Business & commercial Aviation
PILOT REPORT

Inflight Report: Learjet 55C

The third-iteration, largest Learjet claims unsurpassed runway performance among its mid-size competitors.

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For all of our readers who have come to think of a Learjet as one of the most challenging-to-fly aircraft in production, the longhorn Learjet 55C is about to break the stereotype. Its handling is docile and its manners are predictable. It rumbles and buffets clear warnings when flown too slowly. The aircraft is truly controllable throughout the flight envelope, right down through a full aerodynamic stall. There is more good news: By the time you read this article, the Learjet 55C should be certificated.

The prime reason for the aircraft's improved manners is the addition of the much ballyhooed and highly distinctive nine-feet-plus long, "delta-fins," which replace the single, ventral tailfin on the Learjet 55B. Their purpose is two-fold: (1) improve the lateral/directional stability of the aircraft and (2) provide a nose-down pitching moment at the maximum angle of attack (stall) at all center of gravity points.

Subtle changes to the wing's leading edge and the addition of a third short, stall fence just inboard of the winglet, also contribute their share to the aircraft's refined deportment. The result is an improved chordwise airflow that remains attached to the wing at higher angles of attack. However, at very high angles of attack, a stall strip mounted on the wing's leading edge near the wing root disrupts the airflow, thereby generating plenty of turbulence over the horizontal tail. This buffeting provides an unmistakable aerodynamic stall warning.

Another interesting change is the addition of round washer-head machine screws that have replaced every other or every third flush screw fastener in the top of the wing's polished metal leading edge cuff. An engineer explained that during pre-certification development, the aircraft flew better with yarn tufts taped to the wing than with a clean wing. The firm's designers found that the tufts produced a small degree of boundary layer energizing (BLE) turbulence, delaying the separation of the airflow over the top of the wing.

Aerodynamics is still an art to some engineers. Learjet used extensive trial and error testing to find the right pattern of exposed screws to produce the same beneficial BLE results as the yarn tufts. As a result, the high-profile screws were made a permanent addition to the 55C wing. (So much for slick wings and flush fasteners.)

The Learjet 55C's low-speed manners aren't the only handling characteristics to benefit from delta-fins and wing modifications. During wind tunnel testing, Learjet engineers found that the aeromods improved directional stability. The additional tailfins eliminate the need for dual yaw dampers that were formerly required to check the large-amplitude yaw-roll oscillations encountered in certain flight regimes. Now only one yaw damper is installed, principally for the comfort of the passengers. However, final certification of the Learjet 55C may require a reduction of MMO to 0.74 Mach if the yaw damper is inoperative. Full testing throughout the flight envelope with the yaw damper inoperative is not yet complete.

As expected, the delta-fins and other aerodynamic modifications create a significant weight increase and a slight drag penalty. However, the improved aerodynamics made possible the elimination of some old systems: the stall warning stick-nudger and -pusher, the overspeed stick-puller and one yaw damper system. The removal of these systems helps hold down the weight increase.

To reduce even more poundage, the rudder balance weight was lightened by 23 pounds and the upper one-third of the fuselage fuel tank baffle was removed, shedding another 10 pounds. In total, the firm's engineers estimate that the Learjet 55C will gain only about 75 pounds.

The potential drag increase resulting from the delta-fins and wing modification also was a concern, but by pressure-tuning the shape of the engine pylons, the net drag increase was limited to about 0.25 percent. In fact the change is so slight, the firm's engineers do not foresee changing the specific range, climb or cruise charts in the approved flight manual as a condition of certification.

Learjet also has installed an upgraded Collins APS 85-12 digital autopilot system, a takeoff configuration warning system and an increase of the eight-degree flaps speed to 250 KIAS, rounding out the list of new features.

GRADUAL PROGRESS

The Learjet 55C continues a 25-year evolution of the basic Learjet 23 design that revolutionized business air travel in the early 1960s. The latest large Learjet retains much of the design philosophy that was popular two decades ago. Don't expect to find a computer-designed airframe, chemically-milled wing skins or supercritical airfoils. What one does find is a very strong airframe-sturdy to the point of being one of the heaviest business aircraft for its cabin volume.

