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Eclipse 500 Program Update

We fly the first VLJ in production configuration during a break in the race to March 2006 certification.

Text by Fred George
Photography by Phil Forbert

Eight years ago, Vern Raburn, president and CEO of Albuquerque-based Eclipse Aviation, made the biggest gamble in light jet aviation since Bill Lear introduced the Learjet 23 in 1963. Raburn bet that folks would buy hundreds, if not thousands, of twin turbofan aircraft if they could be sold for less than $1 million. Best known outside aviation circles as a high-tech industry entrepreneur, Raburn is a strong believer in price elasticity, a concept he claims is often ignored in general aviation. The main lesson from the personal computer world is clear: Offer more value and drive down price, and you'll wear out a lot of ballpoint pens signing sales contracts.

Raburn's vision was shared by Dr. Sam Williams, chairman of Williams International, who dreamed of reinvigorating general aviation by developing a new generation of affordable turbofan engines. Both men felt that there was nothing wrong with the general aviation market that breakthrough airplanes at lower prices couldn't cure. Lear had priced his light jet at $495,000 in 1963 dollars, a fraction of what contemporary jets cost at the time. Raburn and Williams both dreamed of selling a new generation of jet aircraft for not much more in mid-1990s dollars — millions less than the least expensive entry level jet at the time.

As always in aviation, the pacing item would be propulsion. Williams believed he could build and sell light turbofan engines for as little as $50,000 in volume production. Raburn immediately was hooked on the concept, so he joined forces with Williams to develop a radical new very light jet (VLJ) powered by Williams' revolutionary turbofan engines. Raburn would raise most of the capital for the program. Williams would supply most of the engineering and development. Both would share the revenues from sales.

"In aviation, it's always the engines that have changed things. Sam's company already had won NASA's GAP [General Aviation Propulsion] contract. I liked this engine technology because it was a game changer. I saw this as a really, really, really cool opportunity," Raburn explained. Dr. Williams' FJX GAP engine evolved into the 770-pound-thrust EJ22 fanjet, intended to power what would become the Eclipse 500. The Williams V-Jet II proof-of-concept aircraft was the inspiration for the Eclipse 500. The price was pegged at $837,500.

The Eclipse 500, powered by Williams EJ22 engines, first flew on Aug. 26, 2002. It was its last flight with those fanjets, as well. Ongoing problems with the EJ22, according to Raburn, forced Eclipse to drop the Williams engine by year's end.

Some folks thought that was the end of the Eclipse 500 program, but they soon came to realize that the airplane was powered more by Raburn's passion than by Williams' engines. Raburn and his determined team evaluated alternative engine designs, such as the Agilis TF1000, Honda HF118, Honeywell LTF101 and Pratt & Whitney Canada PW600 in late 2002, and the following February tapped P&WC to provide the PW610F — a 900-pound-thrust derivative of the PW615F chosen to power Cessna's Citation Mustang. Fuel capacity would be increased by adding small tiptanks. Eclipse also raised the price to nearly $1 million for existing customers. New orders were taken at $1.2 million. Type certification and initial customer deliveries were rescheduled for first quarter 2006.


Vern Raburn, Eclipse president and CEO

But the PW610F wouldn't even be ready for flight test until late 2004. So, in May 2003, Eclipse resumed flight tests with a pair of "interim" Teledyne Continental model 382-10E cruise missile engines mounted on its aircraft. This enabled Eclipse to continue aerodynamic development of the airframe, even including leading edge ice shapes, pending the arrival of its new Pratts.

Always pressing the limits of technology, Raburn planned to fit the PW610Fs with brushless AC starter/generators that would have several times the TBO of conventional DC starter/generators with brushes. Potentially, this would lower operating costs and increase dispatch reliability.

Nice try, but no go. The vendor couldn't develop the electronics needed to support the start function of the brushless units on time, so Eclipse had to fashion its own monstrous kluge kit, mounted in the cabin, in time to get the engines started for the first flight in fourth quarter 2004. Not unexpectedly, there were several fits and starts as Eclipse's engineers struggled with the starter electronics. Predictably, Eclipse reverted to conventional DC starter/generators for its subsequent flight test and production aircraft.

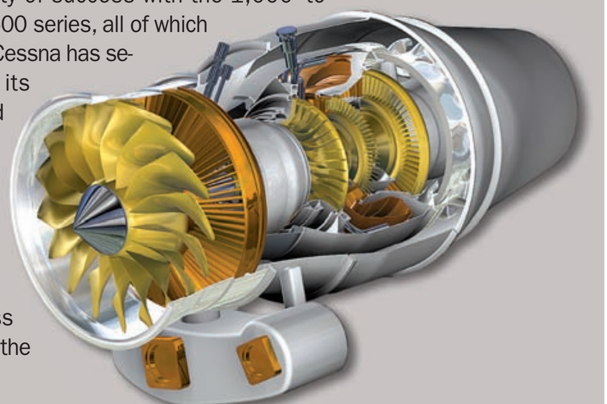
Compounding the start problems, Eclipse also had numerous problems with the Hispano-Suiza FADEC and some growing

Pratt & Whitney Canada PW610F

The Eclipse's PW610F engines are FADEC-equipped for easy operation and rugged for low operating cost. At entry-into-service in 2006, they'll have a 1,750 HSI midlife inspection interval and a 3,500-hour TBO. Projected overall cost is about $150,000 per engine, according to Eclipse officials.

