Business & commercial Aviation
STATUS REPORT

Status Report: Global Express

The clash of the titans officially begins, with heavy-iron rule in the next millennium at stake.

By FRED GEORGE

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Bombardier's December 20, 1993 news release, proclaiming the official launch of the Global Express, created plenty of fervor in the general aviation industry. It wasn't just another new product announcement. It was an unequivocal challenge to Gulfstream Aerospace for the title of "Heavy-Iron King" of business aircraft.

This isn't the first time a challenger has attempted to knock off Gulfstream for the super-heavyweight title. Others, including firms with prodigious aircraft manufacturing experience, have attempted to become the favorite builder of flying flagships for the top industrial companies, foreign governments and eminently successful entrepreneurs during the last 30 years.

None has succeeded.

Bombardier, the family-operated, Canadian transportation conglomerate that has only been in the aircraft business since 1986, now has embarked on this daunting mission. Bombardier's Canadair subsidiary will design, develop and assemble the Global Express for Bombardier. The aircraft, carrying Bombardier's own BD-700 model designation rather than wearing the Canadair label, will be the largest cabin business aircraft ever built and Bombardier's contender for titan-class champion.

What are Bombardier's odds of success? Here are some factors to consider: First, Bryan Moss, Canadair's business aircraft division president, believes a market exists for 550 to 800 ultra-long-range, large-cabin business aircraft, a feeling largely fueled by the increasing global economy and growth of free enterprise. "Global businesses will continue to chase margins and look for cheaper labor markets, while business people will need face-to-face meetings," he explained.

The typical customer profile varies extensively. Prospects include entrepreneurs, overseas companies and traditional top industrial firms, although large U.S. corporations now very cautiously approach new heavy-iron aircraft acquisitions. Customers are more sophisticated than in past years, according to Moss. They plunge into intense discussions of operating costs, extended twin-engine operations (ETOPS) reliability and product support. Long gone are six-pack martini lunches and sales contracts penciled out on cocktail napkins.

Moss conservatively expects to sell 250 Global Express aircraft to such buyers. Canadair currently has more than 40 orders and options for the GEX (short for Global Express), representing more than $1.2 billion in sales. Certification and initial deliveries of green aircraft are slated for late 1997, but the earliest available GEX delivery slot is in the first quarter of 2000.

Next, look at Bombardier CEO Laurent Beaudoin's track record during the last 14 years. (See sidebar.) Beaudoin's skilled team of financial managers now is directly involved with the Global Express project Canadair began in 1991. Beaudoin, mindful of the need to reach break-even early in the program, has formed major risk-sharing partnerships with outside companies. Also, he has meted out tasks for building

the GEX among Bombardier's own aircraft companies—Canadair, Short Brothers, Learjet and possibly de Havilland.

The result: The program will break even when the 100th GEX is sold, Moss claimed.

The third factor is aerodynamic sophistication. In spite of having the roomiest cabin ever offered in a business aircraft, the GEX will be remarkably slippery for its size, according to Canadair engineers. It will have a highly swept, supercritical wing designed for high-speed, high-altitude cruise and an area-ruled, aft fuselage section to reduce drag.

The sharp sweep to the wing will move the trailing edge of the inboard section well forward on the fuselage, away from the engine nacelles. That will lower interference drag between the fuselage, wing and nacelles.

Canadair claims the GEX's aerodynamic refinements will make it unsurpassed in speed, range, airport performance and operating economy in the big-iron business aircraft class.

Fourth, and not to be overlooked, the Global Express is priced about $1 million lower than its only known competition—the Gulfstream V.

Risk-Sharing Partners

Partnerships are a key part of Bombardier's strategy for building the GEX. The team approach allows the $1-billion GEX development program costs to be spread among a sizable number of partners outside the company. All the outside vendors are long on expertise, and they have the financial backing to share $600 million in development costs.

Bombardier, however, didn't just sign up the first qualified partner to run up the flag. Instead, the firm orchestrated fierce competitive bidding, often fine-tuning the program requirements during the bidding process to turn up the pressure on the participants. For example, Honeywell and Collins competed for the avionics package in one of the fiercest campaigns in the history of business aircraft.

In addition, Bombardier made each partner agree to strict price controls on spares, a key element of Canadair's strategy to make the GEX more affordable to operate.

