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Pilot Report: Embraer Praetor 600

Redefining the super-midsize jet.

Embraer Praetor 600 super—midsize aircraft includes three infrared cameras, which are about equidistant from the radome and windscreen.

JAMES ALBRIGHT

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Like many professional pilots, I am always shopping for my next airplane. It is usually on behalf of my current employer, but often it is just me dreaming of the next best thing. When I picked up a brochure about the Embraer Praetor 600, titled “Breaking Boundaries,” I wondered what boundaries were left to break in the super-midsize business jet category. Twelve passengers and 155 sq. ft. of baggage. London to New York, nonstop. Short fields like Santa Monica, California, with enough fuel to make Florida. A cabin altitude of 5,800 ft. while cruising at FL450. Ka-band internet connectivity. While all of that is impressive, the brochure didn’t pique my interest until I got to the last page. Full fly-by-wire (FBW), sidestick flight control system. Enhanced vision system (EVS) with head-up display (HUD). ADS-B In. Autothrottles. Synthetic vision system (SVS). All of that in a super midsize?

Each of those last-page items is a technological innovation that makes flying aircraft safer, but this level of safety is usually reserved for the ultra-long-range business jet class. (Increased safety can be very expensive.) If Embraer figured out how to do this in the Praetor line, that would redefine what we expect from a super-midsize business jet. It wouldn’t be the first time Embraer broke the mold when it comes to designing aircraft.

Like many of the traveling public, I welcomed the introduction of regional jets, specifically the Canadair CRJ100 in 1991. Jets are faster and more comfortable. Moreover, jets are easier to fly, which means they are safer. I thought Canadair would dominate for decades, but the Embraer ERJ145 did the same job for less, and within eight years the market was transformed. Fast forward to the early 2000s, when Embraer rolled out the “E-Jets,” more correctly called the E170/E190, and we were starting to see yet another segment of that market transformed. If you’ve ever been surprised by the size of a regional airline’s aircraft, thinking perhaps you were on a Boeing 737 or Airbus A220, chances are it was an E-Jet. Now it appears they are about to do the same for the business jet world. I had to learn more.

Valtécio Alencar, Embraer’s head of corporate communications, hosted several virtual meetings to bring me up to speed on the aircraft. Although it has a greater range (4,018 nm), the Praetor 600 shares the same type rating as the Praetor 500, the Legacy 450 and the Legacy 500 (EMB-550, in the U.S. FAA). Going from the smaller sibling to the larger will require Level A differences training, which is accomplished through self-study. As of this writing, more than 200 aircraft in this family have been delivered. The more I learned, the more I began to appreciate Alencar’s claim that the Praetor is “innovative and different.” He sums it up by saying the Praetor “brings technology and innovations only available on bigger jets.” There was no doubt: I would need some hands-on experience.

Alencar invited me to Embraer’s 67-acre, Melbourne, Florida, campus. Alvadi Serpa Jr., the director of product strategy and competitive intelligence, was on hand to answer my questions. My instructor for the flight was Capt. Sam Bennett, senior demo pilot.

Preflight Inspection

While many jets in the super-midsize category suffer from what I call the “stubby jet syndrome,” the Praetor 600 looks fast just standing still. That maybe is a result of wing sweep, the tall winglets, or perhaps just the proportions: a wingspan of 70 ft., 6-in., a nose-to-tail length of 68 ft., 1 in., and a tail height of 21 ft.

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Approaching the Praetor 600 on a beautiful Florida morning.

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Alvadi Serpa explains the three-camera EVS system.

