Radio Controlled
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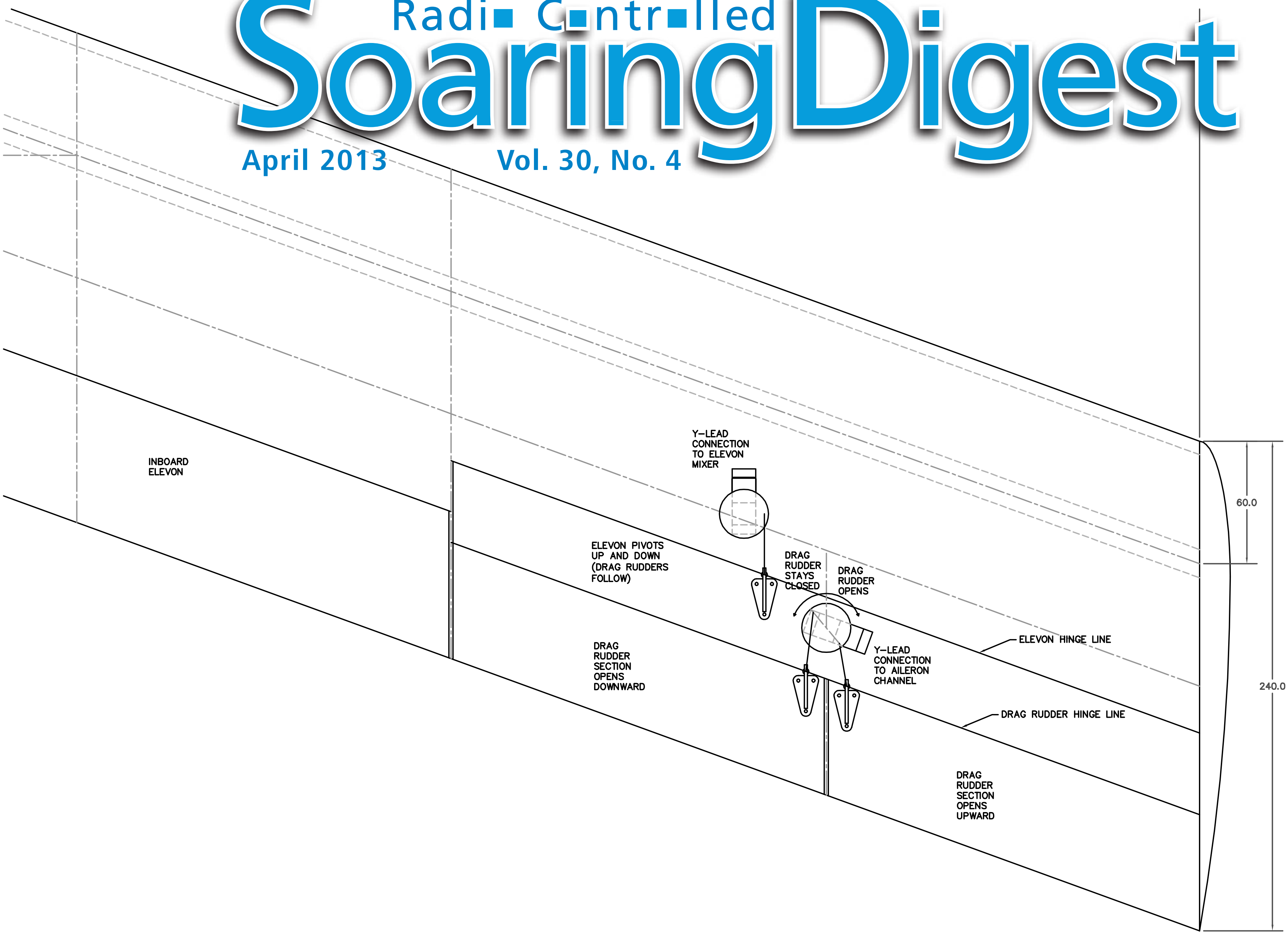

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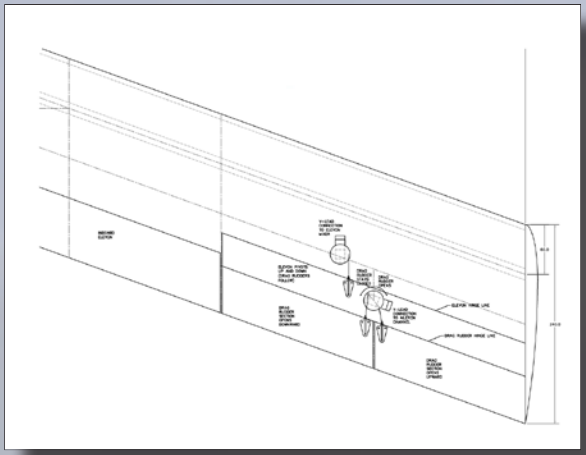

Front cover: A combination drag brake and elevon control system designed by Ken Stewart. A detailed description of this mechanism begins on page 38 of this issue.

Back cover: A Tragi comes in for a landing at 60 Acres in Redmond, Washington, on August 8 2012. at 7:15 PM.
Photo by Kody Kruml
Kodak Easyshare M341, ISO 80, 1/500 sec., f5.7

R/C Soaring Digest

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R/C Soaring Digest (*RCSD*) is a reader-written monthly publication for the R/C sailplane enthusiast and has been published since January 1984. It is dedicated to sharing technical and educational information. All material contributed must be original and not infringe upon the copyrights of others. It is the policy of *RCSD* to provide accurate information. Please let us know of any error that significantly affects the meaning of a story. Because we encourage new ideas, the content of each article is the opinion of the author and may not necessarily reflect those of *RCSD*. We encourage anyone who wishes to obtain additional information to contact the author.

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RC Soaring Digest is published using Adobe InDesign CS6

In the Air

It's the first full day of Spring for the Northern hemisphere as we write this, and it won't be long before the contest season will be in full swing. We're hoping to get our Ken Bates Windlord XC completed some time soon, and we're looking forward to the first scheduled F3B contest in the history of the Seattle Area Soaring Society in August.

Our sincere thanks go to Cesare de Robertis, editor of *Modellismo* magazine, for providing the illustrations and photos for the F3F SiGh article in this issue, in addition to giving permission for *RCSD* to reprint the translated article. Thanks must also go to Giuseppe "Beppe" Ghisleri who spent numerous hours translating the text into English. The design of the SiGh machine is detailed, together with the philosophy behind it, beginning on page 4.

