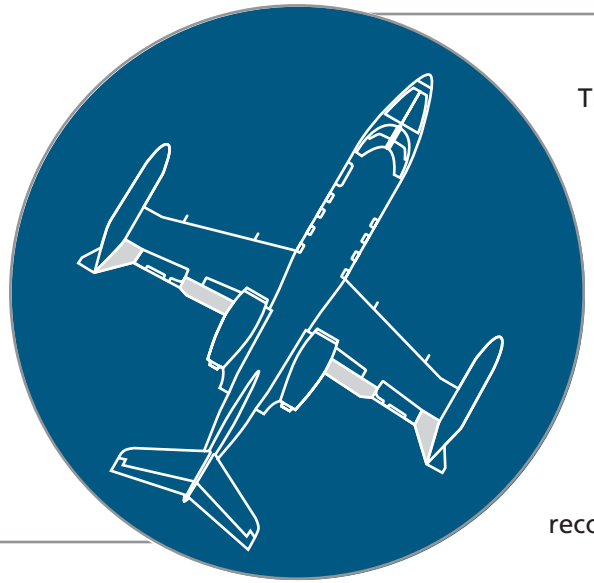
Raisbeck *ZR LITE* Performance System for the Learjet 35/36

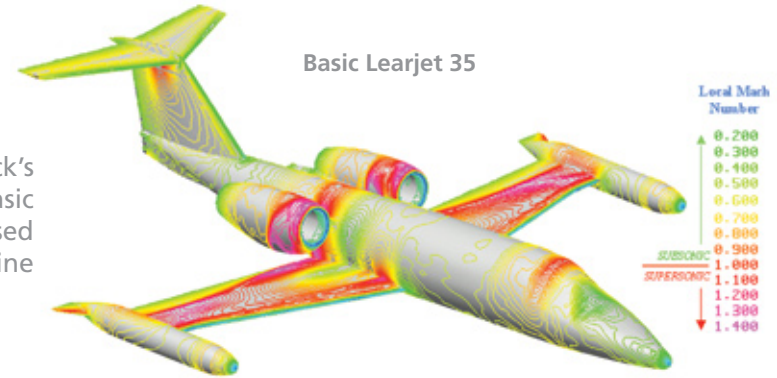
System Summary

The *ZR LITE* System Overview



The ***ZR LITE*** Performance System was designed by Raisbeck Engineering to enhance the takeoff, climb, cruise and descent performance of the Lear model 35 and 36 aircraft. ***ZR LITE*** technology utilizes state-of-the-art components which have been specifically engineered and designed to reduce wave, pressure, interference and induced drag that are aerodynamically imposed upon the aircraft. The system combines the efficient light-weight elements of ZR Technology, which include recontoured trailing edge flaps, outboard trailing edge horizontal winglets ("Batwings"), and wing leading edge vortilons, with a totally new takeoff speed schedule and a new 14 degree flap setting for improved takeoff performance. Furthermore, the ***ZR LITE*** aircraft allowable descent speed at flaps 8 degrees has been increased by 25 percent to 250 knots.

Basic Learjet 35



High Drag Hunting Ground

Computational fluid dynamic analysis was utilized by Raisbeck's engineering team to identify regions of high drag on the basic Learjet and to help predict the impact of an array of proposed solutions. Nearly 500 hours of flight tests were required to refine the technology and achieve Raisbeck's design goals.

The *ZR LITE* Recontoured Trailing Edge Flaps

The trailing edge of the flaps have been recontoured and reshaped. The chord has also been extended. This component of ZR Technology has been incorporated to drastically reduce the wave drag that exists in the surrounding area of the aircraft.

