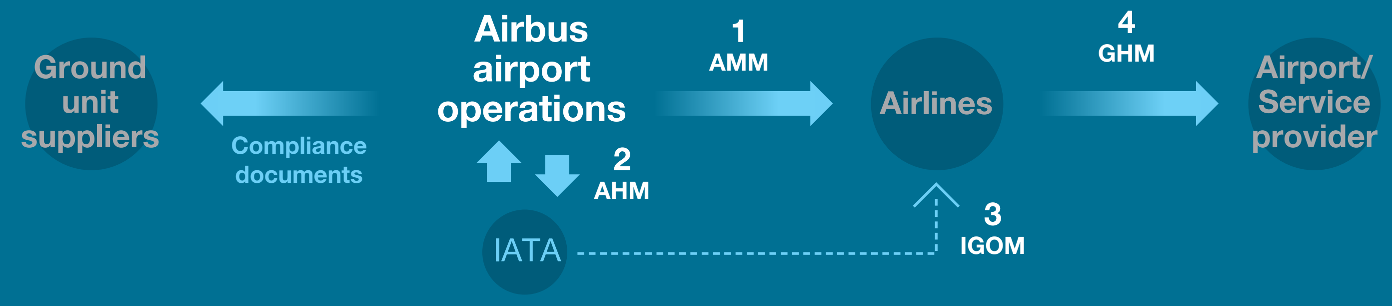
The pull down phase performance of a sub-freezing PCA unit is similar to an aircraft air conditioning pack operation (for the A320 Family, A330/A340 Family and the A380).

Pull down performance

to cool cabin from 38°C to 27°C on ground



The players



1. AMM
Airbus is the owner of the Aircraft Maintenance Manual (AMM); the sub-freezing PCA procedure is a new AMM task. The AMM limits the usage to only ground based units compliant with the Airbus document X21RP1146224 sub-freezing PCA carts: Compliance document for supplier.

2. AHM
The Airport Handling manual (AHM) is a 'what to do' set of requirements for ground unit suppliers.

3. IGOM
The IATA Ground Operations Manual (IGOM) defines 'how to do' ground handling standards for airlines and service providers, ensuring that ground operations' activities are safely and consistently accomplished. The procedures reflect the minimum standards as identified by the aviation industry.

4. GHM
The airline is responsible for the operation, establishes its Ground Handling Manual (GHM) based on the AMM and IGOM, and makes it available to the service provider.

CONCLUSION

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

This new sub-freezing PCA considerably reduces the 'pull-down' phase, even in extremely hot and humid conditions, and allows airlines to keep the aircraft cool more efficiently during Turn Around Time (TAT).

The reduced use of the Auxiliary Power Unit leads to economy of fuel and reduction of direct maintenance costs. Furthermore the 'pack off' operation increases the time between cleaning the pack heat exchangers and contributes to reducing bleed leak overheat occurrences in hot regions.

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

FAST from the PAST

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

'Up a bit - down a bit - reverse-up now.'
'Perhaps we need heavier men on the front of the truck to stop it toppling over.'
'Watch out! - the wind's getting up.'

Positioning an engine is still a tricky business, but now so much easier and safer thanks to the new electrical hoist kit for bootstrap systems (see page 10).

