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100 years of powered flight

Fumigation of aircraft with carbon dioxide (CO₂)
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Worldwide Airbus Customer Services

In a nutshell...

Cover illustration: “Less paper in the cockpit”

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This issue of FAST has been printed on paper produced without using chlorine, to reduce waste and help conserve natural resources. Every little helps.
As we move into the 21st century with the A3XX, an aircraft capable of carrying some 580 passengers and crew over 8000 nautical miles, non-stop, it is difficult to imagine that only 100 years ago a prize was offered for the first man to fly from the Aéro-Club de France at Saint-Cloud, around the Eiffel Tower and back to Saint-Cloud, within 30 minutes. Although there were many entrants for the competition, only one man actually competed, Alberto Santos-Dumont, a young Brazilian.

He won in his airship the “Santos-Dumont No. 4”. It had a 9 horsepower engine driving a two-blade propellor via a long shaft. Mr Santos-Dumont sat behind the engine, on a bicycle seat, in the open. There were no passengers.

He went on to win another prize, in 1906, for the first sustained flight in Europe – 220 metres at a maximum altitude of six metres, with a controlled turn at the end. It was in his “Aeroplane 14-bis” with a 50 horsepower motor driving a two-blade pusher propellor. The first passenger wasn’t carried till 1908.
Operators have reported cases of aircraft infestation by rodents such as mice and rats, and reptiles such as snakes and lizards, causing discomfort and alarm amongst passengers and crew, but also potentially considerable damage to the aircraft. Their presence in an aircraft can lead in extreme cases to the aircraft being grounded, especially when electrical wiring damage has been discovered. Rats and mice seem to be attracted by the odours emitted by the insulation around the wires.

In-service experience has revealed that rodents and reptiles tend to board an aircraft through open doors and access panels, when it is parked for a relatively long period of time either in the hangar or on the apron, especially during the night when human activity is reduced. Also, they have been observed entering the aircraft during loading of catering trolleys and cargo.
Up to mid 1997, Airbus Industrie had provided operators with the possibility of fumigating infested aircraft with a methyl bromide based chemical agent, referred to as ‘SOXAL-PESTIGAS’ in the Aircraft Maintenance Manual (AMM).

However, due to the continuing international process of banning toxic fumigation agents for civil use, and concerns about the usage and potential side effects of this agent, Airbus Industrie decided to withdraw it from the AMM.

Specifically, these concerns were focused upon:

- Residue of methyl bromide still traceable in some areas in the cabin and cargo compartments up to 36 hours after aircraft aeration;
- Accumulation of methyl bromide residues in the thermal-acoustic insulation blankets behind the linings of the cabin and cargo;
- Compatibility of methyl bromide based agents with sophisticated aircraft electronic equipment;
- Existence of chlorofluorocarbons (CFC) in methyl-bromide agents, which are restricted in many countries by law, further to the Montreal protocol.

Airbus Industrie launched an investigation to identify another fumigation agent, possessing the following characteristics:

- Inert;
- Non toxic;
- Widely available in the world market;
- Low procurement cost;
- Easy to contain and transport;
- User friendly.

As a result, it has been determined that carbon dioxide (CO2) can fulfil the above requirements, where the extermination of the rodents and reptiles would be achieved by means of asphyxiation.

CO2 is already used in industry for protecting food stored in holds of ships and warehouses, and for protecting cultivated plants. In addition, the use of CO2 for fumigation was of special interest since its procurement cost is lower than Nitrogen (N2) and less of it is required.

In August 1999, Airbus Industrie conducted CO2 fumigation tests in an A319 aircraft. The test readings were taken using probes placed in designated areas in the cabin, cockpit, avionics and cargo compartments measuring the CO2 concentration at specified time intervals.

**NOTE:** no live animals of any kind were used in these fumigation tests.

The test results were positive, since CO2 concentration reached approximately 90% of the aircraft volume, and scientifically it has been shown that the lethal dose to exterminate a rodent is approximately 60% of CO2 with exposure of about six minutes. Therefore, Airbus Industrie decided to implement CO2 and the associated fumigation procedure into the scheduled AMM revisions for each aircraft.

**CO2 Fumigation procedure**

**IMPORTANT:** Operators are advised to consult AMM 12-21-12 for the specific aircraft fumigation procedure. The AMM for A319/A320/A321 was revised in May 2000 to incorporate fumigation procedure by CO2 and for the A330/A340 in July 2000. The revision to the AMM for the A300/A300-600/A310 family is planned for the first quarter of 2001.

In addition, operators are advised to refer to SIL 12-007, revision 01, issued end of October 2000, since useful supplementary information is provided.
The fumigation procedure by CO₂ is the same for all of Airbus Industrie aircraft. A locally manufactured filling adaptor is installed over the outflow valve of the air-conditioning system and an outlet pipe installed at one of the cockpit sliding windows (see figures 1, 2 & 3).

When Airbus Industrie conducted the fumigation test, an average CO₂ mass flow rate of 3.6 kg/min was selected, corresponding to almost 2000 litres/min of CO₂, by adjusting the pressure to 8 bars at the CO₂ supply. In this case the filling time for an A319 was nearly three hours. Equipment is available, with a higher mass flow rate capability that would allow large aircraft to be filled in approximately the same time. The filling time is calculated using the required CO₂ mass specified in the table below for each type of aircraft fuselage and the mass flow rate selected. When the specified amount of CO₂ has been reached, the filling process stops.