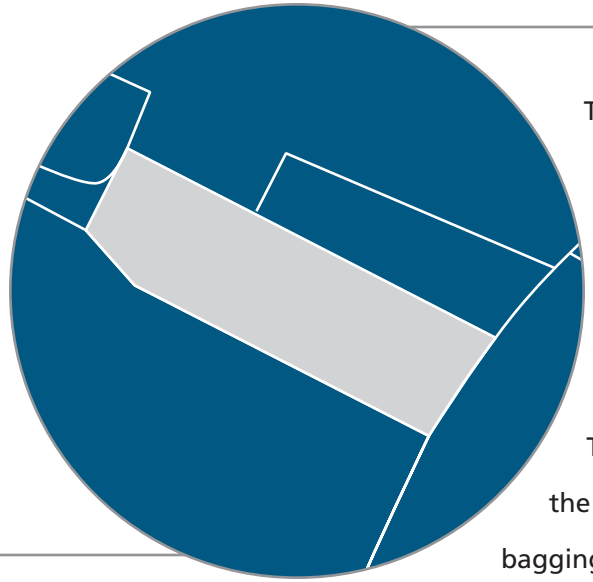
The original all-aluminum aft flap segment is removed along the entire flap span, except for about six inches of the inboard edge. In its place is installed the ***ZR LITE*** full-span all-composite flap trailing edge element. The inboard flap section fits neatly under the basic wing/fuselage aft fairing.

The ***ZR LITE*** flap has a full-span trailing edge chord extension of approximately two inches, fully integral with the flap and contained within the new flap upper and lower surfaces. A small closure is contained at the flap's outboard extremity to bring its chord back in line with the existing trailing edge of the aileron.

The flap itself has been uniquely tailored from fuselage-side to outboard extremity to minimize local Mach numbers at the venturi formed by the wing/fuselage/pylon/nacelle juncture. This tailoring conditions the over-wing air and delays the onset of high-Mach drag rise at the wing/fuselage/nacelle junction.

The trailing edge flap angle changes from its root to its tip. Specifically designed aerodynamic tailoring was accomplished utilizing both computational fluid dynamics and results from flight tests. The flap has a sharply negative angle of attack at the fuselage side, changing after it passes under the nacelle, and gradually returns to a positive angle-of-attack at its outboard tip to match the normally drooped basic aileron angles.

The *ZR LITE* Recontoured Trailing Edge Flaps



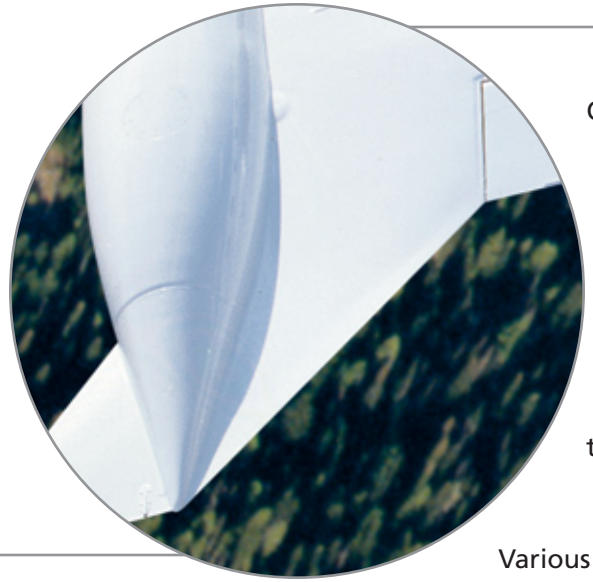
The flap trailing edge itself contains expanded aluminum webbing in critical areas to meet lightning strike and HERF (High Intensity Radiated Fields) requirements. Both upper and lower flap surfaces are extra thick. The thickness of the upper area is designed to minimize hail damage when parked outside, and the thickness of the lower side is designed to protect from potential corrosion and damage during takeoff and landing from sand, ice, rocks and gravel.

The inside of the ***ZR LITE*** flap is filled with Nomex core and is digitally machined to precisely fit into the space provided. The entire design integrates state-of-the-art materials, structural integrity, vacuum bagging and heat bonding, all of which reflects the latest in aerospace industry technology and standards.

The additional trailing edge flap chord further adds to the flap's contribution to improved takeoff performance and increased engine-out climb performance.

One of the benefits of the ***ZR LITE*** flap trailing edge is that the factory flap installation of tracks, rollers, actuation push rod and rigging remain unchanged and are basic to Learjet, which eases the changes in maintenance procedures.

The ***ZR LITE*** Horizontal Winglets



Of particular interest is the incorporation of ZR technology in the design of a uniquely effective Outboard Wing Trailing Edge Horizontal Winglet, or "Batwing." The Horizontal Winglet allows a reduction of the strong wing-tip vortices shed from the basic Learjet 35/36 wingtip-tanks.

