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THE FIRST AVIATION REGULATION?

RESIDENT CUSTOMER SUPPORT REPRESENTATION

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In an earlier article "Hydraulic system - Working practices" (FAST N°13), some fundamental working practices were detailed, aimed to reduce the number of leaks. Since then, a dedicated monitoring programme has been launched and working groups formed to further minimise the occurrence of leaks. The purpose of this article is to provide guidelines for maintenance personnel to reduce the frequency of leaks even further.

**HYDRAULIC SYSTEM**

Preventing leaks

There are three aspects to be considered when looking for the causes of leaks:
- design,
- control of quality in production,
- maintenance.

Only the manufacturer can do something about the first two items and Airbus Industrie is continually studying how repetitive defects can be eliminated from the system either by changing the design, the supplier and/or the production process (Figure 1).

**DESIGN**

Part of the designer’s work is to make the maintenance interventions, scheduled and unscheduled, as infrequent as possible, and the maintenance practices as simple as possible. The Technical Design Directives for the hydraulic system, written originally for the A300, are largely still applicable, however there have been some changes such as the greater use of titanium piping which is lighter than stainless steel and less prone to pin-hole corrosion; the generalised use of flareless fittings; installation of built-in Hydraulic System Monitoring Units and the qualification of new fluids and methods of repairing pipes.

Further work is being done to enhance the built-in test and monitoring capabilities of the system allowing easier and more accurate maintenance interventions as early as possible in the degradation sequence.

**QUALITY IN PRODUCTION**

Computer aided design and manufacturing of pipes have greatly improved the quality of the installation of pipe runs particularly in areas having many pipes with multiple bends in close proximity. The improved installation allied with:
- respect of torque values and proper tightening methods,
- stress free installation,
- seal installation with lubricants
- use of dedicated tools, all lead to trouble free installations.

The Airbus Industrie Process Specification (AIPS) sets the standards for production and installation of the hydraulic systems for all the Airbus aircraft.

One area where manufacturer and operator have to be particularly vigilant is in the inadvertent acquisition of "boilgus" parts that do not always conform with basic quality standards. Hydraulic systems have been known to suffer from the installation of these parts, particularly seals, which has led to reinforced audits at vendors and information being transmitted to the operators through the Service Information Letter (SIL 29-064).

**MAINTENANCE**

Maintenance can be divided into two groups - preventive and corrective.

**Preventive maintenance**

In the Maintenance Planning Documents (MPD) there are scheduled tasks which are defined to ensure hydraulic system integrity and avoid leaks. These tasks are found in the Zonal Inspection Programme under System checks (typical defects are shown in Figures 2 to 6).

**Zonal inspection programme**

The zonal programme asks for visual inspection of various aircraft systems including the hydraulic system, at various locations (wheel well bay, under floor, engine pylons, wing trailing edge etc). It is during the visual inspections that anomalies can be identified and corrected, such as:
- presence of seepage (Figure 2)
- loose or missing ties, spacers or clamp blocks, (Figures 3, 4, 6)
- damaged pipe-lines
- loose connections
- line chafing (Figure 6 and 7).

**System checks**

Some system checks are fundamental to ensure the system integrity and to prevent future damage. For instance, regular hydraulic fluid sampling to allow the operator to maintain the fluid quality within given limits (acidity level, chlorine and water content) and therefore avoid component erosion or corrosion. Moreover, as soon as components become eroded, internal leakage rates increase, fluid is laminated,
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system operating temperature increases which further degrades the fluid, increasing its acidity level. This never ending process will continue until affected components and fluid are changed as necessary. This example shows the prevention role of the systems checks required by the MPD both for mandatory tasks such as internal leak checks and economic tasks such as fluid sampling.

**Corrective maintenance**

For corrective maintenance to be effective and long lasting a certain level of basic maintenance training and knowledge of the specific aircraft are required. These requirements were detailed in the article in FAST 13. A video, poster and related documentation are available from the address at the end of this article.

Most leaks are discovered during line maintenance - on the walk-around, night stop or pre-flight checks - and they have to be corrected as quickly as possible. This may require the installation of a temporary repair kit rather than a permanent hydraulic tube repair requiring pipe manufacturing capability. In this case SIL 29-069 “Pipe repair kit” and SIL 29-067 “Hydraulic tubing repairs” provide useful information.

Other SILs providing related information on the various leak sources are:
- 29-032 for A300/A300-600/A310,
- 29-064 for A319/A320/A321,
- 29-066 for A330/A340.

**LEAK SOURCES Components**

A list of available and essential component improvements is provided in the dedicated SILs listed above. The embodiment of those product improvements on an attrition basis or through dedicated retrofit should provide a significant increase in system reliability.

Tracking of component reliability is necessary to meet on-condition/condition-monitoring maintenance requirements. For hydraulic systems it concerns the main components such as the engine driven pumps (EDP) and power transfer units.

There is evidence that those components, even when a proper overhaul has been performed, do not recover their full potential after the overhaul, which affects their long term reliability. Also, if a part such as an EDP valve block is not changed at the overhaul of the EDP, then it will accumulate many years of operation which may lead to natural damage, fatigue or corrosion.

This is an example of why tracking of component reliability may justify a need for a fixed time between overhaul (TBO), replacement of a part, or embodiment of a modification.

**Seals**

The keys issues for seal reliability are product manufacturing quality and proper installation.

**Manufacturing quality**

The product manufacturing quality has been recently at the focal point of in-service failures on the A330/A340 programs. (Refer to SIL 29-064). As a result, two vendors have been removed from the approved list of suppliers because of identified quality deficiencies on some of their products. Three other vendors (Le Joint Francais, Dowty U.K. and Parker) have been audited and their standard of manufacturing quality judged satisfactory.

**Installation**

Chapter 20 of the Aircraft Maintenance Manual recommends use of certain tools and provides other advice for proper installation of seals.

In the previous article in FAST it was stated that “Seals, O-rings and packing washers should be smeared with MCS-352 lubricant or hydraulic fluid”. It has recently been discovered that the application of MCS-352 on the threads of plug-in unions can have a negative effect, causing the seal to be squeezed and damaged (Figure 5).

For plug-in unions hydraulic fluid should be used as a lubricant.

**Pipes**

There are generally three origins of pipe failure:
- chafing,
- installation under stress,
- corrosion.

High quality of manufacture of the pipes allowing good installation can largely prevent these types of failures. A recent audit performed on all Airbus pipe production centres revealed that manufacturing processes and techniques are well adapted and controlled, with the use of:
- numerical controlled bending machines and improved knowledge of spring back effect,
- laser dimensional check for every individual manufactured pipe,
- chlorine free pipe cleaning,
- laser marking.

Compliance with installation rules will avoid chafing and pre-stressed installations. Design will also help

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**Figures**

- **Figure 2** Detection of typical fluid seepage by stains on talcum powder
- **Figure 3** Pipe clamping (spacer) loosening and moving
- **Figure 4** Detail of spacer loosening and moving
- **Figure 5** Effect of lubricant on plug-in union threads
- **Figure 6** Risk of chafing due to loose clamping
system operating temperature increases which further degrades the fluid, increasing its acidity level. This never ending process will continue until affected components and fluid are changed as necessary. This example shows the prevention role of the systems checks required by the MPD both for mandatory tasks such as internal leak checks and economic tasks such as fluid sampling.

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Compliance with installation rules will avoid chafing and pre-stressed installations. Design will also help...
with improved clamping definition (adjustable brackets) and dampening of pressure pulsation of pumps.

Aging affects the integrity of pipe installations (Figures 3 to 7) justifying the importance of periodic inspection checks such as in the zonal inspection. Typical aging effects are:

- reduced efficiency of clamp blocks due to loosening, wear or damage,
- corrosion development (exposure to contaminants such as saline atmosphere, spillage from toilets),
- damage to pipe surfaces during maintenance.

