

At 1.2 million pounds, the Airbus A380 is the largest airliner in the world, capable of carrying 525 people for 8,200 nm.



DAVID MCINTOSH

Airbus A380

Cutting-edge thinking

by Robert P. Mark

Airbus engineers are never satisfied, and customers of the European airframe builder should have only one response... thank goodness. Despite myriad technological and manufacturing obstacles, the European consortium of Germany, France and Spain successfully built, flew and put into production the largest commercial aircraft in the world, the A380, and the airframer currently has orders for 200 of the double-decker jetliners.

While many point to the A380's size as the achievement of which they are most proud—a maximum takeoff weight of roughly 1.2 million pounds and room for 525 passengers in typical long-haul configuration—that also means the airplane does not slip easily into the aircraft category typically covered by *AIN*. When the opportunity arose to send a pilot to try his hand at the sidestick of the megaliner, as well as report on a few revolutionary technological developments certain to filter down to the rest of the aviation world, including the business aviation beat we normally cover, we knew the time was right to head for Toulouse.

Airbus engineers have developed another airline first in the campaign against airport

congestion with a radical new system called brake-to-vacate (BTV), designed to reduce significantly the time an aircraft spends on the runway after landing. BTV takes the guesswork out of which turnoff the aircraft will use after landing. The A380's auto-brake system exerts the pressures needed to guarantee the aircraft can safely make the turnoff with no input from the pilot, except to pull the engines into maximum reverse once the nose gear has firmly connected with the ground on rollout. Such guarantees mean air traffic controllers will be able to plan additional landings and takeoffs around A380 traffic.

Another, almost serendipitous, evolution of knowing where an aircraft will turn off evolved from reviews of the Boeing 737 overrun accident at Chicago Midway as well as the A340 accident in Toronto, both in 2005. Airbus system logic can now watch the landing trajectory and warn the pilot of an impending overrun.

In addition to the opportunity to fly the A380 around the Toulouse area, I was also briefed on a new, common-sense link among the aircraft's flight director, autopilot and TCAS that can save valuable seconds during the critical moments of a conflict resolution



AIN contributing editor Rob Mark said he soon felt right at home in the left seat of the massive Airbus double-decker.

advisory. Traditionally, a TCAS alert prompts the flying pilot to pop off the autopilot and manually avoid traffic. Many passenger injuries and structural damage have occurred because pilots have been too zealous with their maneuvers, and Airbus engineers believe they have a better idea.

The Briefings: Brake-to-Vacate

At Airbus headquarters in Toulouse, senior vice president of safety Claude Lelaie offered half a day of briefings on new Airbus systems before demonstration in MSN 001, the first flying A380. Despite some initial airline rejection of new ideas, Lelaie said, "We've decided to take action based on lessons we've learned. Runway excursions are now the largest cause of accidents." Such mishaps evolve mostly from poor pilot judgment. Airbus engineers aim to improve cockpit decisions by providing more cues to help solve the misuse of aircraft brakes. The company believes that the new system can lessen problems such as braking too little too

Sizing Up the A380

We flew airframe MSN 001, the first test bed for the production A380, to sample these new technologies. Surprisingly, the length of the A380 is about the same as that of an A330, 163 ft 8 in. for the A380 versus 165 ft 3 in. for the A330. Typical long-haul passenger seating on the A380 is 525. The wingspan, however, is considerably different for the double-decker jumbo. The A380's wings span just under 262 feet, versus 197 feet for the A330. Maximum ramp weight for the A380 is 1.239 million pounds while the heaviest A330 weighs in at 509,000 pounds. The four Rolls-Royce Trent 900 engines on the A380 produce about 70,000 pounds of thrust each.

By contrast, Boeing's current 747-400 weighs in at 877,000 pounds on a wing that spans 213 feet. The big Boeing will fly about 8,000 nm with full fuel—about the same as the A380—although it can't carry as many passengers as the Airbus. —R.P.M.

early in the landing and too much too late, as the runway end approaches, especially in low visibility. An added benefit could be extending brake life by as much as 25 percent and reducing turnaround times.

