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Airbus technical magazine
#57
FAST
Flight Airworthiness Support Technology

AIRBUS

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TAT optimizer

Airbus' Turn Around Time & operations optimizer
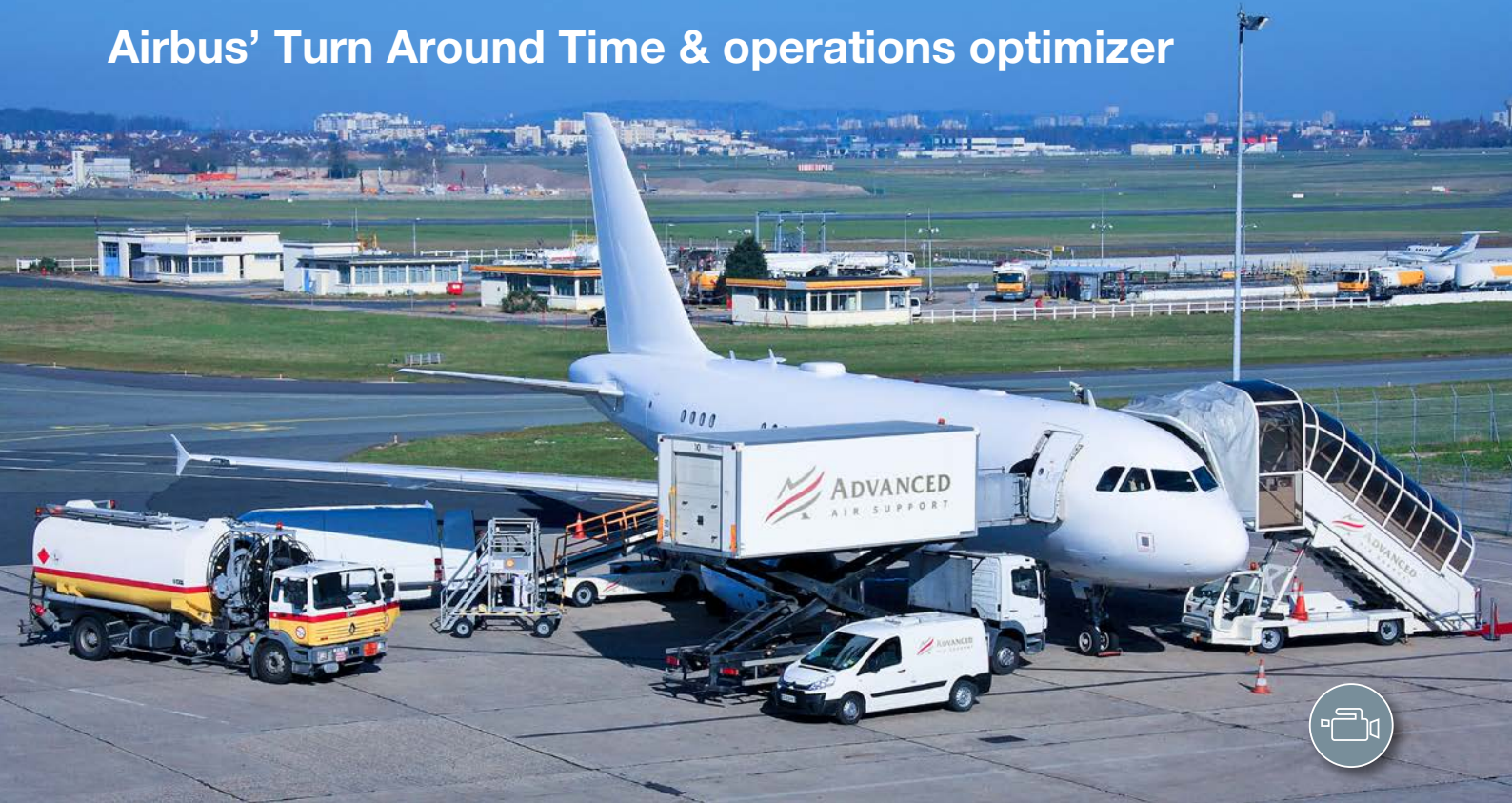
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Improving an aircraft's 'pit stop' performance

An aircraft on ground is an aircraft that does not bring revenue to an airline. During the turn-around time, there are many activities happening in and around the aircraft such as catering, baggage operations, refuelling and cleaning. It is similar to what happens during the pit stop of a Formula 1 race. At a pit stop, everyone is working to optimize the performance of the team. But during an aircraft turn-around, everyone is working to optimize their own performance; not necessarily the overall performance. This can not only cost time and money to the airline, but also lead to a late departure with the risk of losing the slot with Air Traffic Control.

Real-time analysis

To improve the global performance, we fall back on the maxim, *"If you cannot measure it, you cannot improve it"* (William THOMSON, Lord KELVIN – 1824-1907).

Aircraft's computers record even when on ground. They measure how long the doors are open, how long it takes to refuel, how long the aircraft is hooked up to the ground-service power cart, and more. This data allows objective performance measurement of the ground servicing in real-time. Also the computers aboard the aircraft can provide this data on every leg of its journey.

The Airbus solution known as Turn-Around-Time & operations optimizer (TAT optimizer) was conceived at Airbus by the Emerging Technologies & Concepts group in Bangalore (India), based on ethnographic market research. Research covered airlines, airports and passengers. The first proof of concept was developed by a cross-functional team (coming from systems, architecture and integration, flight test, cabin engineering and Customer Services' departments) to demonstrate the feasibility. Since then, with Airbus' Corporate Innovation sponsorship, TAT optimizer has been further developed and enhanced for testing and deployment with customers.

With this new solution, airlines can perform real-time monitoring of on-ground aircraft activities. It does not require any costly and time consuming hardware changes.

The aircraft itself is at the centre of the performance improvement by giving real-time visibility to what is happening on ground. Potential departure delays are systematically integrated into the airline's decision process in order to minimize disruptions to their ground service schedule. The real-time information also becomes input for the Airport-Collaborative Decision Making (A-CDM) for Target Off-Block Time (TOBT) calculation and tracking.

The solution enables remote fleet-wide monitoring to support tactical decisions like fleet swapping, crew rostering, etc. The collected data is used to benchmark the performance of ground-handling activities, pinpoint areas of weakness and identify improvement areas for schedule performance.

Benchmarking of deplaning duration (by aircraft type and airport) - illustrative
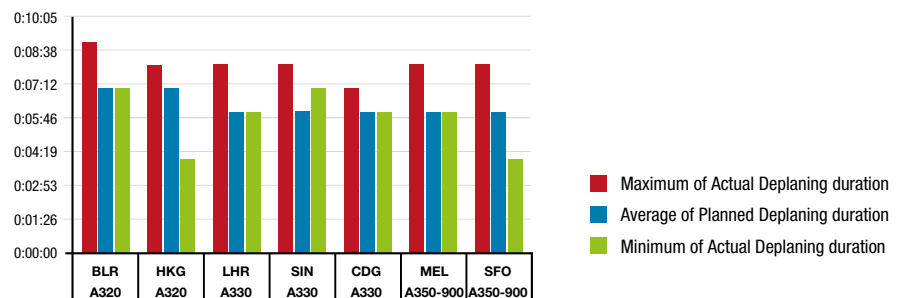
Benchmarking of deplaning start delays (by airport) - illustrative
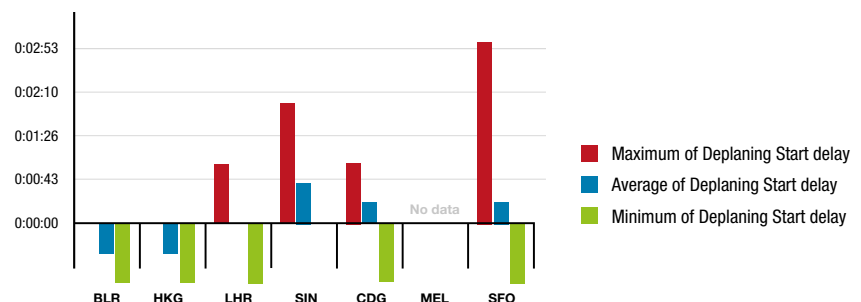
The solution is now geared to cover activities from touchdown to take-off like taxi-in, turn-around activities and taxi-out. The various turn-around activities monitored are deplaning, boarding, cabin cleaning, catering, cargo unloading and loading, bulk unloading and loading, refuelling, water servicing, waste servicing and brake cooling. The data related to these activities are transmitted by the aircraft in real-time to a 'cloud platform'. The data is processed and then presented to users via an intuitive interface on portable devices.

Airport - Collaborative Decision Making (A-CDM) is a joint venture between ACI Europe, EUROCONTROL, International Air Transport Association (IATA) and the Civil Air Navigation Services Organisation (CANSO) which aims to improve the operational efficiency of all airport operators by reducing delays, increasing the predictability of events as the flight progresses and optimising the utilisation of resources.

The TOBT (Target Off-Block Time) is a point in time to be monitored and confirmed by the airline/handling agent at which the ground handling process is concluded, all aircraft doors are closed, all passenger boarding bridges have been removed from the aircraft and thus start-up approval and push-back/taxi clearance can be received.
All ground handling processes, except push-back and de-icing, are based on the TOBT.

The TAT optimizer

The TAT optimizer rationalizes and gives a real-time overview of each and every intervention needed for a swift and efficient turn-around. Priority information such as the aircraft and schedule information along with alert messages are set in the interface header.
Planned turn-around activities are laid out in a Gantt chart denoting the scheduled arrival and departure. Their layout is configured by the airline according to its operations and may also be stored as a template.

The arrival of the aircraft at gate is represented as a blue line on the interface. As the turn-around unfolds, the current time is denoted by a continuously moving red line from left to right. There are several visual indicators built in, to highlight the current status, the actions due and exceptional events at a glance. The border of the activity bar turns 'green' if it is due to start, and turns 'red' if delayed. When the activity starts, the bar starts filling up in 'green' as the activity progresses. If the scheduled stop time is exceeded, then the fill colour turns 'hashed green' and 'amber. This helps to alert a ground handler when his/her activity is due to start and when it is due for completion. When the activity is completed, the time overrun is filled as 'amber'. These visual indications also enable a ramp manager or a dispatcher to recognize at a glance which activities present a risk and he can then react accordingly.

Dependent tasks such as catering, cleaning, refuelling, cargo loading and unloading, are also highlighted on the interface. If the previous task overruns, the overlap is shown on the dependent task bar as a 'red' line. This provides an alert that dependent activities can delay the aircraft's departure and hence are required to speed up. The inbuilt algorithms continuously process the data to identify critical paths and predict the potential departure delay in minutes. This allows ample time for ground handlers and airline personnel to organize themselves to address the cause of the delay. Also, the brake cooling time, which decides the minimum turn-around time, is predicted at block-on* and updated at regular intervals.

Apart from the detailed Gantt view, there is a summary view which contains only the header information. This aids airline personnel to monitor the status of several aircraft at the same time. The arrival time turns blue with block-on. The departure time can turn amber if the delay is predicted. If the aircraft departs as scheduled, then it turns blue again. When all the turn-around activities are complete and the aircraft is ready for pushback, the turn-around time turns green. The alert messages are also part of the header to inform about any exceptional events.

The data driving the TAT optimizer interface comes from the aircraft. Deplaning starts when the passenger door is opened. The start and finish of cargo unloading and loading is triggered by the opening and closing of the cargo doors. Refuelling is monitored with the help of refuel commands and the fuel level. The solution is also capable of taking data from the crew via a mobile interface, from the airline information systems and other known reliable sources.

> **Over a period of time, this data can reveal extremely valuable information.**
> **Careful analysis can determine benchmark performance of various ground handling activities, identify root causes of delays and non-obvious improvement areas which are lost in routine work. An airline can use these data analytics capabilities to boost their Incentive & Performance (I&P) programme at their operating airports.**
>
> **Also, the TAT optimizer enables them to:**
> - **Discover and evaluate possible performance problems before the schedule is established,**
> - **Plan turn-around frequency and optimal durations,**
> - **Manage network interdependencies.**

While providing the above capabilities, TAT optimizer invariably addresses some important comportment aspects. The objective aircraft data reduces conflict, eliminates negotiations (typically seen when assigning delay codes) and assigns clear responsibilities. In addition, the solution ensures a shared understanding for all stakeholders with the ability to share alerts/concerns with others. This gives a sense of teamwork (similar to that of the pit stop team in Formula 1) to every stakeholder who in their current environment is usually disconnected and uninterested.

TAT optimizer was conceived to be truly agnostic. Not only does the software function on any type of device (multi-platform), but it also works on any aircraft type, any airport and can be remotely accessed from anywhere in the world (coming soon on smart watches!). Also, the solution is capable of integrating with airlines' legacy information systems and complies with future data standards of Air Traffic Management (ATM) improvement initiatives. TAT optimizer has been presented to various airlines and they have all confirmed their interest, and one has already started trials.

* Aircraft arrival at gate is block-on. Aircraft departure from gate is block-off.

