Update: IAI Galaxy

On track for December certification; flight and ground testing are on schedule; our first impressions of flying the aircraft.

By Fred George

Something rather unusual occurred on the 49th flight of Israel Aircraft Industries' new super-midsize Galaxy in late May.

After completing only one-sixth of the scheduled 1,000-hour development program, IAIs engineers were sufficiently satisfied with the Galaxy's performance and handling qualities that they invited B/CA to fly and evaluate the aircraft. This marked the first time that anyone outside of company or certification authorities had flown IAI's newest business jet.

Officials from Galaxy Aerospace Corp. (GAC), the Fort Worth-based organization that markets and supports business aircraft manufactured by IAI, cautioned us about the bumps-and-bruises appearance of serial number 003, the first of two flight test articles. This was no cream puff demonstrator, they explained. It was noticeably scruffy after enduring intensive stability and control flight testing, plus numerous test configuration changes since it first flew on December 25, 1997.

Undeniably, serial number 003 was rough around the edges on the day I flew it. In addition, there was plenty of engine and avionics development work, along with some airframe fine-tuning, yet to be completed. None of these distractions, though, could hide the fundamental strengths of the Galaxy, particularly IAIs aerodynamic engineering expertise and its focus on incorporating customer inputs.

Accelerated Development

Twelve months is an unusually short time for a transport category aircraft development program, but LAJ is right on track towards earning full-not provisional Civil Aviation Administration-Israel (CAAI) and FAA type certification by year-end. Notably, this will include approval for thrust reverser use, flight into known icing, and APU operation in flight, along with RVSM and Category 11 landing approach certification.

The Galaxy's evolutionary design, which borrows heavily from the Astra SPX, will help speed certification. Its outboard wing section, most systems, empennage and avionics are derived from the Astra SPX. Key system changes include the addition of inboard leading edge Krueger flaps, a steer-by-wire system, four-, versus two-, panel ground spoilers on each wing, EICAS in place of steam gauges, and a fuel cross-flow as well as cross-feed capability.

The Galaxy also has 20 percent fewer parts than the Astra because computer controlled machines mill large parts out of solid blocks of aluminum, thereby eliminating many small parts and fasteners.

Limiting the number of major changes results in less development risk; however, the Galaxy will be certificated as a completely new transport category aircraft in accordance with FAR Part 25 Amendment 82.

Four and "one-half" aircraft will be used for the certification program. Joining serial number 003 was serial number 004, the second instrumented flight test aircraft. Serial number 004, to be used primarily for runway and cruise performance testing, made its first flight the day I arrived at IAI's flight test center at Tel Aviv-Ben Gurion Airport.

Serial number 001 is being used for proof, limit and ultimate load tests in the static test fixture

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through September. Serial number 002, due to enter the static test fixture in October, and will be used for accelerated fatigue life testing until the end of 1999.

Serial number 005, due for first flight in August and termed the "one half" test aircraft, won't be fitted with flight test instrumentation. It will contain a production interior, then used for function and reliability testing, after which it will enter service as a demonstrator.

IAI's sophisticated flight test center, developed for its fighter and heavy transport aircraft modification programs, helps make possible the accelerated flight test program. Few business aircraft manufacturers, with the exception of Dassault, have the multi-channel telemetry, real-time data reduction and computer analysis tools to accomplish such a daunting task in so little time. This capability allows LAJ to conduct concurrent development and certification qualification tasks on the same test flight because final, hard copy printouts are ready only moments after a task is completed.

In addition, IAI has fostered a close working relationship with the CAAII thereby allowing the certification authorities to monitor the program every step of the way. This prevents surprises in the event that CAM takes exception with any of IAI's findings during any stage of development.

As of early June, the progress report showed that angle of attack, center of gravity and hydraulic system tests were all but complete, with fuel system tests nearing completion. Speed envelope expansion, air data calibration and preliminary engine performance tests were 70-plus percent done. The bulk of flight characteristics evaluation, environmental control system and high-altitude engine operation, plus runway, climb and cruise performance tests are yet to be completed. Serial number 004 will be used for most of the runway, climb and cruise performance testing because it doesn't have the excessive drag of external flight test equipment.

