Understanding Thermal Soaring Sailplanes

...by Martin Simons

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PART 1

Introduction

An international competition class, F3J, for model thermal soaring sailplanes is now recognized. The provisional rules are those of the long-established and popular Open Class championships run by the British Association of Radio Control Soarers (BARCS). There will be no speed or distance tasks. The emphasis is on duration.

Summarizing the rules, only hand towline launching is permitted, with 150 metre lines. The contest site must be as flat as possible. The pilots aim to achieve the maximum possible flight time within a ten minute period or 'slot'. Models are launched immediately at the start of the 'slot' and aim to touch down just before the end of the ten minutes. One point is scored for each second of flight after release from tow up to the end of slot time.

A penalty of 30 points applies for overflying the slot and the score is zero if the overflight is more than 60 seconds. A bonus of 50 points is earned for landing within a 12.5 metre radius circle, 25 points if the model comes to rest only partly within the circle. To score landing points the model must be at rest before the end of the slot. The small bonus for landing within the 12.5 metre radius circle, although not negligible, reduces the likelihood of a contest being decided by landing points alone. Landings more than 75 m from the centre of the target reduce the flight score to zero.

The models are limited in size and weight by the general CIAM rules: total surface area not more than 150 square decimetres, mass not more than 5 kg, area loading between 12 and 75 grammes per sq dm. (1.2 to 7.5 kg/sq m, or 4 to 24.5 oz/sq ft.).

A five minute preparation time is allowed before the start of each 10 minute slot. The usual normalization of scores to 1000 championship points for the winner of each heat applies.

Full details of the rules should be available from the National Soaring Society and the AMA.

A ten minute maximum is unattainable because the models are not launched until the start of the slot time. A potential point is lost for each unnecessary second on tow. Launching is hard and fast. After release, to achieve something over a nine minute flight requires soaring.

The aerodynamic design of the sailplane is only one of the important factors to be considered. Success depends greatly on the pilot's skill and experience, finding and using thermals efficiently, and getting the glider down in the target circle within the stipulated time. The structure of the model is also vital. The models are not launched gently and may have to descend fast.

Even so, attention to the fundamental points of sailplane performance will help to direct sailplane development and piloting strategies along the lines required by this type of contest. These are familiar already to many but it is necessary that they should be well understood, because almost everything else follows from them.

The sailplane polar

Figure 1 shows the appearance of a typical sailplane performance or polar curve. The curve is a plot of flight speed against rate of descent through the air. The scale along the top shows the airspeed of the glider; the scale down the side gives the rate of sink. Whatever system of units is preferred it is best on such a chart to keep both airspeed and sink rate in the same units, such as metres per second. It is not very satisfactory to use, say, kilometres per hour for airspeeds and metres per second for sink, or nautical miles per hour (knots) for airspeeds and feet per second for sink rates. The reason will become plain when the glide ratio is considered.

Suppose the model is flying straight in calm air with no up or downcurrents. To dive, the elevator is deflected down. The glider will accelerate but after a little time, if the controls are held in one position and if the model is stable, it will settle down to a constant, fast, flight speed. Because it is diving it will lose height rapidly. The elevator position as held by the pilot or fixed by the trimmer, determines the airspeed and also the rate of descent. This gives a single point to be plotted down near the right hand, lower part of the chart, or even off the chart altogether if the dive is steep. An airspeed of so many metres per second results in a sink rate of so many m/s. The ratio of airspeed to sink gives the glide ratio; 12 m/s airspeed with 1 m/s sink gives a glide ratio of 12:1. for example. (This is why it is wise to keep the units the same on both scales. If the airspeed is recorded as 43.2 km/h and the sink as 1 m/s some arithmetic is required to work out that the glide ratio is 12: 1.)

If the elevator position is altered so that the model dives less steeply, the airspeed reduces. Any control movement usually causes some oscillations but these are damped as much as possible by the pilot, aided by the inherent stability of the model. The glider soon settles to a new trim at steady, slower airspeed. The rate of sink is also less because the dive is less steep, so another point can be plotted higher on the chart towards the slower end of the airspeed scale. Within the normal flight capabilities of the glider, for each elevator position decided by the pilot there is one steady airspeed and a corresponding steady rate of sink through the air, so for every possible stable flight trim there is a single point to be plotted on the chart. This can be repeated many times. Plotting the points and linking them up allows the construction of the whole polar performance curve.

One end of the curve is at the stall. Normal flight is not possible at slower speeds. The other end of the curve is the vertical dive but the speeds and rates of descent in this trim are too high to be included on charts of reasonable size and are not of much interest in practice. (In a truly vertical dive, airspeed and rate of descent are the same thing. It would be possible also to construct another curve representing the inverted performance of the glider, but this does not normally interest the thermal soaring pilot.)

The general character of the polar curve is roughly similar for all sailplanes, but individual sailplane polars will occupy different places on the chart. The entire curve as a whole may be towards the high speed side of the airspeed scale, or towards the low speed end. Some curves may be high, indicating very low rates of sink, others may be lower down the chart. Some curves are somewhat flatter than others indicating a wide range of airspeeds with relatively small changes of sink rates. Some polars have sharp peaks, indicating rather critical dependence of the rate of sink on trim. The differences in straight flight performance of various designs can be represented by constructing polars and comparing them. Any change of the characteristics of a sailplane is usually reflected in a corresponding alteration of the polar curve. For example, decreasing the total weight tends to shift the curve as a whole leftwards to the lower speed side but also makes it come to a sharper peak, spoiling the high speed portions of the curve. ...continued on page 8

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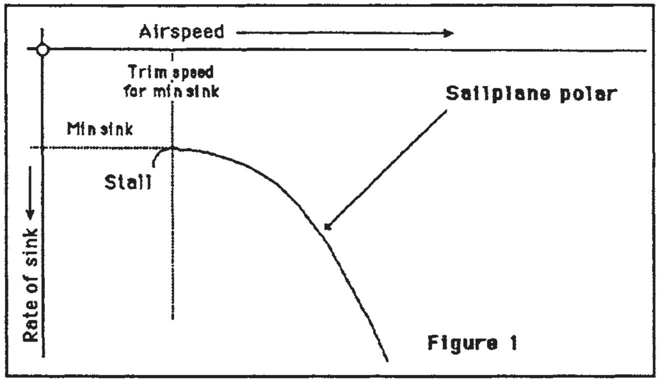

Figure 1

Increasing the weight shifts the curve to the right, flattens the peak and raises the faster side of the curve but increases the stalling speed and the minimum rate of sink.

The polar for a particular aircraft, at a particular weight, may be constructed either from measurements in flight or by calculation. Measurements in flight are extremely difficult to do accurately with models and have rarely been attempted. We normally have to rely on calculation and computer programs are now available for this. The general principles are all that need concern us at present.

It is easy to do worse in flight than the polar suggests. If the model is allowed to skid or slip sideways the fuselage and wing will meet the air at a lateral angle instead of being aligned correctly with the flow. A great deal of extra drag will result. The glider will sink faster than the polar indicates.

Also, if the model is unstable it will not hold any steady glide for long. Every movement of the controls causes a slight increase of drag and loss of performance, so an unstable glider, tending to veer off line and requiring constant corrective action by the pilot, is not likely to achieve its potential. Stability, as most experienced pilots know, is determined chiefly by the position of the centre of gravity. A c.g. well forward makes for a stable aircraft and as the balance point is moved aft, the stability margin decreases.

If the air is turbulent the pilot has to apply numerous corrections and this, too, spoils the glide. Nonetheless, other things being more or less equal, the sailplane with the best polar curve will perform best in practice.

The minimum sinking speed

The highest point on the polar curve represents a trim which will give the model its absolute minimum rate of sink. There is no way, for a particular glider, at a particular weight, that the minimum sinking speed relative to the air can be reduced. The sailplane with a low rate of sink on the polar will, in general, be capable of soaring in weak lift, but there are important reservations to be made here.

A glider which has a good basic polar for straight flight, will also perform well in turns. When circling in a thermal for instance, the polar curve, airspeed against rate of sink, is similar in general shape but the drag is higher and the stalling speed rises. The entire polar moves down and to the right on the chart by an amount depending chiefly on the angle of bank. The stalling speed and drag are both increased and the rate of sink increases. This cannot be avoided and the steeper the angle of bank the worse it gets. However, the losses certainly cannot be reduced by 'turning flat' without bank, as some pilots seem to believe. If the bank angle is either too flat or too steep for the rate of turn required, the glider will skid or slip and come down faster. A stable glider, trimmed for turning flight, is best left

to settle down in its natural steady turn at a constant angle of bank. Too many adjustments by the pilot tend only to increase the drag and increase the rate of sink in the turn. Such frequent changes also make the circles, as flown, irregular. It becomes impossible, from the ground, to judge whether the sailplane is in the best part of the thermal or not, if it is constantly varying its attitude.

The rate of turn (that is, the number of complete circles made in a given time) is decided almost entirely by the angle of bank so, for a given model, at a given flying weight and airspeed, time taken to complete a circle is constant so long as the angle of bank is constant. However, the radius of turn at a given angle of bank depends on the flight speed, wing area, total mass, and stalling characteristics. Thus a heavily loaded jet fighter aircraft flying fast, at a bank angle of 60 degrees, might require the airspace over half a county to complete a circle, whereas a light aeroplane at the same 60 degree angle of bank can circle with a radius of only a few score metres. A model sailplane at 60 degrees bank may complete a circle in much smaller space again. The radius of turn thus depends on the bank, the weight, and the airspeed.

If a thermal is very narrow, a light, slow sailplane which can circle tightly with correct bank at a slow airspeed without stalling, may outclimb a model which has an apparently better straight flight polar, but which flies faster and cannot circle tightly without having to bank excessively. It is often found that even when a thermal is wide, there are narrow 'cores' within it so a sailplane which can find these and circle tightly within them, has an advantage. If thermals are very strong, this difference will hardly appear but with weak and diffuse thermals, it can be very important.

One of the things to be discovered therefore, is how to make a model glider with the least possible rate of sink. But we also like to have a low stalling speed, allowing a small turning radius with gentle bank angles. These requirements are to some extent incompatible with other desirable qualities

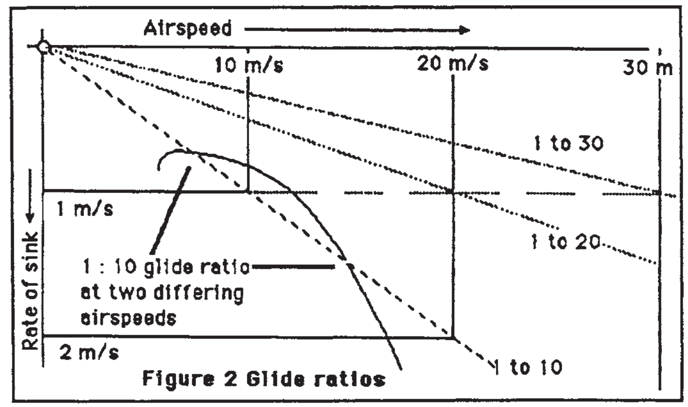

Figure 2 Glide ratios

The best glide ratio

Unless the sailplane happens to be launched straight into a thermal, which does happen sometimes but cannot be relied on, after coming off tow it will be necessary to explore the air for some distance to try to find lift. During this search the sailplane will be descending so the distance it can glide in relation to its rate of losing height becomes very important.

If a glider is flying at 10 metres per second horizontally, and descending at 1 metre per second, it is gliding ten units along for one down, a glide ratio of 10 to 1 (Figure 2).

Such a glide ratio would also be achieved by gliding at 20 m/s horizontally and descending at 2 m/s, a ratio of 20 to 2 which cancels down as 10 to 1, and so on, 30 m/s speed with 3 m/s sink is the same 10 to 1 ratio. A straight line can be drawn on the chart to show all combinations of speed and sink rate which will give a glide of 10:1. On the chart the 20:1 glide ratio line is higher than 1:10, the 30:1 glide ratio line higher ...continued on page 10

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still, and so on. All these L/D lines radiate from the zero-zero or origin point on the chart. The glide ratio is often expressed as the ratio of total lift to total drag or L/D, because when the drag force on the glider is one tenth of the lift force, i.e, L/D = 10/1, the glide will be 10 along for 1 down. Since the lift is for practical purposes equal to the weight, the L/D or glide ratio may also be thought of as the ratio of weight to drag.[1]

A particular glider may never reach high glide ratios With the example of Figure 2, the polar curve does not reach the 20:1 glide line anywhere. However, the polar cuts the 10:1 glide ratio line twice, at low speed, near the stall, and again at a higher speed. The glider can achieve a 10:1 glide ratio by flying at two different airspeeds, slow and fast. It will achieve a flatter glide if it is flown at any trim between these points. The best glide ratio of this model is thus somewhere between 10:1 and 20:1. A straight line drawn from the origin, to touch the polar curve tangentially, indicates both the best possible glide ratio and the speed at which it should be trimmed to achieve it (Figure 3). It is, in this case, roughly, 11 m/s speed to 0.8 m/s sink, a ratio of 11:0.8 or 13.75:1. As the diagram shows, the best glide ratio is not found at the same trim as the minimum sink rate. Minimum sink is found where the polar curve is highest on the chart. The best glide is found where the tangent from the origin touches the curve. These two distinct points require different elevator positions. This is often misunderstood.

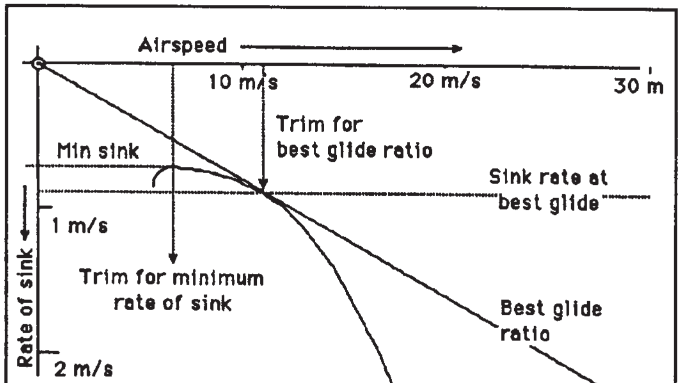

Figure 3 Trim and performance

The trim for the best gliding angle is hardly ever used in practice. The only time when it might be needed is when the air is perfectly calm with no wind and no up or downcurrents. This is a very rare situation. On almost all other occasions the required trim will be either faster, or slower, than that for the best L/D. (Slower when soaring, faster when searching for lift.)

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[1] Strictly, the lift is equal to the weight multiplied by the cosine of the angle of glide. At glide ratios better than 5 : 1 the lift is always more than 98% of the weight.

Press Release

NorthEast Sailplane Products

...by the NSP Gang

As any devout RC sailplane enthusiast knows, finding information on RC sailplane kits and related products can be a frustrating experience. This is especially true of the higher performance ships in the market since they are manufactured mostly by small and widely diversified cottage industries which make great kits, but have difficulty making them well known. Further, aerodynamic design technologies are advancing at such a rapid pace that it is nearly impossible for RC soaring pilots to be aware of the newer kits which exploit these technologies. Indeed, some of the more popular kits currently being flown are relatively outdated from a design perspective simply because information on the newer, more advanced kits is not readily available.

Difficulties such as these are what led to the creation of NorthEast Sailplane Products, or NSP. NSP was founded by Sal Defrancesco, a Marketing Expert, and Jay Kempf, an Engineer, and made its debut at the 1989 WRAM show. This turned out to be a tremendous success, and feedback obtained from RC Sailplane Pilots confirmed the need for NSP services. This year, Stan Eames, a Computer Systems Expert, joined Sal and Jay to create a three man partnership we feel has a special synergy of skills. All three members of the NSP team are fanatical Builder/Pilots of soaring ships and represent a combined experience of over 35 years in RC soaring.

NSP is a mail-order business intended to cater to the RC soaring enthusiast (we don't do power, the airfoil is the airplane). In creating NSP, we set the following goals for ourselves:

- To be a focal point for the latest information on RC Soaring Technologies.
- To provide the largest selection of RC Soaring kits and accessories available in the industry.
- To only sell high quality kits, and to aid designers and manufacturers in improving quality through providing customer feedback.
- To help the hobby of RC Soaring grow by making useful information available to hobbyists.
- To have our catalog be not just a catalog but a key reference on kit specifications that will be a "must have" for any RC Soaring Pilot or Builder.

We're excited about providing our services to the soaring community, and looking forward to making our NSP catalog available soon. The catalog will feature over 70 kits and accessories, full kit descriptions, technical specifications, and valuable reference information for comparing kit specs. Also, we'll include plenty of building and flying tips. Enclosed you will find an excerpt from the catalog. **(Not included in *RCSD*. Please see ordering information below.)** As you can see, our product descriptions go beyond simply copying what is on the kit cover. We review the kits, talk to people who have flown them, and build and fly many ourselves. We want people to be happy with the kits that they buy from us, so we provide the information necessary for a person to make an informed purchase.

People desiring a catalog may call us at 802-658-9482. Also, feel free to call to chat as we love to get information and are always willing to share it.

NorthEast Sailplane Products
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Understanding Thermal Soaring Sailplanes

Part 1 Section 2

on

Penetration

...by Martin Simons

(This is the second in a series of articles by Martin Simons. The material in this section will refer to information & drawings in section 1. Reproduction of this material requires the permission Martin Simons.)

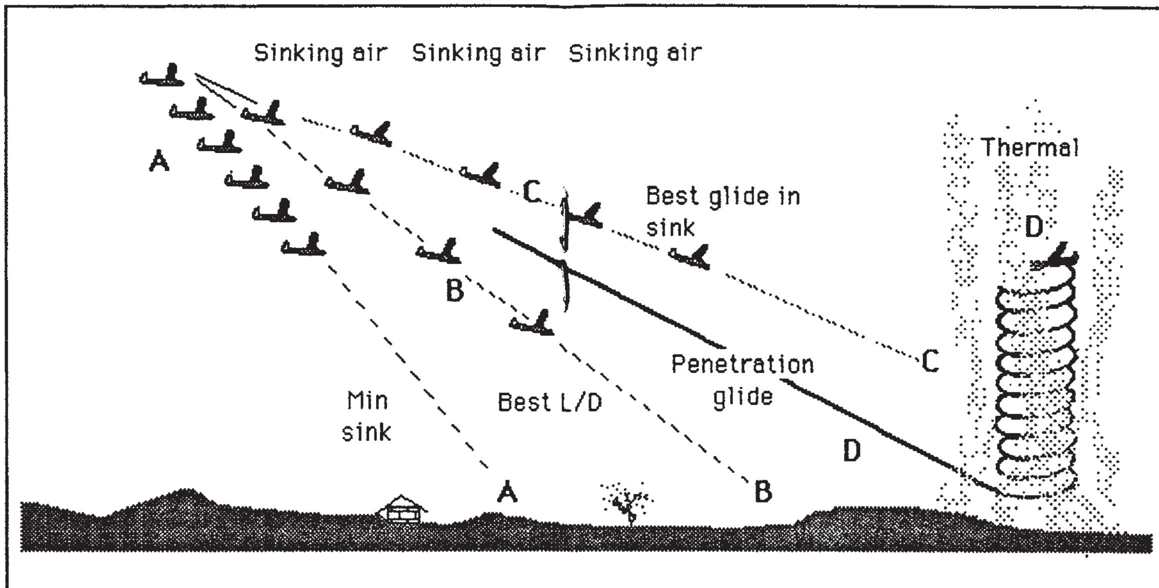


Figure 5 The meaning of Penetration

There has been some argument in the past about the word 'penetration' as it is used in glider flying. It is not very fruitful to argue about words, providing their meaning is clear, so what follows is partly intended to clarify the meaning of the term but mainly to expose some underlying principles.

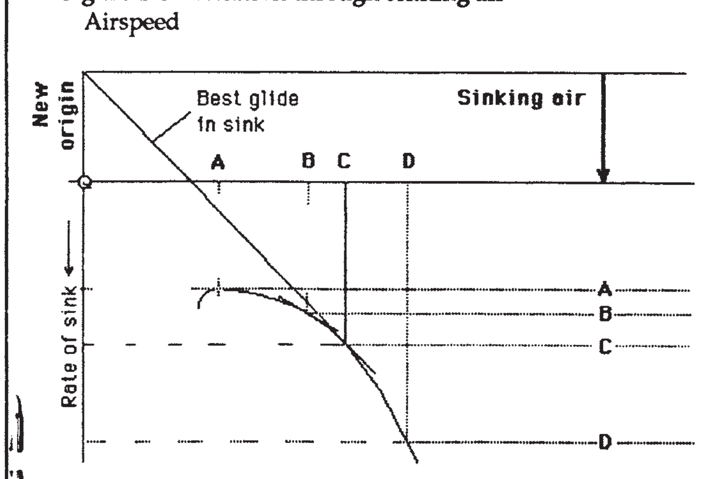
If thermals are present the air which rises must be replaced by air coming down so there are regions of sinking air. When searching for a thermal the model will usually be gliding through sink. It is important to get through the bad air, that is, to **penetrate** the downcurrent with the smallest possible losses of height and time, so as to reach an upcurrent while still having some height left. A sailplane which can do this has 'good penetration'. The best trim for penetrating through sink, as will become clear, is always faster than that which gives the best still air glide ratio.

Figure 4 shows the same polar curve as Figure 1, but now the air in which the model is flying is sinking. This can be shown on the chart by shifting the entire polar curve downwards. The vertical scale is extended by an amount equal to the strength of the downcurrent, using the same scale intervals as for the glider's sink rate. The shape of the polar curve is not changed, because the glider sinks relative to the air just as it did before, but the air itself is now descending.

Suppose there are four pilots with identical models, all of the same weight, all starting at the same height, say immediately after launching at the beginning of a time slot in a contest. Pilot A, inexperienced, thinks the way to score the best possible duration is to reduce the rate of sink as far as possible. The trim chosen settles the glider to fly at the top of the polar curve. The model does descend at its minimum sink rate but it is in sinking air, so it actually descends at its minimum sink rate plus the rate of the downcurrent. It is unlikely that a high flight time will be recorded. Of course an element of luck is involved. Pilot A may be saved by stumbling into a thermal but on most occasions this will not happen and the model will have to land very soon despite flying at 'min sink' trim.

Pilot B is more experienced and knows the important thing when in sinking air is to get out of it and find a thermal. B aims to search the air as much as possible, even if this means accepting for the time being a faster rate of descent than A. Model B is trimmed to fly at its best glide ratio according to the still air polar, faster than the minimum sink trim. B loses height more rapidly than A but makes more progress horizontally which does increase the chances of finding lift. B's prospects are better than A's, despite sinking more rapidly at first. of course, B may fail to reach a thermal; luck does come into the picture, as always.

Figure 4 Penetration through sinking air



But even B is not following the best policy. B is not, in fact, searching through as much air as possible.

Pilot C knows that the origin of the glide ratio lines on the chart has to be changed when in sink, because the entire polar has shifted down. The best glide ratio in the downcurrent is found, not by drawing a line from the old origin, but from the new one, allowing for the downcurrent. The tangential line drawn from this point touches the polar curve at a faster airspeed. The pilot therefore trims faster than the nominal best L/D trim. Glider C loses height more rapidly but, having a better glide ratio, has more height to spare and has a better chance of finding lift than B.

It is important to take this point. Suppose that A, B and C all go off *...continued on page 16*

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in the same direction. (They do not have to do so, but for the sake of argument assume they do. Figure 5.) As A glides along slowly at min. sink, B at every moment will be ahead, flying faster but getting lower. As B goes on, C in turn will at any moment be ahead, and lower, because C's airspeed and sinking speed are greater. If there is no thermal in this direction, C will have to land when B is still flying some way behind. B will score better duration than C. But A will still be flying when B lands, because A is trimmed for minimum rate of sink. None of the three will score a high time but A will score least badly.

But if there is a thermal, and C, flying fast at the best glide in sink, and so penetrating the downcurrent, reaches it, B will be behind and still in the bad air when C starts climbing. C will be gaining height all the time B is struggling on at best L/D through the bad air. B's model may not even be able to reach the thermal and even if it does eventually arrive at the thermal it will be lower than C was at this point.

Arriving at the thermal low down adds to B's difficulties. Near the ground, thermals are smaller in diameter so they may be easily missed altogether by a searching model. Even if found, steeper angles of bank and greater skill are needed to use the narrow core, than when the lift is encountered high up. Hence model C, by flying fast, not only penetrates the sink better than B or A, but also has better chances in the thermal when, and if, it is reached.

Glider A, meanwhile, will still be floating slowly through the sink, losing height slowly but not covering much distance. Very probably A will never arrive at the thermal at all. Despite flying at minimum sink, A will be on the ground first.

Finally, Pilot D, a confident person who can locate thermals when others cannot, is sure that there is a strong thermal ahead. Perhaps this pilot has noticed a soaring bird circling, or sees dust rising, or recognises a spot on the ground which is producing strong lift, or has sighted another climbing model. Even though it means losing a lot of height model D is trimmed to fly even faster than C, coming down quite rapidly, as the polar diagram shows, but penetrating through the sink at high speed. D goes out well in front of C, but loses a lot of height in a short time.

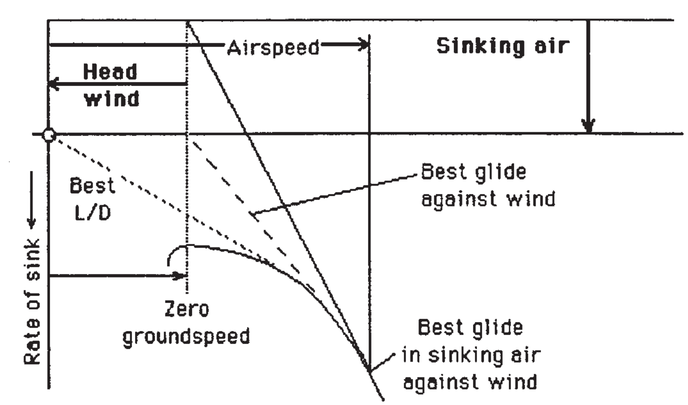
If this pilot is right model D gets to the thermal first, probably low down but flying fast. Some of the lost height can be regained by pulling up into a climb to convert excess airspeed into altitude. Quickly centered in the thermal D continues climbing. When C arrives, later, it will be higher than D was when D arrived, because C flew at the best glide ratio in sink. But by now D may be already well above because it started climbing rapidly while C was still on the way. Gliders A and B of course fall behind C as before.

There is an obvious risk in flying too fast and if D is wrong about the thermal the model might be forced to land. D has to be very sure where the thermal is, if such a risk is to be taken. But if the thermal is found, even if it is weaker than expected, D will be climbing while the others are still losing height.

In full-sized gliding, pilots have various instruments and computing devices in the cockpit which indicate fairly accurately the best airspeeds to fly through sink, and can adjust the trim accordingly. With model flying, such fine judgments cannot be made because the information available to the pilot on the ground is very limited. The principles remain valid, nonetheless.

The rule is, to fly fast through sink to penetrate to the thermal and slow down only when

Figure 6 Making headway against the wind



the model is in lift.

Experience and judgment are all-important here. It is also important for each pilot to watch other gliders, since if one finds a thermal, the others will probably seek to join the climbing model. D, for instance, may race forward and find a thermal, thus 'marking' it for all the others. Then the model which is able to cover the greatest distance through the downcurrent with least loss of height, that is, in this example, C, has an advantage. C can watch D's model while searching a different part of the sky. If D does not find anything, C still will have some height to spare to continue the independent search. But if D does find lift, C will still be high enough to fly in that direction. On average, over a number of competition tasks the pilot who adopts C's technique will do better than those who fly more slowly or faster. C may sometimes be beaten by D if D is good at finding thermals, but if D makes an error C will do better. A and B may occasionally be lucky in finding a thermal without having to search far, but when this does happen C will be in a good position to join them too.

It was assumed above that all four models were identical but if, as a result of aerodynamic improvement, a sailplane can fly fast without a great increase of sinking speed, it will penetrate sinking air better than any of the four models considered in Figure 5. If, for instance, a superior model can fly at D's airspeed and yet have C's glide ratio in sink, it would reach the thermal well in front and higher than any of the others. In a future article, ways of achieving this will be considered.

Thermal soaring gliders frequently need to cover distance against the wind as well as getting through sink. Even an ordinary soaring flight on a club afternoon will find the model drifting downwind in every thermal so that the pilot has to bring it back against the headwind. In a contest, the bonus will be lost if the model cannot reach the landing target, and all points may vanish if the model lands far out. The polar curve helps again (Figure 6).

In the diagram the headwind can be entered on the scale by moving the origin of all the glide ratio lines to the right by an amount equal to the speed of the wind. To emphasize the point it is supposed in this example that the headwind is equal to the airspeed when the glider is trimmed for minimum sink. At this trim the glider will make no distance over the ground at all because its **ground** speed is reduced to zero. It will simply descend vertically, slowly, at its minimum sink rate. Whatever height it may have reached by climbing, it cannot get back to the target at this airspeed.

Trimmed for best L/D, against such a breeze the model will make some distance over the ground. But the best trim against the wind is not the best L/D *...Continued on page 18*

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glide. A faster airspeed is required. The point of origin for the best glide in the headwind situation is shifted to the right, as shown, and the required airspeed is found from this.

If, as well as a headwind, the model on its way home has to get through sinking air, an even faster trim is required. The point of origin for the glide ratio lines moves to the right, to allow for the headwind, and now also upwards on the chart, because of the downcurrent.

The principles discovered in this diagram apply for all wind speeds. In a perfect calm with neither wind nor sink, as mentioned above, the best glide ratio is that found on the simple polar. But flying to reach the landing target, the rule is: fly fast against the wind and faster if there is sink as well. The rate of descent is high but the vital thing in such conditions is to make distance over the ground.

Inexperienced pilots having difficulty reaching the landing target on windy days often try to 'stretch the glide' by trimming slower. The nose of the sailplane rises and a little height may be gained momentarily, since the energy of the excess airspeed enables a small 'pull up' to be made. Settled into the slow trim, the illusion is created that the sailplane is gliding flatter. This is an illusion. The glider makes less progress and may well land out.

Trimming for greater speed causes a brief loss of height as the glider accelerates. Extra airspeed can only be gained by steepening the glide. This too gives a false impression. The model appears to be diving and certainly does come down faster. But more ground distance is covered and, in this situation, the ground speed is more important than the loss of height.

Once again, the importance of a polar curve which shows good glide ratios at high speeds, is clear.

Summing up

The thermal soaring sailplane should have a low stalling speed and small rate of sink in turns, to enable it to climb in weak thermals. It will also need to retain a good glide ratio at high speeds, both to help in searching for thermals through air that may be sinking, and also to get back to the landing target after drifting downwind during a climb. Strong structure will be required for launching fast and high, and powerful air-brakes for landing.

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A Letter to the Readers

Dear Fellow RC Soaring Modelers:

I am writing to you as the AMA appointed RC Soaring Representative to the FAI. I am attempting to create a correspondence list of individuals who are interested in providing input to FAI soaring rule proposals. This input will be considered in formulating a U.S. vote on the proposals.

In addition to F3B, there are four other provisional FAI soaring events:

F3F RC Slope Soaring
F3H RC Soaring Cross Country Racing
F3I RC Aero-Tow Soaring
F3J RC Thermal Duration Gliders

I have not yet received the final version of the proposals for 1990. I do know there will be some for F3B, but I am not sure about the other events.

If you are interested in providing comments on proposals, please send me your name, address, phone number and which event(s) proposals you want to comment on.

I have sent this letter directly to many of you who fly FAI events that I am personally acquainted with. I am especially interested in contacting interested parties whom I do not know. I would appreciate your circulating copies of this letter to friends and club newsletters.

Sincerely, (signed) Terry Edmonds
1 Lakeview Drive
Iowa City, IA 52240

Understanding Thermal Soaring Sailplanes

Part 2 Section 1

on

Weight & Ballast

...by Martin Simons

(This is the third in a series of articles by Martin Simons. The material in this section may refer to information & drawings in part 1. Reproduction of this material requires the permission Martin Simons.)