Adding to the aircraft's weight are the use of a Freon air conditioner instead of a lighter, more modern aircycle machine; the use of separate engine starter and generator units instead of integrated starter-generators; and now, its additional tailfins and corresponding aft fuselage structural beef-up.

Certification time, development money and market pressure weighed heavily in the decision to waste no time in introducing the Learjet 55 in 1981. The firm was in fierce competition with Cessna Aircraft to be the first U.S. airframe manufacturer to certificate a new, attractively priced, mid-size business jet with more passenger room than was available in the affordable light jets. By blending together a larger cabin, the Learjet 28 "longhorn" wing profile and higher thrust TFE731-3A turbofan engines the firm expected a hot blend of high speed, quick certification and low cost .

As there was no time to experiment with high-risk, unproven design technologies, the new aircraft would incorporate many of the design features of earlier models. Unfortunately, the aircraft emerged with a rather high basic operating weight for its cabin size, relatively high V-speeds and long runway requirements compared to other medium-size jets.

On balance, new Learjet 55 operators were happy with the aircraft's fuel efficiency, handling characteristics and stability on approach. Passengers were pleased with the additional room and ease of entry of the Learjet 55, compared to earlier Learjet 20 and 30 models. Thanks to a new aft cabin door, luggage could be conveniently loaded into the aft cabin compartment. And not to be overlooked, for the first time there was a comfortable lavatory.

Although pleased, Learjet 55 owners longed for the sub-5,000-foot balanced field length (BFL) performance of earlier models, that would enable them to operate out of smaller airports close to business locations. To help regain some of these sought-after attributes, a series of performance improvements was initiated about five years ago.

On Serial Numbers 55-065, 55-087 and subsequent production aircraft, the Phase 1 program brought about three principal changes that improved airport performance: (1) additional boundary layer control devices were added to the leading edge of the wing to improve low-speed handling; (2) an automatic performance reserve (APR) feature was incorporated, boosting engine output by five percent, thus shortening FAR Part 25 engine-out, accelerate-go takeoff distances; and (3) accelerate-stop and landing distances were improved by incorporating a weight-on-wheels, automatic spoiler deployment feature.

The Phase 1A program brought the installation of thicker brakes with 13 percent more stopping power, modified wheel axles, reshaped gear doors and redesigned under-wing fairings. These modifications were incorporated on Serial Numbers 55-101, 105, 107 and later aircraft.

Both the Phase 1 and Phase 1A modifications were made available as retrofit options to owners of earlier aircraft. At the time, other aerodynamic improvements were in the works, but these modifications were put on hold as Gates Learjet ran low on development cash.

In autumn 1986, the digital Learjet 55B was announced. Serial Number 55-127 was the first aircraft to roll off the production line in the new configuration. This second major iteration of the basic design incorporated an integrated Collins digital avionics suite,

With all of its systems improvements, the Learjet 55C yields little to its competitors in that area.

improved systems, and a most welcome ergonomic switch reorganization.

For this autumn, the anxiously awaited delta-fin configuration (more than three years late) promises to deliver on the original Learjet 55 promise to provide fuel efficiency and short-field performance in a medium-size jet. Because of the extensive modification of the aft fuselage structure needed to support the delta-fins, this configuration will not be offered as a retrofit kit.

PREFLIGHT

Prior to commencing a complete preflight inspection, it may be advisable to don coveralls because of the need to get under the aircraft to check drains and to access the aft equipment bay to check systems. Also, plan on hopping up onto the wing to check the engine inlet and fan condition, unless there's a stepladder available. When the wing is wet or icy, a stepladder may be a necessity.

Under the fuselage, there are 19 fuel drains to be checked, some of which we found difficult to reach without getting down on our hands and knees. Not all of these fuel drains have to be checked on every flight, however. Checking the main landing gear wheel wells for hydraulic and fuel system integrity is a similar proposition. Single-point pressure refueling is now standard, enabling all fuel tanks to be refilled in about five minutes. On the 55C, it is no longer necessary to pump fuel from the wings to the fuselage tank(s) with auxiliary electric pumps. A two-position switch permits the wing tanks first to be partially refueled or all tanks to be filled simultaneously.

At the engine nacelle, all but the tallest pilots will require a ladder to check the engine oil tank filler cap. Alternatively, the oil access door may be reached when standing on top of the wing. A ladder also is required to check inside the engine tailpipe and for thrust reverser integrity.

