UPDATE

Bombardier Learjet 85

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In mid-January, Bombardier announced a "pause" for an "indeterminate period" in the Learjet 85 program, interpreted by some market analysts as permanently shelving the project. In light of Montreal's taking a pre-tax special $1.4 billion write down that represents nearly 90 percent of development costs, as well as announcing a cut of 1,000 jobs at company facilities in Wichita, Kan., and Queretaro, Mexico, it appears the most ambitious Lear model ever is lapsing into a deep coma.

"Given the weakness of the market, we made the difficult decision to pause the Learjet 85 program at this time. We will focus our resources on our two other clean-sheet aircraft programs under development, CSeries and Global 7000/8000," explained company President and CEO Pierre Beaudoin.

The largest, roomiest and most-capable Learjet yet announced, also has been, arguably, Bombardier's riskiest business aircraft development program. Introduced as the Learjet NXT at the 2007 NBAA Convention, Bombardier predicted the breakthrough, all-composite aircraft would be certified and enter service in 2013. As with many other programs announced by other manufacturers, those milestones never were reached. And now two years past that promised deadline, the Montreal firm has realigned its aircraft development priorities amid a cash flow crunch.

Back in October 2007, Beaudoin said that the aircraft would "set the standard against which all competitive aircraft will be measured."

How true that prediction would become, but in ways Bombardier Aerospace didn't expect or want. To save $1.3 million per aircraft in manufacturing costs, the firm decided to use composites rather than aluminum alloys for most of the primary airframe. It believed composite construction would slash parts count and, therefore, labor hours in final assembly. The material choice also offered easy forming for complex aero contours, no susceptibility to corrosion and long service life, but not necessarily weight savings compared to using aluminum for the airframe.

For additional cost savings, Bombardier farmed out development of the airframe to Grob Aerospace, a German composite sailplane and motor glider manufacturer founded in 1971. The Learjet 85 not only would be the first virtually all-composite business jet, but it also would be the first all-composite FAR Part 25 transport category aircraft built by either Bombardier or Grob.

To save tooling costs, Bombardier decided to build the airframe mostly by using hand layup of carbon cloth pre-impregnated with resin, sandwiched around a honeycomb core, rather than investing in computer-controlled fiber placement or filament winding machines to automate the process. However, using hand layup, sandwich construction would prove very difficult to implement with consistent results.

The largest ever Learjet will have a 665-cu.-ft. cabin with a flat floor that is second only to the Embraer Legacy 500. Windows are 12 in. wide and 16 in. tall.
“Sandwich composite construction is so seductive because it appears to be very easy. Only when you get into the details do the difficulties become apparent,” says one veteran aircraft executive with composite manufacturing experience. “Lapses, voids, hollows and moisture intrusion are constant challenges with hand layup. Those are not problems with which you want to be confronted if you’re flying to high altitude. That’s why the industry is moving toward monolithic carbon fiber structures made by automated fiber placement and filament winding processes, along with high-pressure, high-temperature resin transfer molding.”

The first major blow to the Learjet 85 program came in mid-2008 when Grob declared insolvency. With that setback, Bombardier decided to bring the aircraft’s development in house. Then soon thereafter, it became apparent that it would have to develop a whole new set of composite construction processes on its own to build the structure.

Bombardier had a healthy head start on the challenge as its Short Brothers pic subsidiary in Belfast, Northern Ireland, had developed expertise in composite construction using high-temperature, high-pressure autoclaves, among other techniques. However, rather than capitalize on Shorts know-how in building the entire structure, Bombardier elected to develop a new set of hand lay-up processes at its facility in Queretaro in north-central Mexico, where workers had been assembling wiring harnesses and building aluminum structures for other Bombardier models. And instead of investing in a high-temperature, high-pressure autoclave and resin transfer infusion system at Queretaro, Bombardier elected to use an out-of-autoclave (OOA) construction system that relied on vacuum bagging and low temperature curing of sandwich composite structures. Eventually, achieving consistent, high-integrity bonding between the sandwich layers would prove problematic. So, Bombardier switched to more monolithic carbon construction for most of the fuselage but retained the hand layup processes.