Steps throughout the TAT optimizer's monitoring *(mock examples)*

Deplaning going beyond planned completion time. Dependent activities (catering, cleaning and refueling) highlighted. Following input from cabin crew on cause of deplaning delay, an alert message is given to all stakeholders concerning its cause.
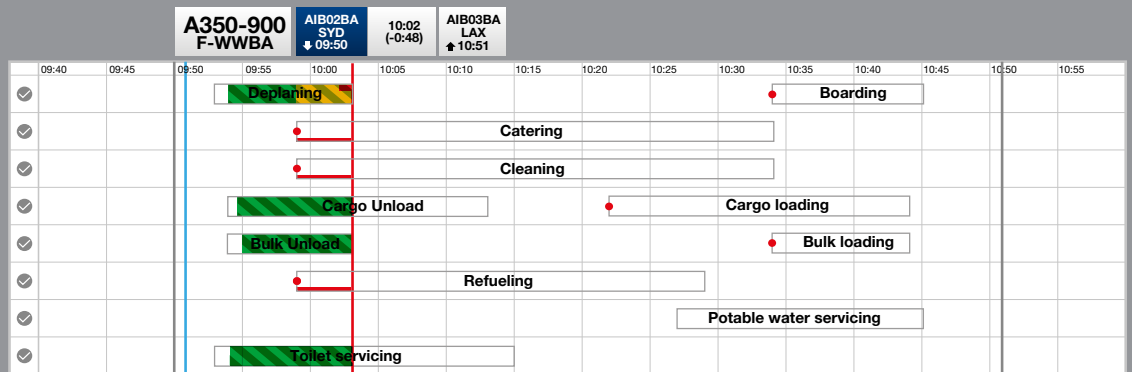
Stakeholders having been informed of the prediction of potential delay of 3 mins to flight departure, dependent activities start. Potential delay alert (amber) remains. Stakeholders work to recover delay.
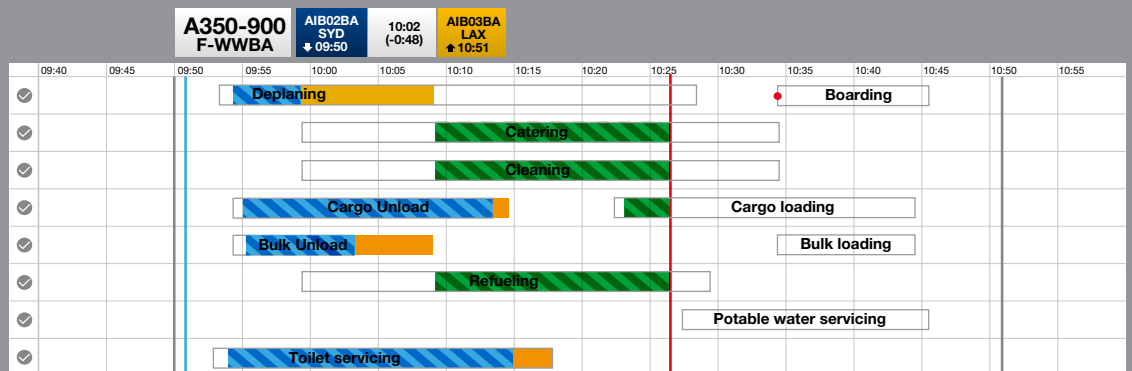
Having cascaded into catering and cleaning, the stakeholders recover the delay by completing the catering and cleaning in a shorter duration.
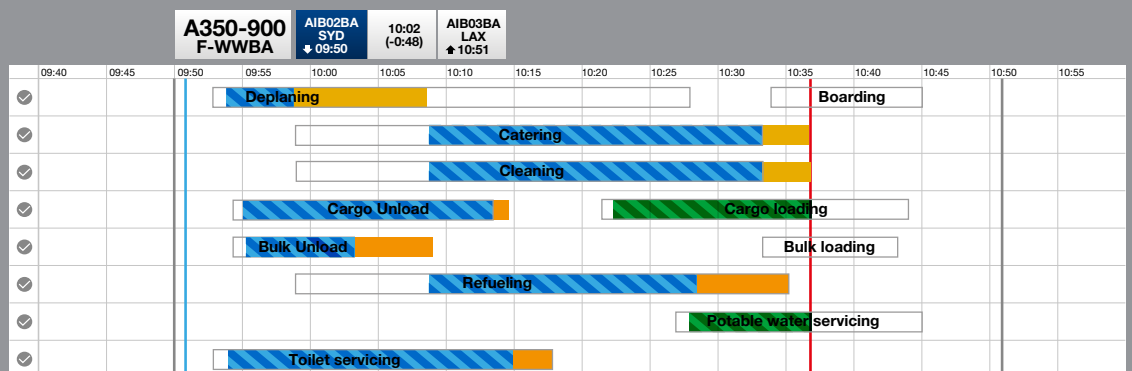
All activities complete (green). Aircraft ready for departure on schedule. The turn-around data is frozen.
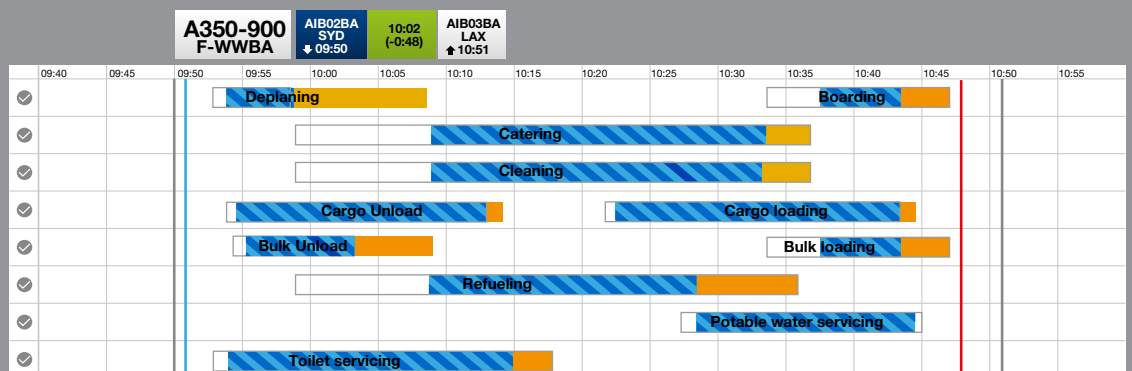
The TAT optimizer is multi-platform. Not only is the software compatible on all devices, but it also works on any aircraft type.

Buffers consumption (between aircraft ready and departure) analysis

illustrative

— Average of Planned buffer between 'Aircraft ready' and 'Block-off'

■ Average of idle time between 'Aircraft ready' and 'Block-off'

■ Max of idle time between 'Aircraft ready' and 'Block-off'
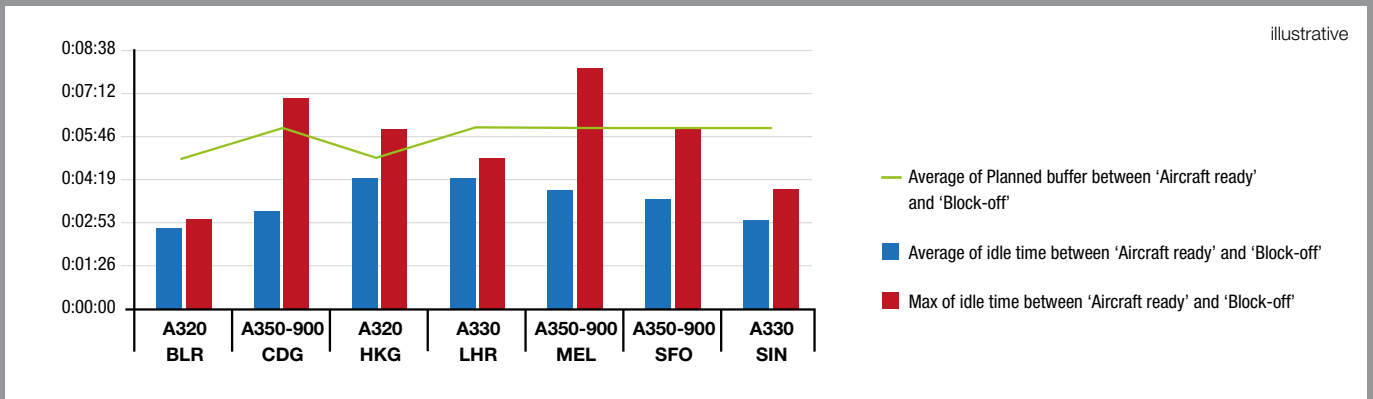
Buffers/Idle times on a theoretical critical path

illustrative

■ Average of Deplaning to Catering idle time
■ Average of Deplaning to Catering idle time
■ Average of Cleaning to Boarding idle time
■ Average of Catering to Boarding idle time
■ Average of idle time between 'Aircraft ready' and 'Block-off'
■ Average of Un-used buffer between 'Block-on and Deplaning start'
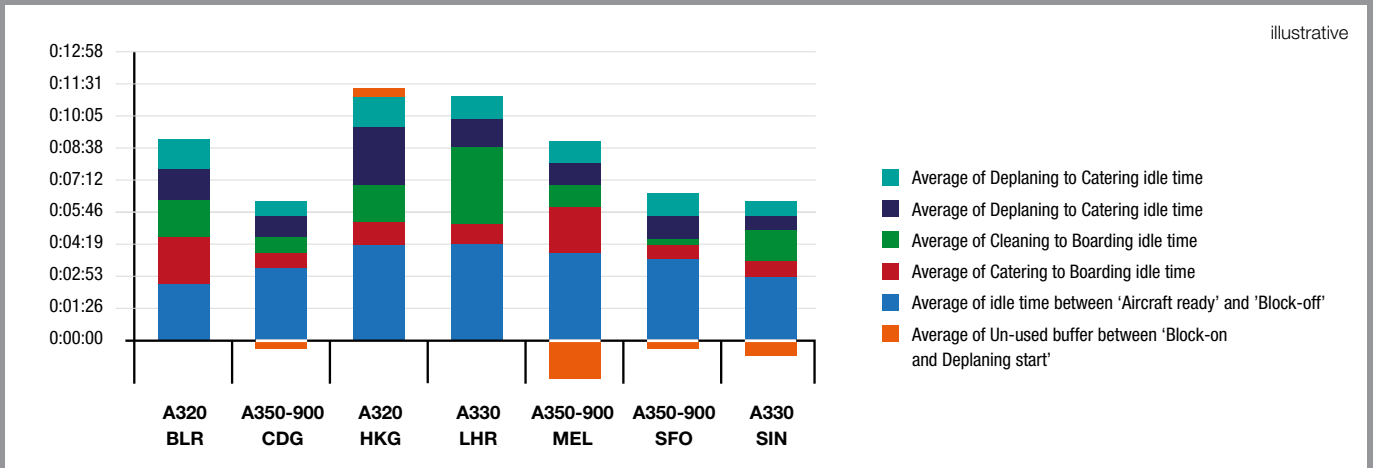
Root-cause analysis of delays

illustrative

■ Count of Delay Departure
■ Count of Delay in pushback
■ Count of Delay by Bulk loading
■ Count of Delay by Catering
■ Count of Delay by Cleaning
■ Count of Delay by Deplaning
■ Count of Delay by Skybridge positioning
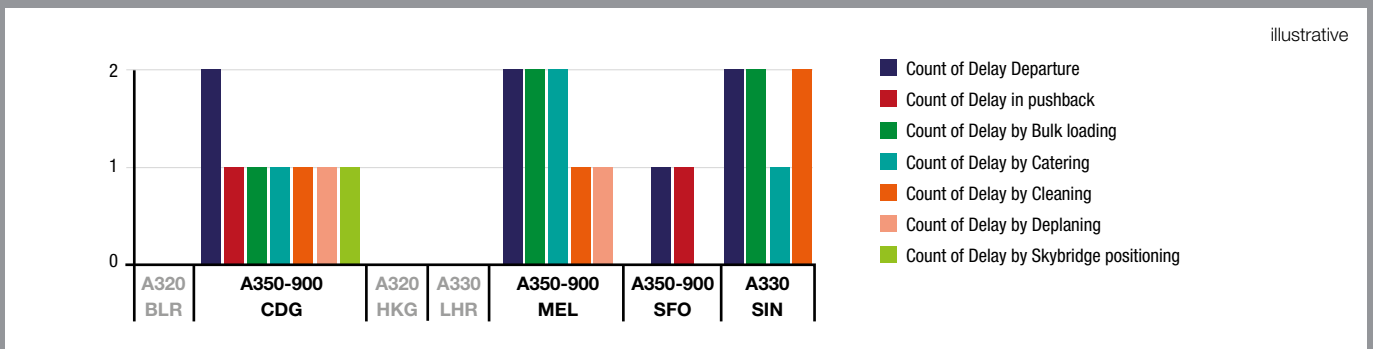
The TAT optimizers of an entire fleet can be seen on the control centre's summary view

Operation monitoring

A320 A-WWBB	AJB02BA CDG ↓14:35	14:45 (-0:34)	AJB02BA FRA ↑15:20	Alert messages
A320 A-WWBA	AJB08BA BLR ↓14:29	14:45 (-0:24)	AJB09BA HKG ↑15:10	Alert messages
A350-900 F-WWCC	AIB08BA CDG ↓14:29	14:45 (-0:57)	AIB09BA BLR ↑15:43	Alert messages
A350-900 F-WWCB	AIB06BA SFO ↓14:29	14:45 (-0:47)	AIB07BA CDG ↑15:33	Alert messages
A350-900 F-WWBB	AIB04BA HKG ↓14:29	14:45 (-0:44)	AIB05BA FRA ↑16:30	Alert messages
A350-900 F-WWBA	AIB02BA SYD ↓14:29	14:45 (-0:44)	AIB03BA LAX ↑15:30	Alert messages

The future roadmap of TAT optimizer includes performing real-time video analytics on the feeds from cabin cameras. This would enhance the visibility of cabin activities and help measure progress. A module to speed-up boarding is proposed by streamlining the order in which seats are filled. Patent disclosures have been filed on current and planned developments. Also, the solution will be integrated with other complementary modules, such as maintenance.