Full size plans for Chuck Clemans' Little Plank III ("thumbnail" on page 49) are available for downloading through a link to the B^{2}Streamlines web site. <http://www.b2streamlines.com/Clemans/Little_Plank_III.pdf>
As a bonus, Chuck has also made available full size plans for his Migisi 662, an electrified model based on Dave Jones' R2 (of which we are very fond). This is a B^{2}Streamlines web site link as well. <http://www.b2streamlines.com/Clemans/Migisi_662.pdf>

Full size plans for other models which have appeared in *RCSD* over the years remain available from the links provided in their respective articles.

Time to build another sailplane!

B^2

F3F SiGh

Much more than the pure design of a competition model: a real treatise on high speed flying wings and on the search for ideal performance.

Simone Nosi and Giuseppe “Beppe” Ghisleri, gghisle@libero.it
English translation by Giuseppe “Beppe” Ghisleri
Special thanks to Cesare de Robertis, *Modellismo* and *VENTUS*

Foreword

The idea was born after an exchange with Beppe Ghisleri started towards the end of October 2002, about a flying wing for F3F (the Emmbè by Beppe) and its possible evolution, the design continued “four hands “throughout the winter until the end of February, during this long period we have evaluated and discussed with many alternatives, arguing about the pros and cons and evaluating them with the help of computer simulations, the result of all our thinking you can read in this article.

An interesting thing that emphasizes the role of the Internet in the story, is that myself and Beppe have never met in person (at least for now), and apart from a couple of fairly recent calls our contacts took place exclusively via email. Soon... we hope to fill this gap!

Another small preliminary observation is that pretty much the time spent designing the model was almost twice that used to build it!

The construction of my model in fact started in early March and ended on May 10th, the date of the test, that was just five days before the only race of the Italian F3F championship!

I decided to participate despite the fact that at that time the level of development was obviously not excellent. On the other hand, the model was very stable and easy to fly and the temptation to see it in the race was too strong .

The name comes from what I exclaimed when, during that race I "painted" the model on the slope... Seriously, the model name is taken from our names: SImone and GHisleri. This funny name was due Stefano Duranti, author of the software Profiles 2, winning the note idiosyncrasy by Beppe against foreign terms with the excuse that "the terms onomatopoeic do not belong to any language" and then are a kind of linguistic heritage of humanity... Beautiful scam eh?

The final point I want to make concerns the cutting premise of the article. In the past I have written things peppered with numbers and formulas, with the result that some (a few) appreciated them but others (the most) complained to the point of giving up reading and understanding the concepts. Lately I've avoided to seek the aid of formula finding, I think, more readers, but some have complained that formulas could technically deepen the topic. To overcome both problems I thought I would write the article according to the latest experience, i.e. without formulas, reserving however a specific section for the latter for the benefit of technical minded. The modeler that does not love numbers and formulas can safely skip it, it is not necessary for an understanding of the concepts.

Features

The model has the following characteristics:
Wingspan: 2600 mm
Chords: 300 - 240 - 220 - 190 mm
Sweep: 9 - 20 - 27 degrees
Wing Area: 59 dmq
Weight: 1660 grams (to be painted and without ballast)
Profiles SN 73, SN 71
Wash-out 0 / -0.5 degrees
Winglets profile SN 73 – SN 71 with 0,5 degrees toe-in
Negative dihedral -1 and -3 degrees on the root end.

The idea

The “challenge” collected by Beppe and myself was to create a flying wing model that can not only fly, but that could also be competitive on the racetrack. And, as we all know, the first thing has nothing to do the second.

In the presentation of “Emmbè” a flying wing model by Beppe there is a passage that, in my opinion, captures well the sense of this challenge:

“Instead of thinking about the purchase or construction of a traditional model, I decided to try a new approach: the model flying wing. You do not see examples of this type in F3F races, and surely there are good reasons why this is so, but trying something new is a good reason to live.”

In fact there are very good reasons to prefer a traditional model, not only in F3F races but also in other types of competitions, the point is that while it is very simple to design a model flying wing that is more efficient than a conventional model corresponding to a precise flight attitude, from the point of view of versatility is instead very hard to keep up with the conventional models, and it is for this reason that the latter are preferred by almost all the competitors of all categories dedicated not only to soaring flight.

Returning to the theme of F3F, being a pylon race, the flying conditions to which the model has to ensure high efficiency are two and, unfortunately, very different:

(1) Fast straight flight
Prompted for the minimum form drag due to the high speed, Cl required is very low, the way to maximum efficiency is precisely to contain the drag. This is a condition favourable to a flying wing that could “save” the parasite drag of the fuselage and rudder and thus would easily prevail over an equivalent conventional model.

(2) Tight turn
In a tight turn, also performed at high speed, however, the situation is quite different. The lift the wing must generate is the equivalent weight of the model to the g of the turn, which are definitely at least 10, then an efficient wing at high Cl is a must. Even in this case there would be no problems to draw a flying wing more efficient than a conventional model... the problem is that this flying wing would be completely different from that of the point 1, hence the need to find the right compromise.

To solve this dilemma we should take a step back and analyse “competition” or as conventional models solve this problem, ie, those with a good stabilizer, which solves a lot of troubles...

The conventional model

The reason for the versatility of the conventional configuration lies in a simple fact: the wing has only to generate lift and therefore is specifically designed for this purpose and can do it as efficiently as possible, while the stability problem is solved by the tail. You may notice that the racing gliders look very much alike, this is because they face the problem with the same aerodynamic configuration, which is brilliant in its simplicity:

- Wing with substantially straight focal line
- Elliptical planview
- Airfoil constant and no warping

We begin by recalling that a wing with an elliptical lift distribution is, given the same wingspan, more efficient than another having a different distribution. This is because such distribution minimizes the induced drag, due to the known tip trailing vortices.

Induced drag is proportional to wing Cl, then raises to high angles of attack (case 2 - tight turn) and reduces at low angles of attack (case 1 - fast straight flight). Exactly the opposite of the form drag which is proportional to the square of speed, and then is highest at high speed.

Another factor to keep in mind is that, as we will see later, wing sweep and wash-out influence in different ways the lift distribution on the wing.

It does not take much to realize that the wing of our “conventional model type,” elliptical in plan, with no swept and geometric or aerodynamic wash-out guarantees for any Cl required an elliptical distribution of lift, and therefore the maximum possible efficiency for that profile and wing aspect ratio.

If that was not enough, there’s more... Should it be needed to reduce the profile drag (case 1-fast straight flight) or increase the Cl (case 2-tight turn), nothing prevents the lucky owners of this type of wing to employ a variable profile across the wingspan while maintaining the elliptical distribution of lift, therefore paying the minimum induced drag, at any flight attitude, regardless of the speed and wing load that remains variable and will easily be adapted to any condition.

To obtain the same by a flying wing with the same shape in plan view is impossible.