In the aft equipment bay, access to each point of interest again favors tall pilots. Others will find a short stepladder helpful. When we completed the walkaround, we looked for a place to store a portable ladder. The external luggage compartment will hold a small ladder, but there is no factory-standard provision for securing it inside.

Boarding the aircraft, we noted that both halves of the cabin door are manually secured by means of locking handles. In contrast to 20- and 30-series Learjets, the electric door closing actuator has been deleted, thus eliminating its complexities.

On the flight deck, the larger area windows and more spacious working environment make the Learjet 55 easier to work in than its smaller predecessors. The standard Ipeco crew seats offer a wide range of adjustments and a high level of comfort. A rotary-knob systems test-panel simplifies many of the pre-start checks that, in earlier models, required a lot of finger movement around the cockpit.

However, the Learjet 55C remains a switch-movement-intensive aircraft, as are the 20- and 30-series Learjets. For example, the start sequence, the AC/DC electrical system, the fuel system and Freon air-conditioning system all require significant switch movement from the crew during normal flight operations.

FLYING THE LEARJET 55C

For our test flight, Robert D. Fisher, Learjet chief engineering flight test pilot, occupied the right seat and I flew from the left seat. As we began, the aircraft weighed 17,702 pounds.

After start on a hot summer day in Wichita, the Freon air-conditioning quickly cooled the cabin, proving to be more effective than some lighter-weight air-cycle machines. The Learjet 55C's Freon refrigeration and electric-coil preheating systems make for a comfortable cabin environment as long as ground power is available prior to start.

After completing the post-start checklist, we taxied out from the Learjet ramp. We found the variable authority, rudder pedal actuated, electrically operated nosewheel steering system to be too sensitive for our liking, but engaging the yaw damper while taxiing smoothes out rudder pedal inputs quite nicely. Nosewheel steering normally is used on takeoff until the first indication of airspeed. The yaw damper is not used for takeoff.

We burned about 95 pounds of fuel during taxi, giving us a takeoff weight of 17,607 pounds. Wichita's density altitude that day was just under 3,500 feet. We chose the flaps eight-degree takeoff configuration, instead of the flaps 20-degree configuration, trading a shorter required takeoff distance for better second-segment climb performance.

In consideration of the impact of the delta-fins on pitch control authority, a new trim indicator has been installed on the Model 55C, shifting the allowable takeoff trim range about two degrees more nose up.

The preliminary Learjet 55C check list called for a V1

LEARJET 55C
PRELIMINARY SPECIFICATIONS

B/CA EQUIPPED PRICE	$6,150,000
SEATS	2+7
ENGINES	
Model	Garrett TFE731-3A-2B
Power	3,700 lb. ea.
TBO	Progressive
DESIGN WEIGHTS (lb/kg)	
Max ramp	21,25019,639
Max takeoff	21,000/9,526
Max landing	18,000/8,165
Zero fuel	15,000/6,804
BOW (B/CA equipped)	13,092/5,938
Max payload	1,908/865
Useful load	8,158/3,700
Max useable fuel	6,690/3,035
Payload (max fuel)	1,468/666
Fuel (max payload)	6,250/2,835
LOADING	
Wing(lb/ft^2)	81.3
Power (lb/lb)	2.9
PSI9.4	
LIMIT SPEEDS	
MMO (M1)	0.81
VMO (KCAS)	350
VFE (approach) (KCAS)	250
V2 (estimated) (KCAS)	138
VREF (estimated) (KCAS)	122
PERFORMANCE	
BFL(ft/m)	5,100/1,554
BFL, 5,000 ft. ISA+20° C (ft/m)	8,560/2,609
Climb (fpm/mpm)	
All-engine	4,180/1,274
Engine-out	1,240/378
Certificated ceiling (ft/m)	51,000/15,545
All-engine service ceiling(ft/m)	41,000/12,497
Engine-out service ceiling (ft/m)	25,400/7,742

of 122 KIAS, VR of 130 KIAS and V2 Of 134 KIAS. In contrast, a Model 55B's V-speeds would have been 126, 134 and 138 KIAS, respectively, under the same ambient conditions. While no BFL numbers were available for the 55C prototype on the day of our flight test, the BFL for a Learjet 55B would have been 5,100 feet and thus we presume the newer aircraft's lower V-speeds would result in a significantly shorter takeoff distance.

