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FLIGHT TEST OF THE LAISTER LP-15

1. This report summarizes the results obtained from the extended flight test program on the Laister LP-15, Nugget, N-1, N6LS from the first flight at Mojave, California on April 29, 1973, thirty hours of preliminary engineering testing in May and 150 hours of service testing throughout the United States in two national and two regional competitions in June, July and August of 1973. Except for minor modifications before the 150 hour service test phase, the sailplane was flown in the same configuration throughout the program.

2. The Nugget is built to meet F.A.A. requirements for certification in the standard category and also fully conforms to the rules for the 1974 FAI Standard Class. Construction is of bonded aluminum except for the fuselage shell forward of the wing trailing edge. Trailing edge flaps are used for approach control, limited performance improvement and as speed brakes. Water ballast (170 pounds) may be carried in an integral center section tank. Bare weight of the N-1 sailplane is 488 pounds which includes approximately 50 pounds of excess filler and paint, test systems, etc. Equipped empty weight is 517 pounds and flight weights for these tests were 725 pounds without ballast and 900 pounds with ballast. Corresponding wing loadings in flight were 6.6 pounds per square foot and 8.2 pounds per square foot. The sailplane has been flown at loadings from 27% m.a.c. to 37% m.a.c. during the testing but flying characteristics discussed in this report are for 35% at 725 pounds and 35.5% with water unless otherwise noted. More detailed information is included in Appendix I covering specifications, dimensions, weight and balance, etc.

3. Although the N-1 Nugget was built as the first production sailplane of this type, later Nugget sailplanes may be different in some respects. Follow-on sailplanes should be approximately 50 pounds lighter than the first sailplane. Further refinements in the flap actuation system should provide a full range of flap from 8° up to 90° down instead of the limited 6° up to 75° down on the N-1 sailplane. Other changes are planned to improve the wheel brake, cockpit canopy and seal, control quick disconnects and cockpit arrangement and finish. Cockpit controls, instrumentations and general cockpit layout of the N-1 are not at all representative of later aircraft; for the most part, references to such items have been omitted from this report, but where mentioned, generally only apply to the N-1 sailplane.

4. The 725 pound and 900 pound flight weights at which these tests were flown do not fully reflect the excess weight in the bare aircraft even though the pilot and chute weight was 205 pounds. This left only 32 pounds for all other items including the instrument panel, instruments, radio, battery and cushion. The oxygen system, emergency kit, tie downs, drinking water, cockpit upholstery, etc., were omitted to keep the gross weight to the obove flight values. With a 170 pound pilot, 20 pound chute and full equipment for contest flying, later sailplanes will probably gross out at about 695 pounds and 870 pounds corresponding to wing loadings of about 6.3 and 7.9 pounds per square foot.

5. Generally, results of the preliminary engineering test flying

(first 30 hours) have been included in pertinent portions of the overall discussions in the body of this report. However, considerable testing was devoted to locating and verifying suitable pressure sources for a production airspeed system. Results obtained for seven different airspeed systems are given in Appendix II. The system selected for permanent installation had essentially zero error at all speeds (± 1 knot). Indicated airspeeds in this report have been corrected for instrument error and are also the same as calibrated airspeeds except at stall where indicated speeds are 1 knot lower than corresponding calibrated speeds. Considerable test time was also devoted to measuring relative performance with a wide variety of flap and aileron droop settings at different speeds. Results are given in Appendix III along with the optimum flap/speed schedule for a fixed aileron droop setting of 2° up for Standard Class and the flap/aileron droop/speed relationships to be used to design a flap-aileron interconnect which may be provided as an option on later sailplanes.

6. Modifications were made to improve the canopy seal, provide a nose air inlet, improve the tow release and flap actuation system at the completion of the first 30 hours of testing. The production airspeed system was installed and the aileron droop was fixed in the 2° up aileron position; the sailplane was cleaned up, wings were smoothed (approx. .006" in 2 inches max. waviness), all gaps and holes were sealed and the sailplane made as ready as possible for contest flying. Discussions in the remainder of this report apply to the sailplane in this condition as flown for the final 150 hours of flying in the program.

7. From the moment of first take-off on a gusty, windy day the solid feel and good control gave the pilot a feeling of confidence. No problems were encountered in the subsequent 80 flights (180 hours) to change this impression. The first flight was for over one hour in moderate thermals broken up by strong winds. A second flight on the same day included climbs to over 10,000 ft. in a wave and a landing in 30 kt. winds at dusk. Sixteen more flights were made in the next ten days to fully explore the flight envelope, check out all systems and to take a good look at stall, spin and short field landing characteristics. Rather than attempt to report on a flight by flight basis, the following discussion summarizes all pertinent findings (180 hours of flying) in a more or less normal sequence from take-off to landing.

8. Excellent control, ease of handling and fine visability combine to provide superb take-off characteristics for all conditions tested which include 30 knot winds down the runway, 10 knot tailwinds and up to 15 knots, gusting to 20 knots, direct cross winds. Take-offs with full water ballast (900 pounds) are equally straight forward with only slightly increased (3 to 4 knots) lift-off speeds. There is little apparent difference in characteristics for c.g. positions from 29% to a normal aft. loading of 36% m.a.c. Any flap setting from 0° to 20° down is satisfactory as is any aileron droop setting from 3° down to the standard 2° up used for most of the flying. Control is positive yet not oversensitive about all three axis in all conditions.

