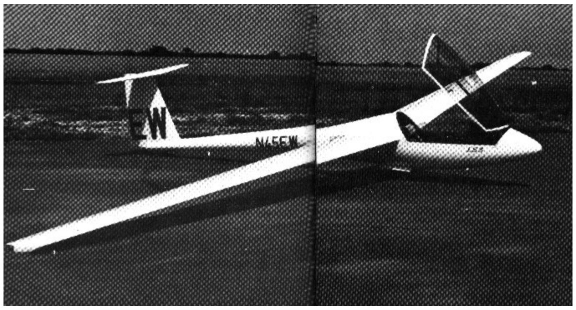
A FLIGHT TEST EVALUATION OF THE LS-3

By Richard H. Johnson, Published in *Soaring* Magazine, November 1978

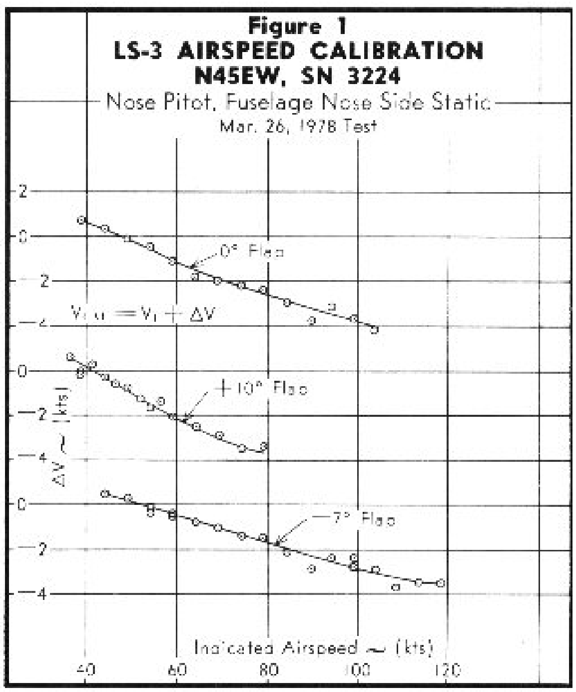
The new LS-3 is another excellent German entry into the hotly contested 15-meter flapped racing class sailplane market. It is manufactured by the Sailplane Division of Rolladen-Schneider and its designer is Wolfe Lemke, a brilliant young engineer who participated in the D-36 development along with Klaus Holighaus, Gerhard Waibel, and Heiko Friesz at Darmstadt during the early 1960's.



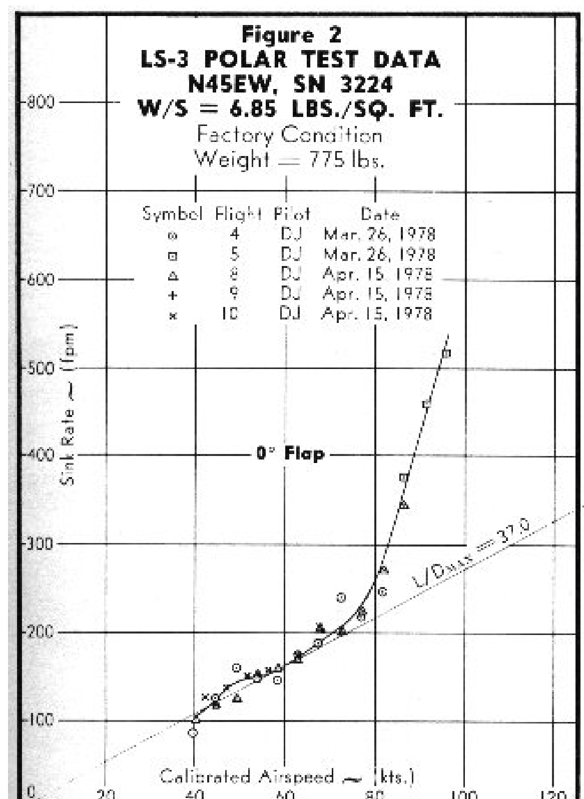
The test vehicle: Eddie Williams' :S-3

Wolfe has not been quite as prolific a designer as Klaus and Gerhard, but his work has always carried a high reputation. His first production design was the unflapped 15-meter LS-lc which was introduced in 1967, followed later with the LS-ld and currently by the LS-lf. An experimental flapped 15-meter LS-2 was built in 1973 and flown to a world championship by Helmut Reichmann in 1974. The LS-2 was not produced, but it apparently was the basis for the LS-3 design, which began production in 1976.

