LEAR 55

A ten mile high

BY EDWARD G. TRIPP

It was a typical Saturday morning of touch and go at the local airport. The approach check list completed, the first officer broadcast our 45-degree entry to the downwind leg while we both looked for traffic. I called for eight degrees of flap and slowed the airplane to the initial approach speed, Vref plus 30—156 knots.

There were two other aircraft in the pattern with us, a Cherokee and a Bonanza. The spacing looked good. The Cherokee was flying a tight pattern appropriate to its relatively slow speed; the Bonanza flew a bit wider. We were flying wider and higher yet.

We stayed in the pattern for about 30 minutes trying a variety of visual approaches. During one, an engine failed on base leg (not really; the instructor simulated a failure).

Anyone who has ever lost an engine on a piston twin can imagine the anxiety and hustle in the cockpit at that point. There was none. Envy of envies, the Lear 55 can go around on one engine with full flaps and gear down at normal landing weights.

Then, too, the laconic statement that it was a typical Saturday morning is a bit of license-taking. Not too many people like the idea of mixing traffic in a pattern with speeds that are one half or double, depending upon which seat you are in. Add to that the consideration that the Cherokee was flown by a student pilot and the Lear by a pilot with slightly more than an hour in it, about 10 hours of total Lear time spiced with a bit more than three hours in simulators.

The Learjet has a reputation as an extremely demanding airplane to fly, particularly in approach configuration. The pilot-induced oscillation in the Lears is not in pitch, it is lateral/directional—the ominous Dutch roll. Easily started, the Dutch roll is aggravated by instinctual pilot attempts to correct. Loss of control, particularly

Smooth lines and a new wing give the Lear its speed. At 51,000 feet and .79 Mach, the wing and winglet shock waves buzz as they collide.

at the point when power is added to start a go-around, is easy and can end in a half snap into the ground.

The point of this little hangar tale is that it was all a carefully controlled exercise. Visibility was excellent, the pilots of the three aircraft spaced themselves properly and kept the others informed of their whereabouts and intentions, and the work load in the Lear was being divided according to an organized, long-proven plan.

I was participating in an intensive week-long introduction to the certified, production version of what Gates Learjet announced with great hoopla four years ago as the Longhorn. These were to be the first aircraft to use winglets to improve efficiency.

The exercise began with lengthy, introductory briefings by specialists from both Gates Learjet and FlightSafety International. FlightSafety provides initial and recurrent training in the 20, 30 and 50 series Lears.

Gates and FlightSafety began working together in 1972 to provide good training to flight and maintenance crews. It is an impressive program. Though FlightSafety is not the only organization capable of turning out competent pilots for Learjets and similar aircraft, there is certainly none better.

One of the most impressive factors in the company's approach to training is the emphasis on training crews rather than individual pilots. There is no question that it takes two in aircraft such as the Lear 50 series. The man in the right seat is definitely a first officer, not a supernumerary.

Essentially, the program crammed into two days what a well-qualified pilot covers in two weeks (the average transition course includes 40 hours of classroom instruction, 20 hours in the simulator and a lot of homework. During the classroom work on the aircraft and its systems, I met my first officer for the program, David Lennox, a captain with Gates' Flight Operations Department.

We started work in the simulator and concentrated on crew coordination and division of work load in anticipation of our flights the next day. The basic division of pilots between the seat-of-the-pants school and the by-the-numbers school ends long before you step into the hostile world of high-speed, high-altitude, all-weather flying. It is definitely by the number, by the book and highly disciplined.

Most pilots look at a Learjet with admiration, much the same way most of us look at a P-51. Sleek. Fast. Sexy. Individualistic, despite the fact that more than 1,000 of the 20 and 30 series Learjets have been built in the past 15 years.

Lears have a deserved reputation for performance. Quite a few jets still flying today have marginal performance. But Learjets always have had a healthy power (thrust) to weight ratio. In many respects, the first—Model 23—was overpowered. One reason for this was the decision to certificate the aircraft to the less stringent Civil Aeronautical Regulation Part 3, which meant it had to settle for a maximum gross weight of 12,500 pounds. Another was that it was a small aircraft, which meant a comparatively small cabin section.