The polar of a plank model

Creating a plank model with an elliptical planform without wash-out, employing an excellent autostable profile (Cm>0), one can obtain higher efficiency in straight flight (case 1 - straight fast flight) since the distribution is elliptical, the minimum drag profile is comparable to that of a normal section (Cm>=0) and the absence of parasitic drag generators as fuselage and stabilizer creates a bias in favor of the flying wing.

When you have to face the turn the situation abruptly worsens.

To generate the needed pitching moment you must raise the profile trailing edge, this will pitch up the model, but at the same time will worsen the polar profile.

In short, while a conventional model in a turn can “afford” to lower the variable profile (flaps) and increase the efficiency of the profile for high Cl (the stability problem is solved by the tailplane), the flying wing must instead raise their flaps and this reduces the profile maximum efficiency and the maximum Cl at a time when it’s needed the most. Figure 1 shows how the polar of flying wing plank changes due to the negative flapping of the profil compared to that of the original profile and that of a positive flapping.

In the same Figure 1 are also indicated the maximum efficiencies and maximum Cl points. These data are arbitrary and are shown only by way of example, although quite realistic.

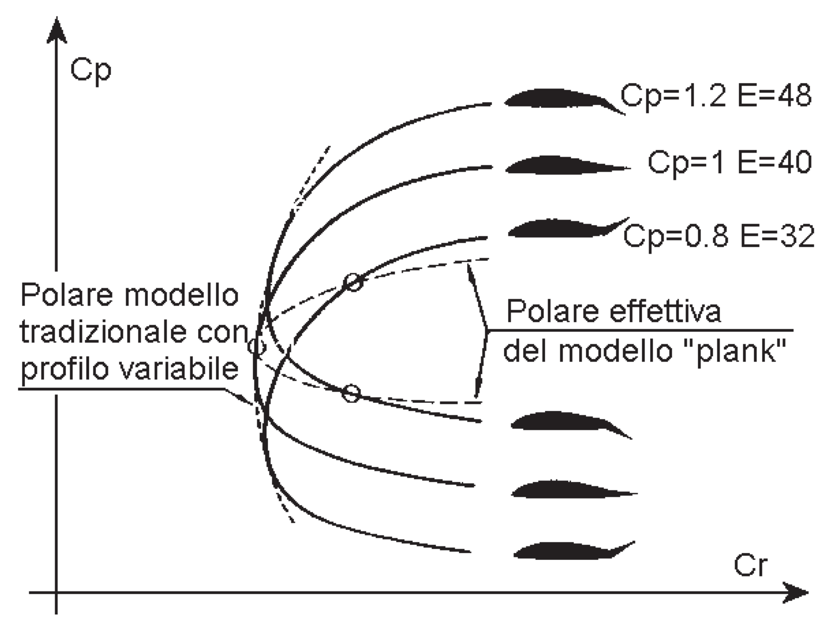


Figure 1

Wing sweep

To solve the above problem, we need to intervene on the geometry of our flying wing, in particular we may limit the extension of the elevons (elevator+aileron) to the wing tips and give a certain sweep to wing planform.

This configuration mimics (purists... pass me the comparison) that of a conventional model when we look at the wingtips as the tail plane and the distance of these from the center of gravity (ie the lever arm) conferred by swept instead of a fuselage.

Thanks to the greater “lever arm” thus obtained, to have the same pitching moment of a plank we need much less elevon excursion, with less decay of the profile polar. Moreover, if the elevons only affect wing tips instead of the entire span, we will have that deterioration of the polar take place only on a portion of the wing instead of the whole.

I would like to draw your attention to the fact that by raising the elevons, when these are limited only to the end, in addition to a result in a change of profile, we introduce a wing twist (wash-out): the chord joining leading and trailing edges will be negative with respect to the wing root chord.

Tips induced incidence

Speaking of profiles and related polar, one speaks of flow analysed in only two dimensions, which may be sufficient when it comes to wings devoid of sweep. The wing sweeping changes things. The incoming flow ceases to be parallel to the chord and changes its behavior in the plan view, but most of all, its incidence varies along the span so that the ends “see” different aerodynamic incidence with respect to the root. How different? Depends on the angle of attack, or from Cl required, the higher the Cl the higher the “induced incidence.”

The air flow around a wing has the shape of a vortex whose form responds to a precise mathematical model. This is not the place to enter into the merits but we will see later something about this topic. For now we need to know that in a swept-wing, the tips induced incidence is positive, vice versa in a forward swept wing this is the opposite, that is, the tips see a lower incidence than the root as the angle of attack increases.

From the above discussion it is clear that, in a swept-wing, tips tend to develop a higher Cl than the root, with deleterious effects on the induced drag.

This wing will also be more prone to tip stall with respect to another wing with the same chords but no sweep.

Returning to our case, namely that of a swept-wing, and reflecting on the conclusions of this section, we see that the negative twist generated by the movement of the elevons, which was mentioned in the previous paragraph, decreases the tip angle attack, increased as a result of the induced incidence, preventing them stalling and decreasing the local Cl, and brings back the shape of the lift distribution “in the ranks” of the ellipse for the benefit of the induced drag.

Thanks to the movement of the tip elevons as elevator, we got to be able to maneuver our flying wing lift distribution always keeping it close to the ideal, and at the same time, to avoid the decline of profile polar across the wingspan.

However, we are still far from the efficiency achievable by classical variable-profile wing at high angles of attack; we have sought only to limit the performance degradation.

Variable wing section and wing sweep

Let’s analyse the effect of the displacement of any moving part, not only from the point of view of its consequences on the profile polar, i.e. its lift and drag, but also from those of its Cm and the relative total pitching moment, of vital importance for the stability of a flying wing model. The position of the CG relative to the center of pressure of the portion of the wing affected by the flap of course has a great importance in this consideration.

The lowering of a moving surface causes in the affected portion of the wing two different effects:
(1) a decrease in the profile Cm, which corresponds in fact to a decrease in the wing stability .

(2) an increased incidence, with reference to the tip of the clean portion of the wing in the case of a flying wing, with respect to the tailplane in the case of a conventional model.

Depending on the aerodynamic configuration of the model the displacement of the total Cm can cause a pitch-up or pitch-down.

While, by definition the effect stated in point 1 always gives a nose-down moment, the effect of the increased incidence as per point 2 causes instead an effect dependent on the geometry of the model:
 - Has absolutely no effect on the total momentum of a straight wing .
 - Causes a nose-down moment on a swept forward flying wing (negative sweep)
 - Causes a nose-up moment in both conventional models and a positive sweep flying wing.
On the latter the effects 1 and 2 are in contrast and, always depending on the geometry, one or the other can prevail. In my experience I have found that generally the effect 1 prevails in conventional models (even though I had a model in which the effect 2 prevailed), while in flying wings, if the sweep is high and therefore the center of pressure of the central portion is far ahead of the CG, effect 2 can be prevalent.