9. Use of 10° flap permits a lower lift-off speed and a near level attitude at lift-off. The relatively aft wheel location on the Nugget makes it easy to raise the tail skid at about 20 knots with the sailplane flying off by itself at about 45 knots. If the tail skid is left on the runway, lift-off occurs at 40 knots or less. After lift-off, as the tow plane is accelerating to a normal climb speed, the flaps may be brought up to 5° down for the remainder of the tow. The gear is also retracted at any convenient moment during this period. Retracting forces are low; the handle is on the right side of the cockpit and is moved forward for "gear up". There are no critical conditions and most any normal technique or procedure may be used with full assurance of good control and an easy take-off.

10. Aircraft tows have been made at speeds from 50 to 90 knots with no problems of any kind. Use of 10° down flap at 50 knots provides a more comfortable nose attitude. Most tows have been at 60 knots with 5° down flap. Again, excellent control, good handling and fine visability combine to give really outstanding characteristics on tow. Control forces are low and the sailplane is essentially in full trim at normal tow speeds. Altogether, an exceptionally fine sailplane on tow.

11. Release is normal in every respect from both normal and extreme tow positions. The release handle is easy to reach and forces are light but positive for all releases with tow rope loads varying from zero to very high during abrupt pull-ups before release. Automatic release occurs with an aft pull on the rope in excess of approximately ten pounds.

12. Once off tow, the generally excellent control and solid feel of the sailplane continue to give the pilot a great feeling of confidence. There is no "canning" of the metal structure except in manuevers in excess of 4 "g's". There have been no structural problems of any kind.

13. The sailplane is in lateral and directional trim at all speeds. Longitudinal trim is at 55 knots (33% m.a.c.) and 45 knots at 36% m.a.c. with zero flap. As flaps are moved down, trim speeds drop proportionately and remain about the same margin above stall speed. Elevator forces are light for any other speed desired and only light back forces are required in turning flight. There are no provisions for changing longitudinal trim but a trim control is really not required and would be of only limited value.

14. The Nugget is statically stable longitudinally at all c.g. positions tested. Stick forces and stick positions vary in the proper direction as the speed is increased or decreased. One test made in wings level flight at 34% m.a.c. yielded the following measured elevator positions and stick forces at various speeds:

IAS Kts.	STICK FORCE lbs.	ELEVATOR POSITION degrees	FLAP degrees
38.5	1.3 Aft	6.5 Up	0
42.0	.7 Aft	2.0 Up	0
49.0	0 (Trim)	0.2 Down	0
56.0	.2 Fwd	1.4 Down	0

IAS kts.	STICK FORCE lbs.	ELEVATOR POSITION degrees	FLAP degrees
65.0	.4 Fwd	2.2 Down	0
75.0	1.0 Fwd	3.0 Down	0
85.0	1.6 Fwd	3.8 Down	0
95.0	2.2 Fwd	4.5 Down	0
120.0	3.7 Fwd	5.6 Down	0
32.0	3.0 Aft	7.0 Up	60 Down
33.0	2.0 Aft	3.0 Up	60 Down
36.0	1.0 Aft	3.0 Down	60 Down
45.0	0 (Trim)	8.0 Down	60 Down
55.0	.5 Fwd	10.0 Down	60 Down
70.0	1.0 Fwd	12.0 Down	60 Down

15. Maximum elevator travel is 18° up and 14° down. In spite of the increase in nose down pitching moment normally associated with the use of down flap, an increase in down elevator is required to retrim the sailplane with flaps down showing that the change in downwash across the tail more than offsets the change in pitching moment. This is common in other sailplanes with this type of flap. It appears that a change in stabilizer setting, perhaps 1/4° more leading edge up, would shift the elevator angles required more toward the center of the range of available elevator travel and also shift the trim speeds more toward 55 or 60 knots with zero flap which would be desirable but is certainly not necessary.

16. The elevator position gradient shows a reasonable level of static stick fixed stability. Forces are light but reflect positive stick free stability. Forces change little with shift in c.g. and it appears that, although the forces are light, there is a reasonable static margin. Complete quanitative tests will have to be run at widely separated c.g. positions to determine the actual static neutral points and corresponding static margins. In an overall qualitative sense, the longitudinal stability and light forces make the Nugget a pleasant sailplane to fly at all speeds.

17. A possible problem may exist in demonstrating compliance with the F.A.A. requirement that, when displaced from trim, the sailplane will return, hands off, to within ten percent of the trim speed. Force gradients are so light that this tendency to return to trim is almost completely masked by the more dominent, long period, phugoid mode with the sailplane slowly oscillating between speeds near stall to high speed. Relatively minor changes could be made to increase the restoring moment on the elevator but this would involve heavier stick forces, a requirement for a mechanical trim device and, overall, a degradation of the existing excellent longitudinal flying qualities. It is understood that the F.A.A. is considering relaxation of this requirement from ten percent to 20 percent which would still be difficult to comply with in the Nugget or any other high performance sailplane with light control forces. The basic idea of the requirement is a holdover from airplane flying where extended periods of flying at cruise speeds are of concern but does not apply, and actually works against good flying qualities, for sailplanes where speeds are constantly changing and much of the flying is in turning flight where light forces and a freedom from the need to trim are a great asset.