A takeoff warning system is now standard. If both throttles are advanced beyond idle and (1) the flaps are not set for takeoff, (2) the parking brake is not released, (3) the thrust reversers are deployed, (4) the spoilers are activated, or (5) the trim is not set for takeoff, audible and visual warning indicators are activated.

Take off roll began 14 minutes after engine start. Power was set to 95.1 percent N., to stay within the normal operating temperature limits of the engines. The Garrett TFE731-3A-2B engines maintain the takeoff-rated thrust of 3,700 pounds to sea level 76°F conditions, but higher density altitudes result in lower thrust availability.

An Automatic Performance Reserve (APR) feature is available to boost N2 rpm by one percent, resulting in an ITT increase of 25°C. The APR is activated when armed and a split of about five percent N2 rpm between the two engines is detected or when APR is manually selected on.

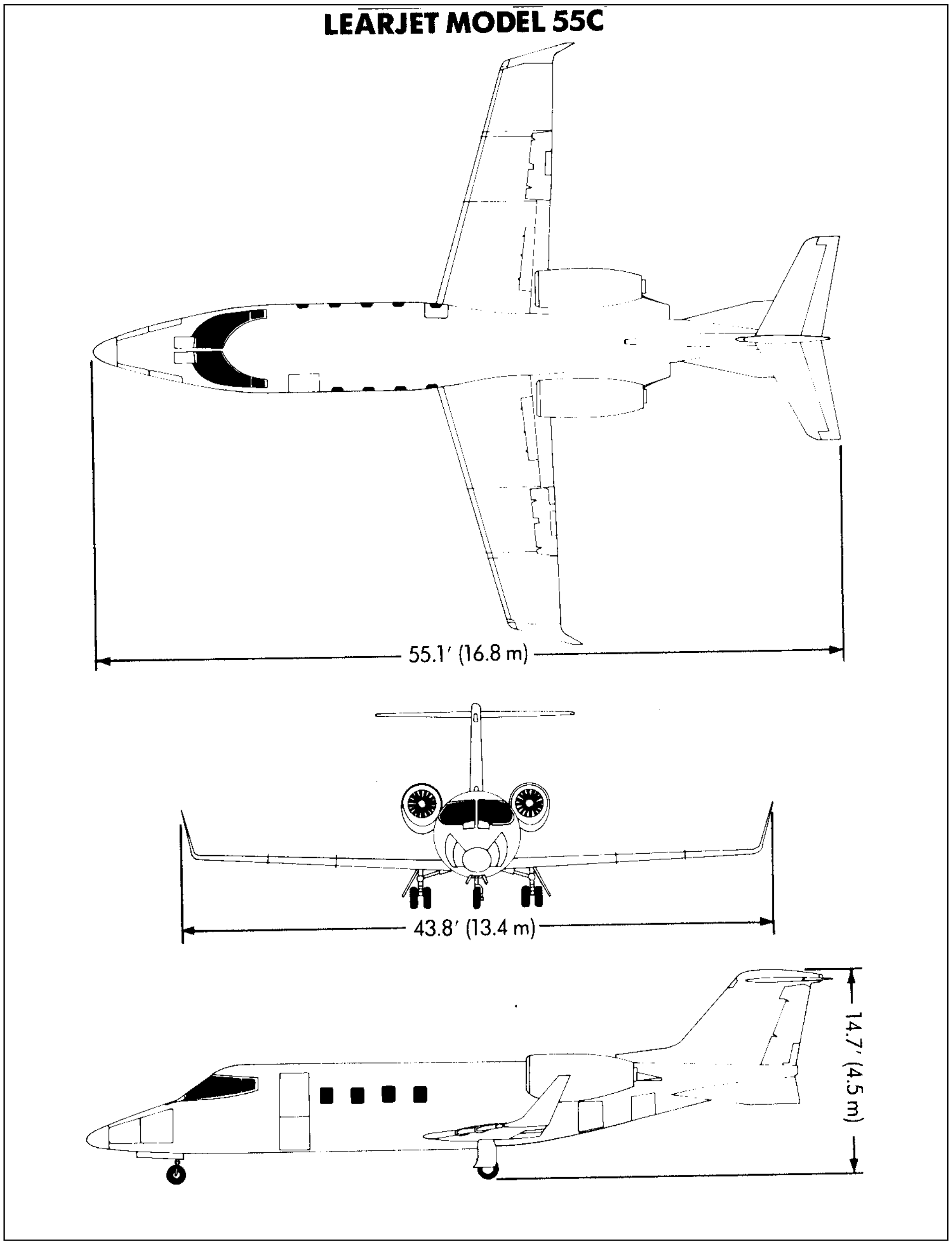
For setting engine power, we found the combination white-on-black counter-drum display engine instruments easier to use than some vertical tape or EICAS instruments we've seen.

