Airbus 319 Corporate Jet

The A319CJ's cockpit layout should be comfortable for heavy-iron business aircraft veterans; its proven fly-by-wire controls make it easy to fly.

By Fred George

What's it like to fly an Airbus? Accompanied by William Wainwright, chief test pilot at Airbus Industries' Toulouse facility, I strapped into the left seat of its A320-001 veteran flight test aircraft, the 22-feet longer and older sibling of the A319. Airbus Industrie intends to tank and trim the A319 to transform it into a corporate jetliner (CJ) capable of flying 10 passengers up to 6,300 nm. As such, the A319CJ will compete head-to-head against the Boeing Business Jet, Bombardier Global Express and Gulfstream V in the ultra-long-range, large-cabin, business aircraft market.

Looking around at the Airbus' cockpit layout from the left seat, the roominess of the front office was impressive. No other corporate jet provides the flightcrew compartment with so much volume.

It then occurred to me that business aircraft pilots who have become accustomed to the cockpits of Gulfstreams, Challengers and Falcon Jets will find a lot of similar design features in the A319CJ, but not necessarily the same avionics nomenclature. The Europeans use some different acronyms and system names, but similarities in avionics and flight control design transcend terminology differences between business aircraft and Airbus, with two big exceptions. Those are the fly-by-wire (FBW) and throttle-by-wire (TBW) systems, discussed later in this report.

There are six, large-format CRT EFIS screens in the instrument panel. Each pilot has a PFD and a nav display. Stacked in the center are two Electronic Centralized Aircraft Monitoring (ECAM) displays, called EICAS screens in business aircraft. The upper ECAM displays pri-

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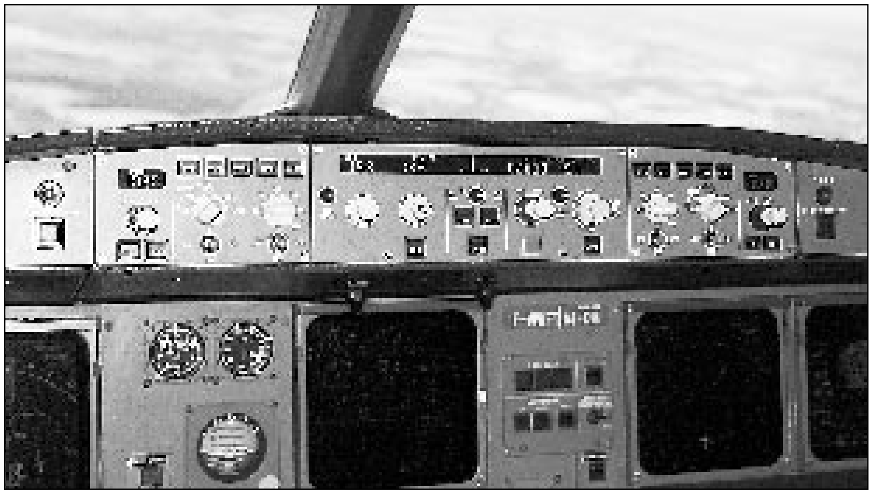
Top right: No knob-ology confusion here. Each glareshield control panel knob has a distinctive feel plus an adjacent display. The baro set knob, for example, has a baro readout just above it. Bottom left: It takes very little time to become comfortable with the side stick controller because of its appropriate heft and control feel. Bottom center: You're in control. Push up the throttles to the stops and you'll get maximum thrust—regardless of autothrottle mode. Bottom right: The throttle quadrant is quite conventional, with one exception. The autothrottles don't back-drive the levers for tactile feedback.



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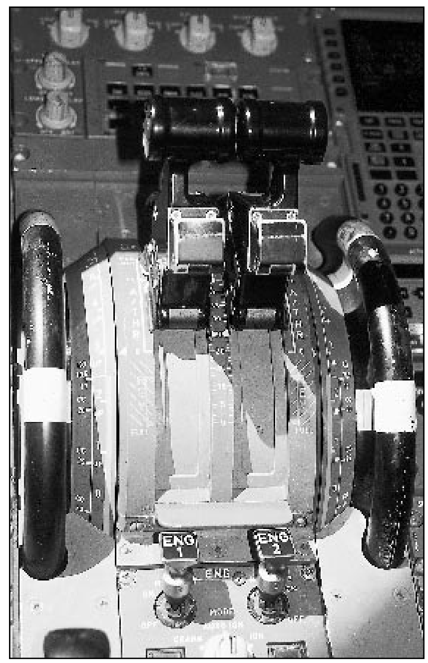

mary engine data, flap/slat configuration and fuel quantity status. The lower screen displays individual system synoptics, plus secondary engine and cabin environment data.