Eddie Williams of Lewisville, Texas received his beautiful new LS-3 during the early spring of '78 and generously offered this fine sailplane for testing. It was of excellent craftmanship throughout and well finished from the factory. Wave-gage measurements showed about .004-inch peak-to-peak values for the upper wing surfaces and remarkably small .0025-inch values for the lower wing surfaces. The airfoil section is reportedly a modified Wortmann FX67-K-1 70.

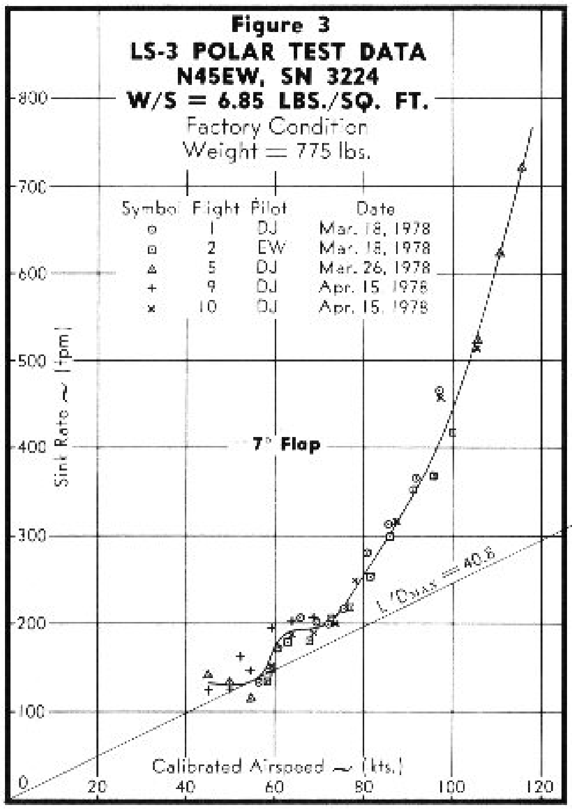


The wing area measured at 113.2 square feet, and caliper measurements showed the wing thickness-to-chord ratio to be .17 and essentially constant from root to tip. This is considerably thicker than the AS-W 20's average of .145, reported in Reference A. Although the published Wortmann airfoil windtunnel test data (Reference B) indicated the .17 thick FX67-K-170 airfoil attained almost identical lift, and equal or slightly lower drag characteristics of that of the thinner .15 thick FX67-K-1 50, it is widely believed that the thinner airfoils really achieve comparatively lower drag values. It would be interesting to see if the new LS-3 with its comparatively thick wing could match the fabulous performance values we recently measured with the AS-W 20 super sailplane.



First, a high tow was made to calibrate the LS-3's airspeed system; Figure 1 presents the errors measured with each of three flap settings. The pitot source is well-placed at the fuselage nose, and the static pressure sources are located on the sides of the fuselage nose. The Figure 1 measured values show near-zero error at about 50 knots, with the error increasing to about 3 to 4 knots too high an indication at 100 knots. This is a fairly accurate airspeed system; not as good as the excellent PIK-20's, but much better than those of the Mini-Nimbus and AS-W 19.

Next, high tows were made in smooth air to measure the LS-3's sink rates at various constant airspeeds with three different flap settings. Figure 2 shows the sink rate versus airspeed data measured with the flaps set to 0°. Although these 0° flap data were measured during five separate flights, they showed a strange behavior with an unexpected flatness of the curve in the 60-to-74 knot region and an actual curve reversal at 50 kts. The maximum LID was only about 37,



which is disappointingly low for this class of modern sailplane.

