

Airbus technical magazine

June 2013

Special edition

A350 XWB

FAST

Flight Airworthiness Support Technology

 **AIRBUS**

Dear reader,

Nowadays everybody talks about innovation and at Airbus we really live and breathe it on a daily basis. However we believe that innovation is only worthwhile if it brings real value to our customers.

Going through the articles of this FAST special edition, you will see that the A350 XWB is ample evidence of this.

FAST magazine is innovating too by introducing a free tablet application alongside the traditional paper version. The added value to you, the reader, is many fold: Articles are enriched with videos giving complementary information, diagrams are animated making them easier to understand, 3D images give a new dimension to technical drawings, hyperlinks ease navigation and so much more...

Enjoy your reading and all the benefits of this innovative new media!

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Airbus technical magazine

FAST

Flight Airworthiness Support Technology

Special edition A350 XWB

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Dear Airbus friends,

We are very pleased to present you this FAST special A350 XWB edition.

This magazine will give you a comprehensive overview of the A350 XWB (eXtra Wide Body), the most efficient long range aircraft ever built.

Intelligent by design, the A350 XWB is combining advanced aerodynamics, innovative airframe technologies and optimized systems, while keeping a high degree of commonality with the Airbus family for the best operational performance.

Having involved customers from an early stage of development, Airbus is offering an aircraft that will meet all their expectations and demonstrate unprecedented maturity from day one. Its 'eXtra Wide Body' will provide a most comfortable cabin that will delight both passengers and crew.

But before we deliver this fantastic product to our customers, we have an extensive testing and certification period ahead of us. After the magic and the emotion of the first flight, we enter a phase where the A350 XWB faces the reality of flight.

All along the development phase, broad testing has been performed with our suppliers, in our integration rigs and on flight simulators. It is now time to make sure that reality confirms calculations and that this outstanding aircraft delivers the expected performance in terms of safety, efficiency, reliability, maturity and operability.

We have written this success story all together, thanks to the confidence and the involvement of our customers, to the great team spirit, the dedication and the passion of thousands of people at Airbus and at its partners all around the world.

We sincerely thank all the people who have trusted us and who have contributed, directly or indirectly, to the development of this 21st century high-tech aircraft, for the benefit of airlines and passengers worldwide.

Together, let's go for the A350 XWB amazing eXperience!



Didier EVRARD
Head of A350 XWB
Programme
AIRBUS



Fernando ALONSO
Head of Flight
& Integration Tests
AIRBUS



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Looking good

An overview of the A350 XWB

As the A350 XWB programme reaches the important and magical phase of real flight, FAST presents the technological innovations that will let this new Airbus family take to the skies. The least we can say is that it's looking very good.

There's a classic design expression that says 'Form follows function'. For this to be true, the function needs to be correctly identified and what better way to define what clients expect from a brand new Airbus aircraft family than by asking them.

Airbus used its latest aircraft, the A380, as a starting reference, then asked client companies to join Airbus in order to develop an aircraft that fits seamlessly into their existing fleets. Listening attentively to what, for them, constitutes the perfect aircraft has allowed us to evaluate what pleased them most about the current Airbus offer and where their priorities lie for aircraft of this type.

By building on success, the A350 XWB will not only retain commonality with other Airbus aircraft but respond perfectly to the needs of our customers.

Airbus' desire to perfectly align the A350 XWB with client needs is embodied in the expression used throughout the programme,

'Shaping efficiency'

Its principal objectives are to create:

- **A complete market-matching family**
One aircraft in three sizes, for the 250 to 400 seats market allowing true long-range capability
- **25% lower operating costs**
 - Efficient design driving costs down by 25%
 - Reduction in fuel burn and CO₂
- **A comfortable and efficient cabin**
 - High comfort 9-abreast baseline economy class with 18" seat width
 - Crew-rest areas outside of revenue space
 - More revenue potential

A new long range market-matching family of technically superior aircraft available in three class configurations



A350 - 800

Seats: 270
Range: 8,500 NM (15,750 km)
Wing span: 64.75 m (212 ft 5 in)
Overall length: 60,54 m (198 ft 7 in)
Overall height: 17.05 m (55 ft 11 in)
Maximum Take-Off Weight: 259,000 kg



A350 - 900

Seats: 314
Range: 8,100 NM (15,000 km)
Wing span: 64.75 m (212 ft 5 in)
Overall length: 66.89 m (219 ft 5 in)
Overall height: 17.05 m (55 ft 11 in)
Maximum Take-Off Weight: 268,000 kg



A350 - 1000

Seats: 350
Range: 8,400 NM (15,600 km)
Wing span: 64.75 m (212 ft 5 in)
Overall length: 73.88 m (242 ft 5 in)
Overall height: 17.08 m (56 ft)
Maximum Take-Off Weight: 308,000 kg

The A350 XWB is designed for eco-efficient operations

Departure

Improving air quality
NO_x emissions up to 35% below the CAEP6 (environment protection standard)

Latest technology
Noise Abatement Departure Procedure (NADP)

Cruise

Low fuel burn
Only 69g CO₂/pax/km

Unlimited ETOPS
(Extended-range Twin-engine Operational Performance Standards)

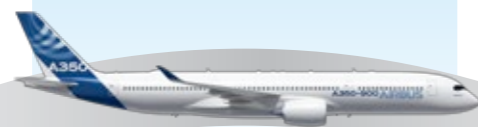
Latest technology
Required Navigation Performance (RNP 0.1) to help optimize routes and approaches

Arrival

Latest technology
Continuous Descent Approach (CDA)
Required Time of Arrival (RTA)

Quieter aircraft
Up to 14dB below ICAO Chapter 4 regulations

Efficient airport operations
Brake To Vacate (BTV)



25% less operating costs by design

Every aspect of the A350 XWB's design has been reviewed and improved to meet this impressive target.

Even noise levels have been greatly reduced making it the most environmentally-friendly aircraft in its category.

Eco-efficiency by design

- Having the lowest fuel burn engines also means lowest CO₂ emissions per person per km
- Quieter aircraft

Less pilot workload and training by design

- Ergonomic flight deck (see page 12)
- Commonality and innovation for lower pilot workload and reduced costs

Optimized wing efficiency by design

- Mach 0.85 cruise speed, reduced flight time validated on the A380 programme and flight tests
- Finest aerodynamics: reduced fuel burn, more range
- Advanced high lift devices

Optimized Turn Around Time

- Commonality also means that no special Ground Support Equipment (GSE) is needed

Less maintenance by design

- Intelligent airframe using 53% composite materials
- New 4-panel concept fuselage
- Simple, robust more efficient systems building on A380 new generation systems

New generation, fuel efficient long range engines

- Lowest specific fuel consumption engines

Carbon-Fibre-Reinforced Polymer (CFRP)

- no corrosion & fatigue tasks

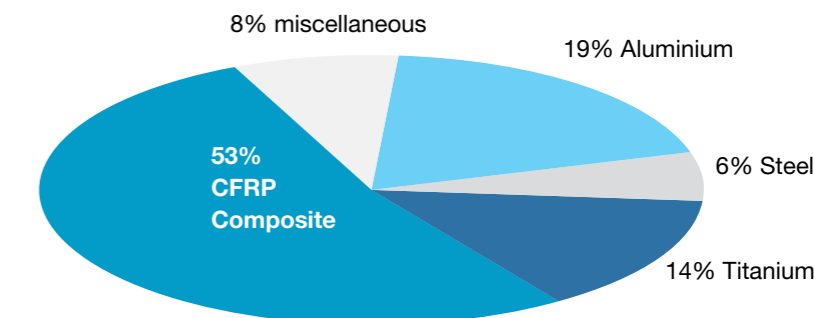
- Wings
- Centre wing box and keel beam
- Tail cone
- Skin panels
- Frames, stringers and doublers
- Doors (passenger & cargo)

Titanium - no corrosion tasks

- High load frames
- Door surroundings
- Landing gear
- Pylons



Light airframe using 53% composites



Cabin sized for comfort and growth

The A350 XWB Family takes comfort and capacity to a different level, for both passengers and crew.

An optimized cross section

- An extra large 220 inch (5.59 m) cross-section (armrest-to-armrest)
- Wide windows
- Flat floor for greater comfort

Adapted crew rest areas

- Cabin crew rest compartment with up to 8 cabin crew bunks
- Crew rest space without using revenue space
- Secluded access and dedicated changing areas

Flight crew rest compartment

- Two flight crew bunks and a workstation with secure access from the flight deck



Zero test means

Before MSN001 even flies, thousands of hours of testing will already have been performed and all potential scenarios for the first flight will have been explored.

By the time the aircraft flies, both the flight crew and the engineers will already know the aircraft and its systems well.

Of course, flight testing will always bring some surprises but many of the issues will already have been seen and corrected even before the aircraft takes to the air.

Expanding suppliers' parameters

With the advent of the Airbus New Supplier Policy (NSP), applied fully for the first time on the A350 XWB programme, Airbus has moved towards a greater reliance on its suppliers to test the systems that make up a modern aircraft. NSP has seen a move towards giving suppliers responsibility for bigger work packages and importantly, for the integration of the various components and software within their responsibility together.

Airbus' role begins when systems, components and software from different suppliers need to be integrated and made to work seamlessly together. This is what is called 'integration testing' and is key to Airbus' ability to develop mature aircraft, as expected by our customers – the airlines.

Before any testing has been done at Airbus, there have already been thousands of hours of testing performed by the suppliers. This testing starts with development testing of prototype equipment for new technologies being introduced on the A350 XWB. The testing then continues with component testing to demonstrate the performance and reliability of each component (qualification testing).

Where a supplier is responsible for a complete system (or part of one) they continue with pre-integration testing of their system, including verifying interfaces with other systems through models provided by Airbus. During this phase of testing, the supplier is in charge of performing the testing, but Airbus' engineers are involved both to ensure the right testing is performed, but also to provide advice and support based on Airbus' know-how built up over 40 years of experience.

Once the pre-integration testing has reached a sufficient level of maturity, the first components and systems in their first standard (S0) are delivered to Airbus and the real work of integration testing begins.

Initial testing

Functional Integration Benches (FIB)

The first tools used by the Airbus Flight and Integration Test Centre to start integration testing are a fleet of Functional Integration Benches (FIB). These benches cover almost the complete scope of the systems present on the aircraft with a mixture of real hardware (systems under test) and models for systems not present. The benches vary in complexity, but are all similar in architecture and are designed to test a 'function' on the aircraft. Examples include the 'Fuel FIB' where the complete functionality of the fuel gauging and management system will be tested. Another example is the 'Control and Guidance Integration FIB' where the complete flight control and auto-pilot system will be tested.

These FIBs are equipped with real hardware which is updated regularly during the development:

- S0 standards for the FIB entry-into-service
- S1 standards for Final Assembly Line testing,
- S2 standards for the first flight
- S3 standards for the aircraft's entry-into-service.

The FIBs are also equipped with models provided by the suppliers of other systems not present on each FIB to test the interfaces with these systems. On modern aircraft like the A350 XWB, no system operates without connections and interfaces with many other systems on the aircraft. Hence the Airbus integration strategy relies heavily on the quality and representativity of these models.

'Zero' means

Testing the aircraft on the ground

A key part of the Airbus integration strategy is also a series of 'zero' means. These test rigs are a complete representation of the systems on the aircraft. These means are as close as we can possibly get to MSN001 – hence the name 'zero' (MSN000) means.

High lift 'zero'

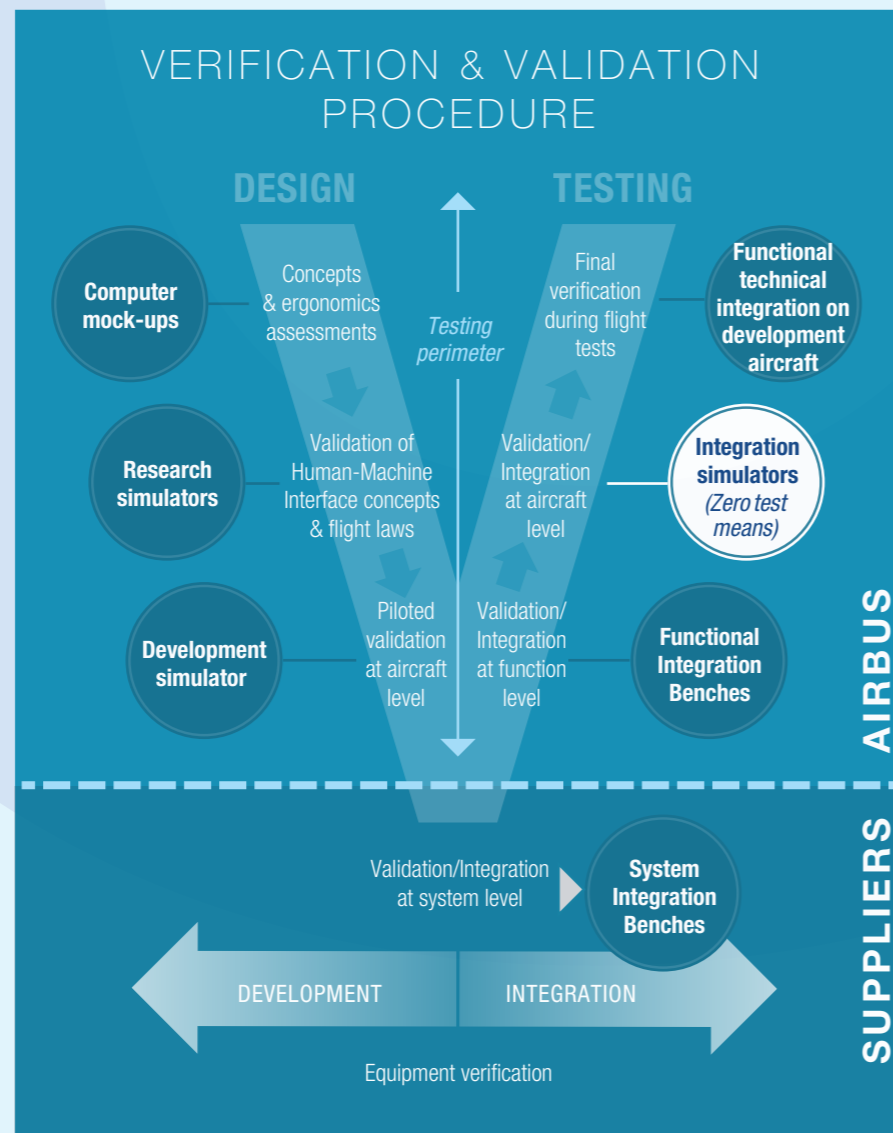
The high lift system is one of the most mechanically complex systems on the aircraft. The system comprises a complex series of mechanical drive-shafts, actuators and linkages that deploy the slat and flap systems for take-off and landing. Due to the potential to generate roll asymmetry that could not be controlled if deflections were different between left and right hand wings, the systems also comprises a complex detection system to lock the slats and flaps in place if a failure is detected. The A350 XWB high lift system also includes new technology with the Advanced Drop Hinge Flap (ADHF) system.