18. In an overall qualitative sense, the sailplane appears to have excellent stability and control in manuevers at constant speed or when the speed is decreasing. On the other hand, there appears to be a tendency to pull more "g" than intended in manuevers involving rapid increases in speed such as recovery from loops and in diving turns. Quantitative tests were made at 34% m.a.c. to measure elevator angles and stick force required to obtain different load factors at several speeds in turning flight with the following results:

	"g"	ELEVATOR ANGLE deg.	STICK FORCE lbs.	$F_{s/g}$
(1) At 50 knots	1.0	0	0	--
	1.2	3 Up	1 Aft	5
	1.4	5 Up	2 Aft	5
	1.6 (Max.)	7.5 Up	3 Aft	5
(2) At 65 knots	1.0	2 Down	.5 Fwd	--
	1.5	0	1 Aft	2.5
	2.0	3 Up	2.2 Aft	2.5
	2.5 (Max.)	7 Up	3.5 Aft	2.5
(3) At 80 knots	1.0	3 Down	1 Fwd	--
	1.6	2 Down	.5 Aft	1.8
	2.5	1 Up	2.2 Aft	1.8
	3.6	6 Up	4.2 Aft	1.8

19. Here again, the elevator positions show a reasonable level of stick fixed stability. The force gradients are again light but stable with no indication of force reversal at any speed. However, the stick force per "g" decreases rapidly as the speed increases. In fact, it takes about the same force to reach a "g" level near maximum lift at all speeds; a force of 3 or 4 pounds giving 1.6 g at 50 kts, 2.5 g at 65 kts, and 3.6 g at 80 knots. It is not surprising that a light pull force used to initiate recovery from loops or from pull-outs after spin recovery results in an increase in "g" with no increase in force as the speed builds up. One would expect that pull forces would increase as the "g" was built up even though the stick was being eased forward. More testing at several widely spaced c.g. positions will be required to determine the longitudinal manuevering neutral points and static margins as well as to fully assess the acceptability of the change in stick force per "g" with speed.

20. Directional stability appears to be quite good. Use of down flap increases the directional stability and also the dihedral effect. Side slips show a positive dihedral at all speeds and flap settings. Rudder and aileron forces are reasonably light with the sailplane returning to zero sideslip if the controls are released. At speeds below 50 knots, it is possible to induce very high sideslip angles by using full rudder and ailerons to induce yaw. Under these abnormal conditions, the excessive sideslip will cause the rudder forces to overbalance so that some pedal force must be used to start the rudder back toward neutral. Although this is not desirable, this characteristic is less pronounced than on most modern sailplanes. It has never been experienced inadvertantly in the 180 hours flown during these tests.

21. Use of rudder and ailerons when rolling rapidly into steep turns,

particularly at slow speeds, reveal the same undesirable adverse yaw characteristics that are common for all high performance sailplanes. The Nugget is as good or better than most sailplanes in this respect. Roll response and roll rate are quite good. At speeds of interest near 50 knots, rudder control is adequate to offset adverse yaw up to about 2/3 aileron. With full aileron and full rudder, there is some adverse yaw but timed rolls from 45° to 45° bank angles took 3.0 seconds at 45 knots and 2.9 seconds at 60 knots. Direct comparison with a Standard Cirrus which is generally considered an excellent sailplane in roll showed that the Nugget had exactly the same roll response in rolls from wings level to 60° bank at speeds from 45 knots to 60 knots. These tests were run with the sailplanes flying about 200 feet apart with the Cirrus initiating the rolls in one series of tests and the Nugget initiating the rolls in a second series of tests at each speed.

22. A series of tests were made to demonstrate that the controls and aircraft were free from any indication of flutter at high speed. The controls were pulsed individually at 80, 95, 105, 115, and 126 knots. At each speed the ailerons, rudder and elevator were separately excited by abrupt pulses to approximately 1/3 deflection or to a deflection produced by a blow of approximately 20 pounds at the higher speeds were deflections were somewhat less. These pulses were induced in the ailerons and elevator by holding the stick lightly in one hand and using the other hand to strike the stick a sharp blow in the desired direction (fwd., aft, left and right). Rudder pulses were initiated with both feet on the rudder pedals then lifting one foot and striking the rudder pedal (left and right separately) as sharply as possible. All resulting motions were essentially dead-beat as far as could be discerned without instrumentation and there was no evidence of flutter at any speed. In the 150 hours of competition soaring, the aircraft has been flown in severe turbulence at speeds up to 120 knots on many occasions and has been flown to speeds as high as 150 knots in smooth air. At no time has there been any indication of flutter, instability or even undue sensitivity. The overall impression is one of a very solid sailplane both structurally and aerodynamically.