Figure 3 shows the sink-rate measurement data made with the flaps set to their full negative -7° setting. Here a better 40.8 L/D_{max} was measured, but the strange 50-knot curve reversal measured with the 0° flap setting was now at about 62 knots and even more pronounced. Something strange was obviously happening to the LS-3's airflows!

Even more incredible were the data measured with the flaps set at their full down + 10° thermaling or landing setting. Figure 4 shows these data. At airspeeds below 53 knots the data indicated that two separate polars existed, one high drag and one low drag, separated by about a 25 to 30 fpm difference in sink rate. At first I thought perhaps a sensitive airflow separation might have been caused by approaching the test airspeed points from a lower airspeed as compared to approaching it from a higher airspeed. This is a fairly common phenomenon with many powered aircraft, but seldom experienced with modern sailplanes to my knowledge. A review of our +10° flap test data showed no correlation with the above theory because approximately half of the high-drag data points had been approached from a higher airspeed.

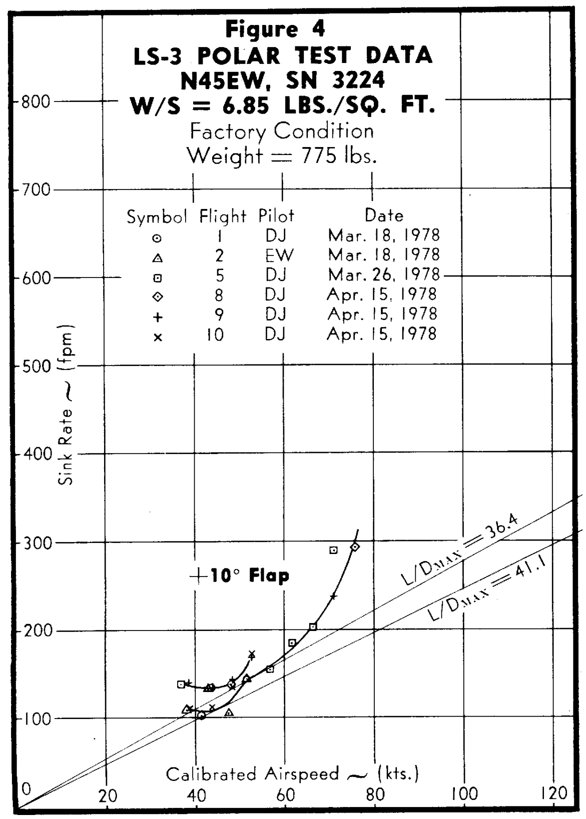
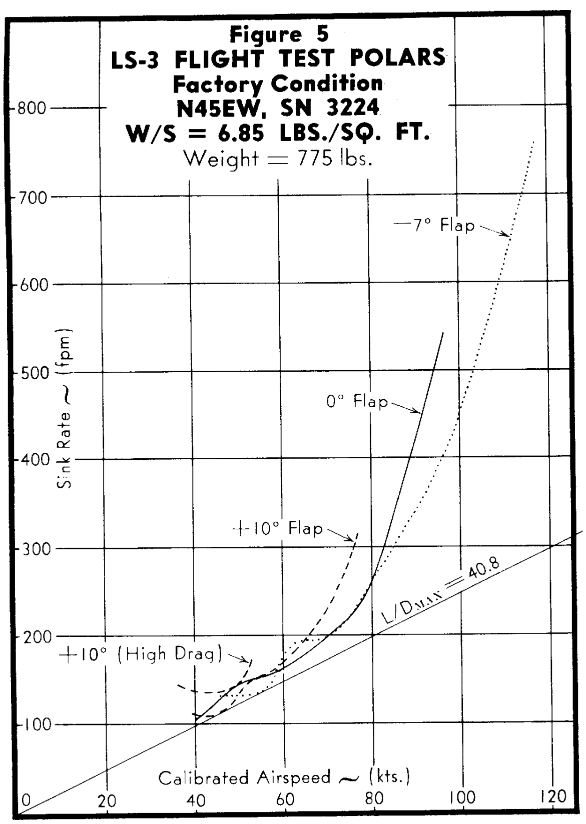
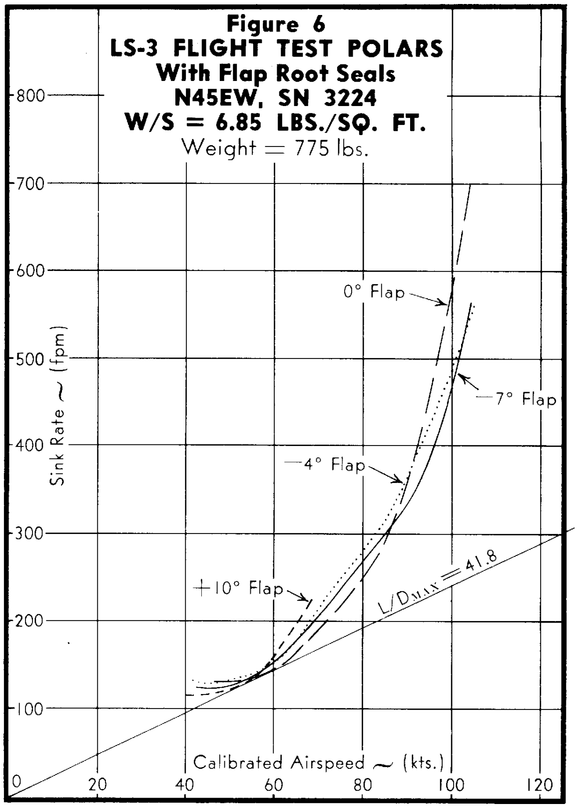