PROJECTIONS VERSUS GUARANTEES

Canadair expects the Global Express to have maximum ranges, with NBAA IFR reserves, of 6,500 nm at 0.80 Mach, 6,330 miles at 0.85 Mach and at least 5,000 miles at 0.88 Mach. Such range capability will enable a GEX to travel from New York to Tokyo in 13.5 hours. That's equivalent to flying a 6,313-mile distance in still air when the 5,845-mile great-circle distance is adjusted for 85-percent probability headwinds.

Moss adds, "High speed is even more of a selling factor than long range." The GEX, cruising at 0.88 Mach, could shear an hour off some shorter international routes, such as Los Angeles to Berlin, Jeddah to Tokyo or Moscow to Johannesburg, compared to the flight times of the present generation of long-range business aircraft.

However, Canadair's range guarantees are much more limited than the marketing projections. The firm's only guarantee is for this design point specific fuel consumption (SFC), according to the aircraft type specification: 0.158 nm per pound at 0.85 Mach at 65,000 pounds. If the maximum range is adjusted for the minimum guaranteed SFC, then the range at 0.85 Mach would be closer to 6,000 nm than 6,330 nm. Industry observers, though, believe that the GEX can make good on its promise of 6,500 nm at 0.80 Mach if it can fly 6,000 nm at 0.85 Mach.

Similar differences exist between airport performance projections and guarantees. Canadair estimates the GEX's takeoff distance at 91,000 pounds MTOW to be 5,540 feet at SL-ISA, while its guaranteed takeoff distance is 5,930 feet. That's in line with Canadair's design goal to have a takeoff distance of less than 6,000 feet, which the company feels is adequate for access to virtually all airports near likely business destinations.

Projections from Canadair for the GEX's weight and performance, although far from guarantees, are quite credible. All of Canadair's partners have agreed to the weight goals, and Canadair's weight estimates have been padded to accommodate unforeseen changes in certification requirements, structural modifications and systems improvements.

Canadair's last two aircraft certifications prove that this methodology works. Both the Canadair RJ regional airliner and CL-415 water bomber met their original design weight and performance goals.

However, the GEX's interior completion weight allowance of 6,000 pounds may be a little lean. For example, the actual interior completion weight of an average Challenger, an aircraft with the same fuselage cross section as a GEX and having roughly one-half the cabin space devoted to passengers, is just under 4,100 pounds. (The interior completion-weight budget for a Gulfstream IVSP is 5,600 pounds and 7,000 pounds for a Gulfstream V, according to the manufacturer.)

Mindful of this, Canadair engineers, working with completion centers, are aggressively pursuing lightweight interior designs. They believe that three tons is sufficient for an interior appropriate to this class of

Acquisition And Operating Costs

Canadair's operating-cost information for the GEX is every bit as carefully thought out as its design and performance characteristics. For example, the $161-per-hour engine reserve is higher than, but consistent with, the cost of operating a Rolls-Royce Tay turbofan. All costs do not include the effects of warranty coverage.

Fixed Costs (per year)	
Acquisition	N/A
Salaries and benefits (two crewmembers)	$157,970
Hangar	75,000
Insurance ($50-million liability)	4,700
Recurrent training	36,750
Interior refurbishing reserve	35,714
Aircraft modernization	120,000
Miscellaneous	9,389
Total	$519,523
Direct Costs (per hour)	
Fuel and oil, 1,500-mile stage length	$636
Maintenance labor: airframe, engine, avionics	140
Maintenance parts:	227
Engine reserves, 3,500-hour mid-life, 7,000 hour TBO	161
APU Maintenance Service Plan	30
Crew expense	135
Supplies, catering	50
Landing, parking fees	25
Total	$1,404

