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#54

FAST

Flight Airworthiness Support Technology

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#54

FAST

Flight Airworthiness Support Technology

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Where you see these icons, videos or slide shows are available on the iPad & Android app versions of FAST magazine.

Telemetry Centre

'Mission control' for flight testing

As aircraft become increasingly complex, and with customers expecting more mature aircraft in shorter development times, the need to optimise flight test cycles becomes critical. The Telemetry Centre is a cornerstone of Airbus' flight testing process and is a key element to ensure the safety and efficiency of our flight tests.

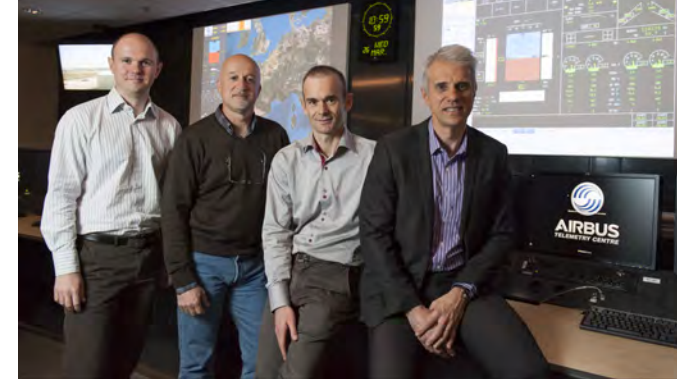
Foreword by
Fernando ALONSO
Head of Flight and Integration Tests

Thanks to the high volume of quality data available through telemetry, Design Office specialists can remain on ground following the tests performed by the flight crews.

Airbus' master Telemetry Centre located in Toulouse (France) has the capacity to follow three different flight tests simultaneously. As many specialists are located throughout Airbus' sites in Europe, annex telemetry rooms have been deployed and are able to view and analyse flight test data in a "live" transmission. The multiplication of specialists viewing data permits a quicker analysis and real-time corrective measures or adjustments.

The progressively rapid transmission of data and its analysis, allows continuous interaction between the Telemetry Centre conductor and the test pilots. The communication is so fluid that it's easy to forget that they're not still up there in the aircraft!

The Telemetry Centre is definitely a safer and more efficient way to test our aircraft.



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With no windows and matt black sound-proofed walls, the environment of the Telemetry Centre has been designed to minimise the stress of carrying out work that requires intense concentration over extended periods of time.

Often likened to a mini NASA control room, the centre is lined with large screens that offer audio and high definition video, and each work station is full of monitors and bespoke computer equipment.

Airbus' master Telemetry Centre is located at Toulouse (France). It comprises three telemetry rooms capable of simultaneously following three separate test flights.

Airbus sites at Filton (UK), Bremen and Hamburg (both in Germany) are also equipped with a telemetry room which can be connected to the Toulouse master centre. Toulouse can also be in inter-connexion with the Airbus Defence & Space Telemetry Centre in Seville (Spain).

Data is transmitted in real-time to these telemetry rooms providing access for more specialists. This immediacy improves the global data analysis as specialists are able to hear the pilots' commentary and see them in the cockpit via the live flight video transmitted from the aircraft.

Systems are checked for performance as specified, and if needed requests can be made to the flight crew to repeat a test, or carry out a certain action.

The most crucial aspect of being able to monitor flights live is that the engineers can better understand the context of each test result. For example, they can appreciate how local weather conditions, may be affecting the flight. As well as knowing what is happening inside the aircraft, they can also see what's going on outside via cameras mounted on the aircraft's exterior.



The size and the shape of each circular area depends on the aircraft's altitude and the local relief.

- Test flights are conducted in six zones of approximately 500 km in diameter
- Six antennas cover the flight test area in the west and south part of France
- Three separate aircraft can be tracked simultaneously
- The optical range is more than 350 km at 40,000 ft
- Antennas are linked and controlled from the Telemetry Centre in Toulouse
- Ethernet IP data transfers 10 Mbits/sec from antenna stations to the Telemetry Centre
- Transmission for useful data from the aircraft is > 5 Mbits/sec

Annex telemetry rooms allow correspondance with specialists in the engineering disciplines of each Airbus site:
Filton - ATA chapters 28, 32 & 47
Hamburg - mainly ATA 21
Bremen - mainly ATA 27-50

See wikipedia.org for ATA* chapters list

* Air Transport Association



The Telemetry Centre, a great strategic choice

This highly sophisticated installation has been set up with two main objectives:

- Enhancing the safety of test flights by minimizing the crew on-board the aircraft while maximizing the number of analysts on the ground.
- Increasing efficiency of the flight test campaign by providing real-time analysis support from the ground which allows optimising the contents of the flight and reducing the number of flights.

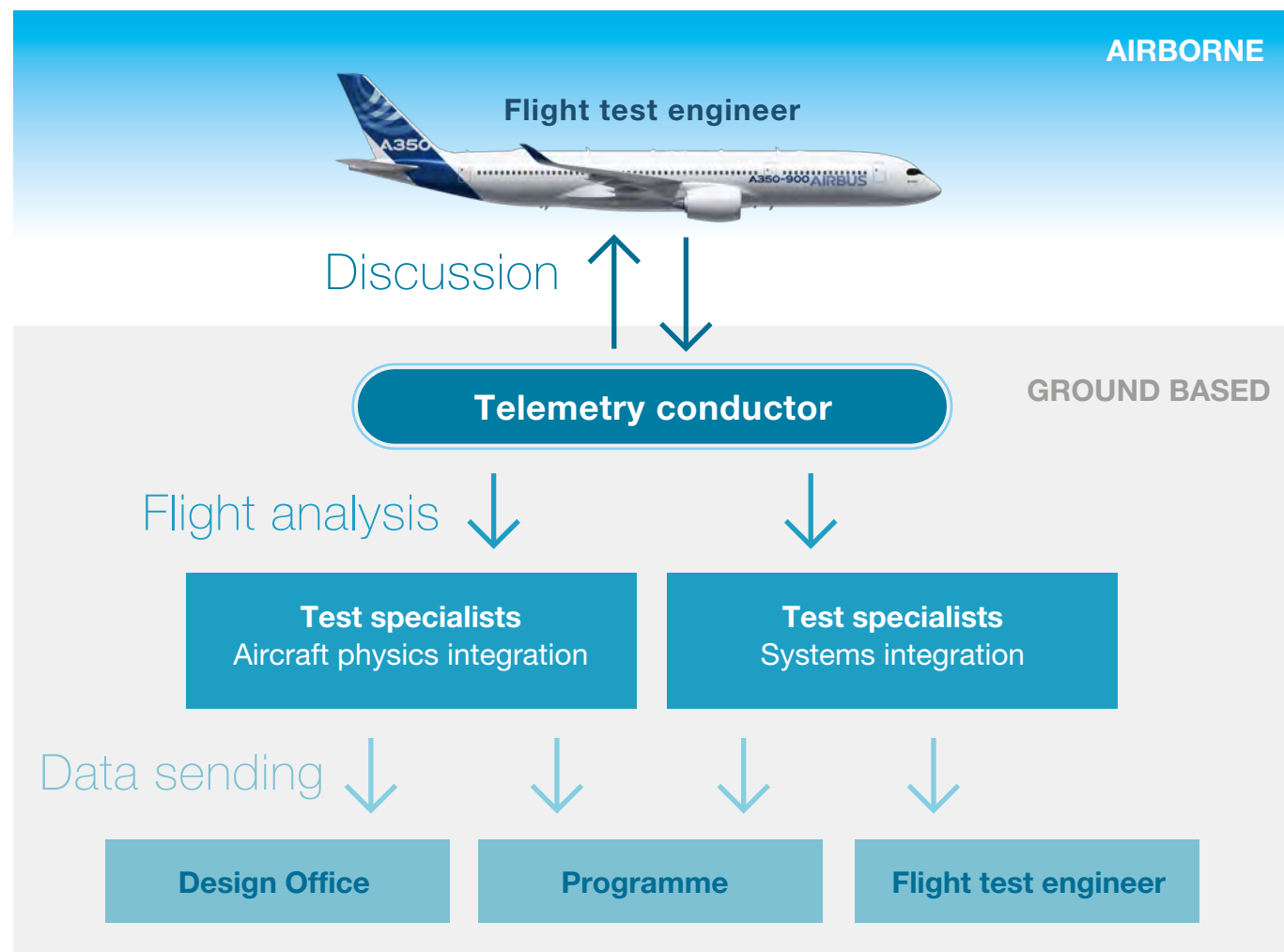
Since its creation, Airbus' Telemetry Centre has seen huge progress. Even if the mission hasn't changed, the level of aircraft support has grown and technical analysis has been improved. The Telemetry Centre was initially dedicated to flight testers. Now, thanks to improvements in the tools and mind-set evolution, the centre has become a privileged place where people coming from different activities share their questions and solutions.

Different tools

In order to fully understand all on-board messages and events, the telemetry room conductors use tools which enable the same vision as the airborne flight test engineers, with the difference that they receive more detailed results. In 2012, an update in the Telemetry Centre's IT improved the analysis efficiency. With new data management and advanced technologies, telemetry is now more reactive and flexible, adapting its analysis during test flights.

Aircraft and telemetry: continuous interactions

The telemetry conductor is in continuous communication with the airborne flight test engineer, sharing instructions and advice. The conductor is also the focal point, sharing information with specialists.



Telemetry took its full dimension during the A380's maiden flight.



The 12 flight test groups

- Performance
- Aerodynamics
- Engine
- Handling qualities
- Flight control
- Braking
- Electricity
- Cabin
- Flutter
- Load
- Autopilot
- Fuel

Telemetry Centre supports the aircraft

The Telemetry Centre surveys the safety of the aircraft and crew, giving warnings during flight regarding structure, loads and systems' events. In real-time, the telemetry analyses flight physics and crucial systems such as electrics, hydraulics, braking, pressurisation, de-icing, etc. Consequently, the main role of the Telemetry Centre is to help the crew, and specifically the flight engineer, validating data and manoeuvres during the flight. Telemetry has now become mandatory for flights such as flutter testing or load calibration. Most handling qualities and performance flights are also performed with telemetry's support during the entire development phase and up to aircraft certification.

Real-time and deferred analysis

The Telemetry Centre is able to analyse data sent by the aircraft both in real-time and in slightly deferred time.

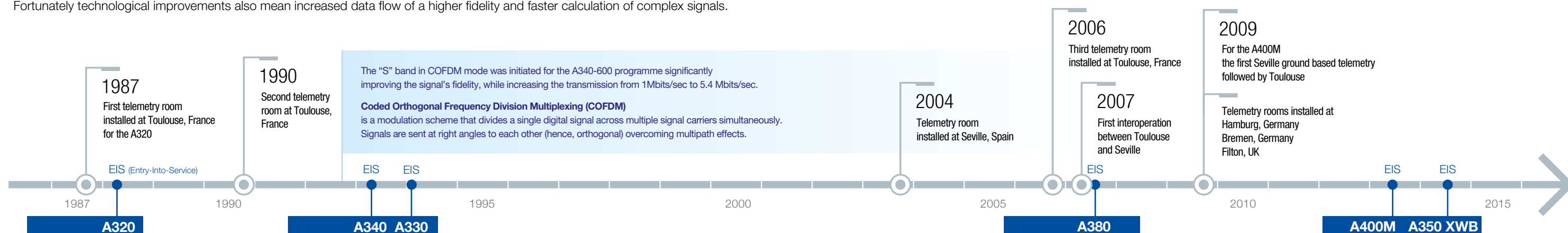
The analysis team of specialists study real-time transmissions from the aircraft on generic or ATA chapter specific screens. Telemetry equipment is pre-configured based on the results of Functional Integrated Benches and simulators (mainly for systems parts) but also on input coming from computations (finite element stress analysis for loads, computational fluid dynamics for aerodynamics, etc.). The equipment then interprets flight test behaviour and is able to send a warning to the aircraft when the situation becomes critical or dangerous.

These telemetry tools also propose real-time automatic monitoring which can warn the specialist in case of an unexpected event.

Deferred computation allows a more detailed analysis which is then compared with previous models and sent to the Design Office, aircraft programme, other crew and test specialists after the flight test in order to get a global overview of the results.

Evolution of telemetry

As the safety and performance of aircraft improves, the need for tests increases. Fortunately technological improvements also mean increased data flow of a higher fidelity and faster calculation of complex signals.