The Airbus high lift 'zero' rig, located in Bremen (Germany), consists of a complete left hand 'wing' with all the systems that will be found installed on MSN001. The aircraft structure is not present and is replaced by a steel structure to allow the system to be installed and operated. The right hand wing is simulated by a high technology electro-hydraulic brake system. This test rig is used to perform many safety tests prior to the first flight to ensure safety. A number of tests are performed on this rig that would be too dangerous to perform in flight – deliberate failures of shafts or drive links, for example.

The A350 XWB high lift 'zero' has been operational since late 2011 and was upgraded to full MSN001 configuration with real flaps installed in September 2012.



Article by
Mark COUSIN
Vice-President
Head of Systems
Integration
AIRBUS



High lift system

Double side-stay landing gear



Landing gear 'zero'

The landing gear system is also a very complex hydro mechanical system which is critical to aircraft safety. The A350 XWB landing gear also incorporates new technologies like the double side-stay landing gear.

The Airbus landing gear 'zero' rig, located in Filton (UK), consists of a complete landing gear system identical to those that will be found installed on MSN001. The aircraft structure is not present and is replaced by a steel structure to allow the system and landing gears to be installed and operated. This test rig is used to perform many safety tests prior to the first flight to ensure safety – for example ensuring that the emergency free-fall (gravity) extension system will perform as intended.

Cabin 'zero'

The cabin systems are tested in cabin 'zero' in Hamburg (Germany). Everything from the air distribution system to the In-Flight Entertainment (IFE) system and toilets must be tested. This is all done on a series of FIBs linked to a mock-up of the full A350 XWB fuselage and known as cabin 'zero'. Cabin 'zero' has been fully operational since early 2013 and will be used to perform a series of virtual cabin flights to test all the cabin systems prior to the first flight of MSN002 (the first development aircraft with the full interior). During these virtual flights, airline cabin crews will be used to simulate the cabin operational environment and ensure correct operation of all the cabin systems.

Integration simulators

The two integration simulators, located in Toulouse (France) consist of a full A350 XWB cockpit connected to the real aircraft computers that are found on the real aircraft. The biggest difference between an integration simulator and the more common training simulator is that the real aircraft computers are installed rather than simulated. The primary purpose of these integration simulators is to ensure that all the systems and computers work together – they have all been tested individually before being installed, but comprehensive testing is needed to ensure all these complex systems work as designed.

The integration simulators are used for two main types of testing. The first category of testing is specifically focussed on the integration of a given system with the other systems around it. The second type of testing is 'operational testing' where the simulator is operated by a 'crew' in a simulation of events that could occur in flight. During these tests, the overall performance of the entire aircraft is under scrutiny.

The integration simulators have been operational since early 2012. Since February 2013, the simulators have been configured in the MSN001's first flight configuration and have been performing the Virtual First Flight (VFF) campaign which will last around three months. During the VFF campaign, the test teams have to simulate all possible scenarios that could occur during the real first flight. Hence 100% of potential failure cases have to be simulated, the behaviour of the aircraft analyzed and its systems checked – for example loss of electrical power (emergency electrical configuration) or loss of engine power.

Integration simulator



Iron bird

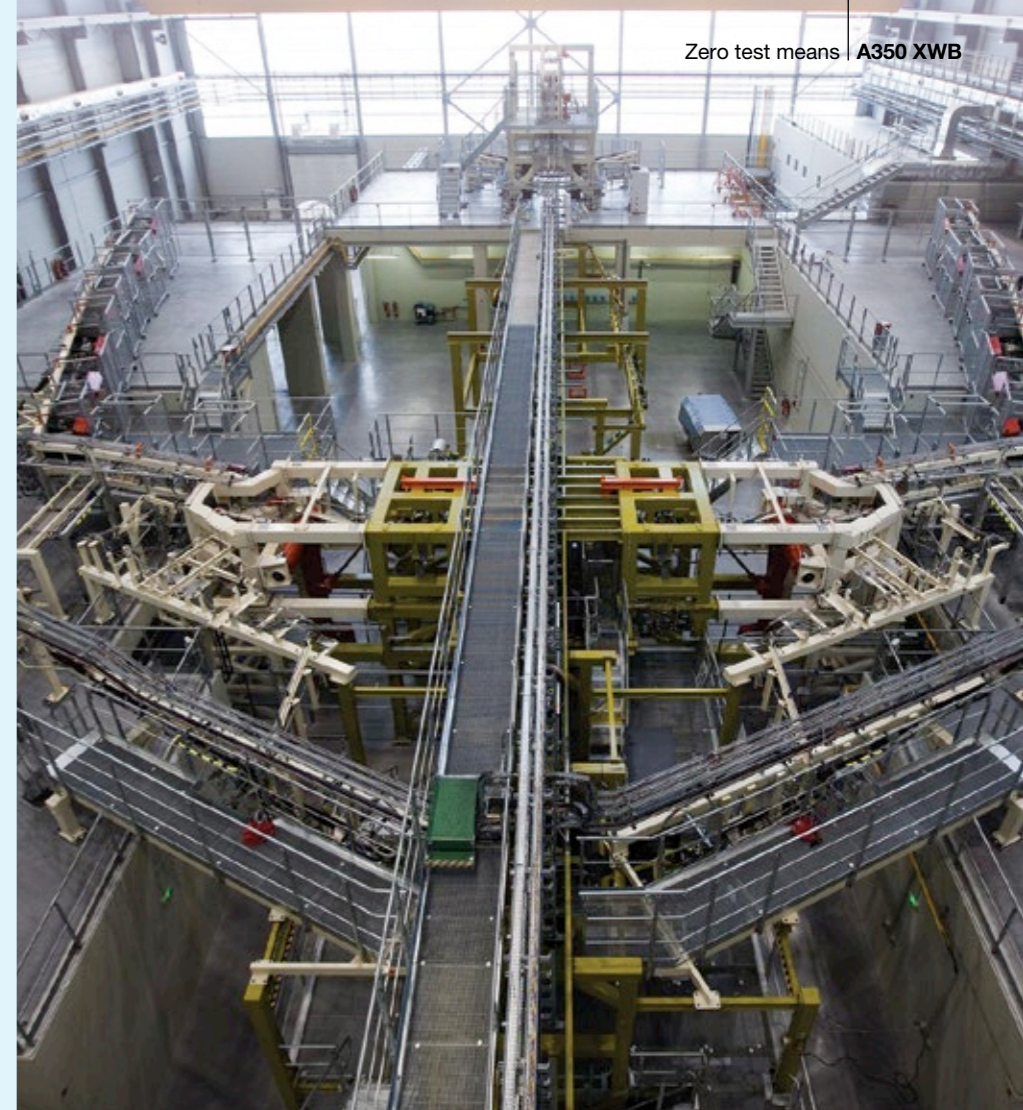
The iron bird, located in Toulouse (France) comprises of a complete hydraulic, electrical and flight control system installed exactly as on MSN001. As with the high lift and landing gear 'zero' test rigs, the aircraft structure is replaced by a large steel (iron) frame, hence the name 'iron bird'.

The iron bird comprises the complete systems right from power generation (aircraft hydraulic pumps and electrical generators driven by industrial motors) through to power consumers (flight control actuators, landing gear actuators, etc.).

The iron bird has been operational since the end of 2010 when 'pressure on' was achieved. At this time there were many industrial parts used to replace missing aircraft parts. The iron bird has been progressively upgraded to incorporate all the real aircraft parts that can be found on MSN001. The iron bird is critical to ensuring integration between the major systems on the aircraft and to perform many tests necessary to guarantee the safety of the first flight.

From aircraft 'zero' to MSN001

The final stage of integration testing before flying the aircraft is to connect the integration simulator to the iron bird to create aircraft 'zero'. In this configuration, we test the systems from cockpit to tail. When the pilot moves the side-stick in the cockpit, the command is processed by the Flight Control Computers (Primary/Secondary) and the commands transmitted to the flight control actuators via the 1553 databus. The flight control actuator (EBHA) takes its hydraulic and electrical supply from the power generated by the aircraft Engine Driven hydraulic Pump (EDP) and Variable Frequency electrical Generator (VFG). All equipment installed on aircraft 'zero' is identical to that installed on MSN001 in the Final Assembly Line. During the Virtual First Flight (VFF) tests, the MSN001 flight crews will be involved in many of the tests so that by the time they fly the aircraft, they will already have many hours of experience 'in flight'.



Iron bird



A350 XWB MSN001

Guy MAGRIN, Chief Test Pilot on the A350 XWB programme presents the

A350 XWB Cockpit

On entering the cockpit of the A350 XWB, one is immediately struck by the clean lines and uncluttered displays presented to the pilots. However, it is soon apparent that the familiar Airbus design philosophies are maintained throughout, giving the cockpit a typical Airbus family feel and making the Airbus pilot feel quickly at home.



A350 XWB Cockpit



The A350 XWB takes the basic A380 concept, but improves the interface with larger and better positioned screens, providing better visibility of information across the cockpit with improved and extended interactivity. In particular, the design (using six identical screens) makes the task of sharing operational information between pilots much easier, while privileging information that corresponds to the given situation.

Using the A380 cockpit definition as a starting point the A350 XWB has integrated several improvements and innovations.

Six identical large format screens

The idea was to adopt a new large LCD (Liquid Crystal Display) screen layout with the lateral screens angled inwards, to allow excellent cross-cockpit visibility and optimum flexibility for displaying information.

Onboard Information Systems' (OIS) applications are adapted to the large screen format whilst at the same time, there is the ability to present information on the central screen (OIS on 'centre') vastly improving the sharing of information between pilots. This configuration also provides a supplementary avionics page which further improves cockpit efficiency.

Extended pilot interactivity allows the pilots to use the cursor control to manage the external screens as well as the opposite Multi-Functional Display (MFD), should the need arise. In case of screen failure, automatic reconfiguration occurs for the avionics pages. For one or two outer screen failures the OIS information can be recovered manually on the lower centre screen.

Even losing three screens (which is highly improbable) does not severely impact the flight in progress, thanks to the 'Push To Be Happy' option which selects the information displayed on screens.

The configuration of six identical large displays covering EFB and avionics does not exist on any other large commercial airliner today. It provides a weight benefit (-30kg less than A380 screens), reduced electrical power consumption and improved dispatch reliability.



Clean lines and optimized space

Styled looks of the A350 XWB cockpit windows



Integrated and intuitive Electronic Flight Bag (EFB)

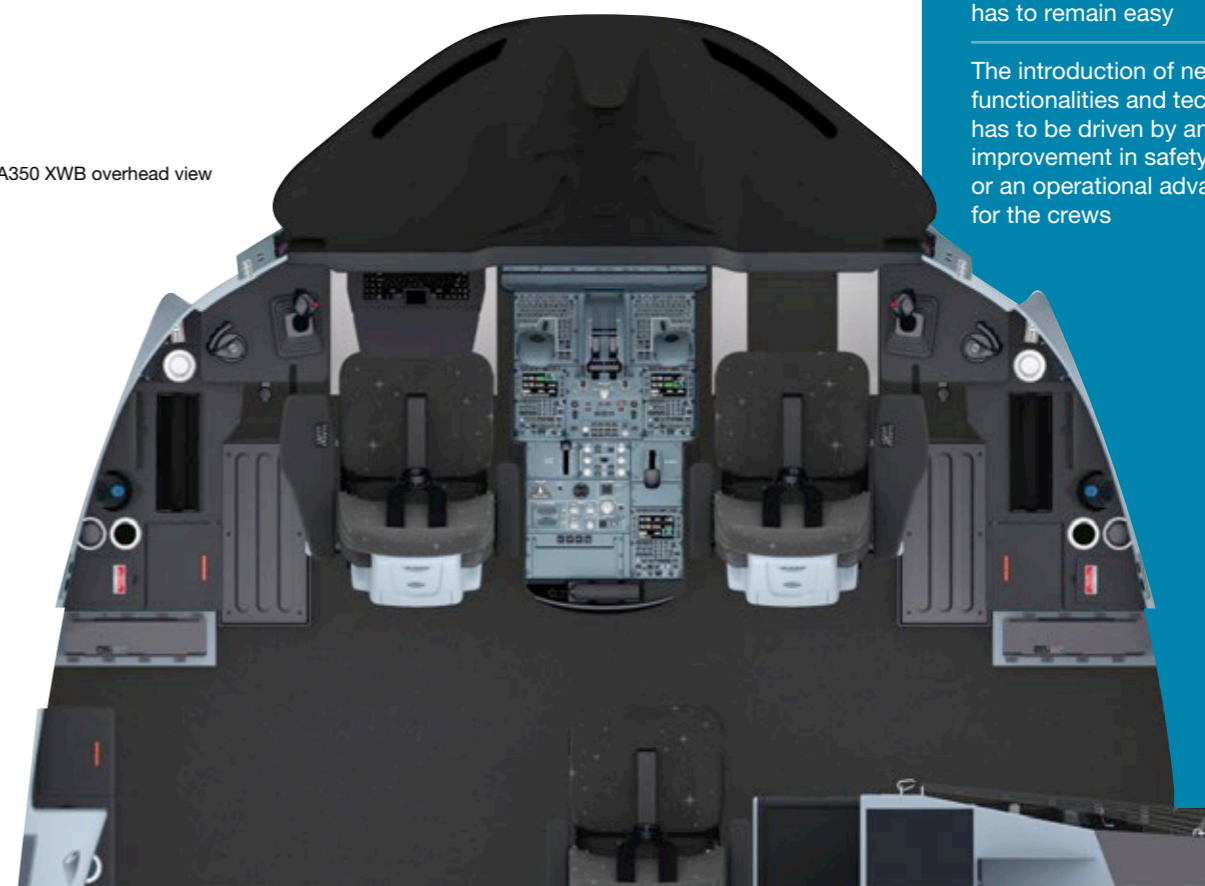
The EFB is a standard laptop computer. However, its integrated Keyboard Cursor Control Unit (KCCU) can interact with the cockpit screens. Furthermore, it benefits from the 'OIS on centre' function to improve crew coordination and share workload. Although completely integrated within the aircraft avionics system, it remains independent (class 2) allowing companies to develop and use their own proprietary applications.

This integration does not endanger the security of the integrated avionics systems since there is a segregation of the two worlds, avionics and EFB. The organisation of the cockpit also allows pilots to place the laptop on the lateral surface. Hereby, the system fulfils the functionality of class 1, fully functional in standalone laptop mode in case of multiple failures. The A350 XWB is also able to communicate with its home-base via classical ACARS (Aircraft Communication Assessing & Reporting System) for data updates by Wi-Fi, wideband SATCOM (Satellite Communications) and cell phone.

Improved Electronic Centralized Aircraft Monitoring (ECAM)

The ECAM interface has been revisited with improved access to information (system pages, shortcuts, deferred and abnormal procedures). A dispatch function has been implemented to ease the crew's workload during pre-flight dispatch. The A350 XWB cockpit now separates the normal checklist from the 'abnormal'. This separation now allows for the normal check lists to be followed without compromising the sequence of the abnormal procedures being run. Isolating abnormal situations improves readability, easing corrective procedure. For multiple failures, a priority system automatically provides the pilot with a recommended order of responses. Failures affecting performance (landing, for example) are presented on the status page with automatic transfer of the failure impact to the performance applications for a correct computation by the crew (Airbus performance package only).