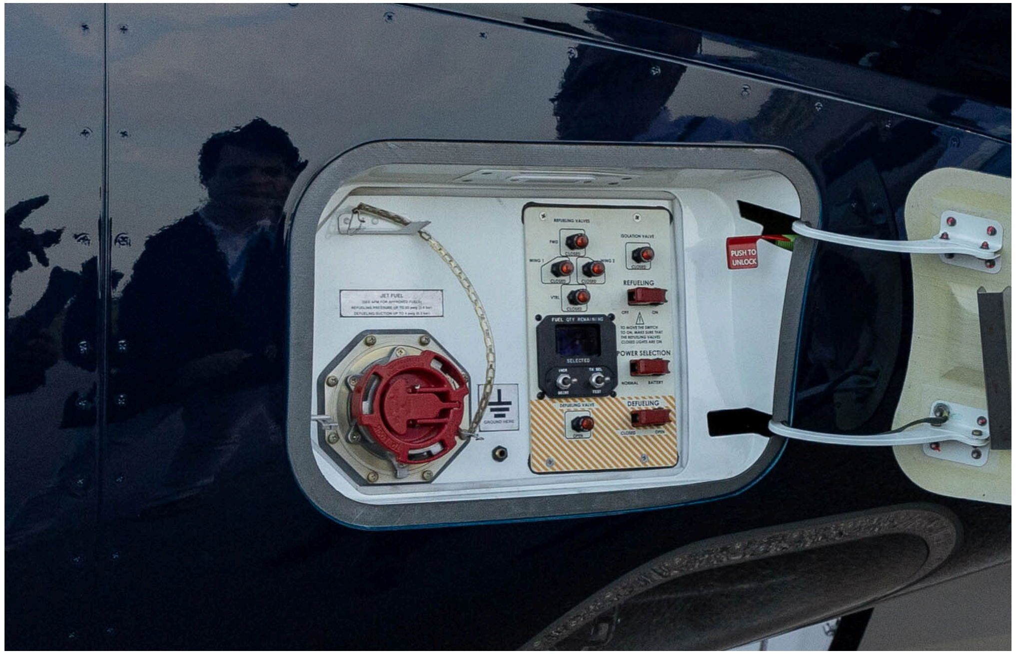
The first thing out of the ordinary that I noticed were the three cameras used for the enhanced vision system (EVS). A typical EVS uses an infrared camera to detect heat sources, such as runway approach lights. Alvadi explained that they recognized the inability of infrared cameras to detect LED lights, which do not generate heat. The Praetor 600's EVS-3000 can see LED lights by using three cameras to process visible light, shortwave infrared and longwave infrared. There is a push to replace the incandescent lamps with LED lights on some approach lighting systems, but it is too soon to tell if the move is inevitable.

There are also two ice detectors just below the windshield. The detectors can automatically activate wing, horizontal stabilizer and engine anti-ice systems. Engine bleed air is used for all three systems. I noticed the horizontal stabilizer appears proportionally smaller than what I expected. Alvadi says the FBW allows for a smaller stabilizer, producing less drag and boosting overall performance.

Below the ice detectors are four "smart probes" that measure air pressures from various angles to generate angle of attack (AOA) information used by the flight control system. I've seen this used to excellent effect on larger business jets, eliminating the need for problematic and less-reliable mechanical vanes. AOA information is used to provide full envelope protection but is not displayed to the pilots. (More on that later.)

A ram air turbine (RAT) sits in a compartment in the right forward fuselage. The Praetor is a DC aircraft, and the RAT provides power to all critical navigation, communication and flight control systems in the unlikely event main electrical sources fail. It will provide power for the entire flight envelope; there are no altitude limitations while you are above 135 kt.

The single-point refueling adapter is on the right side of the fuselage behind a panel that also houses the refueling/defueling panel and all the controls needed to take on and monitor fuel upload. One needs only to turn on the battery switch from this panel, set the desired amount of fuel in pounds, and the process completes automatically. The panel is conventional except for the fact that rather than including a tether to secure the door open, a "push to unlock" handle keeps it open when in use. Total fuel capacity is 16,138 lb.



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The Praetor 600's refueling panel.

The Praetor 600's wings sweep back 26.7-deg. until about the 25% chord line. The result is high-speed performance up to Mach 0.83 and low-speed performance allowing typical approach speeds down to below 110 KCAS. There are no leading-edge devices, vortex generators are placed ahead of the ailerons, and three multifunction spoiler panels are placed ahead of the flaps on each wing. The result is an aircraft with light-jet-like airport performance with ultra-long-range aircraft technology.

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The Praetor's right wing.

The auxiliary power unit (APU) exhaust is at the farthest aft section on the right side of the tail, reducing noise in the cabin and from the aircraft's main entrance door. The external baggage door is on the left, below the left-engine pylon. It is cavernous for an aircraft this size, measuring 110 cu. ft., and is 8-ft. long, designed to accommodate large, long items, such as golf bags, skis or surfboards. Combined with the internal baggage compartment, a total of 155 cu. ft. are available.