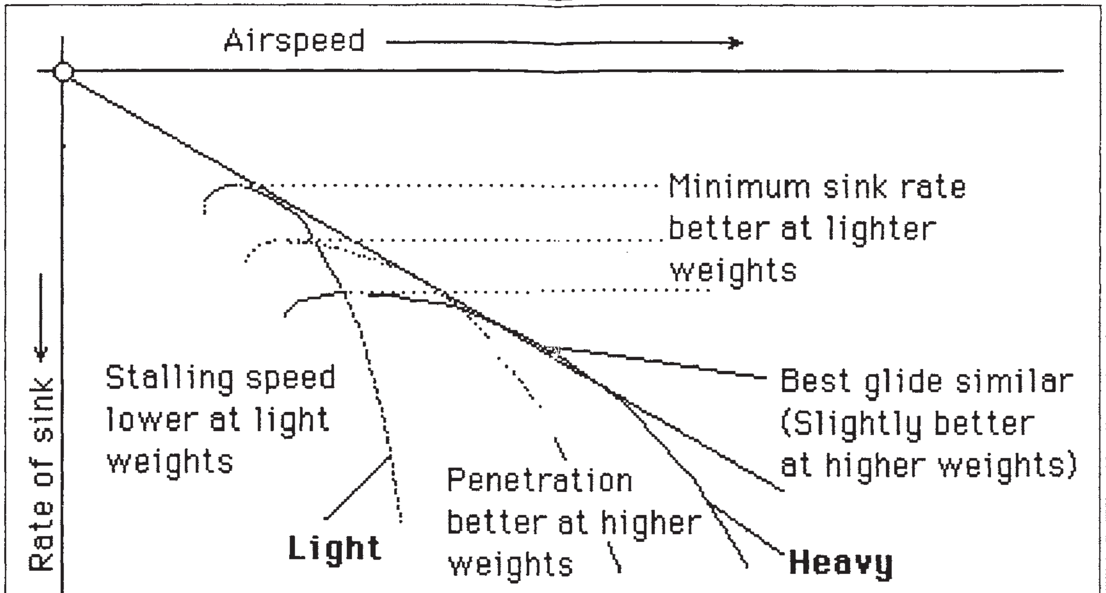

Figure 7 The Effects of adding and removing ballast

In the previous article the importance of penetration combined with the ability to circle with low sinking speed in thermals was emphasized. These requirements are to some extent in conflict.

Weight and ballast

If the weight of the sailplane is reduced, the model will fly more slowly for any given elevator trim position, and its minimum rate of sink will be reduced. The polar curve will take on the appearance shown in Figure 7 on the left. If there are no thermals, or if the only thermals available are extremely feeble and narrow, a very light glider with its low minimum rate of sink and small turning radius may achieve a good duration.

There are few occasions when such a lightweight will actually prove superior in the rough and tumble of contest flying, to somewhat heavier and more robust models. It is certainly not wise to build a sailplane so lightly that it becomes flimsy, especially since the launch must be fast to avoid wasting 'slot' time. Apart from this, there are other disadvantages.

With a very light model the polar curve becomes more 'peaky'. That is, the trim for minimum sink comes closer to the stall, the best L/D speed is closer to that for minimum sink, sometimes so close that the three are almost indistinguishable in practice. More importantly, the right-hand side of the polar curve falls away steeply. Penetration suffers. Taking weight reduction too far can produce a sailplane which will fly efficiently at only one trim: a fraction too slow and it will stall, a little too fast and it dives steeply; aptly termed a 'one speed' sailplane. Trimming a very light sailplane is therefore difficult. (Free flight contest sailplanes are in this situation.) Quite a small error or a disturbance in flight brings the model off its peak and in turbulent air such a model hardly ever does fly at its best rate of sink.

As will be explained later, there are bad 'scale effects' for the very light model, especially if the wing chord (the distance across the wing from leading edge to trailing edge) is small.

A narrow-chord wing flying slowly does badly.

The polar can be made less critical if mass is added, which increases the total weight to be supported by each square metre of wing area, raising the **wing loading.** The additional weight may be used to produce a more practical model, extra material being introduced to strengthen the structure. Alternatively, or as well, penetration can be improved by adding ballast. This option is always open if provision for housing the ballast is made when the model is being built, or by retrospective modifications. On a day with little wind and no thermals, or very feeble ones, the glider may be flown at its minimum weight, that is, at a low wing loading. If the wind strengthens and/or better thermals develop, ballast may be added. The effect on performance is illustrated by the right hand curve in Figure 7. The entire curve with the higher wing loading tends to be flatter. Trimming is therefore less critical, since a small error will move the model only slightly off the highest part of the curve. Still more ballast flattens the curve further.

Adding or removing the ballast ought not to cause changes of trim, so the ballast should be placed as close as possible to the un-ballasted centre of gravity. The structural problems associated with fitting a model to carry ballast will not be discussed, except to say that there are important advantages if the extra mass is carried in the wings as a load distributed spanwise, rather than in boxes in the fuselage or as concentrated lumps of lead in the wing. It is also preferable for ballast to add strength. One convenient and well-proved method is to use very long wing joiner rods of steel which, when in place, form an reinforcement to the main wing spar for a considerable distance inside. Tubes to house the ballast are built into the wing spar itself adding their own strength to it. Different lengths of the joiner/ballast rod allow adjustment of the total weight.

A ballasted model is less easily upset in flight by rough air since the model's greater mass and flight speed will give it more resistance to disturbances. Control response will be changed. The average speed of airflow over the control surfaces will be greater, improving their effectiveness slightly although the additional mass will increase the model's inertial reactions, so response to controls may be slowed. This is particularly noticeable in rolling and turning models with the spanwise distribution of the load, mentioned above, but this effect is usually tolerable. Unfortunately, the heavy model also lands at a greater speed because the stalling speed is higher and, because of the greater momentum on touchdown, there is more risk of damage in a bad landing.

...continued on page 16

Understanding Thermal Soaring Sailplanes ...continued

The minimum rate of sink for the glider with high wing loading is worse, as shown by the flatter top of the polar curve, so the ballasted model will always be less successful in weak lift or in dead calm. In addition the whole polar shifts to the right on the chart, indicating faster airspeeds at each elevator position or trim. Slightly more skill is required from the pilot to manage a faster model.

The best L/D ratio in straight flight remains almost exactly the same, ballasted and un-ballasted, although it occurs at a greater airspeed with the higher weight.[1] Increasing the wing loading raises the whole of the right hand, high speed part of the polar. The heavy model at high flight speeds has a lower sinking speed and so loses less height, than the light model at the same airspeed. That is, penetration is improved.

Turning

At any given angle of bank the radius of the turn, ballasted, will be larger than for the lightly loaded model. Putting this the other way round, to circle tightly and efficiently with a high wing loading requires a steep angle of bank.

A model will fly straight unless there is some lateral force acting to turn it to one side or the other. To compel the wing to provide this lateral turning force it is necessary to bank. If there is no bank, there will be no turn, or at best a very sluggish, inefficient, skidding turn. Trying to turn flat forces the fuselage to yaw, to provide a lateral force which it is not designed to do. Not only is the lateral force small, producing a very slow response, but the fuselage, in a yawed attitude, acts as an airbrake and brings the model down rapidly.

In a turn, the wing must still maintain the upward support which keeps the model in flight, while also providing the additional force which turns the model. This additional lift can be obtained by increasing the wing angle of attack, normally by trimming in some up-elevator. The stalling behavior of the wing becomes especially important because of this. To avoid stalling in a steep turn it is necessary to accept some increase of airspeed. All this increases the rate of sink in turns, the effect being greater as the turn becomes tighter.

Since there is this inevitable loss as the bank angle increases, the rate of sink of the heavy model in a steep turn is considerably worse than the minimum sink rate shown by the straight flight polar. A model with light wing loading can turn on the same radius with less bank, so its rate of sink suffers less in proportion.

The pilot of a thermal soaring, heavily ballasted, model has to choose between a large radius of turn with small bank and only a small deterioration in sinking speed, or a steeper bank, with smaller radius of turn, but with a noticeably worse sinking speed. If the thermals are narrow but have strong centres, the heavy model can still use them by finding the cores and turning in them steeply. If thermals are wide and diffuse but fairly strong, a gentle bank will be sufficient. But a weak thermal which is also narrow presents the heavy model with an impossible task. Circling tightly in the core increases the rate of sink so the model loses height. Turning gently with low rate of sink, finds the model flying round outside the thermal altogether.

Thus, increasing wing loading improves penetration and increases the chances of getting through bad air and finding a thermal, but it reduces the ability to gain height after the thermal is found. Reducing weight to help climbing in the thermal, reduces the chances of reaching a thermal to climb in. This is the fundamental problem facing the model glider flier and, on any particular occasion with a particular model, only experience and judgment can provide a solution as to whether to add ballast or not. The upper limit of 5 kg on mass becomes relevant when ballast is to be carried.

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[1] There is a slight improvement of best glide ratio at the higher loadings because of the scale effect, already mentioned and discussed in more detail below. In practice this is hardly noticeable unless the difference in weight and flying speed are very large.

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CASIO DIGITAL BAROMETER WATCH Model #510

...by Jim Gray

Here's just what we've all been waiting for: An Altitude Reporting Watch!

Bill Kournakakis, Medicine Hat, Alberta phoned me the other night to tell me about the watch he just bought in Florida called a CASIO DIGITAL BAROMETER WATCH Model #510.

Features

Altitude recording to 13,120 feet.

Accurate to +/-.15% (Fifteen hundredths of one per cent).

Reads in 20 foot increments.

Three Alarms

Countdown Timer

Stop Watch

Depth Meter for Divers

Water Resistant to 100 Meters Depth

Calibration set to altitude or zero depending on whether you wish to read absolute altitude above sea level, or altitude above your location.

This watch is very light and probably weighs about the same as a servo. You could put it in your plane (if you don't need it for timing) and get an altitude readout.

The price is $99.95. Another model, with slightly fewer features, is available for $79.95. See your Casio dealer

Understanding Thermal Soaring Sailplanes

Part 2 Section 2

on

The Sources of Drag

...by Martin Simons

(This is the fourth in a series of articles by Martin Simons. The material in this section may refer to information & drawings in part 1. Reproduction of this material requires the permission of Martin Simons.)

Aerodynamic improvements

Ideally, the sailplane pilot would like to have a very light, slow model while in the thermals, and a very heavy, fast one between thermals. Since ballast may not be dropped or picked up during a single flight, improved performance at both high and low speeds has to be sought in other ways.

The purpose of aerodynamic refinement of a sailplane is to achieve better minimum sinking speed, lower stalling speed for circling tightly, and better penetration as well (Figure 8 - See page 16). A refined model can still be ballasted if conditions require it.

The performance of the glider, whether turning or in straight flight, depends on the drag. If drag can be reduced at low speeds, the minimum rate of sink, both in straight flight and in turns, will be less. If drag can be reduced at high speeds, penetration improves.

The sources of drag

Figure 9 shows how the total drag at each flight speed is made up. Every part of the glider over which air flows in flight adds to the drag, but some parts contribute more than others and the proportions change as the speed of flight is varied. The best L/D ratio, i.e., the flattest glide in calm air, occurs when the drag is at its minimum. The minimum rate of sink is found at a slower flight speed.[1]

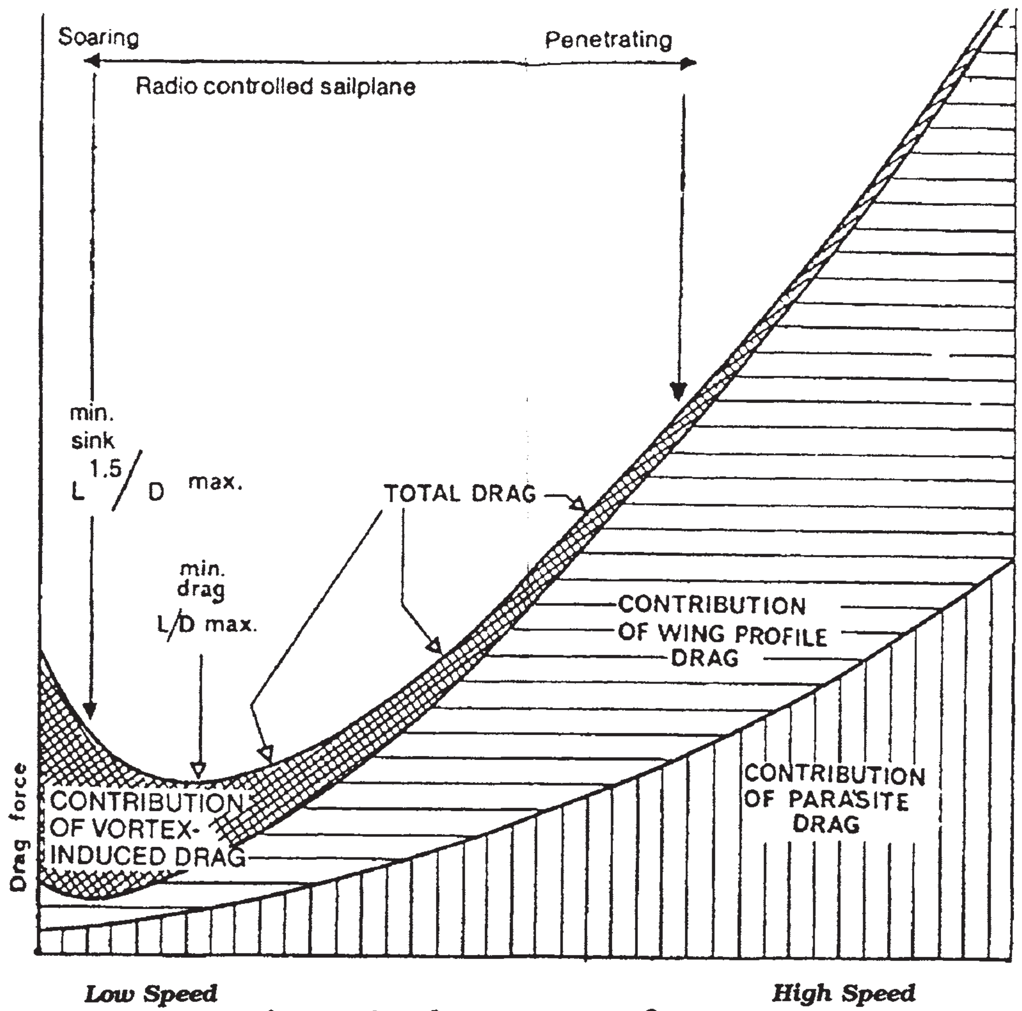

Figure 9 The Sources of Drag

Parasitic drag

Parasitic drag, which is caused by all the non-lifting parts of the glider, fuselage, tail unit, etc., is important at high speeds but less so in slow flight, as the diagram shows. This is one reason why a model which has a good basic wing design fitted to a relatively crude fuselage and tail, will nevertheless be capable of climbing well in thermals although its penetration is poor.

A varying proportion of the parasitic drag is the drag of the stabilizing surfaces, which are really small wings. Everything that follows in the discussion of wings applies equally to these. Depending on the layout and trim of a model, the horizontal stabilizer may or may not contribute a lifting force and this force may be either upwards or downwards. Normally the tailplane of an orthodox aircraft 'lifts' downwards, this being required for purposes of balance and stability. When the stabilizer does contribute such a force, in either direction, it inevitably produces more drag than when it is not lifting. This applies to the forewing of a canard layout, which contributes to the total upward lift but not without a corresponding drag penalty. The drag of the stabilizer for orthodox aircraft layouts is normally counted as entirely parasitic.[2]

Wing drag

As Figure 9 shows, more than half the total drag at all speeds comes from the mainplane or mainplanes. It follows that in trying to achieve a better performance, the wing must be considered first. It is hardly worth bothering about the rest of the model if the wing is poor.

Wing drag is of two kinds, **vortex-induced drag** and **profile drag**. Vortex drag is often referred to simply as induced drag but vortex drag is a better term since it draws attention directly to the cause.

Vortex drag

The vortex drag originates almost entirely with the wing tips. There is, on any wing or part of a wing which is supporting a model (or a lifting stabilizer, etc.), lower air pressure on the upper side than below. Air will always try to flow from high pressure to lower pressure areas and this tendency is most marked where the high and low *...continued on page 16*

Understanding Thermal Soaring Sailplanes ...continued

pressures come close together, at the ends of the lifting surface. The air cannot turn suddenly at right angles, but the flow becomes distorted, slanting somewhat outwards underneath and inwards above. These cross flows are most pronounced near the tips themselves but the influence extends towards the root. The only place where the air flows directly from front to rear on both upper and lower sides, is on the

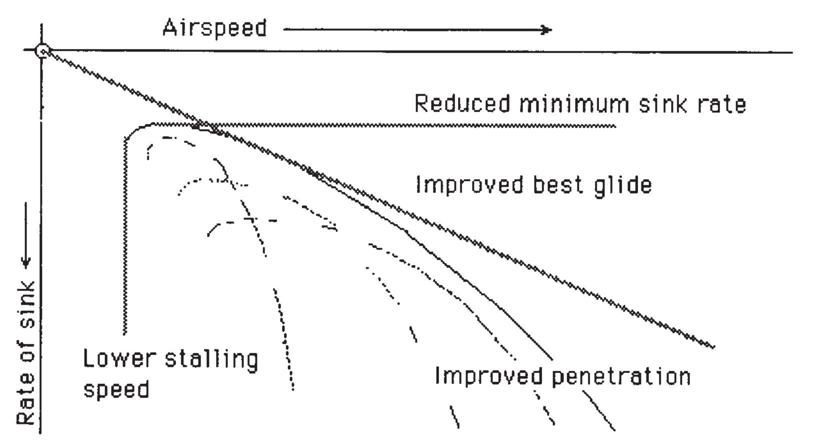

Figure 8 The benefits of improved aerodynamic design

exact centre line of the wing. (Even here it is usually disturbed by the fuselage.) Behind the trailing edge where the upper and lower flows meet, vortices form, the strongest ones nearer to the tip. The numerous small vortices behind the inner parts of the wing are wound into the more powerful ones, rather like a number of tiny twisted threads being spun into a strong yarn, to produce two strong vortices behind and slightly inboard of each tip (Figure 10). These trail off behind the wing for a long distance. The trailing vortices represents loss of energy and this is felt by the glider as extra drag.

When the wing is at high angles of attack, i.e., in slow flight, the vortices are most powerful and the drag so created is greatest. At low angles of attack, i.e., high flight speeds, vortex drag is much reduced although never entirely negligible. Figure 9 shows this clearly.

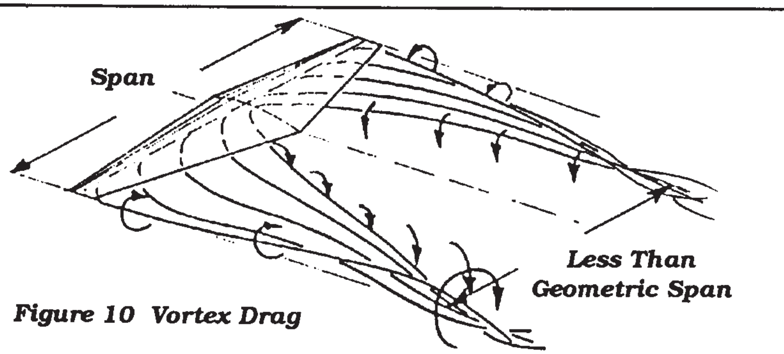

Figure 10 Vortex Drag

Profile drag

Profile drag, as the name implies, depends chiefly on the wing section or profile. Part of the profile drag arises simply because of the resistance of the air to changes of direction and pressure as it flows round the thickness of the profile. This is called pressure drag and arises through the general shape, especially **thickness form** and centre line **camber**, of the profile. The rest of the profile drag arises because of friction of the air in contact with the skin of the wing. This is called skin drag and is affected by the smoothness or roughness of the wing covering and finish. Small bumps and hollows may have a disproportionately large effect on the thin layer of air nearest to the surface, the so-called **boundary layer.**

The skin drag and pressure drag interact with one another so the division between them is for convenience only. In particular, the pressure changes over the wing as the air flows from leading edge towards the trailing edge, have great effects on the character of the boundary layer. The boundary layer responds by changing character and thus exerts an effect on the pressure variations which react again on the boundary layer, and so on.

At the high speed end of the sailplane polar curve, as Figure 9 shows, profile drag is dominant. The wing profile also has important effects on the stalling speed and handling in turns, so a good wing section is important for a sailplane at both fast and slow ends of the speed scale.

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1 The minimum power required to sustain flight is found when the ratio $L^{1.5}/D$ is a maximum. This corresponds to the minimum sinking speed for a glider.

2 Canard, tandem and tailless aircraft require slightly different treatment. Much theoretical and practical work has been done on tailless, canard and three-surface types of aircraft, with some very successful results. Contrary to some enthusiastic claims, however, it has never, so far, actually been established that these layouts have any advantage, for sailplanes, over the orthodox types. For a typical, recent research report, see the Journal of Aircraft, Vol 26, No 8, August 1989, Pages 699 - 704.

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What Do You Mean ...continued

cut the bulkheads a little narrower to make it cleaner looking, have lower drag, and still make the radio fit.

Many of the new multi-channel sailplanes require mounting servos in the wings. In my FALCON 880, I originally used Airtronics 94401 micro servos for my flaps, but they kept stripping gears when landing in the grass. I didn't want to spend about $50 each for all metal gear servos, so I experimented with some Airtronics 94631 servos which cost around $12 at Sheldon's. These are Airtronics' old "standard" servos which have strong gears and 50 oz. of torque. With some easy modifications, I made them fit in my FALCON wing.

First, I cut off the mounting lugs. Then, I took a belt sander to the case and sanded the sides down, tapering towards the trailing edge, until I was sanding into the threads of the screws that hold the servo together. I removed the screw that was towards the TE upper surface and sanded some more until they fit flush, and then "glued" them in with silicone rubber. You could do the same with any manufacturer's larger servo.

Understanding Thermal Soaring Sailplanes

...Cutting Vortex Drag

...by Martin Simons

To reduce the vortex drag of a wing of a given area, what is chiefly required is a **large span**, and accordingly, a **narrow chord**, that is, a **high aspect ratio**. The aspect ratio of any wing may be found by dividing the span by the average or mean chord. **Doubling the aspect ratio cuts vortex drag in half**. The high aspect ratio not only reduces the absolute strength of the tip vortices but moves them further apart, so greatly weakening their influence on the central parts of the wing.

A further saving of vortex drag, perhaps as much as 5 or 6 percent, can be achieved by using a carefully worked out tapered planform. The best planform from the vortex drag point of view has an elliptical distribution of chord. That is, the chord at each point along the span is the same as would be the chord of a perfectly elliptical shape. It is not necessary for the wing to be an actual ellipse providing the chords conform as closely as possible to these proportions. In practice, a moderately tapered wing that approximates to the ideal shape is almost as good.

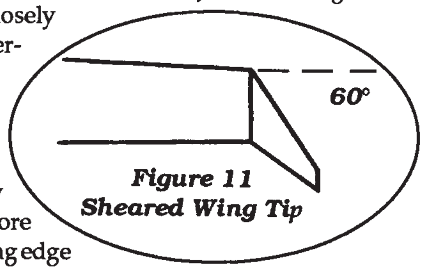

Figure 11
Sheared Wing Tip

Some slight further advantage may be gained by using a planform with a straight trailing edge. There is some evidence that a wing which is slightly crescent shaped, that is, swept back progressively more towards the tips with the taper confined to the leading edge and a raked or 'sheared' outermost end (Figure 11), produces less vortex drag than one which carries taper on both leading and trailing edges. However, such a planform carries certain disadvantages too. Swept back wings are more prone to tip stalling, than straight forms. The chances of flutter are also greater. All wings bend up and down in flight as they meet varying loads, gusts, changes of trim, etc. This is not harmful providing the bending does not actually overstress the structure. With sweep back, especially if the angle of sweep increases outwards, any bending also changes the angle of attack of the outer panels. This can produce a force in phase with the natural torsional resonating frequency of the wing, so that what begins as a normal bending initiates a violent twisting and bending oscillation. (This has in fact been a serious problem for several types of full-sized tailless sailplanes with sweepback.) Experiments in this direction should be carried out with some caution.

Further small gains might be achieved by using special devices such as winglets and wing tip sails, although the value of these for model and full-sized sailplanes has not been proved. To ensure that the winglets do not create more drag than they save, careful design is required. When these devices are used in full-sized aviation they are usually tested in the wind tunnel or experimentally in flight before being finalized. This is not normally practicable for the model flier. When correctly placed they do reduce the vortex drag for a given wing span, but the same gains can be always achieved by extending the wing span slightly and so increasing the aspect ratio. Winglets and tip sails could be of benefit when competition rules place a firm upper limit on wing span. Then a vertical winglet may reduce vortex drag without infringing the rules. In the existing F3J rules, however, there is no span limitation so winglets are probably not useful. Some recent theoretical and wind tunnel research also suggests that a sharply raked or sheared tip, fitted to an ordinary straight wing, saves some vortex drag (Figure 11). It is certainly worth experimenting with such tip shapes since they can be altered on a 'cut and try' basis without much effort.

The benefits, if any, of special tips, winglets, and other vortex drag saving devices, are greatest when the wing concerned is of low aspect ratio. In such a case, the vortex drag is very large and saving a few percent of this does represent a considerable benefit to the total drag of the aircraft. On a typical sailplane, however, the usual high aspect ratio has already cut the vortex drag to a relatively low figure. By using special tips there should be a further saving but this will not represent the same proportion of the total aircraft drag and may not be noticeable in practice. Nonetheless, there is nothing to be lost by trying to save even a small amount of drag in these ways.

Thus, saving vortex drag mainly involves changes to the wing in plan view, especially increasing the aspect ratio and tapering, with some possible further gains from keeping the trailing edge straight and special wing tips. The aspect ratio is by far the most important of these, wise choice of taper is next in importance, and the other devices are somewhat problematic.

Scale effects and model size

Cutting profile drag requires attention to the wing section, but this cannot be considered in isolation.

For all aircraft, and particularly models, there is a complicated interaction between wing section, wing chord and speed of flight which is usually termed the **scale effect**. In very general terms, a wing with small chord moving through the air at low speed, will always be less efficient than a larger one moving faster. Hence, reducing vortex drag by using a high aspect ratio invariably increases profile drag because it reduces the wing chord. What might be gained on the vortex drag swings, may be lost on the profile drag roundabout.

The scale effect is normally expressed in terms of the Reynolds number. The Re number may be worked out by simple arithmetic. If the speed of flight is known and the chord of the wing is measured, the Re number (under standard atmospheric conditions at sea level) is found by multiplying the speed, in metres per second (V), by the chord in metres (L), and multiplying the result by 68459. Thus for a model flying at 12 m/sec with a wing chord of 0.25 metres (25 cm) the Re number becomes:

$$V \times L \times 68459$$

that is:

$$12 \times .25 \times 68459$$
$$= 3 \times 68459$$
$$= 205377$$

The crucial factors are the chord and the airspeed. [1]

The scale effect is more noticeable on models than full-sized aircraft since the wings operate in a range where quite small changes of Re can produce large variations of profile drag, particularly at the low speed, small chord end of the scale. The smaller the Re, the more serious this becomes. It is also to be remembered that tapering a wing to save vortex drag by approaching the elliptical chord distribution, inevitably means the Re number at the tips is reduced and with small models this can be serious enough to cause the tips to stall prematurely. At very low Re numbers, the airflow tends to separate altogether from the wing, so a planform that might otherwise be very good, may, if used on a small, slow flying model, prove quite unsatisfactory. If the wing has a rectangular planform, with chord everywhere the same, the Re number for the whole wing is the same as the local Re at each position. But if the wing is tapered, the Re at the tips will be smaller than at the roots. The important factor here is the taper ratio of the wing. If the root chord is twice the tip chord, a taper ratio of 1 : 0.5, the Re number at the root will be twice that at the tip. If the taper ratio is 1 to 0.25, that is, if the root dimension is four times the tip ...continued on page 12

Understanding Thermal Soaring Sailplanes ...continued

chord, the tip Re will be a quarter of the root, and so on.

It also follows from the above that the scale effect is different at different flight speeds. The faster the model flies, the higher the Re, and the more efficient the wing becomes. A radio controlled model sailplane with tapered wings is therefore quite likely to experience a range of different Reynolds numbers from around 50,000 for the wing tips at low speed, up to about 400,000 for the roots at high speed. (These figures compare with Re upwards of a million for full-sized powered light aeroplanes.)

It is a good general rule that the larger a model is, the more efficient it will be, all other things being equal. This is certainly true for sailplanes.

The large sailplane

To illustrate the kind of improvements in performance that result simply from increased size, example polars have been calculated using a computer program (written some years ago by the author), which relies on wind tunnel test results for the wing profiles concerned and makes proper allowances for planform and taper, Reynolds number variations at different points spanwise and different airspeeds. No allowance whatever has been made at present for parasitic drag. The results are therefore not to be taken as representing any real sailplane, but only as a comparison of a large wing with a smaller one which is otherwise identical. The parasitic drag caused by stabilizing surfaces does depend to a small extent on the profile or section of the mainplane. Wings with larger camber tend to increase the loads to be carried, for balance, by the tailplane and as mentioned above, if the tailplane carries some load, it creates more drag. However, this does not normally make a large difference and can, to some extent, be offset by careful arrangement of rigging angles and trimming. It may be assumed, as a general rule, that the sailplane with the best wing will be the best sailplane, if other proportions are approximately equal.

The largest total projected surface area allowed by the F3J rules is 150 sq dm or 1.5 sq metres. An allowance of 10% has been made for the stabilizer, so the wing area used in these calculations is 1.35 sq metres. A wing span of 4.5 metres then gives an aspect ratio of 15. Tip chord of the example wing is 17.5 cm. and root chord 35 cm., a taper ratio of 0.5. It is assumed that the wing loading is 3.0 kg/sq m,. This gives an all up mass of 4.05 kg., well within the 5 kg limit. Dimensions for Wing 1 are given in Figure 12. A small wing, Wing 0, for comparison is exactly half this size. The aspect ratio is still 15, so the area of Wing 0 is 0.3375 sq m. To give the same wing loading, 3 kg/sq m, the mass is 1.0125 kg. (The Imperial dimensions are: Large wing, 14.76 ft span, 2092 sq ins area, weight 8.93 lbs, wing loading 9.8 oz/sq ft. Small wing, 7.38 ft, 522 sq ins 2.23 lbs., same wing loading)

Table 1
Performance Polar for
Wing Number 0
Clark - Y - PT
Wing Loading = 2.99 kg/sq. m.
Span = 2.25 metres, Aspect Ratio = 15
Root Chord = 17.50 cm.
Mid Chord = 16.50 cm., Taper Ratio = 0.50

Velocity Metres/Sec	Sink M/Sec	L/D Ratio
21.89	2.833	7.73
15.48	1.295	11.95
12.64	0.791	15.98
10.94	0.646	16.95
9.79	0.521	18.77
8.94	0.448	19.96
8.27	0.401	20.61
7.74	0.373*	20.77*
7.30	0.927	7.87
6.92	0.834	8.29
6.60	0.751	8.79
6.32	0.685	9.23

Table 2
Performance Polar for
Wing Number 1
Clark - Y - PT
Wing Loading = 3.00 kg./sq. m.
Span = 4.50 metres, Aspect Ratio = 15
Root Chord = 35.00 cm.
Mid Chord = 33.00 cm., Taper Ratio = 0.50

Velocity Metres/Sec	Sink M/Sec	L/D Ratio
21.92	2.301	9.53
15.50	0.891	17.39
12.65	0.543	23.31
10.96	0.395	27.71
9.80	0.333	29.41*
8.95	0.311	28.79
8.28	0.293	28.25
7.75	0.282	27.48
7.31	0.278*	26.30
6.93	0.815	8.50
6.61	0.734	9.00
6.33	0.670	9.44

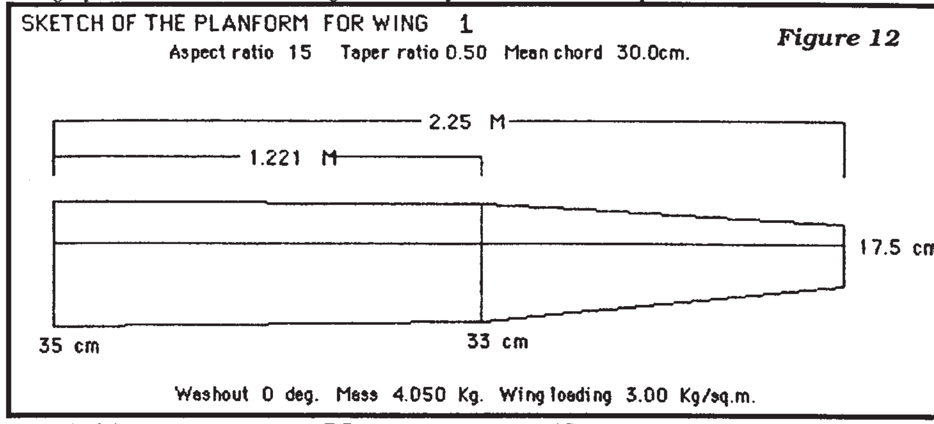

Figure 12

The well known Clark Y wing section is used to begin with. This does not imply that the Clark Y would be the best possible choice of aerofoil for any model although, as will appear in further discussion, the Clark Y, despite its great age (designed in 1920), remains quite hard to beat at least for the slower parts of the sailplane polar curve.