Although the cargo compartments are nominally sealed from the cabin, cockpit and avionics compartments, it was demonstrated during the test that the cargo compartments are also filled with CO₂. This will occur through the cargo compartment drain lines (the leakage in/out is in fact calibrated for the purpose of assuring containment of fire extinguishant).

Usually, the CO₂ gas is contained under pressure in liquid form of about 150 Bars and at low temperatures. Heat exchangers and evaporators, (see photo →), are used to elevate the temperature of the gas prior to approximately 15°C on entering the fuselage.

The following table shows the amount of CO₂ required for each fuselage ↓
CO₂ Fumigation procedure (cont’d)

The CO₂ enters the cabin through a locally manufactured simple adapter that is installed over the outflow valve. To ensure that the CO₂ penetrates to the highest level in the cabin an outlet tube is fitted above the ceiling panel behind the cockpit, with the end placed at the highest position in the fuselage. The other end is taken out through a blank fitted in place of the sliding window in the cockpit. (see figure 3c). Thus as the level of CO₂ rises in the cabin it forces out the ambient air through the tube. After the CO₂ filling process, the aircraft should remain closed for half an hour for rodent extermination and 12 hours for reptile extermination.

General information

Using CO₂ and Insecticides

Fumigation using CO₂ is not totally effective against insects but very effective against rodents and reptiles. In case an operator needs to exterminate insects as well as rodents and reptiles then insecticide in association with fumigation should be used. First the internal section of the pressurised fuselage has to be sprayed with ‘Baygon’, (Material No. 14-004 or 14-004A), and then, the CO₂ fumigation procedure should be performed. Insects such as ticks are almost resistant to high concentrations of CO₂ gas since they can close their trachea and virtually stop their metabolism. Other insects such as cockroaches will lay their eggs prior to dying. CO₂ has no effect on the eggs, however ‘Baygon’ is effective against them.

In the case of reptiles, the fumigated aircraft has to be kept with all doors, hatches and drain ports closed and sealed for at least twelve hours. This is due to the fact that reptiles hibernate when under threat or lack of nutrition. They can reduce their heartbeat significantly as well as their rate of breathing.

Rodents are exterminated after being exposed to an environment with 60% CO₂ content for six minutes. The CO₂ has an anaesthetic effect after 20 seconds.

Penetration of the CO₂ into the thermal-acoustic insulation blankets behind the cabin and cargo linings, was measured at about 90% during the fumigation test.

Using Conventional Methods

If an operator wishes to use conventional traps (spring loaded or with adhesion) to catch rodents and or reptiles then the following technique should be used:

Prior to placing the traps, remove all catering trolleys and the waste from the trash compactors, (if any), from the galleys, from the lavatory waste bins and from any other container which could contain any waste.

Remove all soap bars and dispensers from the lavatories.

Remove all cosmetic products from the lavatories.

Place the traps in the cabin, in the aisles, below the seats, in the galley and lavatory areas, in the cockpit, in the avionics bay, in the cargo holds, and in the Flight Crew Rest Compartment, Lower Deck Mobile Crew Rest compartment and Lower Deck Lavatories, if any of these are installed.

Close all aircraft doors and hatches for twelve hours with no human activity around the aircraft.

The main advantage of fumigating an aircraft by CO₂ over the use of conventional traps is that the result is definitive in a specified time frame.

IMPORTANT: Do not under any circumstances use poison capsules for rodents, since their later removal could be easily omitted by cleaning personnel, leaving them to be swallowed by child passengers.

Do not under any circumstances use ultra-sonic animal repellent devices inside and/or near the aircraft.
CO₂ SUPPLIER

Airbus Industrie encourages operators wishing to use CO₂ for fumigation to use the method described in the AMM. They should contact and use local CO₂ suppliers and their associated equipment for performing the fumigation task. Airbus Industrie performed the fumigation test in association with Linde AG. (see address below) who supplied the gas and also the equipment.

Figure 3  Installation of apparatus

Conclusion

Airbus Industrie, being conscious of the difficulties faced by operators when pests board their aircraft, and with the gradual prohibition of toxic agents against them, has developed an effective, user friendly solution for the eradication of stowaway reptiles and rodents. It uses products and materials that are in common use, and very simple to adapt to the aircraft.

Good hunting!

Contact person and address of supplier
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Fax:+49 40 8531 2125
e-mail: soenke_weidgen@linde-gas.de

Note: LINDE AG has international distribution centres.
Being the only all new aircraft in their class the A320 Family benefited from the advances in technology introduced in the intervening twenty years. Inevitably these advances reduce the maintenance costs by reducing the time that the A320 Family spends on the ground for maintenance purposes, because they are easier to maintain, having easier and accurate trouble-shooting and modern maintenance procedures.
A change in the wing manufacturing process has allowed an improvement in the flap rigging procedure. Until now rigging of the flaps has required disconnection of the flap drive system and use of rather cumbersome devices, which were placed on top of the wing.

With the introduction of new manufacturing tools, to more precisely position flap tracks two and three, and more recently track four, in relation to the top surface of the wing, this rigging method has been replaced by a much simpler one.

This new rigging procedure uses the flap tracks as the datum with a small tool that looks like a shark’s fin, for alignment of the flaps. The drive system does not need to be disconnected, if it is found to be correctly rigged.

**Shark fin tool**

This tool kit is composed of two tools. One for flap tracks two and three and another for track 4. Each tool has a base, a fin and a scale block (see photo 1). They are much smaller and lighter than the previous overwing rigging boards. Thus they are easier to transport, handle and store, which reduces the possibility of them being damaged, and so increases the accuracy and repeatability of the rigging.