Frequency

L Band: 1 to 2 GHz

S Band: 2 to 4 GHz

C Band: 4 to 8 GHz

(5.091 to 5.250 GHz for aeronautical telemetry)

1986 - 1990

- Complex architecture
- Many machines for message acquisition
- One machine to monitor loads
- No graphic station
- Acquisition: only one PCM (Pulse Code Modulation)
- Closed telemetry world
- Possibility of following one aircraft

1990 - 1996

- Acquisition: one PCM
- Semi-closed telemetry world
- Possibility of following two aircraft

1996 - 2004

- Graphic application
- Multi-window
- Multi-application
- Open telemetry world
- Real-time and deferred-time transmission available
- COFDM

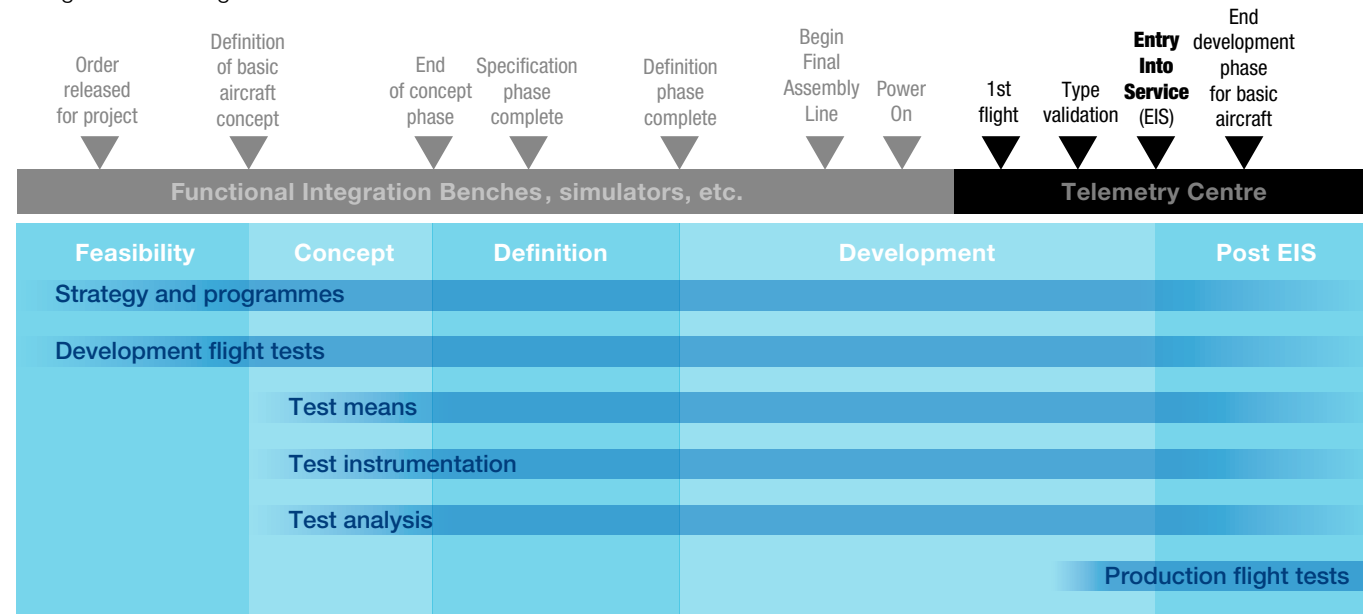
2005 - 2014

- Data Ethernet packets
- Bandwidth: 5 to 10 Mbits/sec
- Multiple parameter lists selectable from the ground
- Uplink (data transmission to the aircraft)
- Data compression
- Possibility of following three aircraft

From test benches to telemetry data

The Telemetry Centre is the concretisation of months of teamwork preparing for the flight test campaign. Activity fields such as design, structure and systems meet to assess the aircraft's behaviour in real conditions, and work on the same operational subject. This way of working allows immediate sharing of information, enabling them to define together the conclusions of preliminary results.

The on-ground telemetry conductor and the airborne flight test engineer are in communication throughout the entire test flight. Telemetry specialists are in charge of preparing analysis tools to face any event during the flight. They assess the overall aircraft behaviour to ensure that all requirements are met in terms of performance and general handling.



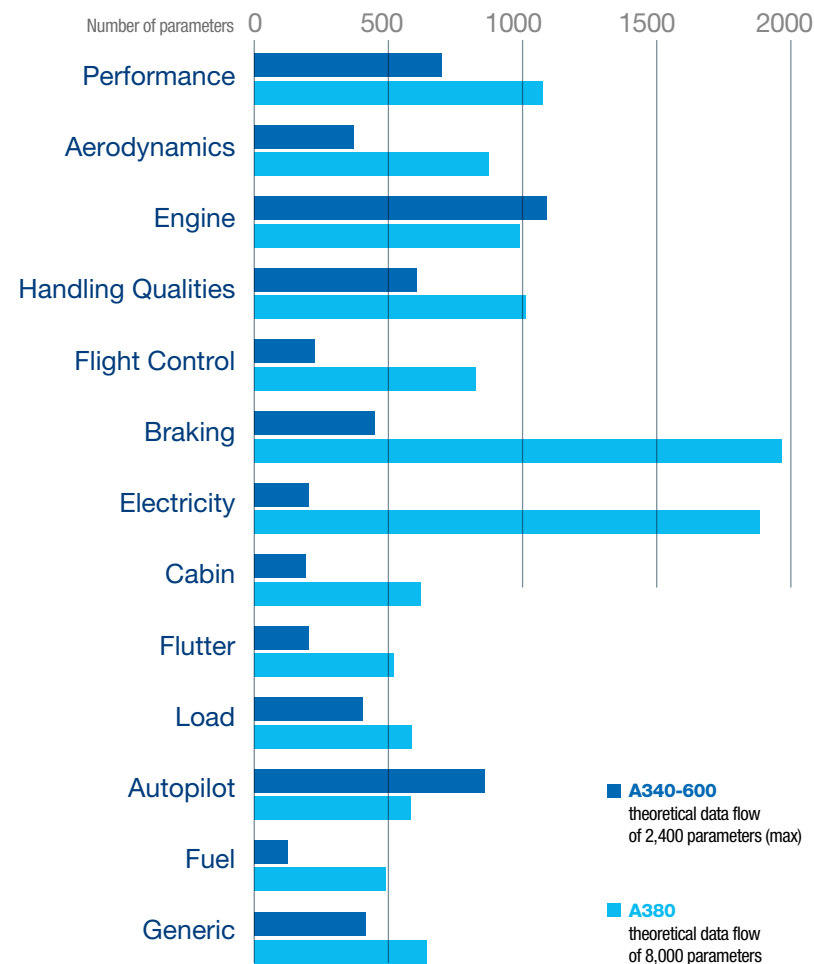
Telemetry support brings advantages in terms of planning and quality

Certifying an aircraft is an activity that has become increasingly complex, requiring testing to be more efficient. Thanks to real-time test validation, Airbus is able to certify its aircraft on schedule and thus respect commitments to deliver on time.

Moreover, the real-time interactions between the aircraft and the Telemetry Centre enable the optimization of the aircraft during flight tests, resulting in high-performance aircraft.

As an example (see right) the data flow necessary for airworthiness certification for the A380 would have taken much longer were it not for improved technology in telemetry data transmission.

Telemetry data transmission for the A340-600 was at 0.8 Mbits/sec, as opposed to the 5 Mbits/sec available for the A380.



The future of the Telemetry Centre

A new European regulation regarding frequencies' transmission will allow the use of a new wave band. This will open the way to increased telemetry capacities, allowing more parameters to be registered in real-time.

Today, telemetry services are limited to France and Spain due to antenna coverage. We hope that one day, we will have the opportunity to analyse flight tests around the world.

CONCLUSION

The Airbus Telemetry Centre receives data transmitted from aircraft during flight tests. This information can be studied in real-time from the safety of the ground or deferred for in-depth analysis.

Flight tests can be followed in telemetry rooms at Filton, Hamburg and Bremen by specialists in engineering disciplines, improving the efficiency of test flights and facilitating the optimization of an aircraft's performance and safety.

The speed and accuracy of the transmitted and calculated data improves as technological advances in Airbus aircraft require more complex testing while respecting development and delivery times.

Greener solutions

Cleaner chemicals with Multi-Programme Substance Projects

As regulations on the use of chemicals in the aeronautical industry become increasingly stringent, Airbus faces an interesting challenge.

On the one hand, regulations that are intended to protect the environment and health of users, align perfectly with Airbus' commitment to offer cleaner and safer aircraft.

On the other, many of these regulations concern substances that provide the most efficient technical solutions currently known.

Airbus' challenge is to find new solutions that adhere to upcoming regulations, without compromising high performance and product quality.

Airbus has created a committee dedicated to Multi-Programme Substance Projects (MPSP) in order to analyse the reports of upcoming regulations from the Environmental Affairs department.

The committee governs the portfolio of substances impacted by new regulations and steers the process to find new manufacturing processes with substitute chemicals.

A transversal management

The MPSP committee comprises a cross-functional management, grouping representatives from all aircraft programmes, engineering, manufacturing, procurement, health and safety departments, as well as the Environmental Affairs department.

The MPSP committee ensures:

- An improved visibility of upcoming changes to evaluate the impact well in advance
- Common priorities to minimize the impact on daily business
- A common strategy
- A common work process
- The sharing of best practices
- The mitigation of obsolescence



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REACH RoHS IARC
ECHA POPs
OSPAR ODS CMR

These names are not the last trendy rock bands but a short list of laws, international agreements and authorities, linked to the regulation of hazardous chemical substances to protect human health and the environment.

The first health and safety laws in western countries to restrict the use of certain chemicals were enacted in the second half of the 20th century. Ever since, regulations have become progressively more stringent covering an ever growing list of substances.

Regulations, such as REACH provide a legislative framework based on the precautionary principle and it is the producer's responsibility for assessing and managing the risks posed by chemicals and providing appropriate safety information to their users.

Moreover, regulations are imposed at the source of production to prevent dissemination and limit exceptions.

It is important to note that the new regulations consider the use of substances throughout the entire production process.

Impact on the aeronautical sector

Apart from regulatory obligations (registration or declaration of chemical use), the main impact on the industry is the disappearance of raw materials used to manufacture or maintain the final products.

Among the many aircraft components subject to obsolescence due to limitations in the use of chemicals are:

- Paints
- Sealants
- Flame-retardants
- Batteries
- Electrical devices
- Extinguishers
- Hydraulic fluids

The challenge is permanent, as regulations evolve and the visibility of substances that may be banned in the future is poor.

Moreover, despite our manufacturing business being global, we have to cope with different levels of regulation from a local law enforcement to international agreements that are diversely implemented.

GLOSSARY

CMR: Contact MicroRadiography
ECHA: European Chemicals Agency
EURATOM: European Atomic Energy Community
IARC: International Agency for Research on Cancer
ODS: Ozone Depleting Substances
OSPAR: Oslo and Paris Commission
POPs: Persistent Organic Pollutant
REACH: Registration, Evaluation and Authorization of Chemicals



An end-to-end process

Facing this challenge, Airbus has put in place an end-to-end process: from the analysis of the regulation to the final replacement of chemical products on the aircraft or at the manufacturing/maintenance facilities.

Survey
the
regulations



Identify the
chemical



List the impacted
qualified products



Set up
a project



Find technical
solutions
to qualify them



Manage the impact
of the new solutions



Implement
the new solution

End-to-end process management

Keystone materials for the aeronautical industry such as aluminium alloys, require special care in terms of protection against corrosion.

The main steps are: degreasing, pickling, chemical conversion or anodic oxidation, followed by the application of structural paint loaded with corrosion inhibitors. To complete these steps, the aviation industry still uses potentially harmful substances, such as trichloroethylene, borax, chromic acid, zinc, barium and strontium chromates; and this only concerns component protection. The treated parts are then assembled to form subassemblies and in the end exterior paints will be applied. These assembly operations involve amongst others: cadmium plated or chromate fasteners, themselves protected by sealants or chromate paints.

A priority-based work plan

Considering the visibility given by the legislators about substances to be banned (3-4 years) and the time needed to qualify new solutions (can be 5 years or more), informed analysis of the regulations and accurate prioritizing of the work plan is necessary.

Examples of topics which remain high on the agenda:

- **Chromates:** anodization, passivation, plating and paints ([REACH](#))
- **Cadmium:** corrosion protection by plating ([REACH](#))
- **Halon:** fire extinguishers ([ODS](#))
- **Phthalates:** plastics ([REACH](#))
- **Short-chained chlorinated paraffins:** fire retardants, plasticisers ([POP](#))
- **Lead:** electronics card soldering, batteries ([RoHS](#))



Looking into future paint regulations

The health and safety of Airbus personnel and the environmental impact of the production process is of paramount importance, and the increasing regulations in Europe encouraged Airbus towards a major overhaul of its industrial processes. In 2005, a first step towards a greener future was taken.

For the first time we treated aircraft parts with hexavalent-chromium-free acid pickling. This single change meant a lengthy work programme for our engineering offices and innovation teams. Once the theory proven in laboratories, the introduction of new facilities in factories is made progressively, beginning with the small size plants then up-scaling to the bigger ones. There, the industrial engineering teams (manufacturing and engineering) had to prepare the facilities to receive these new surface treatment baths, adapt the key process parameters, the rinsing stations and review the quality monitoring plan.