Having a thermodynamic rating of 1,112 pounds of thrust, they're flat-rated to 900 pounds of thrust for takeoff aboard the Eclipse 500 and capable of 990 pounds of thrust in APR. The engines feature a 14-inch, one-piece, integrally bladed fan and deep-fluted exhaust mixer nozzle for improved high-altitude performance and lower FAR Part 36 noise levels. P&WC isn't using any exotic materials inside and the engine will have modest a pressure ratio by today's standards. The result is lower overall operating costs.

P&WC is having plenty of success with the 1,000- to 3,000-pound-thrust PW600 series, all of which will be FADEC-equipped. Cessna has selected the PW615F for its Citation Mustang and Embraer tapped the PW617F for its newly announced VLJ. P&WC is banking on the PW600 to be a large production volume engine, rivaling the success of the PT6A turboprop in the last century.



pains with the PW610F. Hispano-Suiza remains one of Eclipse's problem vendors, according to Raburn, but he cannot say enough good things about product support from Pratt & Whitney Canada.

In mid-2004, Raburn invited *B&CA* to witness the first flight in late November, rescheduling several times until Dec. 31, when at 10:16 a.m., the first flight of s.n. 1087, the first Eclipse 500 in full production configuration and powered by the PW610F, took place. We watched the entire first flight from inside Raburn's Turbo Commander as he flew chase on the test aircraft. Both aircraft taxied into the Eclipse Aviation compound afterward, where Raburn led a celebration attended by nearly 1,000 people. "We promised we'd fly the aircraft with its new engines before the end of 2004 and we did. Eclipse is back. Eclipse is here to stay. And Eclipse is going forward," Raburn beamed.

Eclipse flight test pilots had completed a second test flight by late afternoon. At the end of the day, as the bubbly started flowing, Raburn promised *B&CA* we'd be flying the aircraft by May 2005. He kept his promise, as we've described in the First Flying Impressions section of this report.

Breakthrough Technologies — Sharp, Doubled-Edged Swords

Revolutionary new engines and starters are but two of the potential breakthrough technologies embodied in the 500. Raburn often has said that the aviation industry is so risk averse that technological progress is painfully slow, manufacturing costs are among the highest of any industry, quality is marginal and reliability is low. This is why airplane prices are so high and they cost so much to operate, according to Raburn.

When Raburn embarked upon the Eclipse project, he "saw a technological convergence that could change everything except aerodynamics." It was time to abandon World War II aircraft manufacturing methods, he said, along with "Rosie the Riveter in her polka dot hat whistling 'Boogie Woogie Bugle Boy.'" He saw, for example, the potential for high-speed CNC milling that could make integrated one-piece parts. Watching automakers and computer manufacturers streamline their fabrication processes, he was inspired to try new methods to produce aircraft that "could reinvigorate existing markets and create all-new ones."

So, Eclipse embraced new technologies and new general aviation suppliers since its inception, even if they didn't have a proven track record in civil aviation. But Raburn wasn't ready to buy off on composites. In contrast to the V-Jet II, the Eclipse 500's primary structure would be all-aluminum because the aviation industry has upwards of 85 years' design, fabrication, repair and fatigue experience with the material. By comparison Raburn believes that composites are too much of an unknown commodity in the aviation community regarding such issues and that composite construction isn't well suited to high-volume production. Still, he has high hopes for Boeing's 787 Dreamliner as a composite pioneer.

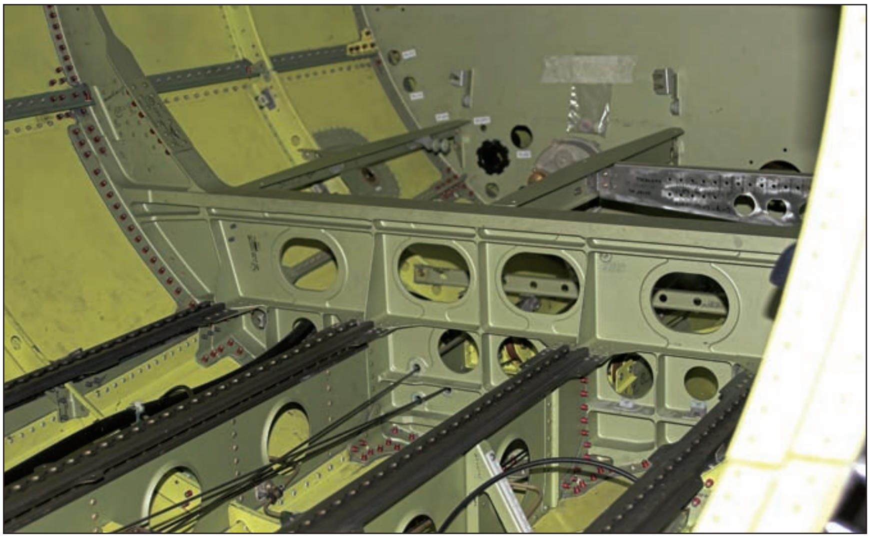
Old aluminum construction methods, however, are expensive since it can take from 4,000 to 5,000 labor hours to build a light jet airframe. Raburn knew he would have to slash those hours to keep his price low. Accordingly, Eclipse employs high-speed CNC milling and friction stir welding