Flaps as elevators

This is the idea. The thought was the SiGh would climb more to the effect due to flaps moving downward than to that of elevons moving upward.

If the sweepback is high, the moving parts close to the root have a pitch-up effect when they go down, at the same time these ensure the increase of Cpmax and efficiency of the profile as is the case in traditional models equipped with a variable profile.

You cannot certainly lower the elevon to pitch-up but... do you remember the story of the induced drag and the need, in a swept wing, to have a certain amount of wash-out? The SiGh, compared to flying wing that we are used to seeing, gets the wash-out lowering flaps at the root rather than raising elevons at the tips and the result is that, in doing so, we recover that elliptical distribution lift curve that we want, the local Cl decreases at the tips so that even the unflapped profile can ensure enough lift even with a lower Clmax... as we will see later in the computer simulation.

How much wash-out?

Now that we have set the overall geometry of our model, defining that a high sweep and a variable profile across the wingspan are needed, thus giving the possibility of progressively lowering the trailing edge to confer simultaneously warping both geometric and aerodynamic for the case 2 (tight turn, remember?), we must decide how much wash-out to use for the fast straight glide, that is the case 1, flying with movable surfaces at rest.

At the beginning of our journey, we assumed a wing without sweep and wash-out, and we concluded that for straight and level flight would be the most efficient solution. Now that we have a swept wing is it still the same?

The answer is no. In fact at high speed the wing needs to develop a low Cl, the total lift will always be greater than zero and so we will have induced drag. It seems clear then that a certain wash-out, although small, would also be of benefit in these conditions, since it would allow the entire wing to fly at the same incidence, with no increased induced incidence at the tips and consequent increased induced drag.

Having established that even in the fast straight glide a certain wash-out serves, we have now the problem of defining how much.

The problem is anything but simple because in a flying wing of given geometry, the Cl, i.e. the flying path, i.e. the induced incidence, are a function of speed and weight.

Since according to the conditions an F3F model will be called to fly with different wing loadings at different speeds we have to analyse what happens in the various cases and what are the situations to be avoided.

The reversal of lift at the tip

We anticipate immediately, if it is necessary, the case in which a greater wash-out is demanded. The greater wash-out case is one in which the model has a high wing loading and proceeds at low speed and thus forcing the wing to work to a high Cl. Conversely, small wash-out will be needed in a model with a low wing loading flying at high speed, the required Cl will be smaller and consequently also the induced incidence.

But what happens if you choose a wrong wash-out?

Suppose we have adopted a twist greater than the optimal one, and look what happens: wingtips are coming to see a lower incidence than the root. This was an advantage until the wing worked at high Cl and the twist was used to “download” the tips from the increase in lift caused by the induced incidence, but now that we have a model designed to deal turns to 10 and more g, that is, to efficiently develop a lift equal to more than 10 times its weight, what happens when the conditions are that of the fast straight fly,i.e. when g = 1 ? The wing will have to develop a lift equal to the weight of the model, and since lift is proportional to the Cl of the profile and the square of the speed, when the latter increases, the Cl become increasingly small tending to zero (Cl = 0 in a vertical dive).

If the incidence at which the wing profile develops the Cl required for a given speed is less than the angle of wash-out chosen, in straight flight the wing will fly in a particular way: the central section will work, as usual, at positive incidence developing the necessary lift, even a lift greater than the weight of the model, while the ends will work at negative incidence, generating downforce, so that the algebraic sum of the lift generated near the root and the downforce at the tips equilibrates the weight of the model.

The reversal of the lift at the ends carries two rather unpleasant consequences: an abnormal increase in the structural stresses in bending and torsion, and an abnormal increase in induced drag .

Oh yes, the induced drag that we were used to seeing decrease until it disappears as speed increases and Cl decreases, now increases again due to the negative lift in the end. The vortices in fact have a marginal trend opposite to that usual - going from the upper surface to the lower - but drag unfortunately develops the same.

Years back myself with my friend Andrea Sacchetti had noticed the effects on the flight, flying at the same time with two flying wings of similar size, one with and one without wash-out. They were gliding at the same time. It happened that the twisted model accelerated rapidly up to a certain speed (presumably the one that manifested the phenomenon of reverse lift), after which it proceeded without accelerating further, as if he had “the handbrake .“ Meanwhile, the model without wash-out, although less loaded, continued to accelerate. It is useless even to say that, on the other hand, the model with the wash-out, in spite of the higher wing-load, soared better.

Now let’s suppose instead of choosing a less than optimal wash-out. The result will be that the tips will work to a greater aerodynamic incidence than the root.

This will not create large differences in the resistance of the form, the increase in lift in the tip area will cause an increase in induced drag. But the induced drag at high speed in straight flight is minimal... and the more you go faster the more the Cl gets smaller and the more the induced drag gets smaller, right?

All in all, increasing by a negligible percentage the induced drag which already is small in this condition, it is certainly better than risking the reversal of lift at tips.

The conclusion is therefore to look for the optimal wash-out and, when in doubt, choose a smaller one; no wash-out is an extreme case only recommended if you seek high speed with low wing loading, in fact, a condition very close to ours, i.e. that of an F3F model in fast straight flight.