Chromic Acid Anodizing (CAA) is under replacement by Tartaric Sulphuric Acid Anodising (TSA). This process which forms an oxide layer on parts provides corrosion protection and is the interface between the metal and the paint coating. Perfect compatibility between these two elements is paramount. However the standard paint in some of our plants and in our supply chain has for long been the well-known PAC33, not compatible with the oxide layer formed by TSA. It was also therefore necessary to qualify and introduce new paints showing affinity with this new substrate. Furthermore, taking into account European regulations related to Volatile Organic Compounds (VOC) - precursors of greenhouse gas - these new paints must contain the least possible solvent. This particularity gives them a different behaviour during their application and drying, thus resulting in the need to invest in humidity control and new application equipment.

In assembly centres too, these new paints are emerging and with them the need to further improve our processes for the surface preparation. We continuously develop, in partnership with DÜRR ECOCLEAN, an innovative process combining steam and high speed air, negating the need for a chemical additive.

We are thus able, for the first time, to completely clean without producing VOCs, without any harmful chemicals and without leaving residues that disrupt the application of new and more demanding paints. This new process promises opportunities in terms of ergonomics, cycle time and automation. Indeed, paint booths, choice of certain fasteners, their installation process, cleaning processes in assembly and the final painting of Centre Wing Boxes manufactured in Airbus' facility at Nantes (France) are being adapted.

The advantages are all now well-known and appreciated at this plant and were shared within the Manufacturing/Engineering community to other plants.

Beyond the substantial ecological gain already provided by the introduction of the first "chromate free" or "low VOC" solutions, the implementation of these new processes has allowed a production overhaul and is part of our constant search for improvement. With lessons learnt from these current projects, we are reaching a significant milestone: chromate-free structural primer and touch-up implementation. As yet, no substitute has shown a sufficient maturity to fulfil aircraft certification standards, the future European regulations and our production requirements. Airbus is actively cooperating with research laboratories and suppliers to make them an industrial reality as soon as possible.



CONCLUSION

Chemical regulation is not a temporary burden but an ongoing opportunity to invent cleaner and safer manufacturing techniques.

Airbus has decided to embrace this challenge by streamlining the way in which upcoming regulation is integrated into our daily business. It has put in place an end-to-end process management committee to treat Multi-Programme Substance Projects (MPSP).

The involvement of all parties is key to ensure this runs smoothly and perpetuates. Issues are now identified, impacts are known and mitigation plans are in place to ensure the smooth continuity of deliveries.

The aim of Airbus and our customers to minimize our environmental impact is perfectly in line with the spirit of chemical regulation. We have to, and will, find the best solution. ■

Non-Destructive Testing

There's more to it than meets the eye

Non-Destructive Testing (NDT) is used to confirm the integrity of a material without causing any damage to the component.

NDT tools and processes allow the user to:

- Detect defects that may occur during the manufacturing process,
- Examine parts for defects during maintenance,
- Assess the severity of damage following an impact.

Techniques for both metallic and composite materials may be used depending on the nature and depth of the indication:

Surface - magnetics, dye penetrants and eddy currents

Sub-surface - magnetics, eddy currents, ultrasonic and thermography

Internal - ultrasonic, thermography and X-ray

These methods can reveal the location, size and severity of any defects within a component.



Steven CRUMMACK (left)
Senior NDT Engineer
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Jean-Pierre LOZES (right)
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NDT in aircraft manufacturing

NDT is a quality step used at key stages to establish whether the component is fit to advance to the next manufacturing operation. By not continuing to add man-hours and production cost to a defective component, significant time and money is saved.

Using knowledge from fatigue tests and data modelling, Airbus can calculate the in-service life of a component. By introducing NDT inspections well in advance, we can avoid large repairs, optimise the design and in many cases, reduce the weight of components.

The following examples of main NDT methods were performed at TESTIA, a certified NDT examination and testing organisation in the Airbus Group.

The tests were carried out by

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1. Ultrasonic

(metallic/composite materials)

Ultrasonic energy can penetrate metallic and composite materials to detect cracking and delamination. This technique is used both in manufacturing and on the aircraft's structure in service.

a. Longitudinal wave

A straight beam from the probe measures the thickness and detects features within the beam path.

b. Shear wave

Beams at varying angles can be generated in metal called shear waves. For example, this method could be used to detect cracks from holes with the fasteners installed.

c. Phased array

Using multiple probes in an array, internal features can be mapped, and for metallic parts, the beam can be steered to examine an area from a range of angles. The maximum reflection is obtained by tilting to the correct angle. This increases sensitivity compared to conventional shear waves.



2. Eddy current

(metallic materials)

Eddy currents are induced using a small electrically magnetised coil. A hand-held eddy current probe is passed over an alloy which can contain the eddy current. When it passes over the defect you can see the display on the screen.

For fastener hole inspection we use a rotating probe which is passed through the bore of the hole. When it encounters a defect it is displayed on the screen; this signal is adjusted for diagnosis.

This is a very common method for in-service aircraft.



3. Radiography

(metallic/composite materials)

Using a booth which protects the operator from X-rays, the component to be tested is clamped to a mount and then placed into the booth, the door then closes automatically,

The component is then exposed to X-rays of the wavelength which are best suited for the feature to be detected.

As it is a digital X-ray you are able to enhance the image by modifying the settings.

Finally when you have saved the image, you can enhance it further by examining chromatic differences.

The aerospace industry is supported by a group of specialised suppliers, many of whom use technology originally developed for the medical industry.



4. Infrared thermography

(metallic/composite materials)

Infrared cameras are used to exploit the reaction of different materials after they pass from a thermally stressed state, back to ambient temperature. During this process, the infrared energy they transmit can be detected and used to display relative difference between materials. For example, water trapped inside composite honeycomb sandwich panels can be highlighted, effective for both rudders and elevators.



5. Magnetic particle

(metallic materials)

This testing method uses fluorescing magnetic particles suspended in a fluid. The liquid is applied to the magnetized component, which then attracts the particles to magnetic flux leakage generated by defects and its edges. The method is limited to ferromagnetic materials only.



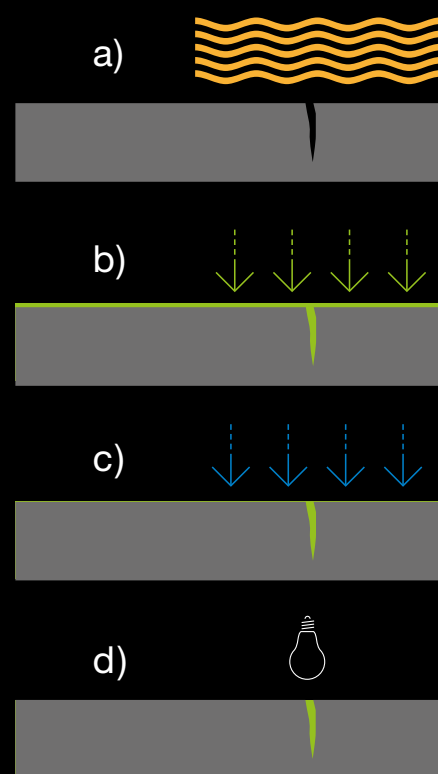
6. Fluorescent dye penetrant

(metallic materials)

This NDT method, mainly used in manufacturing, is effective at detecting surface breaking cracks in non-porous materials (primarily metallic). The component is covered in dye penetrant ink which enters surface breaking features. Afterwards the object is rinsed, leaving the remaining dye in the defects. It is inspected under a ultraviolet black light where the defect fluoresces, against a dark background.

Fluorescent dye penetrant inspection

as performed in Airbus' Nantes (France) facility.

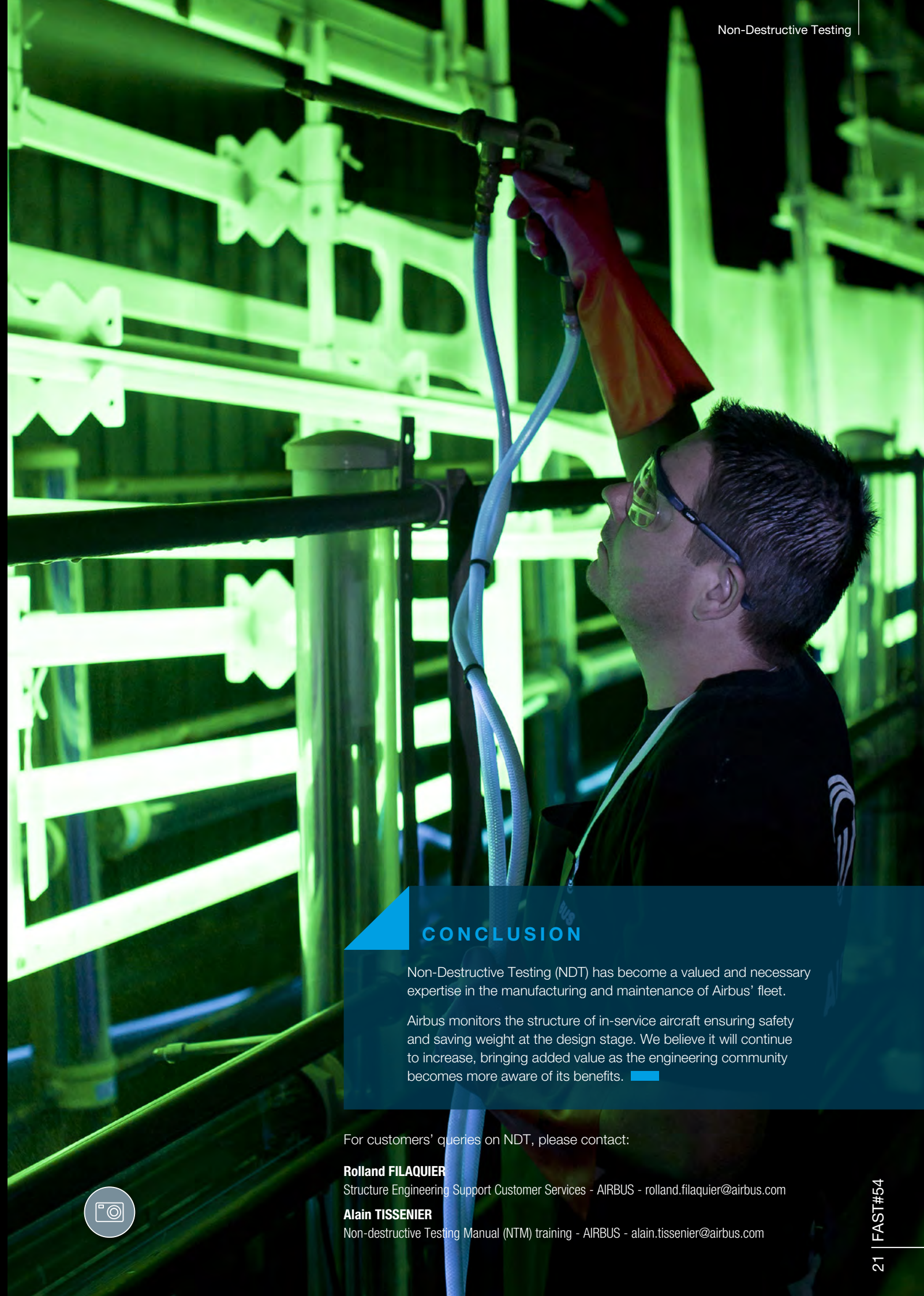


a) Directly after the surface treatment process, the parts are placed in an oven to dry excess moisture.

b) Parts are sprayed with a florescent dye.

c) Residual dye is rinsed off revealing any surface discontinuities where the dye has penetrated.

d) Parts are oven-dried again then visually controlled with an UV light.



CONCLUSION

Non-Destructive Testing (NDT) has become a valued and necessary expertise in the manufacturing and maintenance of Airbus' fleet.

Airbus monitors the structure of in-service aircraft ensuring safety and saving weight at the design stage. We believe it will continue to increase, bringing added value as the engineering community becomes more aware of its benefits.

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Structure Health Monitoring

A real-time on-board 'stethoscope' for Condition-Based Maintenance



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Structural Health Monitoring (SHM) is an innovative way of on-board Non-Destructive Testing (NDT) to directly assess the integrity of aircraft structures. The principle of SHM is comparable to the human nervous system. Discrete sensors which form a network remain permanently mounted onto, or embedded into the aircraft structure, detect and diagnose inevitable structural damage, mechanical loads or abnormal conditions. The sensors are interrogated via an 'on-board' or 'off-board' diagnostic system and information on the structural state is reported to maintenance.

In contrast to conventional NDT, there is no need for a qualified NDT inspector to access the area of inspection and to perform the measurement by hand-held NDT probes which is in most cases costly and time consuming.

As a result, SHM shows for selected use cases a great potential to reduce time and cost for maintenance, to increase the aircraft availability and to realise innovative aircraft design for the reduction of weight.