After takeoff, our initial rate of climb was close to 4,000 fpm. Shortly after takeoff, we turned the yaw damper off for the duration of the flight. With the gear and flaps retracted, we found it necessary to reduce power to 80 percent N1 to avoid an excessively nose-high pitch attitude in the airport traffic area and to stay under the 200 KIAS speed limit. Passing through 3,000 feet agl, we advanced the power to a normal climb setting and adjusted the nose to hold a target airspeed of 250 KIAS.

During our climb we noted that the Kansas mid-summer light chop excited very small Dutch roll (yaw-roll) oscillations of about one degree of yaw movement during a three- to four-second period. In smooth air at lower altitudes at 250 KIAS, such oscillations dampened out after six or seven cycles.

This positive dynamic stability was not apparent at higher altitudes. Above 30,000 feet msl, small control inputs excited slightly larger yaw-roll oscillations. With our hands off the controls, the amplitude of the oscillations remained relatively constant, but the heading gradually changed and the bank angle slowly increased after several oscillations. At 45-degrees wing down and with a heading 20-degrees off course, we initiated a wings level attitude and corrected to the course line. Such divergence was not difficult to control in VMC, but we believe that the Model 55C's lack of natural dynamic stability would require constant attention when flying in choppy IMC without the use of a yaw damper.

We passed 10,000 feet 18 minutes after engine start, having consumed a total of 300 pounds of fuel. Rather than using maximum climb thrust, we observed the recommended ITT limit of 865°C until passing



ty to dampen the pitch oscillations after several cycles. During this pitch stability check, there was a need for lateral and yaw control inputs to check a mildly divergent Dutch roll.

Having burned down to a gross weight of 16,500 pounds, we slowed the aircraft at 45,000 feet, pulled the power to flight idle and trimmed for 140 KIAS in preparation for a clean stall. As the angle of attack increased there was plenty of buffet and light wing-rocking to warn of the impending stall.

The stick shaker activated at 121 KIAS and we continued to hold pitch attitude. The buffeting and wing-rocking increased in intensity as we slowed down to a minimum aerodynamic stall speed of 107 KIAS, at which time we could no longer hold pitch attitude-even with full-aft yoke deflection. The stall was accompanied by a pronounced wing drop, but very little yaw.

Recovery was achieved by lowering the nose, adding maximum power and leveling the wings. Gone are old concerns about settling into a deep stall, a point at which the horizontal tail becomes blanked in the turbulent wake of the wing at high angles of attack.

35,000 feet in order to prolong engine life. The combined effect of the reduced power setting and ambient temperatures 10 to 15 degrees above ISA resulted in a much slower than “standard-day” climb to altitude.

At 47,000 feet msl we trimmed for a speed of 0.72 Mach, and checked the aircraft’s long period pitch damping (phugoid) characteristics. The aircraft settled into a comfortably slow, 60-second-plus phugoid cycle that did not exceed a 10-percent divergence from trim airspeed and exhibited enough positive dynamic stabili-

Descending from 40,000 feet, we accelerated to MMO’ a speed that varies from 0.79 to 0.81 Mach as altitude decreases. At higher indicated airspeeds, pitch control force increases substantially as one would expect with a manual control system.

Learjet’s flight test department has successfully expanded the high-speed margin of the flight envelope to permit the removal of the stick puller system, but the 55C’s aero mods weren’t a factor. The warning against deploying spoilers above VMO/MMO remains in effect to preclude "a significant nose-down pitching moment," according to the flight manual.