Though performance was primary to pilots and to a fair number of entrepreneurs who were content to sit in the back, it has been a selling negative, particularly with larger corporations. In fact, it was not until the mid-1970s that corporate giants began to purchase Learjets in any significant numbers. By then, the combination of the need for relative economy, in terms of operating costs, and the needs of smaller groups of top executives, who wanted to travel without the stigma of using corporate barges to haul two to three top officials, made the aircraft more attractive.

Several other things were going on at the same time. First, while most pilots think of Learjet as one aircraft, the product development since the original Model 23 has been considerable. The pure-jet model, 23, grew into the Model 24, the first general aviation aircraft certificated to Federal Aviation Regulation Part 25 (Air Transport category) standards. Model 24 has gone through four variations as has the Model 25, a longer fuselage version. It can carry up to eight passengers plus two crew. Both the 24 and 25 series aircraft were certificated for flight up to Flight Level 510 in 1977. Both versions also had aerodynamic and powerplant modifications over the years to improve performance.

In 1971 the company began experimental flights with a turbofan engine, a variant of the Garrett AiResearch TFE-731-2, on a Model 25 airframe. The better specific fuel consumption for average cruise levels spawned the Models 35 and 36, which were certificated in 1974 as stretched cabin, long-range aircraft with takeoff weights of 17,000 pounds.

In that year, the 400th Learjet was delivered. By then an increasing number of them were being sold to second and third owners, as were earlier jets from other manufacturers. There was an increasing number of facilities offering short-

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course type ratings for jets. At many of them, pilots were being trained to a minimum standard in a minimum amount of time. Plus, the requirements for copilots were minimal.

By 1977 Gates Learjet had decided to go ahead with a new wing. The Century III modification, which had been certified in 1976, reshaped the leading edge to modify low-speed airflow, improve controllability and reduce approach speeds and landing distances for late versions of Models 24, 25, 35 and 36. Prototype construction of the new wing, incorporating winglet technology, began in mid-1977.

The series 28 and 29 aircraft were certificated at the beginning of 1979. The sail at the tip of the wing, a beautiful, complex piece of metal sculpture, controls the vortex wake to reduce drag and produce a small amount of thrust. Though high aspect-ratio wings provide better aerodynamic efficiency than more conventional ones, structure and weight become significant factors as the size and weight of an aircraft increase. The use of the winglet is a compromise that provides many of the benefits of the long-span, high aspect-ratio wing without the stress/structure/weight penalties.

The wing design did extract a range penalty for the short-run 28/29 series aircraft. The removal of the tip tanks reduced total fuel capacity and essentially made them special-use aircraft—high altitude to achieve range.

Gates announced ambitious plans in the fall of 1977 for a big, walk-around cabin aircraft with the high performance associated with Learjets, fuel efficient turbofan engines and very high-altitude capability (particularly for turbofans).

At the same time, the Federal Aviation Administration was becoming concerned about operations at high speed and high altitude—up in coffin corner. Here the speed margin between stall and overspeed, with its possible loss of control (called jet upset, where aircraft tend to tuck as they approach or pass through the speed of sound), are close together. The administration began to reinterpret the FARs in terms of what had to be demonstrated as satisfactory handling qualities. The new standards affected several programs, although it could be claimed that the Lear 50 series was the first guinea pig. One of the more carefully examined areas was stall divergence in all configurations; another was the investigation of pitch trim malfunction. Reliability of systems and structures as well as flight characteristics were put under far more stringent review.

Following closely on the new interpretations of the FARs by the FAA was a series of accidents involving Learjets in both low-altitude/low-speed and high-altitude/high-speed operations. To oversimplify, while the new 50 series was undergoing far more rigorous certification proceedings, earlier models were being subjected to a certification review.