**Installation**

With the flaps in the up position, the base of the tool is clamped directly to the top, aft end of the flap track, up against the beam end-stops. The fin slides into the slot on top of the base (see photo 2) and is held in the correct position by a pip pin. The scale block sits on one of the steps at the top of the fin.

Having a fixed position, the shark fins are much more accurate than the overwing rigging boards, which were located by measurement. In addition, the fin does not require adjustment before carrying out the rigging, leading once again to an improvement in the accuracy and the repeatability of the rigging.

**Rigging procedure**

The flaps should be in the up position with rigging pins installed in the drive levers at the flap tracks (see photo 3). It is no longer necessary to systematically disconnect the flap drive torque shafts to achieve the required fore and aft flap position before carrying out the flap rigging. This reduces the required rigging time approximately by half.
Alignment of the flap trailing edge with the zero (nominal) position of the tool scale block is done using the main eccentric bearing located on the carriage (see figure 1 ).

Rotation of this eccentric bearing provides the vertical adjustment of the whole flap with regard to the wing (see figure 2 ). On most aircraft this is all that needs to be done.

Rotation of these forward eccentric bearings causes only the trailing edge of the flap to move vertically (see figure 2 ). This deviation from the nominal position of the trailing edge is inherent to the aircraft and is recorded on a label installed on the side of the flap track 3 (as shown on photo 4 ).

Hence, any re-rigging of the outer flap on in-service aircraft must take into account the presence, or not, of a deviation value recorded on this label. If a value is recorded on the label, in the first place the outer flap nominal position has to be recovered by moving the forward eccentric bearings on tracks 3 and 4. Then the flap can be rigged by using the main eccentric bearing, and finally the flap trailing edge should be moved back to the dimension marked on the label, by the forward eccentric bearings on track 3 and 4.

**Conclusion**

This procedure will significantly reduce the time required to rig the flaps. It will also make their adjustment easier to perform and more accurate. As this new rigging procedure is also applicable on aircraft initially rigged with overwing rigging boards, it is highly recommended to take advantage of this new procedure and tool (ref. AI SB A320-27-1119).

**Note:** to further assist the operators, a video “SHARK FIN TOOL FOR EASY FLAP ADJUSTMENT” providing the salient points of the flap rigging procedure, is available on request (see contact ).
The Initial Provisioning (IP) spares investment recommendation is a central determinator of spares investment. This important working document is used not only by airline materiel planners but also by their financial controllers. This article highlights how both have benefitted from the effects which reduced the airline’s initial expenditure in spares. The main reasons for the reduction in the value of Initial Provisioning investment in the last five years have been, improved parts reliability, reduced repair time and spares stock quantities adapted to in-service experience, together with spare parts pricing initiatives.
Where the results come from?

The Airbus Provisioning Department investigated how the value of recommended spares investments given to customers has reduced over the last five years.

The Initial Provisioning recommendations given by Airbus Industrie are based on formulae, statistical distributions, technical and operational parameters.

One of the questions was, whether the spares stock quantity could be further reduced. Another point has been to what extent are different achievements contributing to savings in spares investment. And finally, how can the Provisioning Department support their customers by providing them with cost optimised data.

The customer’s operational input (including items such as annual utilisation, fleet size, transit time) is considered to be a constant. Therefore it indicates only the changes implemented in the past few years through product and process improvements. For the purpose of the investigation we compared the investment recommended to airlines that ordered their single-aisle fleet in 1995 with the value of a similar package today.

We focussed initially on the expensive parts category, the LRU’s (Line Replaceable Units) which represent some 95% of investment within a typical IP-package.

Four main investment-saving initiatives have been developed since 1995:

- A price freeze, against the global tendency of rising prices, kept the cost of spares below the index.
- Improved parts reliability supported by guarantees allowed a reduction in stock levels.
- Cost optimised calculation parameters were applied in accordance with the MMEL, and a staggered fleet build-up.
- Guaranteed lower shop processing time (SPT) shortened the re-supply chain.

Competitive pricing saved money

Inflation is a common phenomenon and was at some 1.6% per annum on average in the aviation industry from 1995 to 2000.

The following chart contains some high cost items that typically can be found within the IP package. It reflects the savings due to price-freezing agreements achieved by Airbus Industrie with the Original Equipment Manufacturers (OEM) and compares the Airbus pricing policy against the US price rise index.
Analyzing the Recommended Spare Parts Lists, the reliability of LRUs has significantly improved when measured by the MTBUR (Mean Time Between Unscheduled Removals) figure. For all LRU items contained in an Initial Provisioning package the parts’ reliability has improved by 11.5% while the 10 most expensive items improved their reliability by up to 46% thus leading to substantially less spares investment.

Parts reliability is usually defined by design, by the manufacturer, and influenced by the airline’s maintenance. Due to the large number of Airbus aircraft now in operation and their accumulated flight hours, more real data became available about the MTBURs. Successive implementation of these in-service MTBUR figures converted our calculations into more efficient planning documents. These in-service figures are supported by guarantees contained in the General Conditions of Purchase (GCP). If a guaranteed MTBUR is not met the supplier will provide a remedy (see figure 1).