23. At the other end of the speed range, more than 100 stalls have been made to determine flight characteristics in the stall and calibrated stalling speeds with different flap settings. In straight, wings level, stalls where the stall is approached slowly (deceleration less than 1 knot per 10 seconds), stall warning is provided by an erratic, small amplitude yawing and rolling which starts about 1.1 V (stall) and becomes more pronounced as the sailplane reaches the stall. The stall is characterized by reaching a minimum speed (maximum lift) where continued back elevator and increased angle of attack aggrevate the rolling and yawing to a point where the sailplane will tend to roll off on either wing. There is no loss in lift or control but it is difficult to stay in phase with the erratic yawing and rolling. Elevator control remains powerful throughout the stall and full recovery can be achieved immediately at any point, even with the angle of attack well beyond that at which maximum lift was first attained, by relaxing the back pressure on the stick. This is not the clean breaking, pitch down stall with no wing drop usually associated with good stall characteristics. On the other hand, there does not seem to be anything dangerous about the Nugget stall. There is no tendency to spin out of

the stall and recovery can be made with very little loss in altitude. At no time in over 180 hours of flying in all kinds of conditions has there been a case of inadvertant stalling with any loss of control or altitude.

24. Stall characteristics at all loadings (29% m.a.c. to 35% m.a.c. at 725 pounds and 32% to 36% m.a.c. at 900 pounds) are essentially the same except that trim speeds are closer to the stall at aft c.g. loadings with a corresponding reduction in the amount of aft stick force required to stall. Use of landing flaps has little effect on the stall characteristics although there is some reduction in the initial yawing and rolling but with the sailplane tending to yaw more sharply when deep into the stall. This has never occurred in the pattern or on landing and is apparently well beyond the angle of attack that any pilot would use for anything but stall tests. Use of an aileron droop setting providing more wash-out on the wing tips provides some reduction in the yawing and rolling prior to the stall but did not eliminate this characteristic.

25. Carefully measured calibrated stall speeds are listed in the following table:

STALL SPEED

WINGS LEVEL, 1 "g", MINIMUM DECELERATION

725 Pounds at 34% m.a.c.
2° Up Aileron

FLAP degrees	CALIBRATED SPEED knots	C_L	R.N.
6 Up	39.5	1.26	900,000
0	39.0	1.29	
6 Down	38.5	1.32	
16 Down	38.0	1.36	
33 Down	34.5	1.65	
60 Down	32.0	1.91	
75 Down	32.5	1.86	720,000

26. Stalls with the ailerons set 3° down were essentially at the same speed. The theoretical difference in stall speed is only 1/4 knot which is within the accuracy of measurement. Stalls at 900 pounds and stalls in pull-outs and turns are at increased speeds consistent with the maximum lift coefficients in the foregoing table. The measured maximum lift coefficients are equal to or slightly above the wind tunnel maximum lift coefficients for the Nugget airfoil at the test Reynolds Numbers. The wing is developing all the lift that could be expected and there is no indication of loss in maximum lift associated with partial stalling of the wing. It is apparent that the maximum lift is attained first at a relatively low angle of attack (11° at 0° flap for this airfoil) and that the lift remains essentially constant as the angle of attack is increased further by as much as 8 or 10 degrees (also shown by the very flat top on the lift curves for this airfoil) as the sailplane is pulled deeper into the stall. Even though the lift in this stalled range remains constant, the drag increases rapidly and non-uniformly across the span at the

higher angles, causing the initial yawing leading to the low amplitude yawing, rolling oscillation at the stall. Further stall tests should be made with tufts on the wings to determine the extent of non-uniform flow across the wings which may indicate possible areas for improvement.

27. Stalls in steep turns show the same characteristics. In turbulent air, the yawing and rolling is aggravated, reducing the useable lift coefficient available to the pilot. Nose high wings level stalls involving rapid deceleration and accelerated stalls from pull-outs pass through this area of yawing and rolling so quickly that it is not apparent, the stall is more abrupt and the nose pitches down in a normal manner.

28. Spin characteristics with 0° flap have been investigated briefly in 23 spins at c.g. loadings from 29% to 34% m.a.c. Four were with water ballast at 900 pounds gross weight at 34% m.a.c. All but the first spins were held for at least two turns and one spin was held for ten turns before recovery was initiated. Spins were entered from wings level, nose on the horizon stalls, from nose high stalls and from stalls out of steep left and right turns. Once in a steady spin, spinning characteristics seemed to be the same regardless of type of entry, gross weight or c.g. position. Recovery from all spins was almost instantaneous as soon as either rudder or stick pressure was relaxed. Altitude required for recovery was minimal without exceeding an airspeed over 90 knots. Pull-outs were sometimes more abrupt than anticipated because of the rapid change in stick force per "g" (Ref. P-19) with speed yet there was no tendency at all to enter a secondary spin. Spin entries from wings level, nose on the horizon stalls were erratic, often ending in diving turns, and sometimes with the aircraft making a 1/2 to 3/4 turn in a 30° nose down attitude before dropping into a steady nose down spin. Entry from nose high stalls, accelerated stalls and stalled turns was much cleaner with the sailplane in a steady nose down spin in less than 1/2 turn. More extensive spin tests at more aft c.g. loadings, with flaps down, and with ailerons with and against the spin will be required prior to certification.

29. Little time was spent investigating aerobatic capabilities of the Nugget. Loops may be made easily without exceeding 100 knots. Again, there is a tendency to make more abrupt pull-outs than intended with a relaxation in force as well as forward displacement of the stick as the speed increases required to make a smooth recovery during the pull-out. Smooth aileron rolls are easily made with the nose about 10° above the horizon at 120 knots at the start of the roll.