Wind tunnel results on the Clark Y-PT from the Princeton research results by Michael Selig, John Donovan and David Fraser, published in **Soartech 8,** *...continued on page 23*

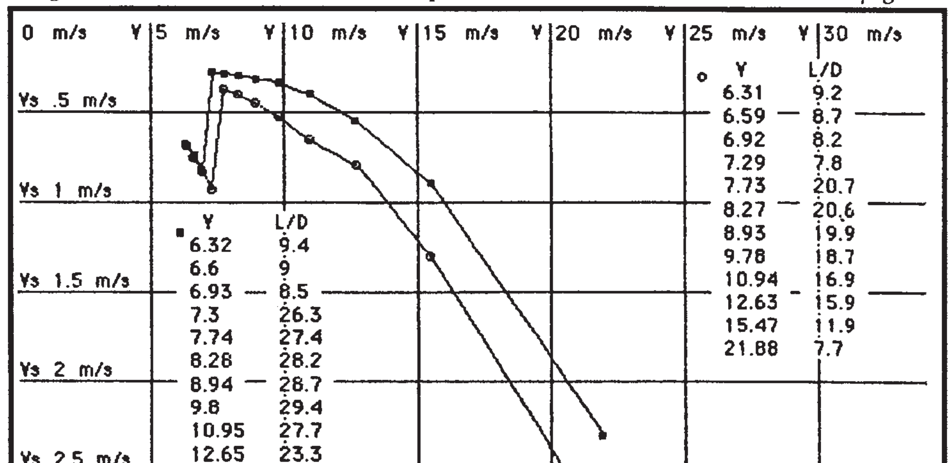

Figure 13 oB = 2.25m A.R. = 15 M = 1.01 k(W/S = 2.9 kg/sq.m.
"B = 4.50m A.R. = 15 M = 4.05 k(W/S = 3 kg/sq.m.

Understanding Thermal Soaring Sailplanes ...continued

wing loadings, since the 5 kg mass limit applies. The wing loading used in the above calculations, 3.0 kg/sq m., is quite low, but the model weighs over 4 kg. Adding ballast to bring this total to 5 kg increases the wing loading to 3.7 kg/sq m (12.1 oz/sq ft.) This is still quite moderate. Successful model thermal soarers have been flown with higher loadings than this.

Despite these problems, the performance advantages are such that thermal soaring sailplanes for major international and national contests will almost certainly be built up to the largest sizes permitted under the rules.

Further improvements

Given two sailplanes of maximum total surface area (1.5 sq m) and similar weight, the one which has less drag will still perform better than the other. Further work has to be done to establish the best compromise between the 'swings and roundabouts' of vortex and profile drag, and the choice of wing profile also has to be considered.

♣ ♣ ♣

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[1] If British Imperial units are still used, the Re is found from V [ft/sec] x L [ft] x 6360.

Looking for Others in the Area

Dear Readers,
We received the following request from the New Hampshire/Maine area:

"Do you know of any active R/C sailplane types in the White Mountain area or nearby in western or southwestern Maine? We are just starting an R/C club here in the Conway area, but I'm afraid there aren't many glider guiders in the crowd. Most of the members are power types, and my main interests are soaring and electrics. As usual, I may be the odd-man out. Anyway, if you know of any active sailplane pilots or clubs in the area, I'd appreciate the info."

(signed), Jack Russell, P.O. Box 369, Madison, New Hampshire 03849

Response: Is anyone in Jack's area? Jerry

Understanding Thermal Soaring Sailplanes

Aspect ratio effects

...by Martin Simons

Once again, computed comparisons show how development might proceed. In Figure 14 a wing design of maximum allowed area with a span of 5 metres, is sketched. This wing has the same section, Clark Y-PT, as the 4.5 metre wing whose polar appeared earlier in Figure 13. A similar type of taper has been used for both. The wing loading, 3 kg/sq m, is assumed to be the same. (This might not be easy to achieve in practice, but the assumption is made for comparative purposes.) The crucial difference between the two wings is the aspect ratio, 15 in one case, 18.5 in the other. The high aspect ratio wing aims to reduce vortex drag, even though this costs some additional profile drag owing to the low Re of the narrow chords. The lower aspect ratio wing tends the other way, vortex drag will be greater but profile drag is saved. The resulting polars are compared in Figure 15, the open circles representing the 5 metre wing, the solid dots showing the 4.5 metre wing. The tabulated figures (Tables 1 & 3) give the L/D ratios and sink rates at each flight speed for the two wings. (The actual values would be worse because of the drag of tail and fuselage, but the comparison remains valid.)

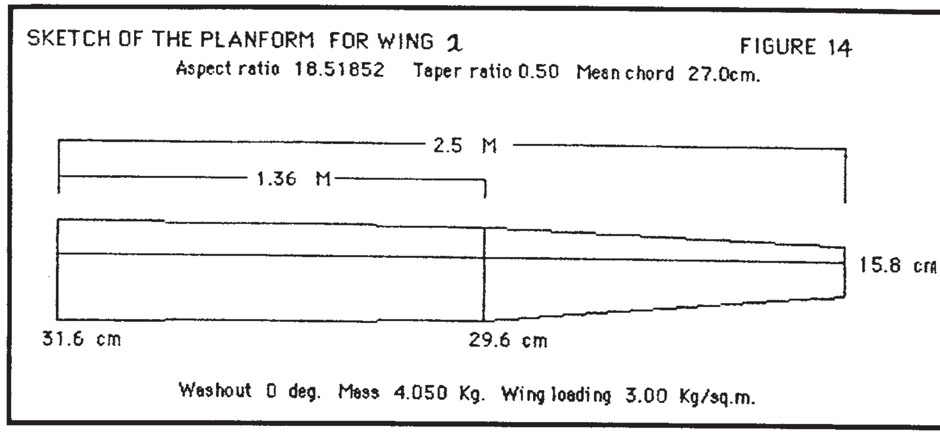
There is not very much difference in the polars for these two wings and if they were used on two otherwise similar models, any difference in flight would hardly be detectable. They stall at the same airspeed. The 5 metre wing would have a better low speed performance; the computer gives minimum sink rate of 0.257 m/s for this wing against 0.278 m/s for the shorter span. Assuming, which is reasonable, that adding the drag of fuselage and tail would not greatly change the **difference** in performance, theoretically, the model with high aspect ratio wing, perfectly trimmed and flying in the same air, would be 1.26 metres higher than the 4.5 metre wing after one minute or, after ten minutes, 12.6 metres (41 ft). This could conceivably show up in a contest between equally skilful pilots. The best L/D ratios of the two wings are very *...continued on page 16*

Table 3
Performance Polar for
Wing Number 2
Clark - Y - PT,
Wing Loading = 3.00 kg./sq. m.
Span = 5.00 metres,
Aspect Ratio = 18.51852
Root Chord = 31.60 cm.
Mid Chord = 29.60 cm.,
Taper Ratio = 0.50

Velocity Metres/Sec	Sink M/Sec	L/D Ratio
21.92	2.347	9.34
15.50	0.887	17.47
12.65	0.547	23.15
10.96	0.400	27.41
9.80	0.331	29.63
8.95	0.298	30.00 *
8.28	0.282	29.38
7.75	0.264	29.30
7.31	0.257 *	28.38
6.93	0.788	8.79
6.61	0.705	9.37
6.33	0.640	9.89

Table 4
Performance Polar for
Wing Number 3
Clark - Y - PT,
Wing Loading = 3.00 kg./sq. m.
Span =6.00 metres,
Aspect Ratio = 26.66667
Root Chord = 27.00 cm.
Mid Chord = 24.20 cm.,
Taper Ratio = 0.50

Velocity Metres/Sec	Sink M/Sec	L/D Ratio
21.92	2.435	9.00
15.50	0.910	17.02
12.65	0.567	22.31
10.96	0.431	25.44
9.80	0.342	28.63
8.95	0.302	29.66
8.28	0.274	30.21
7.75	0.249 *	31.09 *
7.31	0.348	21.01
6.93	0.753	9.21
6.61	0.668	9.90
6.33	0.600	10.54



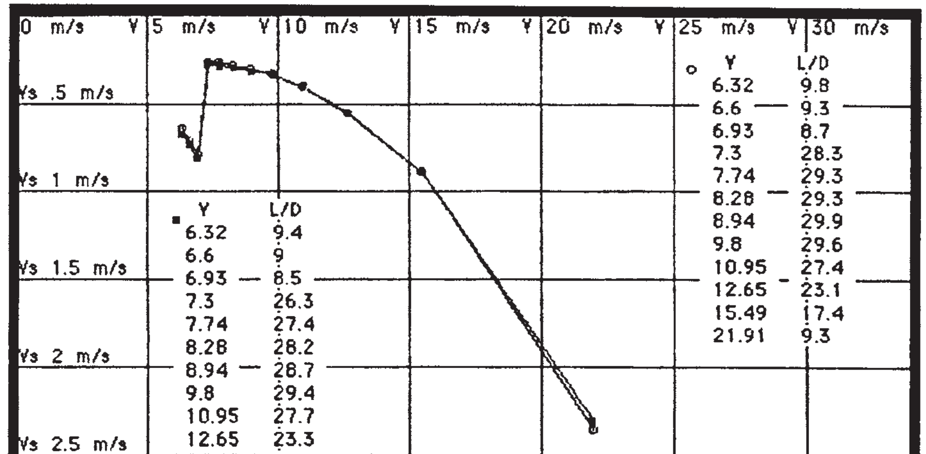
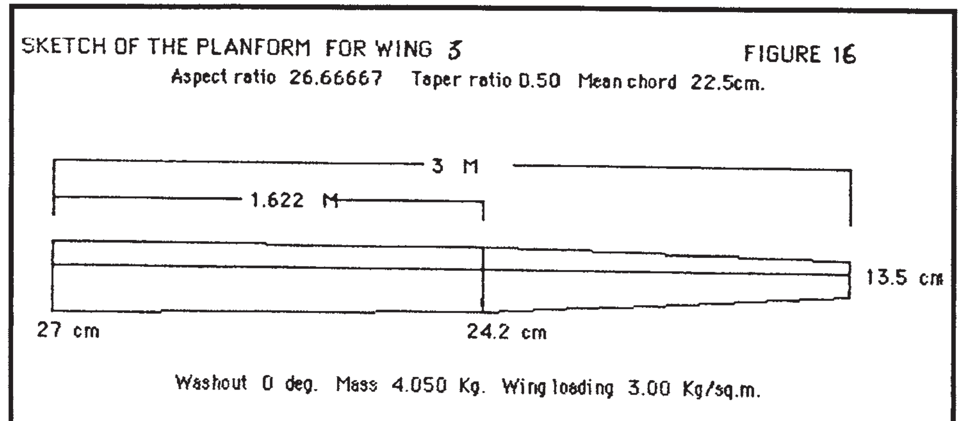


Figure 15 oB = 5.00m A.R. = 18.5M = 4.05 kgW/S = 3 kg/sq.m.
▪B = 4.50m A.R. = 15 M = 4.05 kgW/S = 3 kg/sq.m.



Understanding Thermal Soaring Sailplanes ...continued

close, 29.4 and 30.0. At the high speed end of the scale, the lower aspect ratio wing has a very small advantage showing up at flight speeds above 15 m/sec, but not enough to matter. (15 m/s = 54 km/h = 33.6 mph.) The implication is that for this model, the swings/roundabouts equation is nearly in balance. The saving of vortex drag achieved by the higher aspect ratio is just about offset by the increased profile drag due to the lower Re numbers.

In Table 4 figures are shown for a 6 metre span wing of aspect ratio 26.66, the geometry shown in Figure 16. To build a model with this aspect ratio at this weight might be an impractical proposition but the theoretical comparison is interesting. There is a further improvement in minimum rate of sink, the best L/D improves by about one point, but the 4.5 metre wing does slightly better at high speeds. The polar curves appear in Figure 17.

Moving in the other direction, towards smaller spans and lower aspect ratios, the original 4.5 metre wing is compared in Figure 18 and 19 and Table 5 with one of 4 metres span, aspect ratio just under 12. There is virtually no difference between the two at high speeds. The 4.5 metre wing does better at low speeds, the advantage amounting, theoretically, to 17.4 metres (58 ft) difference after ten minutes in the same air. The 4.5 metre wing also has a better maximum L/D ratio. It seems that here the losses of vortex drag caused by reducing the aspect ratio, are beginning to outweigh, though only very slightly, the savings of profile drag due to higher Re numbers.

Continuing to an even lower aspect ratio, Figures 20 and 21 together with Table 6 compare the polar of the 4.5 metre wing with one of 3 metres span and aspect ratio only 6.67. This speaks for itself. The low aspect ratio wing is considerably worse at all airspeeds less than 15 m/s, and flown at minimum sink would be 81 m (266 ft) below the 4.5 metre wing after ten minutes. Vortex drag has increased considerably. This would undoubtedly be noticeable in competitions. The very slight advantage at high speeds would not compensate for this relatively poor soaring ability.

Table 5
Performance Polar for
Wing Number 4
Clark - Y - PT,
Wing Loading = 3.00 kg./sq. m.
Span = 4.00 metres,
Aspect Ratio = 11.85185
Root Chord = 39.80 cm.
Mid Chord = 36.80 cm.,
Taper Ratio = 0.50

Velocity Metres/Sec	**Sink M/Sec**	**L/D Ratio**
21.92	2.253	9.73
15.50	0.883	17.56
12.65	0.530	23.86
10.96	0.401	27.31
9.80	0.350	28.04 *
8.95	0.327	27.34
8.28	0.315	26.27
7.75	0.311	24.91
7.31	0.307 *	23.77
6.93	0.825	8.40
6.61	0.750	8.81
6.33	0.712	8.88

Three metres, or just under ten feet span, is a very popular size for a model sailplane. Usually, however, such models are not built with large wing areas, so have aspect ratios around 12 to 15. To make a final point in this section, Figure 22 with Table 7 compares the polar of the 3 metre span model of Aspect ratio 6.7, from Figure 21, with a much more 'ordinary' 3 metre model with the same wing loading and aspect ratio twice as much. The remarks above about the importance of using the largest permitted wing, should be considered again in the light of this result. The three metre sailplane is better at low speeds than the low aspect ratio, large area type of similar span, but is inferior at higher speeds. Evidently, the recommendation, to build large models, does not mean simply increasing the wing area while keeping the span down to more or less standard limits. The aspect ratio, and hence the wing span, must increase in proportion. ...continued on page 18

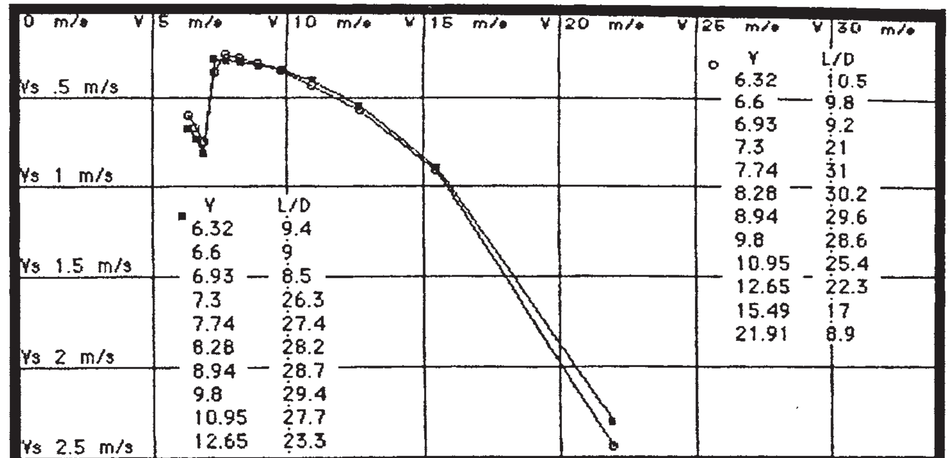
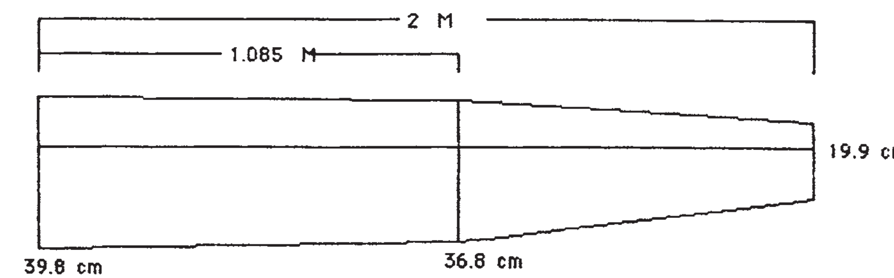


Figure 17 ∘B = 6.00m A.R. = 26.6M = 4.05 k!W/S = 3 kg/sq.m.
▪B = 4.50m A.R. = 15 M = 4.05 k!W/S = 3 kg/sq.m.

SKETCH OF THE PLANFORM FOR WING 4 FIGURE 18
Aspect ratio 11.85185 Taper ratio 0.50 Mean chord 33.8cm.



Washout 0 deg. Mass 4.050 Kg. Wing loading 3.00 Kg/sq.m.

Understanding Thermal Soaring Sailplanes ...continued

At all flight speeds, as comparison of Table 2 and Table 7 show, the 3 metre, aspect ratio 12.7 wing is significantly poorer than the 4.5 metres, A = 15 wing. The three metre model flown at minimum sink, would be 28 metres (91 ft) lower after ten minutes, and also would be inferior in penetration.

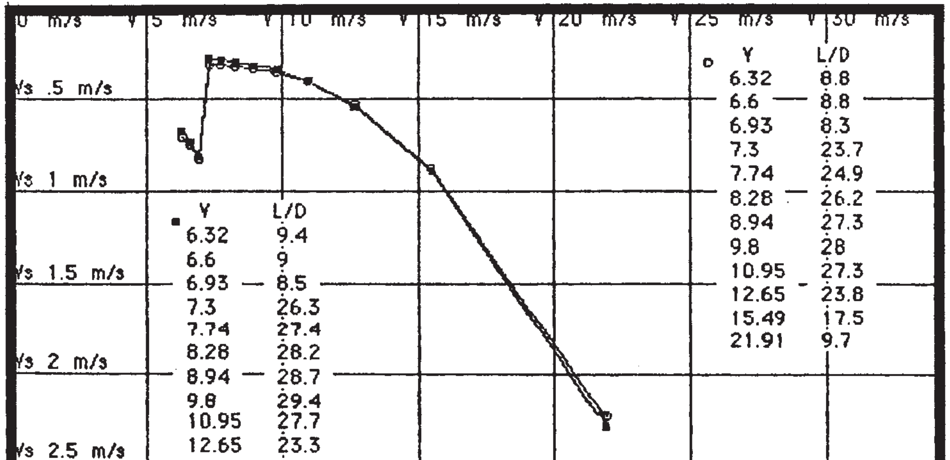


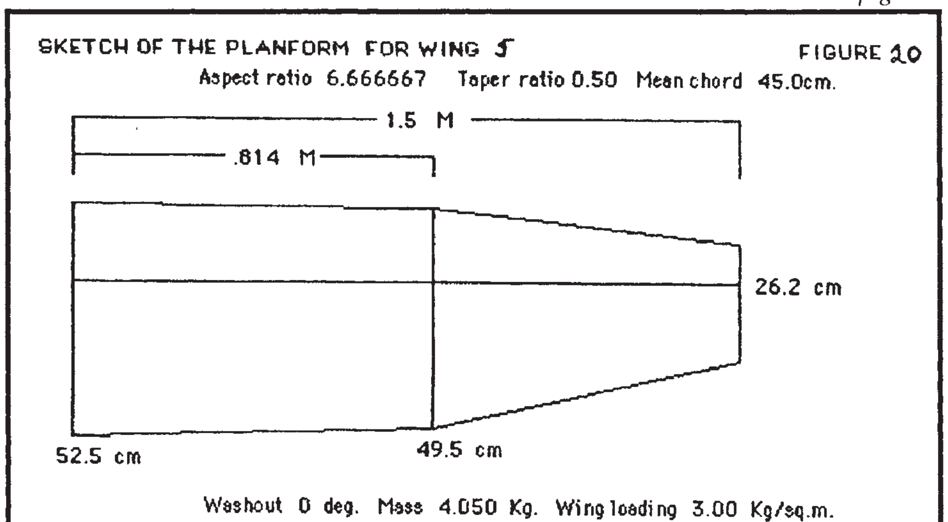
Figure 19 oB = 4.00m A.R. = 11.8M = 4.05 k W/S = 3 kg/sq.m.

▪B = 4.50m A.R. = 15 M = 4.05 k W/S = 3 kg/sq.m.

Summarizing

Generalizing from these results, a model for this type of soaring should be built with a wing span not less than 4 metres. To gain a little climbing ability, at some slight cost in

...continued on page 20



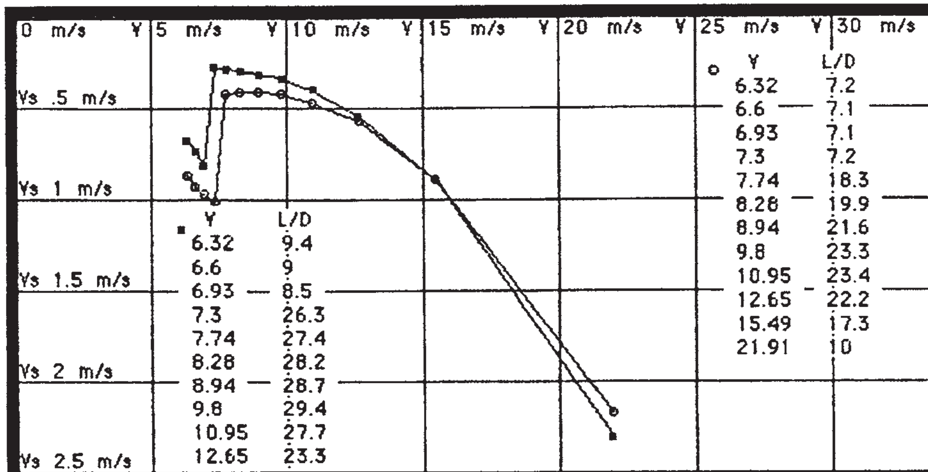


Figure 21 oB = 3.00m A.R. = 6.66M = 4.05 k W/S = 3 kg/sq.m.

▪B = 4.50m A.R. = 15 M = 4.05 k W/S = 3 kg/sq.m.

Table 6
Performance Polar for
Wing Number 5
Clark - Y - PT,
Wing Loading = 3.00 kg./sq. m.
Span = 3.00 metres,
Aspect Ratio = 6.666667
Root Chord = 52.50 cm.
Mid Chord = 49.50 cm.,
Taper Ratio = 0.50

Velocity Metres/Sec	Sink M/Sec	L/D Ratio
21.92	2.173	10.09
15.50	0.895	17.32
12.65	0.568	22.26
10.96	0.467	23.45 *
9.80	0.421	23.31
8.95	0.413 *	21.65
8.28	0.415	19.97
7.75	0.423	18.31
7.31	1.009	7.24
6.93	0.969	7.15
6.61	0.926	7.14
6.33	0.871	7.27

Thermal Flying Wing Contest University of California at Dominguez Hills

(Soaring Union of Los Angles — SULA Field)
June 16, 1990
Three Flights to Make 15 Minutes
Current AMA License & Identification on Plane is Required
Entry is $5.00
Plane can have no separate horizontal tail.
Only other plane limitations are standard FAI rules.
Ability to launch from 12 volt winch with retriever.
CD: Dave Jones (213) 316-3814
Evenings

Understanding Thermal Soaring Sailplanes ...continued

penetration, a span up to 6 metres might be used but in practice anything between 4 and 5 metres would be satisfactory. Any sailplane within these span limits, with the largest permitted wing area, would be competitive, the large spans being slightly better in weak thermals, the smaller spans being easier to handle in rough air and marginally better at high speeds. The 4.5 metre (14.76ft) span, aspect ratio 15 wing seems a very fair compromise.

Martin Simons
13 Loch Street
Stepney
South Australia 5069

Table 7
Performance Polar for
Wing Number 6
Clark - Y - PT,
Wing Loading = 3.00 kg./sq. m.
Span = 3.00 metres,
Aspect Ratio = 13.33333
Root Chord = 26.25 cm.
Mid Chord = 24.75 cm.,
Taper Ratio = 0.50

Velocity Metres/Sec	Sink M/Sec	L/D Ratio
21.92	2.456	8.92
15.50	0.944	16.41
12.65	0.660	19.17
10.96	0.486	22.55
9.80	0.409	23.99
8.95	0.369	24.28
8.28	0.340	24.36 *
7.75	0.325 *	23.82
7.31	0.360	20.30
6.93	0.837	8.28
6.61	0.756	8.74
6.33	0.705	8.98

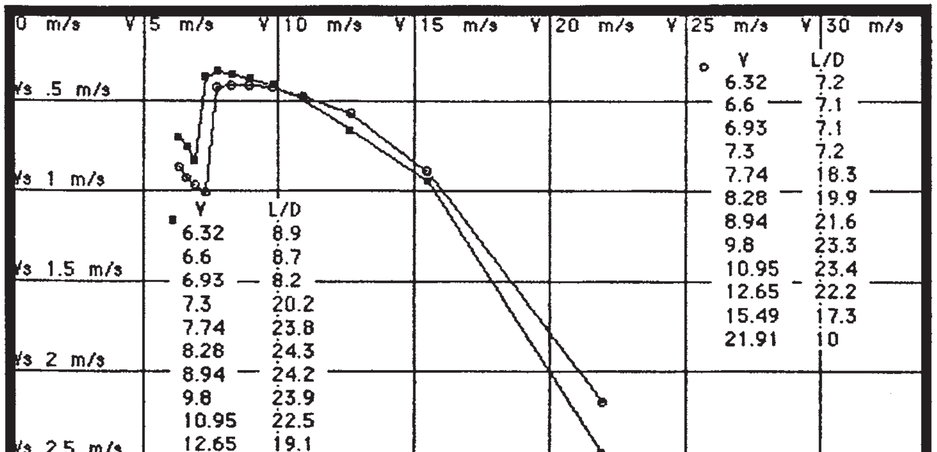


Figure 22 ∘B = 3.00m A.R. = 6.66M = 4.05 k|W/S = 3 kg/sq.m.

▪B = 3.00m A.R. = 13.3M = 2.02 k|W/S = 3 kg/sq.m.

The DIGEST'S MAIL

On the Subject of SMTS

Dear Jerry,

The SASS officers are still considering sponsoring an SMTS "non-competition" (practice) this summer to enable interested parties to get familiar with the speed and distance events so the club can decide whether or not to include them in the 1991 contests.

On the subject of SMTS, I'll put in my two-bits worth. I selfishly want to see the 75 ounce weight restriction go away to be replaced by the 12 ounce/s.f. wing loading limit. The reason this is selfish is that my Lovesong weighs (don't laugh — the extra weight is due to several repairs) 79 ounces. Also, I think locking out pilots just because they fly larger ships is inappropriate, although I have to admit a Lovesong can be built under the 75 ounce limit. The cost and time-to-build differential between, say, a 76 ounce Lovesong and the lighter Falcon 880 or Camano is really insignificant, though. Whether the Lovesong, because of its higher aspect ratio wing, has an unfair performance advantage over the smaller ships is a matter for debate. Maybe our practice session will shake out an answer — except nobody around here is flying an 880. SASS, at least, will be using the wing loading limit rather than the absolute weight limit if we sponsor any SMTS events. After all, this is Lovesong country (and they fly better heavier: higher Reynolds Number).

Sincerely, (signed) Waid Reynolds, Seattle Area Soaring Society (sec./treas./ed.), 12448 - 83rd Ave. S., Seattle, WA 98178

<u>Response</u>: **Thanks for the input Waid. I have a few planes in this condition myself, and I can certainly understand your point of view. Your letter reminded me that now is probably a good time to to tell the readers about the F3B/U.S.A. newsletter. Byron Blakeslee, in the latest issue of *Model Aviation*, says:**

"F3B/U.S.A. is the special newsletter for fans of F3B and Sportsman Multi-Task flying. The objective of F3B/U.S.A. is to print the latest news and information F3B and SMT fliers need to keep up with this fast-moving portion of the sport. Subscriptions were formerly handled out of an Irvine, CA P.O. Box, but since the first of the year editor Randy Reynolds has taken over responsibility for the subscription list. Subscriptions are $12 per year for six issues. Please send your check to Randy Reynolds, 122 E. Uintah St., Colorado Springs CO 80903 (Tel. 719-471-3160). If you sent a check to Irvine and haven't received a newsletter, please check with Randy to see if your name somehow missed getting on the list." Jerry

♣ ♣ ♣

Dear Jim,

S-MTS last year...We, at SOAR, flew MTS with some changes. We put a cap of 30 seconds on speed, 12 laps 4 minutes for distance, and 6 minute duration with FAI landing tape. There was no relaunch and no working time. It worked very well, as both the top guns and the sportsmen flew together. With the cap on speed and distance, there is no need for a 75 oz. or 12 oz. / sq. ft. restriction. the speed was set to the 1984 qualification plus 3 seconds. The distance task was 6 laps for the first round. If you did not make 6 laps, it stayed at 6. If you made 6 laps or more, it went to 8 laps in the next round. Then, it went to 12 laps in the 3rd round.

In 1984, I flew in the finals in California. I was flying a 107 inch SAGITTA flat wing with ailerons and spoilers. This airplane is a very good MTS airplane, BUT it weighs 80 oz. (too bad). Also, if you figure the wing loading, it comes out to be 12.67 oz./ sq. ft. (too bad, again).

Forget the restrictions on the airplane! Design the task to fit what real people are flying.

At our contest, we had COMETS, KINGS, SAGITTA, ANTARIES, and several FF originals. Everyone... *continued on page 22*

Understanding Thermal Soaring Sailplanes
Part 3

...by Martin Simons

The earlier articles in this series dealt in general terms with the glide polar, the effects of adding or removing ballast, and the influence on performance of model size and wing aspect ratio. The importance of high speed performance, or 'penetration' was stressed. It was indicated that for success in thermal soaring, model sailplanes should be built with the largest permitted wing area, with spans between four and five metres, and, accordingly, aspect ratios between 12 and 18. An allowance of 10% of the wing area is assumed for the horizontal stabiliser to keep within the permitted maximum total of 1.5 sq m. A 4.5 metre span wing, of 1.35 sq metres area with aspect ratio 15 was offered as a good compromise. This does not mean such a model will always win contests but on average over a period it will prove more consistent than smaller models and will be fully competitive with other large ones.