The PW306A turbofans still need development work, too. High-altitude cruise performance is anemic, LAI engineers admit openly. Pratt & Whitney Canada, though, told B/CA that the generic PW306 met all its performance numbers, including the planned 1,300-pound cruise thrust output (40,000 feet, ISA, uninstalled), when it was flown on Pratt & Whitney's Boeing 720B flying test bed. Both IAI and P&WC, the powerplant integrator for Galaxy, are aware of the problem. Some nacelle inlet geometry and engine fine-tuning of the PW306A may be needed to meet the installed performance goals. Both firms are confident that the problem can be overcome prior to type certification and initial customer deliveries in early 1999.

Serial number 003, the aircraft I flew for this report, has much more drag than production aircraft because of its external flight test sensors and nose boom, airframe Band-Aid modifications and no Control surface gap seals. Combine that with the lack of installed cruise thrust and the result is a performance plateau above FL 350 that won't be characteristic of production aircraft.

Serial numbers 003 and 004 also are overweight, IAI engineers conceded. Even without flight instrumentation, the manufactured empty weights are about 400 pounds heavier than expected. IAI engineers, though, say that there is more fuel capacity than anticipated and that provisions for weight and thrust growth during development will permit them to make their payload/range goals in production aircraft. They hastened to add that they have embarked upon an aggressive weight reduction program.

The five-tube, Collins Pro Line 4 avionics package also needs development work. The FMSes don't fully link with the EICAS, nuisance alarms occasionally cry wolf, some CAS messages may be changed and the yaw damper has a slight palsy.

Put into the perspective of the development schedule, however, such growing pains are as predictable as the angst of adolescence. Most importantly, IAI has a track record of producing aircraft that meet performance expectations and certificating them on time.

First Impressions of Flying the Galaxy

Hagai Koren, an IAI senior test pilot, guided me through the preflight inspection of serial number 003. The Galaxy's operational and maintenance ease-of-use features were readily apparent. For example, the main batteries are installed in knee-level trays in wing root fairing compartments. The crew can preselect the refuel quantity at the singlepoint pressure refueling receptacle. The APU has an external emergency shut-off switch that allows unattended operation.

The 125-cubic foot, pressurized, external access luggage compartment has an integral airstair door.Step into the Galaxy's fuselage and you might think you're looking at a slightly shorter version of a Gulfstream II. In fact, the cabin width and height of the two aircraft are close to the same dimensions, but the Galaxy's cross section is shaped differently because it has a dropped aisle while the G-II has a flat floor.

The cockpit also is roomy, with plenty of storage space for navigation publications, a triple-wide console with free space to accommodate optional avionics and excellent outside visibility resulting from large windows. Subjectively, the cockpit feels like that of a Challenger, albeit somewhat smaller.

IAI's cockpit design focuses on excellent touch and position identification of most system controls and switches, along with a "quiet, dark," alerts and annunciators, layout. For example, the flight guidance control panel mounted in the glareshield and the radio tuning units are located high in the instrument panel, making them easy to see and to operate by either crewmember.

However, several avionics control knobs in the triple-wide console have the same shape and tactile feel, creating the potential for mistaken control inputs, unless the pilot visually identifies the correct knob before twisting it. Each of these knobs should have a distinctive shape and feel that is unique to the function it controls, in my opinion.

Our computed takeoff weight was 27,800 pounds, a mid-range weight that included 7,000 pounds of fuel. The trailing edge flaps were extended to 20 degrees for takeoff, along with full extension of the outboard leading edge slats and in-board Krueger flaps. Koren set bug speeds of 103 KIAS for V1, 123 KIAS for VR, 137 KIAS for V2 and 160 KIAS for VENR.

After plugging the weights into the GNS-Xls FMS, Koren manually entered the numbers into the EICAS. In production aircraft, the FMS automatically will transfer the data to the center EICAS screen. Production aircraft also will have Universal UNS-1C FMSes, capable of automatically computing V-speeds and takeoff field length. When asked if the PFD's would accept bug speed inputs from the FMS, IAI engineers said that Collins and IAI would work on it.