30. Flying characteristics in thermals are quite good but not as good as one might hope. At speeds 3 or 4 knots above the stall, the same low amplitude yawing and rolling is encountered as described for straight stalls in paragraph 23. In relatively smooth air, the sailplane will turn comfortably at speeds near 45 knots in 30° banked turns. More turbulent thermals require circling speeds near 50 knots and, on occasion, 55 knots has been required in tight and turbulent thermals. In turbulence, the yawing and rolling became more pronounced and is accompanied by full-scale deflections of the variometer needle driven by the total energy venturi located on top of the fuselage tail cone. In spite of this, the thermaling performance is quite good for a sailplane flying at the 6.6 to 8.2 pounds per square ft. wing loading of

the N-1 Nugget. It has been possible to obtain a good comparison of the relative thermaling performance of the Nugget and the best of the fiberglass standard class sailplanes in many hours of actual competition. Most of these were being flown at wing loadings from 1/4 to 1/2 pound per square ft. less than the Nugget. In general, the Nugget had about the same or perhaps a little less climb capability than the best of the fiberglass sailplanes flown by the top competition pilots. In weak lift where the sailplanes were making large circles, the Nugget would slowly sink away from the best of the other sailplanes at a rate of about 10 feet per minute. In very tight thermals or very strong thermals, the Nugget appeared to do as well as the best of the other ships. In turbulent strong thermals, the Nugget appeared to have superior climb capability.

31. The lower performance of the Nugget in relatively smooth air thermals of large diameter is about what one would expect as a result of the higher wing loading. Flying in this type of thermal is primarily a measure of minimum sink rate. Minimum sink on the Nugget is about the same with 0° flap and 5° down flap. Normally it is best to use 0° flap unless it is necessary to use 5° down flap for slower circling speeds in this type of thermal. For stronger, tighter thermals, some down flap, as much as 10° in some cases, appears to be beneficial. Still, as a general rule, it pays to use as little down flap as possible depending on the size of thermals. The flaps really begin to pay-off in turbulent, tight, strong thermals. It pays to use as much as 10° down flap to give a little more pad above the stall but the real payoff comes from momentary intermittent use of as much flap as required to keep the wing unstalled at all times. Normally, this type of turbulent thermal will cause most sailplanes to stall-out momentarily with some loss of altitude and position in the thermal before the wing is flying again. Use of flaps as required to prevent this has, on many occasions, enabled the Nugget to climb away from the best of the other sailplanes.

32. Performance in thermals is not changed as much as one might expect when the Nugget is flying with full water ballast at a wing loading of 8.2 pounds per square foot. This is probably because ballast is normally carried in stronger conditions where differences are not as noticeable. The extra weight does become very noticeable when conditions are weak and the already greater sink of the Nugget becomes even more noticeable relative to the other sailplanes. It is usually necessary to jettison ballast before the others do under these conditions. The slightly poorer performance of the Nugget under weak and marginal conditions (with or without water) is probably its most deficient area as a competition sailplane. The lower basic weight of later LP-15 sailplanes should help in this respect. There is also the possibility that further development may improve the flying qualities just above the stall which could make the Nugget a superior sailplane in all kinds of thermals.

33. No absolute measurements have been made of wings level performance. Comparison tests have been made with several other sailplanes and, as in the case of thermaling performance, there has been ample opportunity to compare the Nugget with the best of the competition sailplanes in many hours of tough competition flying. Generally, the Nugget has a little more sink than the best ships at speeds below 60 knots but is

a little better at speeds over 90 knots. The differences are roughly what might be expected because of the heavier wing loading of the N-1 Nugget. Later production Nuggets with improved canopy, more wave-free wings and a lighter weight could have performance a bit better than the best of the 1973 Standard Class fiberglass sailplanes.

34. From the information available, it has been possible to develop a good estimate of the wings level performance in still air at sea level. Flap settings used at different speeds are those determined from the tests reported in Appendix III for the sailplane at 725 pounds at 35% m.a.c. The information listed in the following table should be sufficiently accurate for use in marking speed rings and for final glide computors but further tests are required to measure the performance and define an accurate polar for the Nugget.

APPROXIMATE LP-15 WINGS LEVEL PERFORMANCE

IAS-kts.	FLAP-Deg.	R/S-Ft/Min.	L/D
40	5 Down	145	28
43	0	130	34
50	0	140	36.5
60	0	180	33.8
70	4 Up	238	30.0
80	4 Up	320	25.5
90	6 Up	435	21.0
100	6 Up	590	17.2
110	6 Up	805	14.0

35. Later Nugget sailplanes should provide 8^{o} of up flap which should be used at the speeds (lift coefficients) where 6^{o} of up flap was used on the N-1 Nugget. The change in performance may be determined from the flap performance data in Appendix III. It is convenient to use two speed rings, one for flying without ballast and one with ballast. Each can be made to show the proper speed/sink relationship for the appropriate weight and a secondary scale can be added to each ring showing the flap settings to use at each speed which also change with weight. All required information may be calculated from the data in the table (P-34) using standard aerodynamic relationships and the data in Appendix III.