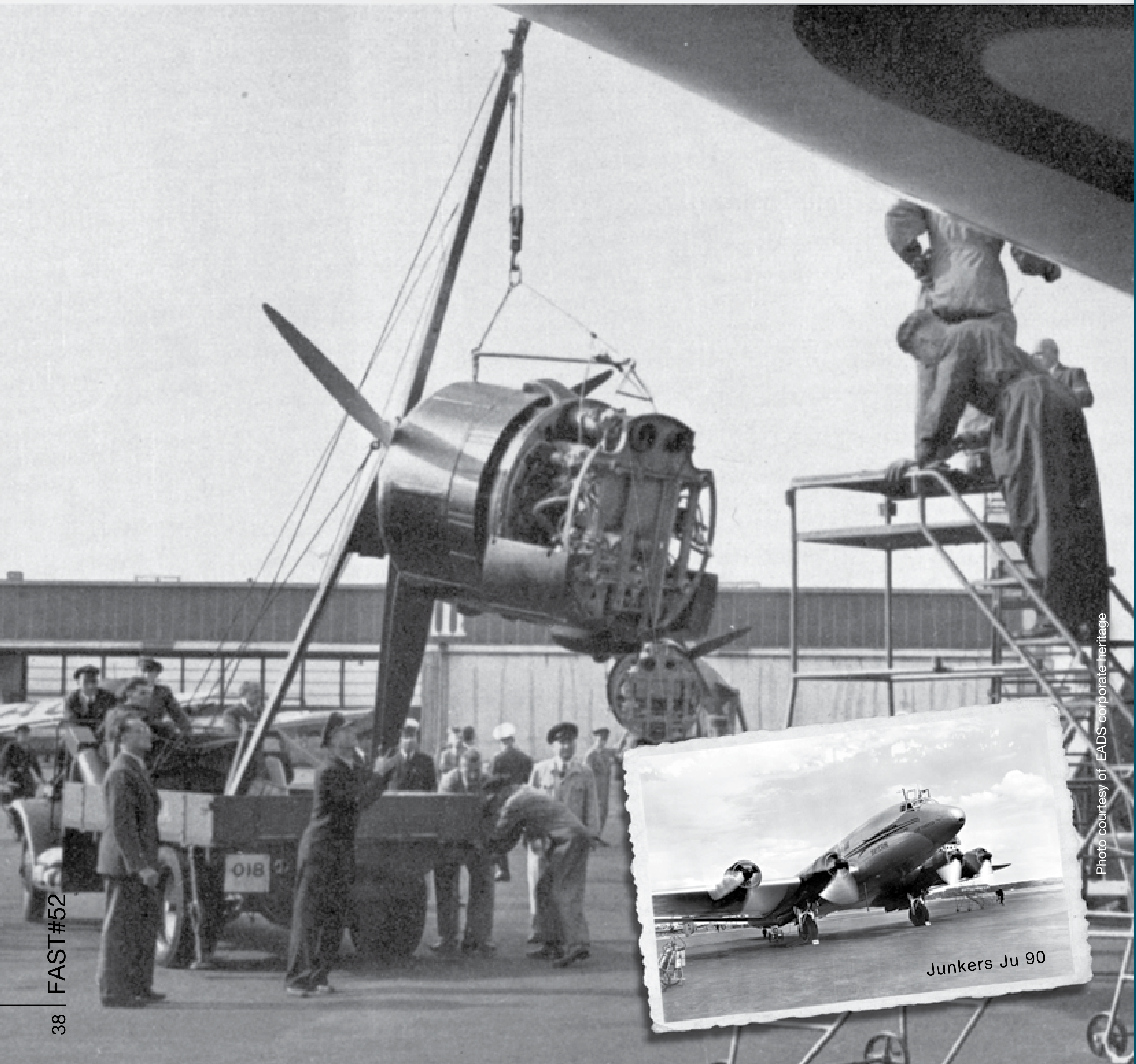


Photo courtesy of EADS corporate heritage

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Around the clock, around the world,
Airbus has more than 240 field representatives
based in over 110 cities

WORLDWIDE

Tel: +33 (0)5 6719 1980
Fax: +33 (0)5 6193 1818

USA/CANADA

Tel: +1 703 834 3484
Fax: +1 703 834 3464

CHINA

Tel: +86 10 8048 6161 Ext. 5020
Fax: +86 10 8048 6162

FIELD SERVICE SUPPORT ADMINISTRATION

Tel: +33 (0)5 6719 0413
Fax: +33 (0)5 6193 4964

TECHNICAL, MATERIAL & LOGISTICS

Airbus Technical AOG Centre (AIRTAC)
Tel: +33 (0)5 6193 3400
Fax:+33 (0)5 6193 3500
airtac@airbus.com

Spares AOG/Work Stoppage
- Outside the Americas:
  Tel: +49 (0)40 5076 4001
  Fax: +49 (0)40 5076 4011
  aog.spares@airbus.com
- In the Americas:
  Tel: +1 70 3729 9000
  Fax: +1 70 3729 4373
  aog.na@airbus.com

Spares In-Flight orders *outside the Americas:*
Tel: +49 (0)40 5076 4002
Fax: +49 (0)40 5076 4012
ifd.spares@airbus.com

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