The Light Glider

by Ann Welch

Presented at the XIXth OSTIV Congress, Rieti, Italy (1985)

Today's high-performance sailplane is probably the most elegant type of aircraft ever built. It is the result of 60 years of design refinement, with the primary objective of achieving the flattest possible glide angle, so that its pilot can use the air's free energy with the maximum efficiency.

It is why flights of over 1,000 miles and average speeds better than 195 km/h have been obtained. This almost incredible improvement in performance over the last 60 years has been realized by:

- increase in aspect ratio to 35 or more, and wingspans up to 24.5 m
- extreme refinement in shape, wing profile, and surface finish.

The Nimbus 3, for example, has a glide ratio of almost 60, or better than 1°. The greatest step forward came with the introduction of glass and carbon fibre construction, now used for all sailplanes where high performance is the priority. Unfortunately, these beautiful and efficient sailplanes are not cheap. A Nimbus 3 costs £ 29,000 not including a further £ 5,000 for trailer, instruments, parachute, etc. Less exotic 15-m production sailplanes, such as the LS-4, are a little over half this amount, but it is enough to put them beyond the reach of many aspiring pilots, even as syndicate members. As a result gliding is no longer growing, numerically, almost anywhere in the world; and the average age of glider pilots steadily climbs.

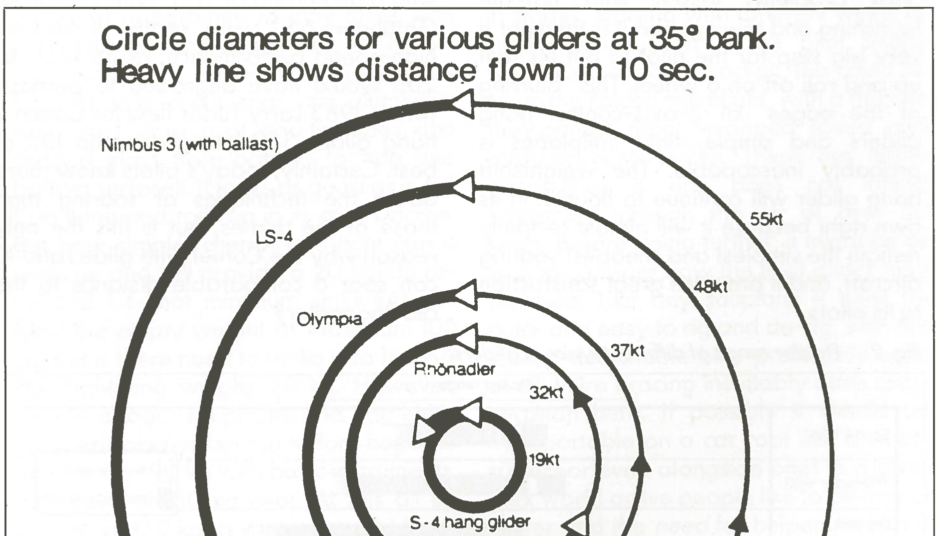
So what is the answer? The re-appearance of slow, light gliders is one which some enthusiasts may be reluctant to face. After 60 years of passionate search for higher and higher performance any idea of going back to a level which made it a struggle to get round a 100-km triangle on a good day is heresy. This is understandable, and I have no intention of suggesting that any pilot who is used to exotic sailplanes of superb performance should fly anything else. There is never anything wrong with the continued pursuit of excellence. But what about those pilots who have much less money, particularly the young ones? Are there not potential glider pilots who would be content with less performance just to be able to fly? And are there not a few existing club pilots who would actually prefer to potter in the sky instead of chasing 300-km triangles? And what about those pilots who do fly the exotica but not frequently enough to operate safely such fast and heavy ships out of reach of the airfield? These are all people who want, or need, air time rather than high speeds. Is there not a need for some dinghies—if one likens the overall scene to that of sailing?

There is, of course, hang gliding. These basic gliders have developed fast in the last 10 years, and can now fly distances over 350 km. They have been restricted to hills, like gliders were in the early days, but now that winching and aerotowing (with microlight trikes) are coming into use this limitation is departing. The capital cost of a hang glider is about a quarter that of a very ordinary second-hand sailplane, and in comparison the running costs are negligible. But although some old, and even disabled, people enjoy hang gliding, it is most suited to the young and physically active. From this end of the spectrum, too, there would appear to be a need for something in the middle; as is the sailing dinghy between the windsurfer and the yacht. At present this wide open space is almost empty. A few individuals have ideas and an even smaller number have turned them into hardware; John Lee and his Lightwing, for example.