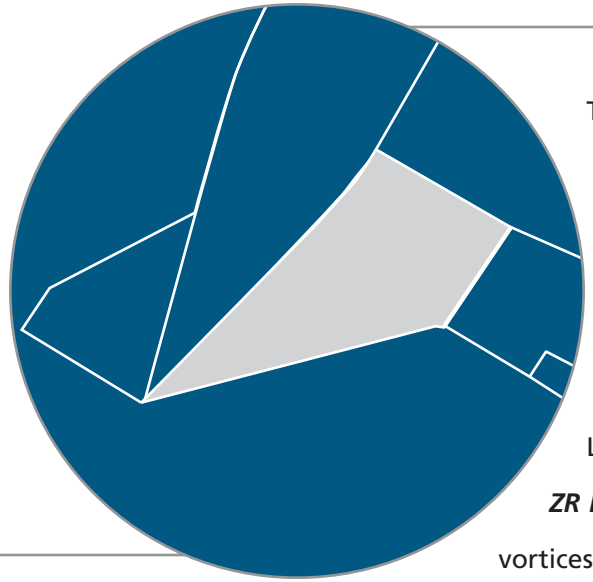
Briefly, the wing lower surface (positive) air is attracted to the upper surface (negative) air as it progresses from fore to aft across the wing and the tip tank. The resulting wing-tip vortex shed off the back of the tip tank is a well-known phenomenon and adds to lift-induced drag.

Various attempts to alleviate this phenomenon have been explored over the years. Perhaps the most notable attempt was the WestWind II "sails" projecting upward and outward from that aircraft's tip tanks.

In general, winglets serve to reduce the wingtip vortices, add a certain amount of lift and lower induced drag. The best winglets are those which do these things most efficiently. ***ZR LITE*** Batwings accomplish those objectives.

In the ***ZR LITE*** configuration, a unique application of the winglet theory and phenomenon has been incorporated. These Horizontal Winglets fill in the space behind the two-foot wing extension on the 35/36, outboard of the trailing edge of the aileron and the aft tip of the tip tank cone. The result is a 45 degree, aft-swept and upward-curving fillet creating a triangular two-foot span.

The *ZR LITE* Horizontal Winglets



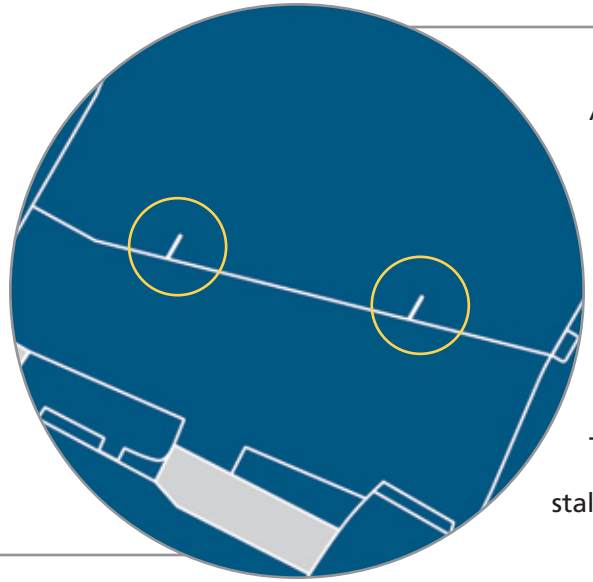
The fillet itself leaves the basic Learjet airfoil at approximately 80% chord at spar 8 and then sweeps up as it proceeds aft, thus decambering the trailing edge. This results in an unloading of the tip tank. It also acts as a positive block for the developing wing tip vortex as it circles inboard over the top of the tip tank and aft.

The all-composite Horizontal Winglet is also drooped at its inboard edge to accommodate the basic Learjet aileron droop of approximately three (3) degrees. This then also matches the droop of the new ***ZR LITE*** flap at its outboard tip, making for a seamless trailing edge. Removal of stray drag-producing vortices from these former discontinuities contributes to the overall ***ZR LITE*** drag reduction effectiveness.

The Batwing all-composite construction utilizes upper and lower surfaces of bonded core construction along with aluminum inboard, center and outboard ribs. The assembly mates the basic wing upper and lower surfaces aft of the spar 8 extension.