36. Location of the total energy venturi on the top of the fuselage 51 inches aft of the wing trailing edge was satisfactory and gave 100% compensation at all normal speeds for flight between thermals. As mentioned in paragraph 30, flight close to the stall in thermals caused the variometer needle to "flick" full scale in a distracting manner. This could be reduced with a restrictor in the line but a better solution would be to clean up the flow ahead of the venturi or, if this is not possible, relocate the T.E. Venturi to a more suitable location.

37. Water ballast may be jettisoned at any time by moving the control knob in the cockpit aft. The valve works easily and in a positive manner; it may be opened and closed at any time permitting partial jettisoning of the water ballast. Almost all of the water is jettisoned in approximately 45 seconds although some water will continue

to drain through the water dump hole in the belly aft of the wheel doors (no wet brakes) for an additional 45 seconds. Residual water remaining in the tank is usually about 3 or 4 pounds.

38. Visability is excellent at all times except in driving rain when water on the canopy makes it difficult to see forward. It is still possible to see well enough to make a landing but not well enough to distinguish objects clearly. Opening the sliding window on the left side of the canopy provides a clear vision panel through which the pilot can see the ground clearly on approach. Otherwise, the canopy glass has no distortion. Cockpit ventilation in the N-1 Nugget was adequate to defog the canopy under all conditions and also provided adequate cooling at all times in flight. The forward canopy frames did interfere with vision at first but one quickly becomes accustomed to it. The size of the removable portion of the canopy is such that a pilot would have some difficulty in making a quick exit if it became necessary to jump. A single piece canopy would solve both of these problems and also provide easier access to the instrument panel on the ground. Also, on the N-1 Nugget, the forward canopy frames were not the right shape and the glass had been pulled in to fit the frames so that there was an unecessary and undesireable departure from a smooth aerodynamic shape on the exterior. The canopy design did not provide for adequate sealing. Some consideration of these factors is required before finalizing the canopy frame tooling for later LP-15 sailplanes.

39. Flap loads are light for all soaring flap settings. These may be selected without any physical effort and the pilot quickly learns to keep track of the settings by listening to the detent clicks without looking at the flap position marks. Flap handle loads at 36° are light for all speeds of interest although they become quite high at speeds over 100 knots. For flap settings up to 75° down, loads are reasonable at pattern speeds but build up rapidly at higher speeds. Approximately 70 pounds of force is required to put the flaps 75° down at 55 knots and the maximum flap available at this force reduces with speed to 65° at 70 knots and 52° at 80 knots. With these loads, the flaps do not serve to limit the speed to red line values in vertical dives but they are more effective as speed brakes than are some of the so-called 45° brakes now provided on the newer fiberglass standard class sailplanes. From a practical standpoint, descent rates in excess of 2000 ft. per minute can be obtained at any speed over 60 knots with reasonable flap handle loads. The flaps also have very favorable characteristics for recovery from high speed dives or other out of control situations (i.e. - loss of visual reference). The pilot can pull the flaps down slowly until he reaches a reasonable limiting load; lateral-directional stability increases markedly as flaps come down and the sailplane slows down rapidly both from drag and change in trim so that, hands off, the sailplane will end up in a steady 30° turn at about 55 knots with 75° flap and a descent rate of about 1500 ft./minute. In 180 hours of flying there have been no occasions where the flap loads limited the flap travel beyond that needed to establish the desired flight path.

40. Even so, further modifications could improve the flap control. Flap travel needs to be increased to 8° up and 90° down. This may require greater flap handle travel to keep the loads within reasonable

values. It would also be desireable to reduce the loads required for full flap at higher speeds. The flap actuation system now in the N-1 Nugget is controlled by a handle on the left side of the cockpit operating fore and aft just below the cockpit rail. Position of the handle changes directly with flap position so that it is seldom necessary to refer to the flap position markings on the slide rod just aft of the handle. A thumb actuated trigger on the handle provides for selection of 5 soaring flap detent positions, a take-off flap position (16°) and an approach flap setting of 36°; the handle moves freely in a speed brake mode for flap settings greater than 36 degrees and will snap back to the 36° detent if released in flight at greater deflections. The trigger on the handle must be depressed to move the flaps up beyond 36°; this should minimize the inadvertant raising of the flaps beyond this setting when making approaches at speeds below the flaps up stall speed (stall at 36° flap is only 2 knots more than minimum stall speed). A more positive means of preventing inadvertant raising of the flaps to zero at slow speeds would be desireable; one pilot has already landed short of the runway when he ran by the 36° detent by mistake. Modification to a system providing greater slide arm travel and for two handles on the arm (one for detent selection in the soaring range fwd of 36° and the other for speed brake) would reduce flap loads, permit a better spacing of the detents for soaring flap selection and provide a more positive deterent to inadvertant raising of the flaps. Such a system is described on page 29 of the October, 1970 issue of "<u>SOARING</u>" magazine.