The entire external preflight, from start to finish, can be accomplished in about 5 min.

Before Engine Start

The Praetor 600's cockpit is spacious, mostly due to the absence of control yokes but also due to the logical layout. All avionics are placed below the glareshield, most aircraft systems are in the overhead panel, and all engine controls are near the throttles. The front panel is dominated by three 15.1-in., high-resolution Rockwell Collins Pro Line Fusion displays, with a fourth at the top of the center pedestal. Each pilot has access to all four displays using their own cursor control panel. Once a display is selected, a track ball moves a cursor, and two buttons select items or toggle choices. It is as intuitive as using a laptop computer with a track pad. Each pilot also has a multifunction keyboard panel with mechanical keys that offer a satisfying, tactile feedback. I prefer this type of keyboard over those presented on a glass panel. My only complaint is that the keys are in alphabetical order; I would prefer a QWERTY layout. I've heard the alphabetic keyboard provides faster one-handed typing because there are fewer columns of keys from left to right, but I find my speed is improved with a keyboard I am more familiar with.

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The Praetor 600 cockpit.

A standby flight instrument located inboard of the center display offers a third independent source of attitude, airspeed, heading and basic navigation (VOR, DME, ILS) information. It is relatively small but positioned right where the pilot needs it.

Starting the APU is simple but does require the pilot to activate other systems first: the batteries, navigation lights, fire test and a fuel pump. Once started, the cockpit comes to life and is ready for engine start quickly. We were ready in less than 5 min.; I am told that is typical.

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The flight plan page (with the author's reflection).

The flight plan can be downlinked from terrestrial or satellite links, or it can be entered manually. Optionally, an ACARS datalink is available via VHF or Iridium. The process is remarkably easy because of the very large FLT PLN page available on the center display unit. Clearances can be obtained via controller pilot data link (CPDLC) using ATN or FANS 1A+, or more-conventional pre-departure clearance (PDC).

Engine Start

Engine start in the Praetor 600 is straightforward. The Honeywell HTF7500E turbofans have full authority digital engine control (FADEC), which handles just about everything for you. You simply lift a clear plastic guard and rotate a switch from "stop," through "run," to a "start" position, and then release. Engine generators, air-conditioning and pressurization are all fully automatic; all that was left to do was shut down the APU and check the flight controls.

The flight control check through the sidesticks feels light with no appreciable increase in force required when nearing the travel limits of each surface. The sticks are not "active" in that moving one stick does not cause the other stick to also move. If one pilot moves the stick in opposition to the opposite stick, the sticks vibrate to notify both pilots of the mixed control inputs. Priority can be taken from one stick to the other using a red button on the stick that is also used to disconnect the autopilot. Priority is announced by a synthetic voice, such as, "Priority left." I asked if the haptic feedback could be confused with a stall-warning shaker. Bennett reminded me that the aircraft doesn't have or need a stall-warning stick shaker, "as you will soon find out!"

Most manufacturers have their own approach to FBW technology and when going from one system to another the flight control laws can be confusing.

A control law is nothing more than a set of software instructions that tell the flight control computers how to turn pilot and various system inputs into control surface outputs. It may be useful to think instead of the control modes in use.

In the Praetor, there are two controls modes: normal and direct. Under normal mode, the system relies on data sensed by the air data system (calibrated airspeed, dynamic pressure, etc.) and the attitude heading reference system (AHRS). The system does not need other navigation systems, such as GPS, to remain in normal control mode. The flight control computers make the airplane "feel" conventional, giving the pilot a sense that there are no electrons involved at all.

Two flight control computers take turns as the system in control or the system used to monitor. Either computer can control the aircraft alone and remain in normal control mode. Losing three of the four data probes will revert the system to direct mode. Of the three hydraulic systems, losing No. 1 and No. 2 will cause direct mode. In this mode, the aircraft responds to stick and rudder movements conventionally without the flight envelope protection afforded by the flight control computers.

With the flight control checks done and with our taxi clearance, I released the brakes and allowed the aircraft to start moving with minimal added thrust. The steer-by-wire nosewheel steering feels conventional, giving 62-deg. left and right authority from the rudder pedals up to 10 kt., gradually decreasing to 3 deg. side-to-side once at 68 kt. The taxi from the Embraer campus to Melbourne Orlando International Airport's Runway 27L was almost a straight shot, and Bennett completed the taxi checklist and then fully briefed me on what was to come.