The lower ECAM is context sensitive, if you'll allow us to borrow the computer industry term. For example, if a system malfunction occurs, the appropriate synoptic display comes into view, along with the abnormal/emergency procedures checklist. Each item on the checklist disappears from view when the appropriate action has been taken. However, it should be noted that other action items on the pocket checklist, albeit lower priority ones, also must be completed.

Directly below the glareshield, there is the familiar flight guidance control panel, plus left- and right-side EFIS control panels and reversion controls for the side-stick controllers. As shown in the accompanying photograph, all these controls have displays that are directly adjacent to the switch, knob or button that controls the associated function. For example, the baro set display window is just above your fingers when you adjust the altimeter baro set knob. It's also displayed next to the altitude scale on the PFD. The individual knobs for different functions also have a distinctive tactile feel, thereby helping to eliminate confusion.

The overhead panel reflects the quiet, dark design philosophy of current generation business aircraft. The airframe systems, exterior light switches and engine controls are intuitive. For example, to start an engine once the APU is running, the pilot just presses fuel pump annunciator switches to make the lights go out, then goes down to the console to turn the start knob to start and move the engine master switches to run, one at a time. The FADECs handle the start chores, the generators automatically come on line. The Airbus' highly automated systems slash the length of checklists. Also located on the console are integrated radio management panels that are virtually identical in function to radio management units in business aircraft, along with Honeywell FMS multi-function CDUs, the conventional left-side speed brake control and right-side flap/slat control.

What's Missing From This Cockpit?

It's the control yoke, along with its clumsy column that bumps your knees and blocks the view of the instrument panel. Pilots strap into the seats of an Airbus as comfortably as they settle into office chairs. A tray below the instrument panel may be pulled out, providing a flat table surface to hold a flight plan, navigation chart or procedures manual.

A FBW side-stick controller replaces the yoke. This is anything but a jittery PC joystick. It has the heft and feel of a

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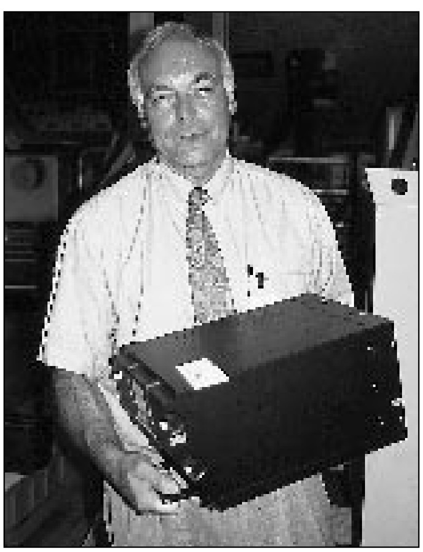
Bumps and thermals don't upset the Airbus. The FBW system, similar to the control wheel steering mode of an autopilot, let's you set the pitch and roll attitude. Configuration changes don't cause pitch trim changes, either.

control stick handgrip in a fighter. Airbus added enough artificial control force to the side stick to make it appropriate to a jetliner.

The FBW system has four basic modes: ground, takeoff, flight and landing. It also has envelope protection to keep you from overstressing the aircraft or inadvertently stalling. Ground mode gives the pilot direct control over the flight control surfaces. During takeoff, the pilot still has direct control, but envelope protection is added to prevent inadvertent stall.

The flight mode, used for climb, cruise and descent, allows the pilot to control vertical load changes in the pitch axis and roll rate changes in the roll axis. Let go of the stick and the pitch and roll attitudes remain fixed, within the flight protection envelope.



Seven FBW computers provide plenty of redundancy, plus MMEL one-box-inop dispatch flexibility. A decade ago, the airlines suffered through all the growing pains of new technology. FBW now is fully mature, according to airlines we contacted.

When the aircraft's radio altimeters sense that the aircraft is 50 feet above the ground and configured for landing, the FBW system makes the transition to the landing mode. The FBW system slowly rolls in two degrees of nosedown pitch trim to provide a natural feel during the landing flare and provides direct control of the primary flight control surfaces with stall protection.

Admittedly, this all sounds complex. However, it works well and feels natural, from what I experienced during my brief demonstration flights.

