Thrill from Brazil

Phenom takes the stage

Embraer's Phenom 100 is the latest entrant in the light jet market, and this may work to its advantage in the long run. The airplane presents its competitors—chiefly Cessna's Mustang, in Embraer's eyes—with a number of design and performance strengths, all of them the product of Embraer's 40-year experience in building regional airliners. Embraer, new to the business jet market, announced it was embarking on the Phenom line (which includes a bigger stablemate, the Phenom 300) in 2005, well before the current economic downturn, and certification and first deliveries of the Phenom 100 occurred in December 2008. As of early April the first 12 Phenoms had been delivered—all to customers in the United States—and more than 500 orders had been placed.

According to one spokesman, Embraer's goal was to give the Phenom "balanced" performance. As it was defined, this means that no element of the airplane's design, systems, or performance would be better or worse than any other competing airplane's That's a pretty modest goal. Then again, another official said that the Phenom

BY THOMAS A. HORNE

PHOTOGRAPHY BY CHRIS ROSE

Embraer's signature ram's horn yokes and the Prodigy avionics suite dominate the Phenom 100 cockpit. The GFC 700 flight control system and integrated ESIS display are glareshield-mounted.

was designed to meet objectives targeted in market studies—studies that said customers prized above all other considerations docile flying characteristics, a comfortable cabin, and the ability to fly four 200-pounders 1,100 nm. That's a target that eludes many light jets.

A recent visit to Embraer facilities; two, two-hour flights in the airplane; and a first-hand look at the Brazilian completion center gave me a good look at the Phenom 100. Because I flew PP-XOM, the number-one prototype, there wasn't a chance to evaluate the cabin. XOM is a flight-test airplane, chock full of data-collecting instruments.

An IFR intro

My days with the Phenom began at Embraer's main factory in São José dos Campos, where I met with Embraer captain and instructor-examiner Luiz Cesar. It was IMC and raining when we left on the company shuttle—a 30-seat Brasilia turboprop twin—bound for the Gavião Peixoto airport (SBGP). That's where Embraer has its flight test center, and where Phenoms are built. The weather never really let up during my two-day visit, and conditions stayed IMC. At Gavião Peixoto, Cesar and flight test engineer Maximilian Kleinubung briefed me on the Phenom's procedures, power settings, and handling characteristics, then it was off to the airplane.

Starting was super-simple, thanks to the full-authority digital engine controls (FADECs). Just lift and turn the start switch momentarily to the Start position, then let it spring back to Run. Monitor the engine start by watching the engine gauges on the multifunction display (MFD)—especially the interturbine temperature (ITT) gauge, for signs of an overtemp.

With our 7,678-pound empty weight, three aboard, 660 pounds of test equipment, and full fuel, our ramp weight came to 10,456 pounds. Max takeoff weight is 10,471 pounds. That's the first clue that this is *not* a *very* light jet. We'll soon point out other such features. We figured our V-speeds for this 25-degree Celsius day: V_1 (takeoff decision speed)—104 KIAS; V_R (rotation speed)—105 KIAS; and V_2 (take-off safety speed)—108 KIAS.

The Prodigy

The cockpit is dominated by the Garmin G1000-based avionics suite that Embraer calls the Prodigy. The Prodigy has been tailored to the Phenom 100 in several ways. Among them are systems synoptic pages that graphically depict the condition of the airplane's fuel, electrical, ice protection, and environmental systems. Engine information is presented on a large vertical strip at the left of the MFD, and at the lower left of the screen are landing gear, flap, trim, battery voltage, and fuel flow and quantity indicators.

In addition to the 12-inch-diagonal MFD are two identical primary flight displays, all of which are interchangeable. Using a reversionary display mode, this lets you dispatch with just two operating screens. Dual attitude heading reference systems (AHRS), terrain awareness warning system (TAWS), traffic information system-broadcast (TIS-B), and full WAAS GPS capability come with the Prodigy, as does an integrated emergency standby instrument system (ESIS). In a unique twist, the ESIS has its own AHRS, which gives the airplane a total of three such reference systems. If you're having a really bad day and lose both main AHRS, the ESIS can power a PFD.