In what follows it is assumed that the sailplane will conform to these dimensions. Although the question of ballast will be re-examined towards the end of this section, for the present it is also assumed that the sailplane will be loaded to 3 kg/sq metre of wing area, i.e., slightly under 10 ounces per square foot, ignoring the horizontal tail area.

The choice of wing section

The above recommendations are not affected by choice of wing profile. It would be a mistake to think that the aerodynamic disadvantages of a small model can be overcome by choosing a wing section that does especially well at low Reynolds numbers. A successful small model will invariably be surpassed by a larger one of similar wing loading and aspect ratio, even with the same wing section. The only advantages of the small model are those previously mentioned: greater maneuverability in the air, greater ease of transportation on the ground, and less cost in money and time spent in building. By far the most important aerodynamic improvement in model sailplane performance comes as a result of using the largest possible wing. After this the choice of profile becomes important but no miracles are to be expected.

As previously, the objective first is to discover a **wing** which will give a low rate of sink when flying slowly, a gentle stall to permit easy circling in the rough air of thermals, and at the same time low profile drag at high speeds to achieve good penetration. All these requirements have been explained in the earlier articles. The fuselage and tail are still omitted on the assumption that the sailplane with a good wing will do better than one with a poor wing. The object now is not to compare absolute sailplane performance figures, but to discover how profile selection affects the wing. This can be established by comparing wing polar curves. All figures below stating minimum sink rates and glide ratios, refer only to the wing. A real sailplane will of course not achieve these performances, but the comparison of wing against wing remains valid. Parasitic drag will be considered later in the series.

Wind tunnel tests

It is almost totally futile to try to select wing sections for models by using the calculated drag polars for wing profiles which have, from time to time, been published. Experiment shows that while the computed drag and lift figures are achieved on full-sized aircraft, scale effect, i.e., low Reynolds numbers, on model wings causes such changes in the boundary layer flows that the calculations are seriously wrong. The errors become greater as the wings become smaller and fly slower. The sailplane models considered here are large, but they still operate at Reynolds numbers too small for boundary layer theory, at its present state of development, to be fully applicable. A good deal is known now about the boundary layer but numerical quantitative work is still very imperfect at speeds relevant to model flying. New discoveries are still being made and developments may be expected eventually but full explanations of the behavior of airflow over a model wing have not appeared yet. Until they do so, the modeller should be very sceptical about theoretical drag charts for wing sections.

The wind tunnel test has the important advantage of testing an actual model wing in real air, and to that extent is more reliable. This is not to say, however, that wind tunnel results can be used without a good deal of caution. Some margin must always be allowed for experimental error. No wind tunnel is perfectly accurate and no wind tunnel test specimen conforms exactly to the specified ordinates. Even when testing the same nominal wing profile, different laboratories never produce identical test figures and confusion follows if this is ignored. It is not always justifiable to suppose even that all tests published by one laboratory will have been done under identical conditions. This applies, for instance, to some earlier and later results from the well known Stuttgart model wind tunnel in Germany.

We are greatly aided by the availability now of the results from the Princeton University wind tunnel tests by Michael Selig, John Donovan and David Fraser, published by Herk Stokely as **Soartech 8.**[1] All the sections were measured under standard conditions by the same team, with the same equipment, so the results are self-consistent. Soartech 8 contains detailed explanations of the test methods.

The Princeton tests encompassed a large number of profiles, many were tested with various types of boundary layer control devices, and some with different types of surface covering and finish. Selig and Donovan also developed a number of new profiles and tested these too, in the hope of making genuine improvements in profile design.

The diagrams and tables which will follow in future months rely entirely on this relatively new data. For the present only plain airfoil sections will be considered, without flaps or turbulators.

♣ ♣ ♣

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13 Loch Street
Stepney
South Australia 5069

[1] Soartech 8 is available direct from Herk Stokely, 1504 North Horseshoe Circle, Virginia Beach, VA 23451, USA

The Casio 376 Altimeter Watch

Readers, if you're considering purchasing a Casio 510, you might want to hold off until you can compare it with the Casio 376. Lee Murray has written an evaluation of this watch, and we're planning on including it in the next issue of *RCSD*. Judy

LS-1...continued

Many club members are building the LS-1, even new pilots are making the LS-1 their first scratch built aileron ship. In the near future a "One Design" contest is inevitable and we are hoping for a good turnout. In order to share this design with other modelers, plans have been made available. For $7.00 (Money Order), you can get really clean CAD drawn plans, a template sheet and a three view drawing.

Mike Reed
1775 Dumitru Way #B
Corona, CA. 91720

Understanding Thermal Soaring Sailplanes

Part 3

...by Martin Simons

Accuracy in building

Before continuing the main discussion, it is worth considering first what effect it may have on model performance if the wing itself, as built, is not very accurate. In full sized sailplane manufacture it is usual now to lay up the reinforced plastic components in female moulds of very high precision. The aircraft is built from the outermost skin inwards. Even so, new wings emerging from the factory commonly depart measurably from the designed ordinates and, in service, the resins and adhesives tend to shift slightly, producing further errors, especially small waves, humps and hollows. These may be large enough to affect flight performance. Owners sometimes spend hundreds of hours sanding and filling the profiles to try to overcome these defects. With model wings, a small wave or bump represents a relatively larger error.

The sections tested at Princeton were made by model fliers and each was measured accurately by a special instrument to see how far it departed from the intended profile. These measurements demonstrated that only the best test pieces fitted the ordinates everywhere within + or - 0.1 millimetres (.004 inches See Soartech 8, p 90.). Many of the samples showed errors, especially near trailing and leading edges, of more than 0.75 mm (.03 ins). It is very easy to build a wing much worse than this. For example, the Eppler 193 section as tested proved to be closer to Eppler 205 than to its own ordinates. It was also found that some nominally different sections actually differed less from one another than each differed from its own ordinates. This should at least give food for thought when model fliers claim that this or that airfoil section has been used.

To achieve precision equal to the better test sections used in the Princeton tunnel, if a wing section is drawn on paper by a modern computer-controlled plotter with a 0.2 mm draughting pen, the outline profile of the actual wing as built should not depart visibly from that 0.2 mm line at any point.

However, modellers with less than excellent skills need not despair. Perhaps because low Re number theory is still somewhat underdeveloped, a slightly inaccurate wing profile may not in fact turn out badly in flight. Figures 23 and 24, with the accompanying tables, illustrate this.

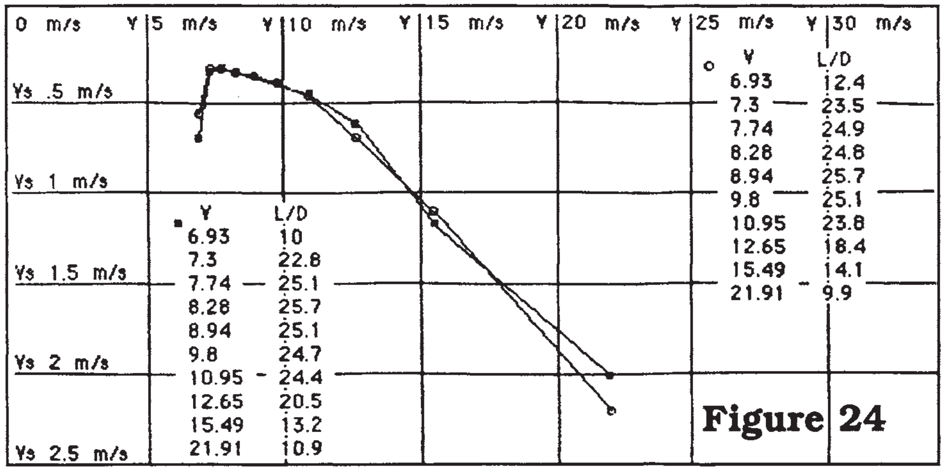

Figure 24

Performance Polar for Wing

	Eppler 374 B-PT		**Eppler 374 B Wavy**	
Velocity Metres/Sec	**Sink M/Sec**	**L/D Ratio**	**Sink M/Sec**	**L/D Ratio**
21.92	2.204	9.95	2.003	10.94
15.50	1.099	14.11	1.167	13.28
12.65	0.686	18.44	0.615	20.58
10.96	0.460	23.84	0.449	24.42
9.80	0.390	25.11	0.397	24.70
8.95	0.347	25.77 MAX	0.356	25.12
8.28	0.333	24.89	0.321	25.79 MAX
7.75	0.311	24.91	0.308 MIN	25.19
7.31	0.311 MIN	23.50	0.320	22.81
6.93	0.556	12.46	0.691	10.03

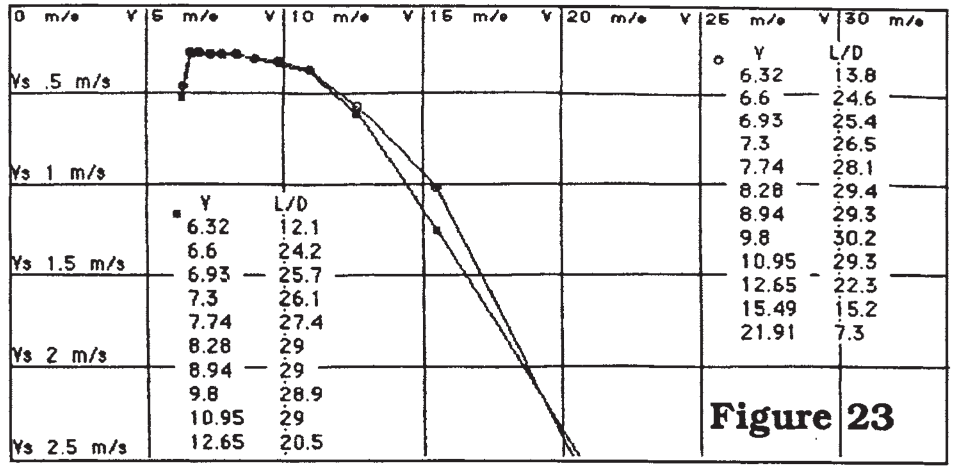

Figure 23

Performance Polar for Wing

	Selig — Donovan 6080		**SD 6080 Thick T.E.**	
Velocity Metres/Sec	**Sink M/Sec**	**L/D Ratio**	**Sink M/Sec**	**L/D Ratio**
21.92	2.970	7.38	2.815	7.79
15.50	1.019	15.21	1.254	12.36
12.65	0.567	22.32	0.615	20.59
10.96	0.373	29.37	0.377	29.06 MAX
9.80	0.324	30.24 MAX	0.338	28.97
8.95	0.305	29.31	0.308	29.02
8.28	0.281	29.47	0.285	29.07
7.75	0.275	28.15	0.282	27.48
7.31	0.275	26.55	0.279	26.18
6.93	0.273	25.43	0.269 MIN	25.78
6.61	0.268 MIN	24.63	0.273	24.22
6.33	0.456	13.87	0.522	12.11

The profile, SD 6080 was designed by Selig and Donovan for sailplanes. It was tested in an accurate form (average departure from ordinates 0.13 mm, 0.0052 in) and was then altered deliberately by thickening the trailing edge. Probably most model sailplanes actually flown do not have a perfect knife edge at the rear. It has frequently been argued that the T.E. needs to be very sharp and many modellers have indeed spent much effort trying to achieve this.

The two wing polars in Figure 23, with the accompanying comparative tables of sink rates and L/D ratios, suggest that such a fault might not be very serious in practice. At low speeds, there is so little difference that it is negligible: the minimum rate of sink differs by only .001 metres per second, i.e., 1 mm. The thick trailing edge is slightly more than one point poorer in best glide ratio. Curiously, at high speeds the two curves approach one another again and even cross over.

Although not perhaps the ideal choice for a thermal sailplane, the Eppler 374 section has been used for some successful cross ...continued on page 16

Understanding Thermal Soaring Sailplanes ...continued

country soarers. This profile was tested in a highly accurate form (E 374B, average departure from contour .016 mm (.0063 ins) and then modelling clay was laid on the leading edge to make the front 15% of the wing distinctly wavy, more so than any normal model wing would be. In Figure 24 the polars of clean and wavy-clay wings of 4.5 metre span are compared. The table with this chart shows the rate of sink and glide ratio at each flight speed (still ignoring fuselage and tail drag). As before, the low speed end of the curves are virtually the same. If any advantage is detectable, it is actually the wavy leading edged profile that does fractionally better. At the higher velocities the wavy leading edge profile again shows a very slight advantage, though the curves cross over twice.

Such outcomes should not be taken to apply to every wing section or to every kind of model. The result may be anomalous or peculiar to these particular profiles. Nevertheless, although general inaccuracies in building can hardly be advantageous in the long run, there is very little evidence so far to suggest that a perfectly accurate wing, on which much time and energy has to be spent, will necessarily perform better on a thermal soaring sailplane than one which has been produced with a more moderate effort.

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SABER...continued

ished wing panels with servos installed weigh only about 16 oz. each! The Saber has a total wing area of about 1030 square inches, a span of 121" and a total flying weight of 70 ounces. It carries 20 oz. of ballast with ease.

The wing planform is similar to that of our old Maestro Megan and Maestro Caliente multi-channel gliders that we kitted in the 1970s. This planform has since become know as a modified Schumann planform. We employed it in the Saber, for the same reason that we used it in the Megan and Caliente, to get the Center of Gravity more rearward on the fuselage to minimize the amount of nose weight required to balance the plane. Many Schumann and modified Schumann winged gliders have had serious tip stall problems and require performance eating tip washout. I am happy to report that the design of the Saber eliminates both any tip stall tendency and the need for tip washout.

The Stabs/Rudder

The stab utilizes quick and easy foam core construction and the new SD8020 airfoil. It is fully sheeted and requires no TE reinforcing. The stabs can be built in a flash, are lightweight and extremely strong and flutter free. The rudder is also foam core and is sheeted with 1/32" balsa.

Controls

The controls are Flaps, Ailerons, Crow, Full TE camber both positive and negative, Rudder and Elevator. A computer radio is required. The plans show an Airtronics Vision radio installation.

Performance

Light-lift low altitude thermaling ability is similar to the Lovesong. The maximum L/D is nearly as high as that of a Lovesong (over 25 to 1). In reflex, it has a top end similar to the faster sinking gliders using the S3021 airfoil. In short, the Saber combines a blend of minimum sinking speed, maximum L/D and high-speed performance.

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Some thoughts on "Understanding Thermal Soaring Sailplanes"...by Greg Harding

"I really liked the Martin Simons article in the March issue of *RCSD* concerning the effects of wing loading. I thought, however, that in the discussion of its effects on turning radius, one rather basic element was left out or over-simplified.

"Mr. Simons says that "at any given angle of bank the radius of the turn, ballasted, will be larger than for the lightly loaded model." I thought it might be worth pointing out that wing loading <u>by itself</u> does not effect turning radius at all. In fact, the <u>only</u> things that determine turning radius (or rate of turn, for that matter) are the angle of bank (already mentioned) and the <u>airspeed</u>. Of course, this means that Mr. Simons was, for all practical purposes, correct because the heavier glider will have to fly faster in order to maintain its minimum sink speed. However, if the two gliders were flying at the same speed and angle of bank, their radii of turn would have to be identical no matter how they were loaded.

"As a matter of fact, that radius is pretty easy to figure out if you know the speed and bank angle. The radius equals the speed times itself divided by 11.26 times the tangent of the bank angle or: $r = V^2 / (11.26 \tan \theta)$ where r=radius in feet, V=true airspeed in knots, and θ=the angle of bank. For example, a glider flying at 25 knots and turning in a 35 degree bank will have a turning radius of 79.271 feet. In a 45 degree bank at the same speed, the radius goes down to 55.5 feet. And it doesn't matter a lick what the wing loading is at all. (The rate of turn in degrees per sec. = $(1091 \tan \theta) / V$.)

"This can be a startling revelation if you've never thought about it before. It was for me. It means that a Piper Cub and a 747 will have the same turn radius if they fly at the same bank angle and speed. Of course, I don't think it's possible for them to fly at the same speed. Either the 747 would stall and fall down or the Cub would rip its wings off. To a certain extent, the same will be true for differently loaded models. While you could probably fly a 6 oz. per sq. ft. HLG and a 20 oz. per sq. ft. slope racer at the same speed, one or both of them wouldn't be flying very well. So, again, Mr. Simons is right and probably all I'm doing is complicating the issue."

Greg Harding, P.O. Box 103 RD 1, Reading, PA 19607

Response: "Greg Harding is, of course, quite right. The radius of turn is not directly determined by the wing loading. The relationship between radius, velocity and bank angle is, as he says,

$$R = V^2 / \tan \theta \, g$$

So, since for a given θ, g and V, the radius is the same whatever the size or mass of the aircraft. I didn't make that clear enough.

But, as Greg also appreciates, to maintain a turn at a given bank angle requires a lift force from the wing and the wing structure has to be capable of withstanding the 'g' loads of acceleration which also depend on the bank angle (and not on velocity). In practice, to make a turn with least loss of height with a glider, the speed is adjusted to maintain efficiency, so the radius is larger with the ballasted model since the airspeed is (normally) greater." Martin Simons

Understanding Thermal Soaring Sailplanes
Part 3
continued
...by Martin Simons

Camber and thickness

If it is allowed that minor errors in construction are unavoidable but also that they need not always have deleterious effects on performance, it seems reasonable to suppose that that major features of the wing section, rather than the finer details, should be considered first.

The two most important features of the wing profile, for the model flier, are camber and section thickness. It has to be said, as it has been said many times before, that these features of a profile cannot safely be judged by eye, and most of the common, extremely old-fashioned terms used, even now, by modellers, such as 'semi-symmetrical', 'undercambered', 'flat bottomed' and even 'Phillips entry', etc, are highly misleading from the aerodynamic viewpoint. To choose an aerofoil section on the basis of such phrases is to choose wrongly. It is a pity that experienced model fliers, and even respected writers who by now should know better, still confuse beginners, and perhaps confuse even themselves, by retaining such sloppy terminology.

There is some excuse for 'flat bottomed' because such wings are easy to build on a simple table or board, but that is the only significance this term has. Similarly, an undercambered section may require special care in attaching covering to a wing, since the film, fabric or tissue tends to pull away from concave areas. 'Semi-symmetrical' is strictly a contradiction in terms; a section is either symmetrical or it has camber. It cannot be semi-cambered, so it cannot be semi-symmetrical. (Consider whether it is possible to be 'semi-pregnant'!) The term, 'bi-convex' is slightly better, but it still does not indicate what the camber of the section actually is. (A fully symmetrical section, for instance, is bi-convex.) The term is unhelpful except when jigging the leading and trailing edges on the building board.

Phillips was an English experimenter of the 19th Century, whose work has long ago been surpassed. The Phillips entry, as patented by him in 1891, was in any case not remotely like the so-called 'Phillips entry' beloved by some confused model fliers today. How this strange muddle entered model flying terminology is rather a mystery, but it has existed since at least 1938 in the literature. It was wrongly applied then, as it is now. Anyone using this term is self-convicted of being a hundred years behind the times and mentally confused into the bargain!

The camber of a wing section is measured from the camber or skeleton line. This is the line which lies midway between the upper and the lower surfaces of the profile. Whatever methods may have been used in designing the profile as a whole, the camber can be found accurately enough for practical purposes by locating the mid line, and measuring its maximum distance from the true chord line of the section. Even a profile devised by drawing curved lines round the traditional bootsole, can be analysed for camber in this way. So can a modern section worked out by advanced computing techniques using 'panel methods' and the latest boundary layer theories. Two sections may look very different (for instance they may differ in thickness), but if they have exactly the same camber they will behave very much alike in the air.

Sometimes the maximum camber of a section may be stated clearly along with the ordinates, or in the numerical system used to identify the section. It is usual to express the maximum camber as a percentage of the chord. Thus, for the famous NACA 4 digit series of profiles, the first figure always indicates the maximum camber in percent, 4412 has 4% camber, 2412 has 2% camber, 6409 has 6% camber, 0010 has no camber (symmetrical) and so on. A camber of 8% is very high, 1% or less is small. Zero camber, of course, applies to all symmetrical sections.

The exact shape of the camber line and whether the curvature of the camber line is evenly distributed or concentrated more towards leading or trailing edge, are less significant factors than the total amount of camber. This is not to say that the form of the camber line may be ignored, but the first thing to consider is the total amount of camber. Its distribution is quite secondary in importance.

The same applies to the thickness. Once the maximum thickness of the wing profile is known, it may be useful to consider whether the equation which was used to work out the exact form to fit round the camber line was intended to encourage a larger or smaller proportion of laminar flow in the boundary layer. But even now it is not really known what effect these details have on the performance of the wing at model sailplane speeds and sizes, whereas the basic thickness, expressed as a percentage of the wing chord, clearly does have an important influence. On model aircraft, sections between 8 and 15% thick are usual but there is no hard and fast rule about these limits. They are quite often exceeded for various reasons.

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A Special Wing Tip
...by Gert Kamffer

Here is something to think about when making foam wings...

I have found that the Koto veneer that is available locally is too thin to give enough strength to a wing without the help of a main-spar. The idea of this design is to keep it as light as possible, and extra glass would only add to the weight. Some years ago I got some aluminum litho-sheets from a printer...sheets 100 X 60 cm and 0,3 mm thick. First, I tried making U-shaped beams but had difficulty, as the taper got thinner. I had intended putting two U-shapes back-to-back, but ended up making two L-shapes. To get the epoxy to hold properly, I drilled some 5 mm holes at regular intervals.

The foam blanks were lined with polythene sheet and the cores were assembled with the litho-spars and epoxy and allowed to cure in the blanks, suitably weighted, before skinning. The finished cores were given Jelotong leading edges before being covered with a single layer of the Koto veneer. Only one litho-strip was used in the polyhedral panels.

The proof of the pudding is that it survived a mid-air meeting which gashed the wing right up to the main-spar without damaging the spar itself. The nice thing about a foam wing is that it's so easy to repair. All I did was to saw a square piece out of the wing, glue another piece of foam back in and replace the leading edge past the break on either side, sanded it to shape and veneered over the top. Except for glue-drying time, it didn't take more than forty minutes! Despite the 9 oz./ft^2 wing loading, the repaired wing can still handle semi-F3B launches...

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Understanding Thermal Soaring Sailplanes

Part 3...continued

...by Martin Simons

Performance calculations

All that follows should be understood in the light of what has been said previously.

Each of figures 25 through 31 (25 & 26 to be discussed this month), each with its appropriate table, is a comparison of wings of the same span, planform and loading, with different aerofoil sections. A similar method was used in Part 2, to compare wings of identical section (Clark Y) but of various sizes and aspect ratios, and above to show the effects of profile inaccuracies.

Clark Y versus NACA 6409

It is often thought that a thermal soaring sailplane should have a strongly cambered wing profile to produce a low stalling speed and minimum rate of sink. Experience with free flight sailplanes reinforces this idea. However, free flight models, apart from the towline launch, are trimmed to fly at one airspeed, whereas the radio controlled model must fly efficiently at varying speeds, as explained in Part 1 of this series. Nevertheless, it is worth considering the possibilities of using large camber. In Figure 25 the NACA 6409 profile is compared with the Clark Y wing which was the basis for Part 2 of these articles. Both sections were tested at Princeton but the 6409 was the only profile in these tests which had an open framework type of construction with film or fabric covering that sagged between the ribs. The 6409 is of course thinner than the Clark Y (9% against 11.72%) but has 6.0% camber, one of the most strongly cambered sections likely to be considered for a radio controlled sailplane. The camber of Princeton Clark Y model is 3.55%.

The outcome of this comparison is probably not surprising. The thin, strongly cambered profile produces a low stalling speed combined with a low minimum rate of sink. The best glide ratio is fractionally better than that of the Clark Y wing but the 'penetration' glide is very poor.

The difference in minimum rate of sink is 1.7 cm (.67 ins) per second, which after ten minutes of perfectly trimmed flight in the same air would be 10 metres (33 ft) difference in altitude. Thus in conditions with weak lift and very narrow thermals, or no lift at all, the NACA 6409 model would have a measurable advantage over the Clark section. However, in almost any other kind of weather, the Clark wing would be more practical, being capable of searching for lift over a wider area and escaping from sink more quickly. Once established in a thermal of reasonable size and strength, the Clark Y wing would climb almost as fast as the 6409, if the 6409 model ever reached the lift at all.

Wortmann FX 63-137 versus Clark Y

Thin wing profiles such as the NACA 6409 tend to have narrow drag buckets. That is, the drag increases rather sharply on either side of the ideal trim. The stall of such profiles also tends to be rather abrupt. Sections of moderate thickness generally have a wider range of useful trims, a milder stall than thin profiles, and develop higher lift coefficients with only a slight over-all drag penalty. It is possible that a sailplane with a thick section of 6% camber, though having higher drag on average, would perform better at both ends of the speed range, low and high, while probably doing less well in the middle range, about the best L/D trim.

Following this line of thought, Figure 26 compares the Clark Y with the Wortmann FX 63-137. The 63-137 was designed for muscle-powered aircraft and was therefore intended to have a particularly good 'power factor', this being also the factor which governs the minimum rate of sink of a sailplane. It was used on some of the earlier human-powered aircraft and it has also been very extensively studied by aerodynamicists looking for aerofoils for high altitude and remotely piloted surveillance vehicles.

The profile, as tested at Princeton has almost 6% camber and is 13.59% thick. It was not one of the most accurate models tested, the average departure from the true ordinates being 0.8 mm (.0322 ins). The polar curve shows very much what should be expected. The stalling speed is lower than the 6409. The minimum rate of sink is not so good, in fact not significantly different from the Clark Y, but it occurs at a lower airspeed. The best glide ratio, in the middle speed range, is not so good, and the high speed glide is better

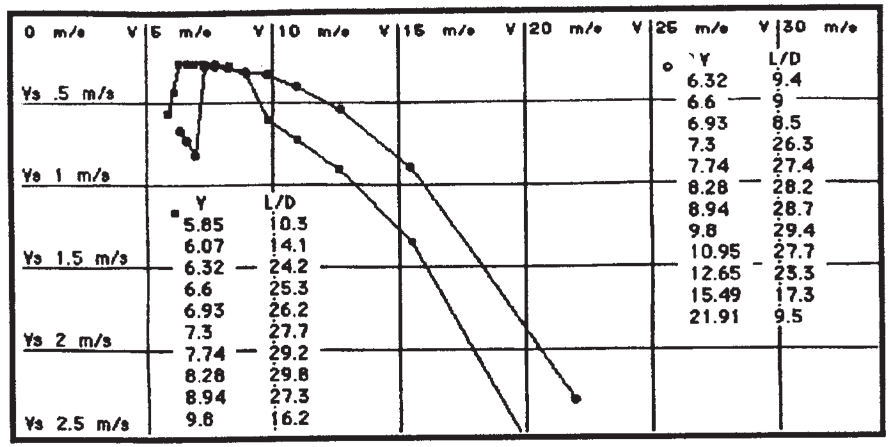

Figure 25

Performance Polar for Wing

Velocity Metres/Sec	CLARK - Y - PT Sink M/Sec	CLARK - Y - PT L/D Ratio	NACA 6409 - PT Sink M/Sec	NACA 6409 - PT L/D Ratio
21.92	2.301	9.53	3.081	7.11
15.50	0.891	17.39	1.348	11.50
12.65	0.543	23.31	0.907	13.96
10.96	0.395	27.71	0.722	15.18
9.80	0.333	29.41 MAX	0.602	16.29
8.95	0.311	28.79	0.327	27.33
8.28	0.293	28.25	0.278	29.83 MAX
7.75	0.282	27.48	0.265	29.27
7.31	0.278 MIN	26.30	0.264	27.71
6.93	0.815	8.50	0.264	26.30
6.61	0.734	9.00	0.261	25.32
6.33	0.670	9.44	0.261 MIN	24.27
6.08			0.430	14.12
5.86			0.565	10.36

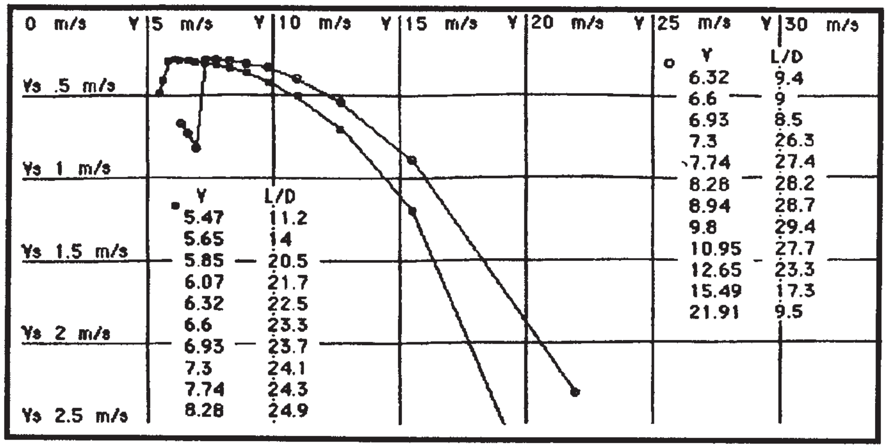

Figure 26

Performance Polar for Wing

	CLARK - Y - PT		**WORTMANN FX63 - 137**	
Velocity Metres/Sec	**Sink M/Sec**	**L/D Ratio**	**Sink M/Sec**	**L/D Ratio**
21.92	2.301	9.53	3.507	6.25
15.50	0.891	17.39	1.195	12.97
12.65	0.543	23.31	0.700	18.07
10.96	0.395	27.71	0.505	21.69
9.80	0.333	29.41 MAX	0.422	23.24
8.95	0.311	28.79	0.364	24.61
8.28	0.293	28.25	0.331	24.99 MAX
7.75	0.282	27.48	0.318	24.36
7.31	0.278 MIN	26.30	0.303	24.12
6.93	0.815	8.50	0.292	23.70
6.61	0.734	9.00	0.283	23.37
6.33	0.670	9.44	0.281	22.51
6.08			0.279 MIN	21.75
5.86			0.285	20.52
5.66			0.402	14.09
5.48			0.488	11.23

than the NACA 6409, although inferior to the Clark Y wing.

It seems from this that by using a camber as high as 6%, with either thick or thin form, the modeller will produce a 'one speed' or 'floater' sailplane suitable only for practically windless conditions with weak and narrow thermals, or no thermals at all. This should not astonish anyone but it should be noted that such camber values do not actually reduce the fundamental minimum sinking speed figures very much, if at all. They produce a model which flies slower, but comes down almost as quickly or at about the same rate, as the Clark Y.

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Using The RC Channel Analyzer

...by Kurt Rosner

Having volunteered to run the transmitter impound and channel security at the 1990 F3B team selection, I was happy to get my hands on Jim Hauser's prototype 'RC CHANNEL ANALYZER' for that spectator event. This device, which I tend to think of as the 'Magic Wand' (MW), was mentioned, with photograph, in Bob Underwood's column in the September 1990 issue of Model Aviation, *page 135.*

MW is not quite a radio receiver, and it is not quite a spectrum analyzer, but it receives radio signals and displays them in visual form like a spectrum analyzer. Picture a fuzzy horizontal line at the bottom of a screen, the fuzz representing background radio noise, with signals showing as bumps or tall skinny peaks, or tall fat peaks, depending on the received signal strength and bandwidth, and you've got it.

Jim created MW for RC aircraft use, so the spectrum it displays is from 72.0 MHZ to 73.0 MHZ. It takes a 3/4 turn of a large knob to cover that range on the prototype. When a signal is lined up exactly in the center of the screen, the frequency or RC channel number can be read off the scale directly under the knob's pointer. Signals up to 60 KHZ away on either side of center can also be identified on the 2-3/8 inch square LCD (liquid crystal display) screen that covers a 120 KHZ chunk of the frequency spectrum horizontally, and 60 db of signal strength vertically. The dial is calibrated in 20 KHZ steps, or it can be calibrated in RC channel numbers.

It's the telescoping whip antenna that creates the magic wand: with the antenna collapsed for maximum attenuation, wave the wand over the transmitter impound area while turning the knob from stop to stop, and quickly see and identify any hot transmitter. Extend the antenna and search for commercial stations and RC turkeys who set up within shoot-down range of your operation without announcing their presence.