Some senior airline pilots have had initial reservations about the FBW system. Without feedback from the flight controls to the side stick controller, one pilot cannot directly monitor the control inputs of the other pilot, as the crew might in an aircraft with conventional controls. The pilots have complained about the lack of a mechanical interconnect between the side stick controllers for that reason.

The other noticeable missing item is a servo-driven throttle system that would move the throttle in response to autothrottle commands, thereby providing tactile feedback of computer commands to the engines. The FADEC controlled engines have TBW controls with detents in the throttle quadrant for max climb and max continuous (flex) thrust. As with FADEC-equipped business aircraft, there are no mechanical connections between the throttles and the engines, only electronic links. But business aircraft have servo-driven throttles to provide tactile feel of authotrottle functions.

Airbus claims that adding a servo-driven throttle would have increased throttle rigging chores, decreased reliability and increased overall operating cost.

Some pilots have criticized the nonmoving autothrottle system for taking away their ability to monitor computer-controlled thrust changes. One senior airline captain told B/CA that more junior pilots may not be aware of subtle thrust changes because they have yet to acquire a feel for the airplane. Similar to their experience with the side stick controllers, senior pilots said they missed being able to monitor directly the other pilot's control inputs because of the reliance upon automated systems.

I found the TBW control to be similar to an automatic transmission gear selector. With the throttles in the max continuous or climb detent, the autothrottle system manages thrust changes, but the pilot can override the system when needed.

If you need maximum thrust for a go-around or evasive maneuver during an approach, for example, just slam the throttles forward to the stops and you get maximum available thrust immediately, regardless of autothrottle function. Conversely, if you want less thrust than that commanded by the autothrottles, you can pull the throttles back out of the climb or flex detent and into the manual control range for less thrust. At the touch of a button, the pilot can disconnect the autothrottles altogether and regain full command authority over the engines.

(For more information on Airbus fly-by-wire and throttle-by-wire controls, see "Understanding Airbus Automation," October 1997, page 52.)

Flying the Airbus

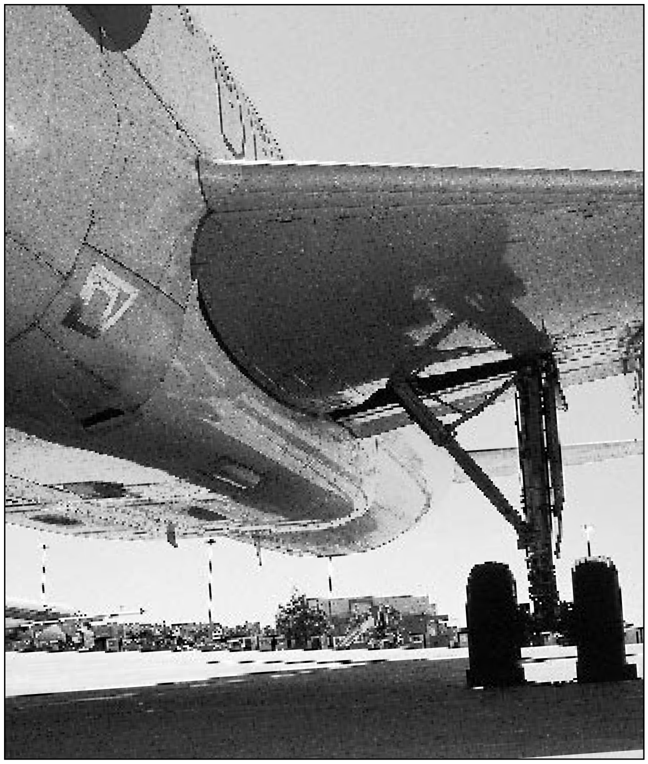
I had an opportunity to briefly fly the A320 in Toulouse with Wainwright for low altitude work and then the A319 with Patrick Baudry in Hamburg at typical cruise altitudes. The two aircraft have virtually identical flying characteristics, thus I've combined my impressions of flying both aircraft for this report.

At its maximum takeoff weight of 166,400 pounds, including 72,000 pounds of fuel, the A319CJ will have about the same thrust-to-weight ratio as its three main competitors. However, on the day I flew A320-001, we had only seven people on board and 22,000 pounds of fuel, resulting in a takeoff weight of 134,000 pounds, about 81 percent of the A319CJ's MTOW. The maximum en-

Captain Patrick Baudry demonstrates how to gain access to an equipment bay.

gine output, commanded by each FADEC, was adjusted to 27,000 pounds of thrust to simulate the A319CJ's maximum takeoff thrust output, resulting in a thrust-to-weight ratio of a Learjet 60.