"Despite Airbus and airline policies, pilots still create unstable approaches," Lelaie added. "There is also no succinct method to trigger a go-around. We have designed some realistic minimum operational landing distances, including real-time computation, with the proper associated alert messages and audio callouts that would be applicable under all dry or wet runway conditions except on a contaminated runway."

Preliminary Airbus research began in 1998 as a Ph.D thesis by Fabrice Villaume, the brake-to-vacate program leader. Between 2002 and 2006, experiments began using a laptop installed to deliver inputs to the braking and flight control systems on an A340-600. The first operational test came at Charles de Gaulle Airport (CDG) in March 2005, and the system first flew on the A380 in May last year. Airbus expects European certification this month when Lufthansa and Air France take delivery of their A380s. Thrust reversers are readied for all landings in case they are needed.

Before BTV, the autobrake system knew only that the pilot was trying to stop the airplane. Now, with artificial intelligence communicating with the FMS, it has the smarts to stop the aircraft at a particular point on the runway. Depending on the geometry of the target runway turnoff, BTV automatically disconnects at a different groundspeed—10 knots if the airplane has to exit the runway with a 90-degree turn, or 40 to 50 knots for a high-speed turnoff. Airbus predicts that CDG could handle 2,400 more flights per year once the system is operational. However, BTV does not factor wake-turbulence separation into its calculations.

Airbus test pilot Armand Jacob recalled an extreme test of BTV that addressed the

issue of an emergency return to the airport. “We landed the A380 at 1.3 million pounds, about 40 tons over the certified maximum takeoff weight and 202 tons above maximum landing weight, all using normal procedures through BTV with maximum reverse. We found that the maximum brake temperature was about 400 degrees C, far below the 800 degrees C that would have deflated the tires.”

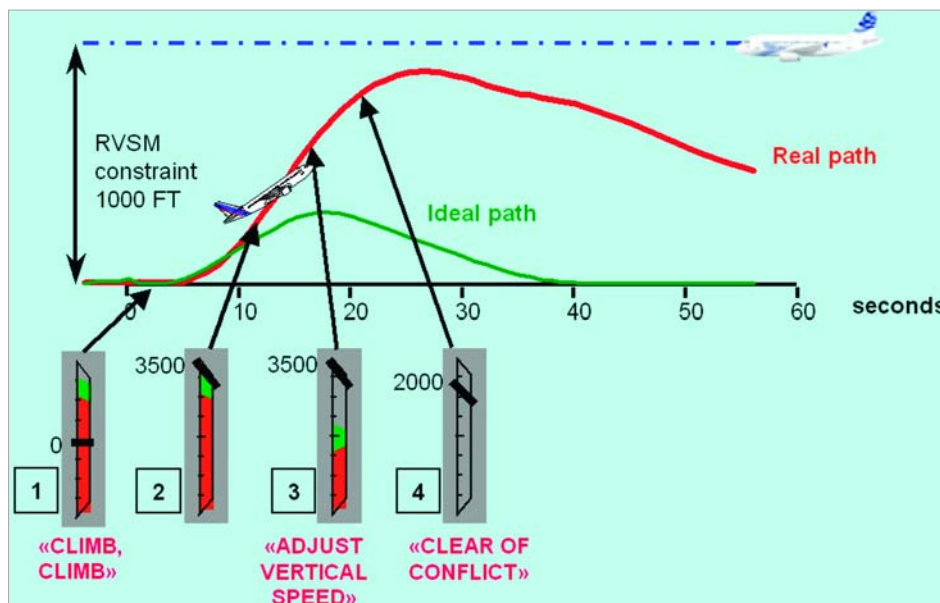
The runway overrun protection is essentially a moving target constantly updated based on approach configuration and speeds. Once the system determines the aircraft could exceed the available landing distance, it shows a yellow warning—IF WET, RUNWAY TOO SHORT.