The shape and position of the ***ZR LITE*** Horizontal Winglet is designed to further adjust span-wise wing loading to its minimum drag (elliptical) ideal shape, while at the same time contributing to an inboard movement of the wing bending to reduce fatigue, structural loads, and to fit within the present airplane's structural certification envelope.

The *ZR LITE* Wing Leading Edge Vortilons



A major goal for the ***ZR LITE*** program has been to increase the docility of the airplane's stall characteristics. Two uniquely tailored vortilons were added to exacting positions on each wing's leading edge as has become recent custom on high performance aircraft. They have found similar application on the Gulfstream GIV/450, the Lear 40/45 and other similarly successful newer design examples.

These vortilons are strategically located on the wing span as determined by continuous developmental stall tests.

The ***ZR LITE*** result is an airplane that stalls within its entire certified flight envelope extremely soft and with virtually no wing roll-off.

The *ZR LITE* Takeoff Improvements

NEW 14 DEGREE OPTIMIZED TAKEOFF FLAP POSITION AND IMPROVED TAKEOFF SPEED SCHEDULE

A newly optimized takeoff flap position of 14 degrees has been incorporated, replacing the former 20 degree takeoff flap setting position.

The new flaps 14 position allows lower takeoff speeds than the former flaps 20, while at the same time realizing a higher lift/drag ratio, combining reduced field length requirements with improved second-segment climb.

The ***ZR LITE***'s new takeoff speed schedule incorporates variable V_{mc} (minimum control speed) as a function of altitude and outside air temperature.

The result is greatly improved field-length performance ability, especially from higher-altitude airports on hotter days. As an example, a ***ZR LITE*** Learjet 35 can now take off from airports such as Telluride, Colorado, with upwards of 820 pounds heavier takeoff gross weight.

THE *ZR LITE* SYSTEM WEIGHT

The ZR LITE System adds only 32 pounds net increase in the basic operating weight. This has been accomplished through extensive use of composites on both the trailing edge flaps and the Batwings.

The *ZR LITE* Technology

The outboard wing trailing edge Batwings can be viewed as horizontal winglets. These winglets tend to unload the lift adjacent to the airplane's tip tanks, greatly reducing the rolled-up vortices shed at the wing/tank juncture. The result is reduced overall airplane drag both at low speed and climb conditions and during cruise, up to and including M_{mo}. The Horizontal Winglets add a triangular web-like shape aft of the outboard wing extension, outboard of the ailerons. They also reduce roll tendency during stall maneuvers, by increasing aileron effectiveness.

The trailing edge flaps are recontoured and twisted from a –6 degrees (trailing edge up) at the wing root, to +2½ degrees at their outboard extremities. Both flaps and Batwings are drooped where they meet the aileron to remove the drooped ailerons' former discontinuity. Reduced drag and increased aileron effectiveness are the positive result of this new design.

The flap's chord has been increased by approximately two inches, adding to flaps-extended lift and reducing drag. The original trailing edge flap mechanisms are retained, while the flaps themselves have been removed aft of the flap spar and replaced with ***ZR LITE*** composite aft segments. They are protected from lightning and under-surface foreign object damage through the use of advanced materials.

There are four leading edge vortilons incorporated in the ***ZR LITE*** System, two on each wing. One is located in front of each aileron's mid-span, and the other midway in front of the flap span. They add docility and regularity to the stall phenomenon but add no additional drag during normal flight. There is no alteration to the airplane's shaker/pusher system and no additional rigging is required.

The *ZR LITE* Benefits

The overall airplane drag is substantially reduced. Certification flight tests have shown an overall cruise drag reduction of up to ten (10) percent or more at high speed. Drag reduction shows itself in all phases of flight, from takeoff, climb, cruise and letdown. Increased initial cruise altitude, faster cruise speed, longer range and reduced block fuel consumption are the resulting benefits.