Data entry can be made with knobs on the MFD bezel, *a la* Garmin 530/430, or by using a central keypad. The GFC 700 integrated flight control system interface is on the glareshield. Bottom line: Anyone familiar with the 530/430 knobology will have little difficulty making friends with the Prodigy's flight plan functions—what's different are the altitude-preselect, VNAV, and airway features that accompany the latest G1000 software iteration (revision 22) used in the Phenom 100.

Takeoff and climb

For takeoff, I advanced power to the thrust levers' "TO" setting. After that it was V_1, rotation, and liftoff, followed by gear retraction with a positive-rate climb. For rotation, Kleinubing's data showed a 20-pound aft-stick force to make the Phenom lift off. Then the drill called for accelerating to V_2+10 at 400 feet agl, enagaging the heading and autopilot functions on the GFC 700, climbing away at 160 KIAS, retracting the flaps from their takeoff (flaps 1, or 10-degree deflection) setting, reducing power to the CON/CLB (max continuous, climb) setting, then accelerating to 200 KIAS for the remainder of the climb. It all happens about as fast as it takes to read those last four sentences.

Initial climb rates were in the 1,500-fpm range, but with altitude the Pratt & Whitney PW617F engines experience a drop-off in power—all turbine engines do. Because of higher-than-standard temperatures (ISA +15, on average) climb rate dropped to 350 fpm as we passed through FL340. Using the ship's ice-protection system, which taps engine bleed air to inflate wing de-ice boots, will also diminish climb rates. In all, it took us 34 minutes to reach our final cruise altitude of FL350.

Cruise news

Max cruise power at FL350 turned in 352 KTAS (or Mach 0.594), well off Embraer's advertised maximum speed of 390 KTAS. The ISA +13 conditions explain the discrepancy; a second flight at FL340 and ISA +15 gave us a 348-knot true airspeed.

Under cooler conditions at or below standard temperatures, Embraer says that the 390-KTAS number is easily attainable.

It all goes to demonstrate just how sensitive turbine power output is to temperature deviations. Weight and altitude are other factors. Most light jets cruise fastest at light weights and in the low-30,000-foot range. By the way, the Phenom 100's 390-knot max cruise speed is some 20 knots faster than originally projected.

Yes, the Pratt & Whitney PW617F engines can each put out healthy, 1,695-pound maximum thrust levels. But at altitude, even slightly warmer than standard conditions rob power. Fuel burn at max cruise worked out to 335 pph (approximately 50 gph) per side, a nicer reminder of the value of "small" jet engines.

The Phenom's PW617 engines put out a lot of residual thrust. For taxiing, you'll use the brake-by-wire system to keep speeds down.

The Phenom's OvaLite cabin means ample elbow room, and the BMWDesignworks interior gives back-seaters comfort and clean lines. An aft lavatory is standard. The airplane pictured for this article—serial number 19—was sold and imported by Eagle Creek Aviation Services of Indianapolis, which has an Embraer Phenom authorized service center at its Naples Jet Center location in Naples, Florida.

For long-range cruise, power was dialed back to yield a 308-pph (46 gph-per-side) fuel burn. The result was a 336-KTAS/0.567Mach performance. Cesar pointed out that at this point in the flight it had been 48 minutes since takeoff, and the Prodigy was telling us that we still had a two-hour, 18-minute endurance to look forward to.

After sampling cruise speeds, I descended to 15,000 feet for some air-work, using the GFC 700's FLC function to deliberately drive the airspeed to the Phenom's "barber pole," or maximum Mach number. In the process, we saw a 6,000-fpm descent rate. But as airspeed closed in on barberpole, the flight control system automatically pitched the nose up—a great feature that protects against overspeeds.