Airbus is developing SHM onto its new generation aircraft to ease structural maintenance, beyond the wider Condition-Based Maintenance (CBM), meaning doing maintenance when the need arises (i.e. after one or more indicators show that equipment or structure is going to fail or is deteriorating).

The evolving integration of on-board systems into the avionics' network and broadband data communication capabilities are setting the scene for a step change that aims at bringing significant benefits to the operators.

Easing and foreseeing maintenance by Condition-Based Maintenance (CBM)

In the past decades, aircraft on-board self-testing functions evolved from Built-In Test Equipment (BITE) which has been applied on engines and other components essential for flight operations, to complex integrated systems' architectures.

SHM is completing the global CBM. The integration of structural on-board monitoring capabilities into the aircraft monitoring and management network is a key enabler for CBM. By replacing scheduled inspections with real-time monitoring or monitoring on demand, SHM delivers increased aircraft availability through the optimization of unscheduled maintenance and accurate follow-up of an eventual degradation.

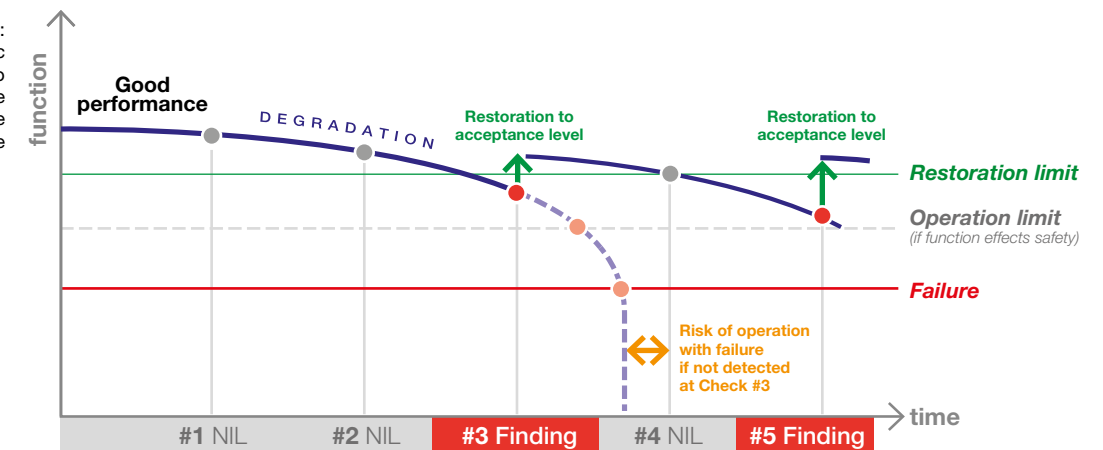
The benefit of CBM versus classic structure inspections

Currently, continued airworthiness and reliability targets are achieved using a comprehensive set of predefined scheduled maintenance tasks. The new releases of regulatory guidance on SHM, issued from advice and discussions on requirements and approaches, have been prepared for the validation of SHM systems.

What does switching from the existing inspection programme approach to CBM mean from a continued airworthiness point of view? Let's look at typical routine of structure inspections carried out at predetermined intervals as a function over time, flight hours or flight cycles.

If we take the time-based model as an example (see figure 1), the degradation will increase over time. The initial period can be described as 'good performance' where the degradation rate is low, or even very low. During this period, classic visual inspection techniques may even fail to identify that degradation has started. It is during this period where many structural inspections feature an interval threshold to account for the good initial performance of an aircraft. However, as time progresses, degradation is inevitable and the acceptable condition of the structural item is questioned. In case the inspection finds degradation which has passed the predefined limit that ensures safe operation until the subsequent inspection, the items must be restored. The respective benchmark is named 'restoration limit' in the example model. Consequently the progressing degradation after Check #2 in our example should stay above the operational safety limits before Check #3, when the restoration limit was not reached at the time of Check #2. With this, the safety margin between the safety limit and failure are maintained. The restoration limit and the repeat interval are interdependent and set by trading of economics.

Figure 1:
Example of a typical classic scheduled inspection scenario showing the generic performance of an aircraft structure versus in-service life time



Checks performed

This example shows a classic finding rate of No Item Listed (NIL) at Check #1 and #2 and a 'Degradation Finding' at Check #3. The item is then restored to near to new quality and is found NIL again at Check #4, degradation is again found at Check #5, to be once again restored.

A second aspect is that restoration does not often bring the item back to its initial state (a restored item is normally close, but not exactly the same quality of a new item).

This conservatism however is necessary to build robust inspection programmes on the current fleet level condition monitoring approach. Inspections resulting in 'no finding' could possibly have been deferred on that aircraft, but there is however still potential for findings on other aircraft triggered by the variation of an individual aircraft's operational conditions and occurrences. In other words, effectiveness of the inspection programme is validated by the 'no finding' rate at fleet level - the current fleet level condition monitoring concept.

Switching the global concept to CBM brings maintenance from monitoring fleet level conditions by inspecting every aircraft of a fleet, to managing the individual aircraft airworthiness against predetermined safety and economic limits with built-in monitoring capabilities.

Let's look into the semantics of such an approach (see figure 2). The on-board system monitors the relevant parameter over time and as from the initial detection, a prognostic function provides a status input on the overall condition monitoring system for the structural item. When the 'maintenance notification limit' is reached, the airline's Maintenance Control Centre (MCC) is notified by the aircraft system. Maintenance can now start planning the restoration slot within the 'maintenance window' (e.g. packaged together with other deferred items in a dedicated shop visit) to optimize the aircraft availability. A cockpit message informs the flight crew and the MCC if the degradation is about to approach an 'operational limit', providing a clear status of the individual aircraft's remaining operational capabilities (e.g. number of flight cycles/hours before the item needs to be restored), limitation of the aircraft's specific capabilities (reduce flight level and/or reduced load), etc.

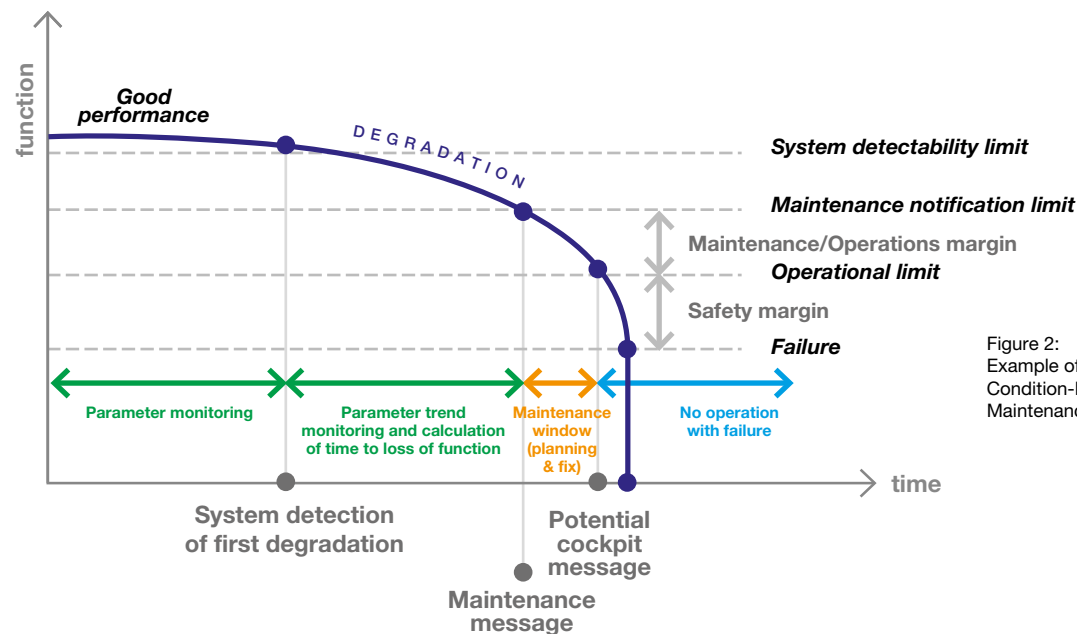


Figure 2: Example of a typical Condition-Based Maintenance scenario

CBM not only eliminates the repeated NIL finding inspections (and associated down-time) but also provides an online status of the individual aircraft's conditions. This clear forecast of the fleet-wide operational capacity enables the airline operations and maintenance control centres to plan ahead and increase aircraft availability.

SHM technology flying on Airbus aircraft today

An example of a fairly straight forward and effective Airbus SHM application flying today is the tail strike indication system (ATA31-28) on its long haul aircraft. Initially developed with the A340-500/600, an adapted version is also on-board the A380. Equipped with 2x2 redundancies (two sensors with two crack-wire lines each), the system provides the flight deck with a clear online indication of conditions to complement the pilot's feel, during take-off manoeuvres. While the main aim is to enhance the overall safety, it is interesting to note that it also enabled Airbus designers to achieve a significant weight saving by integrating the tail strike system capabilities into the structure design.

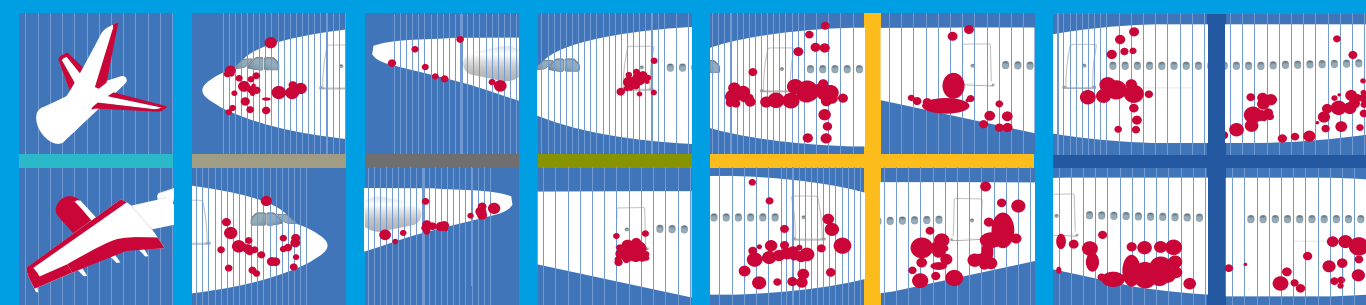
Flight testing today

Airbus' key research today is focusing on opportunities around the A350 XWB (Extra Wide Body) and its extensive structural use of Carbon Fibre Reinforced Polymer (CFRP).

A wide range of uses for SHM is being explored by our design specialists, such as pre-load measurement in the tension bolts of the vertical tail plane attachment, and in-situ measurement of in-service loads in the horizontal stabilizer. However the most prominent and challenging system currently being developed is one that immediately detects and assesses accidental ground handling impact damage to CFRP in door surround areas (see figure 3).



Figure 3: In-service damage mapping for the fuselage of a long-range aircraft. The locations with impact damage are marked with coloured symbols. The door surround areas show a high concentration of impact damage caused during ground handling.



Global percentage of impacts by zones on the aircraft

Example on the A320 Family

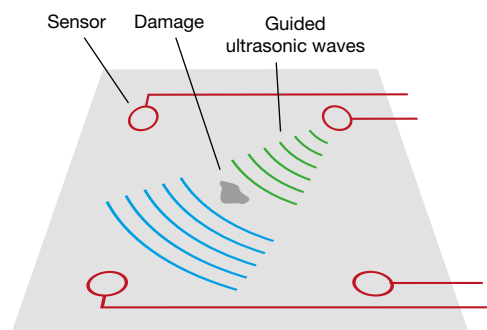
Acoustic-ultrasonic principle

The SHM system for impact damage detection and assessment of door surround structure uses acoustic-ultrasonic technology.

Acoustic-ultrasonic systems use an array network of piezoelectric transducers acting as sensors and actuators for guided ultrasonic waves. These waves interact with structural damage such as delamination and de-bonding. Structural integrity is diagnosed through analysis of changes in wave characteristics before and after the damaged area (see figure 4).

This system is under development and is being tested in two kinds of fuselage ground validators, as well as in-flight validators within the A350 XWB CFRP skin panel demonstrator of the A340 MSN001 (see figures 5 & 6), and in the surround structure of the passenger door 1 of the A350 XWB (see figure 7).

Figure 4: Acoustic-ultrasonic system principle



Figures 5 & 6: SHM impact damage detection system sensor network installed in the A350 XWB CFRP composite panel demonstrator of the A340 MSN001.

