The History of the Slingsby Skylark Series of Sailplanes

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Presented at the 6th OSTIV Congress, St-Yan, France, July 1956

T 37 Skylark 1

In the autumn of 1952 the firm of Slingsby Sailplanes, Ltd., decided to investigate the possibilities of producing a small and cheap high performance sailplane. The first draft was of a sailplane utilising existing fuselage parts and fittings. The Slingsby Prefect fuselage design was selected as a suitable source to draw on as the firm had substantial stocks of sub-assemblies available.

On the assumption that a machine of very small proportions must be cheaper than a large one, the span was kept to what was considered the minimum for a machine designed for high performance, and was eventually determined as 45 ft. (13.4 m), with the maximum chord 3 ft.

As the aircraft was an experimental type, we decided to try out various lateral control devices, short span ailerons, tip spoilers, and spoilers coupled with small area ailerons. To facilitate progress with these experiments we planned the wing in three sections. The centre, or main panel to be of constant chord throughout and to take in the dihedral by an appropriately shaped spar. The dive brakes were also included in the centre panel. The wing connection to the fuselage neck was through simple dural plates and long connecting pins, which could be inserted from the cockpit, and thus obviated the necessity of having detachable fairings or access doors, which are required if separate pins are used.

The outer or wing tip panels were planned with a taper ratio of approximately 2.5 to 1, which we found by experience to be a reasonable proportion.

To simplify rigging, we investigated several methods for the wing joints, and finally settled on a single pin connection with the torsion and drag loads carried through open jaws of dural, engaging wrist pins for a joint forward and aft of the main spar connection. The main connecting pin and the bearing surfaces were generous in proportion to give a good distribution and keep down wear. Adjustment on the torsion and drag fittings was provided by a system of "shims".

The aileron control circuit was by stranded steel cables to a lever at the wing joint. The action being transferred to a similar lever in the outer panel by two points of contact each side of the co-axial bearings. By this method of attachment and control mechanism, no fairings are required at the wing joints and the scheme worked very well indeed. However, it was found to be costly for such a project and was later modified on the subsequent versions.

The original aerofoil section selected for the wing was NACA 4418, with wing tips of NACA 2r212. We later decided that this was an ideal opportunity to investigate low drag aerofoil sections (commonly known as laminar flow sections) and so NACA 63_3—618 was selected for the main chord with a direct transition to NACA 64_2—618 for the tip. This tip section was modified on its under and rearward surface to provide flat surfaces for the ailerons. Experience has proved to us that concave or convex surfaces are not as efficient as flat surfaces for controls.

Therefore the wing resolved into a span of 45 ft. with centre panel of constant chord of 3 ft. having a spar length of 20 ft. Each outer panel had a spar length of 12 ft. 6 ins. to a tip chord of 15 ins. The wing twist from the main chord to the tip was decided as 3.5 degrees (aerodynamic twist or "wash out"). The root incidence to the fuselage datum was made 5 degrees to provide a reasonable flying and ground attitude.

An aileron of 11 % of the total wing area was chosen for the first stage of the project.

With a wing aspect ratio of close on 18 to 1, we had the promise of a good performance over the normal speed range. This high aspect ratio coupled with the widely spaced spanwise centres of pressure resulted in a heavy spar and we had to face the prospect of a wing loading of over 5.5 lbs.

The problem of obtaining a wing surface reasonably free from the buckles and ridges which one must accept with the normal thicknesses of birch ply over the leading edge of the wing, was overcome by the use of low density plywood. We were thus able to use a ply of double the thickness of the dense birch ply with approximately the same weight and strength per square foot. Unfortunately the only low density plywood available to an acceptable aircraft specification is gaboon, a soft and dubious wood but up to the required strength. We fortified the surface of this gaboon by a covering of very light-weight cotton fabric which gave us quite a good base for cellulose finishes. We hope to persuade our plywood manufacturers to produce low density ply in yellow pine or spruce.

A tail surface coefficient of .715 was used to ensure good fore and aft stability for cloud flying.

The first project was completed in a very short time and the aircraft had a good business-like appearance and every promise of success.