A350 XWB overhead view



Airbus develops its cockpits based upon 10 design principles:

The pilot is responsible for safety with complete authority and the means to exercise this authority

Full control authority is given to the pilot whilst avoiding risk of danger or damage to the aircraft

The cockpit has to be adapted to a large variety of pilot experience and pilot abilities

Design priority is safety, then passenger comfort, then efficiency

The interfaces are designed to simplify crew tasks and to provide a rapidly comprehensible appreciation of the state of the aircraft

The automatics are considered as an aid to the crews

The interface must be adapted to crew requirements and characteristics (both good and bad)

The validation process must include consideration of error management

Crew communication has to remain easy

The introduction of new functionalities and technologies has to be driven by an improvement in safety or an operational advantage for the crews

Improved Flight Management System (FMS)

Improvements and functions to anticipate certain failure scenarios are now included, significantly reducing the pilot's workload. A long range mode is permanently available to ease fuel savings. The pilot can play a virtual scenario such as single-engine failure or depressurization using the 'What if' function, to assess the capability of the aircraft following a degradation at any point along the route. Similarly with any problem increasing aircraft drag (e.g.: spoiler fixed deployed), the Flight Management System (FMS) can be adjusted for fuel burn to provide better predictions for the remainder of the flight.

The FMS allows the crew to perform a variety of approaches whether based upon conventional navigation aids or Diff GPS (Differential Global Positioning System) offering increased position accuracy up to RNP 0.1 (Required Navigation Performance). The ability to fly precise trajectories through difficult terrain or for noise abatement reasons has considerably improved.

Robust Auto-Pilot

The Auto-Pilot (AP) has become more robust in the sense that it will remain engaged, even following small excursions outside the flight envelope. In the case of a double engine failure/flame-out, the AP remains available reducing crew workload and thereby improving situational awareness.



When designing a cockpit, commonality with the Airbus family is always privileged. If modifications are undertaken they are for the following reasons:

- Improvement of flight safety
- Changes in regulation or other aeronautical systems and processes
- Aircraft specifics
- Feedback from operators
- Improvement of passenger comfort
- Improvements due to new technologies

Added value for general flight safety and efficiency of operation

The AP/TCAS (Auto Pilot/Flight Director Traffic Collision Avoidance System) allows the aircraft to **automatically respond to avoid conflictual traffic** based upon the Auto-Pilot.

The TCAP (TCAS RA Prevention) **prevents unwanted alarms** due to high vertical speeds prior to altitude capture when other traffic is in the vicinity.

The ATSAW (Airborne Traffic Situation Awareness) provides an **improved awareness of traffic in the vicinity** with added value from ADS-B (Automatic Dependent Surveillance – Broadcast) information such as speed, call sign, turbulence category, etc., and also provides the facility for ITP (In-Trail Procedures).

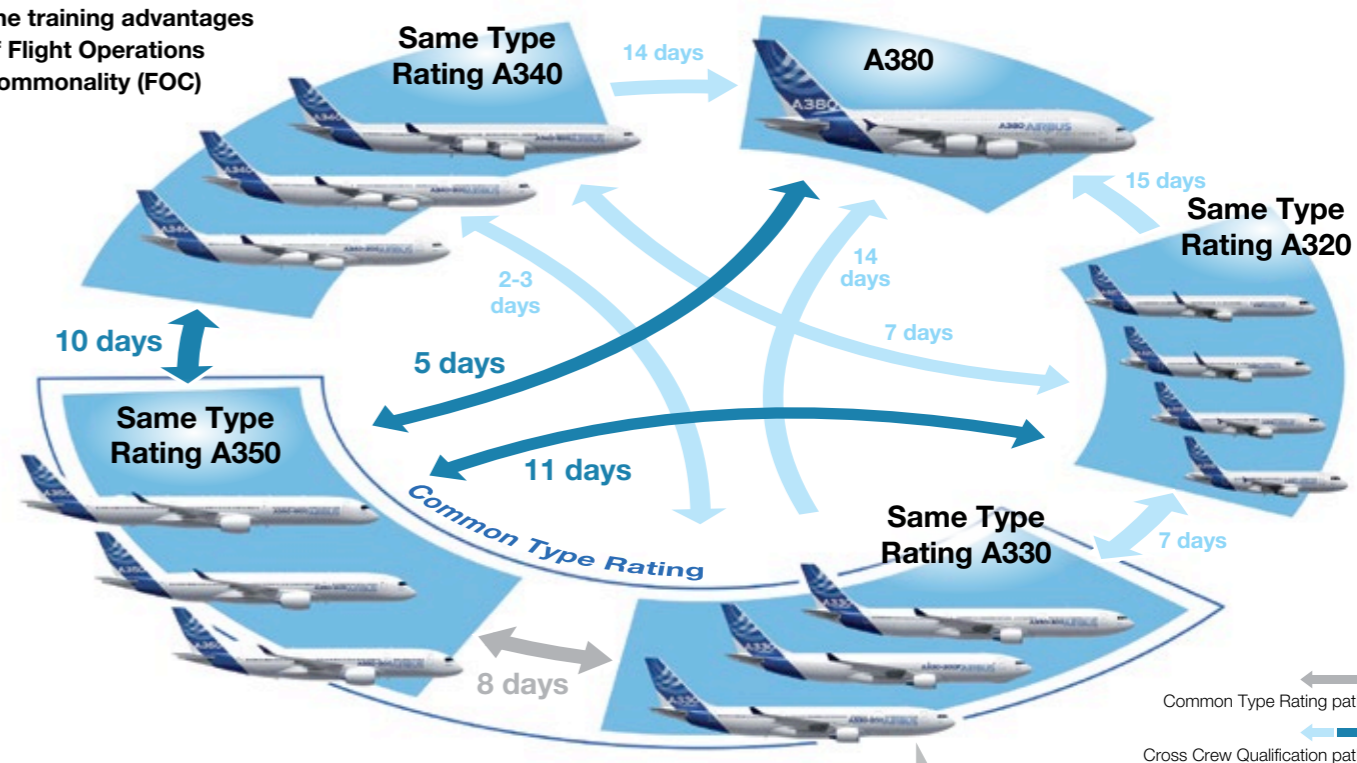
Voice communications have been improved with FANS (Future Air Navigation System) A and B capability data-link via SATCOM, VHF or HF. Monitoring frequencies received in the mailbox can be loaded directly without the risk of a typing error.

In the case of a Windshear, Terrain or TCAS warning, the display automatically adjusts appropriately to **provide an immediately understandable picture of the threat** (AutoRange/AutoMode). If the crew has not selected the radar display and a weather (Wx) threat is detected, the system will automatically provide a 'Weather Ahead' alert.

Correct take-off speed is calculated (often the source of error) checking the coherence of speed values, the geographic position and the aircraft's capacity to take-off in a safe manner.

Brake To Vacate/Runway Overrun Warning & Protection (BTV/ROW/ROP) systems from the A380 are further improved on the A350 XWB with the introduction of runway contamination levels. Furthermore, a specific interface allows the crew to quickly check that the aircraft is capable of landing on the runway available based on selected hypotheses.

The training advantages of Flight Operations Commonality (FOC)



Cost-saving and better training due to A350 XWB commonality

Realistic training for pilots

The A350 XWB Airbus Pilot Transition (APT) training concept will benefit from increased scenario-based training sessions and increased realism. Hands-on training by using the Full Flight Simulator (FFS) has been integrated at an early stage in the course. Future A350 XWB pilots will also benefit from a 'flying school' concept, promoting manual flying from FFS sessions dedicated to normal operations.

This new generation of 'learning by doing' approach uses training tools such as:

- Self-study
- Training with an instructor in a crew configuration
- Systems knowledge
- Aircraft operations training: Computer Based Training (CBT) and Part-Task Trainer (PTT)
- Procedure operations (handling and manoeuvring)

Cross Crew Qualification

The A350 XWB Cross Crew Qualification (CCQ), including Full Flight Simulator sessions, will be available for the A320 Family, A340 and A380 pilots with anticipated durations of 11, 10 and 5 training days respectively.

The standard length of a full A350 Type Rating training course for non-Airbus pilots will be 25 days (projected and subject to approval from the aviation authorities). Airbus will also support airlines wishing to implement Mixed Fleet Flying with A350 XWB and A320 Family, A340 or A380 aircraft.

A350 XWB Common Type Rating (CTR) with the A330

Airbus is pursuing regulatory approval of a Common Type Rating for the A330 and A350 XWB. If granted, A330 pilots are expected to qualify on the A350 XWB in 8 training days without Full Flight Simulator time and to then be able to fly both aircraft under a single license endorsement.

Mixed Fleet Flying (MFF)

Commonality means savings in flight crew training but it also allows facilitates Mixed Fleet Flying. It is practical and economical to let pilots fly several Airbus types. MFF enhances flight crew proficiency and increases productivity through greater rostering flexibility. It also offers a more varied working environment, hence contributing to greater job satisfaction for pilots.

Cabin & cargo design



Extra wide cabin of 221" between sidewalls



A350 XWB forward cargo compartment with a seven track loading system

Cabin & cargo design

Article by
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Cabin & Cargo
Architecture
AIRBUS



‘Form follows function’ is a well proven principle in modern architecture and industrial design. The principle is that the shape of an object should be primarily based upon its intended function or purpose. In aircraft cabin architecture the ‘form’ translates principally by the optimization of weight, seat count and payload while developing comfortable, safe and efficient functionality.

Requirements based engineering

On the A350 XWB, the approach for the cabin design is ‘requirements based engineering’. A set of functional requirements and quantified performance targets was formulated by client companies and based on previous experience. They are the basis for the cabin interior including monuments and seats, the cabin systems and cargo compartment. They cover concerns such as safety and security, cabin comfort and efficiency, cabin operations, maintenance and integration.

One example of a top level operational requirement is commonality with the Airbus family, which reduces crew training.

A performance requirement is, for example, maximum seat count. In the case of the A350-900 there will be a maximum passenger capacity of 440.

Cross section

Using the operational and performance requirements, it was calculated that the A350 XWB needs four door zones and at least three seating areas in between.



← 220 inches / 5.59 metres →
(from armrest to armrest)

Cabin layout

Before a layout is completed, the revenue generating areas for the cabin and cargo compartment need to be defined. One of the first steps is starting with the seating arrangements. The key question is to find the right cross section. The A350 XWB fuselage has been designed to get the right balance between cabin comfort and aircraft performance.

The A350 XWB allows the installation of several seating configurations from Premium seating with 4-abreast suites up to (theoretically) 10-abreast.

A design driver for the cross section is the 3-3-3 seating arrangement. This optimum cross section maximizes seating comfort giving each passenger an 18” seat cushion while providing an acceptable aisle width to perform cabin service.

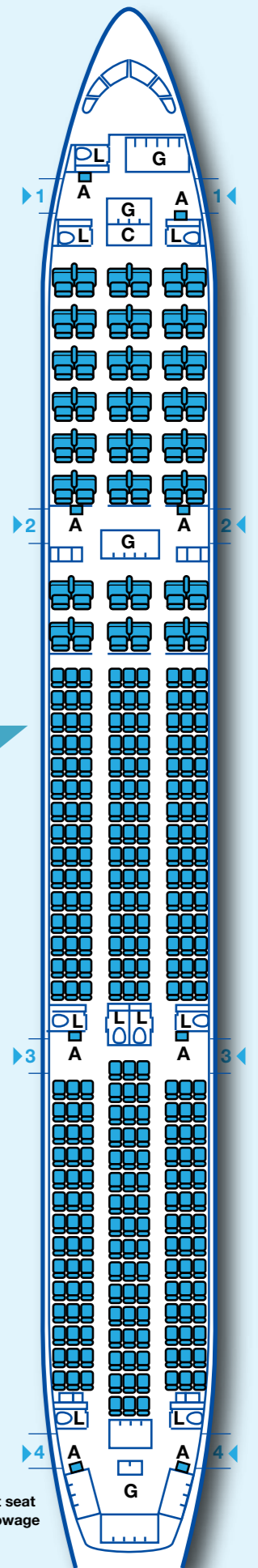
Clearance from the lining had to be added to ease installation of the outboard seats. The result is a 220” cross section.

Cargo compartment

The lower half of the cross section is designed around the cargo compartments and the loading system. The A350-900 has three compartments, i.e.: the forward, aft and bulk compartments and can load up to 36 LD3 containers (see lower image on page 18) or 11 standard pallets of 96 inches. Special equipment is available for the transport of live animals, perishable goods, heavy pallets and vehicles.

Door zones

Adequate space around the doors allows a quick turn-around for boarding and catering. Most of these areas are at the junction of galleys, lavatories and crew equipment stowage. Each door area has a double Cabin Attendant Seat (CAS) and the A350 XWB offers up to 22 standard or high comfort positions. The area between the assist spaces of the exits and longitudinal aisles is a critical dimension for the cabin width, particularly in the conical areas of the fuselage.