One reason, perhaps, for this wide open space is that big, innovative steps are not often initiated by people fully involved in mainstream development. The glass fibre sailplane makers will continue to go for the best possible performance for their price range, and the top manufacturers of hang gliders will do the same. They cannot, indeed, afford the time, money, or their reputation to branch out into an unknown market. Hang gliding was started by people outside mainstream gliding, and if the "wide open space" is to be in any way occupied this is most likely to be done by new designers with fresh ideas and no established manufacturing reputation to lose.

What is needed is a coming together of the technology of the hang glider, and a re-appraisal of what was achieved with the light, slow, sailplanes of 40–50 years ago. It is often said that a sailplane with the performance of a K-8 cannot be made any cheaper than a K-8, but this is no longer valid if hang glider construction

Fig. 1: Circle diameters for various gliders at 35° bank



(Continued on page 35)

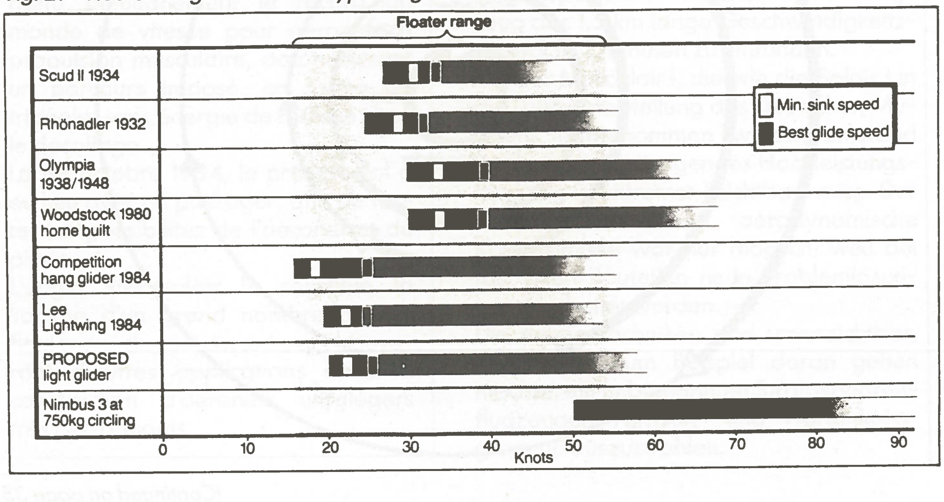
Table A:
Minimum-sink and maximum-glide-ratio performance for some representative aircraft

Glider	Year	Span (m)	Wing Area (m²)	Aspect Ratio	Empty Weight (kg)	Flying Weight (kg)	Wing Loading (kg/m²)	Stall (kn)	Max. Glide Ratio and Speed (kn)	Min. Sink Rate and Speed (kn)
Rhönadler	1932	17.40	18.00	16.8		260	14.40	25	20.0	1.2 / 29.00
Scud II	1933	12.19	9.29	16.0		145	15.60	25	22.0	1.30
Minimoa	1935	17.00	20.00	14.5	200	310	15.50	26	26 / 38.0	1.18
Gull I	1937	15.30	14.86	15.8	172	285	19.10	29	24 / 36.0	1.42 / 32.00
Olympia[1]	1938/48	15.00	15.00	15.0	195	304	20.20	30	25 / 39.0	1.32 / 34.00
Woodstock (home built)	1980	11.90	9.73	14.5	107	205	21.10	30	24.0	1.56
Solitaire (canard sailplane)	1981	12.70	9.5 inc. can	21 wing	145	240	18.90		30 / 53.0	1.5 / 47.00
LS-4[2]	1981	15.00	10.50	21.4	235	472	29.00	37	40.5 / 55.0	1.2 / 44.00
Nimbus 3[3]	1982	24.50	16.76	35.6	390	483 750	28.80 44.75	36.7 46	57 43 54	0.7 0.85 40 50.0
Lightwing	1984	10.70	14.20	8.0	75	160	11.30	19	16 / 22.0	1.50
Proposed Light Glider	1986?	?	?	?	90	170	?	20	20 / 22.0	1.40
Guggenmos Bullet (hang glider)	1984	11.00	15.20	7.5	28	108	7.10	17	10 / 26.0	0.95 / 19.00
Typhoon S-4 (hang glider)	1984	10.40	16.70	6.4	31	111	6.65	16	10 / 25.0	0.95 / 18.00
Sirocco (microlight)	1983	10.10	14.00	7.3	105	205	14.90	21	12 / 34.7	2.2 / 27.00
Pipistrelle (microlight)	1983	11.20	13.50	9.3	115	202	15.00	21	14.0	2 / 29.50