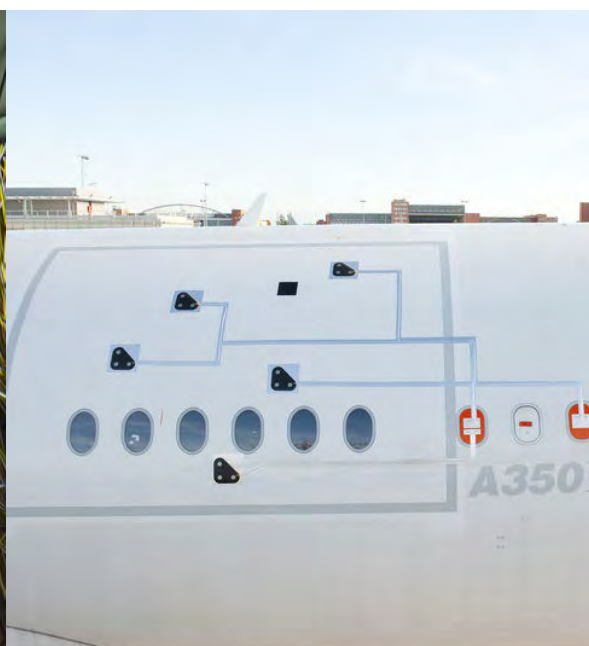
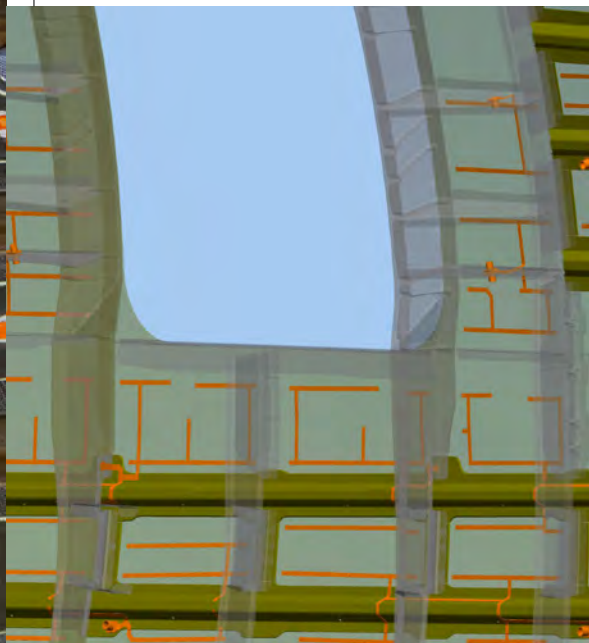


Figure 7: Digital Mock-Up (DMU) display of the acoustic-ultrasonic sensor network arrangement in the passenger door 1 of the A350 XWB MSN001



How Airbus addresses SHM technology

Airbus' Material and Process (M&P) domain is responsible for the development and qualification of SHM technologies. In order to provide the best technical solution at minimum time and cost, Airbus' M&P department not only works in close collaboration with disciplines from stress and design, systems, customer support and manufacturing but also interacts with a world-wide network of technology suppliers, system integrators, institutes, academia, airworthiness authorities and other aircraft manufacturers.

Airbus M&P domain has developed a so called 'SHM Toolbox' which provides a complete set of technological solutions for generic applications, ready to use by design engineers to further enhance aircraft capabilities and performance.

As SHM is merging the worlds of materials, structure and systems, it requires a clear concept to ensure the success of the application. To achieve this cross-functional aim, teams have been formed to integrate the structural sensing technology with the aircraft monitoring system architecture. This approach has successfully led Airbus to establish a comprehensive set of key requirement families for SHM. In the course of the JASTAC (Japanese SHM Technologies for Aircraft Composite structures) project, in close cooperation with Mitsubishi, Kawasaki, Fuji Heavy Industries, Japanese Aerospace Exploration Agency (JAXA) and the University of Tokyo, detailed requirements have been validated in test campaigns expanding on well-established NDT (Non-Destructive Testing) and material test principles. These requirements have set the reference for ongoing research and technology projects like the Vertical Tail Plane - Next Generation (VTP-NG) rib de-bonding detection system. Furthermore, these requirements have also been the bases for the Aerospace Recommended Practice (ARP-6461) guidelines for implementation of SHM on fixed-wing aircraft.

Principally, SHM is developed and deployed in four generations in which the SHM system is given step-by-step more complexity, features and responsibility, in order to gain confidence in this new kind of technology:

Generation 0 For the monitoring of structural tests - already deployed in the course of the A380 and A350 XWB component and full-scale testing.

Generation 1 For in-service aircraft with benefits in maintenance - has achieved technology readiness for selected technologies and given applications.

Generation 2 For in-service aircraft with benefits in maintenance and weight savings at component level - under development.

Generation 3 For in-service aircraft with benefits in maintenance, weight savings on aircraft level and intrinsic quality assessment in manufacturing and assembly - under development.

Today, the emphasis is not on the development of further new SHM technologies, but on testing the SHM system's robustness in representative environments to mature future service applications.

Potential retrofit applications

With the growing number of older aircraft in service, the business case for SHM retrofit applications is gaining more and more momentum. Such an application is typically Generation 1 and aimed at known structure hotspots, associated with significant down-time due to heavy access and complex repetitive inspections, as well as low finding rates. While a high finding rate due to the down-time for access and repair alleviates the business case, it is even more worthwhile if the repeat inspection is removed from the maintenance schedule.

The extensive in-service history and testing of ageing structures in the frame of the current 'long range' and 'single aisle' Extended Service Goal (ESG) campaigns provide comprehensive data for airframe designers studying potential SHM applications.

With this detailed knowledge, the most appropriate technology can be selected from the Airbus 'SHM Toolbox' and adapted to the specific application. Retrofit applications are planned to have a dedicated focus on monitoring only age-related degradation parameters like fatigue, corrosion and delamination. The target SHM technology is lightweight, easy to install and simple to use.

The Comparative Vacuum Method (CVM™)

CVM™ is an excellent example for ready to use Generation 1 SHM technology for monitoring crack initiation and growth against pre-defined limits.

The principle behind CVM™ is uniquely simple (see figure 8) and allows crack inspection in minutes at base or infield. CVM™ is based on a permanently bonded sensor onto the surface of a component where damage could occur. The sensor contains a manifold of alternating fine 'vacuum galleries' and 'air galleries' that are open to the surface. In case the area under the surface needs to be inspected for cracks, vacuum is applied to the 'vacuum galleries' via a hand-held measurement device, the 'air galleries' remain at ambient pressure and the pressure difference between 'vacuum galleries' and 'air galleries' is recorded. If no flaw is present, the pressure difference will remain at a stable level. However, if a crack develops under the sensor, air will flow through the passage created from the 'air galleries' to the 'vacuum galleries', the pressure difference drops significantly and the

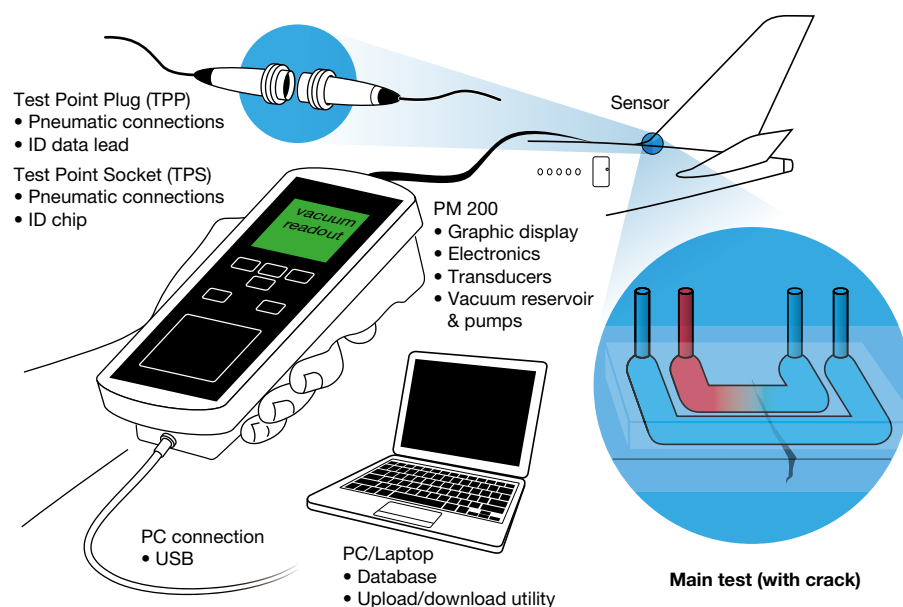


Figure 8: Principle set-up of CVM™ technology for crack detection, comprising a sensor which is bonded to the aircraft structure, a hand-held measurement device and a connector to which the sensing device and the sensor are connected.

crack is automatically detected. Sensors are widely flexible in design and thus adaptable to a wide range of target applications. They may either take the form of self-adhesive polymer 'pads' or may form part of the test component.

The spacing between the 'vacuum galleries' and 'air galleries' determines the minimum detectable damage size. CVM™ for crack detection has been developed between Airbus and the supplier SMS to technology readiness.

Smart structures and materials for the future

The research focuses on multi-functional smart structures and materials with built-in self-sensing, optimized weight and lower costs for global structural CBM. For example, Airbus is developing optical fibre sensors which are capable of detecting, localising and assessing impact damage, as well as monitoring structural loads. These small diameter optical fibre sensors (50 µm to 125 µm) are mounted or embedded into the CFRP structure in the course of the manufacturing process. In addition, the same optical fibres are developed to be used for transferring system's data instead of using heavy conventional data cabling which in turn leads to massive weight savings.

Airbus' future design concepts do not limit the SHM function to monitoring structure conditions during the service life of the aircraft. SHM technology by means of embedded optical fibre sensors, for instance, is developed in the course of JASTAC project (see section above) to become an integral aspect of life-cycle monitoring of CFRP structures, covering lay-up of the part, curing, cooling and demoulding, assembly and operation (see figure 9). Throughout the manufacturing and assembly of CFRP parts, SHM provides direct access to the physical characteristics of the parts (e.g. temperature and stress field during cure, degree of cure, residual stress build-up during assembly) enabling an intrinsic quality control together with further weight optimized design.

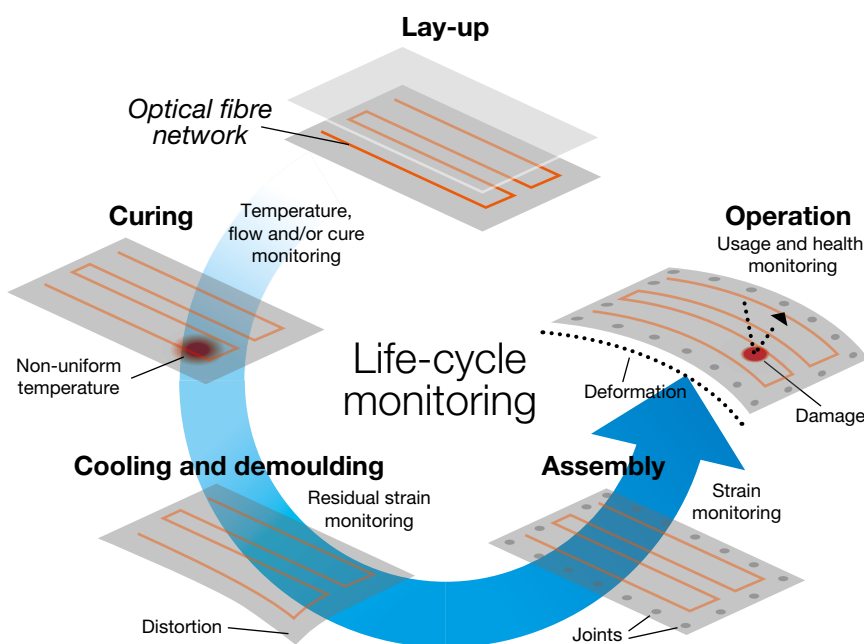


Figure 9: Life-cycle monitoring of a CFRP part by means of embedded optical fibre sensors, covering lay-up, curing, cooling and demoulding, assembly and operation.



The Aerospace Recommended Practice (ARP-6461) guidelines for implementation of SHM on fixed-wing aircraft have been published by the Society of Automotive Engineers (SAE) G-11 SHM committee in November 2013. Airbus is a key initiator and driver of this committee consisting of the world's leading aircraft manufacturers (Airbus, Boeing, Bombardier and Embraer), airlines, system integrators and airworthiness authorities (EASA and FAA).

The ARP addresses gaps in industry-consensus approaches for SHM applications on commercial aircraft. It represents a significant step forward to reducing the product development risk enabling SHM technologies to buy their way onto commercial platforms. The document and further details are available on SAE international's website at <http://standards.sae.org/arp6461>.

Regulatory framework – setting new airworthiness standards

Today, the individual operator's maintenance programme is developed from a number of source documents, including the manufacturer's Maintenance Review Board (MRB) report, Certification Maintenance Requirements (CMR), Airworthiness Limitations Items (ALI) typically summarized in the Maintenance Planning Document (MPD) plus unique national regulatory requirements and others.

Since the late nineties, Airbus has been actively working in various industry committees to build a robust certification path for bringing SHM from the laboratories into service. In April 2009 the International Maintenance Review Board Policy Board (IMRBPB) accepted the revision of maintenance guidelines for the creation of aircraft scheduled maintenance programmes contained in the Airlines For America (A4A)* ATA MSG-3 document to cater for use of SHM technology instead of visual and NDT inspections.