The first flight tests disclosed exceptionally responsive lateral control, far better than any other type we had used previously. The rate of roll was in the region of three seconds through an arc of 90 degrees i.e. 45 degrees bank on one side to a 45 degrees bank on the opposite side. The acceptance rate for such a span is 4.5 seconds. The dive brakes, the area decided from past experience, were also surprisingly effective, and could in fact, be considered too effective. Controls and general stability were of the highest order. The stalling speed however, was around 42 m.p.h. with a normal flying speed of about 48 m.p.h. This, we considered excessive as the turning radius for circling in clouds had to be rather more than desirable because of the high speeds and so the machine would not be popular for cloud flying. That, at the time, was the general impression and the judgement of the pundits. The prototype T 37 was entered in the National Contests in 1953 flown by Lt. Col. A. J. Deane-Drummond, and considering the short time he had had for getting familiar with the type he did some remarkable flights. In the classification for handicap he was placed with the Sky and similar machines so that the Olympia types had a 10 % advantage in marks. Nevertheless, Tony Deane-Drummond did very well indeed, but expressed an opinion that a smaller turning circle was essential if he hoped to compete with machines of lower wing loading.

It was evident that our choice of the "laminar flow section" for this sailplane was satisfactory for the higher speeds but not so good for the lower end of the speed range. At speeds near the stall the sink was very high, although full lateral control remained even at the stall.

We then discovered that at a low Reynolds number the laminar flow sections were much less efficient than the normal NACA 44 series aerofoils. The lift coefficient fell and the drag went up considerably for anything below a Reynolds number of a million. Our tip section was sadly below this, hence the high sink at lower speeds.

We named the machine Skylark.

T 41 Skylark 2

Following the successful results obtained with the aileron system, due mainly to the very stiff wing, we considered that we had nothing to worry about as regards lateral control; so experiments with spoilers and odd shaped ailerons were abandoned. But it became evident that a lower wing loading was desirable for the conditions in Great Britain, where we experience light thermals and require a small and slower turning circle.

We therefore put up the span to 48 ft. (14.6 m), and the chord to 3′ 6″, giving a wing loading of less than 5 lbs., with an aspect ratio reduced to 16 to 1. The taper ratio of the outer wing panels was reduced to 2 to 1. Instead of the laminar flow tip sections we used NACA 4415 which gave higher figures for the same R. number.

As it was reasonably safe to predict the results from this modification to be of a high order we introduced a more shapely fuselage of oval section. Fibre glass fairings and nose cap were tried and found to be stronger and cheaper than either plywood or alloys.

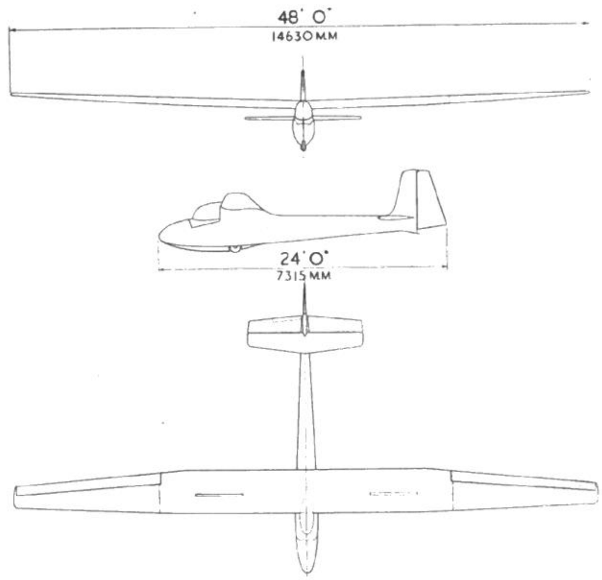
The modified version, type No. 41 on our list, was named Skylark 2.

In the interests of economy we sought to use the same tail units as for the Skylark 1. First flight tests disclosed fore and aft instability and so the area of the tail units was raised to a coefficient of .68 with acceptable results.

As this type was designed for club use, we introduced a built in central landing wheel to the undercarriage system.

The type was very well received by clubs and private owners but the production costs were very much higher than our target.

After the eighth off we were compelled to raise the price when it became evident that no further saving on production costs was possible.



Slingsby Skylark 2

However, dispite the sharp rise in the selling price the demand remained steady, and the general efficiency and handling qualities contributed to the very great increase in performance flights by Skylark 2 owners in 1955.

T 42 (2 Seater)

Running parallel with the development of the Skylark 2 we tackled the design and prototype production of a tandem seat two-seater training sailplane suitable for advanced instruction in altitude and cross country flying. The aim was to meet the requirements of the Home Command, R.A.F. for the Air Training Corps, and also to attract overseas glider training organisations and the civil market in Great Britain, thus keeping the production costs to an economical level.