[1] The Olympia was built in 1947 by Elliots of Newbury from the German Meise, and was heavier.
[2] LS-4 without ballast.
[3] Nimbus. Top figures without ballast. Lower figures with ballast.

is studied and—wheels almost going full circle—to see how it has been modified for use in «aeroplane» microlights, some of which could be relatively easily turned into quite effective basic gliders. Rigid wing hang gliders with 3-axis controls, such as the UP Arrow, never became popular because of the difficulty in foot-launching tailed aircraft off hilltops—where they are also easily blown over. Such problems lessen with flat-site launching and towing; and it is then not a very big step for the pilot to put his feet up and roll off on a wheel. This "blurring of the edges" of 3-axis-control hang gliders and simple, light sailplanes is probably inescapable. The weightshift hang glider will continue to flourish in its own right because it will almost certainly remain the simplest and cheapest soaring aircraft, and it provides great satisfaction to its pilots.

Fig. 2: Floater range of different types of gliders



The key questions which concern the light glider, and whether it will find a place in the soaring world are:

- what is the minimum acceptable cross-country performance, and
- how can such performance be obtained at lowest cost?

In 1935 four pilots flew, on one day, the first ever 500-km distance flights. One of them was Ernst Steinhoff in a Rhönadler, with a glide ratio of 20:1. With its high lift Göttingen 652 wing section it had no high-speed performance; at 45 knots its 20:1 would have degraded to perhaps 14:1. In 1983 Larry Tudor flew his Comet 2 hang glider 359 km; glide ratio 10:1 at best. Certainly, today's pilots know more about the techniques of soaring than those of the thirties, but is this the only reason why the Comet with glide ratio 10 can soar a comparable distance to the old Rhönadler?

Surprisingly, it may seem, the effective speed range of the hang glider is slightly better than that of the Rhönadler. In both, serious decline of the glide angle is occurring by 45 knots, but whereas the Rhönadler's minimum-sink speed was about 31 knots that of the hang glider is 20 knots, some 10 knots less.

It is the very low stall speed—and minimum-sink speed—of the hang glider which makes it such an effective soaring device. It can circle tightly in the strong cores of thermals denied to the fast sailplane with its appreciably larger turning circle *(fig. 1)*. It can make more circles per minute which, combined with its ability to manoeuvre rapidly, gives it a better search and sampling rate for best lift. The very low flying speed also allows it to explore and use smaller areas of weak, and sometimes unexpected, lift, and it can continue to soar safely at lower heights because it can be easily landed in very small spaces. The hang glider may always be better than a 3-axis control glider of the same stall speed in both rapid manoeuvring and small-space landing.

Table A show the minimum-sink and maximum-glide-ratio performance for some representative aircraft (as accurately as can be found from various records). It will be seen that although the minimum-sink rate of the hang glider is about 0.3 kn worse than the Nimbus 3, this is of no great importance if the hang glider can use thermal cores more efficiently *(see also fig. 2)*. The big disadvantage of the hang glider, or any slow, light sailplane, is that glide ratios are much worse, and