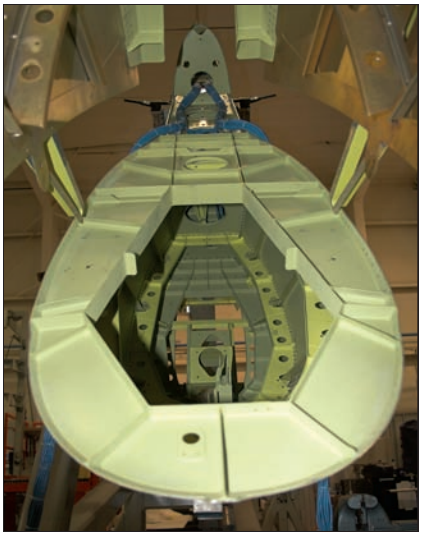
Similar to CNC milling processes used by Bombardier, Dassault and Raytheon to fabricate their latest aircraft, Eclipse is the first aircraft manufacturer to use such techniques to build a VLJ. Wing spars, chord-wise frames and bulkheads, among many other major airframe components, begin life as large billets of aluminum fed to CNC mills that remove 90 to 95 percent of the mass to transform them into complex shaped parts. CNC milling makes possible construction of one-piece components that replace built-up assemblies of dozens of parts joined by hundreds, if not thousands, of fasteners.

Unlike Bombardier and Dassault that have extensive in-house manufacturing centers, Eclipse won't do any heavy construction or machining at its assembly plant at Albuquerque International Sunport. Instead, the company farms out processes like CNC milling to other firms, such as Fuji Heavy Industries (FHI), Ducommon AeroStructures, Compass Aerospace and Empresa Nacional de Aeronáutica in Chile. These firms have high-speed CNC mills and manufacturing methods that can support high volume production of major subassemblies.

Friction stir welding (FSW), now used extensively in missile and marine construction, was invented by The Welding Institute at University of Cambridge. It uses a spinning mandrel that bears down on a lap joint hard enough to create friction heating that welds the two pieces of material together without imparting enough heat to liquefy the metal. The rotating tool bit translates along the lap joint to create a continuous weld that's stronger than a string of mechanical fasteners. FSW is at least as strong as structural adhesive bonding, but the resulting joint weighs much less, is considerably faster to fabricate and should cost less in high-volume production.

Prior to the Eclipse 500 development program, FSW never had been approved as a process for civil aircraft construction. Seeing the promise of greatly reduced construction costs, Eclipse developed FSW for aircraft fabrication and earned FAA approval for us-





The one-piece main spar carry-through structure (left) and the "banjo" (right), the integrated aft tailcone bulkhead/vertical tail main spar, are milled out of massive blocks of aluminum by high-speed CNC milling machines. This is emblematic of how Eclipse is wringing out thousands of assembly hours from the EA 500 production line.

ing FSW in the primary airframe structure, including fuselage and wings. Eclipse invested $20 million in FSW, spending about one-third for tooling and two-thirds for development. The payoff is the elimination of almost 7,400 fasteners and 1,000 assembly hours, according to Oliver Masefield, Ph.D., the firm's senior vice president and senior fellow. There are almost 442 linear feet of friction stir welds in the aircraft's pressure vessel, wings and aft fuselage sections.

The result is no more than 600 hours to assemble the aircraft in Albuquerque, outside of paint work, according to Raburn, plus a five-fold improvement in tolerance control. The goal is to produce each aircraft in Albuquerque in 10 days, including one and one-half days in production flight test and two in the painting process.

"We're fanatical about driving out cycle time and increasing quality," Raburn said. "The single biggest cost in building a conventional aircraft is overhead, including parts inventory, manufacturing plant and the cost of capital. We've modeled Eclipse on the best Japanese lean practices. There, the synonym for 'lean' is 'continuous improvement.'"

Raburn admits that Eclipse has had to fire more than a few partners whom he felt couldn't perform up to snuff. BAe Systems, for example, was slated to supply the autopilot. Now it's Meggitt. Metalcraft Technologies was going to build most of the fuselage. Now, Ducommon and Compass will supply major subassemblies that will be completed in-house by Eclipse. Cal-Draulics was tapped to build the landing gear, but now it's Mecaer's job. Exterior lighting was to be furnished by Devore Aviation. LSI now will supply the LED position, beacon and strobe lights, plus HID landing lights.