At VMO/MMO, the lateral/directional stability characteristics are optimum, with the best Dutch roll damping in the flight envelope. We checked the yaw damping through a series of maximum-aileron deflection roll reversal maneuvers. During these maneuvers we noted excellent yaw stability without the need for the yaw damper or rudder inputs. The turn coordinator never strayed more than one-half a ball-width off center.

At 12,000 to 16,000 feet, we performed another series of stalls in various flap and gear configurations. Stall speeds varied between 93 and 105 KIAS depending on flap configuration. With full flaps deployed, the aircraft has less aerodynamic stall warning prior to the stall, and less nosedown pitching movement at the stall. With the flap 20- and 40-degree configuration, gear down, there isn't quite enough natural pre-stall warning at seven percent above stall speed to permit elimination of the stickshaker. For this reason alone, the company decided to retain the stickshaker, stall warning feature

However, we found the aircraft to be fully controllable even while holding full-aft yoke deflection through the stall in any configuration.

Returning to Mid-Continent airport, we executed a number of landings in various configurations. With the yaw damper off while in the landing configuration in turbulent flight conditions, the aircraft is quite easy to control, exhibiting none of the untoward Dutch roll characteristics that pilots are cautioned about in the 55B flight manual.

Simulated engine-out landings and simulated engine failures on takeoff present no controllability problems in this aircraft. Overcoming asymmetrical thrust at maximum power still takes plenty of rudder pedal pressure, though. However, after the ball is nearly centered, use of the yaw damper substantially reduces the pilot's workload when operating in single-engine conditions. Clearly, this aircraft's engine-out handling chores are not in the same league with those of 20-series Learjets.

Taxiing in after our two-hour flight, we concluded that it would be hard to name a more well-behaved business aircraft in the low-speed operating environment, even considering the refined handling of the Learjet 31 on which we reported in the March 1988 issue (page 40). Yet, the Learjet 55C retains all of the positive attributes of the first- and second-iteration large Learjet models.

PERFORMANCE VERSUS PRICE

The expected reduction in runway requirements should be most welcome to prospective buyers. The firm expects to attain a BFL of just below 5,100 feet, under standard-day conditions. If attained, such performance would be the best of any mid-size jet competitor and would bring the aircraft back to traditional Learjet short-field compatibility.

The newest Model 55 benefits from other refinements as well. The eight-degree flap configuration is now usable to 250 KIAS. The APS 85-12 autopilot has an expanded operating envelope, with no prohibition on the use of spoilers when the system is engaged, no bank limit above 41,000 feet and no limit on engaging altitude hold with large rates of vertical speed. Also, the autopilot now can capture a localizer course at intercept angles greater than 45 degrees.

With all of its systems and runway performance improvements, the Learjet 55C yields little to its competitors in those areas. Many of the Learjet 55B's hot/high runway performance shortcomings have been eliminated. Its fully digital Collins flight control system is unsurpassed in sophistication. The elimination of most of the stall warning boxes improves dispatch reliability.

According to data in B/CA's April 1988 Planning and Purchasing Handbook, on business trips of 300 to 1,000 nm, the Learjet 55C can transport four passengers on less fuel than its competitors, and typically cruises at a higher altitude. With an initial climb rate in excess of 4,100 fpm and relatively high-altitude cruise capability, passengers should be afforded a very smooth ride.

Cabin size, while comfortable, is not the Learjet 55C's strong suit compared to other mid-sized aircraft. Also, its seats-full and tanks-full range may require an en route refueling stop when other mid-size jet competitors might continue non-stop to the destination.

However, for loyal Learjet fans, the 55C offers the best reasons yet to step up into the largest model. It provides familiar systems and controls plus typical Learjet performance while exhibiting much refined handling behavior compared to its early predecessors. Its sleek lines and low stance still attract many admiring glances. The Model 55C is truly the best Learjet ever produced.

With a $6,150,000 price tag, emotional appeal places a distant second to objective considerations regarding the purchase of a Learjet 55C. In a statistical, cost-benefit contest with other midsize jet competitors (both new and used), this aircraft faces formidable challenges from other aircraft with greater cabin volumes, with larger useful payloads and with more advanced aerodynamic features. Yet, it's difficult to imagine Learjet Corporation not taking on all comers - something they have been doing for the past 25 years.
B/CA