The results of the certification review were released this year. They have affected to some extent all 20 and 30 series Learjets, with the exception of the few 28 and 29 models.

Aircraft in the 20 series, which had been cleared for operation at FL510, have been limited to FL450 for a time. Quite a few models must have autopilot, trim and trim-monitoring systems modified, and a large number of aircraft in the fleet

LEAR 55 *The new Lear is larger than the older models; swivel-seats can be ordered for 10 passengers.*

have had changes made to the operating manuals and procedures that, in effect, increase both takeoff and landing distances because of higher speed requirements.

There is some dispute between the company and the FAA about the conduct and findings of the review. The results affect many operators of Learjets, some of whom feel—justifiably, it seems—they are being penalized by the poor qualification of some crews or the failure of others to adhere to the operating limitations of the aircraft. And a further case could be made that the defensiveness of the FAA in recent years has resulted in a tendency to require that aircraft be designed for the abilities, competence and intelligence of the lowest common denominator.

Whatever the philosophic battles and whatever the cost to Gates Learjet and its customers, in some respects the Lear 50 series has benefited from the situation.

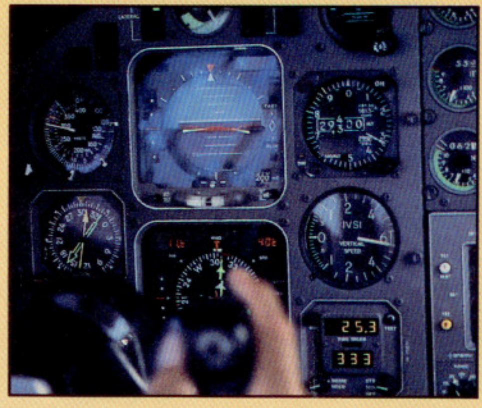
Gates has gambled big bucks on the 50 series. In the four years between the announcement of the program at the Paris Air Show in 1977 and the display of the first customer aircraft in Paris this year, more than two million hours were expended. The company spent roughly $40 million for research and development, mostly on development of the winglet technology on the 28/29 series and the 50 series.

The decision also was made that the 50 series would be built in Tucson instead of Wichita, which required a substantial investment in buildings, fixtures and tools. It also required that the company hire and train a new work force.