Evolving over the generations, built-in self-test capabilities have enabled manufacturers to design a variety of systems that render a growing portion of scheduled maintenance tasks redundant. Namely, engine monitoring and buzz words like Built-In Test Equipment (BITE) are leading examples of the trend towards further integration of the aircraft systems' architecture. In the future, we can think that 'aircraft health monitoring' will become one of its core elements.

Nose to tail SHM capabilities addressing the full envelope of structure conditions are essential to establish aircraft health monitoring as an enabler for ultimately switching from scheduled maintenance programmes to Condition-Based Maintenance (CBM).

*formerly Air Transport Association (ATA) of America

CONCLUSION

In the past decade, aeronautical Structural Health Monitoring (SHM) has moved from extensive research and lab-testing, to the definition of a comprehensive application set-up, now ready for use. Airbus' current focus is on the maturation of selected key SHM technologies and on the development of multi-functional smart structures with built-in self-sensing, optimized weight materials.

SHM is now at the doorstep of retrofit applications ready to monitor structural hotspots on the ageing aircraft in service today. The main benefit for this retro-application is increased aircraft availability and further gained service experience. Furthermore, SHM technology will be a vital feature on Airbus' future component design. By fully integrating SHM into the aircraft's monitoring architecture, it will bring significant weight savings and overall further increased aircraft availability. In addition, SHM will significantly reduce the repeated maintenance tasks which often lead to No Item Listed (NIL).

Structural Health Monitoring is like having a permanent on-board doctor to detect degradation as-and-when it occurs, assess its impact, then treat it in a timely manner. The result is a healthy aircraft with enhanced operability: lighter, safer and easier to maintain.

Importance of reporting events from the field

Continuous improvement of Airbus aircraft's safety

Continually enhancing our products' safety level is more than a corporate objective for Airbus; right from the beginning, a safety culture has been instilled into our employees and has become part of their daily lives.

As an aircraft manufacturer, Airbus is continuously looking at enhancing global fleet safety of our aircraft. We do this not just by applying the continued airworthiness obligations (EASA Part 21.3 - ORO.GEN.160 of EU Regulation 965/2012, EASA AMC 20-8), but looking beyond, and analysing events that may impact the continued safe operation of the aircraft.

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In-service event data

In order to continually monitor the safety of its fleet Airbus needs to know what events occur during operations. While every conceivable condition is either flight tested or replicated during certification activities (read telemetry article page 4), perfectly accurate predictions of events that may arise after years of service are harder to define.

The exhaustive reporting of events from the field and the quality of such data are important steps to get a global understanding of how our aircraft behave and respond to conditions that are met during daily operations.

Your input allows Airbus to perform its duty in terms of continued airworthiness and safety enhancement.

Reports of occurrences are systematically analysed within Airbus, and good quality, timely data is required to enable us to perform efficient and effective analysis of the events. This data also helps Airbus develop an understanding of developing trends in the fleet which may have an impact on the safe operation of the fleet - this is one of the cornerstones for the ongoing activity of safety enhancement.

It is not just information from the field that provides us with the global view of safety within our fleet; we consolidate the reports from our operators by capturing safety related data coming from internal channels such as the production, flight test and engineering domains.

Why is reporting important?

Further to a non-Airbus aircraft accident, the investigating authorities identified that the aircraft had been flying with an identified fault for a number of flight cycles before the accident; this fault had not been reported.

The investigating board concluded that failure of reporting limited the effectiveness of existing safety programmes, meaning that it could result in an inaccurate assessment of risks by both airlines and aircraft manufacturers, which limits their ability to manage the risks. Further to this, the investigating authority issued recommendations on the need to make operators aware of the importance of reporting.



Where does Airbus get input from?

Airbus can only review events that have been reported, so the more data collected, the better the analysis. Our main source of data comes from the fleet of nearly 8,000 Airbus aircraft currently in service.

The new European operational regulation (ORO.GEN.160 of EU Regulation 965/2012), obliges European operators to report in-service events to manufacturers and national authorities in line with identified regulatory criteria (similar to EASA AMC 20-8 guidance material).

In addition to European operational regulation, Airbus encourages operators to report in-service events that are:

- Identified by EASA AMC 20-8 guidance material,
- Defined by your own airworthiness authority
- Considered as added value for the safety enhancement level of Airbus' fleet.

Events should be reported via existing communication channels with Airbus' Customer Services, Engineering department, Field Service Managers (FSM), and/or Customer Support Directors (CSD).

These criteria cover events that fall within EASA Part 21 requirements.

This will enable us to analyse, review and introduce actions to enhance the continued safety of our fleet.

Repair requests or reports made outside of these criteria are not considered as answering the formal reporting process requested by European regulations.

If in doubt about whether an event is important, the best action is always to report the information.

An event you may think of as an isolated case may have a bigger impact on a global fleet level.



How are these reports processed by Airbus?

All events reported to Airbus are collected and analysed in order to address the basic continued airworthiness obligation, and also to look beyond the regulations.

Any events that are identified as having a potential impact on fleet airworthiness are analysed by the Continued Airworthiness activity within Airbus. Following technical investigations and risk analysis, occurrences presenting potentially unsafe conditions are formally presented to the EASA during regular face-to-face Airworthiness Review Meetings (ARM). Events that are identified as safety related, are also internally investigated and assessed, not just to ensure that the continued airworthiness safety objectives are still met, but also to proactively detect areas to be improved.

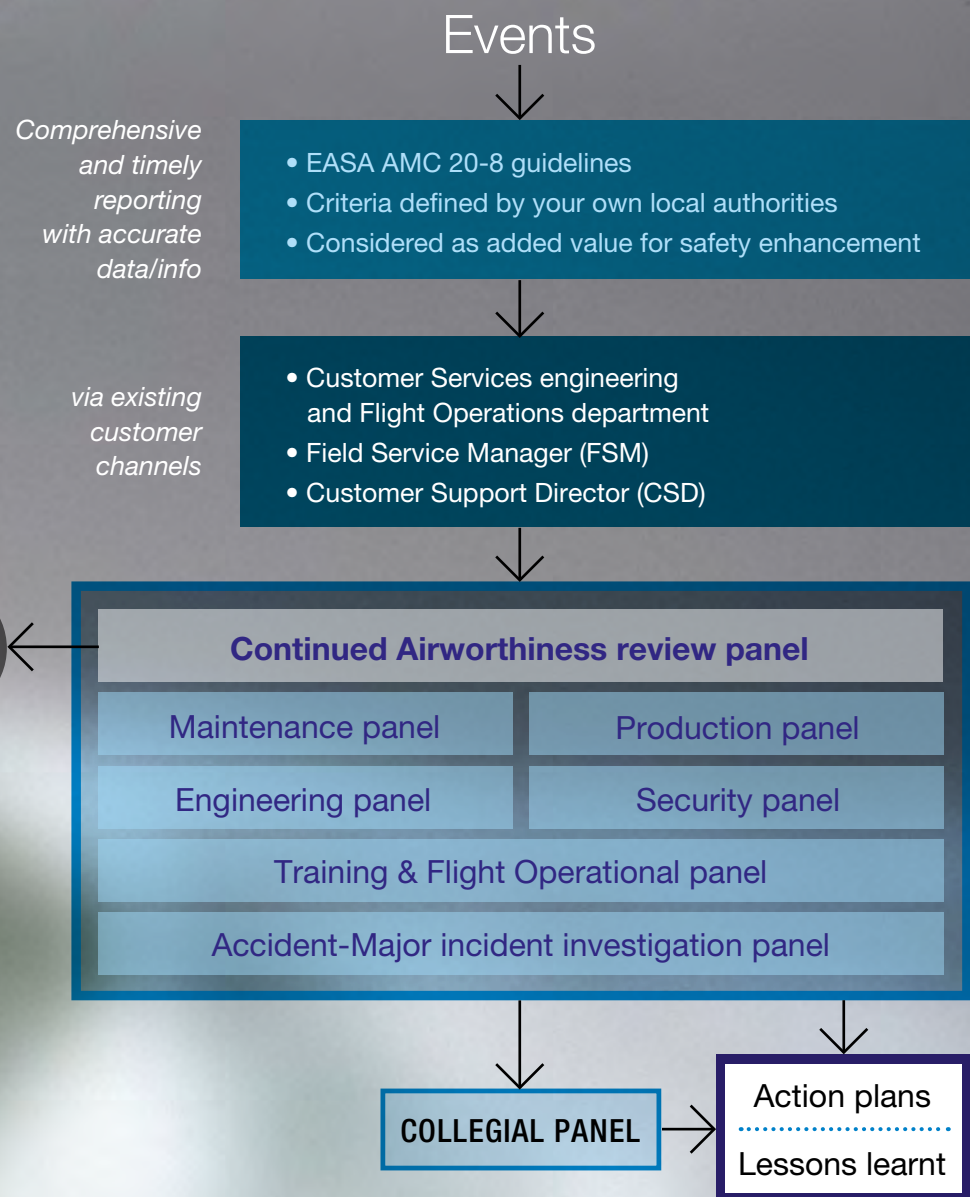
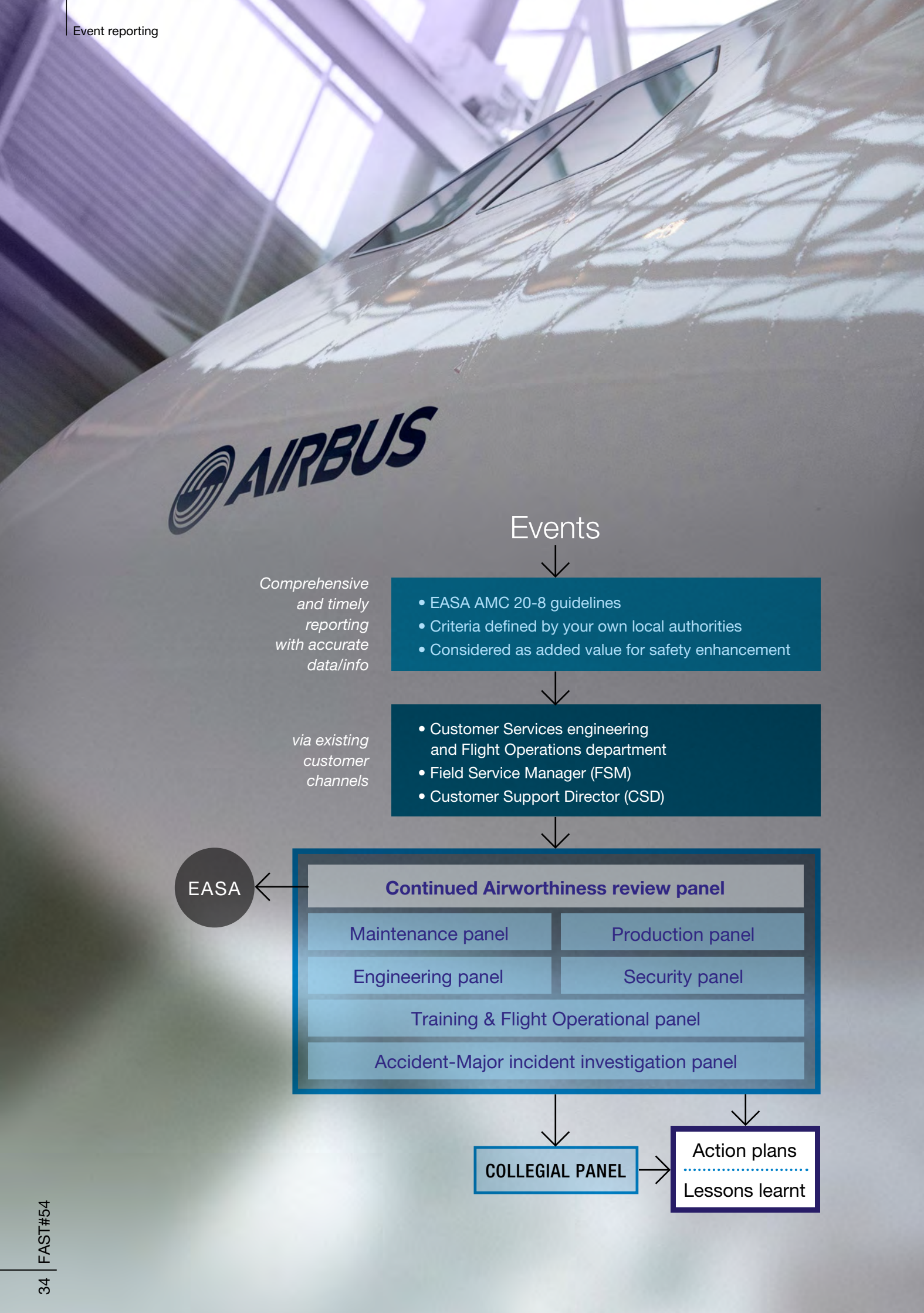
It is important to note that such activities are not only based on the investigation of individual reported events but is also on the review of the related trends. Each report, even if it seems similar to the previous one, remains important.