Benefits

At turn-around level:

• Real-time aircraft turn-around visibility by leveraging objective aircraft data,

• Improved situational awareness and efficient coordination of ground activities,

• Inbuilt predictions and warnings for proactive decision-making to minimize schedule disruptions,

• Shared understanding for all the internal and external stakeholders for system level optimization,

• Input to A-CDM for TOBT calculation and tracking.

A-CDM: Airport-Collaborative Decision Making
TOBT: Target Off Block Time

At fleet level:

• Remote monitoring of fleet-wide ground status and potential risks,

• Decision support for aircraft swapping, crew rostering,

• Enable dynamic prioritisation and ground resource deployment.

At schedule level:

• Integrated network-wide business view of turn-around schedule and planning,

• Discover and evaluate possible performance problems prior to the schedule being established,

• Business insight to plan turn-around frequency and duration reduction/optimization.

CONCLUSION

Airbus' TAT optimizer substantiates a crucial point that activity data of the turn-around time is valuable. And intelligence on top of that data is an area where Airbus can naturally contribute and create value for its customers. An intelligent and connected aircraft offers benefits not only to the airlines, but also to overall Air Traffic Management and passengers' satisfaction. Future endeavours in this direction will include connecting aircraft and an on-board integration of TAT optimizer with the Electronic Flight Bag (EFB), the cabin logbook and the Cabin Intercommunication Data System (CIDS).

ACE by name, ACE by nature

A new vision for flight crew training

Article by
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"Airbus' new training model is set to become the new benchmark for airliner type rating training" [1]

"...a revolutionary training system" [2]

These are just two among many public comments on Airbus' successful new pilot training concept.

Let's take a look at the rationales for changing the way airline pilots are trained and an in depth description of the tool that stands at the core of the new instructional philosophy: the ACE (Airbus Cockpit Experience) trainer - a portable simulator which even enables you to take your Airbus cockpit home with you.

Why did Airbus decide to change its well proven pilot training programmes?

Training instructors and examiners at Airbus, as well as industry observers have noted that flight crew training requirements in regulations have traditionally been driven by the conclusions of hull losses from jets in the 1960s and 1970s. Additional incidents and accidents have subsequently added to training requirements resulting in an inventory or 'tick box' approach that saturated recurrent training and checking programmes.

At the same time, aircraft design and reliability improved substantially, leading to a situation where many accidents occurred with aircraft that were operating without any malfunction. It was apparent that the training philosophy had to be reviewed.

Airbus has supported the International Air Transport Association (IATA) Evidence Based Training (EBT) initiative since 2009.

1 Aerospace, January 2015
2 Flight Global, November 2014

What is Evidence Based Training?

A core principle of EBT is to develop a set of pilot's competencies (rather than training tasks as in the traditional "tick-box" concept); *"You should train the reason of the outcome of a particular event not the outcome itself"* **is the message passed to trainers and EBT recurrent training designers.**

When the pilot training programme for the new A350 was conceptualized, Airbus decided to adopt EBT principles where suitable even in the new Type Rating (TR) courses. It soon became clear that to fulfil this aim within the intended timeframe of a typical TR course, new technological solutions in regards to training aids would be required.

Traditionally Airbus trained the behaviour and failures of aircraft systems on flat panel trainers from the Airbus Pilot Transition (APT) trainer and Full-Flight Simulators (FFS). To gain valuable training time in the FFS it was required to offload APT and FFS sessions. "*We wanted to train pilot's competencies to manage the system and potential failures throughout the whole course - in an operational realistic environment*", describes Jean-Charles MAZENQ, one of the lead course designers.

Instructing in the traditional way (showing and being told by a teacher in a classroom or watching animated slides like in Computer Based Training) seemed neither efficient enough, nor thoroughly effective. Learning psychologists were consulted and it became apparent that in the new concept a learning-by-doing concept should be applied even in course phases that were so far covered by the traditional methods.

Throughout the course, Airbus developed this concept even further into a learning-by-discovering principle, demanding an even more proactive role from the trainee compared to the learning-by-doing approach. The learning speed and retention rate has significantly raised using this approach.

The tool enabling this learning paradigm is a new generation training device called ACE, used from day one of the type course as the primary training tool (in the ground phase) and later as a free-play device in the airborne phase.

Evidence Based Training (EBT)

EBT is a training paradigm introduced in ICAO COC 9995 intended to replace conventional recurrent training and checking.

The aim of an EBT programme is to identify, develop and evaluate the key competencies required by pilots to operate safely, effectively and efficiently in a commercial air transport environment, by managing the most relevant threats and errors, based on evidence collected in operations and training.

Evidence Based Training Implementation Guide, IATA, ICAO, IFALPA 2014

A holistic approach to training

ACE

The deployment of the ACE concept allows Airbus Training to go the extra mile and to propose a much more advanced learning concept compared to conventional interactive Computer Based Training. Learning-by-discovering and reinforcement thanks to free-play are the key pillars of this new holistic training approach.

The Airbus Cockpit Experience
enables you to train wherever
and whenever you wish

ACE

How does ACE work?

Kate WHELLER, the project leader of the ACE development explains: "*It is a mobile and fully functional A350 cockpit simulator which allows the trainees to learn the updated A350 interface and functionalities by trying it out at their own pace. Interspersed with the simulation, a system guide explains the system functionality that the pilot is interacting with. This more interactive and adapted form of learning colours the whole A350 training concept.*"

Concretely, the ACE trainer is a 3D virtual and interactive A350 XWB cockpit. Pilots can perform a self-paced study to acquire knowledge on both systems and procedures, and apply continuous skill reinforcement over and over again. They can use the tool as much as necessary, whenever they want, wherever they want. Trainees repeat and discover details of a system or a function on their own, using the learning-by-discovering method and are guided to ensure that all the entries are controlled and corrected.

"*It results in a more holistically trained pilot who has a better understanding on how to interact with the aircraft*" is the impression of an aviation expert after using the tool for the first time.[3]

The same methodology applies to procedure familiarization, with a focus on:

• Standard Operating Procedures (SOP),

• Flow patterns,

• Abnormal procedures,

• Flight Management System (FMS) functions,

• Electronic Flight Bag (EFB).

This familiarization results in significant time-saving on other training devices.

The gains on the overall course are significant: the length of the course is two days shorter than the traditional one but contains more Full Flight Simulator time, more scenario-based training and a much more solid trained set of competences when the trainees fly their first mission on line.

Using the ACE leads to better knowledge retention in regards to pilot training, with a focus on need-to-understand rather than on the technical details. It provides a more effective, efficient - and above all - motivating training method adapted to individual needs.

3. Blog "Leeham News and Comments" June 2015

"

Customer feedback

One year after its introduction the ACE trainer has provoked some very encouraging customer feedback.

"ACE is much more advanced compared to the previous CBT"

"Very good tool to train with the different systems"

"ACE is remarkable and I would like to continue using it after the course"

This enthusiasm has encouraged Airbus to also develop an ACE trainer for the A330 which will be available in 2016.

CONCLUSION

ACE is a learning-by-discovering method for pilot Type Rating training.

Used on tablet devices it is totally portable and may be used whenever and wherever the pilot wishes. The availability of this self-based-study as well as the motivating, holistic approach to pilot training reduces the training course by two days while freeing-up Full Flight Simulators for longer, more optimized sessions.

A350 XWB composite repairs

Analysis and repair of in-service damage to composite structure

Article by (left to right)

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Although you wouldn't notice from the outside, there is something very different about the A350 XWB (Extra Wide Body) compared to most other aircraft: its primary structure is made of composite. Composite is a short name used for "Carbon Fibre Reinforced Plastic" (CFRP), which has progressively replaced aluminium in aircraft design over the past years.

Not only has this structure improved the aircraft's performance (weight), but also its maintenance and repair procedures. It has been designed to fulfil in-service requirements with benefits such as increased resistance to accidental ground service impacts, simplified damage assessment processes and proven repair solutions.

Robustness by design

The structural robustness of an aircraft is the ability of its structure to sustain in-service loads through its entire life under realistic environmental conditions, with no or minimum maintenance actions resulting from common in-service threats.

In this way, structure robustness improves the availability of the aircraft while reducing the operation and maintenance costs throughout its life.

Robustness is not required by certification. However, Airbus has considered it (through extensive tests) in the development of its new Carbon Fibre Reinforced Plastic aircraft: the A350.

GFRP = Glass Fibre Reinforced Plastic
CFRP = Carbon Fibre Reinforced Plastic
CFRP Sandwich
Titanium alloy
Aluminium alloy
Quartz Fibre Reinforced Plastic
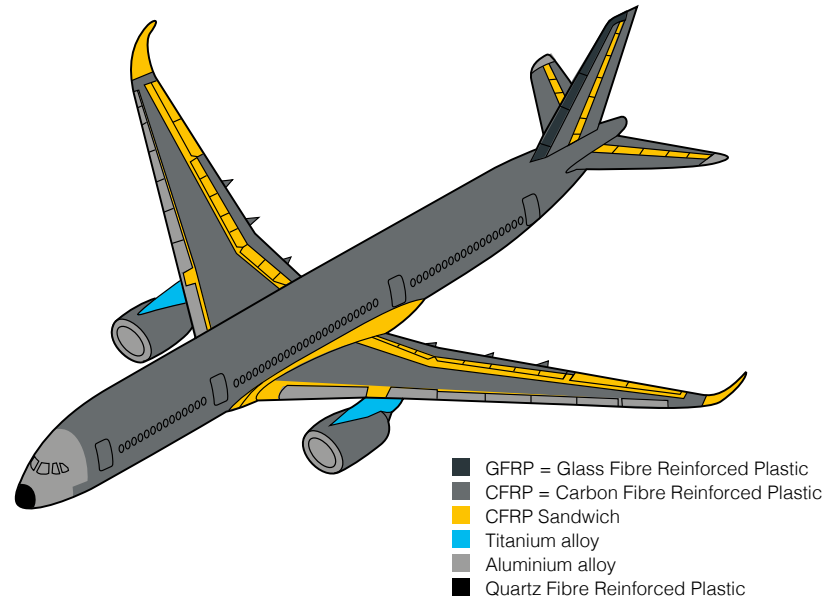
To ensure the strength and resilience required by the new composite structure, Airbus gathered data from its in-service fleet of mechanical impact scratches and lightning strikes (sources, locations and dimensions).

Extensive tests and further engineering analyses permitted a conversion of this data from aircraft metal structures into composite structures and the corresponding threats and damages data.

These 'typical' damages have been implemented in the section of the Allowable Damage Limit (ADL) of the Structural Repair Manual (SRM).

Damage conversion process from metal to CFRP

Metal domain

| Impact tests (metal fuselage) | SRM Chapter 7 |

| In-service damage reports | SRM Chapter 8 |

| Dent depth = f (energy) | SRM Chapter 7 |

| Dent depth in service | SRM Chapter 8 |

| FH/FC date | SRM Chapter 8 |

| Damage location | SRM Chapter 8 |

| Impact energy in-service | SRM Chapter 8 |

| Impact rate of occurrence | SRM Chapter 9 |

| Aircraft zoning | SRM Chapter 9 |

Impact threat

CFRP domain

| Impact tests (CFRP) | SRM Chapter 10 |

| Detectability tests (BVID) | SRM Chapter 10 |

| Damage tolerance criteria for composite structure sizing | SRM Chapter 10 |

| Dent depth = f (energy) — Dent depth = f (delamination) | SRM Chapter 10 |

| Robustness criteria | SRM Chapter 11 |

Calibrated mechanical impact tests on CFRP structure are compared with the same tests performed on aluminium structure.

All types of mechanical impact and lightning strikes are analysed.

The 'Line Tool' is used for analysis when the visual indication of an impact exceeds one inch on the composite structure.

The after sale aspect of securing the robustness, allowable damage annealing or facilitating the maintenance of the A350's structure containing a high amount of CFRP, has from the start of its development been considered.