Following our success with the new type of wing connections and aileron control system, we adopted a similar wing configuration for the two-seater (number 42 on our type list, now known as the T 42), using the three part wing with built in dihedral in the centre portion.

The same family of aerofoil sections was used for this T 42 and the prototype progressed on orthodox lines. Some trouble was found in providing easy access to the rear pilot's compartment, but by reducing the nose portion of the wing locally we overcame this difficulty.

To keep our C.G. within reasonable limits, a swept forward type of wing was adopted and, apart from requiring a rather tortured spar for the centre section, it presented no unusual production problems.

The canopy over the cockpit was, of course, made detachable with a built up Perspex hood. The canopy was removable in one piece, but this caused some misgivings because of its size and weight.

The span was decided as approximately 58 ft. (17.7 m) with a chord of 5 ft. for the centre wing panel, and the outer panel tapering from a chord of 5 ft. to 22 ins. at the tip.

The dive brakes, as in the Skylark 2, were located in the centre panel which had a spar length of approximately 20 ft. This, we afterwards found, was a great mistake as one may read later in this history.

The same tail unit volume coefficient was used for the tail surfaces as for the Skylark 2, with a fin and rudder area of comparable size. The fin was not elegantly proportioned on this prototype, but the first machine was being rushed forward to suit some publicity scheme for the summer of 1954 so mods were discouraged.

The T 42 was designed for an all up weight of 1200 lbs., with a disposable load of 440 lbs. Tare load was estimated to be 760 lbs. The tare weight came out at 768 lbs., with a disposable load of 432 lbs., which we considered acceptable.

This prototype was completed in four months from commencement, and the first test flights showed very great promise. It was easy to handle and quite docile throughout its speed range from stall to max. speed. The dive brakes however, when deflected, set up very severe buffetting over the tail surfaces as the result of placing them too close inboard. This buffetting was reduced to acceptable levels by a line of ventilation holes in each brake surfaces, but the efficiency was somewhat impaired thereby, although not seriously.

The prototype T 42 was granted a C. of A. by the British Gliding Association after a very careful test flight programme by the B.G.A. Test Group No. 1.

It is now in service at Lasham, and has many British Records to its credit.

The *second prototype* T 42 was completed early in 1956, and naturally embodies all the features found necessary from flight tests with the first prototype.

The centre panel, so massive for handling in the case of the original machine, was reduced to a spar length of only 12 ft. This was without either dihedral or sweep and the result was a very simple structure for production. The dihedral started at the wing joints and so the outer tapered panels were also comparatively simple. The dive brakes, so troublesome on the original machine, were located well outboard on the tapered panels, and a simple control connection provided for them. As this machine was designed for training purposes and not for competition flying, quick rigging features were not considered essential if additional high costs were involved. Therefore the aileron and dive brake control connections were made by access through generous sized hinged covered openings in the under surfaces of the wing near the wing joints.

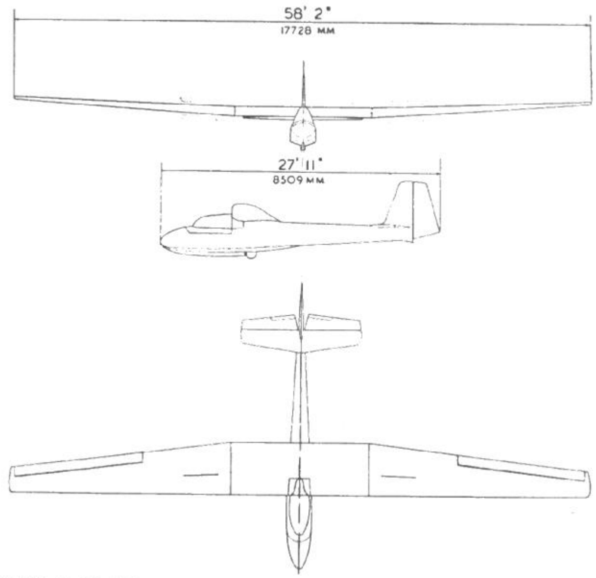
Assuming C. G. problems due to the tandem type seating, and with the pilots forward of the main spar, we decided to keep the leading edges of the tapered portions of the outer wings lineable with the centre section and so bring the neutral point well forward.