In addition, Queretaro’s 6,000-ft. elevation posed challenges. The maximum clamping pressure exerted by a vacuum bag system at that elevation is at least 20% lower than at sea level. Squeezing out air bubbles and achieving complete bonding between the dozens of layers, each applied by hand, was difficult to achieve on a consistent basis, especially considering that some sections included carbon fiber, copper mesh, adhesive sheets and inner moisture barrier plies. Now, a 16-hr. OOA, slow cure process assures 99+% bonding integrity, requiring minimal hand finishing to pass final ultrasonic inspection.

In contrast, computer-controlled composite layup systems, such as the Fibex filament winding system developed by Rocky Mountain Composites, create tightly wound structures with virtually no air pockets or voids that readily can be cured by using OOA vacuum bagging. Appearing to be a spider spinning a web, the fully automated Fibex machine’s tool head precisely applies a small quantity of resin and catalyst with the carbon filament and then winds it into a structure. The process creates no lapses, voids or air pockets. Boeing uses a slightly different fiber placement winding process to build its 787 Dreamliner. Fuselage sections, for instance, are constructed as one piece on a spinning mandrel by using a computer-controlled machine to apply tape layers of varying widths. The Dreamliner parts quickly are cured in very large, high-pressure, high-temperature autoclaves rather than using low-temperature, long-duration OOA vacuum bag curing.

But filament winding and fiber placement machines, along with autoclaves, require a heavy upfront investment. And the Learjet 85 development budget didn’t justify the investment, according to program insiders.

Bombardier, though, did move wing construction to Shorts, which developed a new high-pressure resin transfer infusion process for building both Bombardier’s CSeries regional jets and Learjet 85 composite wings. For the Learjet program, Belfast fabricated the upper and lower wing panels with integral stringers, along with both wing spars, mainly from dry carbon-fiber non-crimp fabric sheets that are precision cut by automated mills. Then, resin is infused during an autoclave cure process. The wing ribs, though, are made from aluminum because that metal has better shear strength properties for the weight than composite materials. Spars, skins and ribs then are assembled into complete wing structures.

Most of the Learjet 85’s construction problems had been overcome. But maximum takeoff weight increased by almost 3,000 lb. over original projections. And industry observers still believe the firm would have been challenged to achieve consistent composite construction quality in full rate production.

Range goal is 3,000 nm, with four passengers while cruising at Mach 0.78.

Bombardier has been impressively aggressive with its new aircraft introductions, announcing the relaunch of its 1990 BRJ-X project as the much-upgraded CSeries regional jet in 2008, the Global 7000 and 8000 in October 2010, the May 2013 introduction of the Challenger 350 and the October 2014 debut of the Challenger 650.

Bombardier apparently felt compelled to proceed with the CSeries, its most
ambitious project ever, or continue to give up market share to Embraer’s E-Jets that entered service in 2004. The CRJ series regional aircraft, based upon the Challenger 601, had well served the company until it was trumped by the larger, roomier E-Jets that offered greater passenger comfort and acceptance.

By 2008, though, Bombardier needed new composite airframe, engine, flight control and systems technology for the new jetliner to be competitive. Each of these areas had its own risk/reward tradeoffs. First, the developers had challenges with the composite fuselage. Next, there were problems with the digital flight control system that set back full function testing by nearly two years. And, third, the Pratt & Whitney Pure Power 1500G geared turbofan engines had aft bearing lubrication problems that led to a catastrophic engine failure and fire that damaged a wing of one of the original test fleet aircraft.

The fly-by-wire (FBW) control system bugs have been the most problematic challenge to the CSeries development program, but it’s now pretty much back on track and CS100 certification is expected in second half 2015 or early 2016 with CS300 entry into service anticipated six months or so later.

