Life after first flight

Aerospace Testing International

Flight testing of the new Airbus A350 XWB is underway in France – what flight progress has been made since the aircraft first flew in June 2013?

By the beginning of December, the first two (of five) Airbus A350 XWB (eXtra Wide Body) test aircraft was expected to have logged more than 600 flight hours (FH) in more than 120 flights since the type's June 14 maiden flight at the manufacturer's Toulouse factory. The lead aircraft – manufacturer's serial number (MSN) 001 – had recorded almost 460 FH in 95 flights by November 20, while MSN003 (the second A350 to fly, on October 14) was close to 140 FH in 25 flights, according to Airbus.

The manufacturer is aiming to obtain airworthiness approval (type certification) in time for entry into service in September 2014. Final assembly of MSN005, the last test aircraft, began on November 4, following arrival of its three main fuselage sections in Toulouse four days earlier.

The A350 XWB twin-aisle twinjet family comprises three models, with a possible fourth extra-long variant a distinct possibility, according to program officials. The family will offer capacity between 270 and a potential 400+ passengers in typical cabin configurations. New business announced at November's Dubai Air Show brought firm orders for the A350-800, -900 and -1000 versions to 764 from 39 customers.

Critical phase

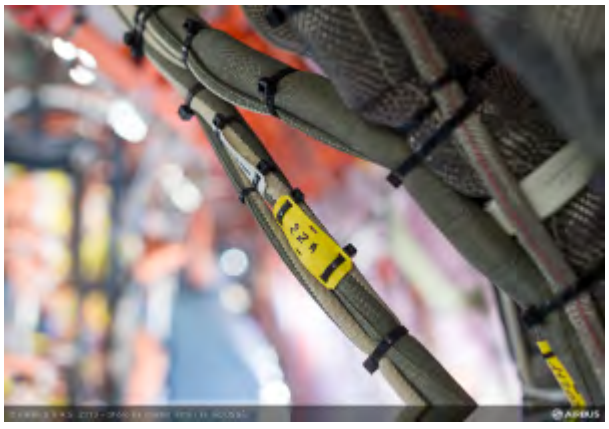
Reiterating the words of Tom Enders, chief executive of Airbus's parent company, European Aeronautic Defence and Space (EADS), executive vice president and A350 program head Didier Evrard says, "Airbus is now entering the most critical phase," one that contains "new challenges". In a first phase of testing, which saw MSN001 accrue nearly 100 FH in the first month of flying before it went in for routine maintenance in July, the A350 was flown by 10 Airbus test pilots involved in assessing handling qualities and behavior, which quickly resulted in clearance of the new aircraft's entire flight envelope.

“We have done a lot of tests. There was a four-week interruption while we upgraded flight test instrumentation. We have done really well with flight tests, and in the first phase we have gathered a lot of information,” says Evrard. Initial testing of key systems covered engines, electrics, ram-air turbine, fuel, cabin pressurization, and landing gear and braking, as well as a preliminary consideration of the autopilot and auto-land functions. During maintenance, the A350’s flight test instruments were upgraded for the second phase, which started in August 2013, while the Airbus design team analyzed the initial test results.

Also in July, Airbus performed a ‘real virtual’ test on the A350 verification and validation platform at its Hamburg factory, as it sought to ensure early maturation of MSN002. This five-hour ‘flight’ involved simulated boarding of 10 flight and cabin crew, plus 129 passengers, for a flight from the Canary Islands to Germany.

The first two flying A350s are scheduled to be joined by MSN002 and MSN004 in February 2014, with final test machine MSN005 following three months later, according to Airbus experimental test pilot Hugues van der Stichel. Providing a flight test update in late October, he reported that MSN001 had completed aero clean and landing configuration, aero identification, clean flights, and air brakes setting. The A350 had performed an automatic landing as early as its fourth flight.

As the manufacturer extended the A350’s flight envelope, operations using basic – or ‘normal’ – flight-control laws were cleared to FL 430. Anti-skid and maximum-torque braking, using all available capability, were also demonstrated, along with landing gear emergency free-fall in the air (following initial ground demonstration with the aircraft standing on jacks). Other achievements involved systems testing (including failure cases) and in-flight ram-air turbine extension, which permits electrical power to be generated from the outside airflow in the event of loss of onboard generation.



VMU testing

Demonstration of the A350’s minimum lift-off, or ‘unstick’, speed (known as Velocity, minimum unstick (Vmu)) on the new jetliner’s 57th flight in late September confirmed the optimum flap setting for take-off, showing that the aircraft is not stall limited, according to van der Stichel. The Vmu testing was conducted on the very long, 3.86km (12,660ft) runway at Châlons Vatry

Airport in northeastern France. Van der Stichel declined to quote actual speeds, saying that engineers were still analyzing data.

Vmu tests, which were introduced after two early-1950s de Havilland Comet accidents that were attributed to over-rotation on take-off, are conducted with a hardwood-block buffer attached to the underside of the rear fuselage to prevent structural damage. The Comet had a wing aerofoil section that suffered from reduced lift at high angles-of-attack (or 'alpha', the angle between the aerofoil chord line and the relative airflow), before introduction of both a modified leading-edge profile and airworthiness regulations aimed at making over-rotation impossible.

During Vmu demonstration, the aircraft's nose is raised until sufficient lift has been generated for the landing gear to leave the ground with the solid buffer scraping the runway. Van der Stichel concedes that Airbus had been surprised at how much buffer material had been eroded in equivalent testing of the A380; during that flight test campaign the A380's fuselage skin had touched the runway – something that Airbus had been keen to avoid repeating, as valuable A350 flight test time would have been lost while repairs were completed. Another thing to be avoided during such testing is the risk of over-rotating about the tail damper (a device fitted to protect the extreme end of the tailcone against a tail strike).