However, as we had also provided a specially well sprung tail skid unit with generous shock absorption travel, the neutral point could have very conveniently been a few inches further aft, so subsequent types will have a more orthodox plan form.

By rearranging the torque tube of the control unit in the fuselage, we were able to seat the pilots so as to allow less depth of fuselage, and this gave us a substantial saving in "wetted surface". Moreover it decreased the tare weight and improved the general appearance of the aircraft.

The cockpits were made wider and longer than in the first T 42, to provide plenty of legroom. The canopy was made in two parts and so arranged that this faired neatly into the leading edge of the wing without any local reduction of the wing nose as on the first machine. Special attention was given to sealing the joints of the canopy, particularly at the wing leading edge, and the results well repaid the trouble taken.

Simple types of canopy fasteners were provided, but the check strap for holding the front part of the canopy still requires improvement. During flight tests it was evident that some sort of balance was required to cancel out the elevator structure weight. As the C. G. was already well aft, system of balance weights on twin arms fitted to the elevator actuating lever in the elevator circuit in the front main bulkhead. Such a method had often been considered in the past, but always rejected as a dubious solution because of the results expected from two opposing masses with steel cable connections. How-



T 42 Eagle 3 Sailplane

ever, this unit, thus installed, has given no indication of trouble to date. (Whilst on the subject of the mass balance; it should have been mentioned earlier that in all the Skylark types we have found the necessity of a partial mass balance in the aileron system and the method used has been most satisfactory.)

The T 42 two-seater is now in service, and has been entered in the World Contests for 1956 at St-Yan, France, by the British Team, despite the fact that it is a training type. Nevertheless, it has a low sink over a very wide speed range with a maximum L/D of 1 in 29. A few machines of this type are already on order for export.

Skylark 3

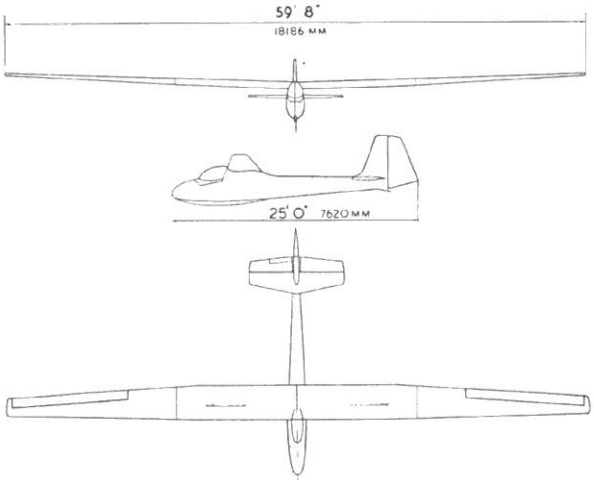
Following the success and popularity of the Skylark 2, the upper level of sailplane pilots in Great Britain urged the firm to step up the performance of the Skylark by increased span. This was not quite such a simple problem as that one sentence implies.

Investigation disclosed a worthwhile improvement by an increased span from 48 ft. to 55 ft. This was at first considered good enough. Further investigation showed that by increasing the span to 18 metres, giving an aspect ratio of over 20 to 1, and L/D of approximately 33 to 1 could be hoped for, and that from estimates based on assumptions used for the Sky sailplane, later checked by performance flight tests.

We therefore went right out for the larger span, and although the centre section spar has assumed a formidable weight the performance gained is considerable. In fact one feels the L/D is rather higher than estimated.

The increased aspect ratio with such a small chord and consequential restricted C.G. range, coupled with the steep slope of the lift curve for the laminar flow sections has posed a problem of fore and aft stability.

A larger tail volume offered a solution, but the larger elevator surface and consequential structural weight raised the question of a bob weight balance in the elevator circuit. Then the build up of weight raised the question of adequate fuselage stiffness. The ply on the rear part of the fuselage was increased and consequently the weight aft of the C.G. neutral point. To compensate for this the whole of the fore part of the fuselage from the parachute support frame was projected forward six inches.



Slingsby Skylark 3

A compensating load was applied in the elevator circuit to partially balance out the weight of the elevator to give more scope to the tail trimmer tab. This device caused quite a complication, and raised problems of instability in certain flight manoeuvres, and was considered a handicap for cloud flying. The elastic cord providing the spring loading was subsequently reduced in power to a few pounds.