Based on these reviews, specific action plans can be developed in order to contain, correct and prevent repetition of safety issues in a timely, efficient and effective manner and also to capture lessons learnt for integration into future developments.

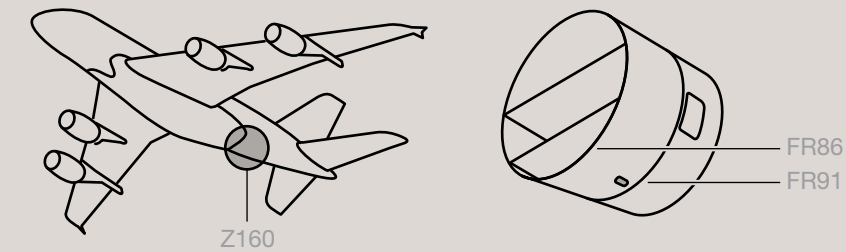
Who performs the safety reviews?

On top of the continued airworthiness obligation, an internal process ensures that the safety related events are reviewed cross-domain and cross-functionality. Panels of experts in the domains of engineering, flight operations and training, flight testing, accidents-major incidents, production, maintenance and security meet to consider whether the safety related event impacts their domain. There is also a regular collegial discussion, where the experts from the panels share their findings and ensure that all disciplines have been taken into account.

Each report,
even if it seems
similar to the
previous one,
remains
important.



Example of event reporting and corrective procedure A380 - Waste water service panel door



Issue (thanks to in-service event reporting)

- Several service panels found damaged/missing on in-service aircraft between 2009 and 2011
- Door does not latch correctly

Interim management

- Inspection of the waste water servicing panel per ISB 52-8016 Rev. 00 dated 24 Feb 2010
- In case the pushbutton is not flush (level) with the panel before departure, it is recommended to:
 - apply high-speed tape on the door surrounding, or
 - remove the door and dispatch the aircraft under MCDL 52-08

Corrective actions

- Design change launched of the service door:
 - introduction of more robust latches
 - addition of a retaining strut
- Modifications Service Bulletin A380-52-8017 available

In order to fully understand and classify the issue, the event reporting originator needs to collect all relevant information

- DFDR (Digital Flight Data Recording)
- PFR (Post Flight Report)
- Trouble-shooting data
- Log book
- Inspection reports
- Photos (highest possible quality and from different angles)
- Maintenance action(s) taken
- Component removal(s)
- Pilot reports
- Any particular relevant information

CONCLUSION

Reporting events directly to Airbus enhances fleet safety and contributes to safer aircraft operations within the air transport system.

Improving event reports is a key factor, and operators and MRO (Maintenance, Repair and Overhaul) organisations are encouraged to report events to Airbus, even if the event is considered irrelevant.

It is important to remember that the timeliness and quality of the data is paramount, in allowing an effective and efficient investigation.

Airbus is not requesting the implementation of extra processes, but as a guideline, we recommend using the format already in place with your own airworthiness authority (e.g. by filling in an Air Safety Report, Major Occurrence Report, Safety Data Report, etc.) and to use existing communication channels with Airbus.

A320 Family noise reduction

The best gets quieter



Noise from aircraft operations impacting communities in the vicinity of airports is recognized as the major source of annoyance from the air transport industry.

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Annoyance not only results from perceived noise levels, sound quality and the number of “events” (aircraft take-offs, landings, etc.) occurring in a period of time, it also depends on social and psychological factors.

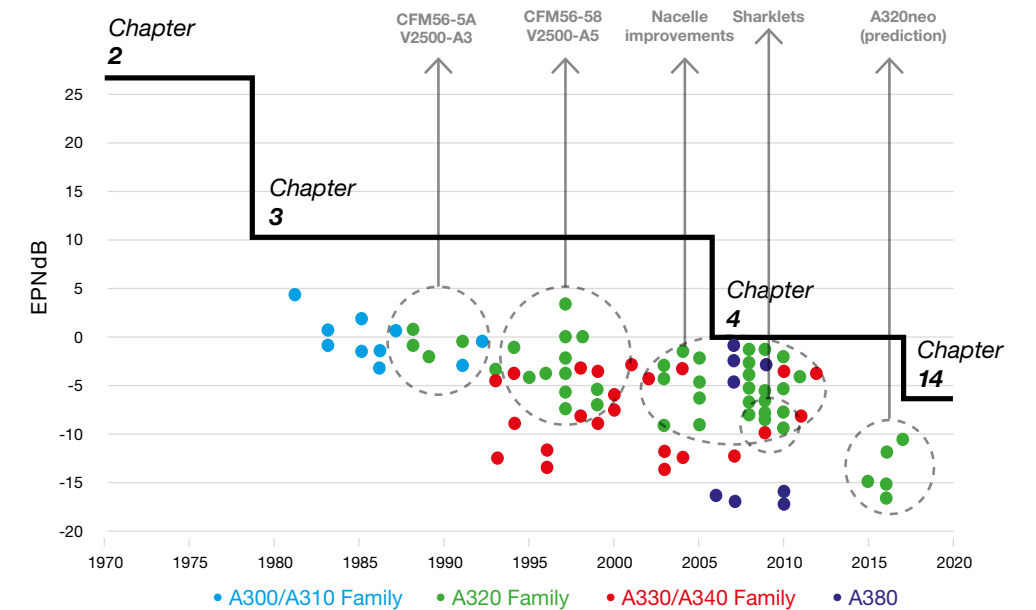
In the regions of the world such as Europe, where aviation has been a factor of economic development for a long time, noise impact is an important obstacle to airport traffic growth. Creating new runways is a subject of huge public debate in certain regions and existing ones are subject to noise restrictions and local regulations of increasing severity.

Operators’ most appreciated single aisle aircraft, is a step-ahead in noise reduction.

Noise certification standards evolution

ICAO (International Civil Aviation Organization) Annex 16 defines an evolving noise certification standard to ensure that aircraft manufacturers implement the latest noise reduction technology available. These increasingly stringent standards are the result of a process that guarantees environmental benefits, while remaining technically feasible and economically reasonable.

Evolution of ICAO Annex 16 noise standards and correlative improvements of Airbus aircraft



An industry vision of how to contribute to sustainable growth with respect to airport noise is to allow for traffic growth by continuous efforts in reducing perceived aircraft operations noise that deliver at least constant or decreasing noise exposure footprints.

To progress towards this objective, Airbus leads the industry with each new generation of aircraft achieving dramatically aggressive noise reduction targets.

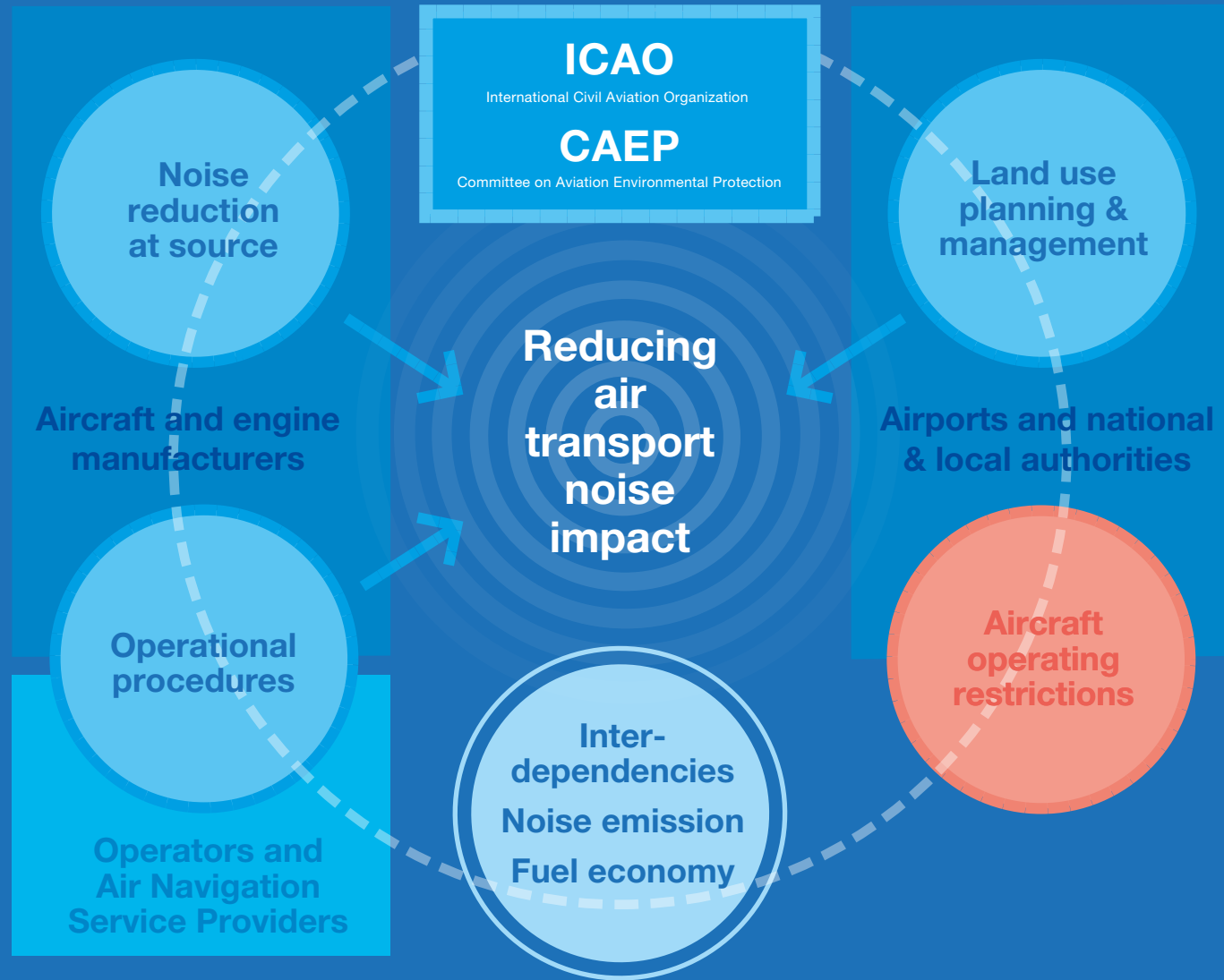
Furthermore, Airbus operators expect that during its production life-cycle, the noise impact of an aircraft family will be reduced. This is a key contributor to the programme’s longevity as it mitigates environmental impact and maximizes airport community acceptance and subsequently, its economic efficiency.

This is particularly relevant to the short/medium range category of aircraft like the A320 Family that supports the majority of commercial operations from large airports which are engaged in rigorous noise impact management. More than 1,500 airports on all continents have A320 Family operations and an A320 takes-off or lands every two seconds.

Approximately 6,000 A320 Family aircraft are in service today and the current backlog is 4,240 aircraft. This very successful family of aircraft is bought by almost 200 customers, a number 47% higher than the competition.

Balanced approach to airport noise mitigation

ICAO resolution A33-7 - voted in October 2001



A320 propulsion system noise reduction

When it was designed in the early 1980's, the A320 incorporated the latest technologies in the areas of aerodynamics, structures, systems and high bypass ratio engines. It achieved a disruptive noise improvement relative to similar aircraft in service at that time. Its noise footprint for a given perceived noise level was about five times less than the majority of the in-service fleet.

Certification in compliance to ICAO Annex 16 Chapter 3 was achieved by the A320 in 1988 with sufficient margins to be able to comply with Chapter 4 when this new standard was enforced in 2006.

Research and Technology (R&T) work undertaken by Airbus and engine manufacturers for contemporary aircraft programmes like the A380 and A350 XWB (Extra Wide Body), generated spin-off applications with significant noise reduction and low impact design changes to the A320 Family. Actually, some of these new technologies and design improvements were subsequently implemented in the A320 Family production lines.