Damage assessment

The objective pursued by Airbus has been to develop a damage assessment process to facilitate aircraft dispatch. Damage to composite materials usually requires the intervention of a qualified Non-Destructive Testing specialist who conducts inspections using ultrasound. This is no longer necessary on the A350 for two reasons:

- Firstly, damage assessment of routine impacts can be visually assessed. If the visual indication does not exceed one inch (2.5 cm) diameter, then the aircraft can be dispatched safely because of the A350's structural robustness. Even in the case of a lightning strike, an aircraft can be dispatched safely with no further NDT if the damage falls within this criterion.

- Secondly, aircraft can be dispatched more quickly because of an Airbus-patented innovation called the "Line tool". This tool is used when the visual indication of an impact exceeds one inch on the composite structure. This 'GO/NO-GO' tool can be used by line mechanics if a significant incident has occurred. After a short functional test, the inspection is performed using a wheel probe on the composite structure. The 'Line Tool' then displays the result of the inspection: 'GO', meaning the absence of delamination, allowing aircraft dispatch; or 'NO-GO', calling for a further NDT inspection. In addition, this tool can help locate structural elements which are not visible from the aircraft's external skin. This tool is provided in a transportable kit that can be easily stored on the aircraft or may be located at an outstation.

Airbus continues to develop this simplified approach to damage assessment on composite structures. For instance, an evolution of the line tool will soon enable operators to automatically obtain the exact size of a delamination, which is expected to save several hours in the damage assessment process.

Used by a
line mechanic
to inspect impacts,
the tool gives
a clear 'GO' or
'NO-GO'result

Using a full scale model,
Airbus successfully demonstrated
complex repairs, mixing bolted
and bonded techniques

Non-structural repairs

For non-structural (cosmetic) repairs on the A350, High Speed Tape (HST) remains the most recommended and efficient way to release an aircraft back into service with the minimum of dispatch disturbance.

An HST repair (600 Flight Cycles) is a temporary repair and a permanent cosmetic repair that must be performed at the next maintenance check or scheduled stop.

Combining adhesive paste (EA9394 or EC2226), dry carbon fibre and lightning strike protection (Expanded Copper Foil - ECF), the quick permanent cosmetic repair can be performed in less than one hour, using a basic skills set, legacy materials and a new fast curing cycle at 100°C.

Structural repairs (fuselage)

For larger damages, a set of SRM temporary repairs has been developed using standard aluminium bolted doublers. A dedicated drilling device (CompDrill) has been certified by Airbus that permits safe drilling from the outside without needing any internal structure access, and avoiding the need for an NDT inspection after the drilling operation. Composite dedicated blind bolt fasteners (Composilock) are installed on the outside of the structure to ease the repair embodiment. Once the temporary grace period (3 years/3,600 Flight Cycles) is over, the conversion to a permanent repair consists of a pre-cured CFRP doubler (Airbus part) replacing the metallic temporary doubler.

Tooling and hardware

Dedicated tooling and hardware have been developed to enable safe and accurate repair. They are detailed in a list available for airlines and Maintenance Repair and Overhaul (MRO) organizations and include:

• A complete set of consumable materials in a kit format to simplify and ensure the availability at the customer's maintenance base location,

• Pre-cured parts (doublers, stiffeners, clips and shims),

• Special drills, fasteners, installation and removal tools needed to perform the repair.

The "COMPDRILL" kit commercialised by CAPAERO (France) is qualified and referenced in the Structure Repair Manual.

Example of standard pre-cured repair part (L-angle)
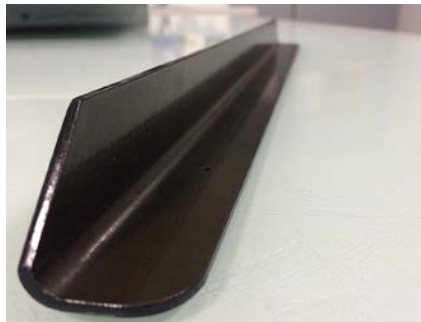
Composite Material Box providing all flyable and ancillary materials for a Quick Cosmetic Repair

Future developments

Launched in 2014 and currently being certified, a dedicated project aiming to qualify 'out-of-autoclave bonded repairs' will enable additional repair scenarios.
Full scale tests have been implemented and tested with success, using a 'CACRC (Civil Aviation Composite Repair Committee) prepreg' material with a 140°C cure cycle. The target entry-into-service of this alternative process is foreseen at the end of 2016.

CONCLUSION

The A350 has entered into service a year ago, and the solutions developed by Airbus on composite structure repairs have proven their efficiency. But this is not the end of the story.
Through an A350 dedicated team, Airbus is continuously developing new solutions to anticipate major damage, develop new repair processes and ease solution embodiment for A350 operators. ■

Virtual Reality & 3D for Technical Data

Digital Mock-Up (DMU) has gradually become generalized in aircraft design since the A380 programme. The investment in virtual 3D modelling has greatly benefitted downstream phases of the product lifecycle, including Technical Data.

At first glance you could be forgiven for thinking that the Technical Data team have offered themselves a "gamers paradise" - in fact the new Virtual Reality rooms created at Airbus plants in Toulouse and Saint-Nazaire, France, as well as Hamburg, Germany allow engineers to consult the DMU with an immersive Virtual Reality experience.

In the darkened rooms virtual 3D models are projected onto a full scale screen.
Wearing 3D glasses that include a unit which captures inertia, the perspective of the projected DMU display is recalculated in real-time, when the user changes position or tilts their head,

The viewer has the sensation of "entering" the virtual environment, and they can interact with the digital model, or even become part of the scene as an avatar artificial figure with human dimensions.

Known as RHEA (Realistic Human Ergonomic Analysis) this fascinating and virtually real experience exists to allow some very real benefits for engineers such as:

- Easier navigation around a virtual 3D aircraft towards the required information,

- Richer graphics that can display a technically complete and/or partially realistic view that can be manipulated by the user to consider different perspectives,

- Animated graphics to show the kinematics of mounting/dismounting maintenance procedures,

- An improved consistency of information with engineering design.
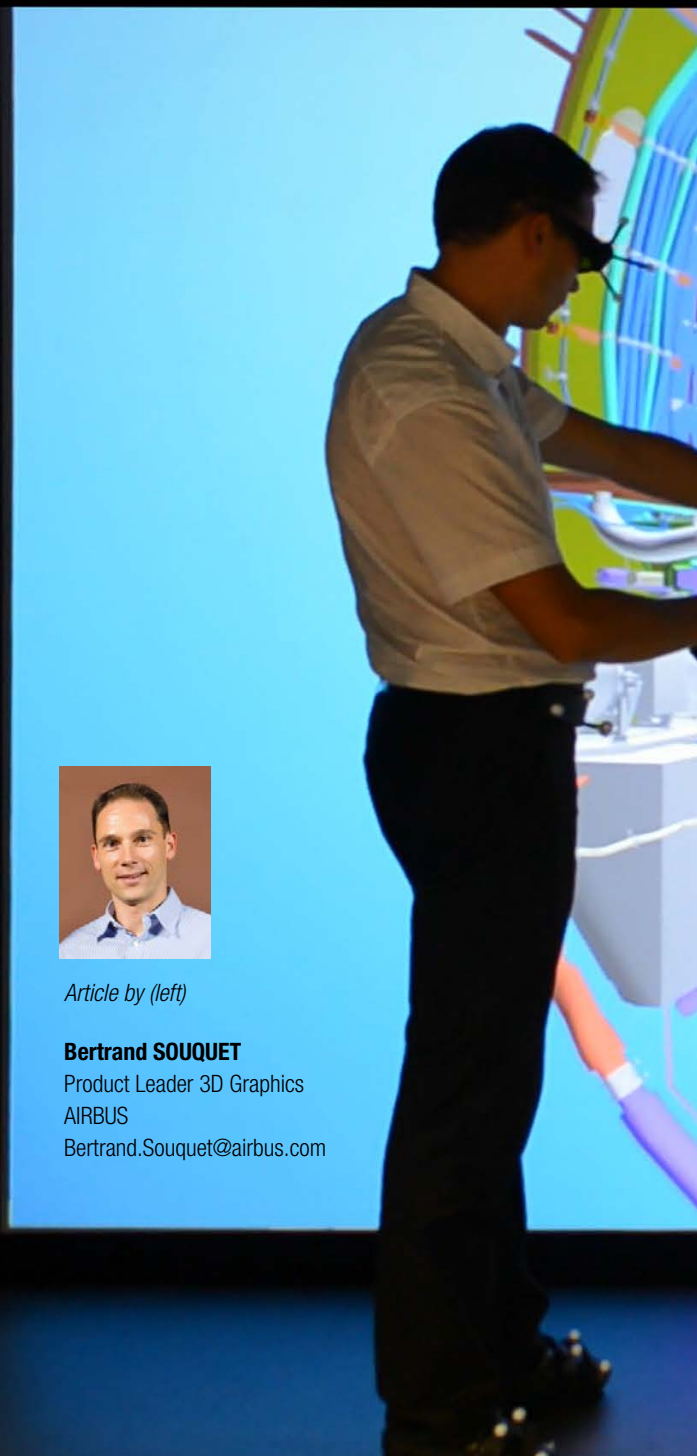
Article by (left)

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What is 'immersive' Virtual Reality?

Immersive Virtual Reality is a computer simulated environment that gives the user the feeling of being in that environment instead of the one they are actually in. A lot of video games have already developed the technology to put the user into an interactive world, such as the driver seat of a car, in the role of a soldier on a battle field or even in your own little world that you have built yourself.

Your perception is not altered, you are simply a spectator overseeing the events that are happening in that world. In order for your brain to perceive a virtual environment there are a few key factors that are vital for the creation of an immersive Virtual Reality experience. Although not necessary, one of the most popular ways to experience Virtual Reality is through a headset that uses stereoscopic display to give the impression of three-dimensional depth in a similar way to how each of our eyes combine and interpret visual information. This ability to present an image as 3D is part of the immersive experience, it is the tracking of your movement and recalculation of the perspective of the projected images that gives the user the impression of being inside this virtual environment.

Immersive Virtual Reality also needs to allow users to be able to freely move themselves within the 3D environment. It is this free movement in a virtual world that recalculates environment perspectives and rendering in real-time that gives users a perception of immersion.

Stimulating the senses

The ultimate aim of immersive Virtual Reality is to convince users that they are inside this make-believe world. To trick the mind, other sensorial stimulation can be used that corresponds with events happening in the visual environment. For example, in full flight simulators the visual projections are made increasingly real by adding hydraulic movement and audio stimulation.
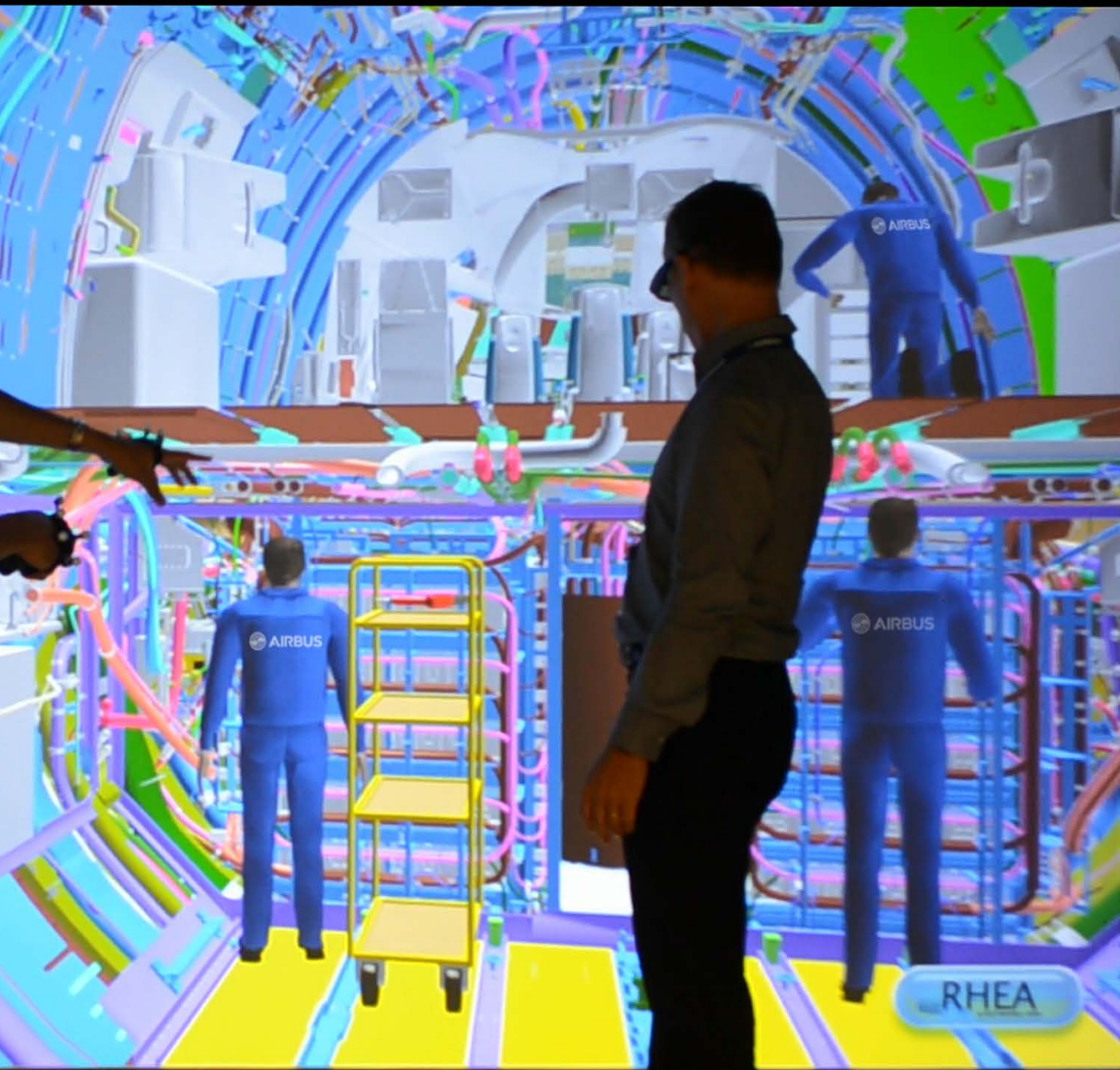
A350 XWB - principal beneficiary of the DMU

Airbus' latest programme was almost entirely digitally designed and as such has the most complete 3D technical data. The programme uses thousands of 3D graphics which complement or replace classical 2D illustrations.