Taxiing the A320 is easy. Cockpit visibility is superb, the steer-by-wire control (SBW) is smooth and precise. The brake-by-wire system (BBW), which uses carbon brakes, has excellent feel. The AFM takeoff computations called for 0.3 units of nosedown pitch trim, but failing to set the proper pitch trim isn't critical. With the fly-by-wire controls, any pitch trim setting in the green arc is acceptable, but it will result in heavier- or lighter-than-optimum stick control force feel at rotation because the FBW system is operating in the direct law mode.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The A319CJ's high stance provides plenty of ground clearance for the engines, but most every service task requires a ladder or another form of lift.

Our flaps/slats position 2 configuration corresponded to flaps 15 degrees and slats 22 degrees. Actually, memorizing deflection numbers is unnecessary. The crew only has to know which of five flap/slat presets is appropriate to the phase of flight. ECAM graphics and symbol color cues tell the crew when the flaps and slats are in the correct position.

The overall cockpit design de-emphasizes rote memorization of numbers and acronyms in favor of color cues and synoptic graphics. Smart redlines and stall speed margin cues on the airspeed scale help keep you in a safe operating envelope for each flap/slat configuration.

Airbus engineers oppose automatic V-speed calculations by the FMS. They say they want to keep the pilot in the loop. In truth, past generations of the Honeywell FMS may not have had enough memory to support V-speed calculations and other performance management functions. Our manually computed takeoff V-speeds were 146 KIAS for V1 and VR, and 147 KIAS for V2, which we plugged into the FMS CDU to set the airspeed bugs on the PFD.

When cleared for takeoff on the roll, I pushed up the thrust levers to an indicated 50 percent N1 thrust lever position (TLP) on the ECAM to allow the CFM56 engines to accelerate symmetrically. After about five seconds, both engines were up to speed. I then pushed up the thrust levers to the forward stop in the quadrant to select maximum thrust.

There was no doubt about having selected full throttle. A large, green TOGA (take off/go around) annunciator on the PFD confirmed the commanded thrust setting, along with the matching TLP/N1 rpm indications on the ECAM. The acceleration was impressive, considering the 67-ton mass of the A320.

For most takeoffs on adequately long runways, pilots probably will push up the levers only to the second, or max continuous, flex detent. This position allows the FMS and autothrust system to set a reduced, or flex, takeoff thrust level to reduce engine wear.

Wainwright called V1 and rotation at 146 KIAS. I initially pulled back too gently on the side stick controller and the aircraft began to rotate at too slow a rate. I moderately increased the pressure to produce a more normal rotation rate until the pitch had increased to 18 degrees. I let go. The pitch attitude remained glued at 18 degrees as the aircraft accelerated.

At 1,500 feet agl, a flashing, amber THR CLB (thrust climb) annunciation in the PFD cued us that it was safe to reduce thrust to the max continuous, or flex, detent. This automatically engaged the autothrust system in the maximum climb thrust mode. The amber, flashing THR CLB annunciation was replaced by a steady, green THR annunciation. This told us that the autothrust system had commanded maximum available climb thrust.

As we accelerated and cleaned up landing gear, flaps and slats, it was readily apparent that the FBW normal control law eliminates all the pitch transients and trim feel changes associated with speed and configuration changes. Indeed, this quasi control-wheel-steering function produced a lack of reaction in pitch trim feel that was almost uncanny. It didn't take long, though, before I became accustomed to the lack of pitch changes. The Airbus philosophy seems to be, "just point and go."

Similarly, the pilot doesn't need to make bank angle corrections in response to thermals, bumps and turbulence. The FBW system maintains the roll attitude commanded by the pilot. Stick inputs only are needed to change bank angle for a turn. Later, from the back of the cabin, I watched as the FBW system made the ailerons dance in response to the low altitude thermals near Toulouse. The passengers, as well as the pilots, are unaware of the automatic roll rate damping that produces a more comfortable ride. Turbulence still can produce up and down movements, but not the pitch, roll and yaw swings associated with conventional flight control systems.

Once level, it's easy to hold altitude. A flight path vector (FPV) symbol on the PFD provides an instant indication of the aircraft's trajectory. This is especially useful when flying steep turns. Pin the FPV on the horizon line and the altimeter scale remains frozen.