The analyzer is compact, light-weight, runs many, many hours on a 9-volt battery, and is easier and faster to use than monitor receivers (scanners). You cannot get the "big picture" instantly with a receiver; scanners lock on to signals, and have to be constantly diddled to continue scanning or searching in the presence of signals. Of course, MW won't alert you if you're not looking at it, and, as I discovered over Labor Day weekend, even a magic wand is only as sharp as its operator!

Jim has started work on an improved version. There will be no knob because of the inherent weaknesses of potentiometers. A key pad will control the "tuning"; pushing one key will show the entire 1 MHZ spectrum, giving you a really big picture, then you zoom in on areas of interest by playing the keys. A digital readout will show the selected frequency or RC channel number, perhaps both.

Enough interest has been expressed in MW by RCers that Jim will produce the improved version in small quantities at about $500 each. That price should put the analyzer within reach of the larger clubs. All RC clubs should own, and use, some sort of "early warning" device. Many RCers have such expensive aircraft now that a further investment to protect the aircraft from shoot-downs seems reasonable. MW should be available in January, 1991.

Please drop Jim a line if you are interested in obtaining additional information.

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Understanding Thermal Soaring Sailplanes

Part 3...continued

...by Martin Simons

Eppler 214 vs Clark Y

The Clark Y profile was designed for full-sized aircraft about 1920.[1] It ought to be possible in 1991 to do better for a model sailplane than this. We are, however, in for some surprises.

The Eppler 214 was designed specifically for models and has been widely used on thermal soarers. The Princeton test piece had 4.03% camber and is 11.10% thick. It is thus only a little thinner and only slightly more cambered than the Clark Y. The main difference is that the E214 was designed according to sophisticated boundary layer theories which Clark could not have known.

The comparison in Figure 27 must be rather disturbing to the theoretical aerodynamicist. As mentioned in Soartech 8, the form of camber used for this profile seems to cause some serious problems. The E214 stalls at higher speed than the Clark Y and the E214 polar curve is everywhere inferior.

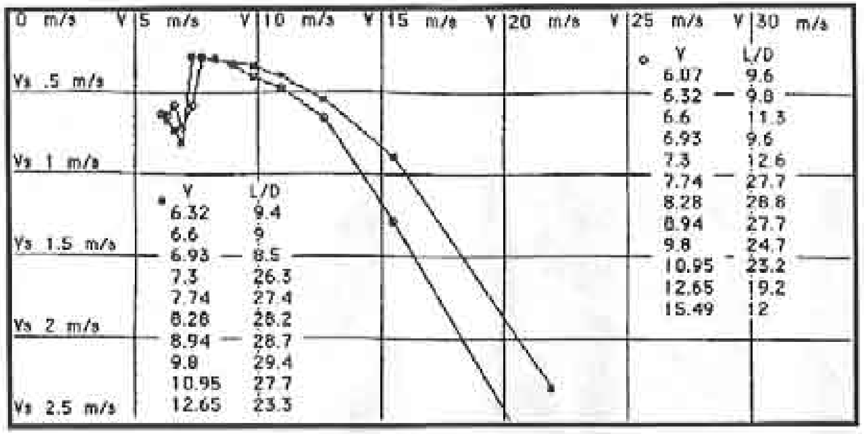

Figure 27

Performance Polar for Wing

	CLARK - Y - PT		EPPLER 214	
Velocity Metres/Sec	Sink M/Sec	L/D Ratio	Sink M/Sec	L/D Ratio
21.92	2.301	9.53	2.930	7.48
15.50	0.891	17.39	1.291	12.00
12.65	0.543	23.31	0.658	19.22
10.96	0.395	27.71	0.471	23.28
9.80	0.333	29.41 MAX	0.397	24.71
8.95	0.311	28.79	0.322	27.78
8.28	0.293	28.25	0.287	28.85 MAX
7.75	0.282	27.48	0.279 MIN	27.74
7.31	0.278 MIN	26.30	0.580	12.61
6.93	0.815	8.50	0.717	9.67
6.61	0.734	9.00	0.583	11.33
6.33	0.670	9.44	0.639	9.90
6.08			0.630	9.64

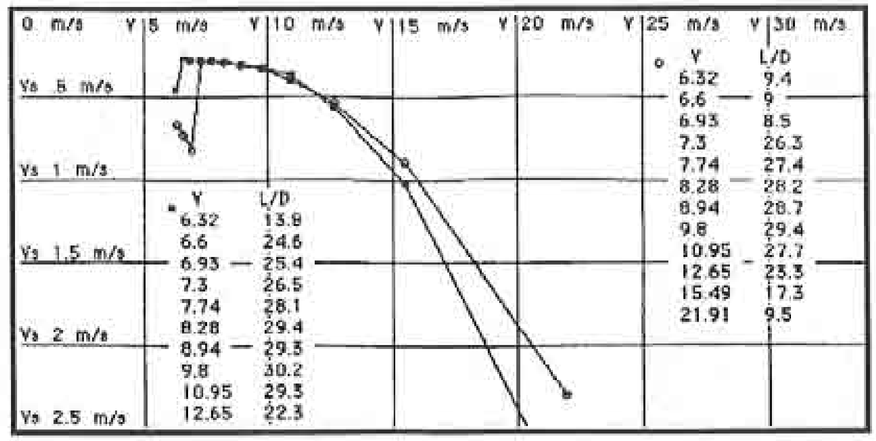

Figure 28

Performance Polar for Wing

	CLARK - Y - PT		SELIG - DONOVAN 6080	
Velocity Metres/Sec	Sink M/Sec	L/D Ratio	Sink M/Sec	L/D Ratio
21.92	2.301	9.53	2.970	7.38
15.50	0.891	17.39	1.019	15.21
12.65	0.543	23.31	0.567	22.32
10.96	0.395	27.71	0.373	29.37
9.80	0.333	29.41 MAX	0.324	30.24 MAX
8.95	0.311	28.79	0.305	29.31
8.28	0.293	28.25	0.281	29.47
7.75	0.282	27.48	0.275	28.15
7.31	0.278 MIN	26.30	0.275	26.55
6.93	0.815	8.50	0.273	25.43
6.61	0.734	9.00	0.268 MIN	24.63
6.33	0.670	9.44	0.456	13.87

Selig Donovan profiles

It would take far too long to examine every profile for which wind tunnel figures are now available. The polar for Eppler 374 appears in Figure 24 (*RCSD* 9/90, page 15), and is not especially favourable. This wing, whether in accurate or wavy form, stalls faster than the Clark Y, sinks quicker, has a poorer best L/D and equals the Clark section only at the fastest airspeeds.

For the rest, a short cut will be taken to consider the most recently designed airfoil sections produced at Princeton which, as far as possible, combine up to date theoretical work with practical testing in the most promising way. The principles and methods used in producing the Selig-Donovan sections are described in Soartech 8 (Chapter 4). The tunnel tests included sixteen of this series, one of which was a symmetrical profile.

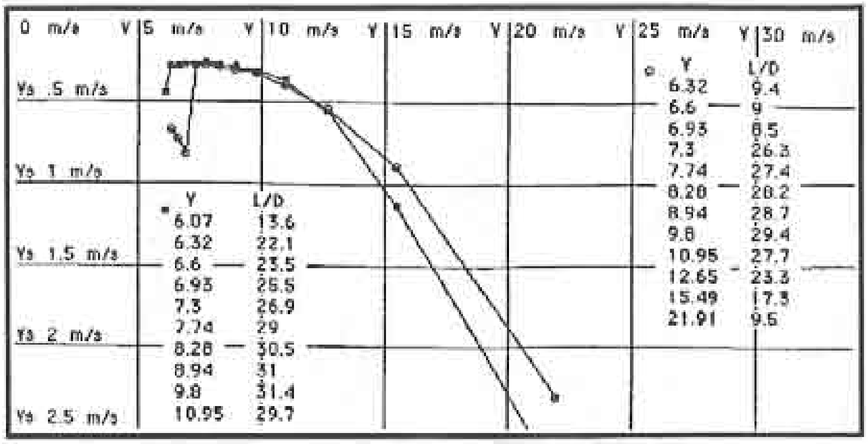

Figure 29 **Performance Polar for Wing**

	CLARK - Y - PT		SD 7032	
Velocity Metres/Sec	Sink M/Sec	L/D Ratio	Sink M/Sec	L/D Ratio
21.92	2.301	9.53	2.768	7.92
15.50	0.891	17.39	1.126	13.76
12.65	0.543	23.31	0.556	22.74
10.96	0.395	27.71	0.368	29.77
9.80	0.333	29.41 MAX	0.311	31.48 MAX
8.95	0.311	28.79	0.288	31.08
8.28	0.293	28.25	0.271	30.52
7.75	0.282	27.48	0.267 MIN	29.04
7.31	0.278 MIN	26.30	0.271	26.92
6.93	0.815	8.50	0.271	25.53
6.61	0.734	9.00	0.280 MIN	23.56
6.33	0.670	9.44	0.286	22.16
6.08			0.445	13.65

Generalising, with one exception the SD profiles are relatively thin, and most have less camber than the Clark Y. Several of them were intended for multi-task sailplanes rather than thermal soarers.

SD 6080 vs Clark Y

Polars for the SD 6080 with thick and thin trailing edge appear in Figure 23 (*RCSD* 9/90, page 14). For the sake of convenience the more accurate model of the SD 6080 is compared directly with the Clark Y in Figure 28. The 6080 is 9.18% thick with 3.74% camber, i.e., thinner but very slightly more cambered than the Clark.

The 6080 shows a better low speed performance than the Clark Y, with lower minimum sink, slightly superior best L/D and a lower stalling speed. The sinking speed would give the modern profile only a 6 metre (20 ft.) height advantage after ten minutes in the same air. It would have a small advantage in very narrow thermals, theoretically being able to turn a little tighter without stalling. At high speeds the Clark wing is better.

SD 7032 vs Clark Y

The SD 7032 is described by its designers

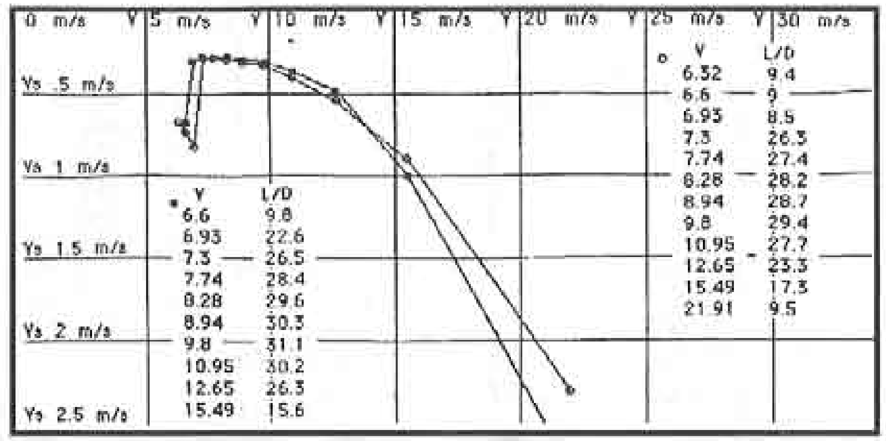

Figure 30 **Performance Polar for Wing**

	CLARK - Y - PT		SELIG - DONOVAN 7037	
Velocity Metres/Sec	Sink M/Sec	L/D Ratio	Sink M/Sec	L/D Ratio
21.92	2.301	9.53	2.768	7.92
15.50	0.891	17.39	0.993	15.61
12.65	0.543	23.31	0.480	26.33
10.96	0.395	27.71	0.362	30.26
9.80	0.333	29.41 MAX	0.314	31.19 MAX
8.95	0.311	28.79	0.295	30.35
8.28	0.293	28.25	0.280	29.62
7.75	0.282	27.48	0.272 MIN	28.49
7.31	0.278 MIN	26.30	0.275	26.60
6.93	0.815	8.50	0.306	22.68
6.61	0.734	9.00	0.672	9.83
6.33	0.670	9.44		

as one of the best sections for thermal soaring sailplanes. It is 9.95% thick and has 3.66% camber, thinner but less cambered than the Clark Y. The polar comparison is shown in Figure 29.

This profile is superior to the Clark Y at low speed. The stalling speed is less and the minimum rate of sink is slightly better. The difference, in the same air, would be 6.6 metres (22 ft.) after 10 minutes. The best glide ratio is a full two points better and occurs at a useful airspeed, although the Clark Y wing is again better at inter-thermal penetration velocities.

Referring back again to the NACA 6409 (Fig.25 - *RCSD* 11/90, page 11), the SD 7032 profile nearly matches the 6% cambered profile at low speeds and does not come down quite so badly at higher velocities. The stalling speed is almost the same and the sinking speed difference is only 6 mm per second, i.e., 3.6 metres (12 ft.) after 10 minutes. The 7032 wing shows a flattish top to the polar curve, indicating quite small variations of sink rate over a range of flight speeds from about 6.5 to 9 m/s. Nonetheless, the high speed part of the polar is disap-

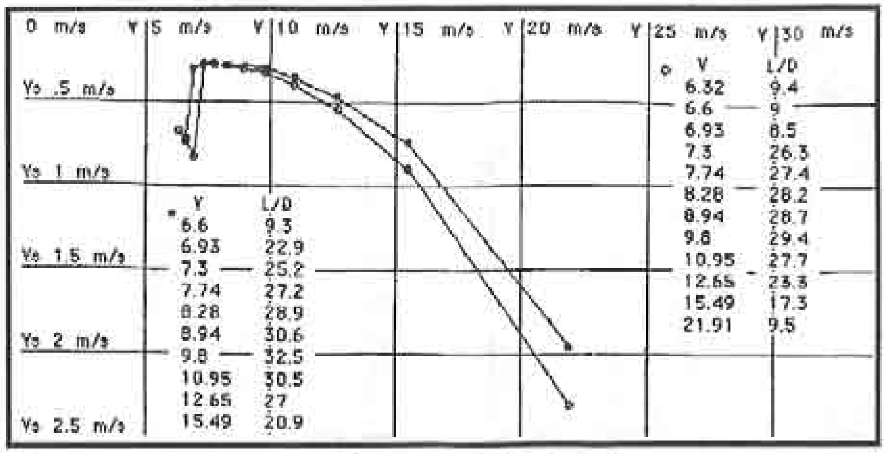

Figure 31 **Performance Polar for Wing**

	CLARK - Y - PT		SELIG - DONOVAN 8000	
Velocity Metres/Sec	**Sink M/Sec**	**L/D Ratio**	**Sink M/Sec**	**L/D Ratio**
21.92	2.301	9.53	1.960	11.18
15.50	0.891	17.39	0.739	20.98
12.65	0.543	23.31	0.468	27.06
10.96	0.395	27.71	0.359	30.53
9.80	0.333	29.41 MAX	0.301	32.53 MAX
8.95	0.311	28.79	0.292	30.69
8.28	0.293	28.25	0.286	28.97
7.75	0.282	27.48	0.285 MIN	27.22
7.31	0.278 MIN	26.30	0.290	25.23
6.93	0.815	8.50	0.302	22.94
6.61	0.734	9.00	0.710	9.30
6.33	0.670	9.44		

pointing. Some further discussion of this profile appears below.

SD 7037 VS CLARK Y

The SD 7037 is described as a thinner, decambered SD 7032, It is 9.2% thick with 3.02% camber. The polar comparison is shown in Figure 30. This profile is minimally better than the Clark Y at low speed, with the flattish top to the polar indicating a very useful performance at speed below 12 m/s (40 ft./s, 27 mph) but still falling behind in penetration. A rather surprising trend begins to emerge.

SD 8000 vs Clark Y

Figure 31 compares Clark Y with the SD 8000 profile which, its designers remark, despite differences in shape is actually very similar in the wind tunnel to older F3B profiles such as the well known RG 15 and HQ 2/9.

For the first time, a profile has been found which is distinctly superior to the Clark Y at high speeds. The interesting question is how much has been sacrificed in terms of low speed, thermal soaring capability. The minimum sink rate of the SD 8000 is only 7 mm per second poorer, 4.2 metres (13.5 ft.) after ten minutes, and the SD 8000 wing has a slightly lower stalling speed. In practice these two wings would climb pretty well together, but the best glide ratio of the SD 8000 is fully three points better and as the airspeed rises further the Clark Y is left further behind.

Subject to all the usual cautions and remembering what has been said earlier about experimental error, it seems now that the best airfoil section for a thermal soaring sailplane is not, after all, very different from the profile that would have been chosen for a multi-task competition model. But such a profile in practice may give hardly any margin of performance above the very traditional Clark Y.

♣ ♣ ♣

1 Virginius Clark's career included service in both the U.S.Army and Navy, and NACA in its early years. He later worked for Howard Hughes.

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Some Photos from the July Davenport Slope Race...by Jerry Slates

Left - Sam Shiller & SWIFT 800 that was modified by Ron Vann.

Bottom Left - Ron Vann's SWIFT 800

Bottom Right - Mark Grand and the OUTLAW! The wing is made of 1.5 lb. gray foam and sheeted with 3/32 balsa wood.

Understanding Thermal Soaring Sailplanes

Part 3...continued

...by Martin Simons

Ballast

The picture is not complete. It has been assumed earlier that the wing loading of the two models being compared is identical. As mentioned earlier in this series, by adding ballast, any sailplane polar curve whatever can be shifted towards the higher speed end of the chart, improving penetration, with some increase in minimum sink rate and stalling speed. By reducing wing loading, the polar can be shifted the other way, reducing stalling and sinking speeds at the expense of

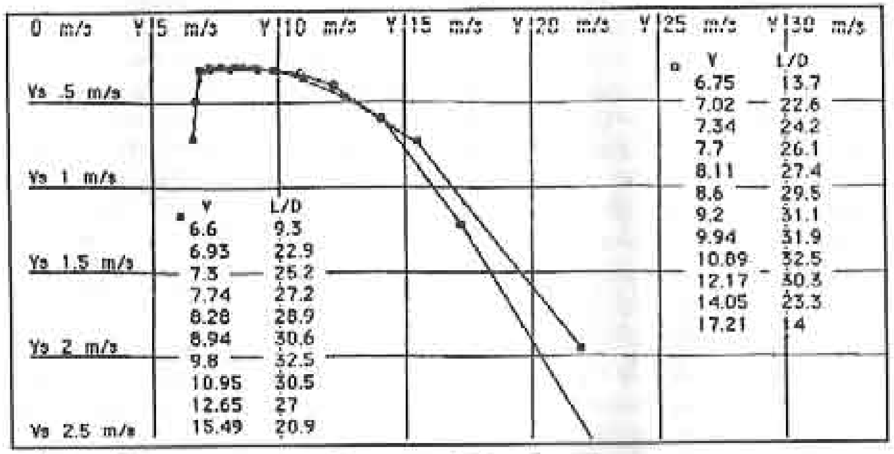

Figure 32 **Performance Polar for Wing**

SD 7032 — Wing Loading = 3.70 kg/sq.m.

SELIG - DONOVAN 8000 — Wing Loading = 3.00 kg/sq.m.

Velocity Metres/Sec	Sink M/Sec	L/D Ratio	Velocity Metres/Sec	Sink M/Sec	L/D Ratio
24.35	3.004	8.11	21.92	1.960	11.18
17.22	1.224	14.07	15.50	0.739	20.98
14.06	0.602	23.36	12.65	0.468	27.06
12.18	0.401	30.35	10.96	0.359	30.53
10.89	0.334	32.58 MAX	9.80	0.301	32.53 MAX
9.94	0.311	31.93	8.95	0.292	30.69
9.20	0.296	31.13	8.28	0.286	28.97
8.61	0.292	29.51	7.75	0.285 MIN	27.22
8.12	0.296	27.41	7.31	0.290	25.23
7.70	0.295 MIN	26.11	6.93	0.302	22.94
7.34	0.303	24.20	6.61	0.710	9.30
7.03	0.311	22.63			
6.75	0.491	13.76			

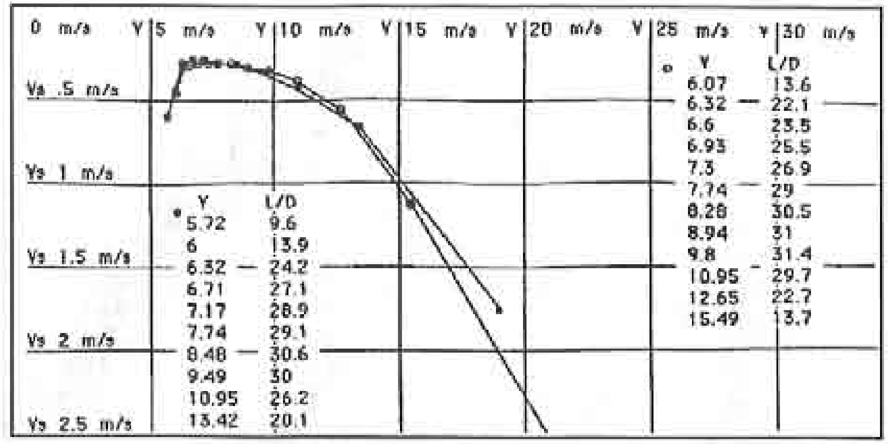

Figure 33 **Performance Polar for Wing**

SELIG - DONOVAN 8000 — Wing Loading = 2.25 kg/sq.m.

SD 7032 — Wing Loading = 3.00 kg/sq.m.

Velocity Metres/Sec	Sink M/Sec	L/D Ratio	Velocity Metres/Sec	Sink M/Sec	L/D Ratio
18.98	1.753	10.83	21.92	2.768	7.92
13.42	0.665	20.18	15.50	1.126	13.76
10.96	0.418	26.24	12.65	0.556	22.74
9.49	0.315	30.08	10.96	0.368	29.77
8.49	0.277	30.65 MAX	9.80	0.311	31.48 MAX
7.75	0.266	28.18	8.95	0.288	31.08
7.17	0.248	28.98	8.28	0.271	30.52
6.71	0.247 MIN	27.18	7.75	0.267 MIN	29.04
6.33	0.261	24.21	7.31	0.271	26.92
6.00	0.431	13.93	6.93	0.271	25.53
5.72	0.590	9.70	6.61	0.280	23.56
			6.33	0.286	22.16
			6.08	0.445	13.65

penetration.

The SD 7032 has been shown to be a very good low speed profile but inferior to the Clark Y at penetration speeds. The SD 8000 appears very good at high speeds and as good as the Clark Y for soaring. Therefore in Figure 32, the 7032 model is assumed to be ballasted up to the FAI maximum permitted all up weight of 5 kg. (The wing loading then becomes 3.7 kg/sq m, 12 oz.sq ft.) The resulting polar is compared with that of the SD 8000 wing at the same total weight as before (4.05 kg, wing loading 3.0 kg/sq m.) Adding ballast in this way brings these two wings so close together at low speeds that it is unlikely any real differences would be detected in practice. Perhaps a slight margin still exists in favour of the SD 8000. At high speeds the 8000 profile retains some advantage.

Note also that the ballasted polar for

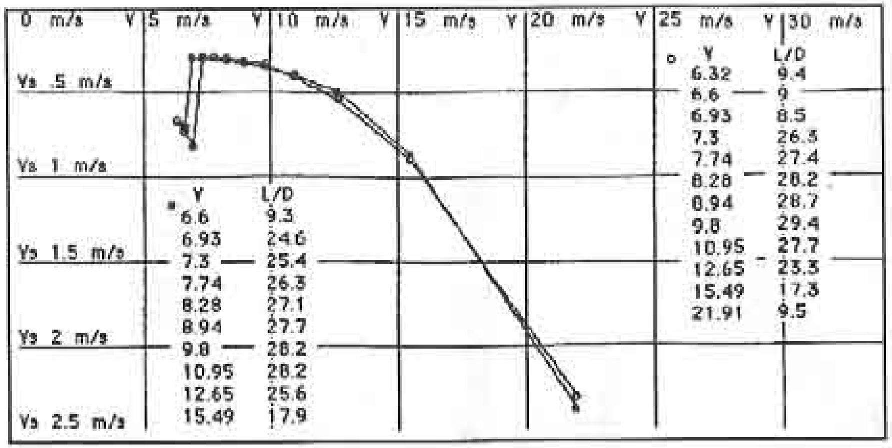

Figure 34 **Performance Polar for Wing**

Velocity Metres/Sec	CLARK - Y - PT Sink M/Sec	CLARK - Y - PT L/D Ratio	Eppler 205 Sink M/Sec	Eppler 205 L/D Ratio
21.92	2.301	9.53	2.375	9.23
15.50	0.891	17.39	0.861	18.00
12.65	0.543	23.31	0.494	25.62
10.96	0.395	27.71	0.388	28.26
9.80	0.333	29.41 MAX	0.347	28.27 MAX
8.95	0.311	28.79	0.323	27.71
8.28	0.293	28.25	0.305	27.12
7.75	0.282	27.48	0.294	26.33
7.31	0.278 MIN	26.30	0.287	25.45
6.93	0.815	8.50	0.281 MIN	24.63
6.61	0.734	9.00	0.709	9.32
6.33	0.670	9.44		

the SD 7032, as the respective tabulated figures show, is no longer superior to the unballasted Clark Y at low speeds. The Clark Y wing (at 3.0 kg/sq m) would climb slightly better and turn slightly tighter. Although the best L/D for the 7032 wing is noticeably better (32.58 vs 29.41), at higher speeds the Clark section once again edges ahead even at its lower wing loading. (It was explained in earlier articles that the best L/D of a sailplane is in practice very rarely important. Soaring requires lower trimmed speeds, penetration always requires a faster trim.)

Adjusting wing loadings and ballast in the other direction, in Figure 33 the SD 8000 model is assumed to have been built very lightly so that the total weight is 3.04 kg (6.7 lbs) and the wing loading only 2.25 kg/sq m (7.4 oz/sq.ft.). The 7032 and 8000 polars are virtually the same at low speeds though again a slight advantage lies with the 8000 profile. As Selig and Donovan remark, other sections originally designed for multi task sailplanes, such as the RG 15 and HQ2/9, behave very much like the SD 8000 and can be expected to give similar results.

Summing up

A rather long and perhaps difficult comparison of wind tunnel test results has produced results that some model fliers will find hard to accept.

First, a very ordinary and long established profile, the Clark Y, performs remarkably well and remains competitive against even the best of modern aerofoil sections for thermal soaring sailplanes. It has quite a good low speed performance, does well at high speeds, is known to have a mild stall and does not seem unduly sensitive to small errors in construction. It also happens to be easy to build and is of moderate thickness, making for strength and stiffness without undue structural weight. It could thus be flown at very light wing loadings for the occasional 'light airs' contest, but loaded with ballast to penetrate better in more ordinary conditions. Reliable wind tunnel data is still lacking on a great many profiles of similar vintage. While it appears that Virginius Clark knew a few good things, there seems no reason to suppose that the Clark Y is exceptional. Probably any of the old NACA four digit or Göttingen profiles **of roughly similar camber and thickness** (i.e., about 3.5% and 11.5%) would do just as well. It may not be necessary to mention in this context the well known and well proved Eppler 205 (3.01% and 10.48%). Figure 34 is a direct comparison of Clark Y with an accurate model of the Eppler 205, both tested at Princeton. The point is perhaps sufficiently made, but the author can speak from some direct experience here. In 1982 when the E205 section was being widely and enthusiastically acclaimed, two otherwise identical model sailplanes, of 3 metres span, were built, one with E 205 and one with Clark Y profiles. No difference whatever could be detected in performance.

Secondly, providing the model flier is prepared to adjust the ballast of the sailplane to suit conditions, virtually the same performance can be obtained from a range of profiles between the SD 8000 (8.86% thick, 1.71% camber and the SD 7032 (9.95% thick, 3.66% camber.) The thin, slightly cambered profiles seem to have a marginal advantage at low as well as high speeds, assuming that the ballast has been correctly judged. Such profiles may, however, turn out to be rather tricky near stalling speeds and because of this it may not be possible in practice to realise their full thermalling potential. It has to be remarked, nonetheless, that F3B sailplanes using profiles such as this, when flown well by experienced pilots under a variety of weather conditions, show themselves to be very good thermal soarers as well as achieving high speeds in multi-task contests.

Some readers may wonder if the Princeton results have somehow falsified the situation. This is not the case. Before Soartech 8 was published, the author ran a comparable series of polar computations using the earlier test figures from Stuttgart. The Clark Y emerged from this, if anything, in an even better position but if any improvement was to be found, those calculations also pointed to an F3B section for a thermal soarer, the HQ2.5/9 or even the 1.5/9. Consequently two models currently being flown regularly by the author have these profiles and perform very well. So does the eight year old Clark Y example.

It may not be exaggerating too much to say that modern profiles have very little, if any, advantage over the Clark Y. It remains only to stress that the Clark Y referred to here is the real Clark Y section, plotted accurately according to Clark's original ordinates, not the strange 'bootsole' profiles carelessly described as 'Clark Y type' by some model designers.

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Understanding Thermal Soaring Sailplanes

Part 4

...by Martin Simons

Previous articles have examined the sailplane polar, the advantages of large models, and the choice of wing profile. Discussion of flaps and turbulators to modify the profile was postponed and will now be considered.

Flaps?

The purpose of fitting simple trailing edge flaps to a sailplane wing is to allow an increase of camber when circling in thermals and for the towline launch. Camber is reduced by raising the flaps for penetration. Whether the gains are sufficient to justify the additional complication in construction and control is not entirely clear.

A serious difficulty is that flaps need to be very carefully designed and fitted in such a way that they do not cause flow separations at the hinge line, or let air leak through gaps. Even in the neutral position, badly fitting or leaky flaps can upset the performance of the wing, leaving things in a worse situation all round than the plain aerofoil. Even the best flap creates small surface irregularities at the hinge line and some wing profiles are sensitive to such defects. The same, of course, can occur with aileron and other control surfaces, but since the intention of the flaps is to improve performance, anything that actually has the opposite effect is particularly deplorable. A possible solution may be to use a flexible wing skin, instead of a hinge, to allow the flaps to be varied without breaking the continuity of the surface. This has been done on some full-sized sailplanes, notably the Jantar 2 and the Speed Astir. Alternatively, flexible hinges may be devised using silicone sealants, the idea being to prevent any sharp change of flow direction at the forward edge of the flaps.

It must be emphasised strongly that camber flaps, if used at all, must run across the whole wing. Flaps which extend only over the inner part of the span are worse than none at all, since when they are either up or down there is a considerable increase of vortex drag at the outer end of the deflected flap. Ailerons, if any, must be coupled with the flaps, changing the camber of the entire wing from tip to tip. This usually has some adverse effect on lateral control but is acceptable if the desired improvement in performance is achieved. If there are no ailerons, the flap still should run from tip to tip of the entire wing.

Wind tunnel tests on flapped wing sections are few and results emerging are sometimes disappointing.

Figure 35 shows what may be possible. All wing dimensions used in computing the polar are the same as before and the wing loading is again 3.0 kg/sq m (9.8 oz/sq ft). The basic wing section is SD 7032, with flaps 21% of the chord in width, as tested at Princeton. The diagram indicates the performance with flaps in two different positions, down 6 degrees for thermalling and raised 6 degrees for penetration. These flap angles have been chosen deliberately to show the maximum effects. In practice the pilot is supposed to adjust the flaps proportionally between these limits, according to the flight speed and trim required.

On a wing chord of 35 cm (13.75 ins) such as that supposed here at the wing root, a 21% flap is deflected 6 degrees when the trailing edge is up or down 8 mm (0.3 inches) from neutral. To arrange for more movement than this is to invite flow separation. If the flap driving mechanism is a little sloppy, it is quite possible to get six degrees of movement on either side of neutral without control from the transmitter at all. Flaps also can flutter at high speeds and mass balancing to prevent this may be required. Once again, the importance of good engineering for flaps is emphasised.