On a dry runway, the approach speed could mean the aircraft will not have sufficient stopping distance. It literally yells at the pilot in a clear male English voice—RUNWAY TOO SHORT. If the pilot continues regardless, said Jacob, the system will do its best to stop the aircraft within the laws of physics and guide the pilot with demanding warnings such as, KEEP MAX REVERSE. When asked if Airbus might datalink actual braking conditions to succeeding aircraft, the company’s non-committal reply was “possibly.”

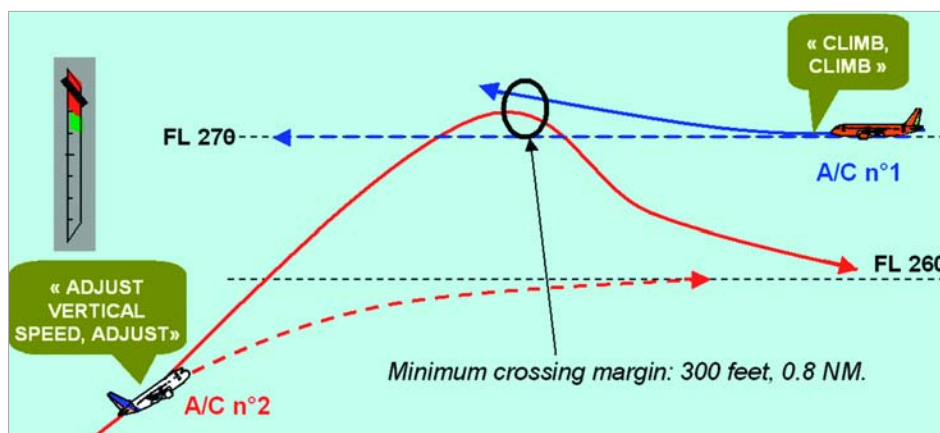
TCAS Technique Improvements

Another major Airbus development is its effort to get the autopilot and flight director more involved in TCAS conflict resolution. The company believes these two resources are currently much underused. Airbus AP/FD TCAS project leader Paule Botargues reminded pilots that currently, TCAS resolution requires the pilot to disconnect the autopilot and flight director before taking action. She explained that “many pilots are overreacting, leading to personal injuries in the cabin and excessive load factors on the aircraft. Some pilots are actually taking the wrong actions to resolve the conflict.”

Flying by reference to the vertical-speed indicator, as dictated by current TCAS alert response protocol, is an unfamiliar operational mode. The new TCAS system will provide guidance through the flight director if the autopilot is off. If the autopilot is already on, the system will control the resolution with no need for the pilot to disconnect anything or make any control inputs. The expected benefits are fewer passenger injuries and less overstressing of the aircraft structure during resolution advisories. The new Airbus TCAS system uses equipment already in



One of the gravest threats to safe aircraft operation is pilot overreaction to a TCAS alert; climbing too quickly can put the aircraft in the path of another, generating a second alert.



place and reduces pilot workload. The system maintains a climb rate of within 200 fpm of what is required and raises structural loading by no more than 0.3 gs to make it all work smoothly. Sensitive to pilots’ concerns about rampant automation, Airbus says the crew can always override the airplane.

Airbus used one million encounters with eight different categories of aircraft to validate the new TCAS system, which the company believes will increase safety by a factor of two. Based on the logic of TCAS v 7.0, it will offer the safety enhancements comparable to what is expected with v 7.1. Airbus expects EASA certification next month for the A380, with approval for the A320 series and A330/340 following within the next couple of years. No date has been determined for FAA approval.

Flying the A380

Aviation journalists typically frame pilot reports from the perspective of their experiences with similar aircraft, but little can prepare a pilot for the sense of awe that comes from simply standing on the ramp at Toulouse looking at the largest airliner in the world. The cockpit towers about 25 feet above those on the ground. Flying the A380, however, meant there would be little to call upon to keep this behemoth in perspective. Never having flown an aircraft with autobrakes either—other than a short stint in the Boeing BBJ—I’d need to remember to steer but not touch the brakes.