**Pipe fittings**

Maintenance is a common source of leakage when loosening is due to under-tightening (often found on large fittings) and damage is due to over-tightening, generally found on aluminium fittings or small fittings and due to cracking from frequent loosening and tightening. The main development in fitting technology has been the introduction of more reliable flareless unions. However experience has shown that there is no substitute for systematic compliance with correct tightening procedures and use of the correct tools.

Airbus Industrie is studying more "damage tolerant" fitting designs such as Rosan (Figure 8) and alternative tightening techniques which can cope with vibration and a maintenance environment where use of torque wrenches is not common practice.

**CONCLUSION**

Lubricant MCS-352 should not be used on the threads of the plug-in unions. Although the hydraulic leak rate on a fleet-wide basis is approaching a satisfactory level it can and will be improved. Further efforts by Airbus Industrie and the vendors to improve hydraulic system reliability together with preventive maintenance actions applied by operators when necessary and proper application of procedures, will keep the hydraulic leak rates within an acceptable level. For this purpose, customers' feedback on in-service experience is vital.

Airbus Industrie will assist any operator suffering from a perceived excessive leak rate to initiate a leak preventive programme. This programme has been successfully implemented by a number of operators one of whom experienced a reduction in leak rates by 50%.

For further information please contact:
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Figure 8
Rosan fitting definition: union and port

Adapter
Locking
O-Ring
Serrations

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Fuel tanks in modern commercial aircraft are housed principally 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 a sealant to prevent fuel seepage (Figure 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 (Figure 2a) and an efficient repair requires that the origin of the leak path (or paths) is identified and properly sealed. If not, there is a high risk that the leak will appear again, and quite often it does.

**THE INNOVATIVE APPROACH**

Airbus Industrie investigated several leak path detection methods and has selected and developed a new detection technique using helium as a tracer gas to allow easier detection of the source of the leak (Figure 2b).

This technique, which was developed in cooperation with two companies, Helitech and Varian, and with the support of different maintenance centres and airlines, was the only one which offered the required sensitivity and reliability, and is a great step forward compared to the methods used previously.

**THE HELIUM TECHNIQUE**

Helium is a non-toxic inert gas which does not react chemically with any other element, making it intrinsically safe. In addition, due to its small relative molecular mass, it has a high penetration capability allowing it to pass through the smallest gaps. Helium is particularly interesting for this leak detection task because of its low concentration in the atmosphere (five particles per million) which allows easy detection of any small increase in this proportion. Finally it is an industrial gas available anywhere in the world.

Pressurised helium is already used in Airbus production lines to test for leaks. The leak is visually located externally (Figure 3) and the source is identified internally by creating a compression chamber around the leak point (Figure 4) and filling it with helium under pressure thereby forcing the helium back up the leak channel into the fuel tank.

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**Figure 1**
Wing structure (typical)

**Figure 2**
Different phases of detection method

2a Identification of leak 2b Use of helium gas as tracer gas

**Figure 3**
Example of visual location of fuel leaking from flap track forward attachment lug

**Figure 4**
Example of artificial compression chamber around the lug shown on Figure 3
Fuel tanks in modern commercial airliners are housed principally 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 a sealant to prevent fuel seepage (Figure 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 (Figure 2a) and an efficient repair requires that the origin of the leak path (or paths) is identified and properly sealed. If not, there is a high risk that the leak will appear again, and quite often it does.

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The procedure must start with a clear mapping of the fuel leak on the outer surface of the tank (precise leak location and approximate leak rate) then the tank can be defuelled, drained and vented until it becomes completely dry. Before entering the tank, all the safety checks have to be performed to ensure adequate ventilation and acceptable fuel vapour concentration.

An artificial compression chamber (Figure 5a) over the leaking area has to be created. This is simply done by penetrating one corner of a plastic bag with the rubber hose from the helium supply and sealing the join with sealant and aluminium tape. The open end of the plastic bag is attached to the skin of the wing around the leak, also by aluminium tape. This simple method can be easily adapted to awkward situations as shown on page 7 where the leak is from a flap track attachment fitting. This artificial chamber must be able to withstand a maximum internal pressure of 200 mbar. When this has been done, the helium injection can start at a constant pressure. The initial pressure choice depends on the kind of leak (rate, location) and must be based on knowledge of the structure and potential leak paths. Then the jet of helium being forced into the tank has to be found. By moving the detection "sniffer" (Figure 5b) probe inside the tank, there will be various sound frequencies emitted by the detection device depending on how far the probe is from the jet of helium (and the origin of the leakage). During this operation, it could be necessary to increase the injection pressure. It should not be forgotten that more than one leak may exist in the same area. Therefore it could be necessary to repeat this operation several times. In this case it is recommended to vent the area between two detection operations.

The artificial compression chamber should not be removed, because when the repair has been performed it can be used to check, in the same way, the quality of the repair. This will prevent re-fuelling and de-fuelling of the tank if the quality of the repair is not acceptable.

**CONCLUSION**

Conventional methods for detecting fuel leaks are now becoming obsolete. This helium technique has been tested and fine-tuned on several aircraft. It is now the most efficient and reliable method of identifying fuel leak sources. It is cost effective as a much lower number of manhours are required to cure fuel leaks and it reduces significantly the aircraft downtime. In addition it also confirms the integrity of the repair, avoiding the use of fuel. This operation alone can easily save four days of ground time.

Airbus Industrie highly recommends that operators apply this procedure, which is described in SIL 57-091 applicable to all Airbus aircraft types.

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The International Regulatory Climate is a continually changing environment but there is an overall major purpose to promote an enhanced air safety environment for the travelling public, without unreasonably increasing the regulatory burden on the Authorities, the manufacturers and the operators. The main theme to be remembered, and from time to time we need to be reminded, is that we are all aiming at the same target - safe, reliable, cost effective air transport. Associated with this theme is an essential need to create a working environment of confidence, and positive technical relationships between all involved parties.
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**THE INTERNATIONAL REGULATORY CLIMATE**

Andrew S. McClymont, Director Certification Strategies, Product Integrity, Airbus Industrie

International cooperation on civil aircraft regulations and certification has been in existence to some extent, initially a small extent, for more than 50 years. It has been increasing in recent years as Europe slowly draws together many diverse national bodies to create a single Joint Aviation Authority to act on behalf of each European country member. At the same time, the level of cooperation on both sides of the Atlantic and with other regions of the world is also increasing in a manner which should - in the long term - achieve a practical worldwide certification process and an improved overall safety regulation system.

That ideal is some way ahead, but is becoming a possibility for aircraft airworthiness certification, if political restraints and perceived sovereignty protection policies can be avoided. It may take longer for operational “control” to reach such a common goal. We need to persuade the politicians to support our justifiable intentions for the overall benefit of all. See the following article on JAR-OPS.

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**Figure 5**

Detection phases

5a Inletion

INSIDE

Fuel tank

Skin

Artificial compression chamber taped over external leaking point

OUTSIDE

Helium injected into the chamber

5b Detection

INSIDE

Fuel tank

Skin

Leak source detected by helium detector nozzle “sniffer”
There are, or have been, two normal types of aircraft certification exercises - the basic domestic certification under the general control of the Authority of the State of Design and Manufacture and then the validation of that basic certification by other countries.

The validations have tended to look at acknowledged differences in the regulatory standard between the domestic Type Certification Basis and the required Certification Basis of the validating or importing country.

This additional certification/validation work programme, with the implication of possible design changes to the aeroplane, is a major burden to the manufacturer, particularly when a number of countries have significant national differences. Regulatory differences have in the past caused some expensive design changes with questionable cost-effective safety benefit.