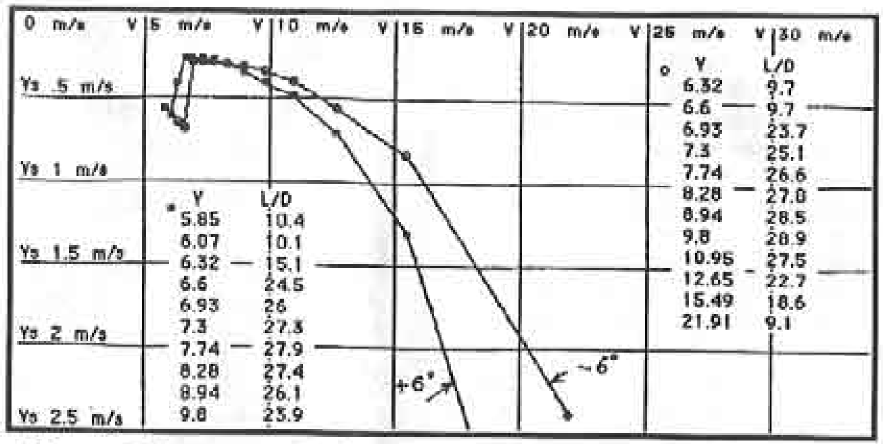

Figure 35 **Performance Polar for Wing**

Velocity Metres/Sec	SD 7032 Flap + 6° Sink M/Sec	SD 7032 Flap + 6° L/D Ratio	SD 7032 Flap - 6° Sink M/Sec	SD 7032 Flap - 6° L/D Ratio
21.92	4.317	5.08	2.394	9.16
15.50	1.302	11.90	0.831	18.64
12.65	0.707	17.91	0.556	22.74
10.96	0.486	22.53	0.398	27.56
9.80	0.409	23.96	0.339	28.94 MAX
8.95	0.342	26.14	0.313	28.59
8.28	0.302	27.44	0.297	27.85
7.75	0.278	27.92 MAX	0.291	26.62
7.31	0.267	27.39	0.291 MIN	25.10
6.93	0.266 MIN	26.07	0.292	23.74
6.61	0.270	24.50	0.678	9.75
6.33	0.418	15.13	0.651	9.72
6.08	0.602	10.11		
5.86	0.561	10.44		

Lowering the flaps 6 degrees, as the chart shows, makes a small improvement in minimum rate of sink and the stalling speed is less, so thermalling circles might be made tighter. This could be useful sometimes but the improvement is not really very great. Note how 6 degrees down flap ruins the high speed part of the polar. Obviously it is very important that flaps should be neutral or raised unless the model is actually in lift. To fly fast with the flaps down is a serious error, much more serious than flying slowly with the flaps up.

Launching with flaps down, reducing the stalling speed, may be an advantage since the towline runner may not have to run so hard.

With flaps up, the high speed performance is improved greatly. There is, therefore, some gain in useful speed range with this profile, which is fairly strongly cambered in the plain form.

The SD 8000 profile, which the earlier study indicated as promising for thermal soarers, has not yet been tested with flaps. Since it has only small camber to start with (1.71%), little improvement should be expected by raising flaps at high speeds but lowering them a few degrees would reduce the stalling speed and possibly improve the minimum sink rate slightly too.

Other possibilities, such as slotted flaps, which encourage and direct flow leakage through the hinge to control the boundary layer over the flap itself, are worth investigating. Little has ever been done along these lines with models and no wind tunnel tests at suitably low values of Reynolds number relevant have been done, so far as can be discovered. The option of Fowler type flaps which increase the wing area when extended, is also worth consideration though if, as recommended in the earlier articles, the model is to be built up to the maximum permitted area, the flaps will have to be at their fullest extension when the area of the wing is calculated. (The international rules require any such device to be operable remotely via the radio control system.)

It may be concluded that there are some aerodynamic advantages to be gained by using full-span camber flaps, coupled with ailerons, on a large thermal soarer, if the engineering complications can be dealt with. Whether the potential advantages of such devices are worth the extra trouble, and can be correctly used in flight, must be decided by the model flier personally.

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California Slope Racers

...by Rich Beardsley

California Slope Racers is now an official AMA club,#2804, and we are looking forward to an exciting inaugural year.

To bring those of you not familiar with C.S.R. up to date, last year in July the International Slope Race was held at Davenport, CA after a period of not holding the race. The race was put together by Ray Kuntz (C.D.), with lots of support and leg work from John Dvorak. The race attracted over 50 pilots from all over the west coast and, needless to say, the I.S.R. was a great success.

It was then decided that a sanctioning body should be formed to insure the continued success of the I.S.R., as well as hold a series of races along the California Coast.

At the next race held by the yet unorganized club, held at the Migellito Canyon site near Lompoc, California, an election was held by the participating pilots to decide who would serve as the Director of C.S.R. and formulate the club rules and guidelines. After a very close count, I (Richard Beardsley) edged out Ray Kuntz by one vote. I would like to thank everyone who supported me and hope I will give the club a good racing start.

C.S.R. held their first board meeting in the form of a fun fly at Los Banos Reservoir in December. There, I presented my thoughts on the direction the club should take. I also presented some basic rules. (The club rules will be published at a later date or can be obtained by sending me a self-addressed stamped envelope.) C.S.R. will adhere to A.M.A. unlimited slope racing rules. We also decided that there will be two separate classes — Division One Pilots, consisting of the top 28 points earning pilots; racing for cash prizes. Division Two Pilots will be made up of the rest of the registered club members, and they will race for Trophies. Division Two pilots will be able to displace the Division One Pilots with consistent top placing in their races.

Scheduled Events

March 16:	Los Banos
April 13:	Migellito Canyon
June 1 & 2:	International Slope Race Migellito Canyon
July 13:	L.A. Area Site to be announced
August 10:	Davenport
September 14:	L.A. Area Site to be announced
October 12:	California State Champs. Migellito Canyon

The 1991 International Slope Race is scheduled for June 1 and 2, to be held at the Megelleto Canyon site near Lompoc, CA. We presently have commitments from 3 pilots that will be coming from England, with a rumor that Nick Wright will attend. I have included the races scheduled for this year at the top of this article.

It looks like an exciting year on the slopes of California. If you did not attend the I.S.R. at Davenport in July and would like to be a member of C.S.R. please send me your name, address, and A.M.A. number with a self-addressed stamped envelope, and I will send you the a current schedule and rules package. C.S.R. will not charge yearly dues as the club will be supported by the race entry fees.

In order to conflict as little as possible with other club contests, we have decided to hold our races on Saturdays. The exception being the International Slope Race, which will be a two day event.

I will try to keep everyone informed of events and changes through this publication, the A.M.A. magazine, and local newsletters. The season will open on March 16 with a race held at Los Banos Res. near Los Banos, CA. Sign-up will start at 9 AM, pilots meeting at 10 AM, first heat at 10:30 AM. Pre-registration should be sent to me with your frequency and the area in square feet of your racer—this should include the horizontal tail area or shadow area in the case of V-tails. Entry fees will be collected at the race, and will be $5.00 for Division Two and $15.00 for Division One.

Please direct any correspondence to me at:
Richard Beardsley
2401 Country Lane
Santa Maria, CA 93455
(805) 934-3191

See you at the start gate!

A Workshop Tip

...from Gordon Jones

When sanding the leading edges on a sheeted foam wing, it is a good idea to put masking tape along the sheeting line so that you don't sand the sheeting. When you start scuffing up the masking tape, you know that you are getting close to the sheeting and from that point on more care is required.

Understanding Thermal Soaring Sailplanes

Part 4

...by Martin Simons

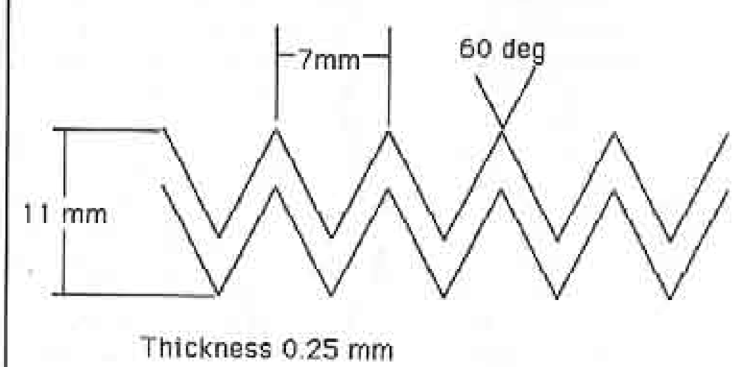
Variable geometry?

The option of telescopic wings, as used by Rolf Decker in 1985 for the *Tele F* sailplane for F3B contests, is also very promising for thermal soarers, although the complications are great and, again, the wing area must be calculated with the wings fully extended. Nonetheless, a high aspect ratio for soaring, and a small span, small area wing for penetration, is aerodynamically ideal, whatever practical difficulties arise in building such a model. (Neither the *Tele F* nor the full-sized telescopic winged *FS 29*, have so far made their marks in regular competitions flying against more ordinary types.)

Turbulators

A good deal of experimental work, in wind tunnels and on aircraft in flight, has been done with turbulators. These are usually thin strips of tape, or fine threads, glued spanwise along the wing at some

Figure 36 Zig zag turbulator



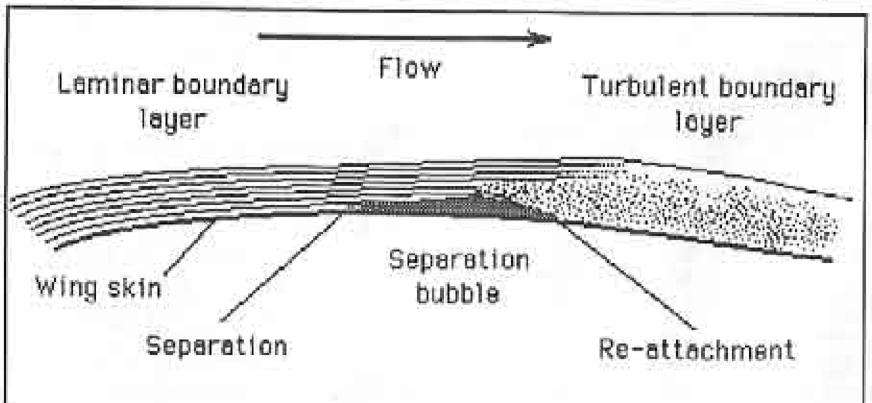


Figure 37 Formation of separation bubble on wing

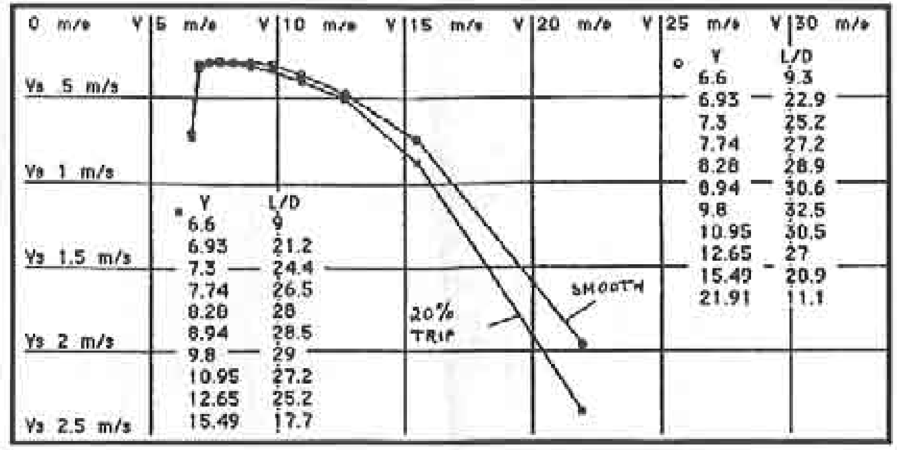


Figure 38 **Performance Polar for Wing**

Velocity Metres/Sec	SD 8000 Smooth Sink M/Sec	SD 8000 Smooth L/D Ratio	SD 8000 Trip 20% Sink M/Sec	SD 8000 Trip 20% L/D Ratio
21.92	1.960	11.18	2.358	9.30
15.50	0.739	20.98	0.873	17.76
12.65	0.468	27.06	0.502	25.21
10.96	0.359	30.53	0.402	27.26
9.80	0.301	32.53 MAX	0.337	28.08 MAX
8.95	0.292	30.69	0.313	28.56
8.28	0.286	28.97	0.295	28.06
7.75	0.285 MIN	27.22	0.292 MIN	26.58
7.31	0.290	25.23	0.299	24.45
6.93	0.302	22.94	0.326	21.28
6.61	0.710	9.30	0.732	9.03

Selig Donovan 8000

Wing Loading = 3.00 kg/Sq. M.
Aspect Ratio = 15
Mid Chord = 33.00 cm.
Span = 4.50 Metres
Root Chord = 35.00 cm.
Taper Ratio = 0.50

chordwise position, or even ahead of the wing on small outriggers. A zig-zag or serrated tape may sometimes be more effective than a straight strip turbulator (Figure 36), though the authors of Soartech 8 found no such difference. On full-sized sailplanes, pneumatic turbulators are also used, these being rows of fine holes, pin-prick sized, through which air under pressure from a carefully placed intake is blown continuously. The single Princeton test with this type of turbulator was inconclusive. Pneumatic turbulators do seem to work on full-sized wings but perhaps are no better than the simple strips. The turbulator, whatever its type, is intended to prevent or at least to control the formation of boundary layer separation bubbles (Figure 37). A full explanation of this will not be attempted here.

The effects of turbulators may be judged directly from the wind tunnel tests. A turbulator which is correct for

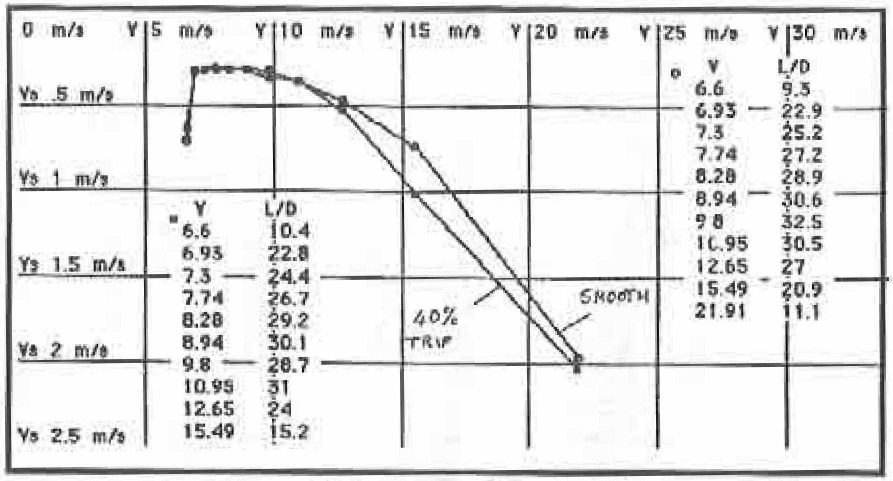


Figure 39 Performance Polar for Wing

Velocity Metres/Sec	SD 8000 Smooth Sink M/Sec	SD 8000 Smooth L/D Ratio	SD 8000 Trip 40% Sink M/Sec	SD 8000 Trip 40% L/D Ratio
21.92	1.960	11.18	2.032	10.79
15.50	0.739	20.98	1.014	15.28
12.65	0.468	27.06	0.527	24.02
10.96	0.359	30.53	0.353	31.02 MAX
9.80	0.301	32.53 MAX	0.341	28.76
8.95	0.292	30.69	0.297	30.16
8.28	0.286	28.97	0.284 MIN	29.21
7.75	0.285 MIN	27.22	0.290	26.72
7.31	0.290	25.23	0.298	24.49
6.93	0.302	22.94	0.304	22.83
6.61	0.710	9.30	0.630	10.49

one trim and flight speed may be wrong for another. Turbulators usually improve the performance of a model wing section at low flight speeds but increase drag at high speeds. Since it is important for thermal soaring sailplanes to fly both fast, for penetration, and slowly, for soaring, turbulators may be more of a handicap than an asset and each wing profile responds differently.

SD 8000 and Eppler 214 with turbulators

The SD 8000 profile was tested at Princeton with a trip in three different positions. The turbulator was a strip of tape 0.17% of the wing chord in thickness, and 1.0% of the wing in width. (0.17% of a 350 mm chord wing, is 0.6 mm or ≈ .02 ins.) This 'trip strip' was positioned for one test series at 20% of the chord on the upper side of the wing, then moved for another test to 40% and finally to 70%. In Figure 38, 39 and 40, using all the same dimensions and methods as previously, the effects of these trip strips are compared with the performance of the plain SD 8000 wing.

With this profile there is evidently little or nothing to be gained by using turbulators on a large thermal soarer. The 20 and 40% trips spoil the high speed part of the polar without any noticeable

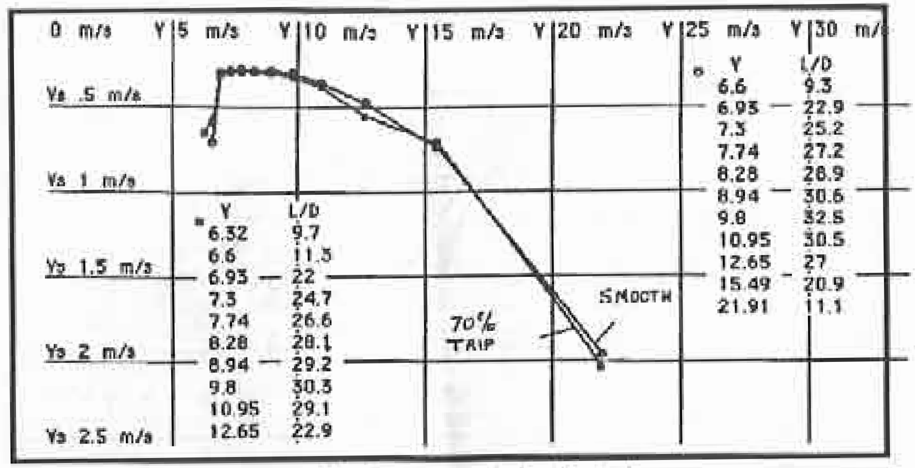


Figure 40 Performance Polar for Wing

Velocity Metres/Sec	SD 8000 Smooth Sink M/Sec	SD 8000 Smooth L/D Ratio	SD 8000 Trip 70% Sink M/Sec	SD 8000 Trip 70% L/D Ratio
21.92	1.960	11.18	2.031	10.79
15.50	0.739	20.98	0.706	21.95
12.65	0.468	27.06	0.550	22.99
10.96	0.359	30.53	0.376	29.18
9.80	0.301	32.53 MAX	0.323	30.37 MAX
8.95	0.292	30.69	0.306	29.25
8.28	0.286	28.97	0.295	28.11
7.75	0.285 MIN	27.22	0.290 MIN	26.68
7.31	0.290	25.23	0.295	24.76
6.93	0.302	22.94	0.314	22.09
6.61	0.710	9.30	0.584	11.32
			0.650	9.73

improvement at low speed. The 70% trip has little effect. At this location it is probably behind the separation point, and so has no effect on the flow ahead of the bubble at all.

This negative result should not be assumed to apply to all profiles. Figure 41 shows the effect of adding a turbulator at 20% of the chord to the upper surface of an Eppler 214 wing which, as previously mentioned, proved disappointing in its smooth form against the Clark Y. With this modification the E214 shows a worthwhile improvement at low speeds: a low rate of sink and low stalling speed. The high speed polar still falls below the Clark Y at moderate and higher speeds, as shown.

Generalising from such limited data is risky but if a model proves disappointing, especially at low flight speeds, it may be worth experimenting with simple turbulators in different positions, to discover if an improvement results.

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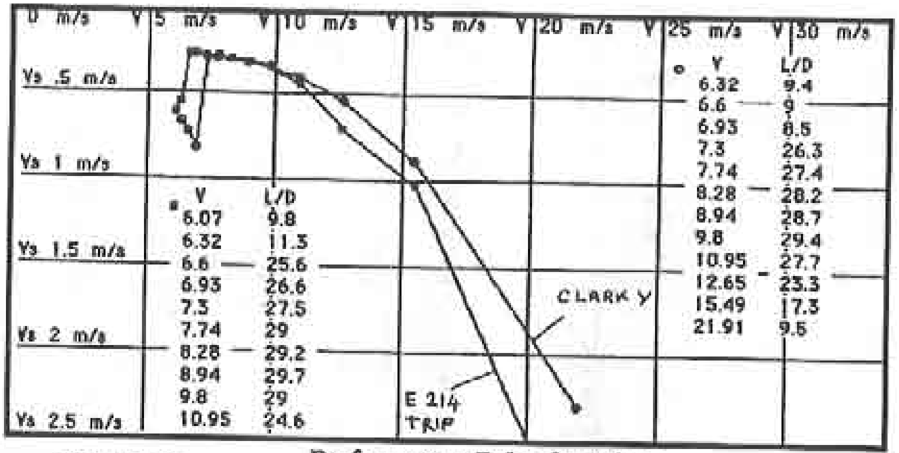

Figure 41 Performance Polar for Wing

Velocity Metres/Sec	Clark-Y-PT Sink M/Sec	Clark-Y-PT L/D Ratio	Eppler 214C TURB Sink M/Sec	Eppler 214C TURB L/D Ratio
21.92	2.301	9.53	3.130	7.00
15.50	0.891	17.39	1.023	15.15
12.65	0.543	23.31	0.706	17.91
10.96	0.395	27.71	0.445	24.63
9.80	0.333	29.41 MAX	0.338	29.03
8.95	0.311	28.79	0.301	29.74 MAX
8.28	0.293	28.25	0.283	29.28
7.75	0.282	27.48	0.267	29.01
7.31	0.278 MIN	26.30	0.265	27.52
6.93	0.815	8.50	0.260	26.67
6.61	0.734	9.00	0.258 MIN	25.62
6.33	0.670	9.44	0.558	11.33
			0.618	9.84

Soaring Kids

...by Chuck Mc Calment

After spending time with preteens who were learning to fly R/C sailplanes, several things come to mind.

A two-meter hits the ground with less energy than larger planes but, more importantly, they are of a scale that does not intimidate these young builder/flyers. Morning flying when the kids are fresh and the wind is light seems to provide the best environment for learning and the most happy faces. If the flying is going well it is easy to extend into the more dynamic air of mid-day. Sometimes the young flyer is uncomfortable with one aspect of flight or another. For instance, one student was uneasy with the plane at full launch height. The solution was for a seasoned pilot (not necessarily an adult) to launch via hi-start as normal, establish a stable glide while talking the learner through a few laps of an imaginary oval circuit whose long axis was at right angles to the launch path. During the descent, anytime the young flyer feels comfortable, they can assume control and continue the flight. The secret appears to be repetition, establishing a normal pattern of flight by example. At about four wing spans above the ground the plane should intercept the landing pattern entry gate. At that time the plane should be turned ninety degrees left (downwind if flying in wind), get the wings level and then make a one hundred-eighty degree left turn. The turn is made with the student at the center, control-line style. As the plane goes by, level the wings and let it land itself, no control reversal problems. A confidence builder and lots of fun if you keep adult directives out and an encouraging smile in.

When building that first ship, it should be stressed that it is a tool to be used to learn to fly. We have tried to soften the blow of that first crash by conferring great status on the best "beater 2-meter" at the field. The young people seem to realize that the patches and repairs are lessons learned and skills acquired. The real pretty planes belong to the "new kids" at the field. In soaring, we have the level playing field that allows the boys and girls to participate on equal terms.

Kids at the field are willing and helpful once the basics have been explained. The Pits are the place planes are protected from those that walk with their head in the clouds and their feet on the ground. Know who is flying on your channel and share the flying time with them. If you launch once, next time it's your turn to retrieve the parachute. Asking a pilot about to launch to wiggle the rudder from side to side proving radio control is not demeaning but really polite. Bringing a garbage bag to clean up after flying is not only a nice way to treat your site but a great way to increase your treasure of misc. R/C paraphernalia. When looking up, wear sunglasses and use a little suntan lotion to protect yourself. A pre-flight check of the plane can save many hours of late night rebuilding. Check all your connectors after a hard landing. People are MUCH more important than planes. We need to think clearly about the safety of all those around us and to teach that attitude to all those that fly R/C. If we teach the up coming flyers to live by rules that make sense then, maybe, they will remind us when we forget.

Flying can be a learning tool for the youngsters as well as a motivational tool for the adult. Direct cause and effect relationships are evident in all aspects of flying. Not only can R/C provide a medium for quality time with the kids but also a means of escaping the dreaded Saturday "Honey due List".

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Understanding Thermal Soaring Sailplanes

Part 4 of 4 Parts Continued

(This column began in January, 1990. Each part covers several months.)

...by Martin Simons

Smooth and textured finishes

Some modellers believe that the type of covering material used on the wing makes a considerable difference to the performance and handling of the sailplane. The effect is thought to be similar to that of a turbulator, creating fine grained turbulence in the boundary layer, but unlike the 'trip strip', the entire wing surface is involved.

At Princeton a SD 7032 profile was tested with a plain balsa skin, which was then covered with plastic film to give the usual glossy surface, and re-tested. The outcome in performance polar terms probably requires no further comment (Figure 42). The smooth film skin shows a marginal advantage, particularly noticeable near stalling speed.

A point made by some pilots is that even though a textured finish may have no noticeable effect on the polar curve of the sailplane, or even make it a little worse, it can render the model easier to manage in the air. This is not supported by the curves of Figure 42, which actually indicate a higher stalling speed for the balsa skinned wing, but it may be correct in some cases. If a profile develops laminar separation bubbles, the bubbles tend to change size, sometimes contracting to the so-called 'short bubble' form and sometimes lengthening to extend over a third or even more of the wing chord. Such bubble separations shift to different locations on the wing at different angles of attack. This alters the pressure distribution on the wing and must have some effect on control and stability. If the slightly 'grainy' finish of a fabric covered wing acts as an ever-present turbulator, there will be a drag penalty and the polar curve will be worse. But if no separation bubbles form, improved stability and smoothness of response to control are quite likely. In such a case it may well be preferable to sacrifice some performance for the sake of better handling. A pilot who finds the sailplane easy to manage is likely to do better with it than with a theoretically superior model which requires frequent corrective actions or which stalls suddenly when a separation bubble 'bursts' at a high angle of attack. There is little doubt that apparently identical sailplanes covered with different material, do behave differently in the air. Once again, experience and experimentation are the best way to proceed.

It may also be the case that the very inaccuracies of some model wings, for instance the use of multiple spars with film or fabric covering sagging between them, has desirable effects in avoiding separation bubbles. The wind tunnel results on the 'wavy clay' version of Eppler 374, mentioned in Part 3, suggest that quite large irregularities of form can sometimes actually improve the performance of a model wing. The Eppler 374 profile was also tested by Dieter Althaus at Stuttgart, with various different finishes and structures. At the lower Reynolds numbers the least accurate type of construction showed up best.[1]

What seems to be true for one profile may not be so for another. Although any such generalisation is rather dangerous, it is probably fair to say that a reasonably accurate, smooth and polished wing will give best results at high speeds, without turbulators. Turbulators, textured coverings, and even rather wobbly construction, may have some beneficial effects with some wing profiles. This should not be used as a general excuse for inaccuracy. A bad profile may be 'repaired' by using turbulators or rough surface finishes, but there is not really much doubt that a modern profile will give better results, if it is accurately made and finished.

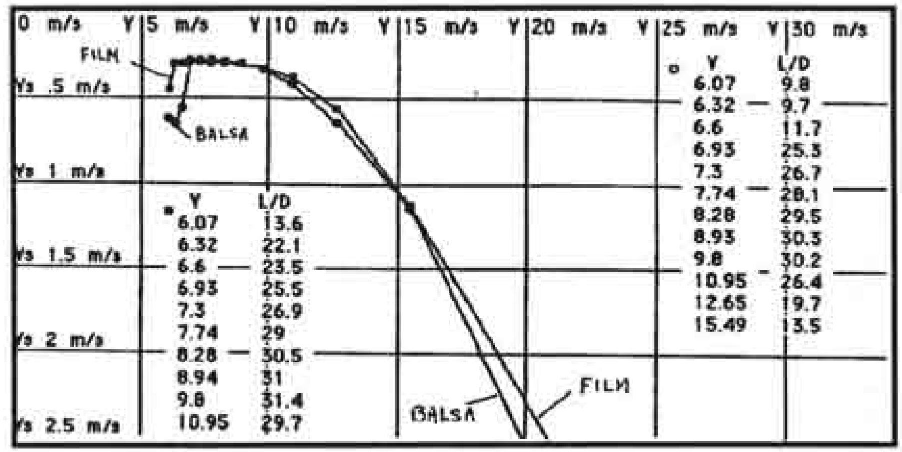

Figure 42 **Performance Polar for Wing**

	SD 7032 A Balsa Skin		SD 7032 B Film Skin	
Velocity Metres/Sec	Sink M/Sec	L/D Ratio	Sink M/Sec	L/D Ratio
21.92	3.139	6.98	2.768	7.92
15.50	1.145	13.54	1.126	13.76
12.65	0.642	19.72	0.556	22.74
10.96	0.414	26.47	0.368	29.77
9.80	0.324	30.25	0.311	31.48 MAX
8.95	0.295	30.37 MAX	0.288	31.08
8.28	0.281	29.51	0.271	30.52
7.75	0.275	28.17	0.267	29.04
7.31	0.273 MIN	26.73	0.271	26.92
6.93	0.274	25.31	0.271 MIN	25.53
6.61	0.562	11.76	0.280	23.56
6.33	0.649	9.75	0.286	22.16
6.08	0.619	9.83	0.445	13.65

Parasitic drag

As shown before (Figure 9, Part 2, *RCSD* April, 1990), parasitic drag is relatively unimportant at low speeds but increases rapidly as the airspeed rises. In a thermal there is only slight advantage in having very low parasitic drag but in searching for the thermal it makes a lot of difference. The chief aim of reducing parasitic drag is therefore to improve the high speed part of the polar.

To bring this into perspective, use has been made of the **Sailplane Design** (Version 3) computer program devised and marketed by David Fraser.[2] This program makes approximate allowances for tail and fuselage drag and uses the Princeton wind tunnel test results for the wing profile drag. A good many factors enter into calculations of parasitic drag which no program so far has been able to

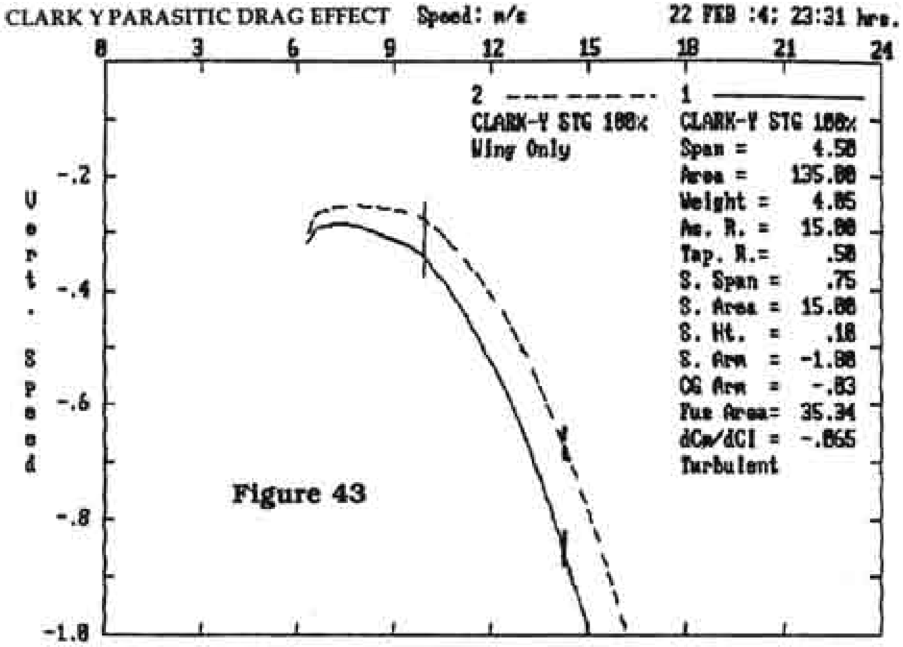

Figure 43

accommodate fully. In what follows, therefore, the various figures and charts should be taken as approximate, rather than exact. The methods of calculation differ slightly from the author's 'wing-only' program which has been used hitherto. Slightly different absolute performance figures appear.