A350-900 standard cabin configuration
48 Business Class (6-abreast seats)
267 Economy Class (9-abreast seats)
for a total of 315 passengers

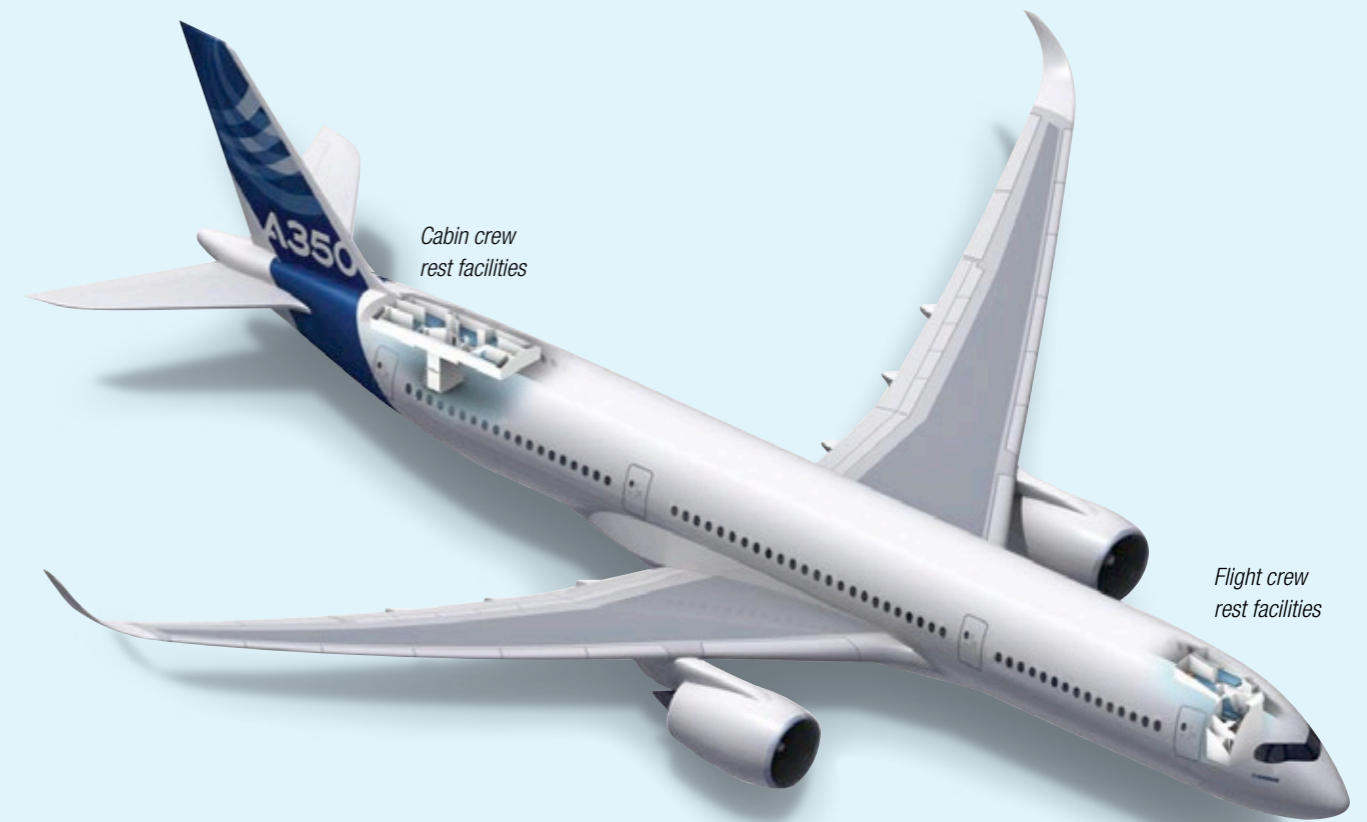
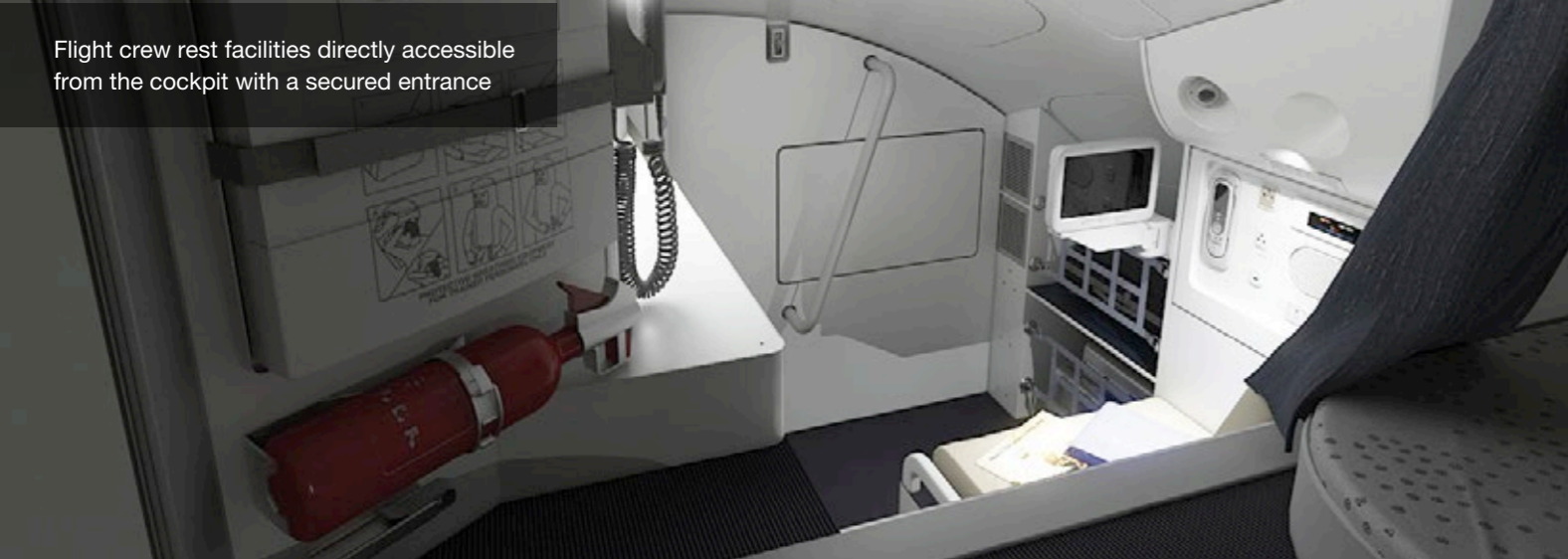
A = Attendant seat
C = Central stowage
G = Galley
L = Lavatory
▶ = Door

Figure 1: A350 XWB reference 9-abreast layout





Flight crew rest facilities directly accessible from the cockpit with a secured entrance



Cabin crew rest facilities

Flight crew rest facilities

Crew rest facilities

While the entire cabin arrangement has to be very flexible in terms of installation, the most forward and most aft door areas allow fixed positions for cabin items, making it the ideal place for crew rest compartments. Two compartments are installed in the over-ceiling area without absorbing revenue space in the cargo compartment or on the passenger floor.

Galleys

A further design driver of the door areas is the service concept of the airlines. The A350 XWB is designed for all service concepts, from high-density low-cost, Economy Class and Premium Economy to Business and First Class services; there are even customers who will offer VIP service.

These concepts require a highly varying amount of catering and very different meal preparations, from a 'home style' kitchen to a 'canteen style' galley. Whatever the style, a very spacious, efficient integration is needed with Premium Class requiring sufficient work top surface and Tourist Class needing sufficient floor space to prepare service carts.

The aft galley complex at 'Door 4' was designed in customer focus groups with mock-ups and catering tests. The result is a spacious and practical working area creating privacy for the crew. Latest technology insulated heating and refrigeration monuments maintain a well balanced working temperature in the crew area.



Cabin systems

The A350 XWB has a set of highly integrated electronic, electric and mechanical cabin and cargo systems.

They include safety systems such as the doors or the evacuation system, the water and waste system, electrical galley equipment or the In-Flight Entertainment.

A much appreciated contributor to cabin comfort on the A350 XWB is the air conditioning system. Providing a reduced altitude cabin air pressure leading to more oxygen and improving

the well-being of the passengers and crew.

The core of the Airbus cabin is the Cabin Intercommunication Data System (CIDS).

The CIDS of the A350 XWB controls all cabin systems with more than 40 applications.

The functionality and user interface of the CIDS has been continuously developed since its introduction on the A320.



'Pure Indulgence' Business Class design theme

Cabin compartment

The cabin compartment consists of the lining, furnishing and floor covering.

The lining is basically everything surrounding the passenger: window panels, overhead stowage compartments and ceilings.

The furnishing is basically all monuments, partitions and seats. Cabin systems like the new full LED (Light Emitting Diode) mood lighting system, the passenger oxygen system or the escape path marking are integrated into the cabin compartment.

Beyond functional requirements, the interior has to meet esthetic requirements, create spaciousness and provide practical ergonomics.

The trim and finish catalogue for A350 XWB is called 'Canvas'. Among the seven design themes proposed are a wide range of standard and optional decorative surface materials, aligned to an overall neutral colour palette that is designed to work in harmony with the new cabin mood lighting system.

Cabin decor choice is focused on two key principles:

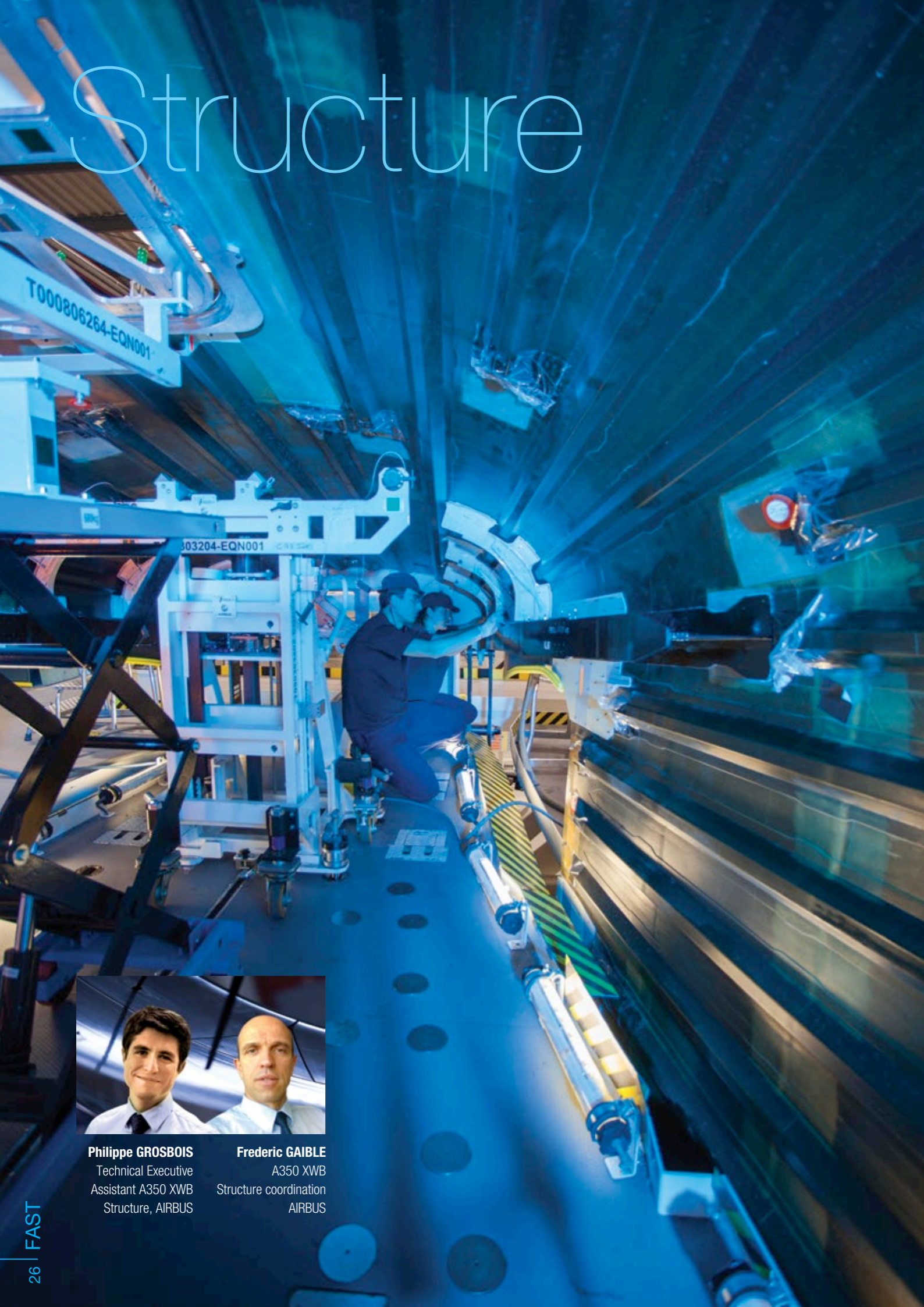
- Using extensive market and consumer research to define design themes that allow for the trim and finish materials to be harmonized into distinct collections within the cabin
- Balancing customer differentiation requests with manufacturing constraints for standard lead time delivery



- Cabin illumination
- Air conditioning
- PAX (Passenger) call
- Passenger lighted signs
- Reading lights
- IFE power
- Lavatory occupied signs
- Smoke signalling
- Doors and slides
- Galley cooling
- Potable water indication
- Waste indication
- Cockpit door surveillance
- Cabin interphone
- Passenger address
- Boarding music
- Crew signalling
- Alerting system
- Recorded announcements
- Service interphone

In the A350 XWB cabin a simplified and harmonized Human-Machine Interface (HMI) will be introduced. It has been enhanced by the introduction of a touch screen control panel, digital handset and display based passenger signs.

Structure



Main deliverables per Airbus site

- Development and/or Testing
- Manufacturing
- Assembly and/or Equipping
- Customer delivery

NANTES (France)

- Centre wing box, keel beam, radome and air inlet
- Centre wing box, keel beam, radome and air inlet

SAINT-NAZAIRE (France)

- Front and centre fuselage
- Front and centre fuselage

GETAFE (Spain)

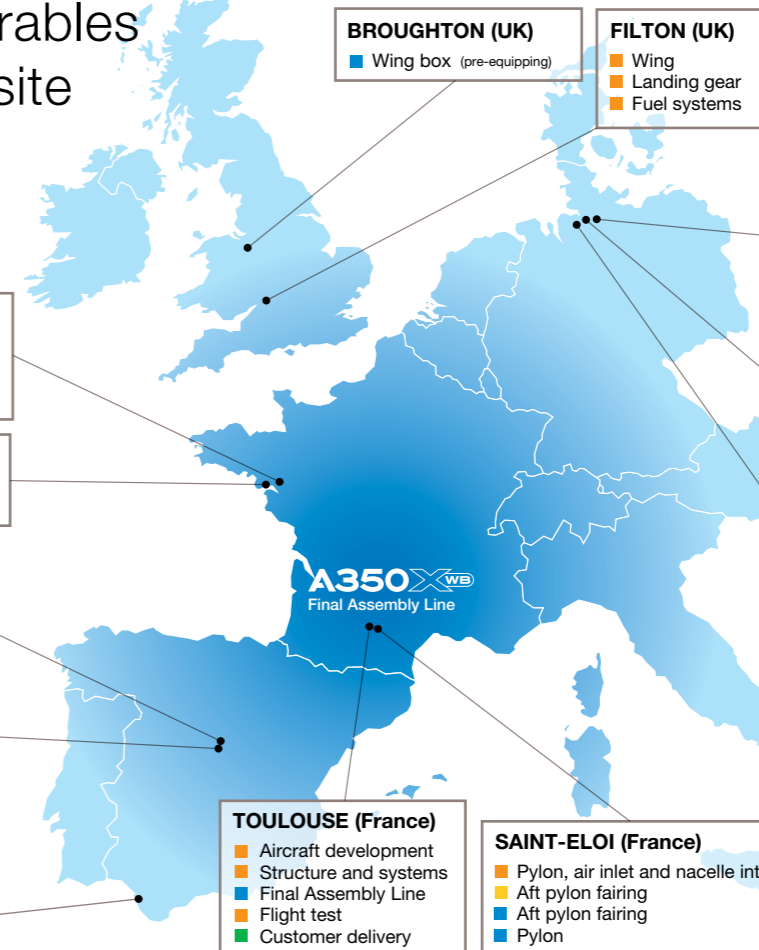
- Horizontal tail plane
- Rear fuselage

ILLESCAS (Spain)