3D products, in VRML format, produced by A350XWB Technical Data are:

- 3D zoning for navigation in AirN@v line maintenance,

- 3D animation for maintenance procedures,

- 3D interactive graphics, in replacement of CGM illustrations for:
  - Structural part identification in structural repair IPD,
  - Electrical harness installation in IPD ATA91,
  - Electrical harness routing and FINs location in AWD ATA91.

- 3D ESN (Electrical Structure Network) for ESN elements available on AirbusWorld:
  - CDIS with ESN-ELA (Electrical Load Analysis),

- 3D ARFC Aircraft Rescue and Fire Fighting Chart.

3D zoning

This is configured at MSN level (-900, -1000 management) and can isolate main zone, sub-zones and individual zones.

Data modules linked to zones are:

- Maintenance procedures,

- Maintenance IPD,

- Structural repair IPD,

- AWD ATA91.

3D animation

The main goal of 3D animation is to provide a quick review of maintenance tasks for better understanding.

3D animation explains the movements or orientations of components when text and illustrations cannot explain the actions sufficiently.

3D animation is not intended to replace the existing technical data deliverables (text and 2D illustration) but has to be considered as a complement to them.

3D avatar and symbols can be embedded to emphasize important messages, such as "warning", "caution", "torque", etc.

3D interactive graphics

These replace classical CGM illustrations, for:

- Structural part identification in Structural Repair IPD,

- Electrical harness installation in IPD ATA91,

- Electrical harness routing and FINs location in AWD ATA91.

3D parts are 'hot-spotted' to allow interactivity with the parts list.

A 3D simplified model of an aircraft section is displayed in translucent on top of the 3D parts in order to immediately localize their position in the aircraft.

A vectorial print of the view is possible.

Some graphics such as composite layers or thickness description are still delivered in classical 2D illustration (CGM format).

AWD - Aircraft Wiring Diagram
CDIS - located on AirbusWorld
CGM - Computer Graphics Metafile
FIN - Functional Item Number
IPD/IPC - Illustrated Parts Data/Catalogue
VRML - Virtual Reality Markup Language

A320neo use case

The advent of the neo (new engine option) has allowed the use of 3D VR in the A320 programme for design changes to the wing, engine, nacelle, pylon, etc.

In the scope of the aircraft's structure, maintenance, programme and definition, information was needed in order to:

1 Validate accessibility related to some of the structure maintenance tasks (corrosion and fatigue)

For example:

- Inspection of the engine pylon spigot receptacle without having to remove the pylon,

- Removal of impractical access from maintenance tasks.

2 Challenge heavy maintenance tasks (e.g. engine removal)

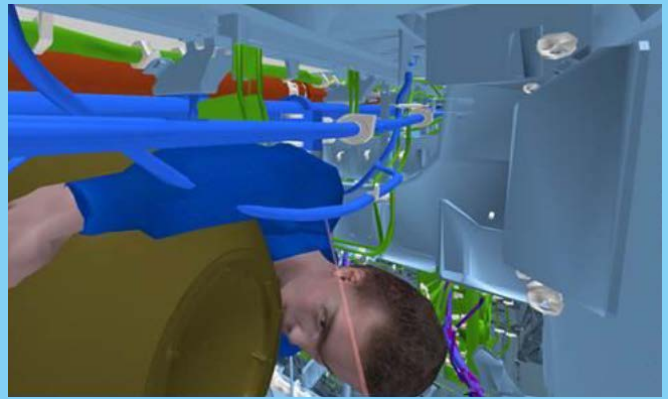For example:

- Is it mandatory to remove the engine in order to perform the fatigue Rototest* inspection of the lateral panels?
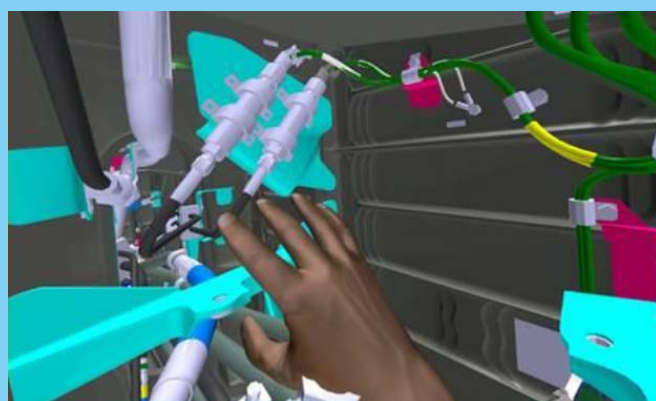
The information supplied by 3D VR calculation allowed the design team to:

- Define the type of inspection (e.g. visual, detailed, special detailed),

- Define the access required to perform structure maintenance tasks,

- Define the task threshold and intervals (only for corrosion, fatigue calculations which are performed by the Stress office).

The task data was communicated to Aircraft Maintenance Manual (AMM) team members who are responsible for writing inspection procedures.

A navigation remote control and a representation of a human hand, allow users to project themselves into the Digital Mock-Up and act on the models to check for ease of access.

* Rototest: inspection tool with a rotative probe
  for testing holes with the eddy current method.

VR calculations found that Polar End Caps could be accessed and replaced without removing the potable water tanks from the aircraft.

A380 use case

A380 aircraft have experienced leaking O-rings on the Polar End Cap (PEC) of potable water tanks. VR was used to review the AMM tasks for their replacement.

Most Polar End Caps are accessible from maintenance panels or decompression panels without the need to remove the tank.

However, confirmation was needed that the O-rings could be replaced without having to remove the tanks located behind the Lower Deck Cabin Crew Rest Compartment, which has particularly confined access.

VR established that the optimal way of replacing the O-rings was to slightly move the tanks from their initial position to provide access to the leaking outboard PECs. It was also calculated that two working shifts with two mechanics would be necessary for this task.

This access check was based on assumptions that the removal is performed by a person of small stature and that a specially designed tool is available.

ARFC 3D (Aircraft Rescue and Fire Fighting Chart)

A recent example of the use of 3D is the A350 ARFC 3D (Aircraft Rescue and Fire Fighting Chart) published on AirbusWorld.

The purpose of the ARFC is to provide rescue personnel with relevant information on the aircraft so that firefighters can evacuate passengers and crew as quickly as possible.

This complements the ARFC, which is currently in poster form and as 2D illustrations incorporated in the Aircraft Characteristics manual.

3m
(9,84 ft)
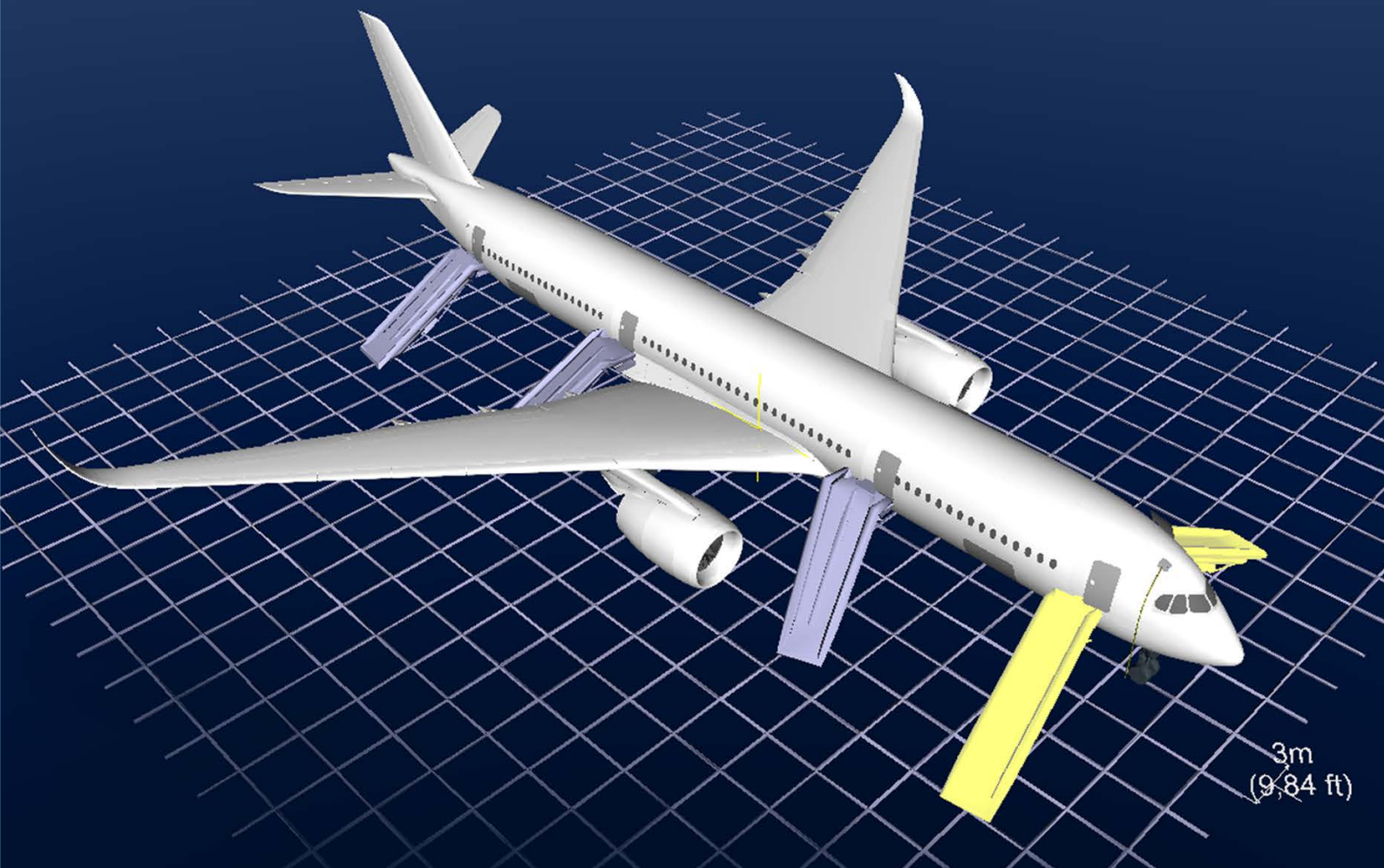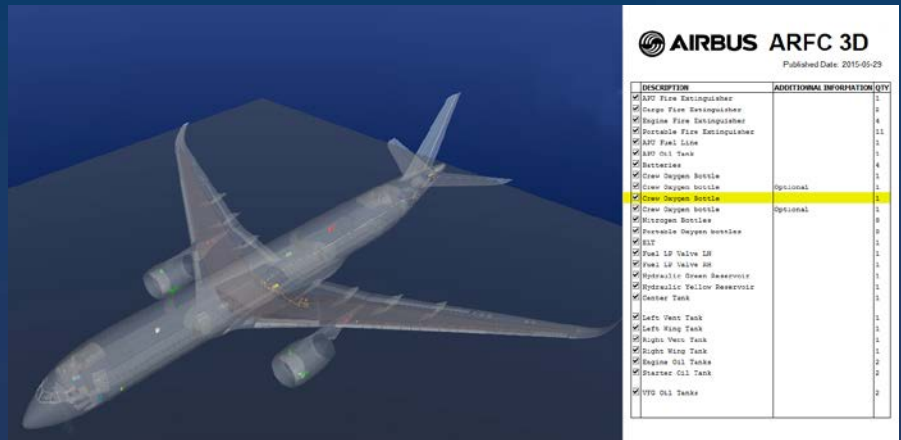
CONCLUSION

One of the intentions of Technical Data is to provide efficient visualization of textual information. Design data from the Digital Mock-Up, can now be converted into 3D interactive graphics that offer capabilities for a richer, navigable experience that simplifies the understanding of technical content.