I couldn't do our usual set of stability and control checks because the FBW system masks the inherent aerodynamic stability and handling characteristics of the airplane. However, the FBW system allows a more aft c.g. for fuel efficiency that, while meeting certification criteria, would make the aircraft quite unpleasant to fly.

Windshear, Windshear!

You've heard it all before, no doubt. Airbus FBW skeptics, almost always folks who never have flown the airplane, claim that the computers take away control from the flightcrew. Pilots only have a vote and the FBW system always makes the final decision.

In reality, though, the pilot retains virtually all the control over the aircraft, but the FBW system's envelope protection makes sure that he or she doesn't overstress or stall the aircraft in the process. Of greater importance, the FBW system ensures that the pilot can extract consistent, ultimate performance out of the airplane.

Wainwright had me slow the aircraft and configure it for landing. We began a slow descent, as though we were on final approach. Then, he said "Windshear! Windshear!" to simulate our encountering the sudden, potentially lethal, cold column of air blasting downward out of an imploding thunderstorm.

The extra seven-plus inches of the A319CJ's 12.1-foot-wide cabin, compared to the next largest business jet, allows appreciably larger sleeping rooms and private offices while preserving an adequately wide passageway, according to Airbus.

I reefed the side stick back to aft stop and slammed the thrust levers to the forward stops. There was no hesitation. There was no doubt that I was in command. The aircraft immediately began to pitch up to 20-plus degrees nose up attitude, precisely at the maximum lift-to-drag (L/D) angle of attack, no less and no more. The engine accelerated to maximum rpm, within the EGT limits.

During the maneuver, the FBW system made a transition from the vertical load command mode to the angle-of-attack command mode, resulting in the maximum possible aircraft performance within the flight protection envelope.

It was clear that I couldn't have extracted the same performance from a conventional flight control airplane, and certainly not on a consistent basis, even with thousands of hours of experience. Unless you're a Top Gun instructor, you just don't hone your skills to the edge needed to extract this kind of performance out of an airplane when it's needed most.

Just as impressively, an ab initio pilot could have obtained exactly the same results. The FBW system is blind to the hours you've racked up in your log book or the chrome color of your hair.

The immediate max performance capability also could take you out of harm's way during an evasive maneuver. Suppose one day, when you get no TCAS warning of an intruder, your windscreen fills up with aluminum. If you snap in full aft and side stick, accompanied by max thrust, the Airbus responds as though it were a light jet. In an emergency, you can roll it up to 67 degrees angle of bank, corresponding to a 2.5-g turn, the aircraft's maximum load limit. If you get too slow, the FBW system automatically will reduce bank angle just enough to prevent a stall. But, there's never any doubt that you're getting maximum performance out of the airplane, especially if you've flown aerobatics or have previous military flight experience.

Routine Flight Operations

There's no question that the Airbus 319CJ is an airliner that's been outfitted as a business aircraft. Don't expect to soar to initial cruising altitudes of FL 410 and higher when fully loaded. FL 350 to FL 370 is more realistic. On ISA+10°C days, plan on FL 330 as the initial cruise altitude.

On the day I flew the A319, we departed at a weight of 131,400 pounds. For takeoff out of Hamburg with near standard day conditions, our V-speeds were 137 KIAS for V1 and rotation, and 140 KIAS for V2. Frequent ATC constraints interrupted our climb to FL 350, thus preventing us from measuring time to climb and fuel burn.

Once level at FL 350, we attempted to climb higher. The A319 could be nudged above FL 370, but we only could reach FL 390 with both air-conditioning packs switched off—hardly a procedure that would be acceptable to business aircraft operators. The unusual maneuver, though, proved that the pressure vessel was very tight. The cabin altitude climbed only about 500 feet with no pressurization bleed air from the packs.

Rolling into a turn at 0.80 Mach, I encountered mild buffet at 37 degrees angle of bank, indicating that there was an adequate high-speed buffet margin at FL 390 for mild maneuvering at a relatively light weight of 123,400 pounds, corresponding to 74 percent of the A319CJ's MTOW.

After a few demonstration maneuvers, we descended towards Bremen for a series of approaches. The speed mode of the autothrust system handled the engines while I flew the aircraft. Hand flying the A319 on approach is easy. The lack of pitch trim changes associated with speed and configuration changes takes away much of the workload. Minor roll upsets caused by low altitude turbulence are countered auto matically by the FBW system.