Harmonisation of regulations and procedures - The Airbus experience

Harmonisation of regulations and procedures has been a major target of joint work both in Europe and across the Atlantic.

As a result of strong Industry pressure both in Europe and in North America, it has been possible to make progress in harmonising the various airworthiness standards in order to reduce significant differences in regulations (Figure 1). Taking the European scene as an example, this problem of national differences was behind the early attempts to create Joint Aviation Requirements (JAR) as a common set of regulations. Unfortunately, they were in the beginning, not very common, because a large number of National Variants were included, to meet long held basic certification standards which some countries were not prepared to give up.

Although the JAR 25 large transport aeroplane design regulations were originally based on the FAR 25 North American format, all the National Variants raised defined differences.

However, it is well worth remembering that no Authority should be implementing a regulation which cannot be sensibly and acceptably justified. That point should of course be part of every new rule proposal justification. It is more difficult later to remove a regulation which might no longer be justifiable for the original reasons.

Harmonising regulations and procedures - The Airbus experience

HARMONISATION OF REGULATIONS AND PROCEDURES

Harmonisation of regulations and procedures has been a major target of joint work both in Europe and across the Atlantic.

As a result of strong Industry pressure both in Europe and in North America, it has been possible to make progress in harmonising the various airworthiness standards in order to reduce significant differences in regulations (Figure 1). Taking the European scene as an example, this problem of national differences was behind the early attempts to create Joint Aviation Requirements (JAR) as a common set of regulations. Unfortunately, they were in the beginning, not very common, because a large number of National Variants were included, to meet long held basic certification standards which some countries were not prepared to give up. Although the JAR 25 large transport aeroplane design regulations were originally based on the FAR 25 North American format, all the National Variants raised defined differences.

However, it is well worth remembering that no Authority should be implementing a regulation which cannot be sensibly and acceptably justified. That point should of course be part of every new rule proposal justification. It is more difficult later to remove a regulation which might no longer be justifiable for the original reasons.

THE PRESENT DAY STATUS

Harmonisation of JAR 25 and FAR 25

Creation of a joint European/American process

Deletion of national variants

Harmonised JAR 25 and FAR 25

Creation of Joint certification in Europe

Separate certifications

Joint certification

National variants

FAR 25

JAR 25

National Requirements

1974

1983

1988

1992

1993

The future

Each participating country defines its own “legal” standards and notifies ICAO, and all other participating countries, how they enable (or accept) compliance to be achieved with the International Standards. In fact, the normal process is to formally notify defined non-adherence or non-compliance with specific ICAO recommendations in each country’s internal legal “package” of regulations. But this “flexible” way of behaving creates the possibility of varying interpretations of regulations, because many countries are not prepared to give up sovereignty, or legal control of their own regulations.

Some of the ICAO-SARPs are quite general in content and leave some room for national interpretations. There is also a problem to be addressed because a few countries claiming that they comply with the ICAO SARPs have in fact not structured aviation authority and no related national regulations.
There are, or have been, two normal types of aircraft certification exercises - the basic domestic certification under the general control of the Authority of the State of Design and Manufacture and then the validation of that basic certification by other countries.

The validations have tended to look at acknowledged differences in the regulatory standard between the domestic Type Certification Basis and the required Certification Basis of the validating or importing country.

The additional certification/validation work programme, with the implication of possible design changes to the aeroplane, can be a major burden to the manufacturer, particularly when a number of countries have significant national differences. Regulatory differences have in the past caused some expensive design changes with questionable cost effective safety benefit.

Harmonisation of regulations and procedures has been a major target of joint work both in Europe and across the Atlantic.

As a result of strong Industry pressure both in Europe and in North America, it has been possible to make progress in harmonising the various airworthiness standards in order to reduce significant differences in regulatory requirements. Taking the European scene as an example, this problem of national differences was behind the early attempts to create Joint Aviation Requirements (JAR) as a common set of regulations. Unfortunately, they were in the beginning, not very common, because a large number of National Variants were included, to meet the long held basic certification standards which some countries were not prepared to give up. Although the JAR 25 large transport aeroplane design regulations were originally based on the FAR 25 North American format, all the National Variants raised defined differences.

Harmonisation of regulations and procedures - The Airbus experience

It was through the principles and activities of the International Civil Aviation Organization (I.C.A.O.) that guidelines were produced in an attempt to create common technical standards in all aspects of air transport regulation. These internationally accepted guidelines, defined in the technical ICAO Annexes, provide the basic principles to enable the air transport industry to operate safely, reliably, regularly and legally.

The broad objectives from the December 1944 Chicago Convention on International Civil Aviation were:

- Safe and orderly development of International Civil Aviation.
- Sound and economical operation for International Air Transport Services, and equality of opportunity.

These objectives remain valid today, providing the background to the defined rules, regulations and requirements which are the basic roots of the flight safety levels achieved in the air transport industry.

There are more than 180 contracting states associated with ICAO, and its Air Navigation Commission, and there are 18 ICAO Annexes covering the relevant Standards and Recommended Practices (SARPs).

It is the word "recommended", however, which creates some of the long term problems associated with the implementation of these ICAO SARPs - these "International Standards". Each participating country defines its own "legal" standards and notifies ICAO, and all other participating countries, how they enable (or accept) compliance to be achieved with the International Standards. In fact, the normal process is to formally notify defined non adherence or non compliance with specific ICAO recommendations in each countries' internal legal "package" of regulations. But this "flexible" way of behaving creates the possibility of varying interpretations of regulations, because many countries are not prepared to give up sovereignty, or legal control of their own regulations.

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The Industry wishes to see the new European Aviation Safety Authority in place by the year 2000. Meanwhile there is a continuing need to maintain dialogue and improve working arrangements between the major aviation safety control organisations across the world. There are signs of progress in this field with the conclusion and actions coming from the 13th and 14th Annual FAA/JAA/TCA and Industry Harmonisation Conferences held respectively in San Diego in June 1996 and in Berlin in June 1997.

The Future Prospects

The International Regulatory Climate is a variable environment. The principles of harmonised regulation and harmonised joint certification processes, acceptable to all, are a proper ideal to strive for in the civil aviation safety scene. We need to maintain the effort to reach the ideal in spite of some unexpected setbacks. The main way to continue to make progress is to talk together and work together in a cooperative and open manner.

The “getting together” in Europe is being promoted both by Industry (manufacturers and now gradually the operators) and most of the NAAs of the JAA. The major problem is how to create a single legal entity with the relevant powers to act on behalf of all the members. The main feature to resolve is the formal handing over of sovereignty for aviation safety matters by the members governments, or safety bodies. There is also the question of covering the costs of a European Aviation Safety Authority.

Recent discussions reviewed a possible legal treaty or convention with relevant connection to the European Union; the EU being the appropriate European political body overseeing the administration by the European Commission. There are legal difficulties to be resolved but generally there is a growing intent to see it happen and eventually the political will to make it happen will be there. The first signs of political commitment were seen at the European Council of Ministers in December 1996.

The regulations do need to be harmonised to an acceptable level before the implementation of joint procedures agreed across the Atlantic, can really result in the easing of the certification burden on manufacturers, by having one single certification process on behalf of all Authorities.

The Type Certificates for the A30

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The Industry wishes to see the new European Aviation Safety Authority in place by the year 2000. Meanwhile there is a continuing need to maintain dialogue and improve working arrangements between the major aviation safety control organisations across the Atlantic, like the FAA/JAA/TCA and Industry Harmonisation Conferences held respectively in San Diego in June 1996 and in Berlin in June 1997.

The Industry and the Authorities have looked into a major problem which has arisen regarding the depth of involvement expected to be undertaken by an airworthiness certifying authority in certifying an aircraft, and have proposed a new concept regarding this problem which is worthy of serious consideration.