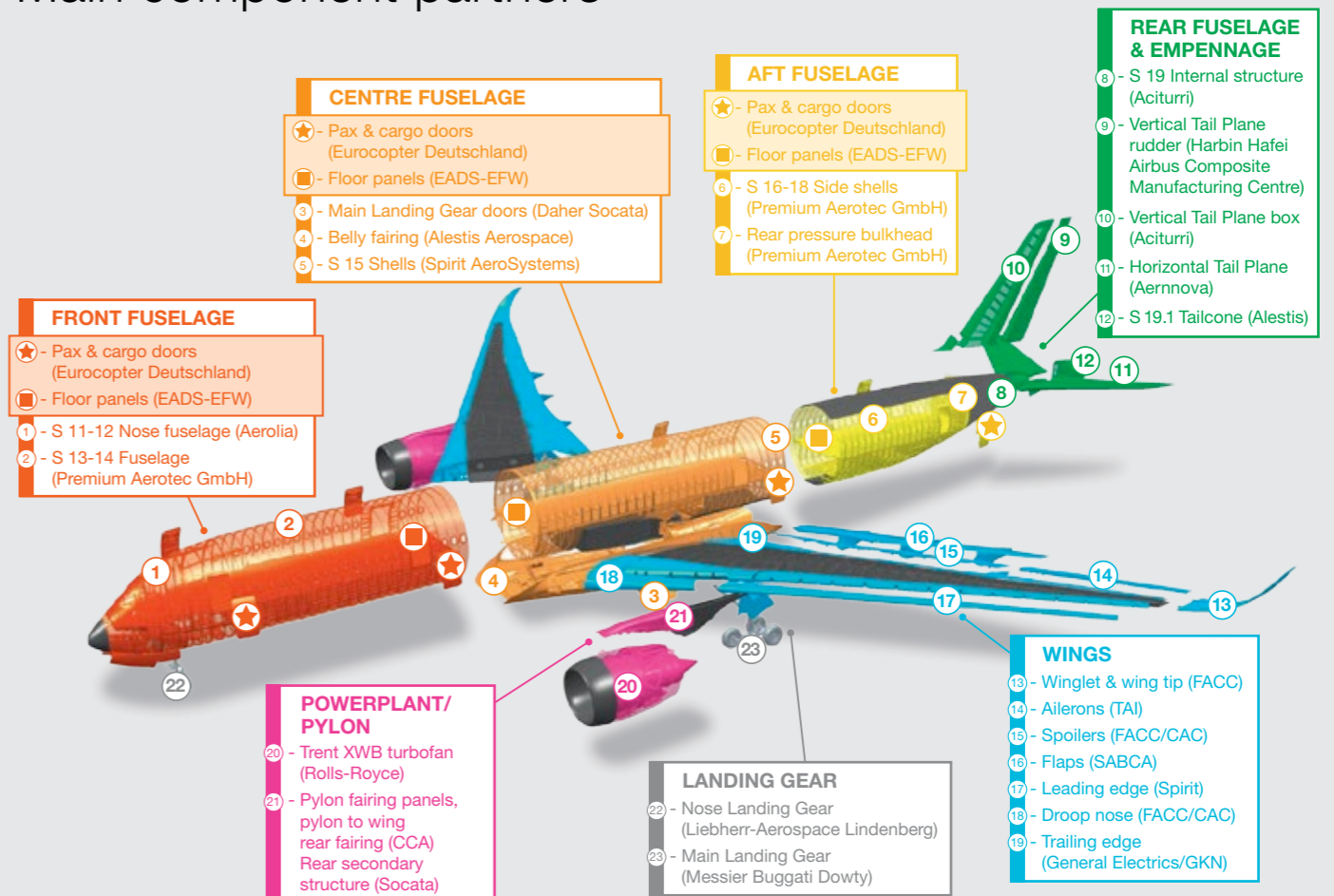
- Wing lower cover
- S19 Full barrel skin

PUERTO REAL (Spain)

- Horizontal tail plane boxes



Main component partners



Philippe GROSBOIS
 Technical Executive
 Assistant A350 XWB
 Structure, AIRBUS

Frederic GAIBLE
 A350 XWB
 Structure coordination
 AIRBUS

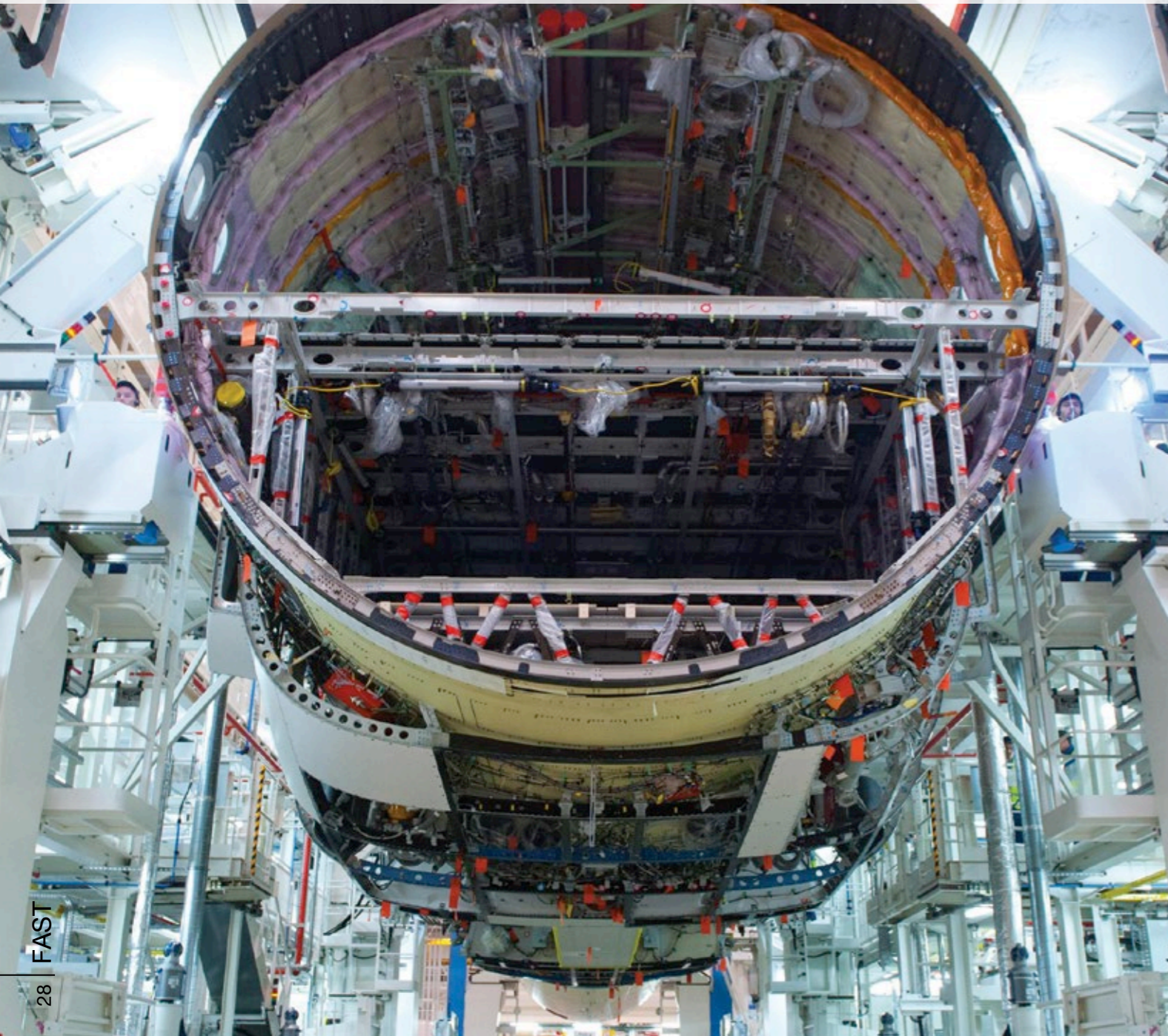
Structure

Intelligent airframe design

If we still ask designers to show us how clever and creative they are, our era has turned aviation design into an infinitely more subtle and complex game where innovation is judged by its impact on quality, cost and performance.

Around mid-2007, in order to answer customers' requests for improved performance, the A350 XWB airframe design was revised, taking into account the latest developments in applying Carbon Fiber Reinforced Plastic (CFRP). It was time to give birth to a concept that had been developed by designers a few years before: **the intelligent airframe.**

The result is an A350 XWB structure that not only uses the material properties of CFRP to achieve weight loss, but using the flexibility of applying the material how and where it is required for robustness. For load-bearing sections CFRP and metal (mostly aluminium and titanium) has been used to address corrosion issues while meeting optimal operational targets. An intelligent airframe is also one that is quicker and easier to maintain. Sections have been re-defined using monolithic carbon fibre technology as well as keeping a 4-panel assembly concept that as proved successful on metallic aircraft.



Main airframe features

A350 XWB design is classically split into its fuselage, wings and empennages and each of them has benefited from experience gathered by Airbus concerning composite use. Empennages have long been made of CFRP; now with the benefit of in-service experience, their movable parts (rudder and elevator) are now made of monolithic structure thus improving their performance in operations. The experience with empennage has also led its use in the wing structure with a 32m long single CFRP cover.

Rear and front spars are split into three pieces supporting both lower and upper covers. The wing box structure consists of single piece CFRP top and bottom covers that are 32m long, front and rear CFRP spars which are manufactured in 3 pieces, internally the box is reinforced with metallic ribs. The main landing gear is attached into the wing box through a forward pintle fitting on the rear spar and a rear pintle fitting on a gear beam. The gear beam is attached to the fuselage inboard and rear spar outboard. A double-side stay is used to better assist in taking braking and turning loads into the airframe structure.

Corrosion

At the concept phase, feedback from operators' inflight experience allowed Airbus to define areas of the aircraft under threat of corrosion by various environmental conditions. The A350 XWB sets stringent criteria to combat this threat. CFRP which is not subject to corrosion, is used for 53% of the aircraft but in areas subject to liquid aggression like the galley areas, traditional aluminium for seat rails has been replaced by titanium. In the same way, metallic frames in the lower part of the fuselage are made of titanium rather than aluminium.

In addition, a design target has been set to limit maintenance inspections (i.e. from less than 15 minutes if performed every 3 months, up to a few hours if the task is required only once every 12 years).

Finally, a dedicated group of specialists has been set-up in order to check that the design guidelines are followed and design teams are helped in meeting their objectives. The result of the work is through a specific material mix, increasing the use of titanium to 14% of the airframe structure's mass, and for a CFRP to 53%. It will also result in an enlarged inspection interval, reaching 12 year inspection-free period for most areas.

Fuselage design and assembly concept

The pressurized fuselage is based on a classical and robust section assembly concept, but it has been optimized to take advantage of new CFRP technology. Each CFRP section is now made of 4 panels. Both circumferential and longitudinal dimensions of panels have been optimized in order to increase aircraft performance:

- Circumferential joints are located far from heavy loaded areas like the wing to fuselage junction
- Junctions are also positioned away from main fuselage cut-outs, like passengers and cargo doors, both in longitudinal and circumferential directions
- The type of junction (one shell overlapping the other or two shells assembled side-to-side) has also been optimized. These junctions offer more supporting structure to repair the aircraft in case of heavy damage

Longer panels assembled together into four sections are considered more mature and more beneficial to aircraft than having only cylindrical sections.

Structure robustness

The damage tolerance of a structure is an integral part of airworthiness regulation and the CFRP fuselage has been subject to specific attention (see article in FAST N°48). The resulting solution is in varying the thickness of the CFRP skin in areas where the aircraft structure is most frequently impacted. The skin thickness in the door surrounds is increased by a factor of 3 to 5 compared to areas with low risk. The result will be a structure that is less sensitive to impact damages than its metallic predecessors, whilst contributing to an overall improved performance.



Installing the first A350 XWB tail

Structure



The lay-head of the
Advanced Fibre Placement Machine

An innovative industrial setup for a competitive and sustainable future

One of the largest industrial challenges faced by the A350 XWB programme was the integration of its composite structural elements. Manufactured in numerous European Airbus sites, the elements are shipped to the Final Assembly Line in Toulouse (France).

With the advent of new tools and specific methods of applying the composite, this production platform of international proportions has been optimized to consolidate similar tasks, helping to achieve ambitious cost reduction targets.

Advanced Fibre Placement Machine

The composite, known as Carbon Fibre Reinforced Plastic (CFRP), is used to make structural parts by laminating series of ribbons to create strong, corrosion-proof and lightweight forms.

The largest skin manufacturing shop located at Airbus' facility in Stade (Germany) houses the 'Advanced Fibre Placement Machine', which produces the upper and lower shell of the A350 XWB.

The rollers of its laying head simultaneously place 32 parallel CFRP tapes that are 6.35mm wide and 1.27mm thick. They can be selected, laid and individually cut by the placement machine, allowing the production of highly complex forms.

The 23 tonne lay-up jig moves it way towards the laying head ensuring the accuracy of the laminate structure, measuring up to 16.5m in length and 3.68m wide.

Due to its highly sophisticated control system, the lay-up system not only manages complex forms, but also ensures that waste is kept to a minimum and that the weight is evenly optimized. It also allows to automatically integrate local reinforcement layers where required. The lightning protection layer is applied manually, afterwards.

Savings by aggregating manufacturing jigs and tools

The jigs and tools' work packages for the A350 XWB were aggregated by a factor of 10 in comparison to those of the A380. Logically grouped work packages have been placed throughout Airbus' European sites in order to harmonize industrial systems.

As an example, pre-assembly jigs at different sites have been aggregated into one single contract, creating the 'Design to Cost' plateau, leading to a smoother flow for the assembly line. This new 'Design to Cost' concept required tight contract management. Together, manufacturers, engineers, A350 XWB programme managers and the general procurement team defined this new project and the contract management processes. Its constant aim was to improve quality, save time and reduce overall costs.

Examples of reducing unexpected costs being detected early were:

- An Airbus project management operating model structured by weekly '4 Box Reviews' and Change Review Boards (CRB).
- A supplier/Airbus contract management defined by monthly Contractual Commitment Reviews (CCR).

Such preventive and collaborative approaches in change management were key in delivering constant performance throughout the A350 XWB's challenging manufacturing schedule. The same measures will also play their part in the A350 XWB's ramp-up and convergence with the planned completion costs. ■■■■

Ultrasonic – innovation in delamination

How can the holes drilled in the A350 XWB's composite fuselage be inspected faster and more efficiently?

This can be done thanks to 'Percephone', an ultrasonic inspection tool developed with EADS, allows the operator to check for possible delamination.

A mini-tablet, a water spray container, daisy probes and 'shoes' of various diameters are provided in a kit to check delamination of the composite for the loss of cohesion between the plies when drilling holes in the A350 XWB's fuselage. Tested with success on the longitudinal holes made in the centre section and the forward lower shell, this new technology leads to substantial savings and an accurate control.

This tool (supported by EADS Development), will allow the operators to check the drilled holes in a minute, giving them direct access to the results. This tool kit saves eight days of training, and improves the traceability for the inspection of the 36,000 existing holes located on the forward and centre parts of the aircraft.

Upstream work is required to create descriptions of the area to be inspected with representation of the drill templates, and to 'feed them' into the software. Then, the operator only needs to spray a little water in the hole to facilitate the coupling between the module and the hole which needs inspection, then aim the probe at the hole. The inspection results are displayed in a visual representation with a coloured code: red if the hole is delaminated, orange for contentious cases and green if the hole is correct. The results of the diagnoses can be directly exported to the supervision software (SPCvision) allowing automatic traceability.