Shaker time

We had loaded 15,000 feet into the Prodigy, so the airplane leveled itself and I began a couple of maneuvers to test the airplane's stall warning system. After disconnecting the autopilot and extending gear and flaps, I held altitude while slowing to 135 KIAS. Then it was a matter of idle power and raising the nose until the stall warning horn went off—at 102 KIAS. At 97 KIAS, the stick pusher fired, automatically lowering the nose. The Phenom 100 requires a stick pusher because, like many T-tailed airplanes, at high angles of attack its horizontal stabilizer can become blanked out—rendered ineffective—by the turbulent airflow coming from the wings. The pusher typically fires

SPECSHEET

Embraer Phenom 100

Average equipped price: $3.6 million

Specifications

Powerplants	2 Pratt&Whitney Canada PW617F-E, 1,695 lbst ea, 1,820 lbst @Automatic Thrust Reserve (10 min. max)
Length	42 ft 1 in
Height	14 ft 3 in
Wingspan	40 ft 4 in
Wing area	202 sq ft
Wing loading	51.8 lb/sq ft
Power loading	3.08 lb/hp
Seats	2 + 5
Cabin length	11ft
Cabin width	5 ft 1 in
Cabin height	4 ft 11 in
Max ramp weight	10,516 lb
Max takeoff weight	10,472 lb
Max zero fuel weight	8,444 lb
Max useful load	3,384 lb
Max payload	1,312 lb
Max payload, full fuel	578 lb
Max landing weight	9,766 lb
Fuel capacity	209.4 gal (2,806 lbs)
Baggage capacity, forward	66 lb
Baggage capacity, aft	353 lb, 55 cu ft
Baggage capacity, wardrobe	66 lb
Lavatory cabinet	33 lb

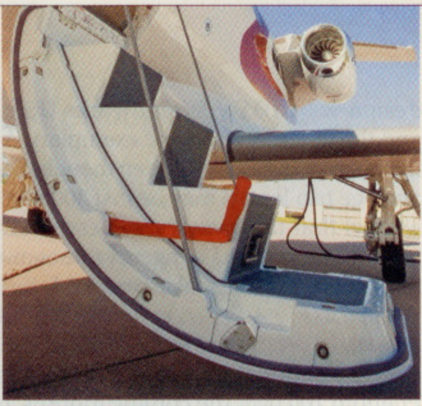
Performance

Takeoff field length, flaps 1	3,400 ft
Max demonstrated crosswind	17 kts
Max tailwind component, takeoff and landing	10 kts
Cruise speed/range w/NBAA fuel rsv @ Max cruise setting, 33,000 ft	390 kt/1,178 nm
Cabin altitude at FL410, 8.3 dpsi	8,000 ft
Max operating altitude	41,000 ft
Landing distance, flaps 3	2,699 ft

Limiting and Recommended Airspeeds

V_1 (takeoff decision speed), flaps 1	102 KIAS
V_R (rotation), flaps 1	104 KIAS
V_{MC}, takeoff (min control w/one engine inoperative)	97 KIAS
V_{MC}, landing (icing conditions)	97 KIAS
V_{MC}, landing (no icing conditions)	86 KIAS
V_2 (takeoff safety speed), flaps 1	107 KIAS
Minimum airspeed in icing conditions	150 KIAS
V_{FE} (max flap extended)	
@10 degrees	200 KIAS
@26 degrees	160 KIAS
@36 degrees	145 KIAS
V_{LE} (max gear extended)	275 KIAS
V_{LO} (max gear operating)	
Extend	180 KIAS
Retract	180 KIAS
V_{REF} (reference speed, final approach), flaps 2	105 KIAS
V_{MO} (max operating speed, SL to 28,000 ft)	275 KIAS
M_{MO} (max Mach number, above 28,000 ft)	0.7 M
V_{S1} (stall, clean)	100 KIAS
V_{SO} (stall, in landing configuration)	77 KIAS

For more information, see the Web site (www.embraerexecutivejets.com). All specifications are based on manufacturer's calculations. All performance figures are based on standard day, standard atmosphere, sea level, gross weight conditions unless otherwise noted.