they cannot fly at anything like the glass sailplane's speed through the air. The make little progress, except downwards, against fresh or strong winds, and so are only capable of triangle flying in light breezes. But is this a serious disadvantage for the pilot who wants to fly for fun at a price he can afford? Glider pilots could not fly big triangles in strong winds until the advent of glass, but I do not remember anyone being unhappy about the flying their old wooden gliders gave them–and still give a growing and satisfied vintage glider community. It was just different.
The idea of a light, cheaper glider is not new, but concentration seems to have been rooted on smaller spans and wing areas to reduce cost, with relatively high wing loadings for penetration. Such gliders have not been successful, as they cannot compete with sailplanes of better glide performance, nor do they have the ability to float around in weak lift. They are invariably too heavy. In case it seems confusing as to why the light glider should be as light as possible when sailplane pilots fill up their aircraft with 100–200 kg of water ballast to make them heavy, it is the difference between the objectives of time in the air, and speed. If speed is not necessary the glider can, and should, be light, cheap, and simple. The FAI Sporting Code for Gliding (CIVV Section 3), defines a light (ultralight) glider as one having an empty weight not exceeding 100 kg. Let us now consider a glide ratio of 20:1, minimum-sink rate 1.4 knots, and stall speed of 20 knots for our glider, which will of course be a single-seater.
Taking the above as a basis the permutations are considerable; if you increase the aspect ratio, the weight, stall speed and minimum-sink speed will go up. Accept a low aspect ratio and you can get more of a light, slow floater. I think John Lee has the right approach, because his Lightwing gives him easy airborne time in slope lift, thermals, and in just subsiding slowly to earth. He has succeeded in avoiding the unsuccessful compromise that has beset so many designers of small sailplanes, and has accepted that what he has is a floater for fun.

Configuration

Put simply, the choices are tail at the back (conventional), tail in front (canard including Rutan variants), tandem wing (latter day Pou), and no tail. It may save time to discard tailless at an early stage, inspite of having no tail to design, build, pay for, or repair. Tailless aircraft with stick and rudder control do have pitch stability complications which, in being overcome, often lead to more drag, or expense, than when there is a tail somewhere. They have been tried as aeroplanes (Westland-Hill Pterodactyl), gliders (AV-36), rigid wing hang gliders (Fledge) and microlights (Mitchell Wing), but popularity has never been sustained. It is not anomalous that weightshift hang gliders are tailless. As well as being c.g. shift, reflex in a soft wing adjusts to increasing speed. Canards and tandem or semi-tandem configurations do work, both in pitch stability and ease of construction, they blow over less easily on the ground, and the pilot also sits nearer the c.g. But none has yet become popular as a canard sailplane, probably because it is difficult to install the release hook in a position where it will *never* foul the foreplane. This would not apply to a Pou wing arrangement, but some thorough assessment would be required to make sure that it would remain controllable when being winch launched at a high angle of attack. To avoid any of the above complications the configuration considered here will be the old, unenterprising, one of tail at the back, with no obstructions in the region of the tow hook, and a good pilot view in crowded thermals.

Construction and Materials

Broadly, these include:

- Conventional, including wood, welded steel tube (for fuselages) and aluminium sheet.
- Synthetics; foam covered with glass fibre, or all glass fibre, like sailplanes.
- Hang glider aluminium tubes and dacron (the cheapest). Microlights would probably not have appeared without the remarkable success of aircraft made from a heap of tubes.
- A combination of the above.