Although I flew no landings in the A319, my experience in the A320 indicates that it will be easy to roll on to the runway. The synthetic voice of the computer keeps you aware of your altitude above the runway during final approach. At 30 feet agl, the voice advises you to pull the thrust levers to idle for the flare. The automatic nose down stab retrim feature and transition to direct control law for landing makes the aircraft feel very natural in the flare, requiring increasing back pressure to slow the descent rate. However, you don't have to make the concerted effort to counter thrust changes in the flare as you must in some large aircraft with conventional flight controls. The A320, for example, feels more like a Gulfstream V than a Boeing 737, in my opinion.

I monitored a Cat IIIb automatic landing at Bremen, complete with rollout guidance and automatic braking. No one would accuse the computer of greasing it on, but the touchdown was spot on the target and the computer didn't waste any runway during the rollout.

A Super Airliner, But Is It a Superior Corporate Jetliner?

Pilots will need some time to learn all the nuances of Airbus automation. The CDU, for example, has many functions outside of controlling the Honeywell FMS. The lack of conventional seat-of-the-pants feedback, along with the fixed side stick and throttles, takes away some of the cues pilots use to monitor conditions in conventional flight control aircraft.

Your eyes, ears and inner ear gyros do the monitoring in the Airbus. Most of the cues are provided by map graphics and display symbols, colors and icons, the context-sensitive checklist and illuminated annunciators.

In exchange for learning all the fine points of Airbus automation, pilots will find that they have more time for planning, managing and responding to changing conditions and clearances, in my opinion. It's also less fatiguing to fly than aircraft with conventional flight controls, a trait that won't be lost on corporate pilots making 6,000-plus mile trips, even if most of the journey is flown with the autopilot engaged. Potential business aircraft buyers should note that Airbus does not intend to offer a standard or optional head-up display system. Airbus claims that when you need to fly a low visibility approach, you should let the triple-channel, fail-operational, Cat III-capable autopilot fly the aircraft until you can see the runway and take over manual control.

Passenger comfort is the biggest asset of the A319CJ. The extra seven-plus inches of the 12.1-foot-wide cabin, compared to the next largest business jet, allows appreciably larger sleeping rooms and private offices while preserving an adequately wide passageway, according to Airbus.

Taking advantage of the extra cabin volume, though, may be a challenge. Airbus' completion allowance is approximately 7,000 pounds for an A319CJ capable of carrying eight passengers 6,300 miles. In contrast, Gulfstream budgets 6,700 pounds for the G-V cabin furnishings and Boeing provides 11,000 pounds as an interior allowance, without having an adverse impact on maximum range with eight passengers. In addition, the A319CJ's forward airstair is a 500-pound option that is not included in the 7,000-pound completion allowance.

The A319CJ's higher stance, compared to a Boeing Business Jet, also allows the use of larger fan, higher bypass engines with better fuel economy. The engines sit higher off the ground for more protection from FOD.

Compared to the BBJ, Airbus claims a performance edge, with lower runway loading, shorter takeoff field lengths, especially under hot-and-high conditions and a higher maximum cruise altitude of FL 410. Airbus may push the cruise altitude to FL 430, if the corporate market demands it.

Airline operators told B/CA that Airbus technical support and parts availability has greatly improved, compared to its state 10 years ago when the A320 was first introduced. It's not the same as Boeing's parts support, but it's now every bit as responsive and cost-effective, operators claim. They also told B/CA that the overall operating cost of the A320 and A319 is lower than many other airliners they've previously operated. However, the carriers with which we spoke were not previous Boeing 737 operators, thus we can't compare the A320/319 and 737 operating expenses.

Reliability is one of the Airbus A320/319's strong suits, now that the airplanes have matured. The A320 was introduced in 1988 and the A319 made its debut in 1996. The airlines suffered through all the Airbus FBW/TBW/BBW/SBW adolescent growing pains, potentially sparing corporate operators from undergoing the same difficulties.

Airbus, however, admits the firm is new to the corporate market and that they will have to bone up on the fundamentals of business aviation.

For example, A319CJ operators will have to get used to dealing with dozens of different parts vendors rather than being able to dial a centralized parts support hot line at Airbus.

If Airbus builds up an in-house corporate jetliner support capability tailored to the needs of business aircraft operators, then, in my opinion, the A319CJ could become a strong, fourth contender in the ultra-long-range, large-cabin business aircraft market. **B/CA**