For a light jet, the Phenom 100 has big-airplane touches—such as a full-size airstair door and beefy, trailing link landing gear. Low-profile pneumatic deice boots, inflated by engine bleed air, are used on wing leading edges.

at a 14-degree pitch-up angle; stall comes at 17 to 18 degrees nose up, according to Cesar. When the ice protection system is armed, an ice mode reduces the pitch angle at which the pusher fires.

On approach

Next came an ILS approach to Runway 15 at nearby Campinas Airport (SBKP), in heavy rain and a 500-foot ceiling. The drill is to fly to the outer marker (or final approach fix) at 150 KIAS with flaps 1 extended and gear retracted. At the FAF, lower the gear, go to flaps 2 (a 26-degree deflection), and slow to 120 KIAS as you go down the glide slope. Our V_{REF} with full flaps (flaps 3, or a 36-degree deflection) worked out to 98 KIAS. The Prodigy's flight director made the approach a breeze, but Campinas tower didn't want us to land, claiming too much traffic. So at decision height it was power up, pitch up, and climb away at 116 KIAS while raising gear and flaps.

Three subsequent RNAV approaches back at Gavião Peixoto's runways 2 and 20 called for basically the same configuration changes at the same stages of the approaches. After one touch and go, I got to sample the airplane's engine-out behavior. Cesar pulled the left engine during the initial stages of the climbout. Then things got interesting. To counter the yaw from the asymmetric thrust, I needed to apply a full 70-plus pounds of rudder pressure. At the same time, I needed to climb away at CON/CLB power and what Embraer calls V_{AC} (approach climb speed, their name for V_2, or takeoff safety speed)—which that day was 116 KIAS—and simultaneously raise the gear and flaps. Even at our weight, the one-engine-inoperative climb rate turned in a 700-fpm performance. How did I know that I was applying 70 pounds of rudder pressure? After all, it's hard to quantify from the pilot's perspective. The answer is that Kleinubung was back there, watching his monitor while the rudder pedal force peaked at exactly 77.24 pounds of pressure. That's probably when I noticed my right leg was getting a major workout. It would have been working even harder had the automatic thrust reserve (ATR) feature been engaged. You do this by shoving the good engine's thrust lever all the way forward to the ATR stop. ATR bumps the maximum power of the operating engine to 1,820 from 1,695 pounds of thrust should an engine fail after takeoff.

I used the electric rudder trim (all trim controls are electric; there are no manual trim wheels) to bring the rudder-force requirement down to a more manageable 20 pounds, and at the recommended 1,000 feet agl engaged the autopilot, then set the FLC for 124 KIAS. By now we were back in the soup, and being vectored around for another RNAV approach. This time, we'd use flaps 2 and a V_{REF} of 119 KIAS. The approach went well enough, but around 90-percent N_1 was needed to prevent any sinking after the landing gear were extended. Cesar said that extending the gear nearly doubles the Phenom 100's drag, and with one engine out, you need to watch your descent rate on approach like a hawk.

As for landings, pilots of average skill (that's me) should have no trouble. There

Embraer wanted the Phenom to be simple to operate, and the pilot's side panel proves it. Electrical and oxygen switches are kept to a minimum. Pushbutton switchlights are used for activating GPU and emergency electrical power sources.

are no special tricks or techniques—even when landing with an engine out. Just flare ever so slightly and the mains roll on very nicely. Don't let the nose-down picture created by the view over the steeply slanted nose trick you into thinking you'll land flat, and tempt you to overflare.

If there's one caution it's to be sure to maintain the correct approach speed. This can be critical if you're facing a landing on shorter runways. The Phenom 100 has no spoilers, speed brakes, or reverse thrust, so a too-hot landing is a definite no-no. The somewhat grabby brakes—a brake-by-wire system that uses hydraulic actuators—are quite effective, but they're not there to compensate for excessive pre-touchdown floating.

Oh, the cabin

After the flights, Embraer's Communications Strategies Advisor Daniel Bachmann showed me the Phenom 100 and 300 final assembly and completion center at Gavião Peixoto. Until the Phenom's Melbourne, Florida, facility is finished (projected for 2011), all Phenoms will be delivered from this location.