The Safety Regulation Codes of FAR 25 and JAR 25 provide generally equivalent levels of safety. The large Regulatory Harmonisation programme which started 5 or 6 years ago, under ARAC, was a good principle to follow, but it has become very costly and time consuming in terms of Industry and Authority manpower resources. A more efficient way to meet the general need for harmonisation has to be found.

A new idea on how to handle this growing concern emerged, after some hard talking between and within the Authority and Industry group. It starts from the general view that the two codes are similar in concept although not necessarily identical in regulation or interpretation in all aspects. It should therefore be possible to consider each code “equivalent”, and a Type Certification based on one code

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**Figure 2**

JAA and European organisations

<table>
<thead>
<tr>
<th>European Civil Aviation Council (ECAC) (36)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Armenia</td>
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<tr>
<td>Bulgaria</td>
</tr>
<tr>
<td>Czech Republic</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>Eurocontrol (23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyprus</td>
</tr>
<tr>
<td>Slovakia</td>
</tr>
<tr>
<td>Turkey</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>European Union (EU) (15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
</tr>
<tr>
<td>Germany</td>
</tr>
<tr>
<td>Luxembourg</td>
</tr>
<tr>
<td>Sweden</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>European Free Trade Area (EFTA) (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iceland</td>
</tr>
</tbody>
</table>

"Heavy" process. The relationship between the JAA and other European organisations is shown in Figure 2.

The harmonisation between Europe and the Western side of the Atlantic is taking its time also. In 1989, a target was declared at the annual JAA /FAA/Transport Canada and Industry joint meeting in Bordeaux, to go for major harmonisation of the FAR 25 and JAR 25 regulations. At about the same time, the US Government, through the FAA, set up their Aviation Rulemaking Advisory Committee (ARAC) structure and invited participation from Canadian and European Authorities and Industry.

After a slow and difficult start, at least in the tasking of the ARAC Transport Aeroplane and Engines Issues Group, the review work and the attempts to reach consensus conclusions have produced some productive results, notably in flight and structures regulations. In other subjects such as cabin safety, there has been little or no consensus and some difficult decisions will have to be taken eventually by the Authorities.

There is a general concern that in spite of all the significant resources put into the ARAC process by both Industry and Authorities, the lack of productive agreed progress in many areas will reduce Industry commitment, and may eventually fail to achieve the original good harmonisation ideal. But by including Industry at a suitable early stage of the review, and in the drafting process, there ought to be less Industry opposition to the final proposed regulatory product.

The regulations do need to be harmonised to an acceptable level before the implementation of joint procedures agreed across the Atlantic, can really result in the easing of the certification burden on manufacturers, by having one single certification process on behalf of all Authorities.

**THE FUTURE PROSPECTS**

The International Regulatory Climate is a variable environment. The principles of harmonised regulation and harmonised joint certification processes, acceptable to all, are a proper ideal to strive for in the civil aviation safety scene. We need to maintain the effort to reach the ideal in spite of some unexpected setbacks. The main way to continue to make progress is to talk together and work together in a cooperative and open manner.

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should in principle be acceptable to countries normally using the other code. With that principle in mind we can concentrate the harmonisation work on key subjects where known differences in regulatory implementation are causing undue burden to industry, without any relevant safety benefit.

This proposal needs careful consideration by all parties before implementation. A very tight time schedule was proposed in 1996 to review and implement the details, and real progress was achieved in June 1997, with the joint agreement to two principle documents defining the future way ahead.

SAFETY OVERSIGHT

The interests of a growing number of countries, or groups of countries, in the world aviation safety scene are also being addressed. This fact, and the recent aggressive FAA policy regarding safety oversight, demonstrate the need to promote further aviation safety initiatives in a coordinated global fashion. Increasing interaction between ICAO and Member States is required, and is happening, to achieve such progress in a practical and controlled manner.

A number of regional aviation safety seminars have been, and are being, organised in various parts of the world, supported by the recognised safety bodies, and by manufacturers and operators and authorities. These initiatives and events provide opportunities for improving safety awareness by communication and dialogue within and between all involved parties.

As a model for the creation of a regional aviation safety organisation meeting the intent of the ICAO principles, the example of the European JAA, and its future evolution into a single authority acting on behalf of all European countries, can be offered. It shows how large and small countries can work together for a common cause. There is already a large body of recently harmonised regulatory material covering all aspects of safety regulation, which will soon also be available in different languages.

Positive progress, using the European example, is taking place among the countries of South Asia, and also in the Caribbean and in South America. Recent increases in ICAO activity and influence in these matters are welcomed.

CONCLUSION

Enhancement of the present aviation safety levels must be achieved in the coming years to meet the increasing volume of air transport traffic with a reduction in the actual accident numbers, in order to maintain public confidence in this major productive industry. Continuing worldwide cooperation to ameliorate the International Regulatorly Climate is essential to improve safety. Airbus Industrie is an active participant with the airworthiness authorities in the effort to achieve that aim.

(*) Austria, Belgium, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Monaco, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom
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Go-around gradient for decision
heights below 200 ft

JAR-OPS formally requests the operators to take into account the one-engine inoperative cruising speed according to the Airplane Flight Manual (AFM). This speed (green dot speed / drift inf speed) is given in the Flight Crew Operating Manual (FCOM), and in the performance chapter of the AFM or in the OCTOPUS performance computation program where AFM refers to this software (A319/A321/A330/A340). This speed has to be used to adopt obstacle strategy.

When obstacles are not a concern, any other one engine-out speed published in the FCOM or computed through the In Flight Performance (IFP) program may be used.

- for takeoff: Special Operations chapter and fluid contained runways section
- for landing: Landing chapter.

For JAR 25 certified aircraft (A319/A320/A321/A330/A340), these performance are certified. Therefore they are also published in the AFM by reference to TCL for A320 and OCTOPUS for the other models.

**One-engine inoperative cruising speed**

**JAR-OPS L195**

**Selection of aerodrome**

For takeoff alternate airport selection, JAR-OPS requires the operator to take into account the one-engine inoperative cruising speed according to the Airplane Flight Manual (AFM). This speed (green dot speed / drift inf speed) is given in the Flight Crew Operating Manual (FCOM), and in the performance chapter of the AFM or in the OCTOPUS performance computation program where AFM refers to this software (A319/A321/A330/A340).

If the takeoff performance computed using the AFM is less than the one-engine inoperative cruising speed published in the FCOM or IFP, the FCOM can be used to take into account the one-engine inoperative cruising speed published in the FCOM.

Regarding allowance on the flight path:
- Climb gradient corrections due to bank angles are given in the AFM Performance chapter.
- The OCTOPUS program can compute real takeoff performance taking the turn into account. No further climb gradient correction need be introduced.

Regarding allowance on the operating speeds, JAR-OPS proposes a calculation method when the aircraft manufacturer does not provide the appropriate data. However Airbus Industrie proposes a calculation method calculated as follows:

**Takeoff line-up distance**

**JAR-OPS L190 (c)(6)**

As per JAR-OPS, the operator must take into account the one-engine inoperative takeoff performance in the Takeoff Safety Training Aid and in the Performance Programs Manual (PPM).

Regarding takeoff performance computation, the AFM or OCTOPUS programs have all the options to take into account any line-up distance chosen by the operator.

**Takeoff obstacle clearance in turn**

**JAR-OPS L195 (c)**

During takeoff, aircraft may be banked by no more than 15° up to 400 ft, then up to 25° when above 400 ft. The NPA published in December 1996 proposes to allow, under specific circumstances, bank angles of 20° above 200 ft and 30° above 400 ft. This speed has to be used to adopt obstacle strategy.