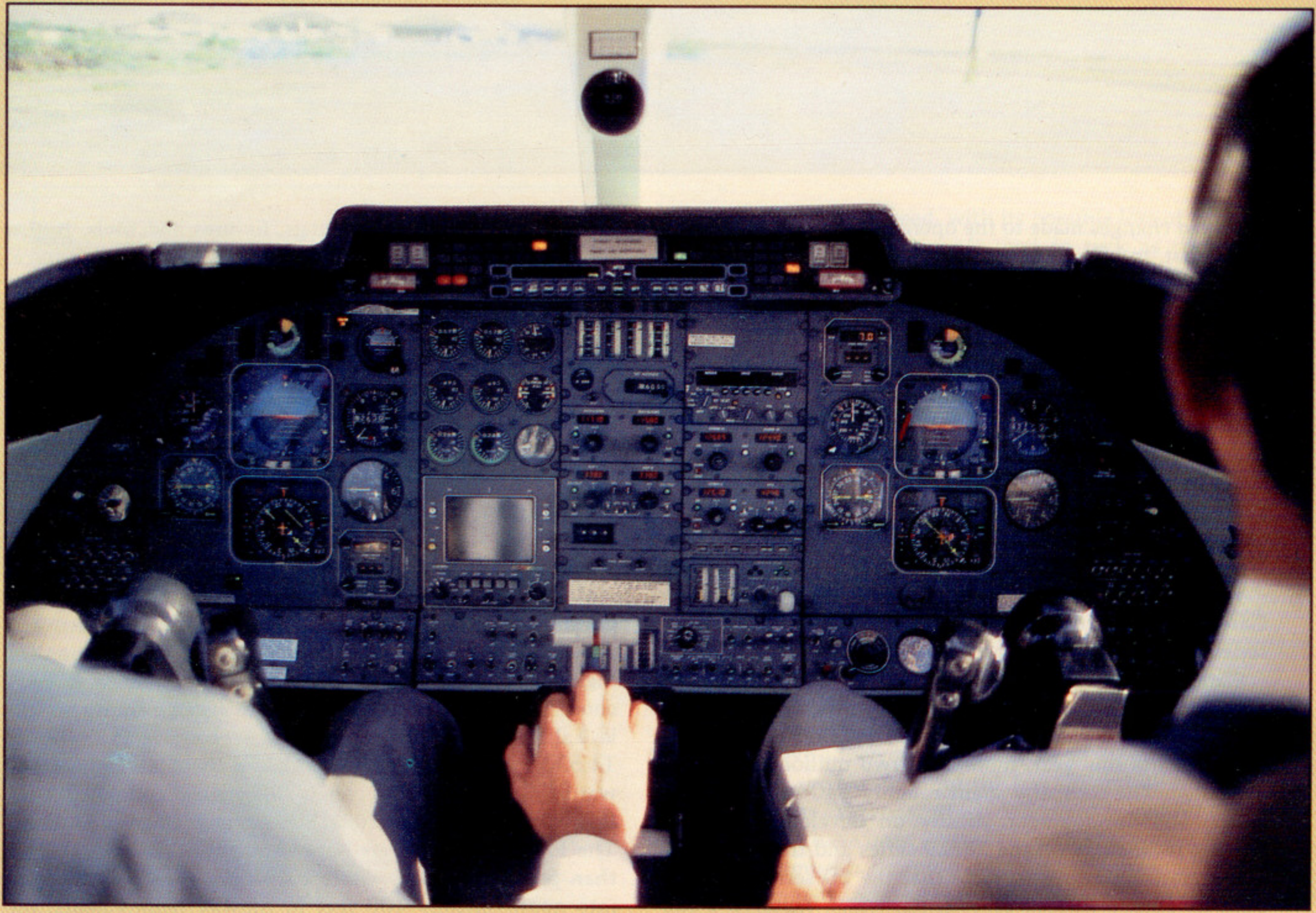
Added to the risks are inflation, some new twists in certification and the basic question of whether or not companies would buy a big aircraft built by Learjet. Also, consider that long lead times for turbine aircraft are beginning to soften and that more companies are reconsidering the speed of jets, the average stage length of their flights and the price of turbine fuel, which is approaching $2 per gallon.

Production, which is moving toward the initial goal of five per month now, is sold through early 1984. Total orders exceed 160 aircraft. The company has announced plans to increase production to a rate of seven per month.

Gates spokesmen point out that there are a few items of unfinished business. Thrust reversers have not been approved yet. There is a 45-minute turnaround limitation for high-weight landings or aborted takeoffs because of FAA concerns about wheels and tires. The average empty weight is 1,000 pounds above the design objective (12,600 vs. 11,530), which reduces payload; and there is a critical forward-CG situation with certain interior and equipment configurations that can require loading and range limitations. The FAA-certificated stall speed averages six knots higher than predicted speeds. Since each knot in speed translates into approximately 100 feet in runway requirements, the



The airplane becomes a life-support system at normal cruise altitudes. Because of pressurization and spoilers, a 6,000 fpm descent rate comes at a near-level pitch attitude; those in back barely know.



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company is experimenting with a 12-degree takeoff flap setting to reduce balanced field length requirements, particularly at high, hot airports.

As it stands, the Model 55 is an impressive airplane. There are no limitations to its certification. It is approved for night, IFR, known-icing conditions. These are levels that frequently are achieved after basic certification is earned.

It is a big airplane. Cabin volume is large—150 cubic feet greater than the 30 series (472 vs. 322)—and the fuselage cross section is 50-percent larger than that of other Lears. Yet it is only four knots slower at high cruise power than the Model 35A and uses about the same amount of fuel.