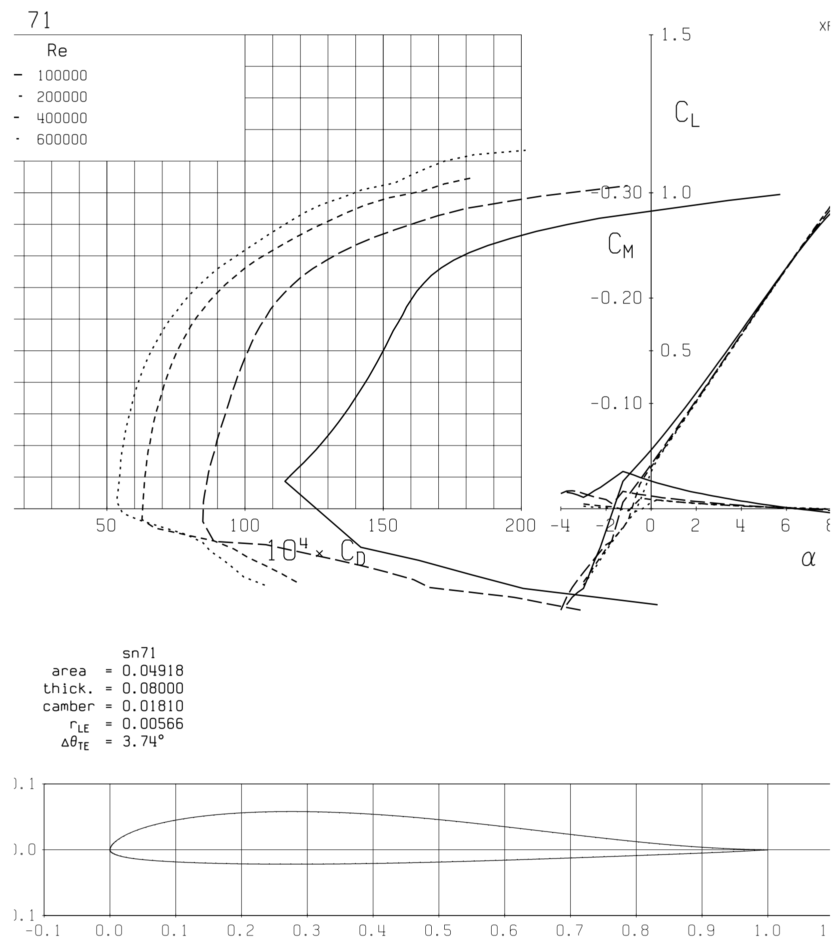
Instead, for the turn, which is a condition of flight at high Cl, would a decent twist would serve, but the benefits gained in the turn would be lost in straight and level flight. Wash-out should rather come by “working” with the elevons in order to ensure proper twist.

It would be different if we were to design a flying wing for a duration task or for DS, types of flight in which a high Cl is always required. In this case a certain wash-out for a swept flying wing could only be of benefit.

The choice of Beppe and Simon

We have made a lot of calculations, of which you will find a taste later in the "numbers and formulas" and "computer simulation" parts, and we came to the conclusion that at the maximum speed reached by an F3F model (we took for reference the current world record time) and an estimated weight of 2100 grams, at the wing loading of the SiGh, the best wash-out would have been -0.5 degrees along the outer wing panel only

With Beppe we decided to check in practice the correctness of these calculations, and given that it seemed a waste of energy to make two perfectly identical models (remember the opening sentence of Beppe: "trying something new is a good reason to live"), we decided to try two different ways. Given the small wash-out value calculated, and given my experiences in electric flight in order to keep the weight down, I was hoping to be able to get a weight less than estimated (as we have seen, this requires less wash-out), I would have made a version with no wash-out, while Beppe would make the version that on paper gives the best results, that is, the one twisted 0.5 degrees, so that later, once both models were built, we could make a direct verification by comparing both models in flight!



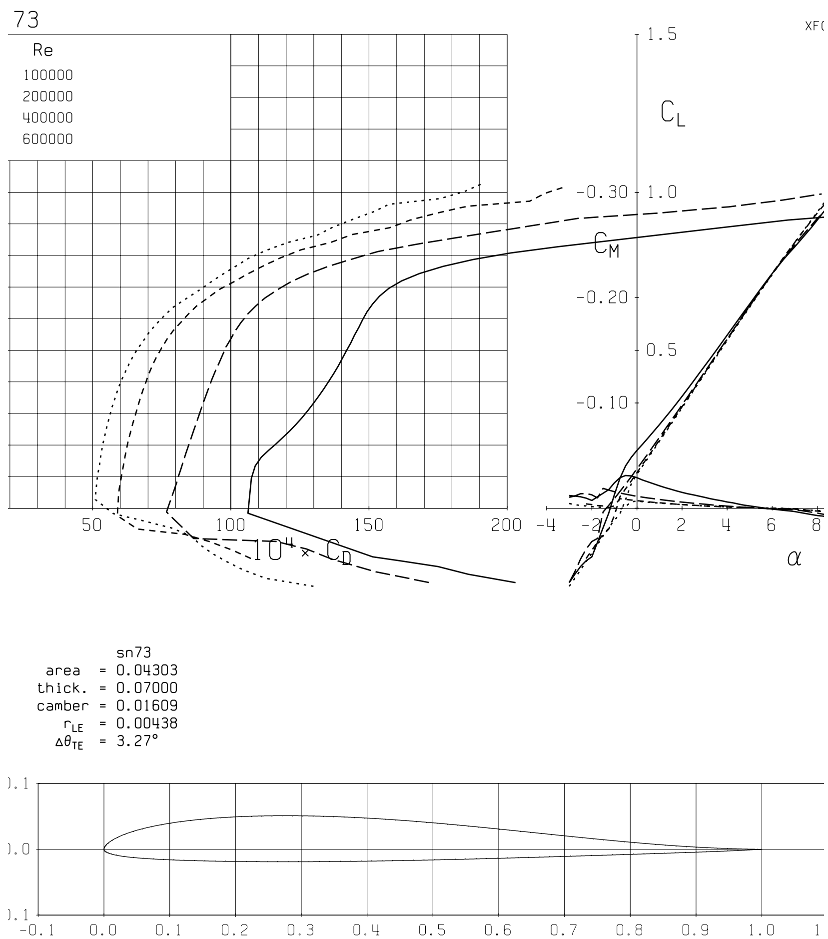
SN71

Profiles

Some time ago I designed profiles for flying wings for F5B / F5F models.

These profiles, called SN73 and SN71 are respectively the evolution of the SN26B and SN28 and are characterized by a slightly positive Cm, hence self-stable at high speeds irrespective of the wing plane shape.

The polar and profile coordinates which are attached to this article can also be downloaded from the site http://xoomer.



SN73

virgilio.it/nosi/ both in TXT or PRO format. The latter used in the excellent program "Profili 2" by Stefano Duranti.

Their position in the wing, strange as it may seem, is as follows:

Chord 300 mm SN73 (7%)
Chord 240 mm SN71 (8%)
Chord 220 mm SN73
Chord 190 mm SN73

So the central panel passes from SN73 to SN71, and the intermediate panel passes from SN71 to SN73.

The reason is that in the lift distribution curve (green - see Figure 2, opposite page), the local Cl is highest at the chord 240 mm, hence a "liftier" profile with respect to the rest of the model is needed there (also with respect to the root).

The profiles used may look too thin, but thicker profiles are not needed, unless you want to greatly increase the wing loading.

This is because a flying attitude requesting high Cl can be reached in the presence of a low wing loading only flying at low speeds, to which unfortunately the Reynolds number would be reduced to such an extent as to nullify the polar of any profile.

A thick profile in models with a light wing loading only serves to decrease the efficiency, because you pay the price of high resistance in order to have a Cl which will hardly be needed.

Wing planform

You have surely noticed that we have talked of the SiGh elliptical lift distribution, but also that the wing of this model has very little to do with an elliptical planform, rather the low taper ratios of our model more closely resembles (sweep apart) to a rectangular wing.