The main steps that resulted in significant improvements on noise levels were:

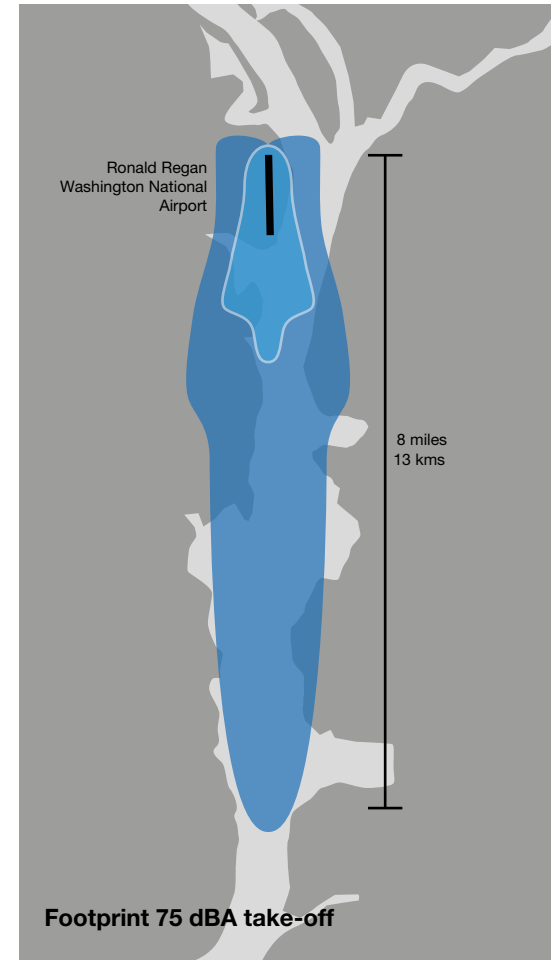
• **New engines technologies:**

- CFM56-5B engine with new fan blades design, larger fan case and improved thermodynamic cycle
- V2500A5 engines with new fan blades design, improved thermodynamic cycle and additional acoustic treatment in the primary nozzle

• **Improved acoustic treatment in the forward CFM56 engine fan case and extension of nacelle acoustic treatment in the bypass duct**

• **“Chevron” type design of the primary nozzle exhaust (V-shaped form).**

Overall these modifications have reduced the certified noise levels of all A320 Family models by more than three EPNdB (Effective Perceived Noise in Decibels) in terms of cumulative margin compared with ICAO Annex16 noise standards.



■ A320-200 ■ Competition's footprint in same category

The A320 reduced the noise footprint by five.

ICAO recognizes that aviation industry noise reduction is dependent on a balanced three-pillar approach to achieve airport noise mitigation:

- 1) Noise reduction at source by design and technology improvement,
- 2) Operations according to noise abatement procedures,
- 3) Noise management: land use planning and understanding annoyance factors.

The success of these three pillars in effectively reducing the noise impact, is expected to minimize the need to apply operating restrictions that would be detrimental to the efficiency of air transport.

Noise metrics

EPNdB: Effective Perceived Noise level in dB is the noise metric used in certification accounting for annoyance factors related to spectral content, tonal emergence and flyover duration.

dBAm_{ax}: abbreviated as dBA is the maximum A-weighted overall sound pressure level measured during an operational event (take-off or landing). It is widely used by airports' communities for assessing the peak noise level associated to an aircraft movement.

Chevron nozzle



New fan blades design



“Sharklet” wing tip devices

More recently (in 2012), the “sharklet” wing tip modification, primarily designed to improve high speed aerodynamic efficiency and consequently fuel consumption, also provides enhanced low speed climb rate capability that results in take-off/fly-over noise reduction by up to one EPNdB. This modification has achieved considerable commercial success; today more than 430 equipped aircraft are in service with 74 operators and retrofit campaigns are ongoing.

Air flow deflectors

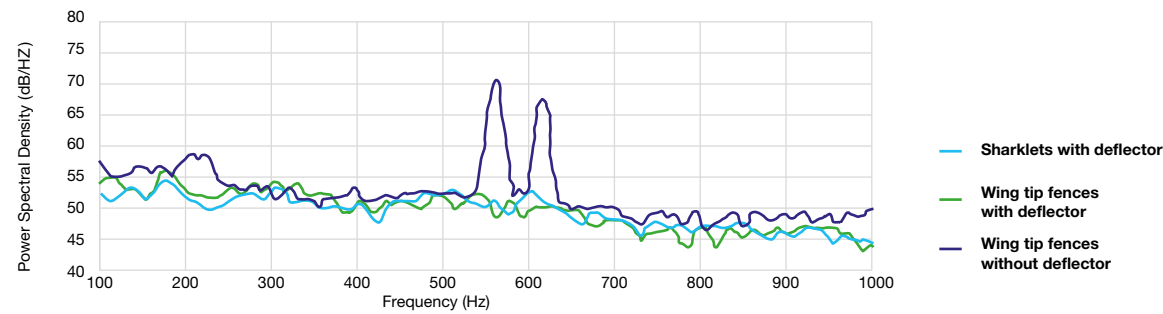
The R&T work aiming at tackling aerodynamic noise sources previously masked by engine noise, has led to the introduction of underwing ‘air flow deflectors’. These devices were implemented in production in June of 2014. They are now also available as a retrofit modification.

When positioned just ahead of underwing cavities associated with the fuel over-pressure protection system, these devices prevent the cavities from generating any tonal noise emerging from other airframe and engine noise sources.

This is particularly noticeable when engines are on idle during the descent phases, with speeds superior of 180 knots, and typically 12 to 50 kilometres from landing. Typically these deflectors reduce noise by 9 to 11 dBA. The air flow deflector has little impact on weight (< 150 grams) and no impact on aero efficiency.

Deflector efficiency - far field noise tests

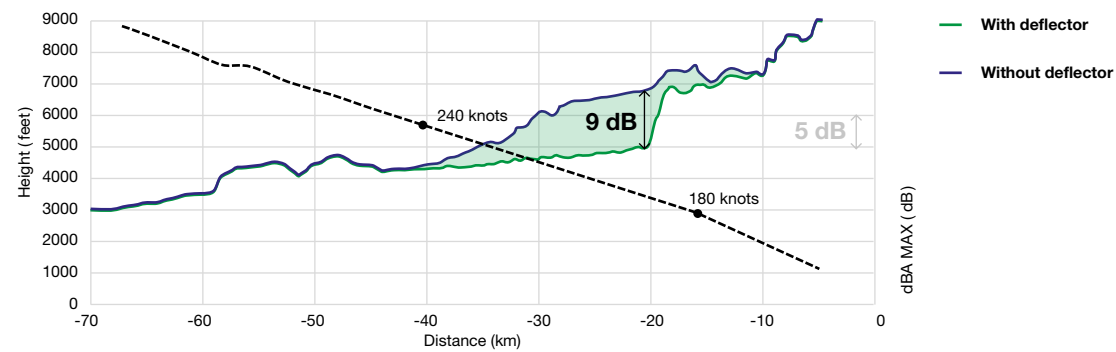
Far field average sound across 40-140° angle of emission - take-off speed 240 Knots



Wing tip fences are baseline configuration for A320 Family
Similar results are obtained at 220, 200 and 180 knots

Air flow deflectors for the A320 Family - test data

Noise simulated on real flight trajectory collected during a flight test in Toulouse (France) airport in the frame of an R&T project
Impact of air flow deflectors on a continuous descent at -2° slope



Aircraft noise significantly reduced in the far approach phase



Sharklets



Underwing cavity fitted with air flow deflector

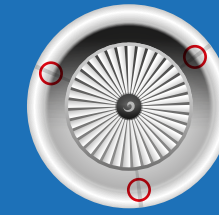
A320neo

In addition to sharklets and air flow deflectors, the new engine options (neo) for the A320neo offer new and improved PW1100 and LEAP1A engines, with very high bypass ratios (between ten-to-one and twelve-to-one), with fan diameters up to 81 inches, and using the latest propulsion system acoustic design and technologies.

The nacelles incorporate acoustic technology successfully proven with the A380 and A350 XWB such as a “zero splice” air inlet acoustic liner, significantly suppressing fan noise over the whole range of engine operating conditions during approach, take-off and climb.

It is expected that the certified noise levels will be reduced, on average by four EPNdB at take-off and two EPNdB at approach (compared with the current delivery standard). This would give a cumulative margin of 15 EPNdB with reference to Chapter 4 and subsequently would comply with Chapter 14 standards to be implemented by 31st December 2017.

The A320neo is already a big commercial success with 2,645 orders from 50 customers, representing a 57% market share. Airlines and leasing companies from all over the world have chosen this aircraft for its reduced noise levels, as well as for its 15% lower fuel burn.



A320 current engine option with three splices



A320neo (new engine option) with zero splices

Cumulative noise margins compared to ICAO Annex 16 - Chapter 14 noise standards

A320 current engine option (ceo) and predicted margins for the A320 new engine option (neo)



Reduced noise with the neo compared to the current A320 Family (excluding A318 aircraft)
• Average of -4 EPNdB at take-off
• Average of -2 EPNdB during approach

CONCLUSION

Initially designed to reduce disruptive noise compared to the previous generation of single aisle aircraft, the A320 Family has continuously improved performance and become quieter throughout its production life.

New noise reduction designs and technologies such as sharklets and air flow deflectors are also available as upgrades allowing aircraft to stay ahead of increasingly repressive noise certification requirements.

This is particularly true for the latest configuration of the family, the A320neo. It is expected that this aircraft will allow operators to minimize their airport community noise impact, and optimize traffic growth in a more sustainable way.

These noise reductions in parallel with the improved performance of the A320 Family contribute to the success of this aircraft with airlines and leasing companies around the world.

FAST from the PAST

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

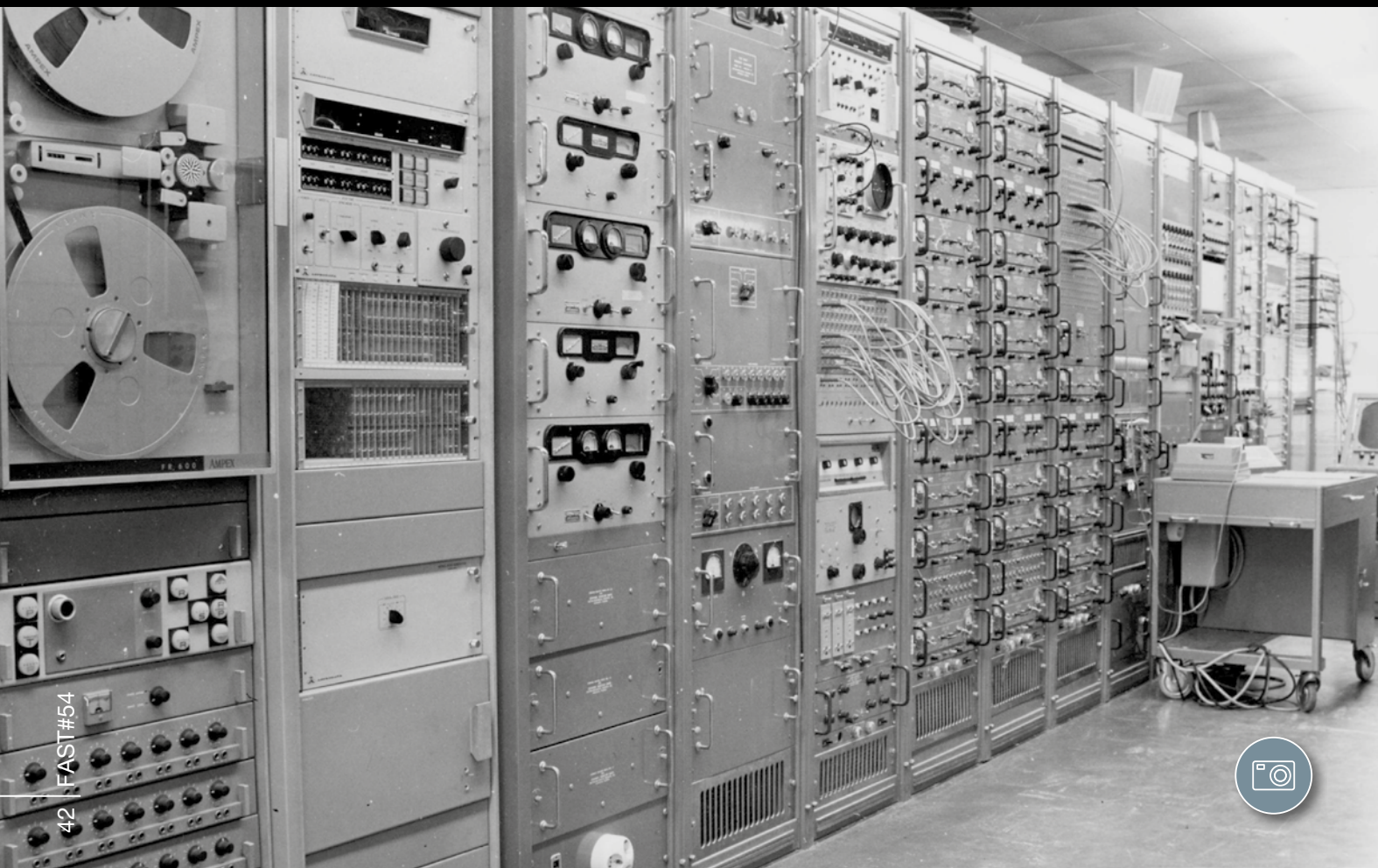
Telemetry was used well before the opening of Airbus' Telemetry Centre in 1987. Here are some images of the telemetry station at Manching airport (south Germany) used for the VJ 101 and later programmes during the mid-sixties. (see telemetry article page 4)



Photos courtesy of EADS Corporate Heritage

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