Overall, Airbus has allocated 2,500 FH to A350 flight testing, with the heavily instrumented MSNs 001 and 003 earmarked for 800 FH and 600 FH, respectively. The next two aircraft, MSN002 (configured with a furnished passenger cabin) and MSN004 should fly in February at the start of programs that call for each aircraft to complete about 400 FH of testing.

Scheduled for three months later, in May, is the first flight of MSN005, another machine equipped with a passenger interior and for which a shorter 300 FH duty is planned. MSN004 and MSN005 carry only light flight test instrumentation, according to van der Stichel. Evrard says that these airframes have been "less difficult" to complete because they have been fitted with less test equipment.

Flutter free demo

The next major milestone in the flight test program is a flutter-free demonstration that will see the A350 being flown at maximum operating speeds (Vmo) and Mach numbers (Mmo) at moderate to high altitudes. (Mach numbers relate aircraft speed to the local speed of sound, which varies with altitude.)

The tests include acceleration from low to high Mach numbers, as well as establishment of maximum permissible dive speed (VD) and Mach number (MD). Another important test exercise, according to van der Stichel, will be flying the A350 in conditions of known icing.

Asked about which maneuvers are most challenging for flight test crews, van der Stichel cites two examples: the establishment of Vmm (maximum maneuvering Mach number), which is "difficult because you can go to flight attitudes that were never intended", and flutter-free flight, which can take the aircraft "beyond the edge of the normal flight envelope".

In the extremely unlikely event of something going wrong – Airbus once lost an A330 and its crew while demonstrating the simulated loss of one engine after take-off at an extreme aft center of gravity and with autopilot selected – what provision is made for flight crew escape? Astute observers of the A350 flight test aircraft will notice a panel set in the belly cargo door on the starboard side. This is a 'push-out' escape hatch from which crew members can parachute, and access to which is via a slide from below a special door in the cabin floor.

In parallel with the initial flying, Airbus is continuing work with the static-test airframe, identified as MSN5000. In mid-October, preparation for the ultimate load test was "progressing well", with Evrard declaring himself "very happy" that it would be complete around the end of 2013 or at the beginning of 2014.

With more than 600 FH recorded by the beginning of December, the A350 is almost a quarter of the way through the scheduled flight test program. "Almost exactly a year since we inaugurated the A350 final-assembly line, we have two aircraft flying," said Evrard in late October. "But a program is never finished; we still have great challenges ahead to be processed."

X-ray, a kilometer away

The Trent XWB aero engine being developed for the A350 has been computer modeled to the same level of sophistication and complexity as that carried out by the UK's Met Office to forecast the weather worldwide, according to Tim Boddy, head of marketing (Trent XWB) for Rolls-Royce.

"The computer models predicted how the Trent XWB would perform – aerodynamically, thermodynamically and mechanically – under normal and extreme abnormal conditions, thereby enabling airworthiness certification for the engine," he says.

The design and modeling techniques were so sophisticated that advancements in engine testing were required to validate findings and identify further performance improvements: "An aero engine operates for the majority of its life in the cruise phase of flight at altitude," explains Boddy. "The engine's efficiency in these conditions significantly contributes to the total fuel consumption per flight. Cruise efficiency was therefore a primary design goal in developing the Trent XWB.

“To meet this objective, it was vital for the company to understand the performance of critical engine components, such as the turbine driving the engine’s fan to generate propulsive thrust. The clearance between the tips of the turbine’s rotor blades and the static seal of the outer case is key to achieving maximum efficiency from this part of the engine.”

However, how do you get under the skin of an aero engine to see what’s really going on while the engine is running at cruise thrust?

Famous five

Airbus will use five A350-900s in the ‘relatively standard’ flight test program, which for each involves five development- and certification-flying phases, before a buffer period ahead of service entry, according to A350 project test pilot Francis Chapman. The “first several” flights constituted initial development testing, during which the manufacturer analyzed flight characteristics and behavior. Each flight test machine has a dedicated program of activity:

• MSN001 is the first of a pair of aircraft with ‘heavy’ flight test instrument (FTI) fits and was earmarked for flight-envelope, powerplant and systems flying, including natural-icing investigation (once Airbus had frozen the aerodynamic configuration) as well as handling-qualities evaluation;

• Also heavily instrumented, MSN003 – the second A350 to fly – is being used for high- and low-temperature and high-altitude work in its airworthiness-approval and development flying, which includes engines, performance and systems activity;

• One of two lightly instrumented airframes, MSN004 is scheduled for avionics development and certification, and other duties will include external noise measurement and analysis, lightning tests, and pilot training for first customer and maintenance teams;

• MSN002, which may fly shortly after MSN004, is to have a medium FTI fit and (with MSN005) will be furnished for passenger-cabin and cabin-systems development and airworthiness approval. It is also planned for partial-evacuation trials and hot- and cold-chamber climatic trials before making early long flights with Airbus employee ‘passengers’ to assess the design’s full-load endurance and ensure cabin ‘maturity’ at entry;

• Otherwise lightly instrumented, MSN005 is to perform route-proving work near the completion of type certification in mid-2014. Essentially cabin-related activities will cover extended-range twin-engine operations (Etops) performance, function and reliability (or ‘operability’) and training, in addition to initial A350 customer crew training.