**Improved component reliability (MTBUR in %)**

<table>
<thead>
<tr>
<th></th>
<th>1995</th>
<th>2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>All IP LRU’s</td>
<td>100%</td>
<td>115%</td>
</tr>
<tr>
<td>10 most expensive LRU’s</td>
<td>120%</td>
<td>140%</td>
</tr>
<tr>
<td>+46.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+11.5%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 1**

Improved parts reliability requires smaller stock quantities

Economical spares availability can be planned with optimised stock levels

To plan availability of spare parts a so-called protection level is widely used. It reflects the probability of having a part in stock when needed.

Furthermore we typically classify the parts following their “essentiality code” in these categories:

- “No-Go”
- “Go-If”
- “Go”

The parts that are essential for aircraft dispatch (i.e. “No-Go” parts) are calculated with comparatively high levels, ranging from 94% to 96%. Starting in mid-1995 an input variation using the essentiality code became possible, thus reducing the recommended investment by lowering the protection levels for “Go-If” parts to typically 85% to 92%. Protection levels for the “Go” items, less essential for aircraft dispatch, were reduced to levels between 70% and 80%. By introducing this feature the investment could be more closely adapted to operational circumstances.

Quicker repair = less stock holding

Looking at the period from 1995 to 2000 the average Shop Processing Time (SPT) for all LRUs in a typical Initial Provisioning package has shortened from 19 to 14 days representing a more than 26% reduction. For the 10 most expensive items the reduction has been up to 32%.
Quicker repair = less stock holding

The SPT is defined as the total number of calendar days from receipt of the part at the repair base until its dispatch from the repair base. As many airlines don’t have the repair capabilities to perform all the maintenance tasks, several vendor repair shops are also involved. Airbus obtained agreements with them to shorten the repair cycles. The latest agreement, called GCP 2000, guarantees a maximum shop repair time of 10 days for avionics and 15 days for non-avionics components. The GCP 2000 has been signed by 40 major OEMs so far (see figure 2).

Streamlined processes within the airline can achieve further improvements along the repair chain. This is due to the fact that the number of calendar days needed for repair administration has a great influence on the formula-based calculation of recommended quantities.

Further savings programme
for Airbus proprietary materiel successfully implemented

The Customized Lead Time (CLT) programme is an initiative in materiel planning and delivery introduced by Airbus Industrie in 1997. Today the 25 airlines already participating can effectively reduce the inventory of Airbus proprietary parts held in stock. Benefits of CLT are:

- Reduced customer safety stocks and holding costs
- Optimization of inventory by common planning for essential items
- Reduced materiel costs through increased use of routine ordering

Essentially the airlines hold no Airbus proprietary parts in stock and obtain the parts needed on a just-in-time basis. Dispatch can be achieved the same day if requested.

Conclusion

The significant reduction in the value of spares reflected in the Recommended Spare Parts List (RSPL) and now being appreciated by Airbus operators results from several initiatives taken by Airbus Industrie over the last five years. In particular, freezing prices, guaranteeing reliability, optimising spares recommendations to meet actual airline operational needs, and guaranteeing shorter component repair times have all contributed to meeting the airlines’ need to reduce operating costs.

Airbus Industrie Materiel Support

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Imagine a world where the pilot enters a paper free cockpit, checks the technical status of his aircraft then switches on his laptop to retrieve his information. The day before his flight, he was connected by electronic mail to his airline to receive the latest Flight Crew Operating Manual/ Minimum Equipment List (FCOM/MEL) updates and also updated his performance modules. He sits in the cockpit seat with his laptop on the table in front of him, checking the ECAM warnings with the MEL Module and selecting the inoperative items before switching to the Takeoff Module. In order to start the LPC software, he must enter the aircraft registration number and the software will present the information relative to this aircraft on his screen...
Imagine his flight is only forty minutes ahead and he is preparing for it. He computes his takeoff performance after selecting the runway, entering the takeoff conditions while the MEL Module just “activated” the inoperative items.

Imagine the passengers are boarding the aircraft and the cargo is loaded. The loadmaster enters the cockpit to give the load details. The pilot selects the LPC Weight and Balance Module to compute the takeoff CG and actual weight of the aircraft. Then he reverts back to the Takeoff Module to finalise the takeoff performance, which is then manually entered in the PERF(ormance) page of the Flight Management System (FMS) in the aircraft.

Imagine the same laptop now gives FCOM data, if required, during taxi-out. Finally, the pilot just closes his laptop and stows it and the table prior to the takeoff roll.

Do not imagine anymore, but visit an Airbus fly-by-wire cockpit to actually live this “Less Paper in the cockpit” experience.

The amount of automation and sophistication going into aircraft today requires more and more information to be handled within the cockpit environment. This, added to the requirement for more precise and complex performance computations have made it necessary to review the way to provide access to information for the pilots.

If the next generation of aircraft includes a server on board with the screen display as part of the cockpit, a transition phase will be required to prepare the pilots to use a Personal Computer rather than paper. At a later stage electronic management of the information through some appropriate software tools will probably completely supersede paper.

Today the progress made in the area of the on-line technologies and particularly in the domain of Internet with the "Web Revolution" has contributed to the general use of the Personal Computer to gain access to information. More and more people now use the Web services at home to get access to an almost unlimited amount of information and this becomes ever easier and faster. The Personal Computer is an essential tool for this environment.

A world in constant evolution

A more productive cockpit environment
Architecture overview

The LPC concept has two parts. The first part mainly concerns visualisation of operating manuals such as the FCOM and the MEL and possibly some specific airline manuals. The second part provides access to performance of the aircraft and concerns the takeoff, landing, aircraft weight and balance and in-flight data.