Environmental sustainability with a green Final Assembly Line in Toulouse (France)

In a bid to reduce its carbon footprint, Airbus has installed 22,000 square meters of photovoltaic solar panels on the roof of the A350 XWB Final Assembly Line, to produce an equivalent of over half of the building's electricity needs. Functioning since September 2010, the panels have produced 2 million kWh. Even on a cloudy day their amorphous membrane which captures diffuse radiation, generates around 20% of full production.

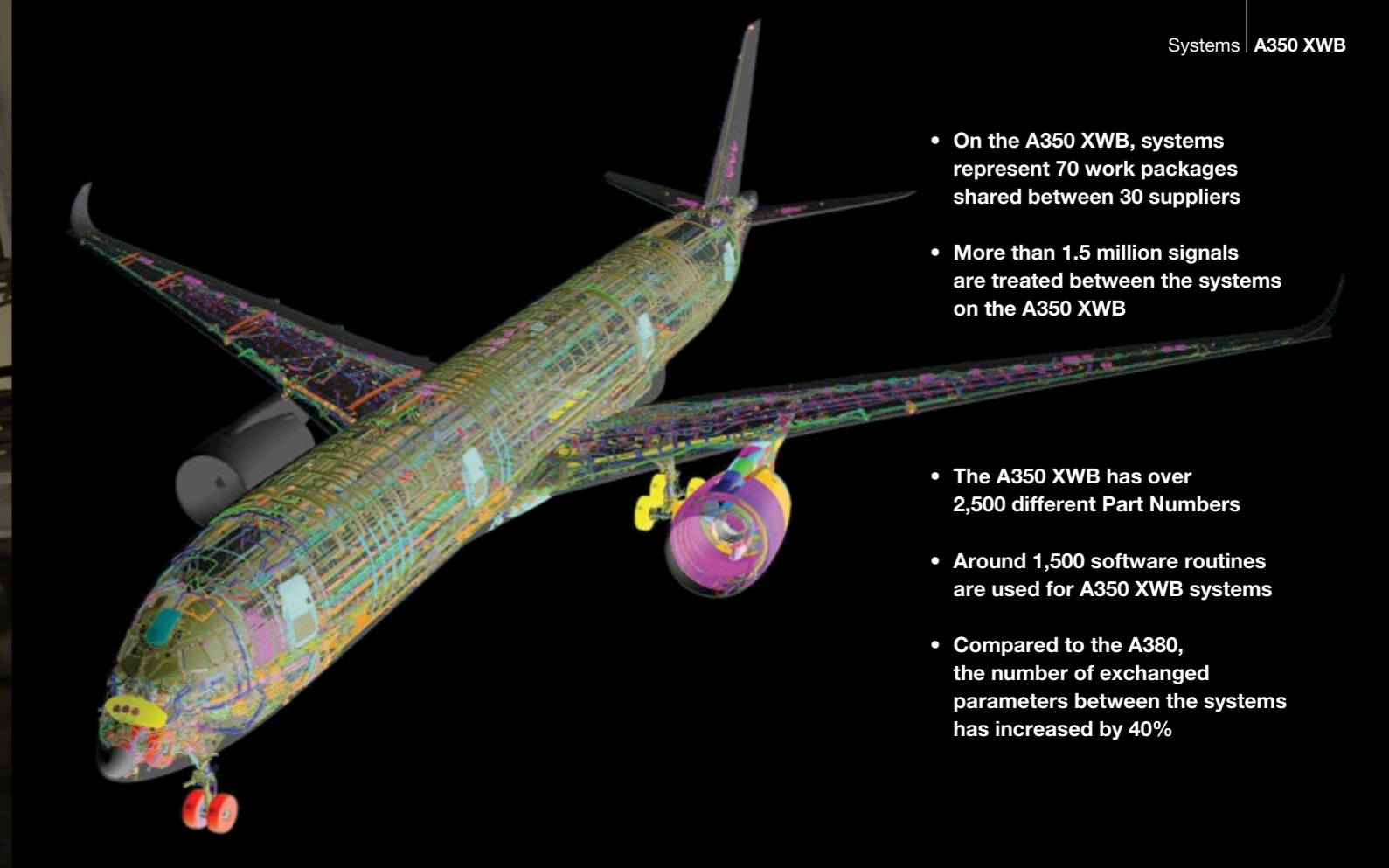
Maintenance-free, the installation will provide power for at least 20 years.



A350 XWB systems, the right alchemy

New functions where needed, commonality wherever possible

by Philippe PALMER Deputy-Head of A350 XWB Systems & Testing AIRBUS



- On the A350 XWB, systems represent 70 work packages shared between 30 suppliers
- More than 1.5 million signals are treated between the systems on the A350 XWB
- The A350 XWB has over 2,500 different Part Numbers
- Around 1,500 software routines are used for A350 XWB systems
- Compared to the A380, the number of exchanged parameters between the systems has increased by 40%

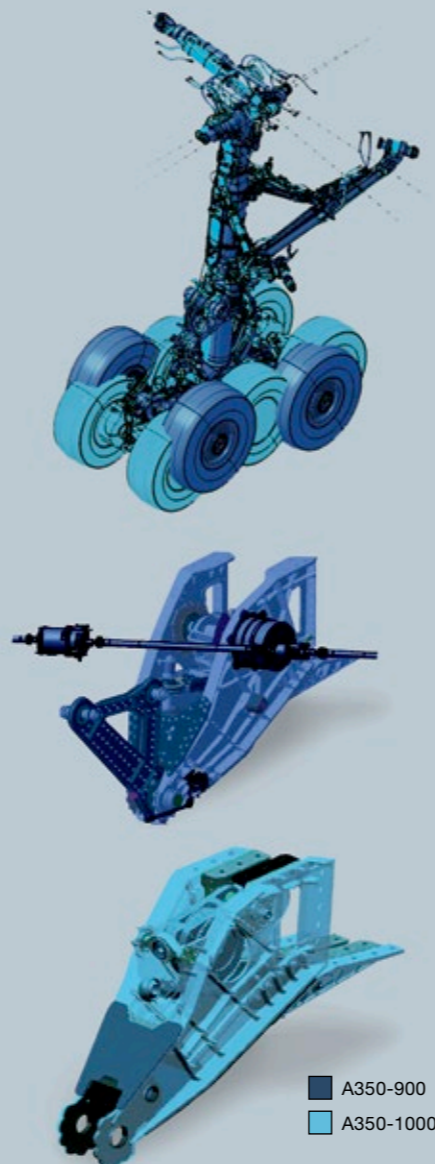
According to Airbus' philosophy on innovation, A350 XWB systems were designed by adding new functionalities where it was bringing value to our customers, while keeping maximum efficiency and commonality with the Airbus aircraft family.

A350 XWB systems family concept

Same Part Numbers (PN), whatever the variants, have been privileged when possible in order to allow a better spares' management and overall airlines' efficiency in terms of operating costs. On the A350-1000, this has been feasible on the majority of systems, except for the ones directly linked to the size of the variant.

For example, the Main Landing Gear had to be different on the A350-1000, because of the Maximum Take-Off Weight (MTOW) increase, the Nose Landing Gear had to be reinforced due to heavier towing loads and the landing gear systems needed to be adapted to a 6-wheel bogie.

The flaps system is also different due to higher aerodynamic loads. For the rest, some systems have just been adapted, such as the venting system to cope with higher fuel quantity or some lighter software adaptations (using Pin Programming when possible).



■ A350-900
■ A350-1000

A350 XWB systems: a real extended enterprise

An earlier and widened supplier involvement

A new policy, applied for the first time on the A350 XWB, has allowed involving our main suppliers much earlier than we used to on previous programme developments.

Main suppliers were selected between mid-2007 and the end of 2008, allowing them to incorporate innovations.

This earlier involvement also allowed them to perform **advanced integration tasks**, even before Airbus could start their internal integration activities. This policy also allowed Airbus to reduce the amount of suppliers and streamlined performance management.

Customer involvement in our design

Since 2010, our design teams have hosted an airline office, which is very efficient in terms of including the way customers intend to operate A350 XWB into our design.

Thanks to their suggestions several maturity improvement initiatives that have been implemented were made easier and more accurate (see Airline Office page 45).



Systems simulation testing

Systems improvement for operability & performance

Innovation has been pushed when bringing either performance or ownership costs improvement, while family concept solutions have been kept on areas where efficiency is already recognised.

Avionics

- Larger cockpit screens have been developed keeping the cockpit concept commonality.
- Automatic reconfiguration has been implemented which makes first low criticality failures transparent to the pilots.
- All communication related computers are now under a single supplier's responsibility, improving the integration aspects.

Common resources

- Within the IMA, the Common Remote Data Concentrators (CRDC) introduced on the A350 XWB have been spread all across the aircraft, instead of Input/Output Modules (IOM) on the A380. They allow significant wiring simplification.
- The introduction of the AFDX (Airborne Full Duplex Switched Ethernet), instead of the A429 and other types of intercommunications, was necessary to cope with the increased number of interconnections between the systems. This system, introduced on the A380, is integrally re-conducted on the A350 XWB.

Electricity

- Integrated primary and secondary distribution centre in the Electrical Power Distribution System (EPDS), including remote control of circuit breakers and Auxiliary Power Unit (APU) starter/generator.
- More use of solid-state power control technology on the A350 XWB, providing a modern method of power control management throughout the aircraft, which eliminates the need for individual circuit breakers in the cockpit, cabin and electronics' bay.

Flight controls and hydraulics

- Implementation of the Modular Electronics' (ME) concept to improve maintenance (Flight Control Remote Module Line Replaceable Item).
- Implementation of 1553 Bus for better robustness in a carbon fibre environment.
- Implementation of electronics' driven devices allowing the improvement of the aircraft performance:
 - Differential Flap Setting (DFS): optimize cruise aerodynamic efficiency and loads through the control of the wing centre of the lift position; inner and outer flaps are deflected differentially.
 - Variable Camber (VC): optimize the cruise aerodynamics' efficiency through the control of the wing camber by the flaps' adaptation in position in or out during cruise.
 - Adaptive Dropped Hinge Flaps (ADHF) function: optimize high lift aerodynamic efficiency through the control of the spoiler-flap gap.

Fuel

- Simpler and easier fuel system: No trim tank, no transfer pump and a much simpler architecture for an improved Direct Maintenance Cost (DMC).
- All tanks are inerted (NB: read FAST N°44, Fuel Tank Inerting System – FTIS).

FlySmart by Airbus - New Generation (FSA-NG)

- The A350 XWB is now connected to the ground in real time, leading to a 'paperless' cockpit including the class 3 Onboard Information System (OIS), Onboard Maintenance Terminal (OMT), Portable Maintenance Access Terminal (PMAT) and docking station. Airbus has generalized a new way to manage embedded software updates, more adapted to the quantity and size of the software (1,200 software Part Numbers on the A350 XWB). Airbus generalized the replacement of the Onboard Replacement Module (OBRM) with a data-loading capability. Maintenance now becomes 'effect orientated', avoiding undue and difficult to treat maintenance messages.

Landing gear

- Corrosion issues were addressed by increasing the use of titanium and low corrosion materials.
- A double side-stay landing gear has been implemented.

Cooling system

- A basic supplemental cooling system is installed in the galleys.



Airline operations

Operability & maturity

A close collaboration between Airbus and its customers

From the start, meeting our customers' expectations in terms of fleet management and operational performance has been at the top of the agenda of the A350 XWB programme. This meant maximizing the reliability of the aircraft and its availability for revenue flights whilst making substantial savings. In order to achieve these objectives, we had to work differently throughout the development of the A350 XWB programme. New processes had to be implemented, not only within Airbus' Engineering, Industrial and Customer Services, but also with our suppliers, with one thing always in mind: **design for airline operations.**

Alain LEROUX
A350 XWB
Maturity Operability
Integrator, AIRBUS

The life cycle of a Product Maturity Item (PMI)

Maturity item acquisition

Lessons learned

2,300 items processed and accounted in design

Product findings

Test results screening with suppliers in place

Operability findings

Airline-like approach

Manufacturing

Supply chain findings

Transversal projects

(leaks, seals, paint, etc.)

Operability test campaign

Solution/development

Maturity network

(Engineering, Industrial and Customer Services' organisations)

&

Design offices

Implementation

Implementation & validation

A collaborative platform: FAMOUS

We started by carefully examining lessons learned from our previous programmes. This allowed our engineers to capitalize on operational experience accumulated on our A320, A330, A340 and A380 aircraft families. We made some determining architecture choices in order to drive a high level of reliability in operations.

The aircraft will be equipped with an innovative feature for support called the 'dispatch function' which continuously assesses the operational performance of the aircraft and its compliance to the dispatch of the aircraft, in order to take corrective actions immediately, when necessary.

With the first flight, we will be entering the final stage of our verification and validation process. Throughout the flight testing phase, we will operate the aircraft as close as possible to real-life airline conditions. The documents which support the aircraft operations, from now on and after its Entry-Into-Service, will be used by flight, cabin and maintenance operations' teams. The documentation includes: Flight Crew and Cabin Crew Operating Manuals, Manufacturer Minimum Equipment List, Maintenance Procedures, Aircraft Fault Isolation Procedures, Maintenance Programme, Ground Support Equipment, etc. Guided by a clear set of objectives during the six years of development and which will continue after the A350 XWB's Entry-Into-Service, we will deliver to our customers what they are expecting from the A350 XWB: maximum aircraft availability and reliability at an affordable cost.

A new approach to maturity and operability

A new way of working was set up during the development phase of the A350 XWB with:

- A dedicated coordination team at programme level, accountable for Operational Reliability (OR) objectives,
- A 'maturity network' of around 70 engineering specialists in all aircraft function domains,
- The continuous assessment of the operational performance of the aircraft on all the test results through regular maturity meetings called TACT (Test Activity Control Team), with the participation of multi-functional teams, (airline representatives, Airbus' Engineering and Customer Services' teams, test engineers and pilots),
- Systematic follow-up of all maturity items - referred to as a Product Maturity Item (PMI) - including their respective corrective actions thanks to a dedicated Electronic Data Processing (EDP) tool: FAMOUS (Forum for Aircraft Maturity and Operability Unified Stream),
- Flight testing the aircraft as close as possible to real airline operations.

FAMOUS Forum for Aircraft Maturity and Operability Unified Stream

A350 | 46.10.00.001 - Airn@v loading impacting platform performances - Windows Internet Exp...