Source: Bombardier Business Aircraft Division

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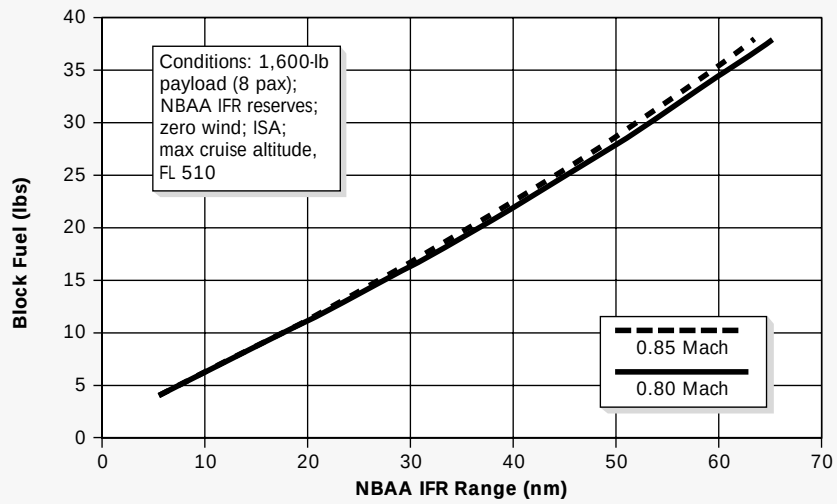
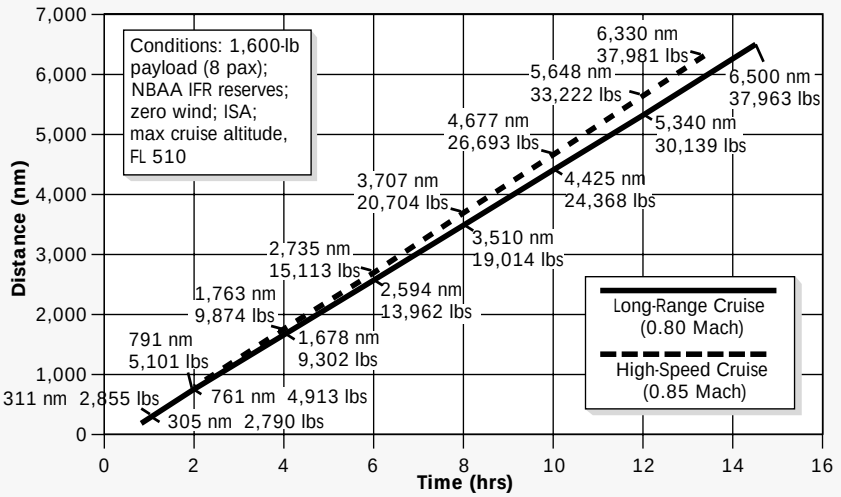


Source: Bombardier Business Aircraft Division All data preliminary

TIME AND FUEL VERSUS DISTANCE

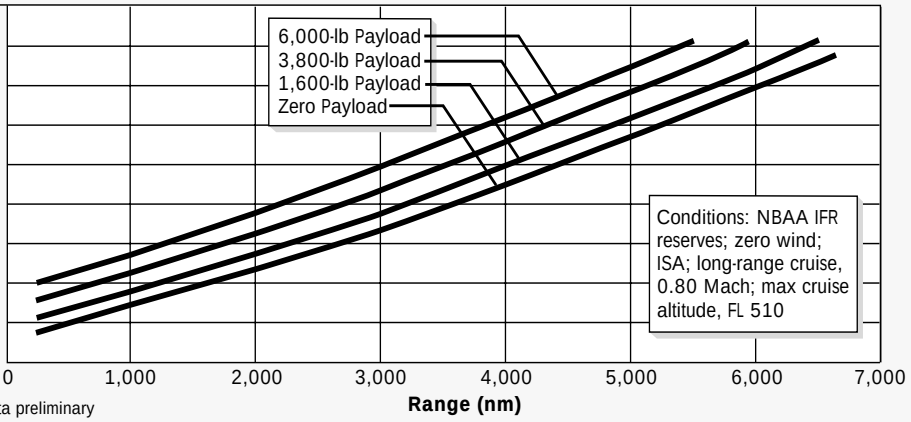


Source: Bombardier Business Aircraft Division All data preliminary

RANGE/PAYLOAD PROFILE

Balanced Field Length		Gross Takeoff Weight (lbs)
SL ISA	5,000 ft ISA+20°C	
5,540	7,680	91,000
4,870	6,700	85,000
4,340	5,940	80,000
3,850	5,250	75,000
3,390	4,610	70,000
3,010	4,010	65,000
3,000*	3,710	60,000
3,000*	3,530	55,000

*Undetermined, but less than 3,000



Source: Bombardier Business Aircraft Division All data preliminary

aircraft, including an airborne office interior similar to the mockup shown in our photographs.