We also said, however, that the sweep affects the shape of the lift distribution, so we will try to understand the reason for the choice of elliptical distribution and why it has been obtained

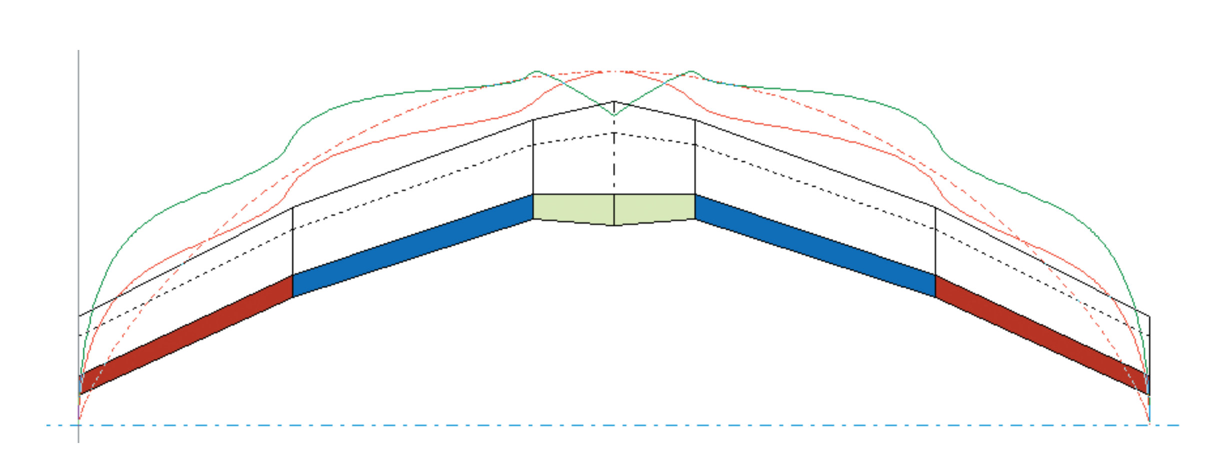


Figure 2

by the plan shape that you see. We will try later to analyse also the bell-shaped distribution of lift and the advantages and disadvantages that this entails.

This is not meant to be an in-depth course, this is not the place. For those who want to deal with the subject more deeply we recommend the book “On the ’Wing 4” by Bill & Bunny Kuhlman, who treat that in a clear and understandable way to the modeller.

I would also grope to dispel some myths and / or legends that form between modelers when the arguments are elusive and little known, unfortunately generating even more confusion on a topic already in itself intricate. I have been contacted by many modeler friends on this issue.

I do not know if I had clarified things to my contacts but, if possible, I would like, before talking about lift distribution, to respond to the most frequent not really accurate statements I’ve heard and which are listed below:

The elliptical distribution of lift is that of conventional models and the bell-shaped distribution is that of flying wings.

Incorrect. You can design and build a flying wing with elliptical distribution of lift (like SiGh for example) and conventional models with a bell-shaped lift distribution. For the sake of madness we can draw a bell shaped plan view wing without wash-out which would then have a corresponding bell-shaped distribution and use it in a conventional model.

The elliptical distribution is that of a flying wing with no wash-out, while the bell is the distribution of the flying wing with wash-out.

Incorrect. You can get elliptical distributions of lift on flying wings with wash-out and bell shaped distributions on wings without wash-out by simply working on the wing plan view.

The elliptical distribution remains so for every aspect of flight, the bell instead remains so only for a narrow range.

Nothing more wrong. It is not the type of distribution chosen that affects the field of useful or optimal incidences. The straight wing with bell-shaped plan view and without wash-out of the first example will retain a bell-shaped distribution in all aspects, similar to what happens for a straight wing with no wash-out and with elliptical lift distribution.

Conversely, the swept wing, for the phenomenon of induced incidence, will tend to modify its distribution to the variations of the angle of attack, independently of the fact that its designed distribution is elliptical or bell-shaped. Also, the wing wash-out plays its role in the variation of the distribution as a function of the angle of attack. We must not forget also that if for reaching certain flight aspects we operate the moving parts in a flying wing, we must take into account the repercussions that this causes on the lift distribution and not only on the model Cm.

Lift distribution and Cl

The distribution of lift can be represented by a curve that describes, along the wingspan, the value of the product between the Cl and the local chord at that point.

The "shape" of the curve is at the origin of the name given to the type of distribution, of course, this curve will be elliptical for the corresponding distribution. An elliptical wing is a particular case, in fact its Cl remains constant all along the wingspan so that the Cl distribution curve is a straight line. In absence of geometric and / or aerodynamic warping this planform also has the characteristic of not having a precise stall starting point, therefore the stall tends to occur simultaneously on the entire wingspan.

A good compromise between efficiency and stall characteristics is given by an elliptical planform with the tips slightly spread, so that the stall tends to start at the root, where the Cl is larger, without penalizing too much the distribution of lift and therefore the induced drag.

Theoretical studies of lift distribution show that an elliptical lift distribution is the best choice when it comes to reduce induced drag and therefore improve efficiency.

More recent studies have demonstrated that, given a certain bending moment at the root, hence a certain weight of the spar and resisting structures, the bell lift distribution offers less drag and more efficiency.

The Horten brothers pioneered the bell distribution on their tailless airplanes so as to have pro-verse aileron induced yaw in order to eliminate the fin and rudder and their drag.

A wing with a bell-shaped load distribution will have a larger wing span to produce the same total lift as that of a wing with an elliptical distribution.

In model airplanes the problem of structural calculation is not intense, the structures are almost always suggested by experience and in my opinion, this is not a bad thing.

Modelers refer only to the bending moment, but if you want the bell-shaped distribution in a swept wing, because of the greater aspect-ratio, there will be greater torsional stresses and because of structures requiring more resistance, hence heavier, the advantage is cancelled and the two configurations return to being equal.

Speaking of competitions, if the limit is the wingspan then the distribution that ensures greater efficiency is elliptical; conversely, if the limit is the wing surface, then you can get a more efficient wing by using the bell distribution and a similar weight / structure, but you will end with a higher aspect-ratio and shorter chords which involve a lower Reynolds number and an increase of profile resistance that will reduce the advantage obtained in terms of induced drag.

All of the above has led the vast majority of designers (not model aircraft only, but full scale too) to usually choose the elliptical distribution.

The bell-shaped distribution has been used by some designers especially in flying wing airplanes and still has avid supporters.