The various modules are linked together through a common interface called F.O.V.E (Flight Operations Versatile Environment). This interface provides some general services to the various modules. These services cover the communications and the inter-operability domains. The design of this interface is flexible enough to enable airlines to develop their own specific modules and to integrate these modules in the same environment as those of Airbus Industrie.

The list of services managed by FOVE are:
- inter-module communications,
- management of software versions,
- management of software compatibility,
- control of integrity between the data and the versions of the software,
- management of updates,
- management of context.

The various software tools, part of the Airbus Industrie “Less Paper in the Cockpit” (LPC) concept are divided into two categories:

- On-ground tools enabling the airline administrator to prepare the set of information to be used in the cockpit by the flight crew. This preparation phase customises the information.
- On-board tools enabling the flight crew to get access to the information prepared by their administrators.

To speed-up and ease the processing flow, the update mechanisms between Airbus Industrie and the Airline are managed by using electronic networks. This means that the performance data as well as the technical information are electronically distributed.
**Objectives**

The overall objectives of the modules part of the LPC are the electronic distribution, update, and consultation of Airbus Technical Flight Operations information, and computation of performance data.

The main goals are:
- To improve access time to the information.
- To improve consultation efficiency through the following features:
  - access information for one specific aircraft,
  - wordsearch through an index,
  - hyper-links within a document or between several documents,
  - shortcut to access to most frequently used parts of the documents,
  - bookmark management,
  - graphics display,
  - identification of the revised information,
  - list of highlights with a direct link to the revised information,
  - possibility to associate some specific airline information to Airbus information.
- To improve takeoff performance.
- To optimise the loading and trimming of the aircraft.
- To ease the updating processes and reduce the distribution cycle time for revisions and updates.
- To ensure technical data accuracy.
- To reduce costs in distribution and management of operational documentation.

**Scope**

The various modules are or will be made available as follows:

<table>
<thead>
<tr>
<th>Module</th>
<th>A300-600</th>
<th>A310</th>
<th>A319 A320 /A321</th>
<th>A330</th>
<th>A340</th>
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</tbody>
</table>
Environment

The LPC is based on the concept that a laptop dedicated to the pilots will hold information relative to operations manuals and to performance computations. The information contained in the laptop may cover all the aircraft types operated by the airline. However, the information displayed is relevant to a unique aircraft type or registration number as selected by the pilot. It is also displayed in a homogenous way irrespective of the aircraft type, size, or model.

As the laptop is not connected to the aircraft systems, the product is not certified. However, to operate the LPC on board, an operational approbation shall be obtained from the local authorities and the appropriate Standard Operating Procedures be developed.

The Airbus fly-by-wire aircraft in service today already have sliding tables, power supply outlets and storage areas to allow the use of laptop computers in the cockpit.

Following a survey of airlines, Airbus Industrie is proposing the installation of two plugs (115volts/60Hz) to supply pilots’ laptop computers (standard option).
Component Overview

Weight & Balance Module

The Weight & Balance module enables the pilot to compute the different weights and centre of gravity (CG) positions of the aircraft and to check them against their operational limitations. This module considers the given conditions of the day so as to optimise the loading and the trimming of the aircraft (see figure 1).

For a given aircraft, the Weight & Balance Module is started with the characteristics of the selected aircraft registration number.

Different information is entered by the pilot. The nature and the number of parameters to be entered depends on the aircraft type as well as on the administrators’ settings: many parameters can be customised or are optional. The Module is very flexible so that it can accept the maximum number of parameters required to perform the loading and trimming of an aircraft.

Firstly, the pilot selects the configuration code for his flight. The configuration code is associated with a specific service type (see figure 2).

A service type is expressed by a given type of:
- passengers (composition and individual weights)
- cabin arrangement (configuration)
- cargo (composition)
- holds (configuration) and by associated operational limits.

With the configuration code, the pilot can select the exact aircraft configuration associated with the actual conditions of the day and operate the aircraft within the optimal CG envelopes.

Then the pilot can select the crew, the catering or any miscellaneous items (a person on a jump seat, a spare part in a cargo compartment…) that are not included in the
commercial payload. Finally, the pilot recovers the dry operating conditions of his aircraft.

In the LOADING frame, the pilot enters the composition of the passengers on-board, the cargo and the fuel. It is possible to have double entry boxes to consider the payload in transit. All the checks against the maximum structural weights are performed and the underload is immediately provided: last minute changes can be entered immediately.

The PAYLOAD DISTRIBUTION frame displays a schematic diagram of the aircraft showing the distribution of the passengers and of the cargo in the aircraft (see figure 3).

The FUEL DISTRIBUTION frame displays the fuel weight in each tank according to the standard refuelling sequence. If this latter differs from the actual fuel quantity in the aircraft, the pilot can directly update it so that it agrees with the ECAM indications (see figure 4).

The pilot gets the results numerically and graphically. These have been checked against the operational limitations.

Interaction of the Weight & Balance Module with other modules will enable exchange of information. For instance, the performance limited maximum takeoff weight can be automatically set so that the aircraft is not loaded beyond this weight.

One important aspect of this module is that it is able to import directly the Weight & Balance data of the aircraft as well as the data linked to a given service type from specific files produced by the Load and Trim Sheet (LTS) software.

The LTS software is the optimal additional tool of the Less Paper Cockpit Weight Balance administrator but it is not mandatory. This programme manages the Weight & Balance data of the Airbus fleet. The administrator enters his own assumptions and defines the cabin layout thanks to a graphical interface. Then, LTS calculates the operational limits and all the loading and trimming information.
The Takeoff Module provides the takeoff performance of the aircraft based on the actual environmental conditions of the day just before the flight (see figure 5). This module provides the best takeoff performance for the given conditions.