To begin with something familiar, the upper curve on Figure 43 shows the performance of a Clark Y profile wing, of 4.5 m span and 1.35 sq metres area, according to the Fraser program. The lower curve results when an ordinary tail unit and fuselage are added to this wing.

The main relevant dimensions are shown in the table of figures on the right hand side of the diagram. The horizontal stabiliser area here is 10% of the total 1.5 sq metres, i.e., 0.15 sq m, or 11.1% of the 1.35 sq m wing area. Stabiliser span is assumed to be .75 m. and it is mounted 10 cm above the estimated position of the wing wake. The program assumes the vertical stabiliser is half the horizontal stabiliser in area. The fuselage skin area is approximated at 35.35 sq dm, the tail moment arm is 1.8 metres, the centre of gravity of the model is 3 cm aft of the wing aerodynamic centre. The last figure in the table is the stability factor, which is discussed below. The boundary layer flow over fuselage and tail is assumed to be turbulent rather than laminar.

At every point the vertical distance between the two polar curves represents the drag penalty associated with the tail unit and fuselage. The figures produced by the program show that at minimum sink trim, 89% of the total drag comes from the wing. (This is found by adding the vortex-induced drag and the profile drag of the wing.) At best L/D, the wing drag is still 82%. and at a flight speed of 15 m/s (33 mph) 78% of the total. Turning this round the other way, at low speeds about 11% of the drag is caused by tail and fuselage, at higher speeds this rises to more than 22%.

These figures apply only to one particular sailplane configuration and method of calculation but they are fairly typical. Comparable calculations with different dimensions show roughly similar proportions. The effect of any single alteration will in practice probably be undetectable but careful attention to all possible details should produce a worthwhile improvement in total drag.

Flying wings?

We cannot, unfortunately, reduce parasitic drag to zero. The idea of the 'all wing' layout is almost as old as aviation itself. Diagrams such as Figure 43 tempt enthusiasts into supposing that a sailplane with no fuselage or tail would show savings of total drag between 10 and 30%. Unfortunately, to make a reasonably controllable aircraft without a tail, the wing itself has to be completely redesigned, usually with a reflexed profile and some sweepback, both of which reduce efficiency. It also proves practically impossible to do without vertical fins and rudders and these sometimes have to be excessively large, to provide stability in yaw. Even with the benefits of up-to-date design methods, some modern tailless full-sized sailplanes have still proved extremely difficult to fly and even dangerous. So-called 'flying wing' aircraft can be made safe and controllable but the outcome is a considerable increase in both vortex and profile drag, offsetting or more than offsetting the gains hoped for, while some parasitic drag from the enlarged vertical stabilisers remains after all.

Tail drag

A large proportion of the parasitic drag of an orthodox design, is caused by the tail unit. Normally the tail comprises a horizontal stabiliser, which incorporates the elevator control, with a vertical surface, usually a fin with a hinged rudder. (If a V tail is used, the total area of the two surfaces is about equal to the total area of the vertical and horizontal members of an ordinary tail.)

Tail surfaces are small wings and all remarks about wings can be transferred, with necessary changes of emphasis, to tail surfaces.

Tail drag, like wing drag, is a combination of vortex drag and profile drag.

[1] See D. Althaus, Profilpolaren für den Modellflug, Vol 2, published by Neckar Verlag, Stuttgart 1985.

[2] Sailplane Design is obtainable from David B. Fraser, 1335 Slayton Drive, Maple Glen, PA 19002, USA

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The 1991 Southwest Regional Sailplane Championships were held on January 19th in Casa Grande, Arizona. The photos were provided by Chuck Wehofer (Secretary/Newsletter Editor) of The Central Arizona Soaring League (C.A.S.L.).

...continued on page 30

Understanding Thermal Soaring Sailplanes

Part 4 of 4 Parts Continued

(This column began in January, 1990. Each part covers several months.)

...by Martin Simons

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Tail vortex drag

Vortex drag is large if the angle of attack of the wing or wing-like surface is large. With tail units, the angle of attack in normal flight attitudes is always small and may be zero. The vertical tail surface, for instance, develops lift only when it is called on to correct a yaw, or when the rudder is applied. In correctly trimmed straight flight there is therefore no difference in pressure between the two sides, so no tip vortex forms. In a correctly flown turn with no yaw, the same applies, or very nearly so. Vortex drag of a vertical tail is therefore either very small or none.

The horizontal tail surface also, normally, creates very little or no vortex drag, but this is not correct if a large share of the total weight of the aircraft is carried by the tail. In an extreme case, the aircraft can become a tandem, with roughly equal sets of wings one behind the other. In such a case, the rear wing may be thought of as an excessively large tailplane, and if it supports its fair proportion of the weight of the aircraft, it will develop a good deal of vortex drag. In a canard layout the same applies. The vortex drag of a canard forewing is not small, because it is rigged always as a lifting member and, for reasons of stability and balance, must operate at a higher aerodynamic angle of attack than the mainplane. Any surface which is made to lift a load will produce vortex drag which will increase rapidly as the load on it increases. So far, canard and tandem type sailplanes have not proved themselves superior to the orthodox layout.

Tail profile drag

The other component, profile drag, of a tail unit is a combination of skin drag and pressure drag. Pressure drag is created when the air has to flow around a body. The thicker the body, the greater the pressure drag tends to be. Tail sections are usually very thin and work at small angles of attack. The pressure drag of tail units is therefore relatively small, although not negligible.

Skin drag, caused by the passage of the airflow over the whole of the exposed surface, therefore constitutes the bulk of tail unit drag. Although it is an oversimplification, it is not far from correct to say that the drag of a tail unit will be roughly in direct proportion to its size. If the tail (including vertical and horizontal components) totals about 20% of the wing area, it is going to create about 20% as much skin drag as the mainplane does. Accordingly, if the total tail area is halved then its skin drag will be roughly halved. There are certainly other small factors involved, such as the proportion of laminar flow in the boundary layer flow over the tail, and how much of the tail is operating in the disturbed wake created by the fuselage and the mainplane, but these should not be allowed to obscure the main point: the larger the tail, the larger its share of the total drag.

Cutting tail area

Hence to reduce the drag generated by the tail, the most profitable thing to do is to reduce its total area. A good approach is to consider existing successful designs and consider whether any savings in tail area can be made without sacrificing other desirable features, especially stability and control.

Moment arms and tail volumes

One possibility, easily understood, is to increase the moment arm of the tail, by lengthening the rear fuselage. This allows a reduction in total tail area, and hence drag, without having much effect on stability and control of the sailplane.

A rough figure for the vertical and horizontal tail volumes of an existing successful soarer can be worked out. One way is to multiply the distance between the wing's and tail's respective aerodynamic centres, by the projected tail areas. The centre of gravity may be used as a reference point instead of the wing's aerodynamic centre, but the purely geometrical dimensions are perhaps somewhat easier to work out for a new design. Either way, the tail area (either vertical, or horizontal) is multiplied by a relevant moment arm length, to give the so-called tail volume. As the moment arm is stretched, the tail areas required to give approximately the same volume and power, are reduced. Thus, a tail moment arm of 1.5 metres multiplied by a tail area of 0.3 sq metres, gives a volume of 0.45, which could be obtained by a smaller tail area of 0.25 sq m on a moment arm of 1.8 m. This would, very roughly, reduce tail drag by a sixth. To achieve a reduction of one third the original figure, by reducing the tail area to 0.2 sq m, the moment arm would have to be increased to 2.25m, and so on.

There are fairly obvious limits to this procedure. As any wing-like surface is reduced in size it loses efficiency due to Reynolds number effects. A small tail unit attached to a fuselage will also be partly submerged in the wake of its supporting structure. The smaller the tail, the more such things will count. Lengthening the tail moment arm cannot safely be taken so far that the tail unit is reduced to vestigial fins like the fletching on an arrow. In any case, fuselage skin drag itself increases as the moment arm is extended, so there is no point in making the tail boom ridiculously long. Keeping the centre of gravity position, for the model as a whole, in a sensible place also becomes more difficult if the tail boom is too long. Excessively long fuselages become very difficult to transport from place to place, and are vulnerable to damage in heavy landings.

It is convenient to have the total fuselage length about equal to the semi-span of the wing and practical experience shows that such proportions are satisfactory, yielding reasonable tail areas, good stability and control. On the other hand, shortening the moment arm and magnifying the tail areas to give the same volumes increases tail drag more than it decreases fuselage drag. Bringing the tail too far forward, closer to the disturbed air behind the wing, decreases tail efficiency, so the simple tail volume coefficient becomes less reliable as the fuselage tail boom becomes shorter.

There is some justification for moderate lengthening of tail moment arms to reduce tail areas. The only argument in favour of shortening tail moment arms is to reduce the moment of inertia of a long tail, thus slightly improving the controllability and maneuverability of the model. This involves a drag penalty because the tail areas, vertical and horizontal, have to be enlarged to keep the volumes in proportion. ■

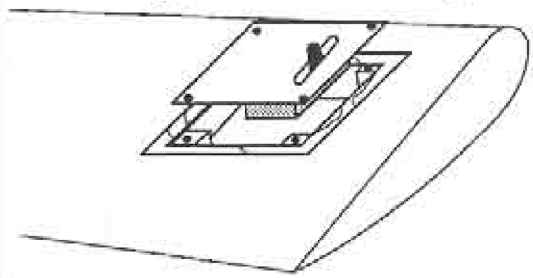
Martin Simons has been actively involved with model aircraft since the 1930's and is regarded as a leading world authority on vintage gliders and sailplanes. He has over 1300 hours flying full-size gliders, many of which are described in his book *The World Vintage Sailplanes 1908-1945*. His column, "Understanding Thermal Soaring Sailplanes", brings the soaring enthusiast insights into sailplane design and construction from theory and design through the building and flying phases. His latest model, a scale replica of the PWS-101, won two competitions within a month of its first flight. ■

8) After the wing is bagged (or sheeted), cut out the mylar temporary hatch. Obviously, it is much easier to find if you are bagging the wing with fiberglass. If you are sheeting with wood, probably the best way to locate the hatch would be with some sort of template that you made before you sheeted over the hatch.

9) You are now ready to attach your servo to the bottom side of the 1/32" ply hatch. I cut small spruce blocks and epoxy them to the hatch. Then, I use #4 sheet metal screws to attach the servo to the blocks.

10) With the servo hatch assembly in place and the servo plugged into its extension lead, drill holes through the corners of the hatch plate, into the spruce blocks. Enlarge the holes in the corners of the hatch plate to clear the screws that you will be using, and attach the plate. ■

Mount the servo to the underside of the Hatch Cover....Drill mounting screw holes in the corners of the hatch cover, and matching pilot holes in the mounting posts.



Understanding Thermal Soaring Sailplanes

Part 4 of 4 Parts Continued

(This column began in January, 1990. Each part covers several months.)

...by Martin Simons

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The horizontal tail

Figure 44 shows how the drag of the model in the previous figure may be analysed further, using the Fraser program. The vertical distance between the upper (wing only) curve and the middle curve here indicates the contribution of the horizontal tail: at minimum sink trim, 6% of the total drag, at 15 m/s, 15%.

If the horizontal stabiliser area could be half the size, its drag would be practically halved. Moreover, since the serious contest model will be built up to the largest allowable total area, a reduction of stabiliser surface frees some surface to be transferred to the mainplane, thus improving the efficiency of the wing at the same time as the tail drag is cut. By doubling the moment arm, a half sized tailplane could be achieved, but fuselage drag would increase and the other problems associated with excessively long moment arms would arise. Suppose, then, that the tail area was simply halved without any other alterations.

The kind of improvement that can result from this is indicated in Figure 45. Here, two models with the SD 8000 wing profile are compared. One has the 10% (0.15 sq m) stabiliser area as before, shown by the broken line on the polar chart. The other model has a stabiliser of half the size (5% of the total) on the same moment arm. The area saved from the tail has been added to the wing, resulting in a slightly greater span (4.62 m) at the same aspect ratio. There is a noticeable, and tempting, improvement in the polar throughout the speed range.

Stability?

Such an improvement in drag is not, of

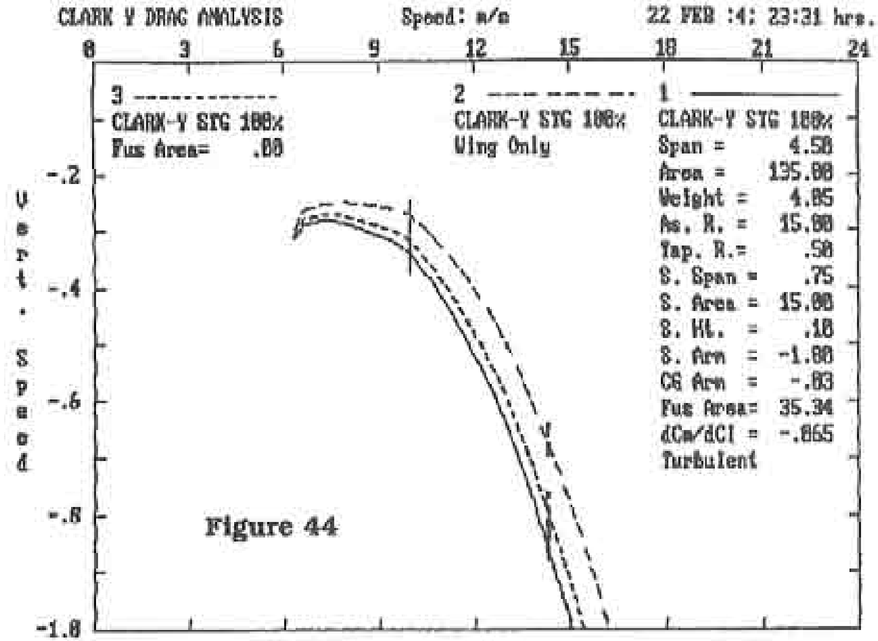

Figure 44

course, without penalty. A stabiliser area of only a little over 5% of the wing area would be considered very small by most model fliers and even a scale model of a full-sized sailplane would probably not have a stabiliser less than 7 or 8% of the wing area. The point remains that tail drag can be reduced most effectively and simply by reducing tail areas. Stability raises some other issues.

If a model sailplane has too little stability in pitch, it becomes excessively sensitive or 'twitchy' on the elevator and extremely exhausting for the pilot, requiring constant corrective control action. At some distance away, or at great heights, it is impossible to judge flight attitudes and speeds, with the result that the model may easily get totally out of control.

On the other hand, if the pitch stability is too great the elevator becomes sluggish and unresponsive. This is safer, since the pilot may let the model fly 'hands off' for fairly long periods, confident that nothing very drastic can go wrong. However, an over-stable sailplane is not pleasant to fly and may sometimes refuse to respond swiftly in an emergency. Excessively stable models may also pass rather solidly through thermals without giving much indication of the change of air, whereas a less stable trim might signal the situation by reacting more vigorously.

In Figure 45, the stability factor of the model is indicated by the figure for dCm/dCl, a large negative figure here indicating a stable model. A positive figure for dCm/dCl means the model will be practically uncontrollable and may be expected to crash within a few seconds of launching. A stability factor of zero is the so called 'neutral' static stability which in flight becomes almost impossible to cope with. Stability factors of about -0.04 would be considered reasonable. and there would be no harm in going to -0.7 or -0.08.

By halving the stabiliser volume in the example, the stability factor has been reduced from -.065, which is safe, to -.024. which is verging on the dangerous.

If the tail volume is regarded as fixed,

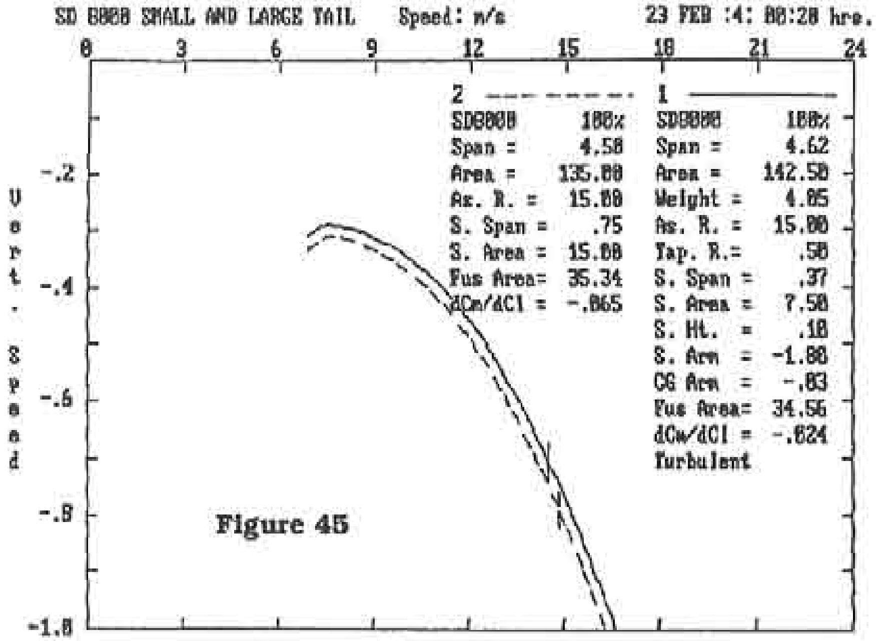

Figure 45

the pitch stability factor depends mainly on the centre of gravity position. The further forward the c.g. goes, the more stable the sailplane becomes. Moving the c.g. aft decreases stability and, as may be found by experiment with any existing model, will produce dangerously sensitive or 'twitchy' elevator response if carried too far.

Other factors enter the equations, such as tailplane efficiency, which can be improved by using a T tail to get the stabiliser out of the wing and fuselage wake, and by designing tail surfaces with moderately high aspect ratios, but these are relatively far less important than c.g. position.

To restore a safe margin of stability with a halved tail volume, the simplest solution is therefore to move the centre of gravity forward. In the next diagram (Figure 46), the c.g. has been moved to coincide with the wing's aerodynamic centre, i.e., the c.g. is placed at about 25% of the mean wing chord. (In practice this simply means putting more trimming ballast in the extreme nose of the sailplane until it balances at the quarter mean chord position.) The c.g. arm has been reduced to zero, as shown in the tabulated figures. Even with the small stabiliser, the stability factor has been improved to -.043 by this. Some stability has been sacrificed for the sake of drag saving, but the outcome is not unreasonable. ■

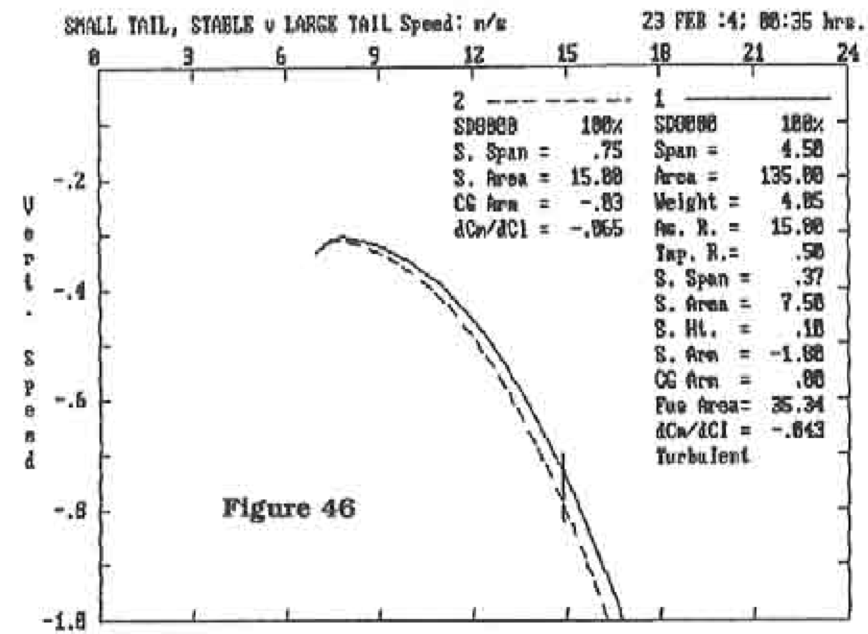

Figure 46

Ridge Writer

...by Wil Byers

RT. 4 Box 9544, W. Richland, Washington 99352; (509) 627-5224 (7:00 PM - 10:00 PM weekdays, after 9:00 AM weekends)

The Mid-Columbia Cup slope races recently past (May 24 & 25) with Joe Wurts coming out on top of the heap, and one thousand dollars richer. Joe is a great R/C glider flyer who is an extremely good race pilot. You will have an opportunity to read more details about the race in another article in this publication, but I want to talk about the question most asked of winning pilots. That question is of course, "What airfoil are you using?"

"What airfoil?" is a very interesting question indeed and one which most soaring pilots highly emphasize. They emphasize airfoils because so many of these pilots are also interested in the design of their models and what physical features cause them to fly as they do. Undoubtedly, they are right, the most important of these features is going to be the airfoil, even though a number of other design parameters play a vital role in the model's overall performance. So this month, because so many would be designers are interested in airfoils, I'm dedicating most if not all of my column to the airfoils that were used at the Cup race. You can study these sections and decide for yourself what would be an appropriate choice for your "World Beater". Remember, however, that the most important ingredient for a winning design is a competent pilot, who knows their model very well.

I've also included the airfoil section that set the F3F speed record in Europe, at the Viking Cup, this last year. That section was the Quabeck 1.0-9. As noted by its number it has a camber of 1% and is 9% thick. The combination of airfoil, model design, and pilot turned in a very impressive 29 second run on the course. Remember, in F3F it is a combination of speed and the ability to perform good turns at the end of each 100 meter leg that turns in fast times and winning performances.

If you would like the coordinates for any of these airfoils I will be glad to provide them. Just send me a SASE to my address

Slope Scenes

On a recent business trip to Virginia, I had the opportunity of flying (flat field) with Herk Stokely and Bob Champine. Herk Stokely as many of you know is the contributing editor for *Flying Models*. Herk was kind enough to loan me one of his models and I was even able to enter their contest. It was a great deal of fun and gave me an opportunity to meet many interesting fellows. One of these individuals is Bob Champine. Bob is, if find its listings useful.

"In addition to chronological listings of material on tailless aircraft and related topics, the bibliography includes other helpful information. A preface furnishes a brief perspective on tailless development and its chief proponents. Introductory material includes discussion of tailless guidelines, content and format of the bibliography, information on acquisition of tailless aircraft information, and suggestions for reasonable core material from the tailless literature. Listed items are commonly accompanied by notations concerning topic, content, length, presentational features, and sometimes other cross-referential material or sources. Brief lists of previous bibliographies and sources of rare materials are also included. Finally, an appendix lists dates for tailless aircraft by more than 100 selected designers.

"The book is spiral bound (helically) in durable patchco grained material, so that it can he opened back on itself without folding or otherwise damaging its pages. It can also be dragged through library stacks - or wherever - with a minimum of wear."

The preface remains our favorite part of the book. It is here, in the opening pages, that we read about a few of the notable designers and their approaches to the unique problems of tailless aircraft. Mr. Krauss, however, goes further. He explains the underlying drives which relentlessly force those individuals to persist, sometimes in the face of strong personal and monetary adversity. We, not too surprisingly, see inklings of these drives in ourselves, and so the preface lends support to some of our own goals, while at the same time reminding us of the existence of fallacies.

As genuine tailless and flying wing fanatics, we have devoured this book several times over. After more than a year it still serves as an efficient source of information, and it has in fact stimulated us to catalog our own collection of materials dealing with tailless aircraft.

The first edition of "Tailless Aircraft - An Extensive Bibliography for Subsonic Types" was printed in December of 1989. Mr. Krauss adds to the tailless bibliography as he finds materials not previously listed and updates it with recent citations. A copy of the current version is available directly from Serge for $20.00, all taxes and postage included. Write to Serge Krauss, Jr., 3114 Edgehill Rd., Cleveland Heights OH 44118. Please be sure to mention *R/C Soaring Digest*! ■

Understanding Thermal Soaring Sailplanes

Part 4 of 4 Parts Continued

(This column began in January, 1990. Each part covers several months.)

...by Martin Simons

Martin Simons, 13 Loch Street, Stepney, South Australia 5069

Balance, trim and vortex drag

Model fliers are often reluctant to trim with the model's centre of gravity forward, even though this allows the use of a smaller tail. There is in fact a fairly widespread belief that having the centre of gravity aft improves the all-round efficiency. Free flight sailplane fliers still almost always rig their models with c.g. well aft, and use tailplanes with pronounced upward camber. There seems to be no justification for this kind of arrangement, other than slavish adherence to fashion. Some further explanation may be required to emphasise this.

If the aircraft is to fly at a steady airspeed, in equilibrium, the total of all pitching moments must be brought to zero, that is, balanced out. The pilot accomplishes this balance by adjusting the elevator. A model can be trimmed to fly with c.g. forward or aft, with an appropriate change of elevator neutral position for each change of c.g.

Stability, and hence elevator sensitivity, will be affected, as described above. There is a range of safe positions for the c.g.: too far aft and the model becomes dangerously unstable, too far forward and the elevator becomes so insensitive that there is insufficient control. These simple effects can be investigated by anyone with a serviceable sailplane and the ability to remove, or add, ballast in the nose of the fuselage.

If the wing has normal positive camber, which in thermal soarers is invariably the case, the camber itself generates a nose down pitching moment (Figure 47). If the centre of mass or centre of gravity of the model coincides with the aerodynamic centre of the wing (always close to 25% of the mean wing chord [1]), the wing camber pitching moment will have to be balanced out by a negative (downward) balancing force generated by the tail. In full-sized aircraft practice, this is in fact considered the 'normal' situation, a download on the tail countering the wing camber pitching tendency.[2] The mainplane then has to support a total lift load slightly more than the weight of the aircraft.

There is a small vortex drag penalty. The extra load on the wing creates slightly stronger wing tip vortices and the download on the tail produces tip vortices there too. Wherever there is a difference in pressure between the upper and lower surfaces of a wing tip, a vortex will form. So, moving the c.g. forward increases both wing and tail vortex drag very slightly. But by moving the c.g. forward, the tail areas, and hence tail profile drag, can be reduced without spoiling stability. A net saving in total drag results. C.g. forward thus improves the polar of the sailplane.

If the centre of gravity is moved somewhat behind the 25% mean chord aerodynamic centre of the wing, the wing lift, acting upwards, creates a nose up pitching moment about the c.g. reference position. The wing camber still tends to pitch the nose down. It is possible to arrange the c.g. position and trim so that the lift (nose up) moment and the wing camber (nose down) moment exactly balance one another in level flight at some airspeed. The stabiliser in such a case will carry no load up or down. This rather delicately poised situation cannot be maintained perfectly over the entire range of possible airspeeds and angles of

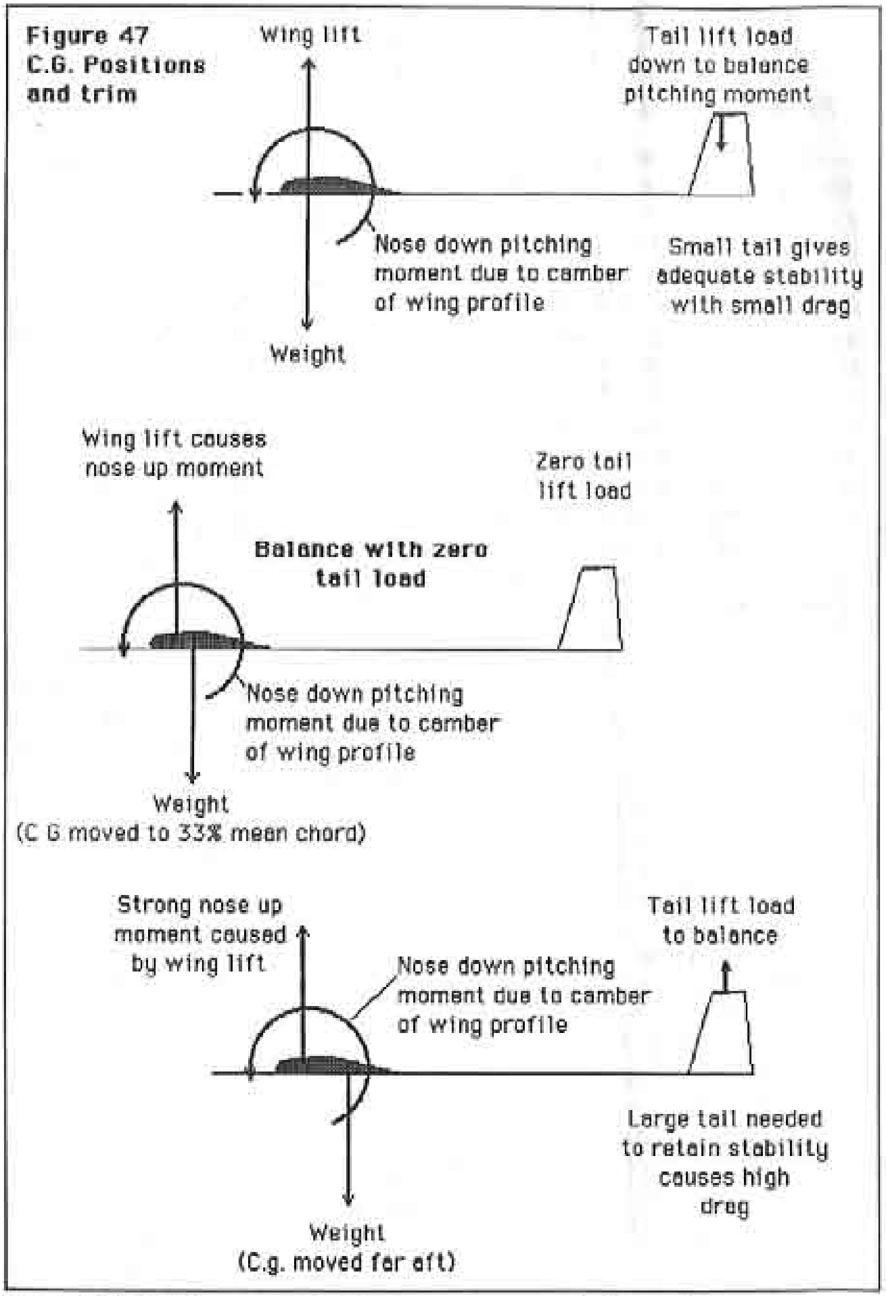

Figure 47
C.G. Positions and trim

attack that a sailplane may experience, but the zero-tail-load trim may be approximated for fairly normal flight speeds, with the c.g. at about 33% of the mean wing chord, a location frequently recommended for models.

Tail vortex drag is practically zero in this situation, and no extra load is transferred to the wing so the wing vortex drag is not increased either. But because the c.g. is aft, to retain adequate stability and control, the tail volume has to be enlarged proportionately and this increases tail profile drag more than the very small saving in vortex drag. The total drag of the sailplane is thus greater than with c.g. forward, for the same stability factor. This not, therefore, the most efficient c.g. position.

If the c.g. is moved further aft still, say to 40 or even 60% of the mean wing chord, as on some free flight sailplanes, the net pitching moment of the model without the tail is strongly nose up. The lift of the mainplane acting on its longer moment arm ahead of the c.g., more than counteracts the nose down pitch of the wing camber. To balance this, the tail has to be trimmed at a positive lifting angle to maintain the balance.

In this situation, there is some reduction in wing tip vortex drag because the wing has less load to carry, some of the lifting work has been transferred away from the wing to the tail. But the tail does develop tip vortices. More importantly, to retain stability, the tail area has to be increased and the total drag rises. Since the tail normally is less efficient than the wing, it produces its small amount of lift at a disproportionate cost in both profile and vortex drag. Despite many generations of free flight model sailplanes with so-called 'lifting' tails, moving the c.g. forward and reducing tail areas accordingly produces a more efficient aircraft, while retaining adequate stability factors.