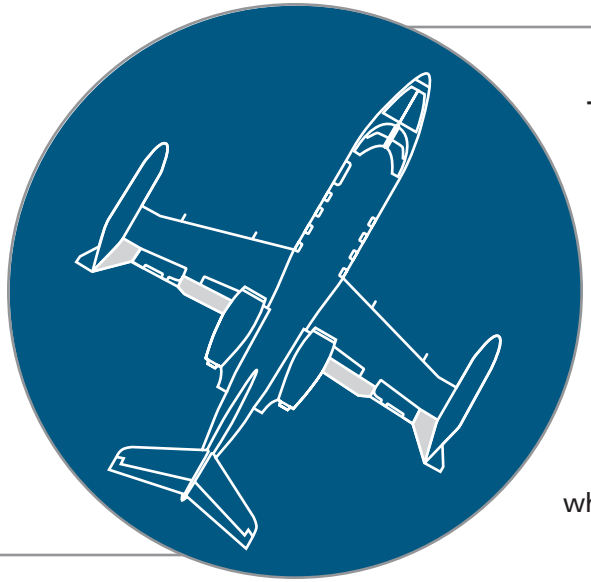
The takeoff segment of flight has been greatly enhanced. The bottom line is more payload/range from presently restricting airports such as Telluride, CO. In addition, more airports have become procedurally available for use. Put another way, the same weight airplane can take off from airports as much as 1000 feet shorter; or the airplane can take off up to 820 pounds heavier from the same MTOW-restricted airport.

The normally used takeoff flaps 8 and its original speed schedule have been retained to meet FAR Part 36 Stage 3 requirements.

The original flaps 20 takeoff position has been replaced by a new flaps 14 position. This new flap setting permits the incorporation of lower takeoff speeds, at the same time reducing flaps-extended drag by up to fifteen (15) percent.

The new flaps 14 setting has lower takeoff speeds than the original flaps 8 and will most likely prove to be the takeoff flap position of choice. A new FAA-approved takeoff speed schedule and corresponding field-length and second-segment climb profiles are also provided.

The *ZR LITE* System Development and RVSM



THE *ZR LITE* SYSTEM RESEARCH AND DEVELOPMENT

The overall ZR Program was in development for four years. Almost 500 flight hours were flown to optimize and prove each element of the ***ZR LITE*** System. The ***ZR LITE*** System was developed through an extensive FAA certification flight test program. The Raisbeck Engineering ***ZR LITE*** System is now FAA approved and certified.

The ***ZR LITE*** System provides greatly enhanced performance benefits for the Learjet 35 and 36 aircraft while providing a high return on investment for the owner or operator.

THE *ZR LITE* SYSTEM IS FULLY COMPATIBLE WITH RVSM INSTALLATIONS

The ***ZR LITE*** System is approved and fully compatible with the current RVSM installations available from Bombardier Aircraft Services, West Star Aviation, Avcon Industries and Royal Air. Furthermore, the incorporation of ***ZR LITE*** does not require any changes to either of these systems and no additional calibrations are required.

The *ZR LITE* Performance System Installation Centers

INSTALLATION CENTERS

Aero Dienst
Nürnberg, Germany
Walter Brisch, +49 (911) 9356-310

Atlantic Aero
Greensboro, North Carolina
Steve Hippert, (336) 668-0411 ext 1056

Avcon Industries
Newton, Kansas
Larry Franke, (316) 284-2842

Banyan Air Service
Ft. Lauderdale, Florida
Paul Rose, (800) 200-2031

Bombardier Aircraft Services
Wichita, Kansas
Bob Johnson, (800) 835-0137

Bombardier Aircraft Services
Tucson, Arizona
David Hutchison, (520) 730-6417

Duncan Aviation
Lincoln, Nebraska
Brad Lennemann, (800) 228-4277

Executive Flight
East Wenatchee, Washington
Tim Thompson, (800) 884-1545

Haggan Aviation
Englewood, Colorado
Jeff Graser, (303) 888-6911

Lider Aviação
Belo Horizonte, Brazil
José Freitas, 55 (31) 3490-4500

Stevens Aviation
Greenville, South Carolina
Scott Kaczor, (561) 744-9971

West Star Aviation
Grand Junction, Colorado
Emily Mason, (800) 255-4193

Call us or visit our website at www.raisbeck.com for more information.

Raisbeck Engineering, Inc.
4411 South Ryan Way
Seattle, WA 98178 U.S.A.
Tel (800) 537-7277
Int'l (206) 723-2000
E-mail: zrlite@raisbeck.com
Website: www.raisbeck.com

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