For a given aircraft, the Takeoff Module will start with the characteristics of the selected aircraft registration number. A number of takeoff parameters will be modified within a frame. These parameters are reduced to a minimum and concern only those parameters that vary at every takeoff. They include outside air temperature (OAT), wind conditions, pressure altitude at sea level (QNH), flap settings, actual takeoff weight, bleeds settings, runway condition, engine option and CG position. An administrator within the airline will have already set the other parameters. The pilot will then select the runway from which takeoff is considered. If any specific comments are attached to a particular runway, these will be displayed to the pilots at runway selection on top of the display of the runway characteristics. Inoperative items, if selected, will be displayed on this takeoff screen.

After the input parameters are set, the computation is run. Takeoff data for the actual takeoff weight will be presented to the pilot (see figure 6). Customization of the results is possible depending on the choice of the airline. Either all possible flexible temperatures are displayed or just the maximum flexible temperature is displayed together with the performance for OAT. The selected flexible temperature and speeds can then be entered on the PERF page via the multi-purpose control and display unit (MCDU) of the aircraft.

The pilot also has the possibility to highlight a specific result line by opening the takeoff card. He can also obtain detailed computation outputs by pressing the appropriate key. Detailed results may display actual runway lengths used, different limiting weights, etc. This list is customized by the airline. The airline, via its administrator, is able to fully customise the Takeoff Module by the selection of the units, the V1 range, defining aircraft degradations among other possibilities.

One important aspect of this module is that the LPC Takeoff Module is able to share a common runway database with the Performance Engineers Programme (PEP) software. Indeed, LPC uses the same airport manager software to manage all runway data as does the PEP.
The Minimum Equipment List Module provides the pilot with a tool enabling electronic access to the MEL information. This set of information is being prepared by the airline administrator from the MMEL (Master Minimum Equipment List) and eventually completed by the AMM (Aircraft Maintenance Manual) digital data supplied by Airbus (optional) (see figure 7). The MMEL and AMM raw data are delivered by Airbus in SGML (Standardized Generalized Markup Language) format. To enable the use of the MMEL SGML data, the MMEL Starter Pack is made available. This software tool enables the conversion of the SGML data into either “FrameMaker+SGML” or RTF formats.

Once the data is converted, the airline administrator has the possibility to amend the information by using some off-the-shelf software such as “FrameMaker+SGML” (Adobe) or Word (Microsoft) and to create either a PDF or a paper version of the airline MEL. By using the FrameMaker version of the MMEL Starter Pack an additional feature is offered which provides the possibility to export the customized MEL data into a database. Once the database has been loaded with the MEL information, a generation tool enables the preparation of the MEL data for the MEL Module.

With regards to the Maintenance Procedures the airline administrator has two choices:
- The administrator creates the PDF version of the concerned tasks by using any off-the-shelf editor such as Word, FrameMaker, etc...
- The administrator uses the AMM SGML raw data to extract the concerned tasks and translates them into RTF format. At this stage the maintenance tasks may be amended to comply with some internal procedures. Of course this action is optional. Then with an additional tool the maintenance tasks are converted into PDF format to be integrated into the MEL consultation module.

Interface based on standard Web browser (see figures 8,9,10).

- Hyperlinks:
  - within the MEL
  - between the MEL and the associated Operational Procedures
  - between the MEL and the associated Maintenance Procedures
  - between the ECAM entry list and the associated dispatch condition in the MEL
- Access information from:
  - the ECAM Entry List sorted by ATA or alphanumeric
  - the MEL
  - the Operational procedures
  - the maintenance procedures
  - the airlines documents
The FCOM/OEB Module gives electronic access to the four volumes of the Flight Crew Operating Manual (FCOM) and to the associated Operations Engineering Bulletins (OEB) and Temporary Revisions (TR).

This module offers two modes of consultation (see figure 11): 

- The Stand-alone mode enabling the pilot to consult the Flight Operations information on his laptop.
- The Connected mode enabling the administrator to consult the Flight Operations information directly on the Airbus server. In addition to this possibility of accessing a full consultation environment, this mode is also used to update the Airline environment with the latest OEB and TR documents released after the CD-ROM publication. The administrator will mainly use this mode.

A CD-ROM containing the information related to:
- FCOM Vol 1, Vol 2, Vol 3, Vol 4,
- TR and OEB documents valid at the CD-ROM publication time, and complying with the Airline fleet is made available with the same revision cycle as the present one related to the paper.

In parallel, the Airbus Industrie server is updated with the same contents as the CD-ROM and any authorised airline end-users have access to this information.

Any new TR (see figure 12) or OEB released after publication of the CD-ROM is made available on the Airbus server. First this information is made available to the airline administrator. The duty of the airline administrator is to ensure that the OEB/TR is applicable to his fleet and to authorise access to this information for his end-users. It should be noted that the airline end-user does not have access to this information until the airline administrator provides the authorisation.

Then the airline end-user may consult this information and download it on his laptop to enable the Module to take into account this new OEBs and TRs and their links to the FCOM.
The possibility to distribute the TRs and OEBs is also made available through E-mail mechanisms (see figure 11). However, a piece of software will be required on the customer side to ensure the integrity of the communications.

The CD-ROM provided by Airbus Industrie is based on Airbus data. However, the airline administrator may prepare a customised package by including for example the airline Standard Operating Procedures (SOP) into the set of data prepared by Airbus.