Bachmann gave me elastic booties, and I went inside a newly completed airplane to sample the interior. There's plenty of room, thanks to the Oval-Lite design that makes for a wide-oval cross-section. There are independent temperature controls for the cabin. The comfortable seats and interior appointments let four travel in style; interior design is by BMW Designworks USA; and the fit and finish were exemplary. A flushing lav is standard. "Even though the average trip length may be just 300 nm, we feel that the lavatory was essential because we know passengers value comfort over all else," a spokesman said.

A work in progress

Expect a series of improvements to the Phenom 100 over the coming months. I used three upgrades myself, during the evaluation flights in PP-XOM: Highway-in-the-Sky (HITS) flight-path symbology; a synthetic vision system (SVS) being developed for the Prodigy; and a Constant Speed Cruise (CSC) feature that functions as a "cruise control" in level flight only. Push the CSC button on the glareshield controls and N_1 automatically adjusts within a 15-percent range to maintain the existing cruise speed. Embraer is also evaluating whether to install spoilers on the Phenom 100, as well as cockpit voice and flight data recorders, an electronic flight bag, and an enhanced takeoff performance package that would tweak the FADECS to reduce published takeoff distances from 3,400 to 3,125 feet. All of these upgrades would be available as a retrofit to existing airplanes.

There's news in the training department as well. Phenom training is conducted through a joint Embraer-CAE SimuFlite training agreement. The three- to four-week training curriculum is currently using flight training devices and customer airplanes to conduct training, but the first Phenom simulator is scheduled to be commissioned in July 2009—at CAE's Burgess Hill, United Kingdom, training center. Another simulator is planned for the CAE-SimuFlite training center in Scottsdale, Arizona. Minimum training requirements will be 15 hours in the simulator and 16 hours in the airplane for those seeking single-pilot type ratings.

In all, the Phenom 100 delivers on its promises—as long as temperatures are on the cool side. It's a sturdy (airframe life limit is 35,000 hours), capable, comfortable airplane that handles well, is a great instrument platform, rides turbulence with aplomb, is long on comfort, and is backed up by 600-hour/12-month service intervals and datalinked fault diagnostics that communicate to service centers in near real time. My guess is that Embraer's business jet family—the Phenoms 100 and 300, the Legacy 450, 500, and 600 series; and the 19-passenger Lineage 1000 (which is based on the company's E190 airliner)—is only beginning its claim on market share, much to the dismay of the competition. AOPA

E-mail the author at tom.horne@aopa.org.

Fly along with Editor at Large Tom Horne as he flies the Phenom 100 in the skies over Brazil. www.aopa.org/pilot (keyword: Phenom flight).

TURBINE TALK

Turbine temps **galore**

RAT-a-SAT-TAT

By Thomas A. Horne

It's in high-altitude cruise flight that turbine aircraft incorporate many sorts of different temperature measurements. Pressure altitude, indicated airspeed, and temperature are the three variables that determine true airspeed, as well as Mach number—but what kind of temperature? The performance sections of turbine flight manuals typically mention two or three different types of temperature. Why the fuss?

Two temperatures that are often displayed on the primary flight displays (PFDs) of recent-model airplanes are static air temperature (SAT) and total air temperature (TAT). Other temperatures can include ram air temperature (RAT) and the old standby—outside air temperature (OAT).

The reason for all these temperature varieties is chiefly the compressional and frictional heating that occurs in the thin air at altitude. A plain-Jane OAT probe moving along at 200-plus knots in the flight levels simply can't give an accurate rendition of ambient air temperatures. That's because air friction and the compressibility of the air caused by the onrushing flow pushing against the airplane cause indicated temperature to rise. This "false-high" temperature indication would yield an incorrect true airspeed computation. It will also make for incorrect calculations of the international standard atmosphere (ISA) conditions in the surrounding air.

Here's a quick, basic rundown of the main temperature terms used in turbine cruise calculations:

- RAT reflects the increased temperature created by compression and air friction at high speeds and altitudes.