In any case JAR-OPS requires a comprehensive detailed and structured list of all items to be covered in the Operations Manual.

**Implementation of JAR-OPS 1**

**Applicability**

JAR-OPS 1 requirements are applicable to the operation of any civil aircraft for the purpose of commercial air transportation by any operator whose principal place of business is in a JAR Member State. Therefore in the JAA Member States, JAR-OPS 1 applies to all airplanes regardless of date of manufacture. In addition some non-European states are adopting JAR-OPS 1.

**JAR-OPS must be implemented no later than 1 April 1998**

For the A300 and remaining A310s, the information will be available in the FCOM by 1st April 1998.

A summary of the various data sources for specific JAR-OPS requirements is shown on the table above.

**Operations Manual**

JAR-OPS 1 200 Operations Manual: "An operator shall provide an Operations Manual in accordance with Subpart P for the operation of its aeroplanes under JAR-OPS and insert "Not applicable" or "Intentionally blank" where appropriate.

- Part A: General/Basic
  - "This part shall comprise all non type-related operational policies, instructions and procedures needed for a safe operation and shall comply with all relevant regulations."

Airbus Industrie developed an Operations Policy Manual that may be produced by Airbus operators as a guide to produce this Part A of their own Operations Manual. It was issued to all Airbus customers in Malaga during the 9th Performance and Operations Conference in June 96. It is also available on diskette from the author.

The structure and the technical content of the Operations Policy Manual developed by Airbus Industrie aimed to fulfill the requirements of the JAR-OPS manual in the first version of the JAR-OPS.

**Support**

- Airbus can assist any customer to determine operational procedure and take-off performance when high bank angles are required at takeoff.

- GO-AROUND GRADE FOR DECISION HEIGHTS ABOVE 200 FT

For instrument approaches with decision height above 200 ft, JAR-OPS requires a minimum go-around climb gradient of 2.5%, or the published gradient, whichever is the greater. Relevant information is already available in the AFM of the A320, as well as for some A310s and for A319/A321/A330/A340 through the OCTOPUS program. It will be introduced in the FCOM as soon as possible.
Data source for specific JAR-OPS performance requirements

<table>
<thead>
<tr>
<th>One-engine inoperative cruising speed</th>
<th>A300B2 / B4</th>
<th>A310 / A300-600</th>
<th>A320</th>
<th>A330 / A321 / A330 / A340</th>
</tr>
</thead>
<tbody>
<tr>
<td>Takeoff line-up distance</td>
<td>FCOM</td>
<td>TLP/FCOM</td>
<td>TAB/TLC/FCOM</td>
<td>OCTOPUS/FCOM</td>
</tr>
<tr>
<td>Takeoff obstacle clearance in turn</td>
<td>AFCM</td>
<td>OCTOPUS/PPM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Go-around gradient for decision</td>
<td>FCOM</td>
<td></td>
<td>PPM</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>heights below 200 ft</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FCOM: Flight Crew Operating Manual</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OCTOPUS: Operational and Certified Take-Off and landing Performance Universal Software</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TAB: Takeoff Chart Computation program</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TLP: Takeoff and Landing Chart program</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>OCTOPUS: JAR-OPS 1.1045 General Rules for Operations Manuals:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

JAR-OPS 1.200 Operations Manual: "An operator shall provide an Operations Manual in accordance with Subpart P for the use and guidance of operations personnel."

JAR-OPS 1.300 General Rules for Operations Manuals: "An operator shall ensure that the Operations Manual contains all instructions and information necessary for operations personnel to perform their duties."

Regarding allowance on the flight path:

- Climb gradient corrections due to bank angles are given in the AFCM Performance chapter.
- The OCTOPUS program can compute real takeoff performance taking the turn into account. No further climb gradient correction needs to be introduced.
- Regarding allowance on the operating speeds, JAR-OPS proposes that unless otherwise specified in the Aeroplane Flight Manual or other performance or operating manuals from the manufacturer, an acceptable means of compliance to this requirement, is to add a 5k increment on V2 minimum speed for bank angles above 15° and 10kt for bank angles above 25° to assure adequate stall margin.

Studies show that there is no need to add any speed increment on V2 minimum for all Airbus aircraft for bank angles up to 20° and even up to 25° for most of Airbus aircraft. Therefore this information will be published in the Performance Programs Manual (PPM).

Airbus Industry Flight Operations Support can assist any customer to determine operational procedure and takeoff performance when high bank angles are required at takeoff.

Go-around gradient for decision heights below 200 ft:

For improved go-around gradient with decision height below 200 ft, JAR-OPS requires a minimum go-around climb gradient of 2.5°, or the published gradient, whichever is the greater. Relevant information is already available in the AFCM of the A320, as well as for some A310s and for A319/A321 (A300/A340) through the OCTOPUS program. It will be introduced in the FCOM as soon as possible.

For the A300 and remaining A310s, the information will be available in the FCOM by 1st April 1998.

A summary of the various data sources for specific JAR-OPS requirements is shown on the table above.

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JAR-OPS 1.300 General Rules for Operations Manuals: "An operator shall ensure that the Operations Manual contains all instructions and information necessary for operations personnel to perform their duties."

- Structure and contents
  - JAR-OPS 1 Subpart P "Manuals, logs and records" defines the general rules, structure and contents for Operations Manuals produced by the airlines.
  - JAR-OPS prescribes the structure of the Operations Manual in four part:
    - Part A: General/Basic
    - Part B: Airplane Operating Matters
    - Part C: Route and Aerodrome Instructions and Information
    - Part D: Training

Appendix 1 to JAR-OPS 1.1045 contains a comprehensively detailed and structured list of all items to be covered in the Operations Manual.

Since it is believed that a high degree of standardisation of Operations Manuals within the JAA will lead to improved overall flight safety, JAR-OPS strongly recommends that the structure described in the JAR-OPS Subpart P should be used by operators, as far as possible. Manuals which do not comply with the recommended structure may require a longer time to be accepted/approved by the authority.

To facilitate compatibility and usability of Operations Manuals by new personnel, formerly employed by another operator, JAR-OPS recommends operators not to deviate from the numbering system used in Appendix 1 to JAR-OPS 1.1045. If there are sections which, because of the nature of the operation, do not apply, it is recommended that operators maintain the numbering system described in JAR-OPS and insert "Not applicable" or "Intentionally blank" where appropriate.

- Part A: General / Basic
  - This part shall comprise all non-type-related operational policies, instructions and procedures needed for a safe operation and shall comply with all relevant regulations.

Airbus Industry developed an Operations Policy Manual that may be used by Airbus operators as a guide to produce this Part A of their own Operations Manual. It was issued to all Airbus customers in Malaga during the 9th Performance and Operations Conference in June 96. It is also available on diskette from the author.

The structure and the technical content of the Operations Policy Manual developed by Airbus Industry aimed to fulfill the requirements of the JAR-OPS manual.

With the evolution of JAR-OPS, a second issue is now under preparation.

The Airbus Industry Operations Policy Manual is made of the following chapters as prescribed by JAR-OPS:

- Administration and control of Operations Manual
- Organisation and responsibilities
- Operational control and supervision
The consequence of water ingress into the gearboxes in slat and flap actuation system is well known to aircraft operators. In the event of seal damage and because of the decrease in air pressure after take-off, air can escape from a gearbox. Then as the aircraft descends to land, humid air is sucked into the gearbox and condenses. This action is known as “breathing” and with time can cause a build-up of water content in the gearbox.

Until recently it has been difficult to carry out an analysis of the oil in the gearboxes to determine the degree of water ingress. It required a specialised person and a laboratory with specific equipment.