Serial number 003 was not yet equipped with the standard AlliedSignal GTCP 36-150 APU, so the cabin became warm prior to engine start with no bleed air running through the air cycle machine. In production aircraft, the ACM will be able to pull down the cabin temperature from 113°F to 75°F in 20 minutes, according to IAI.

Onboard battery or external electrical power is used to power the starter generators for the PW306A engines. We opted to use external power.

Engine start is simple because of the FADECs. Turn on the fuel boost pumps, disarm the engine shutoff switches and press the start switches, and the FADECs handle the rest. At idle, the fuel flow of each engine was 250 pph.

Rolling out of the chocks, Koren pointed out that the variable gain, steer-by-wire, nosewheel steering system is a little sensitive to tiller movement, so it would be best to make small inputs. The limited authority rudder pedal nosewheel steering (NWS) had been disconnected because lateral gust loads on the manually actuated rudder may cause pedal movements that induce unwanted NWS inputs.

During taxi, though, the NWS proved easy to control and it didn't seem overly sensitive.

Wheel brake pressure was firm, an attribute that may be changed in production aircraft. The carbon brakes showed no tendency to chatter or squeal.

The control movement check of the fully powered ailerons and elevator revealed that the artificial roll and pitch control forces are substantial, but well balanced. A 20-pound twist is needed for full aileron deflection. A dynamic force proportional, pitch feel system, commonly referred to as a Q feel unit, produces about 21 pounds per g of longitudinal stick force. In other words, the Galaxy's control feel is strictly heavy iron.

The manually actuated rudder has a bleed-air powered bias system that is used to deflect the rudder to counteract asymmetric engine thrust.

On production aircraft, the FADEC will manage the takeoff thrust setting, but on serial number 003, a special, high-performance trim plug used for development work required that Koren set the thrust by hand. With 96.7-percent N1 set, I released the brakes and prepared to enjoy the flight. From then on, advanced telemetry did most of the work. Virtually all the numbers in the following paragraphs were printed as hard copy and in my hands within 15 minutes of the end of the flight. IAI's open-the-kimono candor left no doubt as to the authenticity of the data.

Telemetry reported an initial total fuel flow of 5,500 pph, a 22-second ground roll and an initial climb rate of 3,600 fpm. As expected, the pitch and roll control forces were hefty, but well balanced.

After a momentary level-off at 3,000 feet for ATC purposes, we were essentially cleared to FL 450 in successive steps. We climbed through FL 250 in 10 minutes and FL 350 in 16 minutes. At that point, the climb performance flattened out and we finally reached FL 420 in 23 minutes and with a total fuel burn of 1,200 pounds, but we were unable to accelerate above 0.75 Mach in ISA-3°C conditions. At maximum cruise, the total fuel flow was 1,600 pph. Descending to FL 410 and setting maximum continuous thrust, the fuel flow increased to 1,800 pph and the aircraft accelerated to 0.80 Mach during a 25-minute period at the same ambient temperature. Serial number 003's high drag and under-performing engines resulted in a high-speed cruise Mach and fuel flow at FL 410, slightly lower than IAI's estimates for high-speed cruise at FL 390 in a production Galaxy. However, the numbers were close enough to verify that the performance projections are in reach for a clean production aircraft with production engines.

A gradual increase of bank angle indicated that initial buffet Mach occurred at 35 degrees with pronounced buffet at 45 degrees. Because of its relatively high wing loading, we could maintain buffet free flight only to about 1.5 g's, implying that the Galaxy shouldn't be pushed to higher cruise altitudes than LAJ will recommend in its cruise performance charts. The Galaxy's high- and low-speed buffet margins aren't as generous as those of the Astra SPX. However, the high wing loading and the flexible wing structure should yield a soft ride for passengers.

Switching the yaw damper off, I induced a pronounced sideslip to start yaw oscillations. At a mid-range 34.5-percent MAC center of gravity, telemetry showed mild yaw damping.

Disabling the Mach trim, I pulled the nose up to start a long period (phugoid) pitch oscillation at a trim speed of 0.79 Mach. The pitch cycle was 135 seconds and the pitch oscillations were well damped even though we reached 0.89 Mach. Our conclusion? Take away the artificial stability augmentation systems and the Galaxy's natural aerodynamic poise puts it into a class with few equals.