"We always assume a partner can live up to its promises, until it proves otherwise," Raburn explained. Old school pundits might say this approach is overly optimistic and leads to program delays. Raburn, though, is determined to achieve new standards for functionality, dependability and low operating cost. More changes are likely. Several suppliers have earned below average marks for inadequate ramp rate readiness for high-volume production that is slated to begin in 2007. They must grow production capacity by at least 50 percent to meet Eclipse's production targets. Eight of the 51 suppliers are being watched closely, because of ramp rate deficiencies, process control problems or development shortcomings.

While supplier performance remains a concern, Raburn's 425-person team in Albuquerque is confident they can hold up their end of the development schedule. Weight control has become an obsession. The aircraft was 110 pounds overweight, but Eclipse had worked off 35 of those pounds by early June. While suppliers and staff remain under the gun to reduce weight further, Raburn said, "We're pretty comfortable we'll be able to make our [projected] performance and range numbers."

Interior design, maintenance access and weight control also are top priorities during the development process. The entire interior is designed to be removed and replaced in two to three hours. All scheduled maintenance operations, including engine changes, are being designed to be accomplished in a single eight-hour shift. Fly all day and fix at night is how Eclipse is running its flight test program. The object is to perfect routine maintenance processes for customers, as much as maximize aircraft availability for flight test.

Technicalities aside, we wanted to know how it flew.

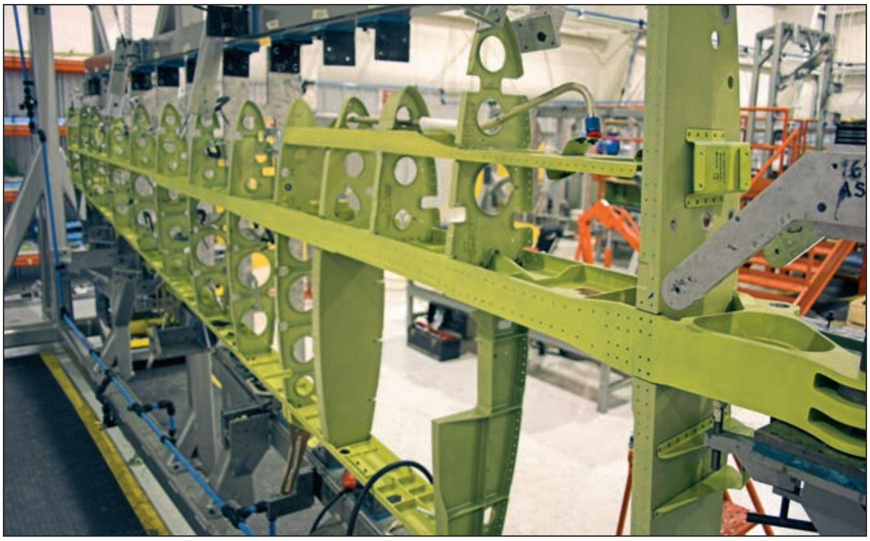
First Flying Impressions

Just after returning from EBACE 2005, we strapped into the left seat of s.n. 109, the third flight test aircraft and the one Eclipse will use primarily for avionics and electric system certification. Terry Tomeny, director of flight test engineering, occupied the right seat as pilot in command.

Aircraft 109 first flew on April 21, 2005, and had logged less than 15 hours when we took the controls on the 18th and 20th missions. As a result, many functions and systems were yet to be made fully operational. Flight operations were limited to daylight VFR, the ceiling was limited to 25,000 feet and there was a 230 KIAS speed restriction. We also could fly it no slower than 82 KIAS pending flight envelope expansion.

The aircraft had most of the production interior panels installed, because fit, finish and durability of those parts are being evaluated during the flight test program, along with the green airplane. Serial number 109 also had the usual array of orange test equipment in the main cabin, bolted down through the carpeting to the seat rails. Telemetry equipment aboard the aircraft transmitted hundreds of channels of data to the Eclipse flight test department, enabling engineers on the ground to monitor the aircraft's engines, systems and flight controls during our flights. We were outside line-of-sight telemetry range during portions of our test flights, so we don't have precise data for all phases of the two evaluation missions.

The aircraft's empty operating weight was 3,693 pounds, which was at least 300 pounds heavier than a production aircraft fitted with



Production aircraft wings will be built by Fuji Heavy Industries. The interior structure has very few parts outside of the one-piece main- and aft-wing spars and a dozen or so one-piece chord-wise ribs all produced by high-speed CNC mills.

the LX upgraded interior, thicker insulation and optional sixth seat. Our two-crew arrangement raised the zero fuel weight to 4,058 pounds. With a full 1,507-pound fuel load, the ramp weight was 5,565 pounds, according to Eclipse's engineering flight test department.