Figure 5 is a composite plot showing the measured polars for each of the three flap settings discussed above. At airspeeds above 70 knots, the factory-condition LS-3 appeared to have outstandingly good performance, fully equal to that measured with the AS-W 20. Below 48 knots, the LS-3 was again outstanding, provided the low drag +10° flap polar is achieved. In between these airspeeds the LS-3's performance was erratic and generally subnormal.



Fortunately, between performance tests, I had the opportunity to fly the LS-3 during about 20 hours of soaring with a good variety of other sailplanes. Its thermaling performance was consistently excellent, and I could outclimb all but the 20-meter sailplanes at Caddo Mills. It appeared that the LS-3 was achieving its low-drag +10° flap polar consistently while thermaling. Why this occurred consistently while thermaling but not during the level flight still air measurements is unknown.

After reviewing the above curious LS-3 flight test data, it was decided that our tow funds would just have to stretch far



enough for some further investigations.

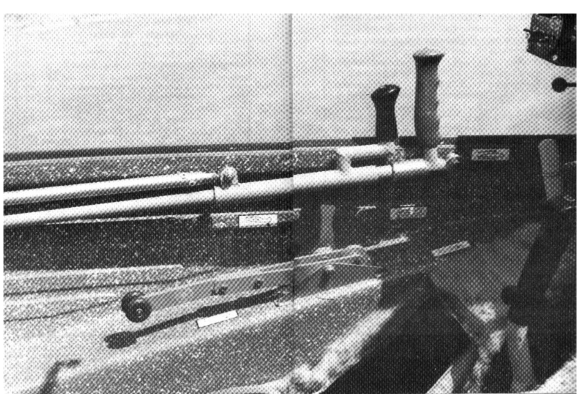
The LS-3 uses single piece flap-ailerons called "flaperons." They move up and down in unison for flap and differentially for aileron control. Between the inboard end of the flaperons and the fuselage sides there exists an open gap that varies in width with flap position, but averages close to 1/4 inch. At low and middle airspeeds the air pressures above the flaperon are considerably less than those on the lower side. This pressure differential causes the air to flow upward through any unsealed gaps, and this in turn invariably reduces lift and increases drag.