41. On approach and landings, the sailplane has the same excellent visability, ease of handling and positive control response that was so apparent on take-off and tow. Landings have been made in extreme turbulence, in driving rain, in winds as high as 40 knots and in 20 knot direct cross winds. Standard procedure in normal conditions is to slow the sailplane to 50-55 knots in the pattern, extend the gear (this requires a positive movement aft and a rotation of the gear handle into the gear down detent), extend the flaps to the 36° detent (gear warning will tell you if the gear is not down and locked with flaps more than 20° down) and remove the thumb from the trigger on the flap handle for the remainder of the approach to limit handle travel to the 36°-75° flap range. From this point, the Nugget has roughly the same performance and same approach speeds as a 1-26 but with more effective flight path control from the speed brake portion of the flap travel. Use the flaps to hold the desired flight path with 50-55 knots airspeed maintained until after the turn to final. The speed can then be reduced to 40-45 knots once the runway is well in hand. 38-40 knots "across the fence" will leave enough speed for flare with touchdown (two points) at about 33-35 knots. The wheel brake is very poor but the speed is so slow that it is not needed under normal circumstances.

42. The approach with full flaps appears to be very steep but the flight path is not as steep as it looks since much of the nose down attitude is due to the change in effective incidence of the wing with the flaps full-down. This same effect is associated with the greatest difference a pilot will see in making landings with flaps as compared to using spoilers. As flaps are used to control the flight path on approach, the sailplane attitude must be changed at the same time to maintain the desired speed. Use of spoilers requires much less change

in attitude. The approach angle is not only not as steep as it looks but is not as steep as one would like in the case of the N-1 Nugget. The approach angle is the same as that of a Standard Cirrus at 50 knots, steeper at higher speeds and less at lower speeds. The flaps are not as effective as the flaps on an HP-14. Part of this is because of the greater weight of the Nugget per square foot of flap area. In any case, excessive speed on approach will lead to overshooting the intended touchdown point. Later production sailplanes with full 90° flaps which may provide more drag for steeper approaches. If not, some consideration should be given to other ways of increasing drag at approach speeds.

43. Even with the present flaps, a pilot learns to keep the speed down and is able to make consistently good landings. One can hardly tell the difference in landings at 900 pounds (14 made during this program); speeds are 3 or 4 knots faster and roll-out is a little longer. With practise, and if the air is not too turbulent, it is possible to make reasonable short field landings with approach at 37-40 knots but this allows little margin for error, sink or gusts. Eight off-airport landings have been made in fields varying from one full of rocks covered by high weeds (gear door chipped on rock) to fields with soft dirt and deep furrows and one with ankle deep mud. All were made with gear down and with no gear or ship damage. The limited ground clearance provided by the extended gear actually proved to be an advantage for landings in soft dirt or mud as the wheel sank into the dirt or mud so far that the sailplane slid along on its bottom with no tendency to nose over or ground loop as is often the case for sailplanes with the gear more forward and providing more ground clearance. In two of the fields in which landings were made, other sailplanes elected to land gear up to avoid possible gear or sailplane damage.

44. At the beginning of the test program, the relatively aft location of the main wheel and the limited (6") ground clearance provided when it was extended were a source of concern. When flown at forward c.g. loadings (27-30% m.a.c.), the sailplane will go over on its nose very easily. It was anticipated that the ground clearance would be insufficient to protect the gear doors and bottom of the fuselage in off-airport landings. There have been several instances where the wheel dropped in chuck holes or sank in soft sand where the lack of ground clearance has caused problems in ground handling, but everything considered, the gear location and ground clearance have proven to be a good compromise as shown by experience in off-airport landings. The sailplane is normally flown with the c.g. near the aft limit so that, along with the lack of wheel brake effectiveness, there have been no problems with inadvertant nose over. A flush skid is incorporated in the nose fiberglass shell so that any nose over damage is limited to superficial scratches. Structurally, the gear has demonstrated great strength and no repairs or adjustment has been required during the 150 hour service test portion of the program.

45. The landing gear handle is located high on the right side of the cockpit and moves forward to retract the gear, aft to put the gear down. A number of sailplanes have gear handles which move in this fashion but most move in the opposite direction. Either way is satisfactory but there is obviously an increased chance for error as pilots

move from one type to the other. It would be a good idea to have the direction standardized but it is not clear how this can be achieved. Gear handle forces are not excessive but the cycle is not as smooth as it could be and one has to develop a techniquie of rotating the wrist to engage the detents in the up and down positions. The down detent is not very positive and it is easy to find the handle out of the detent unless recheck just before landing. This was of sufficient concern that a separate block was used throughout this program to block the handle in the detent in a positive fashion. It is also easy to bruise the back of the hand against the canopy frame when moving the handle into the forward (gear up) detent. The frame was heavily padded to minimize this during these tests. The gear handle set up should be modified to eliminate these problems. A slide arrange similar to that used for the flap handle would be an acceptable solution.

46. The tow release was modified early in the test program; this new release has proven to be very satisfactory in flight (ref. paragraph 11) and has many good features. The hook retracts when the tow rope is released and can be rotated out to the extended position and the tow rope ring inserted in the hook by one person outside the sailplane with no need to operate the cockpit handle. The hook mechanism and mounting does not appear to be very substantial. However, no structural problems have developed so far. The retract spring needs to be relocated so that the hook will fair properly when it is retracted. There is some evidence of chipped paint and filler on the bottom of the fuselage from the tow rope ring hitting the area around the release.