Descending to 15,000 feet, I evaluated the effect of thrust and configuration changes, plus I flew a series of steep turns and stalls. Adding full thrust causes the nose to pitch down two degrees and the aircraft descends. Reducing thrust to idle produces just the opposite effect. Extending the speed brakes causes a one and one-half degree pitch up, but also about one-tenth g drop in lift resulting in very little net altitude change. Retract the speed brakes and the aircraft "balloons" slightly and the nose pitches down the same amount.

Extending the flaps to 20 degrees at 200 KIAS, which also extends the leading slats and inboard Krueger flaps, produces a mild increase in pitch attitude because of the flap/stab interconnect function, a slight balloon in lift and almost imperceptible airframe rumble. Further extending the flaps to 40 degrees results in a moderate drop in pitch attitude, accompanied by typical airframe rumble.

The steep turns reinforced the impression of the Galaxy's heavy-iron control feel. They also made me aware of the non-linear acceleration rate of the engines with power control lever movement. IAI and P&WC told B/CA they're working on refining the power-by-wire throttle quadrant/FADEC interface.

In contrast to the Astra SPX, the Galaxy won't have an automatic slat deployment system that operates when approaching the stalling angle of attack, according to the current plan. Instead, the aircraft has a stick shaker, an audible stall-warning alarm and a stick pusher for stall warning/recovery. Notably, the stick pusher actually activates above the wing's maximum lift coefficient angle of attack. As a result, there is no performance penalty or increase in V-speeds associated with defining the stall by means of the stick pusher rather than the natural stalling angle of attack.

Approaching the clean stall, the Galaxy provides aerodynamic pre-stall buffet warning along with mild wing roll near the maximum lift coefficient. At 24,900 pounds, stall occurred at 130 KIAS. Even when pressed to the stick pusher, though, the ailerons continue to provide plenty of roll control authority and there is only about 150 feet of altitude loss in the stall recovery.

Aerodynamic warning of the approach to a stall with gear and flaps extended is more vague. The artificial stall-warning devices play an important roll in defining the stall. At 102 KIAS, the stick pusher fired and I promptly initiated recovery. There was very little altitude loss during the recovery.

Returning to Tel Aviv-Ben Gurion for a series of landings, the Galaxy was stable on approach. Our bug speed was 128 KIAS at a landing weight of 24,400 pounds. I found thrust control somewhat challenging because of the non-linear engine response to power control lever movement.

Touchdown and rollout in the Galaxy is easier than in the Astra. There is ample aerodynamic cushion in the flare, thus it's advisable to land on speed. Although the Galaxy retains the Astra's trailing link, main landing gear design for softer landings, the Galaxy's track is much wider, thereby eliminating any tendency to "duck walk" or teeter in reaction to wind gusts or unequal wheel brake application.

Back on IAI's ramp two hours and 32 minutes after engine start, I walked down the airstair door to undergo an impromptu baptism in Israel, celebrating the flight. The Galaxy team made sure that my wetting down party was more than a token toast at the "0" Club.

Busy Months Ahead

The summer and fall weather in the eastern Mediterranean is hot, dry and clear, resulting in virtually no weather delays in the flight test program. IAI's biggest challenge may be finding natural icing conditions in northern Europe this fall to test the Galaxy's ice protection systems. Serial number 003 actually flew in icing conditions early this year, but not for certification qualification.

In the next six months, IAI will validate the Galaxy's range, payload and runway performance projections, including its ability to fly the 85-percent probability, 3,620-mile equivalent still-air distance between Paris and New York with four passengers. Brian Barents, GAC president and CEO, is confident that it will. "We have a fairly generous contingency for weight and thrust growth," he said. "You'll be able to fly the Galaxy internationally when needed. But it's really an everyday, fill-the-seats, U.S. coast-to-coast airplane that can fly at 0.80 to 0.82 Mach."

Green Galaxy aircraft will be flown from IAI's factory in Tel Aviv to GACs Fort Worth facility for completion. The interior shells, cabinets and most interior parts will be manufactured or furnished by the Nordam Group, according to Barents. Nordam is building a precise fuselage interior mockup, so that the completed interior parts may be pre-fitted to fuselage attachment points to speed later installation in production aircraft. Completed interior subassemblies will be joined to Galaxy fuselages by GAC.