Our takeoff weight was to 32,293 lb. at 27C, giving us a 3,360-ft. takeoff distance using Flaps 1, which equates to about a 7-deg. flap angle. We could have reduced the distance to 3,071 ft. using Flaps 2, about a 21-de\g. flap angle, but with a 10,181-ft. runway in front of us, we didn't need to. We also armed the automatic brakes to rejected takeoff (RTO) mode, which would provide maximum braking with anti-skid should we need to abort the takeoff.

Our V_1 was 111 KCAS, V_R was 117 KCAS, V_2 was 125 KCAS, and V_{FS} was 144 KCAS. The Praetor 600's maximum takeoff weight is 42,858 lb. and its maximum landing weight is 37,478 lb., so an immediate return was our plan should that be necessary. In the event of an engine failure after V_1, the FBW would apply enough rudder and aileron to eliminate any roll but allow a slight sideslip to help the pilot to identify which engine has failed.

I rotated the HUD into view during taxi and found it is unlike any I've ever used before. It does not have an overhead projector that sends the required imagery to the glass plate in front of the pilot's head. The Praetor's HUD projects the image from within the glass itself and the result is a much smaller installation with no HUD equipment required above the pilot's head. The Praetor HUD is narrow compared to others I've used, perhaps no more than 5 in. from left to right. Keeping the imagery in view during takeoff wasn't natural for me; I suppose I move my head outside the field of view more than the designers had anticipated. I've not had this problem with other HUDs, but I think with more time in the seat I would have gotten used to it.

Takeoff, Climb and Cruise

Once we were cleared for takeoff, I aligned the aircraft with the runway centerline and pushed the throttles forward. Once they were beyond about 40-deg. thrust lever angle, the autothrottles took over and allowed the FADEC to set takeoff thrust. We achieved V_1 and V_R quickly and I rotated into the flight director V-bars to maintain V_2+15 kt. Stick forces were light, and I didn't notice any tendency to over-rotate. It wasn't until we had accelerated to 250 KCAS that I noted not having to trim at all.

The sidestick's position felt ergonomically right to me. The combination of the armrest and stick position made left and right movements easy without inducing unwanted pitch; the same was true about forward and aft movements leaving the roll axis free. The normal climb schedule of 250 KCAS through 10,000 ft. and then 270 KCAS transitioning to Mach 0.74 made quick work of our climb to our initial altitude of 30,000 ft. in just 10 min. on an ISA+15C day. An uninterrupted climb to 41,000 ft. would have taken 17 min.

Keeping situationally aware departing the busy airport was easy, using the aircraft's ADS-B In or cockpit display of traffic information (CDTI). CDTI is one of those recent innovations I wonder how I ever got along without. You

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The Praetor 600's radar in action.

can think of it as TCAS, only more accurate and with more information. You not only see the traffic's relative position but also where it is heading and how fast.

We negotiated a further climb to 41,000 ft. while navigating around some coastal weather using the Rockwell Collins MultiScan Weather Radar, which has an 18-in. flat-plate phase-array antenna. The radar image is presented on the map display horizontally as well as in a vertical view, making easy

Low-speed and asymmetric thrust protection demonstration.

work of deciding if the aircraft's flight path will be impacted.

We accelerated to Mach 0.82. Bennett noted that many operators cruise at Mach 0.80 for better fuel efficiency. Even at the higher speed, our fuel flows were easily below 1,000 pph per engine. Our cabin altitude was around 4,800 ft., 9.7 psi, with the aircraft at 41,000 ft. The system is capable of a 5,800-ft. cabin at the aircraft's maximum cruise ceiling of 45,000 ft.

The aircraft has a single pressurization and air-conditioning kit (PACK). Passengers can have 100% fresh air or select the option of adding up to 50% recirculated air to help control temperature and humidity to a comfortable level. Even with some of the air recirculated, 100% of the cabin air is exchanged every 3 min. Recirculated air is scrubbed through a 0.3-micron HEPA filter. With the PACK turned off, a backup PACK mode provides pressurization all the way up to 45,000 ft. with air conditioned to 75F.