The larger aircraft gets its high relative efficiency from the combination of a higher aspect-ratio wing, winglets, less drag (particularly as the result of the higher location of the engines on the fuselage) and—surprise—higher power engines. The TFE-731-3A version of the AiResearch engine produces 3,700 pounds of thrust for takeoff compared to the 3,500 pounds available in the 731-2 version, which is standard on the Model 35A.

Everyone inside benefits from the increased fuselage size. The typical cabin layout provides comfortable seats for seven. It can carry up to 10 passengers, and there are 13 different interior arrangements offered by the factory. The cabin also has good galley space—including provision for heating food—a stand-up lavatory with flushing toilet and hot and cold running water, and 33 cubic feet of baggage space that can be loaded from the outside through the emergency hatch without disturbing the cabin.

The cockpit is raised above the cabin. Many large corporate aircraft do not leave much room in the cockpit, so large pilots are uncomfortable, and the seats leave something to be desired, particularly during long flights. But the Lear 50 series' cockpit is long and wide enough for heavy pilots of well above average height. The rudder pedals are electrically adjustable fore and aft. The seats have nine adjustments to make just about anyone comfortable for a long period.

Cool-, hot- and fresh-air flow has been designed to keep everyone comfortable; those in the sun do not bake while those in the shade freeze. The noise level is unusually low. In fact, the crew has to be careful what is discussed up on the flight deck, since the rearmost passenger can hear the conversation without trying.

The arrangement of instruments, controls, switches and levers in the cockpit is very logical. Though the airplane is a mass of necessary systems to preserve life in the hostile atmosphere where it normally flies, it takes little time to learn where everything is.

Visibility forward and to the sides is almost as good as in a helicopter. In fact, there is very little to provide visual clues for eyeball flying, particularly for the transitioning pilot. This is particularly true at altitude. Attempts to level off from a climb or descent using strictly outside reference can become the cause for high frustration or great laughter.

Beyond the preflight inspection, there is a great deal of calculation to be done before engine start and departure. Weather, distance, payload, runway requirements, takeoff power settings, fuel requirements and a variety of critical speeds must be figured.

For instance, before takeoff, the following speeds must be calculated precisely, based on temperature, pressure altitude, runway condition and takeoff weight: V_1, critical engine failure speed; Vr, rotation speed; V_2, safe takeoff speed (in the event of an engine failure at V_1); Vfs, first segment climb speed; Vse, single-engine climb speed; and Vref, final approach speed based on 1.3 times the stalling speed in the landing configuration. Then you must do all the calculations based on estimated weights for the destination and alternate airports, including assurance that the field lengths are adequate for the weather and your landing weight.

Aircraft in this category do not give their joys away lightly. Once all the preliminary work is complete, there is a host of checks to be made before and after engine start. Engine start itself is almost anticlimactic; even the noise level for this operation does not intrude inside the aircraft.

Ground operation is easy, despite a nearly 10-ton ramp weight and the great dimensions of the airplane. Steering is hydraulically actuated and controlled through the rudder pedals and is operated either by a steering-lock selector to the left of the pilot's yoke or by a yoke-mounted button. It takes a bit of practice to keep from lurching, but the steering system is not too sensitive.

Nosewheel steering is engaged via the yoke button during takeoff and landing up to and down from about 45 knots.

Throughout calculating, checking the aircraft and its systems and preparing it for flight, the pilot and first officer challenge each other through a series of check lists. On the runway, the teamwork begins in earnest. The pilot making the takeoff (or landing) controls the airplane. The other calls "airspeed alive" as the indicator moves, cross-referencing both pilots' instruments. It is the signal to disengage the steering and let the rudder take over directional control.

Both pilots monitor the process and the instruments, par-

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ticularly the airspeed indicator, at this point. The pilot in command sets the approximate takeoff power setting; the second in command does all the fine tuning while he monitors speed and calls V_1 at the appropriate time, then Vr.