Others are inclined to think that there might be an optimal intermediate solution between the bell and the elliptical curve. One thing on which all designers agree, however, is the fact that, whichever distribution is chosen, it must remain the same over the entire flight envelope, and that the only way to do so in a swept flying wing is to use moving surfaces along the entire wingspan.

Another thing on which everyone agrees is that the higher aspect-ratio given by a bell-shaped distribution, combined with a swept wing leads to an increase of Cl at the tips and anticipating stall unless appropriate measures are taken.

The real advantage of the bell-shaped distribution

So far the fundamental advantages in adopting a bell-shaped lift distribution have not come to evidence; it looks like there are far more disadvantages (more wingspan, tip stall problems), confirming the large preference given to elliptical distribution in the aeronautical field.

Yet there have been extremely brilliant designers who have made a bell curve lift a “creed.” The most famous are certainly the Horten brothers. Their intention, I would say their “obsession,” was to build an aircraft consisting of one wing and nothing else — no fuselage, no horizontal stabilizer and no vertical surfaces. In such a wing, if the longitudinal stability is ensured by the combination of sweep and wing sections and the roll stability by combining sweep and dihedral, what is there to solve the problem of stability in the yaw axis?

In particular there is the problem of inverse yaw caused by ailerons movement.

As we all know the aileron movement gets a desirable increase in lift on the wingtip external to turn but also, unfortunately, an increase of resistance at the same wingtip that has to move faster !
The adverse yaw in conventional models is compensated by the action of rudder or diminished by aileron differential.
Aileron differential is not a good option in a flying wing, since it would also generate changes in the pitch axis, leading to a pull-up.

It would therefore appear essential to adopt one or more fins, as is the case of all the flying wing sporting a more or less elliptical distribution.
The approach used by Horten instead uses a combination of swept-wing, bell-shaped distribution and tips wash-out. In this configuration the tips profile fly at an incidence that is near that of their zero lift, so that the lowering of the aileron involves, contrary to what usually happens, a decrease of resistance rather than an increase. All this produces a desirable pro-verse yaw-axis moment and makes unnecessary the vertical surfaces.
In this configuration, the advantage of the bell-shaped configuration is tangible: it eliminates all the drag caused by fin and rudder!
Both Beppe and I have already tried the Horten configuration, i.e. sweep + bell-shaped distribution in other models, we both agreed that for our purposes (F3F flying wing) elliptical distribution + winglets would have been a better choice, thinking that precise flight would have more importance than minimum drag.

Flying wing models can fly easily and safely without vertical surfaces, but if you want to drive them on a precise track you better put them on.

Beppe:

Do you think that is convenient to adopt bell shaped lift distribution instead of fins to improve efficiency ?

You have already used it, so it looks like your reply should be positive, but what would you say about that experience ?

Simone:

Talking about efficiency only, the bell-shaped distribution should have an edge on having fins.

A friend told me that the Manta was the most efficient (2m wingspan) model he had ever seen.

Flying along with other models of the same category (conventional 2m wingspan) with the rate of sink,that flying wing had a much higher speed and was controlled quite well, the turns were coordinated and you can easily direct it where you wanted. In turbulent air the situation unfortunately changed, controlling direction with absolute precision became difficult because of yaw axis oscillations, in the speed test while turning the pylon the outbound direction of the turn depended on the point of the oscillation where pitch control was fed in.
In fact I totally agree with your earlier statement that the benefits gained from installing fins more than offset the disadvantages.

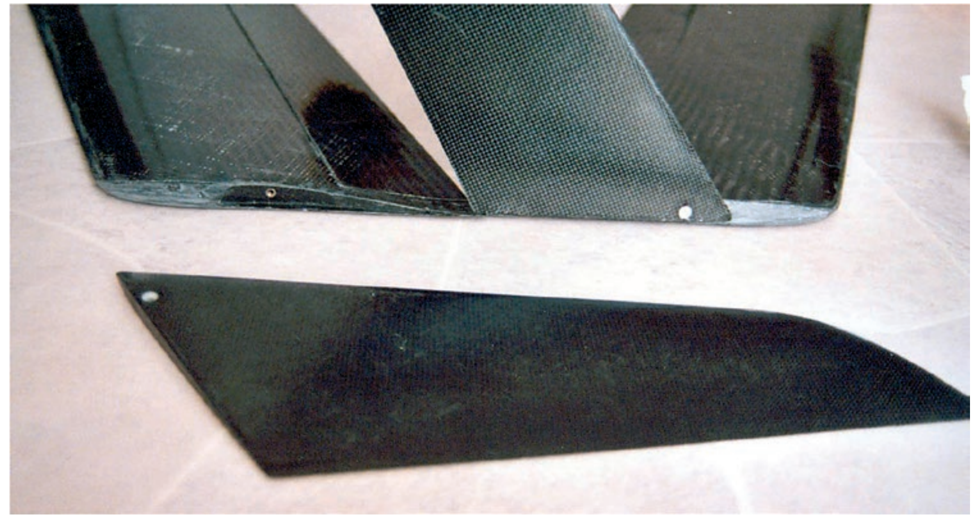
In view of the use of the model, F3F racing, I agree with you that fins are essential, and consequently believe at this point that we can orient on an elliptical distribution.

Beppe:

I have built Horten229 V2 as a PSS model, to exact scale, according to 3-views I found obviously, with profiles that may be the original Horten ones and no fins.

The model flew quite well, but had the terrible tendency to Dutch roll if it was slowed too much or if it was hit by a burst. It was able to self stabilize after two or three oscillations, provided that the pilot gave no radio input except some down pitch.

Winglets



Having decided that an F3F model must track precisely even in a turbulent wind, we thought that the vertical surfaces are required regardless of the type of distribution choice, their presence reduces the real advantage given by the bell-shaped distribution, hence the preference for the elliptical distribution of lift.

Now let's see if and how you can use the vertical surfaces not to be a source of drag only, but to increase the lift and therefore the efficiency. On many aircraft of various kinds the so-called "winglets" are used, i.e. fins placed vertically at wing tips. Their task is to reduce induced drag generated by tip vortices.

These fins are really effective, increasing the efficiency of the aircraft, only for certain flying conditions, in particular those in which a high Cl is requested, i.e. when the high pressure difference between the top and bottom of the wing is the cause of a lot of induced drag, much more than that caused by the presence of the winglet. The total drag of the wing decreases because in these arrangements the drag produced by the fins is less than the reduction of induced drag that they introduce.

Otherwise at low angles of attack, as in fast straight flight, they end up increasing the overall drag of the wing since their form drag increases with the square of the speed, while the induced drag, which diminishes with the decrease of the Cl, instead decreases with increasing speed.

We have already seen that in our case the adoption of fins will be useful in order to obtain a precise tracking, in a flying wing with a discrete sweep placing fins (yaw stabilizing surfaces) in correspondence of the wing tips, requires them to be designed in such a way that they are functioning both as fins and winglets.