The ramp in front of the A380 reminded me of a beehive, with a swarm of ground personnel checking everything—the landing gear (all 22 wheels and tires), the engine oil levels and every other aspect of the fuselage and wings that are out of reach from a pilot on his ground walkround.

Reaching the main cabin level with no jetway meant climbing a standard four-foot-wide stairway pushed against the side of the fuselage. The cockpit is another few stairs up from there, the upper cabin is a few more steps above and behind the pilots. The cockpit of the A380 is massive by any measure, with some two-and-a-half feet of space between the two pilots once they’re seated. In addition to three jumpseats, we had as many as seven people moving about behind us in flight after we switched off the seatbelt signs. Since MSN 001 is a test bed, the cabin on both levels was fitted out only with test equipment and water ballast tanks.

With several pilots planning to try their hand at the A380, the plan was to demonstrate the brake-to-vacate to each of us, then land and switch seats during the taxi back to Runway 32L at Toulouse. The runway is 11,483 feet long by 246 feet wide. Takeoff weight was calculated as 846,575 pounds, considerably below the maximum of just over 1.2 million pounds. All the avionics were already up and running as we pushed back from the gate. The engines, started two at a time, are so far aft of the cabin that the gauges are the only indication of what is happening in the



Armand Jacob, Airbus test pilot



Claude Lelaie, Airbus senior vice president of safety

back. Even with the engines running, the noise level in the A380 cockpit was no more than in a regular automobile with the windows rolled up. Only Lelaie’s interactions with the ground crew and ATC from the right seat broke the silence.

Taxiing the A380 is not nearly the challenge I had anticipated. The aircraft is equipped with two video cameras, one built into the leading edge of the vertical stabilizer—it delivers a spectacular view guaranteed to wow anyone sitting in the back of the airplane—and another under the belly a few feet behind the nose gear. Calling up each on the pilot’s multifunction display makes it easy to use the tiller to keep the nose gear on the centerline. With the outer main gear trunnions separated by just 46 feet—a footprint only slightly wider than that of a 747-400—the pilot will find it easy to nail the centerline.

V₁ was calculated as 127 knots, V_R 130 and V₂ as 136, so any decision to abort would be problematic. In this configuration, however, the A380 would fly even if two engines quit on takeoff.

The day’s flight plan called for each demo pilot to take the left seat to view a demonstration of the updated TCAS, which was programmed with enough pseudo targets to fool the A380’s conflict system and trigger the automated response. The final landing of the day was planned as an all-out maximum braking effort to demonstrate what a pilot might experience should he ignore the computer’s call of RUNWAY TOO SHORT and land anyway, or possibly during an emergency arrival like the one detailed by Armand Jacob. Since that effort would produce maximum brake heating, there would be only a single demonstration, with all the guest pilots observing from the jumpseats.

The side-stick controls open up much real estate in the cockpit (as Airbus and Dassault Falcon 7X already know), and it’s beyond me why anyone would continue to want a control column and wheel in front of them.

The strangest part of flying a very large aircraft is the loss of a degree of depth perception and a relation to speed. On takeoff, I brought the thrust levers up about one quarter, to be certain the four Rolls-Royce Trent 900s were stabilized for acceleration. But there was precious little sense of acceleration—some force pushed me back in the seat as I moved the levers to takeoff power, but not as much as I had expected, as I steered with the tiller to remain on the runway centerline. Despite the diminished sensation of acceleration,

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Fabrice Villaume, Airbus brake-to-vacate program leader



Paule Botargues, Airbus AP/FD TCAS project leader

Airbus A380

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the A380 reached V_1 in what seemed like no more than 10 seconds and rotation speed shortly thereafter. Looking out through the expansive cockpit windows, it seemed we were too slow to fly, but rotate we did with a slight pull on the sidestick to reach a 15-degree pitch angle. The A380 virtually leapt off the ground. At positive rate, I called for gear up and soon we were accelerating to 200 knots for the brief demonstration flight. I tried some 30- to 40-degree-bank turns before leveling off



at 3,000 feet, and was amazed at how easy the three-quarter-million-pound-plus aircraft was to maneuver with simply a few movements of my left wrist.