The FCOM raw data is provided by Airbus Industrie in SGML (Standardized Generalized Markup Language) format. To enable the use of the SGML data, the FCOM Starter Pack is made available. This software tool allows the conversion of the SGML data into either “FrameMaker+SGML” or RTF formats. Once the data is converted, the airline administrator has the possibility to amend the information by using some off-the-shelf software such as “FrameMaker+SGML” (Adobe) or Word (Microsoft) and to create a PDF version of the airline specific piece of information (see figure 13).

With the "FCOM Navigation Tree Customisation" the airline administrator is in position to amend the FCOM tree structure. These changes take into account the airline specificity (airline information such as the SOP) and may correspond to the setup of some different views of the FCOM. Based on the same source of information, different structures of the FCOM are presented to the end user:

- Access by cockpit localisation
- List of valid OEB documents
- List of valid TR documents

(see figure 14,15,16)
Other Modules

At this stage some other modules are also foreseen. For instance, Airbus is evaluating an In-Flight Module which may provide high speed data, currently not available from the FMS. Details of computations are not fixed for the time being and all possibilities will be explored.

Hardware and software requirements

The required or recommended hardware and software are as follows:

Hardware
- Laptop 400 MHz Pentium Processor
- 128 Megabytes of RAM
- 2 Giga-byte hard disk
- 1 modem at 33600 baud
- 1 CD-ROM reader 11X speed
- 1 Display unit with following characteristics:
  - XGA TFT active matrix
  - 14” minimum
  - Resolution 1024 x 768 64K colors

Software
- Windows 95 or Windows NT (required)
- Netscape 4.7 browser or Microsoft Internet Explorer 5.5 (required)
- “Acrobat reader” Plug-in PDF format viewer (required)
- Plug-in able to display the graphics in TIFF/CCITTG4 format like

The following sites can be consulted for additional information:

www.TMSequoia.com
www.visionshape.com
www.cartesianinc.com
Prizm from TMSequoia has been adopted by Airbus for internal use.

Network
To access AOLS (Airbus OnLine Services) an access to one of the following Networks is required:
- AERONET (SITA)
- INTERNET (service provider to be selected by the airline).

Landing Module

This module will enable the pilot to determine the landing performance of the aircraft either before departure (flight planning) or at any time during flight. It gives the maximum weight corresponding to a given landing distance and accounts for the external conditions (OAT, wind, etc), and the technical status of the aircraft (inoperative items, bleed selection, etc) and runway conditions (runway state, lengths, etc). The pilot will also be able to retrieve operational data such as landing with autobrake and autoland (if data permits).

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Conclusion

Several airlines already use the Takeoff and the FCOM-OEB Modules. So far Airbus Industrie has received some encouraging feedback. On the performance side, some simulations have been conducted which show that the use of the LPC will lead to savings in the engine maintenance area. Another customer has highlighted potential safety improvements when consulting the Technical Information. This is a promising start which provides encouragement to continue with the development of the use of laptop computers so as to finally remove the need for paper in the cockpit.
Until now, curing fuel leaks has been a relatively difficult and time-consuming operation for operators and manufacturers alike. The methods available to speed up the curing time of the repair sealants have been with hot air blowing or heating lamps, neither method being very efficient. This article describes a new heating device based on catalytic combustion, which has been tested and qualified on all repair sealants recommended by Airbus Industrie.
**Introduction**

Fuel tanks in modern commercial airliners are principally housed in the wings, and the wing structure is also the fuel tank structure; there are no rubber tanks or other forms of inner walls within the wings. Wing structures are composed of large skin panels, dozens of ribs and stringers, and thousands of bolts and rivets covered with sealant to prevent fuel seepage (see photo 1). This structure is flexible, as anyone who has flown in turbulent weather will have noticed, as they watch the wing tips moving up and down. Eventually fuel seepage does occur and the leaks become evident on the outer surface of the skin.

The visible point of seepage is at the end of the leak path. An efficient repair requires the origin of the leak path (or paths) to be identified. When this is achieved, the area around the source of the leak has to be de-sealed before being resealed properly. However, in-service experience has shown that when fuel leak repairs are not successful, it is due to the two following major reasons: either because the fuel leak source has not been properly identified, or because the aircraft was refueled before the new sealant has reached an adequate state of cure.

Concerning the identification of the fuel leak source, Airbus has already addressed this issue with the helium technique (SIL 57-091, also described in FAST number 22 of March 1998). For the curing time of the sealant, as this is directly related to temperature and humidity level, in-service experience has shown that it is rarely respected.

**The innovative approach**

Airbus Industrie investigated several devices and methods to decrease the curing time of the repair sealant. Following a study made by the French Air Force with Sunkiss Aéronautique, Airbus Industrie investigated and selected the thermoreactor technology which is based on catalytic combustion. Therefore, new equipment using this technique has been developed to offer reliability and time saving. This is a great step forward compared to the methods used previously.

**The thermoreactor technology**

Combustion means conversion of the chemical energy of a combustible substance, such as gas, into heat. This is done by a complete or partial oxidation of the gas by air, the oxidizing element. The catalytic combustion allows complete combustion at a low temperature without any mixture between the gas and the air. The main advantage of this type of combustion is that it prevents any inflammability and is therefore completely safe. The Sunkiss Aéronautique thermoreactor is made of a catalytic support, which is composed of different materials including mainly platinum.
This support is exposed to a flow of propane gas. Then, the catalytic reaction starts and develops all over the catalytic element (see photo 2). The thermoreactor produces an infrared radiation between 2 and 10 microns. The main advantages of this new technique are based on the energy transfer and on the quality of the polymerisation. Figure 1 makes a comparison between the old technologies — warm air blower, electrical infrared source — and the thermoreactor.