Serial number 109's instrument panel was very clean, perhaps too clean. Eclipse still is waiting for Luminescent Systems, Inc., a unit of Astronics, to deliver the glareshield DFCS and center console control panels and for Avidyne to deliver the audio control panels. At this stage in program development, most of the technical risk is associated with vendor delays rather than airframe development, according to Eclipse officials.

Outside visibility from the cockpit is somewhat restricted compared to some other light jets. The windshield is steeply raked and the top of the instrument panel is relatively high. Lateral visibility through the side windows is not as good as in some other light jets. This is not a problem when looking through the side window closest to the pilot, but it's noticeable when looking through the cross-side window. However, a pilot can see out through the cross-side cabin windows, augmenting the view available through the cockpit windows.

The position of the aircraft's side stick control is an almost perfect fit for the pilot's natural hand position. It's angled forward and inward to match one's hand position when the forearm is on an armrest. The grip has a trigger switch for press-to-talk, plus buttons for autopilot disconnect, gear warning horn mute, control wheel steering and all-interrupt for trim, autothrottle, autopilot and yaw damper functions. The side stick and short center console also make it easier to get in and out of the cockpit, compared with aircraft that have conventional control wheel controls and long center consoles. Plan on flying with a knee board, if there's someone occupying the right front seat. Chart and nav publications storage volume is limited without the availability of the right front seat cushion as an ersatz chart table.

Long-legged pilots may find it necessary to move the rudder pedals aft and position the crew seat well aft to avoid interference between the side stick and outboard knee. Still, the forward section of the fuselage curves inward toward the nose, so room in the cockpit isn't nearly as generous as in the main cabin. Cabin interior shape, though smaller, feels a little like a Piaggio P180 Avanti — relatively tight up front and roomy in the midsection.

The one-piece main spars are unusually stout for a 5,650-pound MTOW aircraft. The Eclipse 500 should sail through static and fatigue tests at South West Research Institute in San Antonio.

The throttle position in the short center console requires an unsupported reach. Production aircraft will have crew seat armrests, in addition to passenger chair armrests, providing a place to rest one's forearm behind the throttles.

The Eclipse 500 promises to be the easiest to fly twin-engine aircraft yet built, piston or turbine, because of its docile flying characteristics and systems automation. This starts with its AVIO Total Aircraft Integration system, a design that goes far beyond conventional avionics integration. AVIO connects with virtually every system on the aircraft, including the engines, avionics, dual zone climate control, pressurization and electrical components. When fully developed, it will have interactive normal checklists and abnormal/emergency checklists that are automatically called up in response to system malfunctions.

AVIO can be compared to Dassault's EASy cockpit, although perhaps it's even more integrated with aircraft systems. Both AVIO and EASy take some time to master because they're essentially required crewmembers, albeit digital entities, on the flight deck. Both systems feature interactive system synoptics that are used to control functions, as well as monitor them. Once a pilot masters AVIO, the rest of the aircraft will be as easy as a light piston twin, but without the hassles of catering to and caring for finicky recip engines, and with virtually no asymmetric thrust. Notably, the aircraft will have better one-engine-inoperative takeoff performance than most FAR Part 23 twin turboprops, but VMCA will be considerably lower than stall speed in any configuration.

Switch and knob position conventions are logical. When the switch blades are in the down position, the function is off, open or disabled. Up is for activation or normal in-flight mode. Knobs are positioned left for off, 12 o'clock for normal and right for special or abnormal functions. The LED nav lights come on as soon as electrical power from any source is switched on. The red LED beacons and white LED strobes are controlled by a single three-position switch with off, beacon and beacon/strobe stops.

Starting the aircraft consists of flicking up five electrical panel switches, checking battery or external power voltage and then pressing down and turning each engine control knob from the nine o'clock to 12 o'clock position. The on-side fuel boost pump automatically operates, the starter spins up the engine and the FADEC handles all the other chores. After start, the generator automatically comes on line in production aircraft and the boost pump shuts off. Each engine's FADEC automatically terminates the start in case of a malfunction.

Interior sound levels, even with the test aircraft's acoustical insulation package, were low. The engine inlets are well behind the aft pressure bulkhead and partially masked by the fuselage midsection contours. Total fuel flow at idle was 197 pph.

Each of the PW610F turbofans, in current configuration, produces about 40 pounds of idle thrust. Once the aircraft is rolling, frequent use of wheel brakes is needed to check taxi speed. An upcoming FADEC software revision should reduce ground idle thrust to 25 pounds of thrust. That should alleviate most of the need to use the brakes during taxi and also reduce ground idle fuel flow.

Nosewheel steering authority during taxi through the rudder pedals is mushy at best, in *B&CA*'s opinion. We'd like to see pedal steering made crisper. Tight turns require liberal use of differential braking. The aft-mounted engines are spaced so closely together that using differential thrust to tighten the turn is virtually ineffective.

Takeoff V speeds for our flights were padded by five to 10 knots, pending full expansion of the flight envelope. Rotation, for instance, was pegged at 94 KIAS and liftoff was set for 100 KIAS. We set the fowler flaps to 10 degrees for takeoff, a position that causes them to move aft on their tracks by several inches, thereby increasing wing chord for substantially more lift.