47. As sailplane cockpits go, the Nugget cockpit has plenty of shoulder and hip room; there is ample leg room for tall pilots and in flight pedal adjustment is available for any leg length. Some big pilots with large torsos may have a tight fit because there is no space available behind the wing leading edge for moving the seat back or providing additional space for a standard parachute. Location of the pilot entirely ahead of the wing leading edge also leads to the need for lead ballast in the tail for pilots weighing more than 150 pounds. This balance problem also requires that the weight of instruments and other equipment which might be installed in the cockpit be kept to a minimum or be balanced by additional lead ballast in the tail. With a pilot weight of 185 pounds and a 20 pound chute, it was necessary to install 10 pounds of lead on the vertical fin spar even though all other weight in the cockpit was reduced to a bare minimum. This was 10 pounds of weight that could be ill afforded in view of the 6.6 pound per square ft. wing loading. The ballast could be omitted under these conditions but the c.g. would be toward the forward limits with reduced performance and a tendency to go up on the nose on landings.

48. Space is provided behind the seat in two compartments, one on each side of the wheel box, for battery installation and servicing and for carrying water, emergency kit and tie downs but most of this space was unuseable on the N-1 Nugget because control push rods (flap and gear) ran through these spaces. There is ample room aft of the rear spar for installation of all kinds of equipment such as oxygen bottles and batteries but there is no easy access to any of this space. As is true for many other modern sailplanes, there is no access of any kind to many parts of the airframe and controls.

49. The basic water ballast system is excellent (ref. paragraph 37) but some improvements would make a good feature even better. Small leaks did develop around the drag pin tubes in the center section tank as the RTV sealant around the tubes worked loose (installation of "O" rings should correct this). The filler cap on top of the center section was in a position where any spillage would fall and run on to the controls mounted below the wing front spar and also allow water to get on the parachute and anything else left in the cockpit. This could be eliminated completely, tank construction could be simplified and the entire water servicing operation could be greatly simplified by modifying the drain pipe to permit filling the tank through the drain hole behind the wheel doors. There would be no need to install a filler hole and cap in the tank and the tank capacity would be increased by 10 or 12 pounds.

50. One of the new features of the Nugget is the use of bonding to assemble the aluminum structure. The success of this technique along with the demonstrated soundness of the engineering design of the structure has been most impressive. The sailplane certainly appears to be very strong and extremely well-built in all aspects pertaining to the basic airframe. No problems of any kind have appeared so far in the roughest kind of use. There have been no signs of any kinds of cracks around any of the joints or in the paint and filler covering them. Maintenance required has been limited to inspection, cleaning, and lube of moving parts.

51. On the other hand, many design details had not been worked out at the time the N-1 Nugget was built. These are primarily in the cockpit area and involve things like the canopy frame, controls, flap and gear actuation, and, suitable quick disconnects for the ailerons and elevator to simplify the task of assembly and disassembly. Another area that needs further attention is one of achieving a satisfactorily smooth mating of the wing surfaces where the outer panels join the center section. This may prove to be difficult because of inherent displacement of the panels under load at this point. However, the major area of misalignment is at the leading edge where the leading edges are not sufficiently supported to retain an accurate shape. It should be relatively easy to correct this part of the problem. A radio antenna was installed vertically along the inside of the fiber-glass fuselage below the main spar of the center section (with the center section as a ground plane). For some reason this did not work well and all flying was done with a temporary antenna taped inside the nose. The lower edge of the rudder did not provide sufficient clearance so that the ship would rest on the lower aft tip of the rudder any time the tail skid was in a depression or if the nose was raised to run the ship into the trailer. Later ships will have the aft tip of the rudder raised 3 or 4 inches.

52. There is no easy way to lift the tail for ground handling or when loading or unloading the trailer. People usually end up picking up the tail by the aft end of the rudder or, when assembled, by lifting under the horizontal tail, neither of which is satisfactory. The lack of a tail wheel or any adequate hand holds requires the use of a removable tail wheel dolly for all normal ground handling of the sailplane. Assembly and disassembly is easily accomplished by two people and is satisfactory except for the lack of suitable quick disconnects for the

elevator and aileron push rods. Those on the N-1 Nugget are completely unacceptable. Loading and unloading on a trailer is simple but depends on the type of trailer. The center section as an integral part of the fuselage presents some new considerations when adapting the Nugget to most small trailers. The tips may be run forward under the center section but this requires that the wings be removed and laid on the ground until the fuselage is removed. Or the wings may be run in root forward before loading the fuselage but this means that the fuselage can not be left in its saddle on the aft end of the trailer for assembly or disassembly. By making the trailer 60" wide on the inside, it is possible to load the wing either fwd. or aft and to load or unload the wings or fuselage independantly in any sequence (for repair work) while still retaining the capability of assembly/disassembly with the fuselage supported on the aft end of the trailer.

53. Overall assessment of the N-1 Nugget shows it to be an excellent sailplane with a very sound structure, good aerodynamic design, superb control and excellent performance but with further refinement required in many design detail items and with some room for further improvement which could make it superior to any of the 1973 sailplanes in its class. Even as flown in 1973, the Nugget was, overall, equal to the best in actual competition as demonstrated by placing above 100 of the 114 glass standard class sailplanes while taking first in its class in two regional contests, eighth at the Standard Class Nationals and eighth in its class at the Open Nationals as well as best U.S. sailplane in all classes at all four contests.

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