### Table: Weight Distribution

<table>
<thead>
<tr>
<th>Category</th>
<th>Adult</th>
<th>Children</th>
<th>Holiday Children</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>84 kg</td>
<td>35 kg</td>
<td>35 kg</td>
</tr>
<tr>
<td>Female</td>
<td>70 kg</td>
<td>69 kg</td>
<td></td>
</tr>
</tbody>
</table>

The Load and Trim sheet provided on request by Airbus Industrie is customised taking into account the passenger weight value defined by the airline.

### Conclusion

The operational documentation provided by Airbus Industrie to its customers already meets most of the JAR-OPS requirements. Airbus Industrie went even further by the production of an Operations Policy Manual which should help Airbus operators to build their own Operations Manual. This is another example of the continuous safety and support improvement that Airbus Industrie offers to its customers.
The technical content of the Airbus Industrie Operations Policy Manual is given for information only and is not approved by any authority. The information mentioned in it represents in some parts a strict application of requirements, elsewhere it includes guidelines or examples.

Although many parts of the Airbus manual may be used as they are or with minor amendments by an operator, it has to be customised to include specific airline policies, special organisation, area of operations and some detailed compliance and interpretative information which some Civil Aviation Authorities and industry organisations would like to see.

- **Part B: Aeroplane operating matters**
  - This part shall comprise all type-related instructions and procedures needed for a safe operation. It shall take account of the different types of aeroplanes or variants used by the operator.
  - The Flight Crew Operating Manual (FCOM) and Quick Reference Handbook (QRH) produced by Airbus Industrie may be used as they are or with minor amendments by an operator, it has to be customised to include specific airline policies, special organisation, area of operations and some detailed compliance and interpretative information which some Civil Aviation Authorities and industry organisations would like to see.

- **Part C: Route and aerodrome instructions and information**
  - This part shall comprise all instructions and information needed for area of operation.

- **Part D: Training**
  - This part shall comprise all training instructions for personnel required for a safe operation.

### Mass and balance (Subpart J)

- **Part A:**
  - The present Weight and Balance Manual provided by Airbus Industrie is not affected by JAR-OPS requirements. JAR-OPS gives a method to make statistical evaluation of passenger and baggage mass to be used for aircraft weight and CG determination. However, JAR-OPS also gives standard passenger mass values including hand baggage as follows:

<table>
<thead>
<tr>
<th>Category</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult</td>
<td>84</td>
</tr>
<tr>
<td>Child</td>
<td>35</td>
</tr>
<tr>
<td>Female</td>
<td>70</td>
</tr>
<tr>
<td>Male</td>
<td>88</td>
</tr>
<tr>
<td>Children</td>
<td>35</td>
</tr>
</tbody>
</table>

The Load and Trim sheet provided on request by Airbus Industrie is customised taking into account the passenger weight value decided by the airline.

- **Instruments and equipment (Subpart K)**
  - There are small differences in terms of instruments and equipment requirements between JAR-OPS and FAR. This greatly depends on equipment defined by the operator which are responsible for determining compliance with the regulation.

Airbus Industrie can provide assistance to operators in determining on a case by case basis, compliance of their aircraft instruments and equipment with JAR-OPS.

### Conclusion

The operational documentation provided by Airbus Industrie to its customers already meets most of the JAR-OPS requirements. Airbus Industrie went even further by the production of an Operations Policy Manual which should help Airbus operators to build their own Operations Manual. This is another example of the continuous safety and support improvement that Airbus Industrie offers to its customers.
FLAP AND SLAT JAMMING

The presence of more than 5% of water in the oil quantity in gearboxes can be disturbing because the water can freeze, causing increased torque in the drive system and perhaps causing it to jam. Water ingress also degrades the quality of the oil and can cause corrosion of the components. To date there has been a procedure to take a sample of the suspect oil but no practical tool to allow the mechanic to determine quickly the percentage of water. The analysis had to be done by a specialist in a laboratory, which was a time consuming process.

THE SOLUTION

Geserco and Airbus Industrie have developed a tool called the Preciwatertest which allows the mechanic to get a direct reading of the water percentage at the aircraft. The Trouble Shooting Manuals (TSM) for the A300-600 (Chapter 27.50-02) and A310 (Chapters 27-50-02 and 27-80-02) are being modified to incorporate the new method, as is the FIM Chapter 27-50-00 for the A300. In addition modifications to the seals are available (Mod 06555 for A300; Mod 10796 for A300-600 and Mod 10961 for the A310).

THE WATER DETECTION TOOL

The Preciwatertest contains two kits, one for sampling the oil, the other for measuring the water content. Both are transported in a single small suitcase (38 x 33 x 27.5 cm) (see page 21) but can be carried independently if required. For example if the sampling and the measurement were to be done at the aircraft then both would be carried.

However if the analysis is not urgent then the sampling kit may be taken to the aircraft and the measurement done later.

SAMPLING

The sampling procedure depends on the gearbox from which the oil has to be extracted. The oil can be extracted from some gearboxes without a syringe. For the other gearboxes there are three different nozzles for the syringe: one in metal, one curved in plastic and the third, a flexible plastic tube (Figure 2). In the sampling kit one bottle is provided for each gearbox.

However if the analysis is not urgent then the sampling kit may be taken to the aircraft and the measurement done later.

MEASUREMENT

Measurement of the water content can be done at the aircraft or in a workshop by a non specialist. The oil sample is poured into a reaction flask (Figure 3) which is linked to an expansion vessel and manometer which gives a direct reading of the percentage of the water in the oil (Figure 4 on the following page).

The function is based on a chemical reaction. The cap of the reaction flask has housings in which capsules containing a reactive powder are placed. When the powder and oil are mixed a foam will form if there is water in the oil (Figure 3). The mixture gives off oxygen in direct ratio to the amount of water contained in the oil sample. Pressure in the expansion vessel is measured by the manometer.

The water detection tool is calibrated for a 10cm³ sample. Therefore only 10 cm³ of oil should be placed in the reaction flask and the reading of the manometer should be taken five minutes after all the powder has entered the sample. If these conditions cannot be respected a formula and chart are provided with the kit to allow calculation of the correct result.
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The water detection tool is calibrated for a 10 cm³ sample. Therefore only 10 cm³ of oil should be placed in the reaction flask and the reading of the manometer should be taken five minutes after all the powder has entered the sample. If these conditions cannot be respected a formula and chart are provided with the kit to allow calculation of the correct result.
ADVANTAGES

The Preciwatertest has many advantages:

- It is portable and small.
- The easy sampling and direct reading can be done quickly by non specialists.
- It reduces maintenance costs, since it can be used for preventive maintenance and it can significantly reduce trouble-shooting times.
- It improves trouble-shooting by providing operators with a method to almost immediately assess whether or not water presence in gearboxes is at the origin of system jamming.
- Consumable and spare parts for the kits are readily available.

CONCLUSION

The ability to determine almost instantly, at the aircraft, whether or not there has been water ingress in the gearboxes of the flap and slat systems can be used as a preventive measure to avoid delays due to system malfunction. It also significantly reduces trouble-shooting times when a system has malfunctioned. Using the Preciwatertest can avoid expensive maintenance and delays on the A300/A300-600/A310.

For further information please contact:

- AIRBUS INDUSTRIE Customer Services AISE-E53
  Flight Control Systems, Mr Delletain, 1, rond-point Maurice Bellonte, 31707 BLAGNAC Cedex, FRANCE, Tel: +33 (0)5 61 93 22 33
  Fax: +33 (0)5 61 93 44 25
- GESERCO SARL, Mous Pons, 87130 NEUVIC ENTIER, FRANCE, Tel: +33 (0)5 55 69 75 72
  The Part Numbers are:
  - Preciwatertest; WT TGC 96-10000 / Measurement kit; WT TGC 96-11000 / Sampling kit; WT TGC 96-12000

Captain Chris Krahe, Vice President
Operational Flight Group Training and Flight Operations Support
Airbus Industrie Customer Services Directorate

Pilots new to fly-by-wire aircraft tend to ask very legitimate questions concerning the effect of lightning strikes on the systems of these technically very advanced aircraft.