The factory had indicated that the LS-3 gaps resulted in only a negligible performance penalty; so our initial flight testing was in the as-factory-delivered condition. Obviously our LS-3 needed improving, so Eddie agreed to install some quickly-made, relatively crude, flap root seals for further flight testing. Also, the factory requested that one additional flap setting, -4°, be evaluated. Seven more high tows were subsequently performed to completely remeasure the LS-3 polars with the flap root seals installed.

The resulting test data happily indicated that the seals eliminated the strange curves and anomalies of the prior polars, and that the LS-3's performance was now superb throughout the whole airspeed range. To conserve space, only the Figure 6 composite polar plot showing the four flap-setting summary curves is included here. In particular the 0° flap setting polar showed the most improvement. Its L/D_{max} increased from about 37 to a remarkable 41.8 at 59 knots, fully equal to that of the AS-W 20 reported in Reference A. At the important 80-knot interthermal cruising region, the LS-3 data indicates about 8 percent less sink rate than measured for the AS-W 20. At 100 knots the performance is about equal. It was also gratifying that the 10° flap data now consistently followed the low-drag polar and that thermaling performance continued to be excellent. For some unknown reason the -4° flap polar was not optimum at any airspeed (it logically should have been best at the 87-knot airspeed where the 0° and -7° flap polars cross).

The last polar shown in Figure 7 is that of the LS-3 with our standard 20 "bugs" per meter applied to the wing leading edges to test for sensitivity to leading-edge roughness. Almost invariably in prior testing, sailplanes showing the highest performance with clean, smooth leading edges showed the greatest degradation when tape "bugs" were placed on their wings. The AS-W 20 bug test showed unusually large performance degradation, but designer Gerhard Waibel rightfully argues that its thinner wing would likely impact fewer insects than a thicker wing and last summer's experience at Chateauroux seemed to bear him out.

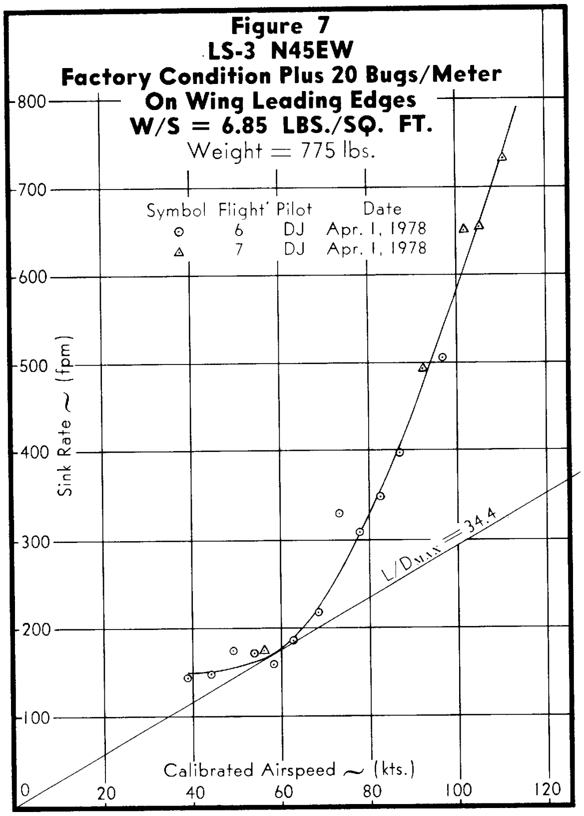
The Figure 7 LS-3 bug test data does show a significant performance reduction, but it is less than expected at the middle and high airspeed ranges. At 80 knots the LS-3 buggy polar shows about 12 percent less sink rate than the AS-W 20's, reported in Reference A. For some reason the thicker LS-3 wing appears to be more tolerant to our bug roughness effects than the AS-W 20. However, Ingo Renner, who flew a light-winged LS-3b at Chateauroux, said he felt there was no notable difference. Perhaps simulated tape bugs don't completely approximate the airflow disturbances of nature's bugs.



Left-hand levers: gear handle, flap and dive brake mechanish, and trim lever.