Our ride conditions were quite smooth, so I didn't get a chance to evaluate the FBW "active turbulence reduction," something I've not seen before. I later asked Embraer engineers to explain how it works while still adhering to Reduced Vertical Separation Minima (RVSM) requirements. They told me the FBW monitors and corrects flight parameters about 100 times per second, allowing it to "cushion" the turbulence, while still maintaining altitude within RVSM tolerances.

Fly-by-Wire

Praetors are designed to be "flight path stable." The FBW maintains desired aircraft trajectory by providing auto-trim, automatic roll compensation with sideslip, and automatic pitch and yaw compensation in turns. You simply point the aircraft where you want it and release all stick pressure--the FBW does the rest. It even relieves you of the need to trim. If you are greater than 33-deg. bank or +30-deg./-15-deg. pitch and let go of the stick, the system returns you to those limits. These are called "soft limits," which can be overridden by the pilot. Once we were cleared for a block of altitude, I practiced each of these by placing the aircraft beyond a limit, releasing the stick, and verifying that the aircraft returned to the limit.

Bennett asked that I explore the "hard limits," which cannot be overridden. He turned off the autothrottles and I brought the throttles to idle and extended the speed brakes. Going through 160 KCAS, the speed brakes auto-stowed and we got a "lever disagree" CAS message telling us the speed brakes were stowed and the handle was extended. I stowed the handle to remove the message. Once we slowed to 1.13 V_S, the autothrottles automatically engaged and bugged 1.13 V_S, and then maintained that speed, which ended up being 120 KCAS at our altitude of 13,000 ft.

Of course, we wanted to go even slower! So, I disengaged the autopilot and autothrottles as Bennett negotiated a block altitude with Miami Center and instructed me to bring the throttles to idle and hold our altitude until I couldn't. The airplane let me know with a repeating aural alert, "low speed." As I ran out of aft stick, the aircraft started a gentle descent, no more than 500 fpm. I saw an airspeed as low as 102 KCAS. Bennett then advanced both throttles and once I started climbing, he pulled the right throttle to simulate an engine failure while I kept my feet on the floor. The FBW system protected us from the low-speed thrust asymmetry and kept us flying with most of the required rudder, leaving just a little as a clue that there was an asymmetric thrust condition.

If you are wondering about flying 102 KCAS in a jet at 13,000 ft., I was too. The system is designed to prevent you from flying slower than V_{AOA}, 8% above the stall while holding a fixed altitude or 1.03 V_S, (V_{LIM}) with full aft stick. Pilots are not provided an AOA indication, but the primary flight display (PFD) includes all the necessary low-speed and high-speed awareness tapes. Since they are based on AOA, all warnings are correctly compensated for aircraft weight and configuration, as well as environmental conditions. As a former U.S. Air Force pilot, I don't understand why so many manufacturers are reluctant to provide their pilots with AOA, but the robust symbology in the Praetor's PFD is the next best thing.

On the opposite end of the envelope, the autothrottles will reduce thrust and the FBW will adjust aircraft attitude to prevent an overspeed. You can override the throttles, but the FBW hard limits will not allow you to stall or overspeed the aircraft. This is on par with other FBW systems I've seen. Each manufacturer uses different margins before a limit is reached and a tactile stall-warning system may or may not be employed.

Approach and Missed Approach

My plan for the remainder of the flight was to fly a fully coupled approach to a missed approach, followed by a hand-flown approach to a landing. I normally do this to fully appreciate the performance of the automation and the manual flying characteristics of the airplane. (We can't let the electrons have all the fun.)

Embraer touts the Praetor 600's ability to fly Special Authorization (SA) Category I instrument approaches down to 150-ft. synthetic vision guidance systems (SVGS) radio altimeter (RA) decision height (DH). I wondered what the utility of this was versus a standard instrument landing system (ILS) approach. With a little research into FAA Order 8900.1, Volume 3, Chapter 18, I found the answer. An ILS SA using SVGS gets you down to 150 ft. RA DH even on runways without touchdown zone or centerline lights. Operators will need C059 operational approval. There aren't many such approaches in the U.S., although the number is growing. You can identify them by the "SA" in the title, the "SA CAT I ILS" in the minimums section, and the "RA" DH. See the Logan International Airport (KBOS) ILS Rwy 4R SA Cat I for an example. Melbourne does not have any qualified approaches, so I opted for a more-conventional RNAV approach to LPV minimums.