The OAT was 34°C, local altimeter was 30.10 and Albuquerque's field elevation is 5,355 feet, so density altitude was close to 8,375 feet. The hot-and-high field conditions sapped engine performance, but the PW610F has an APR feature that boosts thrust by 10 percent if needed in the event of a one-engine-inoperative takeoff.

Once cleared for takeoff on Runway 08, we pushed up the throttle levers to the stops. Fuel flow stabilized at 955 pph. Acceleration was modest, as expected, in light of the hot-and-high conditions. We rotated at 94 KIAS, noting a little more aft stick force required than one might expect in an airplane weighing less than three tons. That's undoubtedly the result of the main landing gear being positioned well aft of the center of gravity. Once we lifted off at 100 KIAS, considerably less stick force was needed to control pitch. Roll control authority was good, but a little heavy in force. Eclipse engineers plan modifications that will reduce roll control effort. Passing through 400 feet agl, we retracted the flaps at 110 KIAS and reduced thrust for climb, noting 830 pph total fuel flow.

As speed increased, we observed that there was only modest pitch force change with air-

AVIO – The Next Step in Total Aircraft Integration

Few aircraft in the world have more avionics and systems integration than the Eclipse. Most aircraft that boast this level of integration actually have federated systems, collections of independent systems and avionics boxes that function like a union of independent member states.

Not so with AVIO. This truly is a full integration of avionics using hub-and-spoke architecture between the core computers and virtually everything electrically powered on the aircraft. AVIO's dual computers replace dozens of stand-alone computers installed on other light jets. The core hub hosts FADECs, FMS, secondary flight controls, autothrottle, digital flight control system and control of landing gear, pressurization and air-conditioning.

AVIO will set new standards for light jet avionics performance. It will have a fully functional FMS that supports all ARINC 424 procedures and airways navigation, full authority autothrottles, weight-and-balance and airport performance computers with automatic V speed bugging on the PFD. Comm and nav radio frequencies will be stored in the FMS and popped into the standby windows of those radios at the touch of a button. The FMS will host a simplified advisory VNAV function and it will support all types of WAAS approaches, including precision approach procedures.

The large central MFD will feature full EICAS, interactive normal, abnormal and emergency checklists, graphic system synoptics and system control functions. The final version will have single-level access to all menus, controlled by individual line select keys or knob controls.

Dual aviation grade byte-flight data busses, as well as some conventional ARINC-spec links, are used as the communications spokes between components and AVIO's twin central computers. The system has extensive maintenance history and exceedance event logging capabilities. As an added benefit, AVIO's total integration will result in lower manufacturing costs.

With the exceptions of the manually operated primary flight controls and hydraulic wheel brakes, every other system on the aircraft is electrically actuated. Left- and right-side engine-driven generators, plus forward and aft batteries, power all the electrical systems. Virtually all motors are long-wear DC brushless designs, except for the starter/generators. Stepper motors, slaved to the FADECs, schedule fuel flow to the engines.

What if both generators fail? Statistically, that's mighty improbable based upon over 40 years of business jet operating history. But if that were to occur, there's still at least 30 minutes of battery power. After half an hour, the pilot can shut down one engine, if needed for descent and landing, to control thrust and then use gear and flaps to modulate speed. On short final, the other engine can be shut down and the aircraft can be stopped on the runway using wheel brakes.

speed change, a possible result of airfoil design and the T-tail configuration. It was easy to keep up with pitch trim changes as airspeed increased, using the four-position elevator/aileron trim switch atop the side stick. It has a comfortable rate of travel that accommodates rapid trim changes up with pitch force changes at low speed and avoids over trimming at high speed.

The aircraft has excellent short period pitch and roll stability, plus strong spiral stability. Although yaw stability isn't its strong suit, prompt rudder pedal inputs quickly dampen oscillations. In addition, the rudder on the test aircraft has yet to be modified with production-configuration trailing edge wedges that should promote clean flow separation and help dampen yaw perturbations.

Without rudder inputs, the aircraft has a natural 2.5-second yaw period and prominent yaw-roll coupling (Dutch roll), especially with its short coupling about all three axes. The aircraft has very little rotational or translational inertia. Production aircraft will be fitted with yaw dampers.

The stability checks also revealed noticeable latency in the PFD and standby attitude indicator. Yaw, pitch and roll indications lagged actual aircraft attitude changes by several degrees. This display latency also is noticeable when making system configuration changes through AVIO. An upcoming software update from Avidyne, supplier of the displays and radios, should solve latency problems. The Eclipse 500 has very little inertia because it's so lightweight. Slam the throttle forward and you'll notice immediate acceleration, initially accompanied by a slight nose-down pitching moment. Pull the thrust levers to idle and the aircraft slows down right away, however, at first, with a slight nose-up pitching moment caused by thrust reduction.