Such a wide variety of materials gives plenty of opportunity to play tunes with cost, weight, and complication. The Sirocco microlight, for example, has a glass fibre D-nose main spar, an aluminium tube "rear" spar, root, and tip tubes, and shaped glass fibre battens for top and bottom surfaces. It looks as good as a J-3 Cub wing and rolls up in its own Dacron. But how simple, cheap, and light can a wing be and still provide a 20:1 glide ratio and 1.4-knot minimum sink? FAI defines the empty weight as maximum 100 kg, but is there need to make it so heavy? The Lightwing weighs 70 kg. However, the old adage "simplicate and add lightness" has always been a forlorn hope, so let us go for 90 kg with basic instruments, and have an 80-kg pilot. At this all up weight, of 170 kg, a wing area of 14.1 m^2 giving a wing loading of 12 kg/m^2. An increase in span from 11.9 to 13 m, and aspect ratios respectively of 10 to 12 would give an L/D improvement of about 1.25, for example, from 15:1 to 16.25:1. But it will be a heavier or more expensive wing. For this reason it might be sensible for future FAI competition rules to include an aspect ratio limit of, say, 12, to keep down cost.
The Lightwing aspect ratio is 8 for a cantilever span of 10.7 m using traditional construction, while the Sirocco microlight has a wire-braced wing of 10.2 m span and aspect ratio 7.3. It is, however, a parallel chord wing and to obtain satisfactory circling characteristics the wing should be tapered. Extending a Sirocco wing to, say, 12 metres, and giving it appropriate taper, should not be very difficult and, without the engine, cause no increase in weight.
The fuselage offers plenty of opportunity, from the creation of a loving work of art in plywood to a simple tube on to which are bolted goodies, such as the wing attachment structure, tail, pilots seat etc, but probably the most effective is a simple but elegant glass fibre moulding with integral pod and fin. Built in tow halves using polyester resin and stuck together with epoxy it is not difficult to make and need not be expensive. If the wing is to be braced the fuselage will have to have a neck, and if wire braced a kingpost as well, but both give good pilot protection should the aircraft turn over. The tail can be high, low or vee, but the disadvantage of a low tailplane on a glider is that when the wingtip is on the ground so may be the tailplane. A vee tail is better, but could have mixing box complications, including the spin recovery case. With a T-tail the most likely problem is torsional stiffness of the fin or fuselage. The temptation to build an all flying tail should be resisted, as a lightly loaded glider gets bounced around enough in gusts without having twitchy controls as well.
It is odd that possibly the quickest way to make a workable light glider might be to start with a microlight, such as the Sirocco or Pipistrelle. Development could be done in stages, starting with different wings of similar construction. If the pilot finally wanted an enclosed cockpit, this could be as on the Falcon microlight, with a flexible transparent sheet wrapped round and attached with velcro. There are many possibilities if one does not intend screaming through the air at over 50 knots. Before going further, it might be as well to consider how the light glider may be used. Like any sailplane it must be quick and easy to rig and de-rig, with the fewest detachable bits–preferably none at all. Wire bracing inevitably adds complication here. If possible it should be transportable on a car roof like a windsurfer–or even alongside one! In a complex world active people like to be free of clutter and the *need* for helpers; which is not the same as operating together with friends. With some types of construction a trailer may be necessary, and could double as overnight accomodation. If a glider is complicated and slow to assemble it is unlikely to become popular. Obviously, the light glider should be easy to inspect and repair.
Launching by aerotow, winch or car tow, or bungie should be free of difficulty. Aerotowing behind conventional powerful aeroplanes is unlikely to be satisfactory, and it might be better to use microlight tugs. Car towing and winch launching are cheaper, which is why there are

usually queues waiting for launches. Inevitably, there would be a move towards private towing from a friendly farmer's field, because an ordinary Land Rover would be more than adequate to provide the power. This same independence would exist with bungie launching from hills (except that a new bungie costs over £ 300), but in winds over 15 knots hand launching would work.

Finally, the light glider should, above all, be easy and pleasant to fly. It should have airbrakes or spoilers, and a landing wheel; not only a skid. The desire, today, for independence from establishments and bureaucracy should not be underestimated, but for the light glider it could be to some extent counter-productive. Gliding works well because of its club structure, which allows education of new pilots to be comprehensive. Hang gliding works well because its clubs have made arrangements for using the hills, and microlight and light aeroplane pilots fly from farm fields on the same basis. In all cases self-discipline is strong, with the occasional cowboy quickly dealt with by his fellow pilots. Although it is unlikely that new light gliders will suddenly arrive in quantity, it might be wise to think how they can best be helped to operate within existing organizations; rather than lone pilots spoiling the fun of others in ignorance. Until recently, expeditions into the hills were part of gliding club activity, declining as sailplanes grew heavier. With the light glider exploration could return, with the pilot having to learn—or relearn—different soaring techniques, like flying close to the ground without running into it. For the computerized sailplane pilot such seat-of-the-pants flying may seem a relic of the past, but the light glider will be flown this way, and it is no bad thing for a pilot young in experience to have to develop a bit of instinct and animal awareness in his aviating.

It has not been the purpose of this paper to design a new, light glider, much as it would be fun to do so, but to look briefly at those factors which appear to favour lightness, cheapness, and floatability. It may be that the proposed 20:1 L/D cannot be achieved without giving way a little on one or other of the parameters, but that will be for some new designer to use his ingenuity to discover.