There are other factors which enter the complete equations for tail drag and stability. For example, the direction of the airflow at the tail is influenced by the downwash from the wing. The combination of downwash and the negative tail angle of attack when the c.g. is forward, can produce a slight inclination of the tail lift vector in the forward direction. This, in a completely rigorous analysis, appears as a small force in the direction of flight, equivalent to a reduction in drag. In complementary fashion, a tail which, with aft c.g., is made to lift upwards, may produce a slight rearward component of force, and hence an equivalent increase of drag. Such effects are almost vanishingly small in practice and may safely be neglected.

♣ ♣ ♣

[1] The aerodynamic centre of the wing is not the same as the centre of pressure. Older texts used the abstract concept of a moving centre of pressure to explain the pitching tendencies of cambered wings. The same results are obtained by using a fixed aerodynamic centre at 25% mean chord, together with a pitching moment which depends on the amount of wing camber.

[2] Note that the position of the elevator is not directly related to the load carried by the horizontal stabiliser as a whole. If the elevator is slightly up this does not mean that the load on the tail is down. Similarly, if the elevator is slightly down, the load on the tail may not be up. To explain this apparent anomaly would require a much longer article. ■

Common Abbreviations

A.R.	Aspect Ratio	L.E.	Leading Edge
C.D.	Contest Director	L/D	Lift over Drag
C.G.	Center of Gravity	NAA	National Aeronautic Association
F3B/F3E/F3J	FAI Competition Classes	SMTS	Sportsman Multi-Task
FAI	Federation Aeronautique Internationale	T.E.	Trailing Edge

originals were also visible.

Sunday's results were: Paul Morrow - SAGITTA 3138, Sam Smith - LOVESONG 2418, Chuch Woolridge - CUMIC 2354, Tom (The sleeper) Long - LOVESONG 2335, Boots Blanton - WINDSONG 2190.

Many thanks to C.D. Ken Gulliford for all his hard work and great preparations especially since most of his regular help was not available, Dorchester County R/C for the field, Ron and wife (I forgot your last names) for tireless scorekeeping, Bernie Coleman for photography and the Atlanta gang for helping me get my bird back. Great meet folks, lets do it again in September. ■

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Understanding Thermal Soaring Sailplanes

Part 4 of 4 Parts Continued

(This column began in January, 1990. Each part covers several months.)

...by Martin Simons

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Stabiliser profiles

It is probably already clear that large savings in drag cannot be expected by variations in the stabiliser, or fin, profiles. Certainly, the tail profiles should be thin and they will operate most of the time close to zero angles of attack, so they should normally be symmetrical. The symmetrical profile gives least drag when it is at zero angle of attack, but slight variations up or down, over the range of angles normally required for a tail unit, make little difference.

For a stabiliser to have an upward cambered section is actually a disadvantage. With c.g. forward, and hence the smallest practicable tail area, the load actually on the tail will be downwards and any upward camber will be the wrong way round. It is quite possible then to cause a large increase of tail profile drag since the section will probably be forced to operate outside its most efficient, low drag range or 'drag bucket'. The horizontal stabiliser section, if not perfectly symmetrical, might be better with a **negative** camber. (Some very successful model sailplanes, for example Sean Bannister's original *Algebra*, have flown with this kind of stabiliser.) However, the amount of negative camber required is very small, less than 1%, and in practice it is unlikely that any real drag saving will be noticeable compared with the symmetrical section.

The stabiliser dead spot

It is sometimes suggested that a thick tail section, rather than a very thin one or a flat plate, makes for smoother control response. The author's experience does not support this. Models fitted experimentally with alternative thick and thin tail sections respond very much alike providing the centre of gravity is in exactly the same position on each occasion. Of course, if the c.g. creeps one way or another, the difference in elevator sensitivity is immediately apparent.

There are, however, some symmetrical sections which behave badly at angles of attack close to zero. This is caused by the formation, near the leading edge of the profile, of separation bubbles. At zero angle of attack, a bubble may develop on both upper and lower sides. The profile behaves symmetrically and no lift is produced, as would be expected. However, at a slightly positive angle of attack, the bubbles tend to shift position and the one on the lower surface may actually disappear. The effect is to make the symmetrical profile behave as if it had a slight inverted camber. The main flow on the under side follows the solid contour of the profile closely, but on the upper side passes round the bubble. Instead of producing lift as the angle of attack increases, such a profile may actually produce a downward force. This does not persist for long. As the angle of attack increases further, the flow changes and positive lift is developed. On the standard wind tunnel test charts, such sections show a lift curve which takes a distinct S shape, the curve actually slanting downwards from left to right through the zero point instead of upwards (Figure 48). This effect has been measured, and is apparently most likely to occur in its extreme form, on an 18% thick profile which is not likely to be chosen for the tail of any model sailplane.[1]

Nonetheless, a good many thinner symmetrical profiles at the low Reynolds

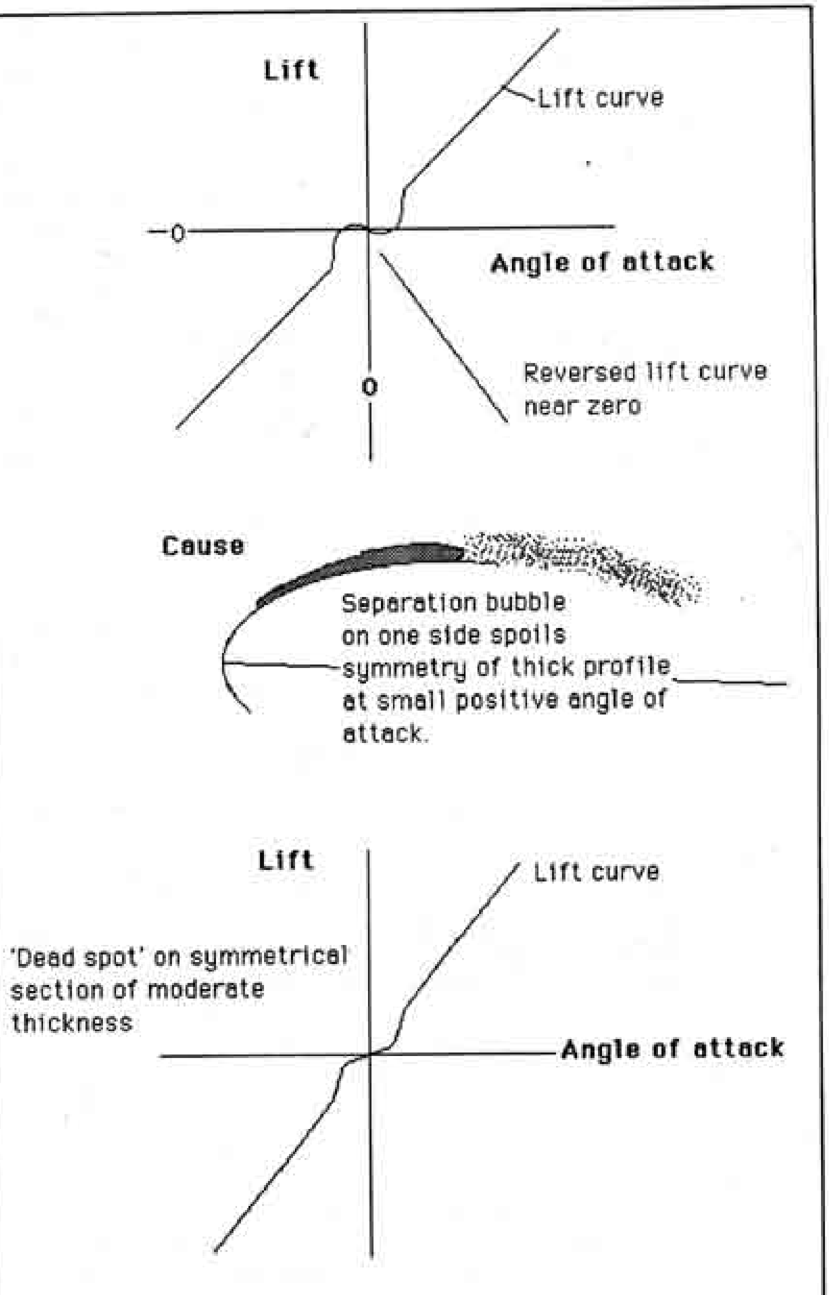


Figure 48 'S' shaped lift curve of thick symmetrical profiles near zero angle of attack may cause 'dead spot' in control response.

numbers appropriate to model tail units, show some irregularity near the zero angle of attack. In a bad case the profile may exhibit a distinct 'flat' in the lift curve, so that when the pilot trims forward or aft from this point, nothing seems to happen, a definite 'dead spot' is noticed. This apparent insensitivity may be combined with slop in the control system of the sailplane and imprecise centering of the servo gearing, so can become quite serious.

Several points may be made. First, the 'dead spot' does not occur with all profiles, and it seems that the thinnest sections, such as flat plates, are not seriously affected. The flat plate is basically a turbulent flow profile, and even with the 18% thick section, roughening the skin to produce a turbulent boundary layer, cured the problem.

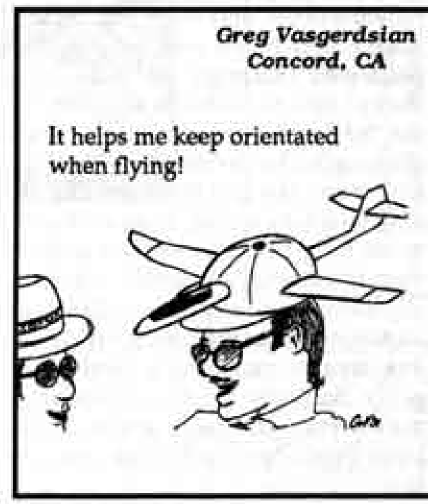
Secondly, the dead spot is most noticeable when the symmetrical section is at, or very close to zero lift. Thus the hiatus in control is likely to be more noticeable if model is rigged with c.g. close to the 30 - 35% position which corresponds, roughly, to the zero tail load balance mentioned above. The tailplane with the 'dead spot' close to zero, will not produce the control or stabilising forces required until the departure from zero angle of attack is fairly marked. If the c.g. is forward, as recommended, the stabiliser will normally be clear of the dead spot around zero. Fine control will be smoother and more reliable, although as the model manoeuvres, the stabiliser will still sometimes pass briefly through the bad zone.

Thirdly, if the stabiliser profile is cambered slightly, although the problem may not disappear entirely, the separation bubbles on the two surfaces will not be alike and there is much less likelihood of actual reversal of the lift curve near aerodynamic zero. As suggested above, if any camber at all is present in the tailplane, it should be very slightly negative.

Slab stabilisers

The all moving, slab or, as older texts often termed it, the 'pendulum' elevator, may show a very slight theoretical saving in drag against the fixed tailplane with hinged elevator, chiefly because there is less likelihood of the profile being made to operate outside its low drag range as the trim setting varies at different flight speeds. Flow separation and leakage at the hinge line of an elevator can occur, as with any hinged control or flap. There may, however, be equally serious leakages at the un-sealed root of an all moving elevator. The difference is not likely to be apparent in practice. In terms of sensitivity, the hinged elevator achieves control response just as good as the pendulum type, providing the control throws or angular movements are correctly adjusted. The fixed tailplane is perhaps less prone to flutter at high flight speeds. The popularity of the all moving elevator is probably due mainly to its relative simplicity in construction, rather than any real aerodynamic superiority.

[1] See AIAA Journal, Vol 20, No. 4, April 1982, pp 457 - 463, article by Mueller and Batill. ■



Understanding Thermal Soaring Sailplanes

Part 4 of 4 Parts Continued

(This column began in January, 1990. Each part covers several months.)

...by Martin Simons

Martin Simons, 13 Loch Street, Stepney, South Australia 5069

The effect on the tail of wing camber

A little tail drag can be saved if the wing camber is reduced at high speeds. Since it is camber that causes the nose down pitching moment, using a less cambered section for the wing reduces the counteractive balancing work the tailplane has to do, other things being equal, and tail vortex drag, small though it is, can be saved.

Camber changing flaps on the wing have similar effects. If, when flying fast, the wing flaps are sufficiently raised to reduce the wing pitching moment to zero the stabiliser will not be required to provide any negative balancing force.

Tuck under

The phenomenon of 'tucking under', which has been discovered by model sailplane fliers, is in the first place caused by the wing camber. The more cambered the wing, the larger the nose down pitching moment coefficient produced by the profile in the wind tunnel. As a model in actual flight is trimmed to fly faster, nose down, the airspeed rises. All aerodynamic forces increase in proportion to the square of the flow velocity, so as the model picks up speed the nose down force produced by the camber increases rapidly. A correspondingly more powerful counter force is required from the tail to prevent the nose going down further.

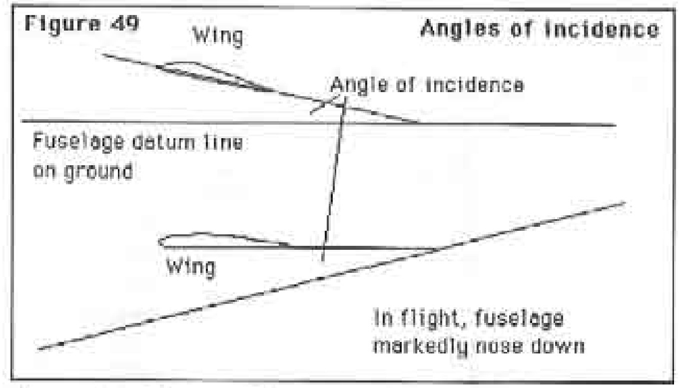
Although other factors probably enter the situation it is almost certain that a 'run way' tuck under results from too much structural flexibility of the model under the rapidly increasing loads at higher and higher speeds. The elevator pushrod or cables may flex or bend, the tailplane itself may distort or even break, the rear fuselage bends under the load, and the wing itself will certainly twist. All these can produce a situation where the model does not respond to the elevator but pitches further forward into the inverted diving attitude. (A quick-thinking pilot can often save the situation by pushing the model through into the fully inverted position, climbing to reduce speed and then rolling upright.)

If the wing has less camber, there will be less nose down moment from this source and all the loads will become correspondingly less. In addition, of course, a stiffer structure all round will reduce the danger. Note also that raising the wing flaps, if any, reduces the pitching moment and as a by-product, is likely to prevent tucking under.

Vertical tail drag

To cut the area of the vertical tail will save drag, but the scope here is not large. Sailplanes lack the effect of a fast slipstream blowing from a propeller, which enables many powered aircraft to fly safely with relatively small vertical fin and rudder surfaces. (When the motor is throttled back or stopped, lack of control in yaw often shows up.) The model sailplane usually needs a relatively large vertical tail and some drag penalty has to be accepted.

Again, basing the argument on an existing successful design, some small saving may be achieved if the aspect ratio of the vertical tail can be increased. A good many model sailplanes have vertical tails designed for fashionable appearance rather than either drag reduction or control power. They are quite often swept back with long dorsal extensions, to make a pretty shape but with an aspect ratio



even less than unity. They would be improved by reducing their total area, but increasing their height. A tall, narrow surface is considerably more responsive in stabilising or control action, than a relatively short and broad one. This being the case, the same power can be achieved with less drag from a tall, narrow vertical tail, as from a low aspect ratio surface of larger area and larger drag. Unfortunately, this recommendation is not fully compatible with the preferred low drag arrangement for the horizontal tail, which is a high mounted or 'T' layout. If the vertical tail is tall and narrow, mounting the horizontal stabiliser at the top of it becomes difficult and the entire tail unit tends to be vulnerable to damage. Flutter is also more likely. An aspect ratio for the vertical tail of two or three is, nonetheless, quite achievable, and makes a distinct improvement to lateral stability and control.

The fuselage

The earlier diagram shows roughly what proportion of the total drag is produced by the fuselage of a typical model sailplane. Evidently, with wing and tail together never producing less than 90% of the total, the difference between an excellent fuselage design and a rather poor one, is not likely to make more than a small difference to the final result. As usual with parasitic items, any improvement that can be made will show up most at high speeds.

Fuselage drag is mostly a form of profile drag, consisting of skin drag and pressure or form drag.

Form drag is reduced by making the body as slender as possible, and keeping it in line with the airflow so that it moves through the air with the least possible disturbance. Probably the most important factor affecting fuselage form drag is the angle at which it is rigged with respect to the wing, that is, its angle of incidence. The angle of incidence is best thought of as the rigging angle of the fuselage to the wing, rather than the wing to the fuselage, because in flight it is the wing angle to the air, not the fuselage, which controls the flight and the performance. The fuselage moves nose up or nose down with the wing. As it does so, it may be more or less in line with the airflow.

When the model sailplane is flying slowly, the wing is trimmed to a high angle of attack, but the glide path through the air is inclined downwards. Old time sailplanes were often rigged so that the fuselage, at this low speed, was accurately aligned with the low speed glide path, so presenting the least possible frontal area to the flow at this speed and hence, least possible drag and minimal rate of sink. The setting of wing chord line relative to the fuselage datum on the drawings was perhaps five degrees or even more. On the ground, with the fuselage more or less horizontal, the wing appeared to be set at a very high angle (Figure 49). In slow flight, the wing being trimmed by the elevator to a high angle of attack, the fuselage then was pointing along the glide path. For early sailplanes, and free flight models, designed always to fly at the minimum possible rate of sink, this was an efficient system.

When the importance of penetration was realised, it was recognised that a different policy was required. At high speeds the wing's angle of attack is reduced. If the fuselage angle to the airflow is correct for the minimum sink, as the airspeed rises the fuselage finds itself lying distinctly across the flow and virtually acts as an airbrake.

As repeatedly emphasised above, parasitic drag becomes most important at high speeds, so to rig the angle of incidence too high is bound to spoil the penetration of a model sailplane. In low speed flight, parasitic drag is less important, so it matters less if the fuselage is rigged so that it appears distinctly nose up. There will be only a small drag penalty. At high speeds, such a fuselage will be more accurately in line with the glide path, and its drag will be less. For minimum parasitic drag at high speed, which is where this form of drag really counts, the fuselage should be set close to zero degrees relative to the wing chord line. This is not a hard and fast rule, for it must be stressed that as the trim changes, so does the angle of the fuselage to the glide path. Flap settings of the mainplane also make a difference. At one trim, and one flight speed, the angle will be right. At all other airspeeds, the fuselage will, to greater or less extent, be angled slightly across the flow. The required compromise should always be biased toward saving drag at high speeds, rather than low.

Assuming the fuselage alignment is close to the best angle, some further, but relatively small, savings can be made by attention to details of the fuselages form and skin drag. This means, basically, reducing its maximum cross sectional area and ensuring that the outline is streamlined with an oval or circular cross section. A correctly streamlined form for subsonic flight never has a sharply pointed nose entry. Nothing is sacrificed if the extreme fuselage nose conforms to the legal minimum radius, 7.5 mm, whereas a pointed nose is actually less than ideal from the drag reduction viewpoint.

The side and vertical projection of the fore end of the fuselage should then be based as far as possible on a suitably thin symmetrical aerofoil section outline, or on any of the established 'low drag' bodies whose ordinates are available in well known textbooks.

The fuselage skin drag depends, like the skin drag of wing and tail, on the total area of surface in contact with the air and on the character of the boundary layer. If laminar flow can be preserved in the boundary layer over the front of the fuselage, the skin drag of the whole component will be reduced. If the fuselage in front of the wing has badly fitted hatches and access panels, or switches protruding into the airflow, these can have unexpectedly large effects, not only because they contribute directly themselves to the form drag, but also make the boundary layer turbulent, which increases skin drag. The disturbance resulting continues aft and spoils the flow over the rest of the surface and the central parts of the wing.

For some years now, the best sailplane models have been fitted with perfectly smooth, detachable, streamlined nose cones which are slid over the front of the fuselage to form an airtight sheath. The cone extends back as far as possible, right up to the wing leading edge, so the model presents to the air a smooth and seamless form. With such an entry, there is every chance of preserving laminar flow. Such a nose cone is also eminently practical, giving free access to the radio equipment as soon as it is removed. In a bad landing, if the nose cone is destroyed or split it may be replaced quickly with a spare. The joint at the rear of the cone can be made very accurately so that the air flows over it with minimum disruption (Figure 50).

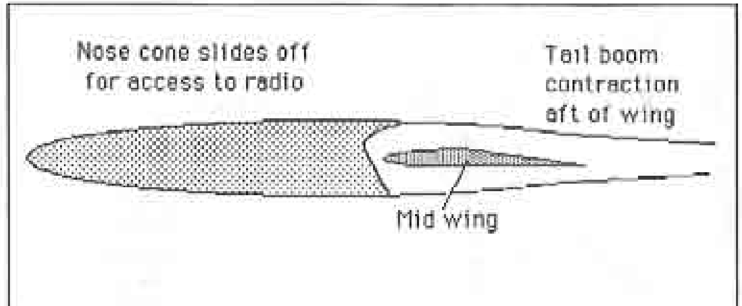


Figure 50 Detachable nose cone for low drag

Aft of the smooth nose cone, the flow will be disturbed by the wing root. The boundary layer will will almost certainly become turbulent, and skin drag will therefore increase rather sharply. To reduce the total area of fuselage skin exposed to this turbulent flow, the cross sectional area of the fuselage should be reduced to produce a slender tail boom. The contraction should be gradual because if it requires too sudden a change of flow direction, it will produce total separation and increase form drag and defeating the main purpose. Also, of course, the stiffness and strength of the tail boom must be adequate to prevent flutter and breakage under normal loads.

City, contact Bob Harmon of the Intermountain Silent Flyers, 10424 Golden Willow Dr., Sandy, Utah 84070; (801) 571-6406. On October 4th John M. Salevurakis died of injuries sustained in an auto accident in Lovelock, Nevada. He was on his way to the Visalia R/C Fall Soaring Festival when the accident happened. John's article speaks to his enthusiasm for the hobby and his job, Chief of Field Services for Wildlife Resources in Salt Lake City, Utah, tells of his concern for others and the world around him. John Salevurakis will be greatly missed by us all. ■

Schedule of Special Events

Date	Event	Location	Contact
Nov. 9	Duration 2M & Open	San Antonio, TX	Tom Meeks (512) 590-3139
Nov. 10	3-6-9 2M & Open	Dallas, TX	Gordon Jones (214) 840-8116
Nov. 10	Dual Elimination	Houston, TX	Julian Tamez (703) 540-3944
Nov. 17	Hand Launch	Dallas, TX	Gordon Jones (214) 840-8116
Nov. 29-12/1	2 M & Unlimited - Tangerine Soaring Champs	Orlando, FL	C. Baylor (407) 699-8750
Dec. 8	2 Meter Only	Dallas, TX	Gordon Jones (214) 840-8116
Feb. 1-2	Southwest Winter Soaring - Unlimited - 444 (D)	Scottsdale, AZ	Iain Glithero (602) 831-1905
Mar. 14	Hand Launch	Irvine, CA	Scott Smith (714) 651-8488
May 29-31	Mid Columbia Scale Int. Fun Fly	Richland, WA	Roy (509) 525-7066 Gene (509) 457-9017

A Special Event

1992 Mid Columbia R/C Scale Soaring International Fun Fly

May 29, 30, & 31 1992

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Skip Johnson, 2626 Eastwood Ave., Richland, WA. 99352

You may get information via the phone by calling Roy at (509) 525-7066 or Gene at (509) 457-9017.

Room reservations can be made now at Cavanaugh's Inn at (800) THE-INNS or (509) 783-0611. Be sure and indicate you are with the TRICS soaring party. Remember this event is just for Fun!!!!!

Understanding Thermal Soaring Sailplanes

Part 4 of 4 Parts Continued

(This column began in January, 1990. Each part covers several months.)

...by Martin Simons

Martin Simons, 13 Loch Street, Stepney, South Australia 5069

Interference drag

Wherever two different bodies, such as a wing and a fuselage, or a fin and a tailplane, join, the airflow for some distance all round the junction is disturbed. This has several unfortunate effects, particularly for the wing root/fuselage area. Not only is the total drag increased because of the disturbed air but the wing lift over the centre section is reduced. One important reason for reducing the fuselage cross section, and paying special attention to the flow over the nose, is because a badly designed fuselage front end will have a proportionately greater disturbing effect on the wing.

Ever since the importance of fuselage interference at the wing root was recognised, aerodynamicists have tried to discover ways of reducing the disturbances. These have varied from the simplest, mounting the wing on a tall pylon to remove it as far as possible from the fuselage, to working out highly elaborate fairings to blend the body into the wing smoothly. No conclusive results have appeared but it is consistently reported that a mid wing mounting is better than the alternatives, with relatively small fairings filling the angles where the wing joins the fuselage sides. If the fairings are increased in size too far, they apparently cause more drag than they save.

Some recent wind tunnel test work done on models very close to the sizes and speeds of radio controlled model sailplanes, indicates that the leading edge of the wing root should be extended in the manner shown in Figure 51.[1] The shape of the extension is not accidental and if used, should be followed as closely as possible. Note that there is little attempt to fill in the corners where the wing abuts the fuselage behind the leading edge, or to extend the trailing edge. Rather, the wing root section is stretched forward progressively and the leading edge is slightly sharpened. This reduces the percentage thickness of the wing section at the root and, according to the wind tunnel results, inhibits the worst disturbances which develop, above and below the wing, with the unmodified junction. Such a modification, it is claimed, reduces the total drag of an already very efficient sailplane by as much as 2 - 3%. As usual, this claim should be treated with caution.

To indicate how careful the designer must be, tests done with fairings which at first sight appear to differ only slightly from that shown, actually increased the total drag, in some cases quite seriously.

It must not be forgotten that additions to the wing root, of the kind described, might, under contest rules and interpretations by scrutineers, be regarded as additions to the total surface area of a model. This could lead to disqualification, so when calculating the total wing area, aspect ratio, etc., any such areas should be included.

Interference drag at the tail is, of course, subject to the same type of effects but little research has ever been done on this. The V tail, which involves only two surfaces, has inherently less interference drag than the orthodox cruciform design, but the T tail is probably as good.

Controls

Large sailplanes have been flown successfully with two main controls, rudder and elevator, but it would probably be agreed by most pilots that effective ailerons are advantageous, giving more positive control, especially when coming in to land.

The larger aircraft is less disturbed by rough air, but at the same time if there is a bad landing, damage is more likely because the total mass of the aircraft is greater. When a small model strikes the ground it may bounce or cartwheel, yet escape serious damage. The larger model arriving in similar fashion is likely to break. Hence ailerons are to be preferred. As with all control surfaces, more effect results if the control surface area is of high aspect ratio. That is, long, narrow ailerons are more effective than short, broad ones. Ailerons reduce the need for the large dihedral, or polyhedral, angles which are essential for the 'rudder only' type of turning control. However, five or six degrees of dihedral on a model thermal soarer, although not absolutely necessary, are of considerable value for stability in circling flight. The effectiveness of the ailerons is not reduced by such moderate dihedral.

Brakes

Another significant requirement for a thermal soarer, especially a large one of high efficiency, is a powerful set of airbrakes, not only to ensure an accurate landing, but to bring the model down safely from great heights. The brakes should be speed-limiting for this situation, rather than merely lift spoiling. A speed limiting brake is one that may be opened fully and kept open at any airspeed, creating enough drag to keep the model's airspeed to a safe figure even when diving very steeply. The sailplane may then be brought down quickly from any altitude, without damage. Some types of brakes, and spoilers, will not remain fully open at high airspeeds because they are blown back by the force of the airflow. Apart from their failure to limit speed, such brakes may also cause the servo driving them to stall, with consequent severe drain on the model's batteries.

It is almost as important to make sure that the brakes do remain fully closed when they are supposed to be shut. Many of the simpler types of hinged spoiler, on the upper, low pressure side of the wing, are almost permanently blown partly open in flight by higher pressure air leaking round them from inside the wing.

The detailed design of speed limiting brakes will not be considered here. The best advice available is to make them big enough, and then add another 50%. It is, in fact, hardly possible to have airbrakes that are too powerful, but of course the pilot must be prepared for changes of airspeed and trim in proportion to the power of the brakes, when they are opened.

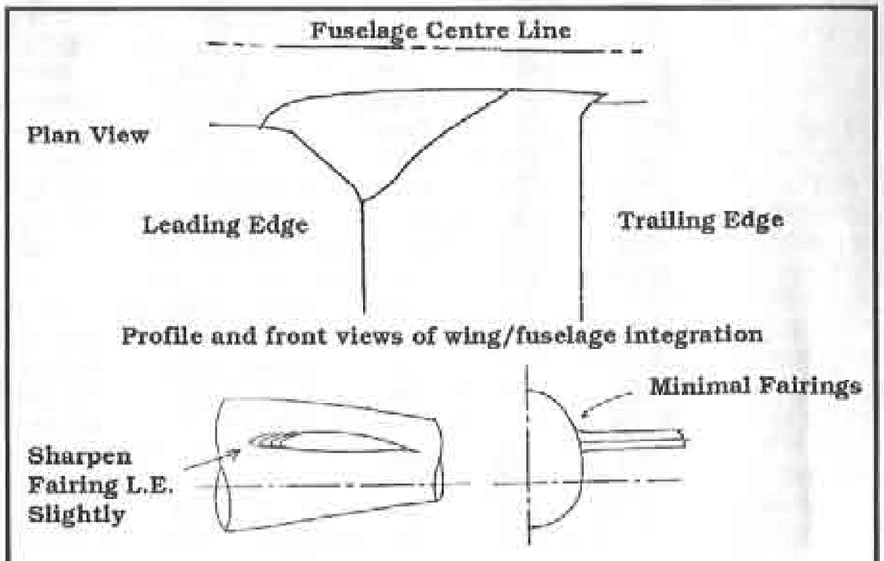

Figure 51 (Taken from Journal of Aircraft, August 1989)

Conclusion

The F3J thermal soaring sailplane should be as large as the rules permit, with a span between 4 and 5 metres, and the maximum allowed total surface area. An aspect ratio of about 15, with wing span of 4.5 metres, should be satisfactory. There do not seem to be any advantages in tailless, canard or tandem layouts, though there remains scope for experiment.

There should be provision for adding ballast, up to the maximum 5kg limit. Ballast is best carried in the form of extended rods within the wing, adding strength to the wing as well as additional mass.

The wing profile should be chosen, preferably from those proved in the wind tunnel, with camber around 1.5 - 2.5% and thickness about 8-10%. More camber might produce a 'single speed' floater but this would not be suitable for any but the lightest soaring conditions. Reasonably good standards of workmanship are apparently enough to produce a good result. Probably a smooth and polished wing skin will give a superior performance all round, but turbulators or textured wing skins may have desirable effects on control and stability. It does not seem that very precise, moulded wing skins are required.

Simple flaps extending across the whole span, should improve the speed range slightly. More elaborate types of flap, and variable area wings, remain to be tried and developed.

The horizontal stabiliser should be as small as possible, combined with a forward centre of gravity position. A thin symmetrical or very slightly negative cambered profile is required. No measurable advantage in terms of aerodynamic efficiency seems to lie with the all-moving type of elevator as against the fixed tailplane with hinged control surface. Both have advantages and disadvantages from the structural point of view. A T tail layout, or a V tail may yield a slight saving in drag, compared with the orthodox cruciform type.

The vertical tail surfaces should be tall and of aspect ratio as high as practicable.

The fuselage should be of minimal cross sectional area, rigged close to zero degrees angle of incidence to the wing, and carefully streamlined, with a carefully fitted smooth nose cone and contraction of the cross section aft of the wing root.

There is some justification for small leading edge extensions at the wing root, but more elaborate forms of root fairing are not recommended.

Powerful, speed limiting airbrakes are essential.

Full controls, rudder, ailerons and elevator, are to be preferred to the rudder-elevator only system, although given sufficient dihedral, the simpler control system can produce satisfactory results under most circumstances.

For launching such models to maximum heights at maximum weight, special athletic towline runners may be required. Training programs should begin now.

It is probably safe to say that all the above principles have already been discovered by experience among those model fliers who have specialised in thermal soaring, and who have developed models along these lines already to a high degree of aerodynamic and structural sophistication.

[1] See *Journal of Aircraft* Vol 26, No. 8, August 1989, pp 705 - 711.

THE END ■