Augmented Reality in Airbus

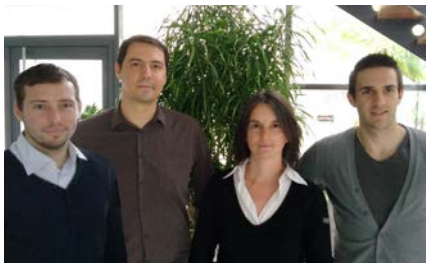## New opportunities to assist aircraft maintenance and engineering

Article by (left to right)

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Augmented Reality (AR) is a field of technologies that improves a user's situational awareness by bringing them relevant contextual digital information in a suitable format and time frame. Unlike Virtual Reality, which is entirely based on a simulated world, AR roots are the real world, which is then mixed with a numerical world.

AR can result in time, cost and energy savings; for example, natural, dynamic, step-by-step visualisations of complex processes can lead to fewer errors and better task comprehension and execution. For these reasons, Airbus is considering the deployment of AR systems that are finely-tuned to specific identified uses and which are compliant with aeronautical industry requirements.

Several Airbus Group teams are working together to design, assess and deploy concrete AR solutions and support various internal initiatives. In the research entity Airbus Group Innovations (AGI), a dedicated team is exploring uses and suitable algorithms. They are working closely with ProtoSpace, the Airbus project catalyzer environment inspired by Fablabs, which is deeply involved in that domain and focused on both technology assessment and rapid knowledge acquisition. Studies for Airbus Customer Services are conducted by the @MOST Research & Technology project, converting the experiences into solutions that pave the way for implementation with the business. Following the successful deployment of AR technologies in Airbus manufacturing, other domains have become candidates: Airbus Customer Services is among them.

Definition

The term "Augmented Reality" was introduced by an aeronautic engineer in early 1990s.
The foundations of this technology field started in the 1960s with the elaboration of the first rudimentary, experimental see-through displays, superimposing digital images on top of the user's field of view.
Nevertheless, although AR is often limited to a visual context, it is in fact much more than that, as it includes all other human perception modalities of hearing, touch, smell, etc.

The definition given by Sébastien BOTTECHIA in 2010 takes into account this multidimensional aspect of AR: *"It is a combination between the physical space and the numerical space in a semantically linked context".*

In other words, it is a system that enriches users' natural perception of their surroundings by overlaying digital information in an suitable format that is linked to it, in real time. This process aims at "augmenting" the limited human perception through access to relevant numerical data, which is not naturally available in the environment: the term "Augmented Perception" would be actually more appropriate to designate this domain.

Architecture

Major components of an AR system are:
• Sensors collecting data about the near user environment > context recognition,
• Means to compute input and output data > data integration,
• Interfaces to bring the information to the user and eventually enable interaction > data communication.

A simple example of an AR system is the radar-assisted parking technology that is fitted into the rear bumpers of some cars. The driver's natural field of view behind the car is limited by the structure.
As a consequence, some parking manoeuvres are not easy. So, some car manufacturers have put sensors in the rear bumpers to collect distance data in real-time. This data is then processed, integrated and translated into exploitable information, and communicated via different interfaces (sound, display, vibration): drivers know the distance to impact through their augmented perception of the current situation.
Thanks to this system, parking becomes easier, quicker and safer.
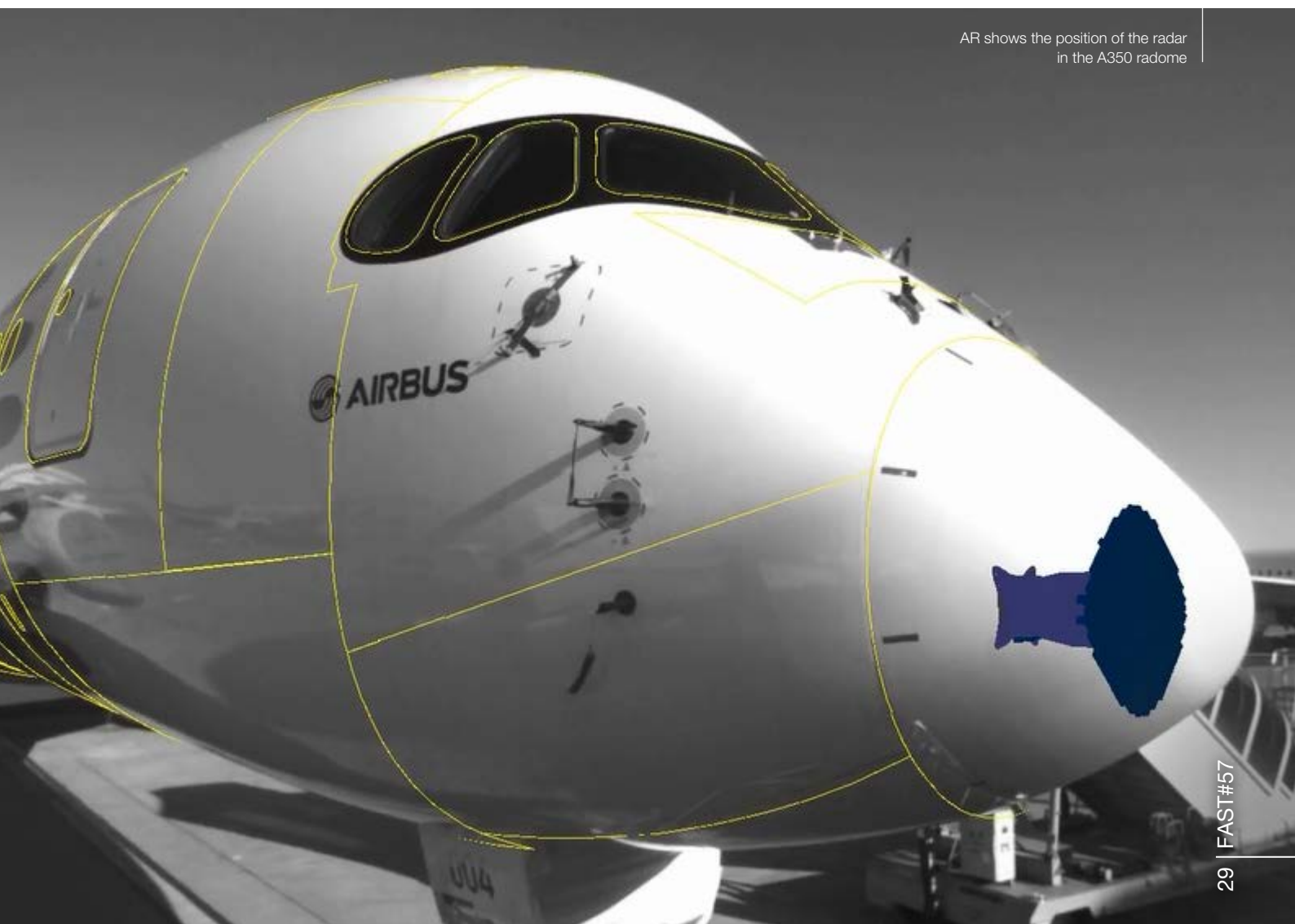
AR shows the position of the radar in the A350 radome

Augmented Reality in aeronautics

AR has been known in aeronautics from the 1970s with the development of Head Up Displays (HUD - see FAST 56). It is a system enabling pilots to access relevant information in their direct line of sight when looking through the windshield. Using it, they can pilot the aircraft without looking away from their focal point (runway, other aircraft, etc.), and still collect external environment information. Developed for air-to-air combat operations in which pilots had trouble switching between internal instrument and external view, such systems have also proved beneficial for commercial operations.

Based on progress in the digital industry democratizing high technology (such as, increases in processing capability, ever-shrinking hardware, more efficient batteries, improvements in the ratios of cost-performance in optics and electronics components, etc.), new ways to design and use AR systems can now be considered. For example, the automotive industry is currently trying to develop HUD systems that fit industry constraints (cost, layout, etc.).

Such technologies can now be applied at the scale of individuals in aeronautics such as workers on the Final Assembly Line, engineers, mechanics or pilots.

This industry, which requires extensive know-how and relies on man-based processes, is conducive to deploying AR technologies. Indeed, systems are increasingly complex while design and training phases are becoming shorter and shorter. Easier, faster and safer operations, that capitalize on available big data and potentially lead to time, cost and energy savings are key differentiators in this very competitive environment.

AR is one of several solutions that can open new perspectives especially for the manufacturing and maintenance of a product which requires the highest quality standards possible. Mobile, light and inexpensive technologies will enable people to connect and access relevant 'big data', accessing relevant digital content on-demand to perform their daily jobs.

Head-Up Displays allow pilots to access relevant information in their direct line of sight

Design criteria: the example of Google Glass®

AR systems are by definition intrusive, impacting the user's perception of the environment. A fine balance needs to be found between the various design criteria: technology, use and user, that allow the benefits of AR without potential negative effects (disturbing the user's environment, too complex, etc.). Each time one of the criteria changes, the global balance has to be reconsidered. This explains why there are currently no standard mass-market AR solutions available that are powerful and versatile enough to satisfy the varying needs and wishes of all users at the same time.

The best recent example illustrating this complexity is the programme "Glass®", launched in test phase in April 2012 by Google®. Google® designed a semi-autonomous system (coupled with a smartphone or computer) embedded in a single arm of a pair of glasses. It includes sensors (camera, Inertial Measurement Unit), computing means (processing units, storage, and battery) and an interface (a transparent screen adding digital images on the top right of the user's field of view).

Google Glass® was presented as the future mass-market AR connected mobile electronic device for everyday use. In 2015, after an initial positive welcome from the public and several test phases, the Google Glass® project was not launched as a general release product, having been paralysed by the gap between user expectations and technology capabilities as well as social and human factors issues (privacy, self-image, distraction, limited autonomy, etc.). Google® is no longer targeting a public release for Glass®, but the company now appears to be developing for specific professional uses.

Indeed, professionals are very interested in the benefits that this type of technology can bring because the industrial environment makes it a relevant candidate for initial deployment. Tasks and processes can be precisely studied and controlled, and users can be specifically chosen and trained, overcoming the issue of variability. Microsoft® were quick to understand this when developing its new product HoloLens®, which introduces a new generation of mobile smart devices and opens new perspectives for applications compared to previous solutions (thanks to the integration of new technologies and its intrinsic ergonomic qualities).

All the various devices, technologies, algorithms and uses are constantly evaluated in Airbus: first in Airbus Group Innovations and ProtoSpace centres to learn and acquire the technological experience required for potential future deployment, then in close collaboration with the various Airbus business experts. Specific developments are then undertaken and the teams iterate towards an industrial solution.

Comparitive analysis: Google Glass® vs Microsoft HoloLens®

Google's Glass® (2012 edition) is a semi-autonomous system (coupled with a smartphone or computer) embedded into a single arm of a pair of glasses, running the mobile Android OS. Its hardware architecture is limited by its minimalist design, which nevertheless allows ergonomic qualities. It includes a full pack of sensors (camera, Inertial Measurement Unit), computing means (processing units, storage, and battery) and a transparent screen displaying digital images on the top right of the user's field of view (monocular – no 3D). Interactions are based on a small touch area on the side of the glass. The limited capacities of the device and the screen interface type make it very well adapted for the display of simple as-and-when needed notifications (pop up mode). It is not adapted to display complex information and is not ideal for prolonged use (forces users to focus unnaturally with one eye to the top right).

Integrates digital notification to the user's perception of the environment.

Microsoft® refers to HoloLens® as the first untethered holographic computer. It is a fully autonomous augmented reality headgear, that hosts computer-class components and runs Windows 10 (an AR specific version). Easily settable, well balanced and quickly removable, Hololens® integrates advanced sensors allowing very precise tracking of the user in their surroundings. Two high definition transparent screens in front of each eye, display digital images in the user's natural field of view, in 3D, overlaid on top of the "real" world. The advanced integrated tracking and scanning capabilities, very powerful architecture, binaural sound system and display performances enable digital artefacts to be seamlessly integrated with the environment, to interact with it and be perceived by the user almost as non-digital. Interactions are based on natural gestures (head, hand) and voice.

Integrates digital objects, that are perceived and behave almost as if they were real in the user's perception of the environment.

See instructions on page 2
to see the cover of this magazine
'augmented' by a 3D A380 aircraft.

Users and uses

One of the latest Airbus successes comes from integrated teams from AGI and manufacturing centres who developed and deployed MiRA, an AR based application. This application for the inspection of Airbus aircraft elements superimposes a corresponding digital version onto the real installation (thanks to a camera based calibration process). MiRA, deployed since 2011 and commercialized outside of Airbus by Testia (an Airbus subsidiary), is used by 600 engineers to ease inspection tasks at Airbus plants. Used with tablets, the application will soon be available in a projection version for installation support, giving access to step-by-step instructions directly projected onto real parts.

Glasses-based AR applications which significantly reduce task lead time are also to be deployed for seat installation setup. This time reduction greatly improves working conditions for technicians that have to kneel to prepare floor brackets. The glasses automatically provide them with real-time distance information thanks to a connection with a laser that is synchronized with the aircraft plan. This also allows them to perform their operation hands-free.