This is standard for all properly conducted jet operations. While all the controlled work is going on in the cockpit, the runway rushes by. In the Model 55, there is no great rumble and roar, particularly inside. The amount of time from application of power to rotation is brief, but the only sense that something mighty is being hurtled into flight is visual.

While rotation is a positive maneuver, it is not abrupt or dramatic. It must be done precisely; rotating too soon or too late can increase greatly the length of runway required.

When V_2 is reached, the pilot flying commands "gear up" and "yaw damper on." At V_2 plus 30 knots, he calls for flaps up. Then it is time for the after-takeoff check list.

During all of this, a great deal of thought must be given to the comfort of the paying customer. Except for high-weight takeoffs in very hot weather, the Lear can perform an airshow quality departure. But the passengers probably would become alarmed by the high deck angle. The name of the game is to adjust power and airspeed to keep the deck angle below 20 degrees and the airspeed below 200 knots.

Once through 5,000 feet, you can accelerate to 250 knots and relax a bit. As you approach FL180, the climb speed is about 270 and it is time for the FL180 check list.

Unless you are using airspeed hold and altitude preselect on the flight-control system and letting the autopilot fly the airplane, leveling off presents an interesting challenge, which shows how easy it is to get behind and stay behind an aircraft with this kind of performance. It is illegal, uprofessional and, usually, hard on the passengers to hunt for the

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right attitude and altitude. The throttle-jockeying that can go with it just adds to the aggravation.

During my introduction to the 55, I elected to level off at 12,000 feet for slow flight, steep turns, different configurations with approaches to stalls in all of them, together with demonstrations of the stick-shaker, nudger and pusher stall-avoidance aids. In all phases of flight, I found the two-speed (for low- and high-speed operations) horizontal stabilizer trim to be my biggest aid—next to the first officer. Power, airspeed and attitude changes produce heavy forces that must be trimmed off to minimize divergence from the chosen configuration as much as to reduce arm strain.

Watching high-time Lear pilots fly, I have been struck by how the trim is in motion almost constantly as the aircraft's attitude and/or configuration changes. During level-off at cruise altitudes, after descent and when changing configuration, I quickly learned that the trim must be used in anticipation of an attitude, rather than establishing an attitude and then trimming off the force. The sound of the trim-in-motion audio warning became my constant companion.

The average weight for my flights was 17,000 pounds. That is a lot of mass and inertia to wheel about the sky, but the 55 handles well in the denser air in which we were maneuvering with the help of the trim button. You do not see or sense a large aircraft around—mostly behind—you. And it is highly satisfying to hit your own wake in continued steep turns, trying to hold an altitude.

Approaches to stalls start with a hey-you from the stick

shaker, which approaches something akin to Clark Gable buffeting in *Test Pilot.* (Except, the aircraft is not buffeting yet, just the control column is.) Let the speed degrade a bit more, and the nudger reminds you. Then the pusher tries even harder to wake you up. In the stall proper, the aircraft will try to roll off on a wing.

The Lear 55 is equipped with spoilers that can be used to descend and to dump lift after landing. With more than 25 degrees of flap, they also function as spoilerons to improve roll control. They are proportional in actuation during their spoileron function. Roll control is enhanced without the abrupt inputs or snatching that can occur in some aircraft.

To keep the aircraft within its design operating envelope at high airspeed and high altitude, there is another aid that comes into play: the stick puller. Actually, it is a two-part, two-phase system. If Vmo (maximum operation speed) is exceeded, an overspeed warning horn will sound. At altitudes where Mach number becomes the maximum-speed limiting determination (Mmo), the aural warning is combined with the stick puller and the nudger. For those of us who are used to struggling up to altitude at a less-than-desirable forward speed, it is amusing to note that it is possible to reach the limiting speed in the Lear 55 in cruise or climb.

At the normal cruising altitudes of the Lears, it is an understatement to say that the air is less dense. There is less lift; the range from overspeed to stall is fairly close, thus an aircraft cannot pull as many Gs in a turn or in turbulence. For all the advertising about soaring high above traffic and weather, in some ways, the hazards are increased.