At 15,000 feet, we checked low altitude max cruise speed performance. At a weight of 5,270 pounds, the aircraft achieved an indicated airspeed of 223 KIAS and a cruise speed of 288 KTAS while burning 760 pph in ISA+26°C conditions. At 200 KIAS, fuel flow dropped to 650 pph and the aircraft cruised at 260 KTAS. Fuel flow was 560 pph at 180 KIAS, 425 pph at 150 and 380 pph at 120 KIAS. Down at 15,000 feet, the Eclipse 500 achieved specific ranges of 0.37 nm/lb to 0.41 nm/lb, depending upon cruise speed. It's essential to put these numbers into context. Serial number 109 has substantially more airframe drag than a production aircraft because of the relatively abrupt transition between the wing deice boots and the wing top surface, plus it has numerous exposed washers that secure various composite pieces onto the aluminum airframe.

Cruise performance was better at FL 250, as expected. That's as high as we could fly

Generous ground effect and long-travel, trailing-link main landing gear all but eliminate any possibility of making a bad landing. The landing gear are electrically actuated. The only hydraulic system on the aircraft is the wheel brakes.

pending the outcome of high-speed flutter tests that were slated for June. At a weight of 5,100 pounds, we accelerated to 170 KIAS. The aircraft cruised at 255 KTAS while burning 480 pph. Slowing to 154 KIAS, fuel flow dropped to 400 pph and the aircraft cruised at 231 KTAS — a speed not unlike that of an entry-level twin turboprop. We concluded that while the Eclipse 500 indeed is efficient, it's still a jet. Maximum speed and range performance will require flying in the mid- to high thirties.

Slow speed handling is one of the aircraft's strong suits. Extending the gear produces a noticeable, but easily controllable, nose-up pitching moment while the gear is in transition. Extending the flaps to the first notch, the takeoff position, also produces a mild nose-up pitching moment. Further extension to the approach position causes a slight nose-down pitching moment. The transition to full flaps causes very little trim change. The electric trim has plenty of rate authority to keep up with such configuration-induced trim changes and there's ample thrust to check deceleration, even at 15,000 feet.

The landing pattern is where the Eclipse 500 excels relative to other turbine aircraft, as well as most piston twins still in production. We entered downwind, slowing to 110 KIAS in the clean configuration. The aircraft was quite comfortable at that speed with ample stall margin, but the nose was cocked up at five-plus degrees. We extended the flaps to the 10-degree takeoff position, enabling us to lower the nose to an almost flat attitude. There was some aerodynamic noise from the flaps, and a slight increase in thrust was needed to stabilize at 110 KIAS.

We flew the pattern fairly tightly, extending the gear when abeam the downwind numbers along with approach flaps. We turned to base almost immediately and slowed to 100 KIAS. Turning final, we extended the flaps to the landing position and slowed to 85 KIAS, the slowest we could fly until stall testing is complete. Even so, that speed was the slowest we've yet flown an approach to landing in a civil jet. It was considerably slower than we could fly in virtually any twin turboprop business aircraft. We'd not feel comfortable flying that slowly on final in most piston twins.

About 30 feet above the runway we pulled the throttles to idle. The aircraft decelerated quickly in the flare. There was plenty of ground effect to cushion the landing and the generous travel, trailing link landing gear made for a soft touchdown. After several touch-and-goes, we concluded that it's virtually impossible to make a bad landing in the Eclipse 500.

On one touch-and-go, we retarded the right throttle to idle at rotation to simulate a one-engine-inoperative takeoff. Mild rudder pressure checked the yaw rate and the aircraft climbed straight ahead with very little aileron input. After gear retraction, we recorded a 500 fpm climb in spite of Albuquerque's hot-and-high density altitude conditions.

Our final approach was Tomeny's trademark Simulated Flameout approach, starting out at high key above the runway downwind numbers, not unlike a single-engine fighter that's run out of fuel. But in the Eclipse 500, we only had to be 2,000 feet agl above the runway at high key at 120 KIAS, descending at idle to and 1,000 feet agl at low key abeam the numbers. We extended the gear and flaps to approach and flew a right racetrack pattern to final, slowing to 100 KIAS with 90 degrees turn to go and 500 feet agl remaining altitude. On final, we slowed to 90 KIAS and coasted in for a smooth touchdown. Runway deceleration was sluggish, though. There is excessive ground idle thrust pending a FADEC software revision; furthermore, we landed with a slight tailwind and the wheel brakes were a little spongy.

All of this seemed fairly routine until we returned home and jumped into an F33A Bonanza the following weekend. It was then we put the two Eclipse 500 flights into perspective. This is an aircraft that promises better-than-Citation II cruise speed, twin-piston fuel efficiency in cruise and almost Bonanza-like docility in the landing pattern. In less than three hours in the Eclipse 500, we felt far more comfortable than after dozens of hours in any single- or multi-engine turboprop. In our opinion, any pilot who has mastered a high-performance piston twin will find the Eclipse 500 far easier to fly, especially in the event of an engine failure on takeoff.

Nine Months Until TC, If . . .