In general detail and handling, the LS-3 is quite excellent. The cockpit is comfortable and well configured, and good visibility is provided. An air-spring-supported, forward-hinged canopy is used that closes easily and appears to seal well just as it comes from the factory. It is surprisingly quiet in high-speed dives. Because of this, a two-revolution scale airspeed indicator should not be used, as it is not obvious to the pilot whether the actual airspeed is that of the first or second revolution. A standard 1-1/2 revolution indicator is satisfactory.

All the controls except the water ballast dump handles are located on the left side of the cockpit. The landing wheel retraction is by a long, beautifully-functioning, pivoted lever that I really like, compared to the relatively crude typical ASW 20, Std. Cirrus, PIK-20, and Nimbus II straight push-pull systems. The only objection I have is that the LS-3 lever functions backwards to most other sailplane systems. A forward lever mo-



tion retracts the LS-3 wheel, whereas the same motion extends most other sailplane wheels. A gear warning horn is always a good investment; I have seen too many champions understandably confused and harried during a contest finish landing with the gear in the up position.

The flap control system is the only thing that I would really need to change if I owned an LS-3. It is an easily operated, two-position handle that stays by itself, through springs and cranks, only in the full-up or full-down positions. For takeoff, tow, thermaling, and landing, the full-aft +10° position is optimum and normally used. Above 90 knots indicated airspeed the full-forward -7° position is optimum, but our test data shows that a 0° flap position is optimum for all cruising below 90 knots. No flap-handle detent is provided for the 0° position and a tiring 2 or 3-pound flap handle force must be applied to maintain the flap in that setting. We used mechanical spacers to hold the handle at the 0° and -4° positions during our flight-testing.

Also somewhat objectionable is the flap-handle guide's being mounted concentrically around the same tube that is used to guide the airbrake handle, and this does not permit the flaps to remain in the up position when the airbrakes are opened. The airbrakes themselves are excellent double-paneled, top-surface-only devices that provide splendid glide path control. The landing wheel is the same relatively small 12-inch diameter by 4-inch wide unit that the Mini Nimbus uses. I like a bigger wheel, but perhaps it is adequate. The wheel brake appears to work satisfactorily, and I like its unique heel-force actuating system that helps unclutter the cockpit.

One objectionable feature that most people complain of with their LS-3's is the relatively high empty weight. Ours measured about 580 pounds without instruments, battery, or radio, and about 599 pounds equipped to fly. This is actually only about 15 pounds heavier than the recently tested AS-W 20. Despite its weight, the LS-3 is a real champion in a thermal with climb matching its handling qualities. Our test aircraft's right wing panel weighed 168 pounds and the left about 170 pounds. I understand that 45 pounds of the total wing weight is lead mass balancing attached to the leading edges of the full-span flaperons, likely needed to prevent flutter at high airspeeds.

These long flaperons are actuated only from their root end; therefore they are somewhat flexible torsionally and require considerable mass balancing to be dynamically stable at high speed. Last summer at the world championships, Ingo Renner flew a much lighter LS-3b model in which the balance weights were-eliminated and separate conventional flap and aileron surfaces were used. The LS-3a is said to be considerably lighter, and so the objections may have been answered already.

The LS-3 flight-surface controls are delightfully light and function well in flight. Plus 45°-to-45° rolls at 50 knots are accomplished easily in about 4.5 seconds with +10° thermaling flap. Stall characteristics are good from both level and turning flight. The tow hook is attached low and aft to the forward part of the landing gear, and therefore the gear must remain extended until after release. It is slightly more stable during airplane tow than the AS-W 20, but not significantly. Towing is somewhat like standing on a ball, and it requires the pilot's full attention to stay correctly positioned. Overall the LS-3 rates very high, and I expect that it will remain in considerable demand by competition pilots throughout the world.

Thanks go to DGA, Rolladen-Schneider, and three kind SSA members for towing funds, Bob Gibbons for data reduction, and Eddie Williams for the generous use of this fine new sailplane.

References

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