A350 | 46.10.00.001 - FAM_004349 - Status: Pending - Agreed Priority: P3

What is a PMI?
A Product Maturity Item (PMI) is a technical subject which has an impact on the maturity and/or on the operability of the aircraft. The various sources for PMIs are:

- The lessons learned from our previous Airbus programmes
- The product findings resulting from the A350 XWB tests; laboratory test results, the Final Assembly Line and the flight tests
- The results of maturity transverse projects (like seals' damage avoidance, leaks avoidance, parasitic noise, etc.) or from operability test campaigns
- The issues resulting from the airline-like operation with the flight test aircraft
- The findings discovered during the manufacturing process
- The maturity reviews with our suppliers

Identification | **Priorization** | **Solution**

General

Program: * A350

External reference: * 46.10.00.001

Author: Unknown

Creation date: 08 Jul 2010

Last modified by: LEROUX, ALAIN (KEO)

Event Identification

Status: Pending

Title: * Airn@v loading impacting platform performances

Source: * Lessons Learnt

Description: * DESCRIPTION : Copy of Airn@v data into the repository have impact on NSS platform performances. NSS standard affected: 2a and 2b. CONSEQUENCE :

Relevancy: Yes

Attachments (2 max): TFU 46[1].10.00.001 1.pdf

Select a file - File size Max 10 Mo | Browse... | Upload

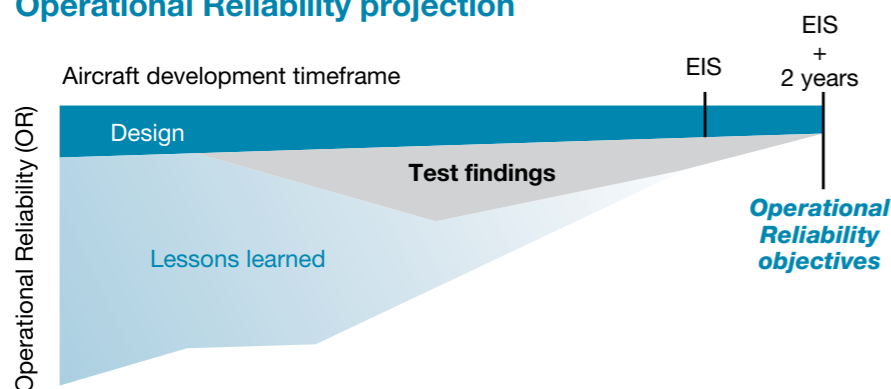
Airline operations

Operability test campaign

Cabin Operations	(Cabin Crew Operating Manual - CCOM)	
Airport Operations	(Ground Handling Manual - GHM)	
Flight Ops	(Standard Operating Procedures / Master Minimum Equipment List - SOP/MMEL)	
Unscheduled maintenance and maintainability demonstration		
Maintenance Operations		
Scheduled maintenance		
Validation on cabin 'zero'		Validation on 'iron bird'
		Validation on flight test

To ensure a mature product at EIS, a dedicated test campaign has been set-up in parallel with the flight test campaign. The purpose is to demonstrate the aircraft's operability and the feasibility of the maintenance and dispatch procedures. This campaign has already started with tests performed on cabin 'zero' and on the aircraft 'iron bird' (read article 'Zero test means' page 08).

Operational Reliability projection



FAMOUS, the collaborative platform, allows providing the right assumption in terms of the prioritisation of solving the issue and gives a projection of the estimated Operational Reliability at the aircraft Entry-Into-Service.

Improving maintenance

The A350 XWB design has been reviewed against lessons learned from previous programmes. Transversal projects were created to ensure that lessons learned were consistently applied throughout the programme.

Examples of projects include:

- Seals - to improve their resistance to wear and damage,
- Ram Air Inlets/ Ram Air Outlets - to improve their robustness to fatigue,
- Parasitic noise - for passenger comfort,
- Painting - to improve the product aesthetics, key for airline branding.

Testing the aircraft in an airline-like environment

During the A350 XWB's flight test campaign, particular attention to the airline-like operation has been highlighted. From the outset, an organisation set-up was put in place to ensure that the flights and ground support related activities were performed as close as possible to a normal airline operation.



ICAO Code E
ICAO ARFF Category 9

Airport operations

Ensuring the A350 XWB integrates well into the current airport infrastructure is key for the successful operation of the aircraft. Aspects like obstacle clearances, manoeuvring, pavement loading and ground operations needed to be considered right from the beginning of the aircraft design process. The Airbus Airport Operations' department has been involved from the definition of requirements with assessments at each major design milestone, to the setting up of test scenarios to ensure maturity. The experience and lessons learned from the A380 airport compatibility activities have been very valuable for the A350 XWB.

Airside activities - the right size for existing airport infrastructure.

Airbus has analyzed the impact of the A350 XWB key dimensions (wing span, fuselage length, landing gear wheel base and wheel track) on airports within its regulatory category (code E aircraft). As a result, Airbus demonstrated that the A350 XWB has the same good ground manoeuvring capability of comparable aircraft in service today. In addition, thanks to the 65m wingspan, the A350 XWB can be easily accommodated in a vast majority of current wide body gates. Airbus will conduct flight tests to ease the A350 XWB's Entry Into Service by looking in advance at our customers' destinations and alternate airports. In case one of these airports is not fully code E compliant, we will take advantage of the widely implemented operational standard processes to accommodate the A350 XWB without compromising safety (AACG, ICAO Circular 305).

Pavement activities

Airbus analyzed the loads of comparable existing in-service aircraft in order to design the landing gear of the A350 XWB for pavement limit certifications in alternate airports.

Ground operations activities

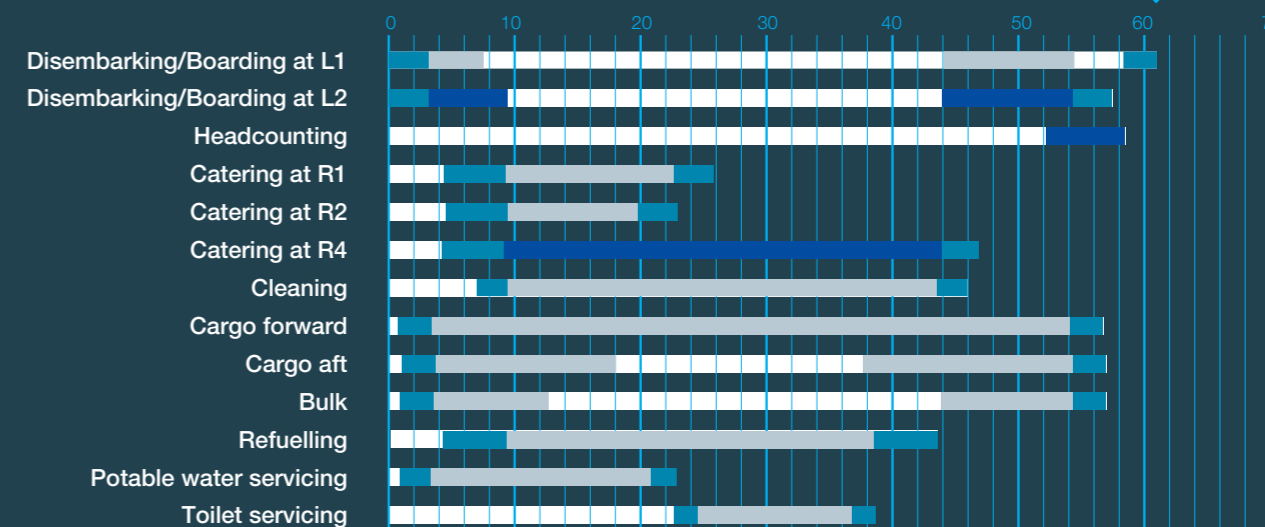
By using advanced 3D modelling, Airbus demonstrated at a very early stage the feasibility of using existing detailed Turn Around Time calculations, using the standard layout as well as customized cabin layouts.

Turn Around Time (TAT)

With the availability of the first flight test aircraft, the next step will be to run the various airport operational scenarios to validate both design and procedures. Using nominal as well as extreme operational scenarios will ensure, like for the A380, smooth operations from the first day of Entry-Into-Service.

Positioning/Removal
Activity
Critical path

Turn Around Time for the A350 XWB 61 minutes





Airline operations

Marc VIRILLI
Airline Operations
Technical Manager
AIRBUS

The A350 XWB will build on the advanced monitoring and diagnostics' systems already developed for the Airbus aircraft families in-service. The A350 XWB will be fitted with an advanced Onboard Maintenance System (OMS), instead of a stand-alone Centralised Maintenance System (CMS).

A330 maintenance features

Based on independent systems

- CMC (CMS)
- FDIMU (ACMS)
- MDDU/CDLC
- Physical circuit breakers
- Paper documentation
- Paper logbook

> Access through MCDU

A350 XWB maintenance features

Software integrated on FSA-NG

- Centralized Maintenance System (CMS)
- Aircraft Condition Monitoring System (ACMS)
- DLCS
- PDMMF
- Onboard electronic documentation
- e-Logbook
- Enhanced navigation through hyperlinks

> Access through OMT

ACMS	Aircraft Condition Monitoring System
CDLC	Centralized Data Loading Connector
CMC	Central Maintenance Computer (CMS)
CMS	Centralized Maintenance System
DLCS	Data-Link Control System
FDIMU	Flight Data Interface Management Unit
FSA-NG	FlySmart by Airbus-New Generation
MCDU	Multi-purpose Control Display Unit
MDDU	Multi-purpose Disk Drive Unit/
OMT	Onboard Maintenance Terminal
PDMMF	Power Distribution Monitoring and Maintenance Function

Unscheduled maintenance

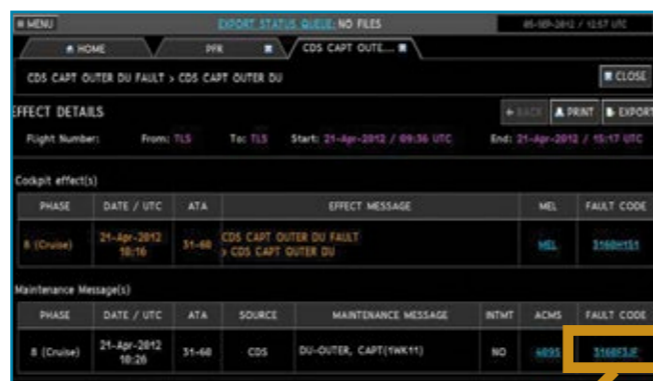
Onboard Maintenance System and advanced diagnostics

The crew is informed of functional degradations through consequential effects which will be handled at the end of the flight by a mechanic, based on their association with maintenance messages in the Post Flight Report (PFR). The A350 XWB is designed in such a way that no maintenance message is triggered if no effect impacts flight, cabin or maintenance operations.

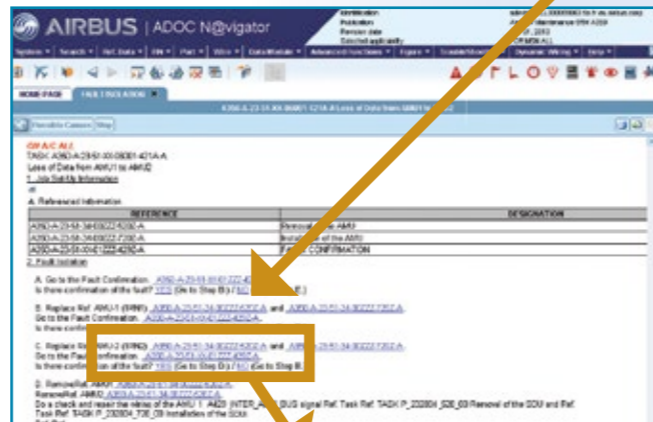
This allows the maintenance staff to isolate the important fault messages and concentrate on their final troubleshooting solution using interactive links in the main maintenance technical data, such as the Aircraft Fault Isolation (AFI) and the Maintenance Procedures (MP).

As proved with the A380, the Onboard Maintenance System (OMS) reduces the time for fault-findings and fault-isolation, with less potential for non-routine work and with a reduction in terms of No-Fault Found (NFF) removal rate. An estimation has been made revealing that the A350 XWB's NFF removal rate will be reduced by 50% compared to current generation aircraft.

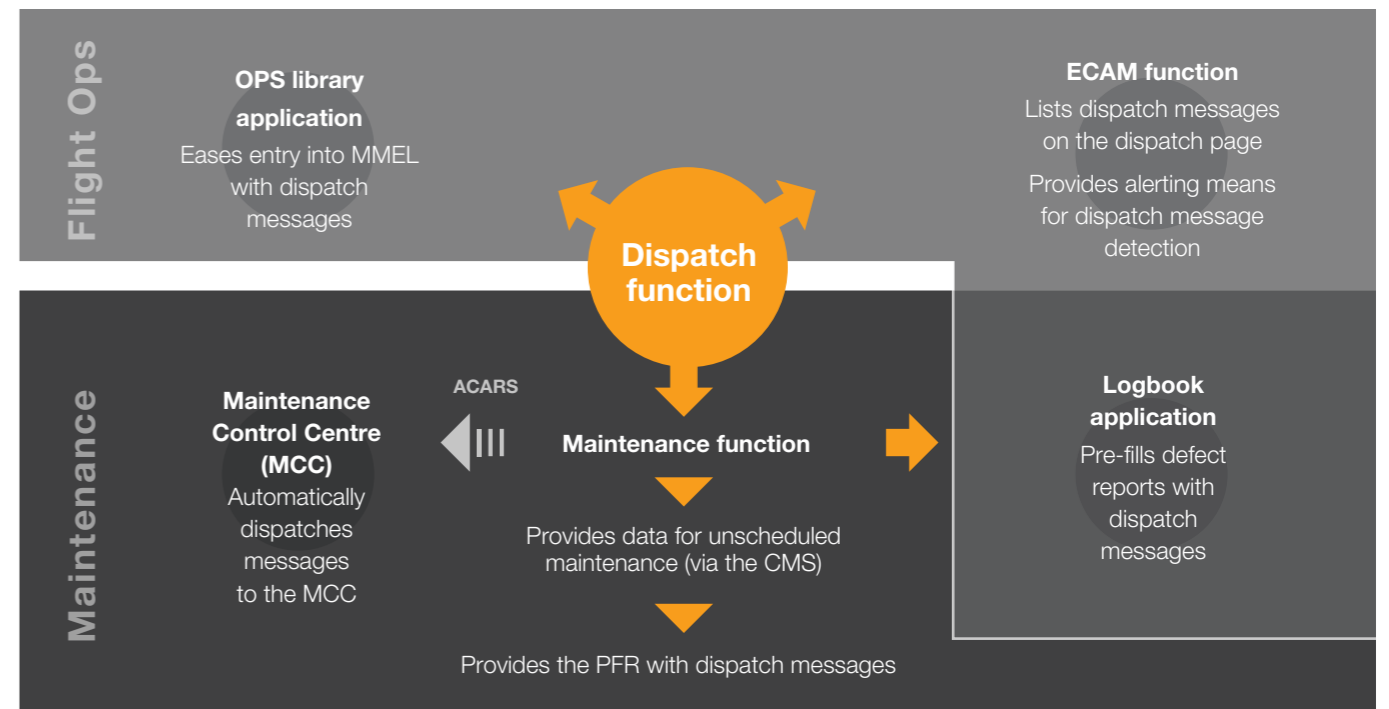
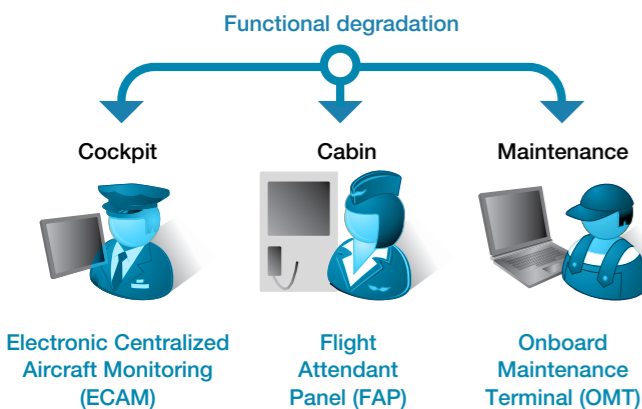
The consequences of this will become visible in terms of reduced spares and line maintenance man-hours.