The aircraft becomes a life-support system, and the knowledge, training, discipline and awareness of the flight crew are the first link. The quality and integrity of the aircraft and its systems are, in combination, a close second.

Under normal circumstances, the airplane is a pleasant place to be. It is easy to hand fly, so long as the pilot's attention does not wander and no abrupt maneuvers are attempted. The air was calm at FL450 on the day I flew, so there was no opportunity to sample its behavior in nasty conditions, when Dutch roll is induced easily without the aerodynamic and flight control aids.

The newly certificated JET FC550 flight-control system (manufactured by Jet Electronics and Technology, Incorporated) includes a soft mode for flight in turbulent conditions, a half-bank mode for high-altitude operations and a variety of self-monitoring circuits. There also is a dual yaw-damper system. The yaw damper is a no-go item and is on for all operations except takeoff and landing.

The approach to either side of coffin corner is announced to the somnolent with aerodynamic fanfare. The low-speed boundary proclaims itself with a rumble that is not a buffet, as the boundary layer at the wing-root/fuselage juncture begins to separate. At the high-speed end, as limiting Mach speed is approached, a higher-frequency buzz is produced as the air flowing at the wing-tip/winglet juncture begins to separate. Neither phenomenon is alarming, nor do they affect controllability; but they do attract the crews' attention.

I was able to taste more than a normal-cruise situation during our high-altitude flight, as we did circuits in a block of airspace that ended at the Mexican border. It gave me the chance to try higher-bank and higher-G turns than one normally would perform during a passenger run at altitude.

I also was able to try both normal and high-rate descents. The only difference to the folks in the back is the noise and slight buffet from the extended spoilers. With an acceptable deck angle and enough power to maintain pressurization, you can peg the vertical speed indicator on its limit of 6,000 fpm.

There is another series of check lists for descent and all the way through to shutting the aircraft up for the night.

Approaches, even ones that are not stabilized because of ATC requests or for other reasons, such as spacing for other traffic, are solid-feeling. The excellent visibility from the cockpit is a big aid, as is the fact that most of the critical numbers, from speeds to engine power settings, have all been calculated beforehand. Most of the guesswork—again with the qualifier "when everything is working right"—has been taken out of such machines. That is as it should be, since the reason for being for such an aircraft is the safe, predictable delivery of valuable passengers.

My first landing in a Lear was interesting. I had this mental picture of jet aircraft on final in huge nose-up attitudes, the cockpit 10 stories above the people in the back seats. The check pilot said: "Fly it onto the runway." "I am," I said. "Get the nose down. . .get the nose down. . *get the nose down!*"

I was trying to land it on the main gear and the tail skid.

I still am tempted to cheat a bit and flare more than is required, so I worked at it extra hard with the 55. What looks like driving into the runway, from way out there ahead of the rest of the airplane, is really the proper attitude for landing. The airplane rewards the pilot for the proper landing attitude—on glidepath, on speed—with a very satisfying arrival and no waste of runway.

For all of the visual flair of a Learjet, it is a by-the-book, by-the-numbers airplane. The Model 55 is even more so. For all that, it is an airplane. It is a very exciting, enjoyable one to fly, and it needs pilots to fly it. Mr. Corporate Head, what is wrong with getting the job done and having fun at the same time? □