Now level, I punched the autopilot on so I could pay close attention to Lelaie's brake-to-vacate demonstration. Summoning the correct page on the multi-function display is easy thanks to the trackball that rests at a comfortable position beneath the pilot's right hand. We selected S-8 at Toulouse—2,300 meters down—as our exit point for the first time around, which meant that if I was on the mark, we would have about 7,500 feet to stop the aircraft and turn off. The key is to set autobrakes to AUTO and let the system figure out the rest. The pilot is expected to add maximum reverse and keep the aircraft on the centerline but do nothing else until 10 knots, at which speed the system will automatically disconnect. Even with the autopilot off, the A380 was extremely light and easy to control down the ILS to touchdown. Once on the ground for the first landing, I pulled the reversers out and stayed on the pedals but off the brakes. The giant aircraft slowed until I disconnected the system about 10 feet from the S-8 intersection.

Another test involved trying the runway overrun protection system by creating an artificially short runway in the flight management system. On short final, the technology calculated the touchdown zone and, based on our speed, concluded we'd never get it stopped. On short final at about 200 feet, it began yelling RUNWAY TOO SHORT in a tone that was clear in its urgency. This would be the signal for a

pilot to go around.

The final landing was a maximum-performance arrival targeting the closest intersection possible at Toulouse, S-6, approximately 1,650 meters (5,413 feet) from the start of the runway. Once the A380 was programmed, another pilot this time flew to short final, crossing the fence at ref speed. After touching down, he called for maximum reverse while the A380 worked the brakes. The first five seconds were exciting as the aircraft decelerated rapidly, and everyone in the cockpit applauded as we easily made S-6. Brake temperatures never exceeded 400 degrees C. On a low-visibility landing, it would have made for an impressive demonstration as well.

As a point of reference, the A380 uses reverse thrust on only the two inboard engines because of the aircraft's vast wingspan. Engines one and four might well be so close to the outside edges of the runway, or even hanging outside the concrete area, that Airbus worried about FOD damage to those outer powerplants when in reverse.

During the TCAS demonstration, we climbed to FL100 in the Airbus practice area near Toulouse. With the aircraft fully coupled to the flight director and autopilot, TCAS traffic targets were generated by the A380 software significant enough to allow the aircraft to follow the commands. At the first sign of traffic, the system displayed a TCAS alert light to advise the crew that, should the target become a resolution advisory (RA), it would automatically move our airplane out of the way using the autopilot and autothrottles. When the traffic indeed became an RA, the power came up and the airplane smoothly entered a climb to match the TCAS command, much faster than a pilot would most likely have accomplished the same. But the most important element was how smoothly the autopilot/flight director combination made the aircraft climb, and how smoothly the A380 returned to its original altitude when clear of traffic. Another TCAS demo demanded the aircraft first descend and then almost immediately climb back to avoid another aircraft beneath us. The airplane certainly performed these maneuvers more smoothly than a human could have.

Computers versus People

Airbus firmly believes that maneuvering a big aircraft with pilot muscle power is no longer a good use of resources—especially since Airbus computers can take much of the mental gymnastics out of the equation, giving pilots more time for big-picture decisions. BTV is sure to be in the vanguard of efforts to increase runway capacity, with runway overrun protection evolving as a valuable corollary to the thinking process in Toulouse.

The notion that the autopilot can resolve TCAS conflicts better than a hand-flying pilot is so simple that one wonders why it took this long to come to fruition. Watch for these systems to appear on a business airplane near you soon. □