The Skylark 3 was granted a Certificate of Airworthiness by the British Gliding Association and the Air Registration Board after extensive flight tests by the B.G.A. Test Group No. 1, and Mr. A. W. Bedford for the Air Registration Board.

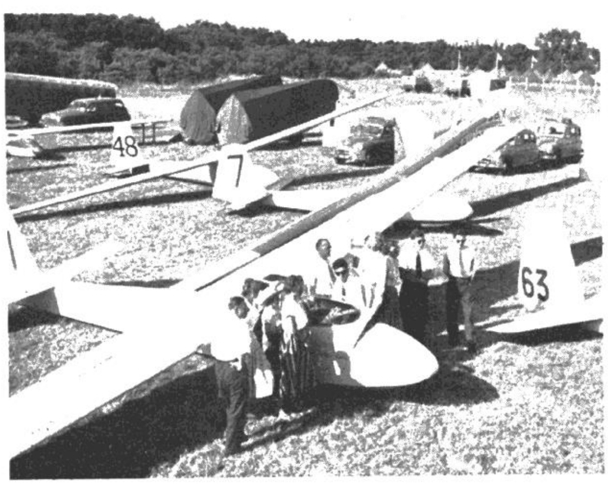
Several of the Skylark 3 type were built in the first six months of 1956, and six have been entered in the World Gliding Contests. The second prototype of the two-seater training version of the Skylark series, the T 42, has also been entered in these contests.

A modification to the Skylark 3 to provide a convenient ballast scheme for a wide range of pilot's weights is now being incorporated in the latest production.

The transition from the Skylark 2 to the Skylark 3 has been an expensive step. The production costs are raised by nearly 30 %.

A lot of valuable data has been gained by the development and production of the Skylark series, with the introduction of the low drag sections, the use of low density plywood, and the advantages of fibre glass laminates for complicated shapes, fairings, canopies, and fuselage noses.

The firm intends to make greater use of fibre glass laminates for fuselage construction in future sailplanes.



The British team beside the T 42 at St-Yan, France. The Skylark 3 is in the background

Postscript (20th February 1957) **to Paper**
"The History of the Slingsby Skylark Series"

Skylark 3 B

Since the paper was presented to the OSTIV Meeting at St-Yan in July, 1956, two modifications have been embodied in the Skylark 3.

To simplify the problem of providing a wider C.G. range, the front portion of the fuselage forward of the main bulkhead has been extended by 7.5 c.m. including the pilot's seat, instrument panel and control mechanism.

To improve the handling characteristics of the Skylark 3 in rough air and at higher speeds, a fitment incorporating a balance weight has been installed in the elevator control circuit amidships.

Machines so modified have been classified as Skylark 3 B.

T 42 Eagle

The front portion of the fuselage has been extended forward of the main bulkhead, an increase of 15 c.m. for improved C.G. consideration.

The area of the dive brake panels has been increased by approximately 10 % without changing the position of the dive brake lever arms.

The sudden application of the dive brakes at high speed, with fore and aft controls almost "stick-free", set up a sudden change of trim requiring a relatively high stick force to correct it. This is considered to be a characteristic of a two seater type when the C.G. point in the vertical plane is low because of the high weight ratio of a loaded fuselage in relation to the position of the dive brakes. "Fuselage" type dive brake panels were unacceptable. A solution was therefore considered for the use of a trimming device which would counteract the undesirable features of the wing type dive brakes.

A hinged and adjustable trim tab was introduced to the port side of the elevator, similar in area and construction to that of the normal tail trim tab on the starboard side. The controls for this new trim tab were connected to the dive brake mechanism by a suitable lever and the results were satisfactory.

Summary of Dimensions and Weights

	T 42 B	*Skylark 3*	*Skylark 2*
Wing span, meters	17.8	18.2	14.63
Length, meters	8.4	7.62	7.31
Height, meters	1.86	1.75	1.52
Wing area, meters²	21.2	16.1	13.4
Aspect ratio	14.8	20.5	16
Empty weight, kg	353	256	210.5
Flying weight, kg	545	359	308.5
Wing loading, kg/m²	25.7	22.2	23.0
Glide ratio	29—31	32—35	28—30
at—km/h	80	74	69
Sinking speed, m/s	.61	.56	.65
at—km/h	78	65	60
Maximum speed, km/h	237	218	216
Terminal velocity with brakes opened (at maximum all-up weight)	237	218	216
Wing profile, root	63₃618	63₃620	63₃620
Wing profile, tip	4412	4415	4415