It will be tough, though, for cabin interior designers to stay within the 6,000-pound weight allowance and still accommodate desirable amenities, such as a shower with at least 160 pounds (roughly 20 gallons) of extra fresh water, a 135-pound satellite communications system, office equipment and a galley sufficiently large to serve the food and beverage needs of eight or more passengers on a 14+ hour flight.

AERODYNAMIC REFINEMENTS

"Clean-sheet design" must be one of the most overused terms in the aircraft industry, but the all-new shape of the GEX's wing, tail section and empennage leaves no doubt that it applies to this aircraft.

Wing design is the most critical factor in Canadair's being able to achieve its 6,500-mile-range goal. The GEX will have a wing far different from any other on a business aircraft, swept back to 35 degrees at quarter chord for efficient high-speed cruise. Few civil aircraft, other than the Citation X (37-degree sweep) and the Boeing 747 (37.5 degrees), have more sharply swept wings.

The wing's shape, refined with Canadair's own Computational Fluid Dynamic (CFD) software running in the firm's supercomputer, now has been validated in wind-tunnel tests using a seven-percent scale model. According to Fassi Kafyeke, Ph.D., advanced aerodynamics section leader, this is Canadair's third CFD-designed wing, providing the firm with confidence that the full-scale airfoil will achieve the performance numbers forecast by the supercomputer.

Also, the wing design provides a generous, 15- to 40-percent mean aerodynamic chord, center-of-gravity range.

The wing structure will be built in three pieces—left, center and right sections—that will be bolted together. The wing will have a relatively small area (1,022 square feet) for lower drag, having a root-to-tip high-taper ratio and an 8:1 overall aspect ratio that increases from root-to-tip because of the double-crank, increasing-sweep trailing edge. The inboard section of each wing has generous volume for fuel storage, and it is, by far, the most heavily aerodynamically loaded section.

The GEX's maximum wing loading of 89 pounds per square foot will be higher than any other business aircraft, making it necessary to fit it with both leading edge and trailing edge high-lift devices to achieve the desired takeoff and landing performance. Each wing will have four segments of aluminum leading-edge slats, with landing, takeoff and cruise position settings. Three, single-slotted fowler flap segments will be attached to the trailing edge. The top of each wing will have two ground spoilers and four multi-function spoilers that serve as speed brakes, spoilerons and ground spoilers.

Third generation composites will be used to make the spoilers and trailing-edge flaps. These structures will take advantage of fully toughened epoxy resins for improved damage tolerance and substantially lower maintenance—compared with the composites used on business aircraft certified in the mid-1980s.

Using both leading-edge slats and trailing-edge flaps raises the issue of increased drag in the takeoff configuration, which is especially critical when departing hot and high airports. However, Dr. Kafyeke claims that the GEX will have excellent hot/high airport performance with no need to use reduced takeoff flap settings. Just as importantly, he foresees no restrictions on the maximum allowable takeoff weight related to FAR Part 25 one-engine-inoperative, second-segment climb requirements under most hot/high takeoff conditions.

CFD software and the supercomputer also are being used to refine the shape of the aft fuselage section. Dr. Kafyeke's team must pay close attention to the airflow in the proximity of all the components—the comparatively large nacelles, the widest fuselage of any business airplane, pylons and empennage—to minimize interference drag at high-cruise speeds. The GEX will incorporate a modest amount of area rule shaping in its aft fuselage section to reduce the airflow pressure and velocity changes, thereby reducing drag at high-cruise speed and helping the aircraft attain its projected maximum-range performance.

PASSENGER SPACE

No business aircraft yet announced offers more floor space or cabin volume than the Global Express. All of the cabin, including the 324-cubic-foot aft baggage compartment, is forward of the engine rotor-burst zone, making it accessible in flight with no restrictions.

Cabin width is the same as that of a Challenger 601, with the maximum width at 8.17 feet. Floor width is 6.92 feet. The cabin will be fitted with windows that are 25 percent larger in area than on Challenger models. In addition, the floor will be dropped two inches, compared to the Challenger's, to increase the headroom to 6.25 feet, not including floor coverings.

The GEX cabin mockup features a forward crew rest and galley area that occupies about 11.67 feet of the floor space, according to scale drawings. The crew rest area has its own lavatory and a two-seat compartment that converts into a bunk.

Just aft of the main lavatory, the baggage compartment takes up about four feet of floor space, providing approximately 32.33 feet in net passenger cabin length.