Meanwhile, the Global 7000 and 8000, both launched in response to Gulfstream’s G650 flagship, respectively are scheduled to enter service in 2016 and 2017. For the programs to meet those deadlines, the Global 7000 will have to start flying this year and the Global 8000 will have to begin flight tests in 2016. However, Bombardier has yet to announce a rollout for either model. Meanwhile, development of the models’ all-new General Electric Passport turbofan engine is well underway (see Intelligence, page 11).

The Challenger 350, a significant midlife upgrade to the Challenger 300, now is entering service with production rates ramping up. And deliveries of the Challenger 650, the latest iteration of the Challenger 601, are slated to begin later this year.

That’s a lot of development activity for any manufacturer. And it comes at a hefty price. All these programs, including the Learjet 85, are estimated to have consumed almost $900 million in research and development funds during the past three years alone and R & D activity had to be scaled back to match available resources.

Beaudoin said in mid-2014 that Bombardier needed to reassess resources and development schedules. Logically, that put the Learjet 85 at the bottom of the pecking order. “The majority of the Learjet 85 flight test people have been shifted to higher priority programs. Or they’ve been laid off,” says one company
insider. And that was prior to the company’s announced mid-January layoffs in Kansas and Mexico.

Nonetheless, by that time the Model 85’s Flight Test Vehicle 1 (FTV 1) had flown more than 75 flights and 150 flight hours since its first flight in April 2014. Stall behavior is benign, according to test pilots who have flown it. FTV 1 has both a stick shaker and pusher, but flight test engineers hope production aircraft won’t need stall barrier systems. Stall speeds have yet to be defined and the aircraft hadn’t yet been tested with ice shapes.

Range and speed looked to be on target. Control forces were reportedly heavy and roll control authority in gusting crosswind conditions took a lot of effort. Nosewheel steering was too sensitive, but that could have been tuned out of the steer-by-wire system. The bleed air system was being upgraded for more efficient environmental system operation.

Meanwhile, FTV 2 was in final assembly and it was due for release to flight test in first quarter 2015. Five aircraft originally were planned for the flight test campaign, but the number later was reduced to four. Bombardier never predicted when FTV 3 and 4 would be built or flown.

**Advanced Systems**

For all its structural development challenges, the Learjet 85 promised to offer buyers advanced engines, avionics and systems. Two 6,100-lb.-thrust Pratt & Whitney Canada PW307B engines, with improved fan aerodynamics, more durable hot section materials and reduced emissions TALON II combustors, powered the aircraft.

The Model 85’s Bombardier Vision flight deck featured Rockwell Collins Pro Line Fusion integrated avionics with three, 15.1-in. portrait configuration displays with synthetic vision PFDs, dual FMS with GPS WAAS receivers, an inertial reference system, dual EFIS and an auto-throttle system. The air data system will use solid-state UTC Aerospace (nee Goodrich) pitot/static/angle of attack/sideslip sensing SmartProbes.

Systems design was more like a Challenger 350 than a legacy Learjet, but even more advanced. This was to be the first business jet to have brushless DC starter/generators, 28-volt, 625-amp units supplied by Innovative Power Solutions. It had few mechanical circuit breakers. Astronics Corp. furnished its Corepower electronic power distribution system with integrated electronic circuit breakers in five boxes that were controlled through the avionics system.

The 10-psi cabin pressurization system provided a cabin altitude of 6,000 ft. at the aircraft’s maximum certificated 49,000-ft. cruising altitude. Liebherr Aerospace provided the integrated air management unit, including air cycle machine pack. And C & D Zodiac provided the cabin interior while Lufthansa Technik supplied the CMS. B/E Aerospace furnished the vacuum lavatory system.

Primary flight controls were manually actuated, resulting in hefty control forces, considering the aircraft’s 36,700-lb. maximum takeoff weight. As noted, that’s a 2,950-lb. increase from original projections.

Heroux-Devtek and Messier-Bugatti-Dowty furnished the landing gear, brake-by-wire controlled wheel brakes with carbon heat packs and nosewheel steering system. This was to be the first Learjet with a steering tiller.