Raburn and his team believe that they can earn FAA type certification by March 31, 2006. They allow that the program is 45 days behind schedule in late May and that the "largest area of concern is now the flight test program." Last winter's El Niño put an IFR damper on test flying for several days. N503EA, the first fully conforming test aircraft, flew only 18 hours in the first 90 days, but it then flew three times that amount in the following 60 days.

But flight test progress is accelerating. N503EA was a work in progress on its first two flights on Dec. 31, 2004. One wing had a slight warp, the nosewheel was prone to shimmy, the cabin wouldn't pressurize and the engines were difficult to start because of the experimental brushless AC starter/generators. That's all been cleaned up now. A new wing has been fitted to the airplane, production starters have been installed, a new nosegear has been fitted and all systems are go. The aircraft will be dedicated to FAA certification testing for mechanical systems.

N502EA (s.n. 103), the second flight test aircraft, first flew on April 14, 2005 and shortly it will start high-altitude flutter tests, with full FAA certification testing for aerodynamics and structures to follow. N504EA (s.n. 109), first flown on April 21 and that which we flew for this report, will be used for AVIO, avionics and systems development, among other tasks. N505EA, the first of two beta-test aircraft, was to enter flight test by mid-June, pending engine deliveries. The fuselage of N506EA, the second beta-test aircraft, is nearly complete and it's almost ready for wing mate. The static test article has been shipped to Southwest Research Institute in San Antonio, and the fatigue test article airframe soon will have its tailcone mounted to the airframe. Soon thereafter, wing mate will occur.

The flight test team has a new U.S. Air Force fighter pilot can-do approach due to the influence of Tomeny, who is expected to attract like-minded test pilots to the Eclipse 500 development program. The pace of flight test operations is accelerating and the trend is fast absorbing the 45-day lag in program development. Type inspection authorization now is slated for August, a lean seven months prior to Eclipse's March 31, 2006, goal for type certification.

Every aspect of the program under the direct control of Eclipse employees appears to be proceeding apace. Reminiscent of the Larry Bossidy era at AlliedSignal, most folks at Eclipse now view weekends as workdays with less road traffic and fewer phone calls. Having already raised nearly $400 million in equity, Raburn has launched a final round of private equity fund-raising, with the goal of preparing for full-scale production, training and support, as well as aircraft type certification. "We're going to keep fortifying this company" to assure its success and growth, Raburn asserts.

LED position and strobe lights at the wingtips have 10,000-plus-hour service lives. This is part of Eclipse's drive to improve dispatch reliability by several orders of magnitude over current production light jets.

But Raburn and others seem a little edgy when probed about the fitness of certain outside vendors. Chief Financial Officer Peter Reed, senior vice president of finance and administration, is wearing out the carpet between his office and Raburn's as the two meet several times per day to discuss supplier problems, such as technical development progress, production process controls, overdue certification documents and ramp up capacity deficiencies.

N505EA and N506EA, the two beta-test Eclipse 500 aircraft, are nearing final assembly. These aircraft also will be used, if needed, to supplement the flight test aircraft to finish the program on schedule so that type certification can be earned by March 31, 2006.

Eclipse officials are stepping up their onsite visits to vendor facilities. Several vendors will be able to meet Eclipse's goal of building 150 aircraft in 2006, but some will struggle to ramp up to a production rate of 600 aircraft per year in 2007. Eclipse now has 40 people working full time on supplier ramp up issues in 2007 and 2008.

Raburn remains confident Eclipse can make its March 31, 2006, type certification goal, "but there are a number of events on the part of the vendors that drive the game." While he avows the deadline is achievable, he also admits "we're out of pad." He's hopeful, but he admits "there are days when it gets very frustrating, when I get very tired. If I had known how hard it would be, I probably wouldn't have done it."

In the midst of all of this, Raburn has been highly complimentary of the support Eclipse has received from the FAA. "The regulatory process has not been a surprise and I believe that it's the most maligned process in aviation." The FAA has furnished many more solutions than problems, according to Raburn. It's basically a matter of explaining your case to the right FAA people, he maintained.

Paraphrasing Charles Dickens, Raburn says it's been the best of times and the worst of times. One of his biggest challenges has been an aviation supply chain that's geared up for 1950s technology, production methods and quality control. His biggest surprise has been the quality of people Eclipse has attracted to the program, folks from Boeing, the U.S. Navy and U.S. Air Force flight test center and general aviation veterans, plus fresh all-star aviation graduates from the University of North Dakota and Embry-Riddle.

While the odds that Eclipse will win its race to March 31, 2006, type certification may not be in Raburn's favor, it would be imprudent to underestimate him, based upon his ability to overcome formidable challenges from the start of the program.

Besides, that date may be irrelevant to the first customers. From what we've seen on the ground and in flight, a few extra days, some weeks or even a couple of months will be well worth the wait. When initial Eclipse 500 deliveries begin in 2006, the face of general aviation could change as much as it did over 40 years ago when first deliveries of the Learjet 23 began. **B&CA**

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