The mockup's main passenger compartment is divided into three sections: forward airborne office suite with seating for three; center salon with two, three-place,

Heavyweight Leadership

Laurent Beaudoin, chairman and CEO of Bombardier Incorporated, has had a twinkle in his eye since December 1993 when his firm officially launched the 6,500-mile-range Global Express. Indeed he should, for the BD-700 Global Express will be the largest aircraft any firm has ever designed for business use, as well as the first aircraft to carry the Bombardier name.

No other manufacturer has announced a faster or longer-range business aircraft. No other proposed aircraft in this class claims to offer better airport performance. No other direct competitor has a lower advertised purchase price.

Can Beaudoin pull off this feat? When he took over leadership duties in 1982, Bombardier's annual revenues were only $500 million (Canadian) and its profits were less than $7 million (Canadian). Business grew well for the next four years.

In 1986, Bombardier acquired Canadair Limited of Montreal from the Canadian government. Subsequently, the firm bought Short Brothers, Learjet and de Havilland—hardly aerospace industry cash cows by any past measure. Beaudoin saw the potential in these firms, however, and he purchased them at bargain-basement prices. That resulted in exceptionally low debt service and more capital for product development. For example, after being acquired by Bombardier, Learjet Corporation put the spurs to the Learjet 45 development program, and Canadair launched the Regional Jet and the Challenger 604.

Beaudoin restructured operations at Bombardier's four aerospace companies with surgical precision, and they emerged as the profitable core of an aerospace business segment that now accounts for more than one-half of its overall business. Bombardier's aerospace business grossed $2.243 billion (Canadian) in 1993, and it netted in excess of $176 million (Canadian).

That financial track record should be enough to sober the Global Express' most bombastic critics. In fact, Bombardier only has 40 percent of the program's $1-billion development cost at risk. The remainder is being funded by its joint-venture partners. The firm says it will break even at 100 airplanes, making the GEX as much of a financial triumph as it is a technological tour-de-force.

Clearly, Project Global Express no longer is a "paper airplane." It's the tangible start of an entirely new approach to the financing, design and development of business aircraft that might reorder leadership of the heavy-iron class.

side-facing divans; and an aft executive suite with seating for four—including a two-place divan that converts into a double bed. A shower and main lavatory is located aft of the third passenger area.

TECHNICAL DETAILS

The GEX is Canadair's first aircraft designed with ETOPS requirements in mind, demanding that certain critical systems have less than a one-in-a-billion chance of total failure. Although ETOPS regulations currently apply only to air carrier aircraft, Canadair engineers anticipate that ultra-long-range business aircraft may cause ETOPS requirements to catch up with Part 135 operations and possibly Part 91 operations.

Customers, as well as certification authorities, are insisting on higher standards of reliability. Marketing an ultra-long-range business aircraft that didn't comply with the spirit of ETOPS would be difficult at best.

Canadair has selected team partners on the basis of their expertise—not just on their willingness to financially participate in the program and supply parts. Each supplier has proven the systems technology intended for use on the GEX on several previous air carrier aircraft, military aircraft and/or business aircraft. Thus, suppliers' previous experiences eliminate the painful learning curve associated with introducing new ideas on a new business aircraft.

Engine reliability is the single, most important factor in complying with the spirit of ETOPS requirements. The GEX's BMW Rolls-Royce BR 710 engines, although being new designs, rely upon proven technology. (See sidebar.)

Canadair elected to forego fly-by-wire (FBW) primary flight controls in favor of a well-proven, cable-actuated and hydraulic-powered flight control system. FBW technology will be limited to control of high-lift devices, spoilers and automatic pitch trim functions. Such secondary control surfaces will be controlled by two dual-channel FBW flight-control computers.

Two separate elevators, each with a dual hydraulic actuator and each linked to an independent pitch control mechanical linkage, will be used for primary pitch control. Triple hydraulic actuators will power each aileron plus the rudder. Each of the 12 ground and

multi-function spoiler panels will have its own hydraulic actuator. The slats and flaps will be electrically actuated by motors powering flex shafts and ballscrew actuators. Electromechanical actuators also will be used for trim functions.

Three independent and isolated hydraulic systems provide the power for the flight controls, wheel brakes and nosewheel steering (NWS). Steer-by-wire and brake-by-wire control, supplied by dual independent computers, will be used for greater reliability and lower weight.