In general, lightning strikes generate direct and indirect effects on aircraft.

- The direct effects cause physical damage to the structure of the aircraft. This is due to the high energy content of a bolt of lightning in the span of fractions of a second. The aircraft structure, built to represent a Faraday Cage, has been thoroughly bonded and in particular the many parts made of Carbon Fibre Reinforced Plastic (CFRP) have been treated to be electrically conductive by applying various techniques.
  Lightning protection of the carbon fiber vertical and horizontal tailplanes is mainly based on the ability of the CFRP material to carry large amounts of lightning current without suffering damage and the electrical continuity is ensured within the whole structure.
  Great effort, therefore, has been spent by Airbus Industrie to ensure that lightning current can spread over the whole structure avoiding areas with significant current concentration and making sure that electrical continuity is maintained at all structural joints.
  It has been proven by lightning strike tests on the components themselves, that this design gives a remarkable inherent current carrying capability.

- The indirect effects of lightning strikes on aircraft are more likely to disturb or generate damage to electrical and avionic equipment. This damage is due to the electromagnetic physics generated from the circulation of high currents in the structure of the aircraft.
  Airbus Industrie and its suppliers of avionics equipment have made use of the most advanced technology to protect these aircraft against external radiation effects such as Electro Magnetic Interference (EMI) and lightning strikes.
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  Fax: +33 (0)5 61 93 44 25
• GESERCO SARL, 87110 NEY-VIC ENTIER, FRANCE, Tel: +33 (0)5 55 69 75 72
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The protection of the Airbus aircraft systems, (electrical distribution) against indirect effects of lightning strikes represents a quantum leap forward in evolution. Segregation of protected components and separation of wiring lanes is paramount (Figure 1).

System components are protected by filters allowing only spike-free voltage and current to access the functional parts of the computer.

An example: during a lightning strike, voltages may get superimposed on signals that have no lightning protection, and thereby increase the overall signal levels 500-times. The currents that are produced by this phenomenon can be 300,000-times higher than under normal conditions. The excess output power, which the built-in filtering circuits have to neutralize, could have had an equivalent magnitude of 500kW, whereas, the total power consumption of the equipment itself is far below 100W under normal conditions.

Airbus Industrie has requested from the suppliers of electronic equipment to design and manufacture them according to stringent standards and specifications that are considered to be the highest in the industry. From the outset and with the design aim of enhanced electronic hardening, a considerable amount of research and development has been invested into this task. Within the framework of the possibilities that were available, the following means have been applied in order to guarantee protection against lightning strikes:• An integrated grounding/shielding concept with short connections, and impedances that are kept as low as possible.
• Guided shields of external cables right up to the main grounding point of the computers.
• Symmetrical or separated ground connections of critical signals (wherever possible) with the help of transformers, integrated circuits, etc.
• Distinctly separated critical electronic circuits from interference-prone areas ("dirty areas") through mechanical separation and electrical filtering.
• Eradicated voltage surges using sufficiently large-sized varistors, transzorbs, or zener diodes in the “dirty areas”.

Generally speaking, the protection device or filter accounts for 25%, the power supply part for 10 to 20%, and the pure functional part of the computer represents 55 to 65% of the total design effort (Figure 2).

With respect to the wiring, the method of double twisted wires running in metal shielding has successfully been applied.

The effectiveness of the lightning protection concept was confirmed through extensive qualification tests in Electro Magnetic Interference (EMI) chambers. In production and during the entire life time of the aircraft, the function will be tested in accordance with acceptance test procedures.

The Airbus test aircraft were also exposed in ground tests to high voltage induction of several thousand Volts per metre. Thereafter, in a dedicated flight test campaign, the test aircraft were exposed to multiple lightning strikes by seeking purposely to be hit by lightning through flight in real thunderstorms or highly ionized air masses.

Today, the Airbus fly-by-wire aircraft have accumulated over nine million flight hours in more than eight years of airline service. There are nearly 900 of these aircraft flying worldwide and a considerable amount of experience with lightning strikes is available.

Like any aircraft in service, they are struck by lightning.

The experience gathered and the operational feedback Airbus Industrie has received from the operators have confirmed the effectiveness of the concept and design. We can state today that there were virtually no indirect effects on the systems by lightning strikes.

We know of two significant lightning strike events in the Airbus fleet that speak for themselves, and which we wish to share with those interested.

In August 1995, during the intermediate approach in a thunderstorm into an airport in Denmark, an A320 was hit by lightning strike - according to the crew, no aircraft systems were affected. However, the approach had to be interrupted with a subsequent diversion to Copenhagen because the destination airport was hit by lightning as well, which caused a complete electrical blackout including ILS and communication.

On 9 October 1996, an A330-300 suffered at least two very severe lightning strikes while approaching the Greek island of Rhodes where the aircraft made an uneventful landing.

The flight crew reported that during these severe lightning strikes, there was not the slightest flickering of the displays or other effects on the avionics or aircraft systems.

However, according to the direct effects on the structure, Zeus must have hit extremely hard this time. The first impact of the lightning on the fuselage was slightly above door 3K and showed jumps from frame to frame about one meter above the row of cabin windows until door 3K. On its way, it burned out about 30 rivets. Apparently, the lightning struck the aircraft on top of the vertical fin where it burnt the usual one-inch hole. It should be noted that according to the operator’s maintenance department, this lightning hit was the most severe suffered across all its aircraft types during the company’s 40 years history (Figure 3).

Lightning strikes are by nature uncontrollable. They channel their energy content on a small size pinpoint. Concentration of the energy is the source of physical damage. All that lightning strike protection does is to disperse this energy.

Bonding of panels is not meant to avoid damage at all. It is there to evacuate the static charges generated by air friction and to provide protection against High Intensity Radiated Fields (HIRF) in addition to limit damage due to lightning strikes.

CONCLUSION

The very stringent tests that the Airbus fly-by-wire aircraft were subjected to, have ensured that they can withstand the most severe lightning strikes without effect to their electronic systems, which has been demonstrated in commercial service as the crew reports demonstrate.
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With AIM-FANS, Controller-Pilot communication is achieved via two DataLink Control and Display Units (DCCDs), the screens visible at the bottom of the centre instrument panel of this A340 flight deck. They provide each crew member with a dedicated interface for ATC communication.

AIM-FANS customers (full installation), as of early December 97. The list is growing rapidly.

Jean-Pierre Dambrine
Product Marketing Director
Airbus Industrie

Airline involvement in the development of the Airbus Interoperable Modular - Future Air Navigation System (AIM-FANS) avionics suite, which is due to enter service this year on the A330 and A340, has been key to its present success.

A core team of seven major Airbus customers has been working in close co-operation with Airbus on all aspects of the programme: system design, schedules, product support and commercial. In addition, a series of semi-annual review conferences allowed the collection of further valuable inputs from all customers.