Honeywell supplied the RE100 APU and EMTEQ furnished long-life LED interior and exterior lights. There were no incandescent, halogen or HID lights on the aircraft.
Construction challenges at Bombardier’s Queretaro plant have been overcome, but industry observers wonder if customers will embrace an all-composite airframe.

Other suppliers included PPG Aerospace Transparencies for the glass windshields and stretched acrylic cockpit side windows, Kaman Aerospace for doors, Sonaca for the aluminum wing leading edges and wing anti-ice system, Eaton for the concentrated nitrogen fuel tank inerting system and hydraulic pumps, Cox & Co. for the thermal and electro-expulsive horizontal tail deice system, and HBL India for the nicad batteries. As with previous Learjets, the new model was to have both wing and fuselage fuel tanks. Original fuel capacity was planned to be 11,310 lb.

What Would Happen if it Eventually Enters the Market?

If Bombardier resurrects the program, it will face severe competition. The Learjet 85’s promise of 3,000-nm range, a 5,000-ft. takeoff field length, Mach 0.78 cruise speed and eight passenger seating capacity are attractive, but those numbers may be tough to attain considering its wing area is fixed at 401 sq. ft. and the engines currently are rated at 6,100 lb. thrust for takeoff, yet weights have increased.

Richard Aboufalia, analysis vice president for the Teal Group, questions the market research that helped launch the model. “All other composite business aircraft have been a complete disaster. Look at the Starship, the Premier I and the Hawker 4000. And the greatest irony is that Bombardier taught the world the same lesson when it built the aluminum Challenger 300 to compete against the part-composite Hawker 4000.”

When the Learjet 85 was announced as the Learjet NXT eight years ago, it was priced at $16 million. Its main competitors were the Learjet 60XR, Gulfstream G150, Hawker 900XP and Citation Sovereign. Since then, Embraer’s Legacy 500 earned certification in December 2014 and full-scale customer deliveries in North America soon will begin. While the Embraer offering is $2 million to $3 million more expensive than the Learjet 85, it offers buyers more range, higher cruise speed and a larger cabin, along with fly-by-wire flight controls. The Brazilian jet could gobble up a lot of market share while the Learjet 85 remains sidelined, not unlike the way the Challenger 300 captured market share while the Hawker 4000 suffered through development woes.

Meanwhile, Cessna expects the Citation Latitude, a larger cabin derivative of the Citation Sovereign with a flat floor and excellent runway performance, to enter service this year as well. It has 500 mi. less range than the Learjet 85 and slower cruise speeds, but it’s also priced at $15 million, less options. In short, the competitive field is getting crowded.

“It’s really hard to be optimistic about the program,” Aboufalia adds. Others are equally unconvinced about the Learjet 85’s future prospects.

“These are conservative buyers, people not necessarily in love with composites,” says Rolland Vincent of the Plano, Texas, consulting firm bearing his name. “And what with the delays, all of a sudden the technology is two generations old. What I think they needed was a Challenger 325 as a Learjet 85 alternative.”

Vincent believes that with all the Challenger 300 non-recurring costs being fully amortized during the past decade, a mildly reworked Challenger 300 derivative could have been developed at very little cost and priced aggressively to compete with less-capable midsize offerings from other manufacturers.

“A lot of me wants them to succeed [with the Learjet 85],” Vincent continues. “But when it comes to Learjet, it’s a recurring headache for Bombardier. Montreal puts its best talent into the Challengers and the Globals. Wichita looks like a decimal place in the master spreadsheet. I wonder if the window [of opportunity] has opened and shut.”

That view, if confirmed, would be unfortunate indeed because it appears that Bombardier’s engineering team has conquered many of the Learjet 85’s biggest challenges. With the exception of its lacking fly-by-wire flight controls, the aircraft’s engines, avionics and systems technologies virtually are unsurpassed in the midsize class.

If the Model 85 eventually does come to market and succeeds, it will establish a new and higher standard for the proud and enduring Learjet marque. But timing is critical. The longer the delays to certification and customer deliveries, the more time the competition will have to saturate the segment with alternative products. That could slam shut the window of opportunity for Learjet and seal its future.