To allow for future growth, the landing gear and NWS system will be sized for 100,000 pounds MTOW. The GEX will be fitted with dual, NWS hydraulic actuators—not a rack-and-pinion system—which is almost identical to the Canadair RJ's well-proven NWS system.

The GEX will have a variable frequency, AC electrical power system powered by four direct-drive AC generators (two per engine), plus an unlimited operating envelope, air-driven generator that can be deployed in the event of a total electrical failure. Variable frequency, constant-voltage AC generators are so named because they don't use constant speed drive units to regulate their rpm to produce constant frequency current. Thus, direct-drive AC generators save weight and increase reliability.

In the GEX, the heaviest electrical load equipment will be designed to use variable frequency AC power. More-sensitive electrical equipment will be fed by AC power supplies or DC transformer-rectifier units.

Three separate wing fuel tanks—left, center and right sections—will be used to store the aircraft's 41,150 pounds of fuel. Each engine will be fed by dual AC-powered fuel-boost pumps, mounted in collector tanks so that they can be changed without defueling the aircraft. The boost pumps will be augmented by jet pumps in the center and outboard wing sections. The GEX single-point pressure refueling system will allow refueling in 15 minutes.

The GEX's 14+ hour endurance and high-operating altitudes may require the use of fuel tank heaters to prevent waxing, the partial congealing of aviation kerosene at very low temperatures. However, Canadair has enough weight-growth margin to accommodate fuel tank heaters, if they prove necessary.

Conserving engine bleed air, principally used in flight to pressurize and air-condition the GEX's copious 2,077 cubic-foot-cabin, will be essential to achieving the fuel economy needed to stretch the aircraft's range to 6,500 miles.

Forty percent of the cabin air will be re-circulated through ultra-fine particulate filters to reduce the demand for bleed air. Dual air-cycle machines will supply conditioned air to the cabin for pressurization.

A 350-hp AlliedSignal RE220 APU with full-authority digital engine control (FADEC) will be capable of starting up to 43,000 feet and of continuous operations, including supplying 30 Kva electrical power, up to 45,000 feet. The APU also will be capable of main engine start—up to 35,000 feet.

BMW Rolls-Royce BR 710-48-C2 Engines

Canadair's March 1993 announcement of the selection of BMW Rolls-Royce BR 710 engines to power the Global Express allowed the company to boost its projected maximum range, an increase of more than 15 percent. (For a detailed description of the engine, see B/CA, June 1993, page 66.)

The engine will be rated at 14,690 pounds-takeoff-thrust, flat-rated to 95°F (SL ISA+20°C) for the Global Express. Just as importantly, it will produce 13,150 pounds-thrust at 5,000 feet, 77°C (ISA+20°C), giving the GEX excellent hot and high airport performance.

Officially launched in August 1992, the BR 710 is an evolutionary, low-risk technology engine with a moderate 3.9:1 bypass ratio, a high-pressure compressor derived from the V2500 used on the Airbus A320, a new low-emission combustor and lower operating costs because of fewer parts. According to BMW Rolls-Royce, the engine's noise levels will be substantially lower than FAR Part 36, Stage 3.

Compared to a Rolls-Royce Tay 611-8, the BR 710 will have 15 percent better specific fuel consumption and slightly better high-altitude thrust output, while weighing slightly less and having three-percent lower maintenance costs, according to the manufacturer.

The firm has accumulated more than 100 hours of run time on the core. The core will have more than 500 operating cycles prior to the scheduled first run of a full-scale BR 710 prototype engine this September.

BMW Rolls-Royce says the engine will have a dual-channel FADEC that eventually will allow dispatch with one channel inoperative.

Ease of maintenance is another prime design objective of this powerplant. Engine changes could be done overnight, not including buildup time.

European and Canadian engine certification is slated for February 1997, with subsequent FAA approval scheduled for April 1997. Function and reliability testing of the engine will continue until it enters service in late 1997.

Status Report

Honeywell Primus 2000 Avionics For The Global Express

What's missing from this cockpit? Side-stick controllers, flat-panel EFIS screens and an electronic library system were some of the features that were originally planned for the Global Express. Ultimately, they didn't make the cut because of unproven reliability, extra cost and additional weight.