Customers generally confirmed the validity of the basic concept presented in FAST 17 (issue December 94) with its major benefits of operational flexibility, development potential and commonality, but added inputs which significantly improved the value of the AIM-FANS product. A few examples are:

- The tuning of the design and schedules of AIM-FANS to provide the right FANS functionality at the right time in each region of the world. This results from the progressive development of a common understanding by the group of the various FANS environments now emerging around the world.
- The use of VHF Data Radios (VDR) instead of VHF radios. This makes AIM-FANS consistent with airlines' general move towards VDRs and enhances its development potential.
- The incorporation of the Aircraft Communication Adressing and Reporting System (ACARS) Airline Operational Communication (AOC) functions into the Air Traffic Services Unit (ATSU), the AIM-FANS communication management box. This removes the need for a separate ACARS box, which simplifies the overall architecture of the aircraft communication system and reduces airline costs.
- The use of VHF Data Radios (VDR) instead of VHF radios. This makes AIM-FANS consistent with airlines' general move towards VDRs and enhances its development potential.
- The development of a crew-friendly FANS cockpit arrangement, able to support later developments of FANS, avoiding the need of burdening and costly downstream reshuffling of cockpit configuration and operational philosophy.
- The introduction of a new Flight Management System (FMS), common to the A330/A340 and A320 family, with greatly increased computing power, memory size and ability to cope with upgrades. This gives the new FMS a large growth potential, matching that of the ATSU. Across-the-range commonality and easy upgrades reduce airline costs. The ability to procure this new FMS from two competing suppliers is another cost-cutting factor.

The equalization of the retrofit installation into one-shift work packages and the ability to fly any combination of FANS-modified / un-modified LRUs. This eases retrofit and cuts its cost.

Thanks to its built-in development potential, the AIM-FANS A configuration entering service this year on the A330 and A340 will seamlessly evolve by the year 2000 to the AIM-FANS B configuration, fully compliant with the ATN (Aeronautical Telecommunication Network).

No AIM-FANS A step is planned at this stage for the A320 family but a direct move to AIM-FANS B by 2000, because the type of route on which the aircraft is operated will likely require the ATN directly. The A320 family, however, will be fitted with a "Pre-FANS" installation a few months after the A330s receive AIM-FANS A. It will consist of the ATSU with AOC functions, the new FMS, re-arranged cockpit instrument panels ready to accept the installation of AIM-FANS controls and displays, and wiring provisions. This will make the future installation of AIM-FANS B easier for customers and will also allow speedy installation of AIM-FANS A on the A320 family, if finally needed.

Flight testing of AIM-FANS has started and will lead to certification of the system in the second half of 1998.
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- The tuning of the design and schedules of AIM-FANS to provide the right FANS functionality at the right time in each region of the world. This results from the progressive development of a common understanding by the group of the various FANS environments now emerging around the world.
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- The incorporation of the Aircraft Communication Addressing and Reporting System (ACARS) Airline Operational Communication (AOC) functions into the Air Traffic Services Unit (ATSU), the AIM-FANS communication management box. This removes the need for a separate ACARS box, which simplifies the overall architecture of the aircraft communication system and reduces airline costs.
- Competition between three AOC software suppliers further reduces costs.
- The development of a crew-friendly FANS cockpit arrangement, able to support later developments of FANS, avoiding the need of burdening and costly downstream reshuffling of cockpit configuration and operational philosophy.
- The introduction of a new Flight Management System (FMS), common to the A310/A340 and A320 family, with greatly increased computing power, memory size and ability to cope with upgrades. This gives the new FMS a large growth potential, matching that of the ATSU. Across-the-range commonality and easy upgrades reduce airline costs. The ability to procure this new FMS from two competing suppliers is another cost-cutting factor.

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Thanks to its built-in development potential, the AIM-FANS A configuration entering service this year on the A330/A340 will seamlessly evolve by the year 2000 to the AIM-FANS B configuration, fully compliant with the ATN (Aeronautical Telecommunication Network).

No AIM-FANS A step is planned at this stage for the A320 family but a direct move to AIM-FANS B by 2000, because the type of route on which the aircraft is operated will likely require the ATN directly. The A320 family, however, will be fitted with a "Pre-FANS" installation a few months after the A310/A340 receives AIM-FANS A. It will consist of the ATSU with AOC functions, the new FMS, re-arranged cockpit instrument panels ready to accept the installation of AIM-FANS controls and displays, and wiring provisions. This will make the future installation of AIM-FANS B easier for customers and will also allow speedy installation of AIM-FANS A on the A320 family, if finally needed.

Flight testing of AIM-FANS has started and will lead to certification of the system in the second half of 1998.
Over 430 representatives from 64 airlines, 46 vendors and Airbus Industrie attended this conference. This Symposium was hosted by Roger LeCocq and chaired by Thierry Hérald. Several sessions were devoted to present the new Airbus Technical Information System (ATIS) and Single Point of Contact (SPOC) concept for online access. These presentations were supported by true online demonstrations of online access to Service Bulletins and Technical Follow-Up.

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Over 400 delegates from 60 airlines, 98 suppliers, Airbus Industrie and its partners gathered recently for the fourth Materiel Support Symposium. The conference, which was the largest and most successful of its kind, provided an open forum for all parties involved in the Airbus Industrie supply chain to discuss a wide range of issues related to materials management, with an emphasis on the need to achieve an effective balance between cost-reduction and service.

Speaking at the conference, Peter Klopfer, Vice President Material Support, announced that continued cost-reduction at the industrial level, combined with improved efficiency in administration and manufacturing processes, would mean that average material cost expenditure for Airbus Industrie proprietary parts in 1998 would once again remain at 1991 levels. Peter Klopfer also praised the efforts of third party suppliers in recent years to support Airbus Industrie’s cost-reduction and service enhancement initiatives. "Each year since 1993 a significant number of Airbus Industrie suppliers have applied zero escalation on their prices," he said. "At the same time many of the suppliers have also responded positively to customer requirements for reduced shop processing times, improved part reliability and more flexible support contracts."

The Suppliers which had shown the strongest commitment and support for Airbus Industrie initiatives were recognized at a special gala dinner with awards presented by Bernard Cattelain to:

- DASA Kid Systems
- Hexon
- Vistech Ventures
- Sully Products Spécial

Providing an opportunity for the operators, suppliers and Airbus Industrie staff to discuss technical subjects of common interest and share in-service experience.
Over 430 representatives from 64 airlines, 46 vendors and Airbus Industrie attended this conference. This Symposium was hosted by Roger Levecque, Vice President Engineering and Technical Support, and chaired by Thierry Héralde, Director A320 Program from Airbus Customer Services. From the 500 inputs received from the operators prior to the Symposium, 60 subjects were retained for formal presentations and discussion during the plenary sessions and around 25 subjects were reviewed in side meetings. In addition, written answers to remaining questions were given in the documentation provided to each participant.

Several sessions were devoted to present the new Airbus Technical Information System (ATIS) and Single Point of Contact (SPOC) concept for on-line access. These presentations were supported by true on-line demonstration of on-line access to Service Bulletins and Technical Follow-Up.

Following tradition at the opportunity of the opening ceremony, Bernard Carrière, Senior Vice President of Airbus Customer Services, presented awards to A319, A320 and A321 operators for excellent achievements obtained by some operators.

The awards for OPERATIONAL EXCELLENCE were given to:
- Air France for the A319
- All Nippon Airways for the A320
- Swissair for the A321

In addition, SPECIAL RECOGNITION was given to:
- Cargolux for the highest yearly utilisation in flight hours achieved with the A320: around 3000 flight hours per aircraft and per year.
- Freuadale for the highest yearly utilisation in flight cycles achieved with A321: more than 3300 flight cycles per aircraft and per year.
- Hainan for the highest average flight time achieved with an A320: 3.3 hours per flight.

All of the latter demonstrate the high versatility of the A320 family.

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- DASA KIDSYSTEMS
- Diehl
- Vibriometer
- SIXES PRODUCTS

First flight of the "Globe Aerostatique" from Versailles on 19 September 1783

April 23, 1784
The headquarters of Paris Police
Airbus Industrie’s improved production technology has helped to reduce the proprietary spares expenses for Airbus operators every year since 1994 to average 1991 levels. So you can keep your Airbus aircraft in the air and your operating costs firmly on the ground. **AIRBUS**

http://www.airbus.com