The following graph gives an example of the typical time saving for PR 1422 B2 sealant. In theoretical conditions (25°C and 50% of Relative Humidity), the 35 shore A hardness is reached after 30 hours and the final hardness after 72 hours. When, using the thermoreactor, the 35 shore A level will be obtained after 2.75 hours and the sealant will be fully cured after 6 hours.

**Figure 1**

**Old and new technology: comparison between the old technologies - warm air blower, electrical infrared source - and the thermoreactor**

**Typical time saving for PR 1422 B2 sealant**
Airbus Customer Services has redefined the equipment to answer to its customers needs (with the inputs from some of its major operators). The basic equipment is today composed of two boxes (see figure 2). One box is dedicated to the supply of gas. The other one contains all the control equipment, which allows the operator either to select one of the sealants proposed and qualified by Airbus Industrie, and therefore no additional data is requested, or to introduce the specific data linked to a different sealant. These boxes have been designed for easy transportation.

In addition, other options, such as a trolley to transport them around the maintenance facility are proposed by Sunkiss Aéronautique.

**Figure 2**

The Sunkiss Aéronautique Thermoreactor:

Today, Airbus Customer Services has redefined the equipment now composed of two boxes, one for the supply of gas and the other one for the control equipment.

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**Conclusion**

Conventional methods for curing fuel leak repair sealants are now becoming obsolete. The thermoreactor technology has been tested and qualified on different sealants. It is now the most efficient method to cure sealants used for repair of fuel leaks. It is cost effective as it significantly reduces the aircraft downtime.

In addition, it has been demonstrated on several aircraft that this technology, used in combination with the helium technique for fuel leak source detection – SIL 57-091, can reduce a conventional fuel leak repair from 5 days to 2 days. Airbus Industrie recommends that operators use this equipment which is described in SIL 57-096 and is applicable to all Airbus aircraft types.

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WORLDWIDE AIRBUS CUSTOMER SERVICES

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In a nutshell...

JUST HAPPENED...

A319/A320/A321 Technical Symposium,
Sevilla, Spain, 5-8 December 2000

The purpose of this conference was to discuss and share views between the operators and Airbus Industrie about the technical status on the A320 family in service fleet. The agenda had been prepared with a large amount of input from all operators and resulted in more than 40 dedicated presentations and fruitful discussions. Social events and side discussions involving Airbus Industrie Program and Customer services top executives as well as major suppliers added to the overall success of this symposium. The airlines’ feedback was very positive and Airbus Industrie committed themselves to another symposium two years from now. Questions & answers and presentations are available on CD-ROM.

Regional Operational Liaison meetings and Human Factors Symposiums in 2000

In 2000 we continued our intensive dialogue with our customers, by having seven regional operational liaison meetings on different subjects as well as two human factors symposiums.

For the A300/A310 family two events took place in Prague and Seoul. The A320 family was the subject of the programs in Sevilla and Gatwick; the A330/A340 operational meeting was held in Lisbon. General topics related to the Fly-by-wire technology were covered at conferences held in Bangkok and Phoenix. The Human Factors conferences were in Melbourne and Aspen. The content of all the conferences is available on CD-ROM.

COMING UP...

11th Performance and Operations Conference
Puerto Vallarta, Mexico
26 – 30 March 2001

The preparation for the conference including input from our customers is already in progress. During three and a half days the program will cover briefings of our new products the A318, A340-500/600 and the A3XX as well as an update of key operational items. Furthermore all participants will be briefed on the latest Airbus Safety Initiatives. Separate sessions are organized to cover operational aspects of the Fly-by-wire and the A300/A310 aircraft family. Dedicated sessions will focus on aircraft performance and flight operations documentation. Throughout the whole conference different demonstrations will take place, such as for the ‘Less Paper Cockpit’ (LPC) and the Line Operations Monitoring System (LOMS).

A300/A310/A300-600 Technical Symposium,
Munich, Germany
11-15 June 2001

More than 100 operators worldwide are still flying over 700 aircraft from the first Airbus widebody generation. As usual, all operators have been asked to provide us with topics of specific interest in order to establish the program accordingly. Issues such as the problems of aging aircraft and the goal for extended design service will be key points in the final program. Input forms are available from your local Resident Customer Support Manager or they can be requested from the engineering department in Toulouse.

NEW SERVICES...

Airman 2000

Airbus Industrie has developed a new software tool, called Airman 2000, which will increase the efficiency of aircraft maintenance. This software package is to be used by ground personnel, permitting real time access to the onboard maintenance data while the aircraft is still in flight. All necessary maintenance actions can be therefore prepared before the aircraft arrives. With this new troubleshooting tool you will save time and money and maximize the actual flying time of your fleet in a safe environment.

AOLS

After a successful pilot phase, in July 2000 Airbus introduced the Airbus On-Line Services. 19 airlines are already connected, within this number there are 450 certificates for different end users. Ten services are presently in operation. The range of services goes from access to the Airbus drawings, the consultation/download capability of the Flight Crew Operations Manual, up to the quarterly in-service data as well as supplier information and agreements. A broad range of other services, such as the AMM and IPC in PDF format are coming soon.

Please send any requests for brochure(s) and/or CD(s)
by fax (+33) (0)5 61 93 47 73