Bombardier instead elected to choose a proven package, the Honeywell Primus 2000 avionics system, currently in revenue passenger service aboard the Dornier 328. By the time the Global Express enters service at the end of 1998, the Primus 2000 system will be a 750,000-plus-hour airline veteran. Reliability is Bombardier's top priority.

The Primus 2000, as configured for the Global Express, will have six eight- by seven-inch CRT displays arrayed conventionally in the instrument panel in left- and right-side groups of three screens. Lack of instrumental panel space and depth ruled out the use of eight- by eight-inch CRTs.

In the Global Express, the primary flight displays (PFD) will be outermost in the panel, with multi-function displays (MFDs) in the middle and the engine instrument/crew alerting system (EICAS) screens on the inside. The MFD screens will feature TCAS, a vertical navigation profile display, plus dual independent checklists. The EICAS will display system synoptics as well as gauge graphics and malfunction annunciators.

The displays will have "full sensor reversion," meaning the design allows any sensor—inertial reference system, air data computer, nav radio, FMS and other components—to be used by either the left- or right-side displays.

Standby flight instruments will be mounted in the center of the panel. Audio control panels will be positioned outboard of the CRT displays.

The left- and right-side PFD controllers, along with the automatic flight guidance system (AFGS) control display panel, are mounted just below the glareshield for ease of access by either crewmember.

The secondary avionics system controls—including weather radar, multi-function controls and EFIS reversion panel—are mounted forward in the triple-wide console.

Farther aft in the console are dual Primus II radio management units (RMUs), with color flat-panel displays. These units control left- and right-side remote-mounted, integrated communications and integrated navigation radios, plus dual HF radios and single TCAS avionics. Honeywell's Lightning Sensor System, dual microwave landing system receivers and third system nav and comm radios will be offered as options. The RMUs also can function as back-up engine instruments and backup navigation displays.

The FMS control display units (CDUs) are mounted well aft in the console. On a 10- to 13-hour, high-altitude flight, the pilots will slide their seats back to a comfortable position and, from that vantage point, will control most functions by means of the FMS CDUs.

The left, center and right CDUs—only two are shown in this illustration—are the crew's windows to the triple integrated avionics computers (IACs) upon which the Primus 2000 avionics architecture is based. The Primus 2000 uses both the Honeywell Avionics Standard Communication Bus local area network and ARINC 429 to link various system components to the IACs. Two of the three IACs are fitted with FMS computer cards as standard equipment.

The standard package also includes a single Honeywell-Marconi, 12-channel Global Satellite System Navigation Unit, capable of GPS instrument approaches. Options include a third FMS computer card, a second GPS receiver and a satellite communications (satcom) system controlled through the FMS CDUs. If the third FMS is not ordered, the third CDU controls a standard equipment Lasertrak long-range navigation unit.

Each FMS contains tabular, certified takeoff and landing performance numbers, and each will have Honeywell's

MID-'94 DESIGN FREEZE

The GEX will be one of the most carefully planned aircraft designed for business use. All of the risk-sharing partners have been holed up with GEX engineers in a massive central design room at Canadair, hovering over 92 CATIA (Computer Aided Technical Interactive Application) terminals for months. They've been participating in the joint-definition phase that ends this October or November.

Most assuredly, Canadair is using the measure-three-times-and-cut-once design approach, consistent with Bombardier's fine-tuned financial management style. The GEX's aerodynamic design should be frozen by now, and Canadair's teammates, all using CATIA, will continue to refine each component until late this year.

CATIA allows the cycle time between the final design freeze and assembly-line production to be shrunk. The time savings is due to the partners' fabricating most of the parts using numerically controlled machines that use a common CATIA computer design program for the GEX. Little more than two years are being budgeted between the initial manufacturing phase in 1994 and the GEX's first flight in fall 1996.

Another big reason why the initial production lead

adaptive learning SmartPerf climb, cruise and descent performance function. SmartPerf monitors the actual performance of a specific aircraft during the first several hours of flight operations, and then learns how to predict subsequent aircraft en route performance. SmartPerf automatically compensates for changes in aircraft performance caused by adding antennas or aging engines.

The FMS offers a four-megabyte database that pilots will be able to update by means of a 3.5-inch personal computer diskette. The database eventually can grow to at least eight megabytes, but don't expect it to accommodate a high-resolution terrain database. That will require a CD-ROM drive, such as the ones used by personal computers to store map graphics.