Increasing aircraft availability

The large increases in passenger traffic over recent years makes aircraft availability one of the major challenges faced by airlines. Each minute the aircraft is on the ground is considered counter-productive: reducing aircraft immobilization during maintenance activities has become a high priority for airlines.

To help airlines achieve these objectives, Airbus is prototyping AR systems to provide maintenance operators with mobile and real-time functionalities that simplify and accelerate their activities. One particular time-saving functionality is the capability to guide operators through the various aircraft zones, automatically optimizing their path. No time is lost searching for the right aircraft area or access, and users are guided straight to the next step of the process, depending on their position.

Another tested functionality aims at precisely locating and visualizing components that are not directly visible (under various layers of structures or systems). Given the thousands of components in an aircraft, locating and identifying the correct one to test, then fixing or replacing, are time-consuming recurrent issues for maintenance operators.

Another AR function currently being investigated is to superimpose digital information of the correct process needed to perform a task, directly onto the concerned part and based on existing documentation (AMM, IPC etc.). This visual technical demonstration could also be explained with a voiceover that the user can fully control.
Added to the benefits of a guided, hands-free operation, the operator would also be able to give input and provide notes on the task performed directly digitalized and stored through the AR interface.

This has led to the exploration of systems that enable operators in the field to reach any expert in the world, show them the situation in detail and get their informed recommendations. This is a reassuring AR solution that will drastically improve remote operations and many more use cases are currently being considered in various areas.

Airbus teams are testing and prototyping
various types of AR systems taking into account
the end-user and its environment.

AMM - Aircraft Maintenance Manual
IPC - Illustrated Parts Catalogue
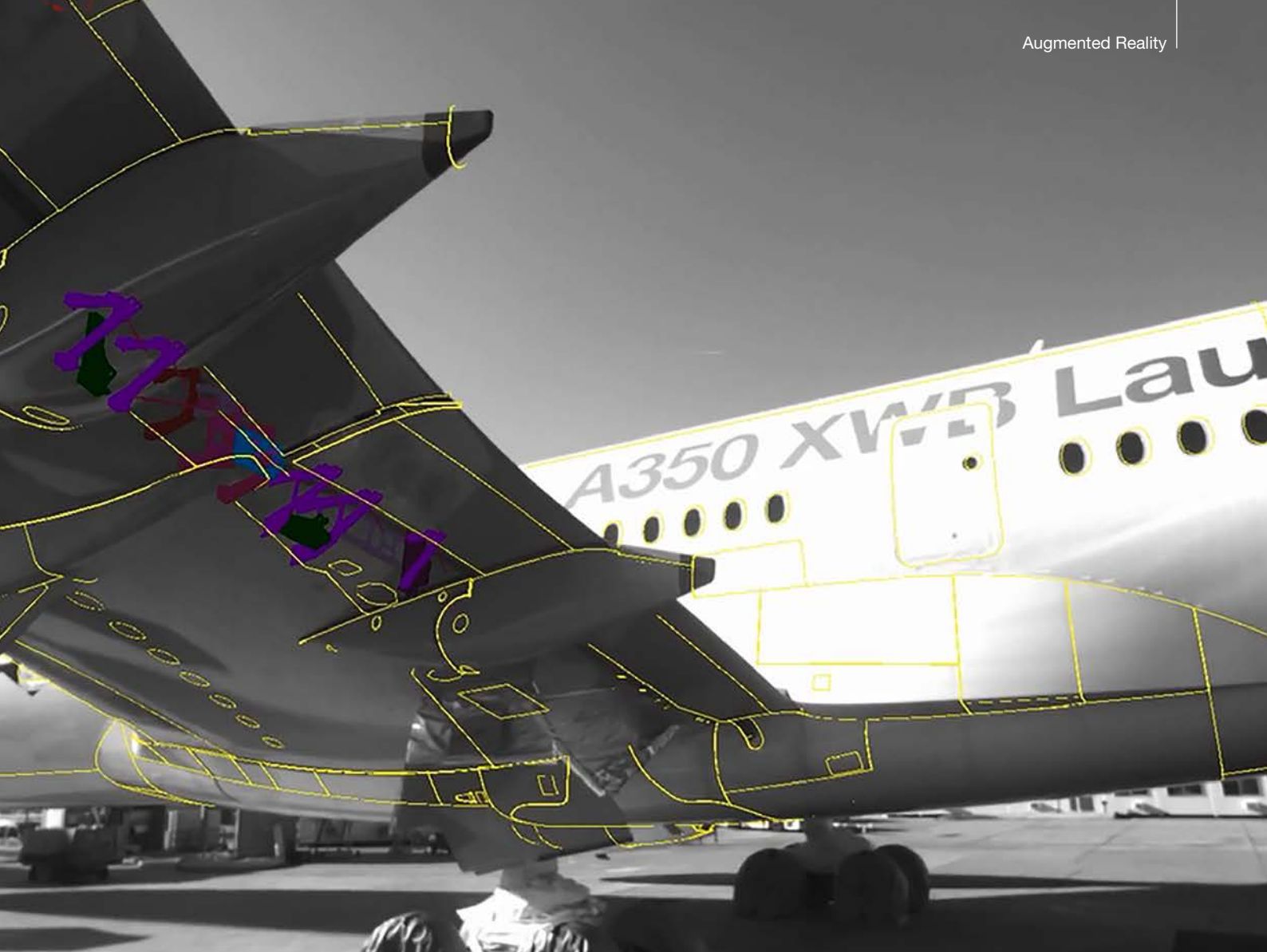
CONCLUSION

Today, Augmented Reality technologies are at a decisive point where progresses are increasingly meeting user expectations within the framework of the aeronautical industry. This progress corresponds with the developing capacities of current technology.

Airbus' permanently growing experience in this field, based on robust research by Airbus Group Innovations and practical knowledge acquisition by ProtoSpace, has resulted in increased benefits for business testing, adapting and applying preliminary solutions. Simulations show that the added value of AR deployment increases compared to Non-Recurring Costs (NRC).

The use of AR, which will significantly impact ways of working, is not only interesting for Airbus, but for airlines, Maintenance Repair and Overhaul (MRO) organizations and other new maintenance services too.

Conscious of this pool of improvement, Airbus continues to push the boundaries of technology via discussion, test and collaboration with the world's best AR players. The opportunities to increase the efficiency of maintenance are encouraged by previous successes such as the MiRA project or the Final Assembly Line seat installation concept.

Nevertheless, the maturity of current development has to be proved in an operational context. This is why Airbus, through its ProtoSpace centres that link between research, technology, business across the divisions, as well as the various industrial internal and external stakeholders around the world, is:

• Preparing a transition phase to a new philosophy through internal rapid experience acquisition,

• Building a global vision instead of case-by-case successes, spreading its know-how,

• Taking the human factor and operational context into serious consideration during development.

The comprehensive command of Augmented Reality and the rapid integration of this knowledge into deployable and scalable solutions, will enable Airbus to find new solutions to facilitate and accelerate airlines' operational activities.

Configuration management

Article by

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The efficient way to simplify Service Bulletins

It took 15 years working in the aeronautical Customer Services environment, dealing with Service Bulletins every day, before I performed an internet search to discover more about this technical publication which is well-known for any aircraft engineer.

My attention was immediately drawn by the first "hit" displaying a fascinating question: "What is a service bulletin in aviation". The answer was a surprisingly uninformative: "A Service Bulletin in aviation is the same as a Service Bulletin in any other field".

The aviation industry, in both civil and military sectors, produces thousands of Service Bulletins every year, to improve the original aircraft design, correct issues in service or introduce customer originating aircraft conversions by modification. Service Bulletins can be found on the internet for almost every conceivable product we buy (cars, electrical appliances, pinball machines...). All Service Bulletins share a certain degree of commonality with those in aviation - they give detailed instructions and provide illustrations for ease of understanding.

Airbus Service Bulletin effectivity

Airbus released the first Service Bulletin in 1974, only a few months after delivery of the first A300, to improve engine vibration detection circuits. Since this first publication, 15,000 Service Bulletins applicable to a total of almost 7 million individual aircraft Manufacturer Serial Number (MSN) items have been produced.

In the graph below, each dot is a Service Bulletin dispatched since 1997, with the number of aircraft MSN covered in effectivity on the vertical axis. Service Bulletins are not necessarily applicable for the whole in-service fleet; however clouds of dots clearly follow the growth of the fleet for each aircraft family.

Service Bulletin effectivity

A300/A310   A320 Family   A330/A340   A380
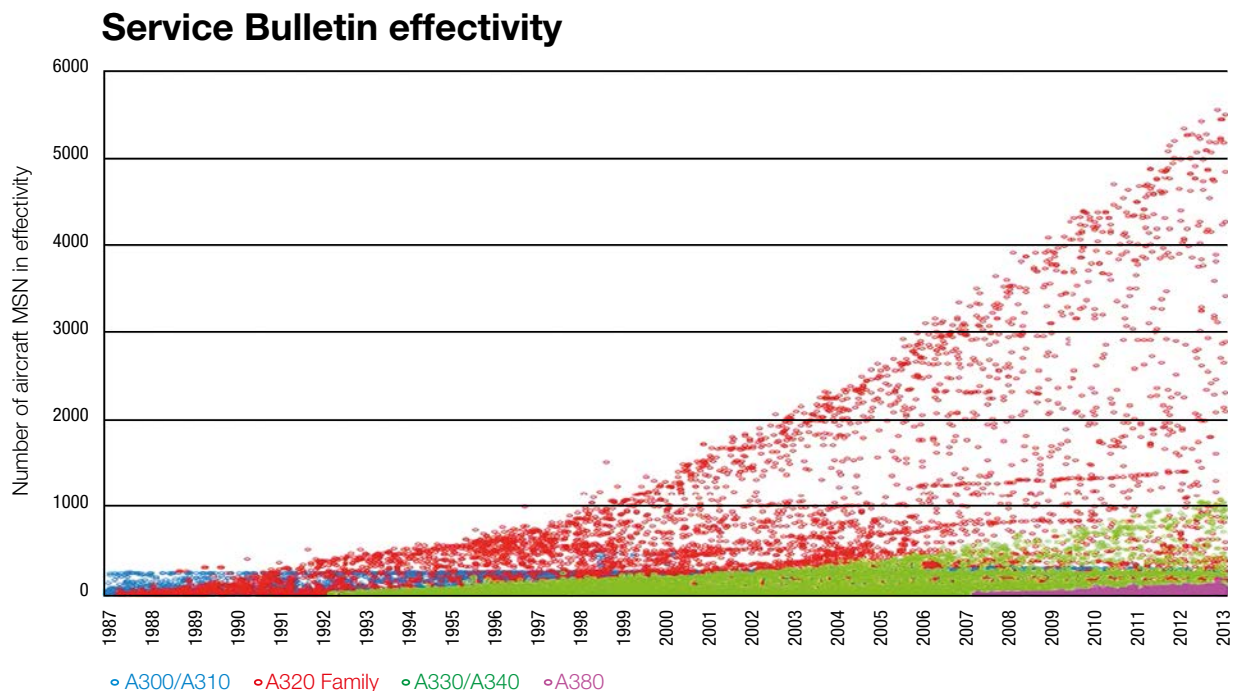
Service Bulletins in aviation can be described in different ways depending on the user's views. They are primarily technical, detailing inspections or changes to the aircraft type design through a set of approved instructions. Service Bulletins also describe the benefits and the repercussions associated with the implementation action and provide commercial, operational and contextual data for decision makers. Last but not least, accomplished Service Bulletins are reported by operators, guaranteeing the continuity of in-service aircraft configuration management.

**What is configuration management applied to Airbus Service Bulletins?**

While a novice will depict an aircraft as a cylinder fitted with wings and engines, an aircraft configuration manager will see an individual aircraft as a large stack of modification numbers characterizing its exact technical definition status. Modification stacking is indeed the fundamental principle in configuration management.

Each aircraft evolution by modification stacks on top of the previous modification. The last post-modification status serves as the pre-modification basis for the next modification of the stack.

When an aircraft is delivered, Airbus provides operators with an aircraft inspection report (AIR) of the recorded modification stack for the given aircraft. This list of modifications is made up from the initial set of modifications necessary to achieve aircraft Type Certification and of additional standard modifications introduced as product improvement through later evolutions of the aircraft standard. Optional modifications chosen by the customer can also be added as the result of the aircraft customization process.

Service Bulletins cover the embodiment of retrofitable modifications after aircraft delivery. Hence, Service Bulletins follow the same "modification stack-up" principle and link up with the previous Service Bulletin of the stack. The illustration below shows this principle.