AFI (former Trouble-Shooting Manual - TSM)



MP (former Aircraft Maintenance Manual - AMM)



As part of its new advanced Onboard Maintenance System (OMS), the A350 XWB adds another feature which allows the reduction of fault-findings and fault-isolation time, the so-called 'dispatch function'. This function, posted for the pilots, consists of cockpit messages which have an impact on the aircraft dispatch (linked to the Master Minimum Equipment List - MMEL). A dispatch message indicates that the MMEL must be consulted for dispatch, and each one is used as the entry point into the MMEL.

The advantage is to have a clear and single link between the root cause and associated dispatch consequences, thus reducing unnecessary messages and troubleshooting time. Operational information/warnings during the flight itself do not automatically generate dispatch messages. This means that the crew will see a dispatch message during the flight, only if they wish to see it, in the dedicated 'dispatch' page.

Moreover, as per other Airbus aircraft, the A350 XWB will fully benefit from the AIRMAN (AIRcraft Maintenance ANalysis) solution. The parameters of all the principal onboard systems will be available in real time at the operator's preferred location, as for example the operator's Maintenance Control Centre (MCC). This allows engineering and maintenance staff to gain access to aircraft data such as failure and/or warning messages while the aircraft is still flying. Not only does AIRMAN assist real-time troubleshooting but also proactive maintenance and failure anticipation, allowing maintenance staff to be ready for component replacement well before the aircraft lands at its final destination.

Scheduled maintenance

The A350 XWB Maintenance Review Board Report delivered

During a meeting organized in January 2013, the A350 XWB Industry Steering Committee (ISC) delivered the first draft of the Maintenance Review Board Report to the ISC members and Maintenance Review Board (MRB).

The A350 XWB maintenance programme highly benefits from the composite structures and the new system technologies through a significant reduction in the number of tasks and a general increase of the intervals. Thanks to the A350 XWB's design innovations and to the maintenance programme philosophy approach, analysis results show a reduction of about 45% for scheduled maintenance man-hours, over a 12 year heavy maintenance visit cycle.

In addition to the reduction of man-hours required, the A350 XWB maintenance programme provides increased aircraft availabilities extending the periods between 'high ground time' tasks. For example, the A350 XWB's cabin floor structure design and its selected new materials have permitted increasing the inspection interval for the tasks which necessitate the removal of the toilets and galleys, from 6 years to 12 years.

Another major contribution to the aircraft availability is the capability to schedule an A-check light maintenance at 1,200 FH (Flight Hours).

Moreover, those tasks are quick and easy to perform and depending on the operator's decision to schedule those tasks, they may be done during their standard weekly maintenance, achieving an even higher A-check interval. By the end of this year, Airbus will organize a set of maintenance working group meetings to perform a final review with the customers and the aviation authorities, to update the analysis dossiers in the frame of the finalisation of the MRB report for the approval scheduled mid-2014.

A350 XWB maintenance and structure training

A new aircraft,
stronger training concept,
new training tools,
extended commonality,
same family approach.

A350 XWB maintenance training will use the proven efficiency and success of the Airbus Competence Training (ACT) concept. This operationally-orientated scenario-based concept is focused on a 'learning by doing' approach. Courseware has been optimized with an in-depth Training Need Analysis (TNA) of 1,200 maintenance tasks.

By extracting the corresponding training objectives and focusing on the 'need to know', the A350 XWB course duration was reduced by 20% compared to initial estimates based on previous aircraft experience. The A350 XWB mechanics/ avionics full Type Rating course takes eight weeks. A specific two-day course on new technologies has been designed to bridge the gap with previous generation aircraft to start cross qualification.

The new Airbus-developed A350 XWB ACT trainer includes an interactive virtual aircraft and a virtual cockpit. It will allow both theory (with animated system descriptions) and practice of troubleshooting and maintenance tasks. Based on optimized simulation scenarios, this light, versatile concept runs on a laptop, making it available at airline facilities.

Successful and proven Airbus structure courses will now include A350 XWB composite material specificities for both theoretical and practical training, and the different modules will integrate perfectly into each stage of the damage assessment and repair workflow. Courses will be available on site, supported by training kits for practical exercises, and in different training centres, and in Airbus training centres.

Virtual Aircraft Walk Around
maintenance training software
takes you directly to the part

Radio Frequency IDentification technology (RFID)

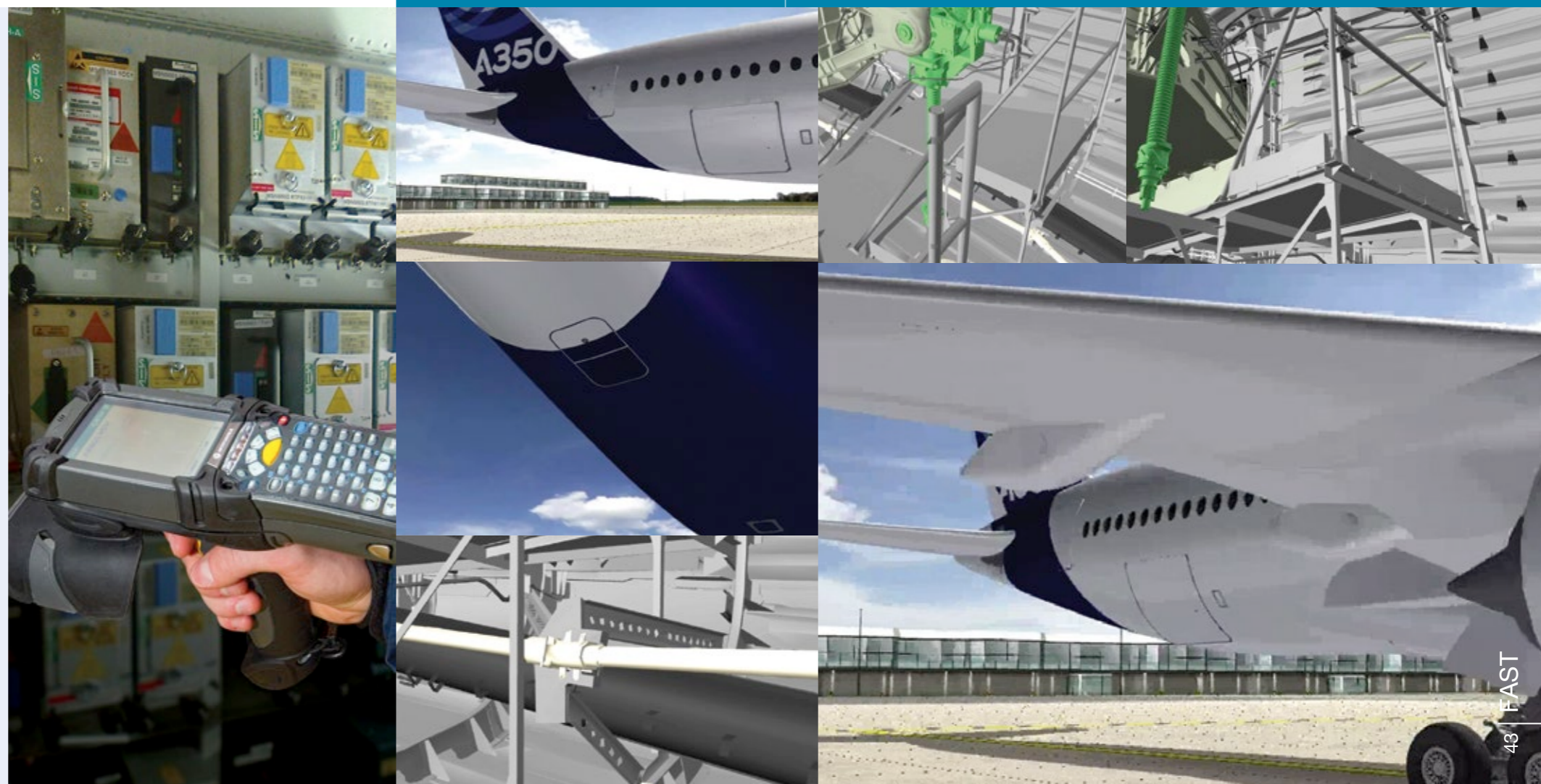
The A350 XWB is the world's first commercial aircraft to enter into service with permanent RFID tags.

The A350 XWB makes extensive use of this technology. Over 2,000 avionics, systems and cabin parts are delivered by suppliers with Radio Frequency IDentification (RFID) tags attached.

RFID technology allows remote reading and writing of component data from a handheld device. This provides significant maintenance benefits, such as a quicker and more reliable management of part information.

The large quantity of memory incorporated in each RFID tag allows storage of the complete detailed history of the part to which it is attached.

This high-memory RFID technology, pioneered and developed by Airbus, is now an industry standard (read FAST magazine N° 47).



Customer involvement

A joint approach from design to in-service operations

Customer involvement is key to a programme's success. That is why Airbus decided to involve customers in a joint approach to the A350 XWB's development from the early stages of the programme design to in-service operations. The suppliers have been systematically involved in collective reviews with our customers, as this integrated approach was essential to a successful Entry-Into-Service.



Alberto GRANDE
Airline Operations
Readiness Manager
AIRBUS

Between 2007 and 2010, a series of Customer Focus Groups joined the contribution of 180 people from potential customers' companies to the design definition.

Then, to continue collective reviews while focusing on the optimisation of the future operations and the preparation of the EIS of the A350 XWB, Airbus introduced the Customer Operations Seminar (COS), opened the full-time Toulouse-based Airline Office (France), started the Extended Airline Office remote collaboration forum and lately, defined the generic roadmap for bilateral discussions.

COS are conducted with clear objectives of both customer and Airbus readiness, anticipation of in-service programme issues and mitigation plans through a proactive collaboration.

Customer Operations Seminars

Customer Operation Seminars (COS) are a communication channel with the global A350 XWB community (customers, suppliers and Airbus teams). The main objective is consistent and transparent communication for sharing general information, engaging customers in optimizing future aircraft operations and paving the way to EIS. Held regularly since late 2010, 14 COS have gathered different groups of airline representatives depending on the operational domain (maintenance & engineering, ground & flight operations, technical data, training, powerplant, e-operations, cabin operations, etc).

As a result, more than 500 participants from 34 airlines as well as participants from 16 different suppliers exchanged with Airbus specialists their operational expertise. Field visits are organized ahead of the presented domain to have a full scale view.

For example, the 'Structure' COS held in February 2013, provided an update on in-service composite structure management: damage assessment, non-destructive testing, repairs, painting, training, etc. In particular, customers had the opportunity to use the first prototype tool for damage assessment by line mechanics, which supplied valuable feedback for Airbus. The customers appreciated the visit to the major static test of the A350 XWB (MSN5000) integrated in its impressive test facilities.

Bilateral:

Joint Airbus and customer adjusted EIS preparation.

Airline Office:

Currently six airline representatives embedded in the A350 XWB programme teams.

Extended Airline Office:

Online participation of selected airline customers together with the Airline Office through a collaborative platform, representing the community of airline customers.

Customer Operations Seminars:

Communication channel with the global A350 XWB community, per airline operations domain. General information to engage the customers in optimizing future aircraft operations and paving the way to EIS.

COS events

2010	2011	2012	2013	2014	2015
<ul style="list-style-type: none"> • Technical data • Maintenance • e-Operations 	<ul style="list-style-type: none"> • Airport operations • Maintenance • Technical data • Maintenance • e-Operations • Training & simulation • Powerplant • Flight deck & flight ops 	<ul style="list-style-type: none"> • e-Operations • Cabin crew operations • Powerplant & extended mechanical systems perimeter 	<ul style="list-style-type: none"> • Maintenance & engineering • Structure • Powerplant (jointly with -1000 CFG) • Avionics & electrics 	<ul style="list-style-type: none"> • Maintenance & engineering 	<ul style="list-style-type: none"> • Maintenance & engineering
<p>COS themes Technical data, powerplant flight operations, ground operations, cabin maintenance and structure</p>					

The Airline Office

Launched in March 2011, the Airline Office has brought customers' operational expertise into the A350 XWB programme and contributed to the development, verification and optimisation of Airbus Customer Services deliverables.

Team members from Cathay Pacific, Finnair, Qatar Airways, TAP Portugal, United Airlines and US Airways include launch customers with varying size orders and types of operations. Working together at the A350 XWB central plateau in Toulouse, France, the team members remain connected to their respective airlines and proudly represent the community of A350 XWB customers.

The Airline Office aims at optimizing the operability of the aircraft and the support deliverables, bringing customers' operational expertise into the A350 XWB development teams. For instance, it ensures that complexity, time-consumption or costs are kept to a minimum for airlines in terms of technical activities such as maintenance, repairs or cabin operations. Its role is also to prepare and ease airlines' aircraft EIS, favouring commonality with the A330 and A380 where appropriate and recommending innovation where possible. The main objectives for 2013 are to continue supporting operational test campaigns, to continue preparing an A350-900 mature EIS in 2014, and to contribute to the A350-1000 development.

A win-win situation for both the A350 XWB programme and its customers, the Airline Office corresponds perfectly with Airbus' innovative ways of working. Customers carrying out in-depth work on the product before delivery, bringing valuable skills and expertise on a wide range of topics and giving Airbus employees a constructive insight of real life operations. This new relationship has entailed a real change of mindset both from customers and Airbus employees.

Quotes from Airline Office representatives:

"...a very valuable project for airlines since we are close to the source and we can get all the necessary information to prepare for EIS"

"...gaining a clear understanding of the end-to-end, design, production and maturity process"

"...when we help to find a solution which adds no cost or weight to the aircraft there is a great feeling of accomplishment, and we know that we have helped the A350 XWB become an even better aircraft"

"...our responsibility is to see EIS issues before they arise and then help to envision solutions"

The Extended Airline Office

At the request of several customers, Airbus is extending and complementing customer contribution to the A350 XWB by means of the A350 XWB Extended Airline Office. This will be a collaborative and interactive forum for sharing operational expertise with the off-site participation of a selected number of additional A350 XWB customer airlines, together with the six current members of the A350 XWB Airline Office.

Mainly focused on the maintenance, engineering and flight operations' domains, it will focus on the anticipation of potential in-service issues and the final development, verification and optimization of the support deliverables.

FAST from the PAST

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

Planning for the future

We never stop asking ourselves 'How can we design this better?'

As technology evolves new solutions become available to make the flying experience, more comfortable, more profitable, more reliable, cleaner, quieter and above-all safer.

But as much as our customers appreciate these ongoing improvements they will eventually expect more.

At Airbus we're well aware that today's innovation is tomorrow's 'old hat' !

Courtesy of the Airbus Flight Test Photo Lab

Airbus Customer Services

Around the clock... around the world

More than 240 field representatives based in over 110 cities



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A350 XWB

Efficiency now has a shape



13h00 - 13th May 2013
Roll-out of the A350 XWB MSN001



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