GAC will complete the passenger seats and install them after the Nordam interior is in place. Barents has slated 18 weeks for the initial completions, but GAC should shave one-third from that time period by mid-1999. As a result, Galaxy aircraft should enter service with operators in the second quarter of 1999.

Heavy-iron cabin comfort, the longest range in the super-midsize class and medium-jet operating costs are the three primary design goals for the Galaxy.

The first goal is virtually assured. IAI's track record with the Astra adds credibility to the second goal. The third goal is guaranteed in writing by GAC. For 2,000 hours or five years, GAC guarantees that the direct operating costs won't exceed $850 per hour. This includes $2.02 per gallon for fuel, Pratt & Whitney Eagle Service Gold Plan for the engines, APU reserves and all maintenance parts and labor, including brakes and tires.

Our next report on the Galaxy will focus on its performance, fuel economy and utility in everyday operations. If LAJ and GAC accomplish their three main goals, then the Galaxy will set a new standard for comfort, performance and affordability in the hot, new, super-midsize business aircraft class. **B/CA**

KERET IS BULLISH ON IAI'S CONTINUED UPTURN

Moshe Keret, IAI's president and CEO, is all smiles these days. We imagine he must have sighed mightily in relief when he saw the final financial performance figures for 1997. IAI's revenue was up 15 percent from 1996 to $1.7 billion. More importantly, the firm earned a modest $24.3 million profit, reversing five years of losses, including a $42 million loss in 1996. "We're now out of the recovery period and business looks very good for the first six months of 1998 and beyond. Our backlog has increased. I'm 100-percent sure that 1997 was not an exception, but the start of a trend." Keret commented.

In the early 1990s, Keret made some difficult decisions to reverse the trend. He slashed IAI's work force, rescheduled debts to banks and changed the firm's strategic plans to boost commercial business because the military market was waning. He pressed hard for more subcontract work from international aerospace firms. IAI's commercial aircraft business increased from 20 percent of total sales in 1992 to 37 percent in 1997. Keret wants to boost that portion to 40 or 50 percent of revenue.

Business aircraft development and production will be a major player in the commercial market, according to Keret. "This is one of our most important strategic lines of business. This market looks solid to me," Keret claimed. "We've been insistently and consistently committed to it for 30 years." During the lean years of 1992 to 1996, Keret said that IAI continued to invest in business. aircraft development, pressing ahead with the Astra SPX and Galaxy programs. That was a hard sell to IAI's lenders. "You're hardly breathing and you want to invest in business aircraft development?' they asked me," explained Keret. "We convinced them it was the right thing to do. There is no better signal to the business aircraft market [than that commitment during lean times]," Keret emphasized.

Keret has reason to reassure business aircraft customers, considering the Galaxy's turbulent path to its first flight in December 1997. Announced at the 1992 NBAA convention as the Astra IV, the Galaxy originally was slated to first fly at the end of 1995. Russia's Yakovlev Design Bureau was scheduled to supply the fuselage and empennage. When Yakovlev balked IAI had to retool to make some of the parts in-house. France's SOGERMA now is slated to take over all fuselage and empennage production at serial number 013.

Regarding IAI's involvement with Yakovlev, on the Galaxy, Keret commented "we couldn't assure ourselves that we could make the [program] milestones." Long term though, Keret believes the experience with Yakovlev will pay dividends. "I don't regret it for one minute. Russia eventually will become a heavy market [for business aircraft]. It's spread out and it's relatively heavily populated."

Now that the Galaxy is on track for certification this year, Keret is confident IAI belongs in the business aircraft market in large part because of the firm's technological expertise and entrepreneurial spirit. "IAI today is driven by the market, the expectations of our customers. When you go one step beyond the company's first tier, you find that what's driving us is high technology," Keret said.

Just as importantly, IAI has the clout of GAC to add credibility in the business aircraft market.

In context, the Galaxy is more than just IAI's latest business aircraft, It's the firm's technological flagship in the civil aircraft market.