Aircraft modification stack-up management principle
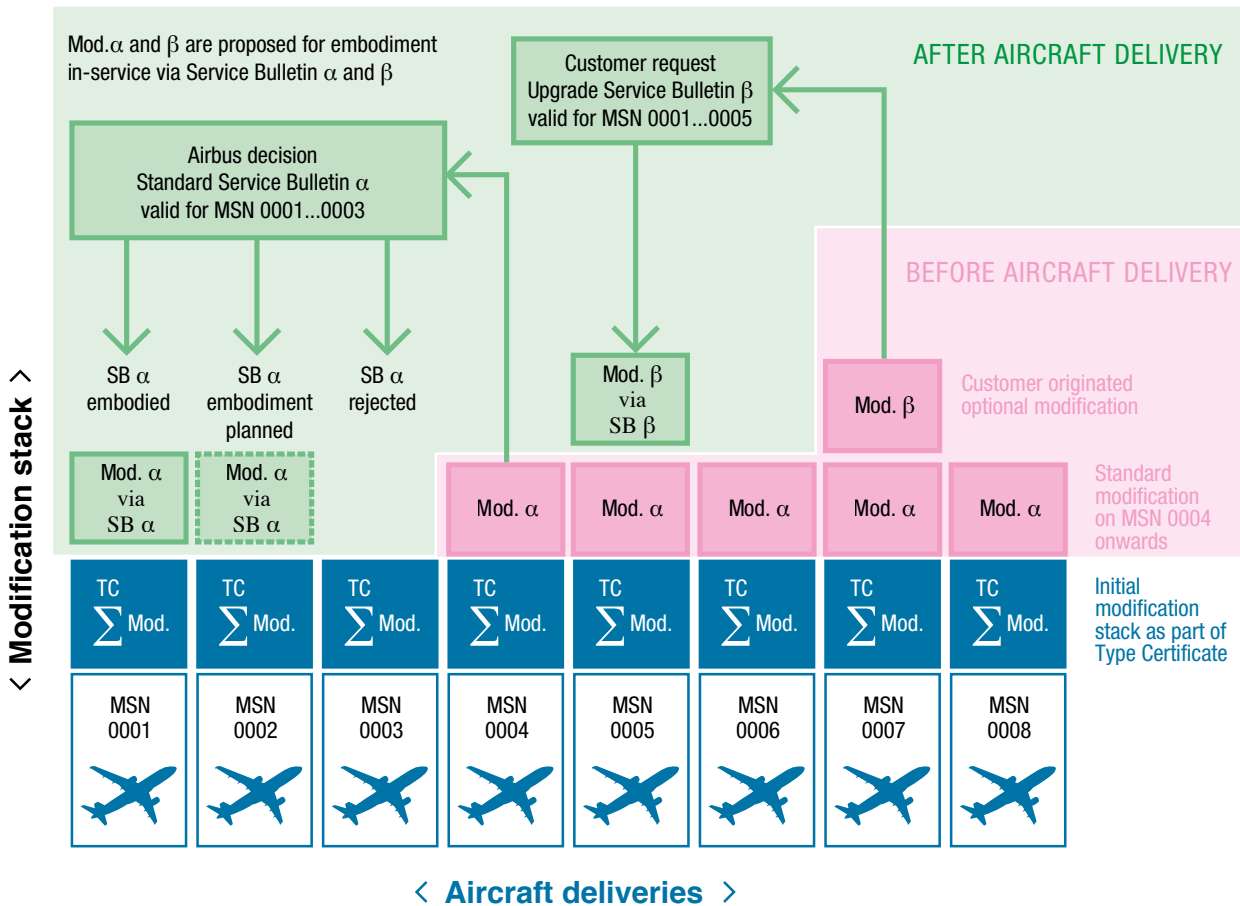
Evolutions of the modification stack are recorded at Airbus for each in-service aircraft based upon operator reporting Service Bulletin embodiment status. This data is the primary source for customization of technical and operational documentation. It also defines the pre-modification status for each aircraft MSN in the effectivity of a later Airbus Service Bulletin.

Why configuration management improves Airbus Service Bulletins?

Aircraft MSN with the same modification stack, are managed in a similar way, allowing cluster groups of MSNs under specific Service Bulletin configurations. Configuring Service Bulletins results in a higher level of technical accuracy by defining pre and post-modification status and enabling appropriate detailed instructions for a given configuration.
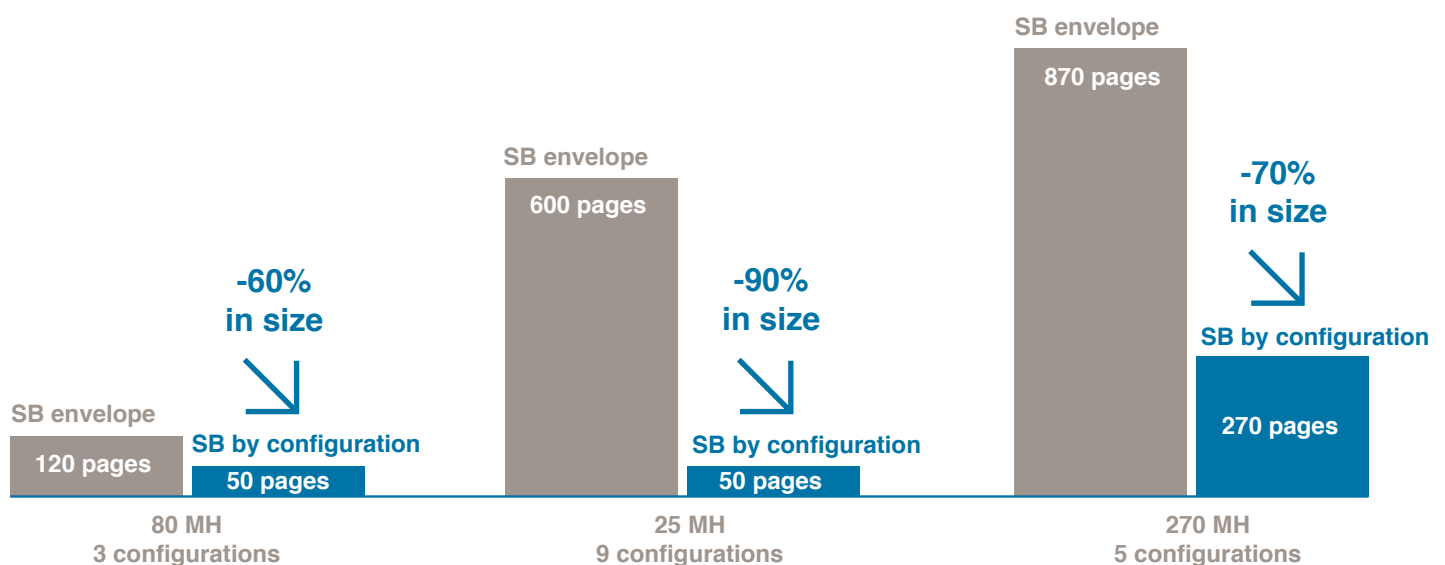
With configuration management, the content of Airbus Service Bulletins is not necessarily proportional to the amount of aircraft MSN included in the effectivity of the document. As the effectivity of Service Bulletins generally covers a large range of aircraft MSN, configuration management is used to simplify the content by grouping aircraft MSN in a configuration* where the technical solution is identical and the same technical instructions can be followed.

Configuration management avoids duplication of technical content and significantly reduces the length of Service Bulletins.

Producing service instructions for airline mechanics is a time-consuming exercise, especially for complex Service Bulletins. To save airline resources a solution known as SB+ was developed to reduce the time required to process and access Service Bulletin data (for more details contact: sbplus.services@airbus.com):

- Service Bulletins can be customised by configuration management. For example, by MSN or a set of MSN which use the standard filtering function in AirN@v Engineering.

The benefits in terms of reduction of content size can be significant as shown in the example below.

SB envelope 120 pages	**SB envelope** 600 pages	**SB envelope** 870 pages
-60% in size ↘	**-90% in size** ↘	**-70% in size** ↘
SB by configuration 50 pages	**SB by configuration** 50 pages	**SB by configuration** 270 pages
80 MH **3 configurations**	**25 MH** **9 configurations**	**270 MH** **5 configurations**

In both cases the reduction of the Service Bulletin content is achieved by using appropriate functions to display the applicable work instructions for one or several of the configurations defined in the Service Bulletin.

* other criteria exist such as aircraft type, weight & balance, etc.

CONCLUSION

Configuration management based on the 'Modification stack up' principle is a powerful tool deployed by Airbus to manage and record the detailed technical definition of each aircraft MSN, both before and after its delivery. Airbus Service Bulletins fully use this principle to ensure the most complete and accurate technical solutions are provided to customers. With configuration management, Service Bulletins are simpler and easier to understand allowing airlines' engineering to save resources and Airbus to offer more services to operators. ▬

FAST from the PAST

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

Not so long ago the time taken for turn-around was not calculated into the profitability of airline operations and the ground service was... rudimentary.

Stewards assisted their glamorous passengers as they clambered up the rungs of a ladder to board their aircraft, while engineers refuelled by rolling in barrels on rails and filling by hand-pump.

Destination and take-off times were carefully chalked onto a departure board attached to the aircraft.

Today, aircraft carry a hundred times more passengers, and cost infinitely more. Every second on the ground is a second that the aircraft is not paying for itself. Which is why each ground operation is followed and optimized to minimize the time on-ground and maximize passenger comfort (see article on page 4).
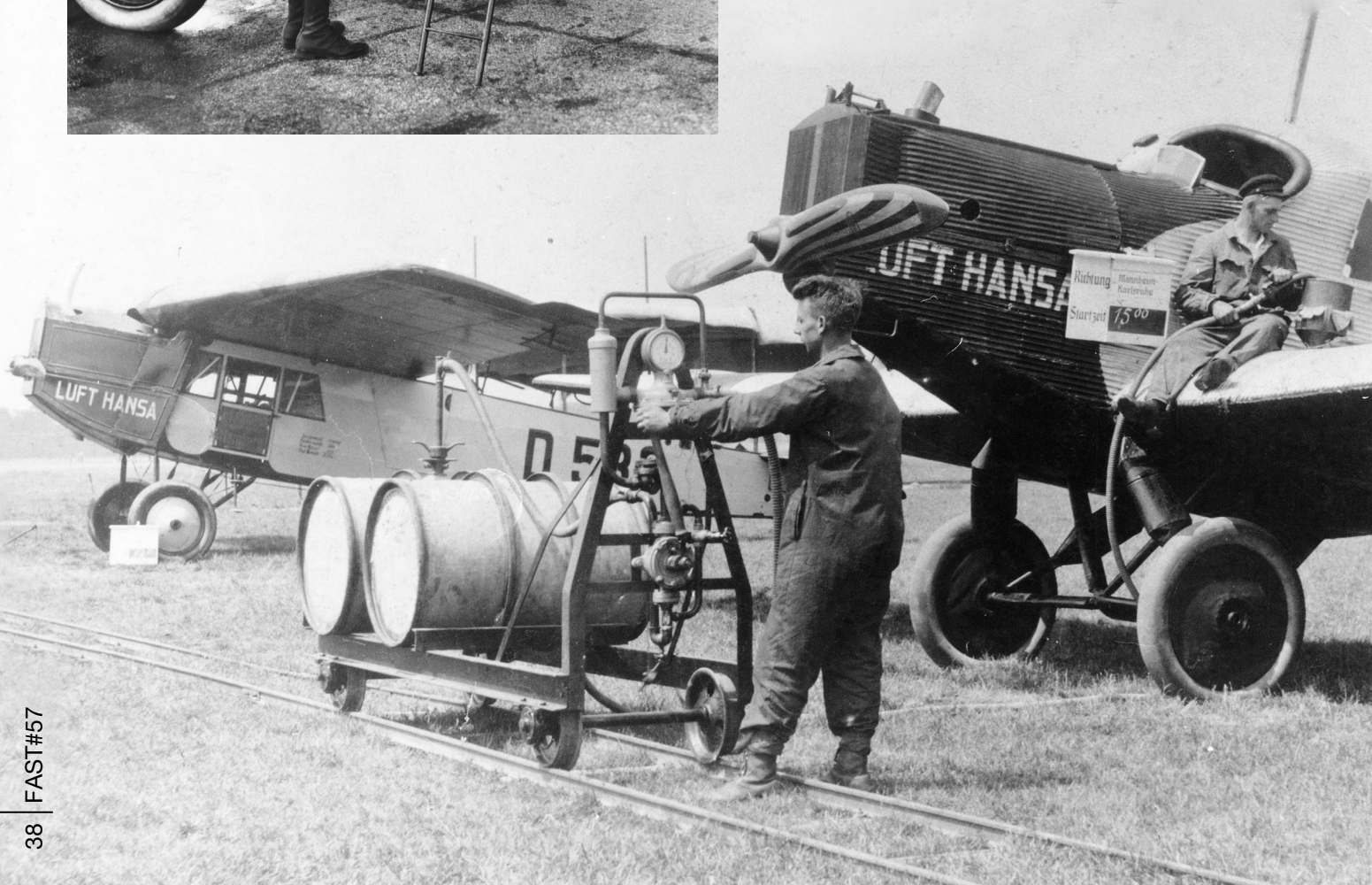
We've got it covered

Around the clock, around the world,
Airbus has more than 240 field representatives
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