The FMS units are designed for compatibility with the FAA's Future Air Navigation System (FANS). When implemented, FANS will enable aircraft equipped with two-way datalink to automatically upload flight plans, Automatic Terminal Information Service (ATIS) data and en route clearance changes. Automatic dependent surveillance (ADS) position reporting will be automatically downloaded by means of satcom to air traffic controllers for en route surveillance during transoceanic flights, enabling ATC to track aircraft beyond radar coverage. ADS will allow reduced aircraft-to-aircraft spacing on transoceanic routes, thereby increasing airspace flow capacity.

The three CDUs also control the triple Laseref III inertial reference systems that provide three-axis rotation and position-rate data to the PFDs, FMS computers, wind-shear/ground proximity computer and other systems. Other AFCS features include:

- Dual, fail-operational autopilot and yaw damper systems that automatically switch to the cross-side system in the event of a malfunction;
- Triple air data computers;
- Dual aileron, elevator and yaw damper servos; and
- Autothrottle servos that physically move the power control levers.

The Primus 2000 also functions as a health status monitoring system for the aircraft. Triple data acquisition units are linked to most airframe systems by means of ARINC 429 digital interfaces, enabling the MFDs to display virtually any significant problem as soon as it's detected. In addition, a central aircraft information management system (CAIMS) computer will log airframe system events and engine malfunction events, labeling them with a time and date stamp and identifying problems at the line replacement unit level. In other words, the CAIMS computer not only logs problems, but it also frequently tells the crew in plain language exactly which part numbers are causing the headaches.

Other avionics manufacturers will supply the dual HF radios, dual radio altimeters, selective calling feature, flight data and cockpit voice recorders, and standby attitude instruments. A head-up display, emergency locator transmitter and a wide selection of airborne office equipment also will be options.

This is the bottom line: The belt-and-suspenders approach to avionics boxes eventually will permit dispatch with a substantial number of inoperative systems. Typically, the master minimum equipment list (MMEL) may include five of six display tubes, one of two (or three) FMSes, two of three Laseref III boxes, two of three air data computers, plus a single autopilot/yaw damper channel. Don't, however, plan on such a liberal MMEL for transoceanic flights. Government aeronautical officials already are talking about extended twin-engine operations (ETOPS) requirements for certain long-range business aircraft. Those requirements would mandate double or triple equipment redundancies, even though the ETOPS rules apply only to scheduled air carriers at the present time.

time will be comparatively short is that Canadair won't be manufacturing much of the aircraft in-house, other than the cockpit section and forward and aft fuselage sections. Mitsubishi Heavy Industries will build the entire wing, stuffed with most internal components and flight controls, plus the center fuselage section. Short Brothers will build most of the composite structures, fuselage fairings and the horizontal tail. BMW Rolls-Royce will deliver the engines, complete with nacelles and thrust-reverser assemblies, ready for mounting.

Roland Gagnon, Canadair's executive vice president of manufacturing, said building a Challenger or an RJ currently takes nine months, but that will shrink to six or seven months by the end of this year by taking advantage of just-in-time manufacturing processes. His time estimate for assembling production-run Global Express airplanes is a mere 90 days.

Some of our readers may be shaking their heads in disbelief at all of these claims. Here a firm with only eight years in the aircraft manufacturing business plans to build an ultra-long-range airplane that will be capable of carrying eight passengers in business aviation's largest cabin from New York to Tokyo nonstop. Doubtlessly, it will be one of the most complex business

aircraft yet produced, but it will meet the intent of ETOPS requirements. All the details haven't been finalized, yet the aircraft is scheduled to fly in two years. Completed aircraft will enter service in mid-1998. Gagnon says he can build the aircraft in three months.

Consider this: Bombardier is in the transportation business for the long haul and the GEX, while being an audacious venture, represents much more to the firm's future than just being the ultimate business aircraft. For example, the GEX, if stretched several feet, could be the basis for a new generation of 70- to 100-passenger regional airliners suitable as replacements for the DC-9, Fokker 100 and turboprop commuter aircraft.

Because of the GEX's strategic importance to Bombardier, Beaudoin and his team will spare no effort to ensure its success. It's like a keystone in a bridge that will open the way for Bombardier to expand its aerospace business well into the 21st century. **B/CA**