We asked for and were cleared to fly the RNAV (GPS) Rwy 27L back at Melbourne Orlando. The autopilot and autothrottles provided an almost effortless arrival, keeping on top of our programmed altitudes and airspeeds. For our first approach at just over 29,000 lb., our Flaps 3 (21-deg.)

V_{REF} was 108 KCAS and our approach speed was 113 KCAS. The computed unfactored landing distance was 2,351 ft.

The approach was remarkable because it was unremarkable; all configuration changes were met with smooth pitch and speed transitions, and we settled nicely on the vertical path. I was starting to see the utility of the Praetor's HUD once the nose came down into an approach attitude and much of the symbology appeared right where I wanted it. (It could also be that I was doing a better job of keeping my head in the correct zone to see everything.) While the LPV minimums were 200 ft. above the runway, we took it to 100 ft. After I pressed the TO/GA switch on the left throttle, the power came up and the pitch rotated into the TO/GA flight director commands. Bennett retracted the flaps partially, raised the landing gear, and then got the rest of the flaps. We climbed smartly to our missed approach altitude, ready for another approach.

Approach and Landing

I disengaged the autopilot for the second approach and discovered the "flight path stable" philosophy of the FBW made it easier to hand-fly a stable approach, even for my first attempt in the aircraft. The "heads down" needles centered nicely, and I transitioned to the HUD and found the "heads up" symbols right where they needed to be.

For most professional pilots, the quality of a landing is judged by the quality of the approach (was it stable?) and the touchdown (was it in the touchdown zone and on speed?). Pilots adept at using a HUD have an

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An example view from the Praetor 600's HUD prior to landing.

unfair advantage in both areas if the HUD is properly instrumented. Allow me to explain.

I was obviously too busy to take a photo, but Embraer provided one showing an accurate view of what a pilot can expect. I am a big fan of having a flight path angle (FPA) displayed with a flight path vector (FPV). In the Embraer example, the FPA is set to -3.0 deg. and is seen as a series of dots flanked by "-3.0" on either side. The FPV is a circle with a horizonal line on either side (wings) and a vertical line on top (the tail). It is key to remember that the FPA draws an angle from the airplane, not from the ground. It shows a true glidepath, but it doesn't show where the aircraft is headed. For that you have the FPV. You can guarantee a stable approach that ends in the proper touchdown zone if you aim the FPV short or long of the touchdown zone until the FPA is on the touchdown zone. And then place the FPV right on the FPA. Easy. That's what I did until it was time to flare, and then with a gentle pull on the stick until I had the right attitude. The nose stayed there until the wheels lightly touched. Out of habit I gently lowered the nosewheel to the runway but am told the aircraft will do that for me.

Activating the thrust reversers was a simple matter of lifting up on levers under each throttle and pulling aft. We had the autobrakes set to medium, which gave us a 10 ft./sec^2 deceleration. We could have selected LO for a gentler 6 ft./sec. ^{2}, or HI for the maximum available deceleration. Even using the medium setting, we used less than 3,000 ft. of the runway.

After we taxied in, shut down and deplaned, I thought of how comfortable I was after just one flight. The Praetor 600 is what we used to call "an honest airplane." It reacts to pilot inputs as the pilot expects. I can see any competent pilot who comes up the ranks from smaller aircraft having no difficulty graduating into the world of super-midsize business jets. But the Praetor 600 also has a delightful surprise for those coming from longer-range airplanes. It has no shortage of safety features that are usually reserved only for more-expensive business jets. There was indeed a boundary of sorts between the super-midsize business jet class and the larger categories. If you wanted true fly-by-wire and all the flight-envelope safety protections that go with it, you had to look to the longer-range aircraft. But not anymore. That boundary has been broken by Embraer's Praetor 600.

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*—**James Albright** is a retired U.S. Air Force pilot with time in the T-37B, T-38A, KC-135A, EC-135J (Boeing 707), E-4B (Boeing 747) and C-20A/B/C (Gulfstream III). Since turning civilian, he has flown the CL-604, Gulfstream GIV, GV, G450, and now the GVII-G500. He is the webmaster and principal author at Code7700.com*