GATES LEARJET LONGHORN MODEL 55

Base price $4,950,000

AOPA Pilot Operations/Equipment

Category: Global

Specifications

Powerplants	2 Garrett AiResearch TFE-731-3A-2B turbofans; 7,400-lb total takeoff thrust
Maintenance	Progressive maintenance intervals of 150 hours; turbine section inspected and serviced at 1,050-hour intervals.
Wingspan	43 ft 9 in
Length	55 ft 1 in
Height	14 ft 8 in
Wing area	264.5 sq ft
Wing loading	73.7 lb/sq ft
Power loading	2.6 lb thrust/lb
Seats	10 max
Cabin length	16 ft 8 in
Cabin width	5 ft 9 in
Cabin height	5 ft 8.5 in
Empty weight	12,130 lb
Useful load	8,620 lb
Useful load to ZFW	2,870 lb
Payload w/full fuel	1,663 lb
Max ramp weight	20,750 lb
Zero fuel weight	15,000 lb
Max takeoff weight	20,500 lb
Max landing weight	17,000 lb
Fuel capacity	1,001 gal/6,707 lb (997 gal/6,682 lb usable)
Oil capacity, ea engine	6.7 qt
Baggage capacity	
Nose	75 lb/8.5 cu ft
Aft cabin	500 lb/33 cu ft
Tailcone	200 lb/18.5 cu ft

Performance

Takeoff balanced field length	
Flaps 8 deg	5,650 ft
Flaps 20 deg	5,400 ft
Rate of climb	4,380 fpm
Single-engine ROC	1,250 fpm
Max level speed, 23,000 ft	487 kt, 0.81 Mach
Max level speed, above 36,000 ft	464 kt, 0.79 Mach

Cruise information based on 6 passengers at 200 lb each, 1,300 lb rsv fuel and the following IFR requirements: go to destination; miss approach; climb to 5,000 ft; hold for 5 min; climb to 35,000-41,000 ft; fly additional 200 nm; shoot approach at alternate; have 30 min fuel left. Block time and fuel include 11 min and 130 lb for taxi and takeoff.

Max cruise speed	439 kt
takeoff weight, 16,483 lb; block time, 1 hr 24 min; block fuel, 1,582 lb; altitude, 43,000 ft; fuel consumption, 1,069 pph (155 gph); range, 500 nm	
Economy cruise speed	401 kt
takeoff weight, 16,431 lb; block time, 1 hr 28 min; block fuel, 1,531 lb; altitude, 43,000 ft; fuel consumption, 916 pph (136 gph); range, 500 nm	
Max range	1,960 nm
takeoff weight, 20,315 lb; block time 5 hr 8 min; block fuel, 5,415 lb; altitude 47,000 ft; cruise speed, 401 kt; fuel consumption, 886 pph (132 gph)	
Max operating altitude	51,000 ft
Pressure differential	9.4 psi (8,000 ft cabin @ 51,000 ft)
Landing distance (@ 17,000 lb)	2,800 ft

Limiting and Recommended Airspeeds

Vmcg (Minimum single-engine control, ground)	90 KIAS
Vmca (Minimum single-engine control, air)	
8 deg/20 deg flaps	104/99 KIAS
V1 (Critical engine-failure)	
8 deg/20 deg flaps	136/132 KIAS
Vr (Rotation)	
8 deg/20 deg flaps	143/136 KIAS
V2 (Takeoff safety)	
8 deg/20 deg flaps	150/143 KIAS
Vyse (Best single-engine rate of climb)	149 KIAS
Vxse (Best single-engine angle of climb)	140 KIAS
Vy (Best rate of climb)	133 KIAS
Vx (Best angle of climb)	N/O
Va (Design maneuvering)	
20,000 ft	190 KIAS
51,000 ft	225 KIAS
Vmo (Max operating)	
up to 8,000 ft	300 KIAS
above 8,000 ft	350 KIAS
Mmo (Max Mach operating)	
to 37,000 ft	0.81 M
37,000-45,000 ft	0.81 to 0.79 M
above 45,000 ft	0.79 M
Vfe (Max flap extended)	
flaps 8-20 deg	200 KIAS
flaps 40 deg	150 KIAS
Vle (Max gear extended)	260 KIAS
Vlo (Max gear operating)	200 KIAS
Vs1 (Stall clean)	133 KIAS
Vso (Stall in landing configuration)	111 KIAS
Vref (Final approach @ 17,000 lb, 1.3 Vso)	133 KIAS

All specifications and performance figures are based on manufacturer's calculations. Operations/Equipment category for aircraft as tested: see June 1981 Pilot, *p. 103; N/O: not obtained.*