In fact, the operation of the winglets is much more complex than I have just described simplistically. In fact the not negligible increase of efficiency is also due to the fact that they change the distribution of lift increasing it at the ends.

There also occurs a particular phenomenon.

Because of the particular angle of attack that the winglets assume with respect to the flow of the vortex, they generate even a small component of traction called "induced thrust."

To explore these topics see the reference N.5 and 8. According to these readings we have chosen to use for winglets the same wing section used for the wing external panels, i.e. SN73.

The winglets are 0.5 degrees divergent relative to the line of flight, this is the null-lift incidence of the profile used. In practice winglets are aerodynamically parallel even if they are geometrically divergent.

The point is that to improve the yaw stability they should be convergent, while to work well as winglets they should be divergent, the incidence chosen is a compromise solution that, in the light of what we have seen so far, I would repeat.

Beppe:

The suggestion that I can give with regard to the fins is going to seen on the site of Hepperle, there are some helpful pages to clarify a problem.

If you want my opinion on the fins I can tell you that I consider them essential to any model, whether it be for fun or racing.

The only model on which I have some doubt would be one dedicated to pure speed. Everyone else, sooner or later must turn, gain altitude, or land.
The maneuverability earned in each of these cases more than offsets the loss due to friction.

Simone:

I did the research that I told you about winglets and their effects, in particular on the distribution of lift (but there are others as well).

Needless to say, the most complete and accurate (at least among those understandable) I found in the book Nickel & Wohlfhahrt. :-)

What I read on one side has comforted me, I found some other things which I did not expect.

In particular, I did not expect that the presence of winglets (on a flying wing with positive sweep) could worsen the stall characteristics for two reasons, until yesterday when I thought they could, at least, better.

*The first reason is that the presence of winglets causes an increase of lift generated at the tip (Cl * chord length) by means of increase of Cl (if the required local Cl is greater than the maximum of the profile then stall occurs), the second is that the presence of a induced convergence (even if winglets are geometrically parallel) procures a further increase of the angle of incidence induced at the ends.*

What comforted me is that both in terms of increased lift and reduction of induced drag and therefore of general efficiency, the winglets length behave approximately as a corresponding extension of wingspan less some 5-10%.

Beppe:

I would say that we should reduce somewhat the aspect ratio, trusting in what is promised by aerodynamic fins.

Please note that we will never have the efficiency of a wing that has no turned up extensions... that wing should instead have the tailplane to do the job, but the tailplane produces drag, doesn't it ?

Simone:

Yes, whereas the tail plane surface is about one tenth of that of the wing, I believe that we must assume an increase of at least 10% of the form drag, with the fuselage and fin it should reach a total of about 20%. According to the book of Nickel & Wolfhart the winglets should provide an efficiency of 5% - 10% lower than an equivalent increase of wingspan.

Considering our level and our design experience I would say that is most likely the rate of 10%.

I tried to brutally apply the fins to the model above, obtaining the file SIGH 4.4W, the efficiency thus obtained is greater than 35.5, less 10% it should be about 32.

I would say at a guess we approached a lot, do not you?

Swept wing and efficiency (middle-effect)

The particular pattern of SiGh wing planform characterized by a sweep back gradually decreasing toward the root, is used to eliminate or anyway to reduce to a minimum an effect similar (but opposite) to that which occurs at the tips. At the root of a swept wing there is the tendency to create a "valley" in the distribution curve, i.e. a local decrease in lift. This has a negative impact on the efficiency both directly (by decreasing the lift, the efficiency is decreased, too) and indirectly, by altering the pattern of distribution compared to the ideal elliptical curve and which procures an increase in induced drag.

There is also another reason, brought up by the Horten brothers. If the focal line (the line that connects the points placed at 25% of the chords length) has an appreciable sweep at the root then an increase of resistance occurs.

The problem of the wing root in a swept wing is a particular case as much as that of the tips, and in fact has been the subject of particular solutions such as the famous bat-tail configuration (Horten IV and VI), the wing with parabolic focal line (Horten Parabel) or the "arc" central section (SB-13).

In fact, all of those centered on the reduction of the sweep angle at that point in order to limit the adverse effects on the lift distribution (the famous "Valley") and the drag.

Sweep and dihedral effect

On SiGh, like on other swept flying wings that I got to try or see, it was adopted a negative dihedral of -1 degree at the root and -3 degrees at the tips. This leaves puzzled many modellers used to seeing configurations with positive or no dihedral.

We'll try to explain this solution in a few words.

The sweep in the flying wings procures a strong "dihedral effect" and thus high stability on the roll axis. This in turn tends to cause the phenomenon known as Dutch roll, a combined oscillation around both yaw and roll axis, due to the excess of roll axis vs yaw axis stability.

In conventional models it is useful to eliminate the Dutch roll by reducing the dihedral; the same applies to flying wings, and not wanting or being able to reduce the sweep the remedy is bringing the dihedral to negative values.

The behavior of the model in flight benefits a lot from this configuration, is not at all critical (unless you exceed) and the coordination achieved in turns is surprising, to use an expression I've heard “looks like it is turning by coupled aileron and rudder.”

A rule of thumb is to consider that seven degrees of sweep is approximately equivalent to one degree of dihedral.

To those who were (rightly) dissatisfied with this simplistic statement, I recommend the book “On the wing N.3” that clearly and adequately explains the topic.

Numbers and formulas

Previously we stated that there are two phases of flight that the F3F model has to face. We have also stated that in the phase of the straight flight we have to provide that the reversal of lift at the tips doesn’t appear, in order to keep to the minimum possible the overall drag.

The wing surface and the wing load of the model will instead be dimensioned to obtain the highest possible efficiency in the turning phase.

The wing profile has to provide the requested Cl and a high efficiency at the same time.

Let’s calculate how high has to be Cl given these numbers thought as average for an F3F model:

Flying weight (Q) = 2.1 kg (4.6 lb)
Average speed (V) = 30 m/s - 108 Km/h (98 ft/s - 67 ml/h)
Turn radius (r) = 10 m (33 ft)
Wing surface (S) = 0.39 m^2 (604 sq inch)

First we calculate the acceleration normal (perpendicular) to the path (an) at which the model is subject

$$an = V^2/r = 90 \ m/s^2 = 9.2 \ g$$

where g = acceleration of gravity = 9.8 m/s^2 (32.15 ft/s^2) and consequently calculate the centrifugal force Fn acting on the model

$$Fn = m \bullet an / g \ , \ m = Q/g \ \text{->} \ Fn = Q \bullet an$$

where m = mass of the model, which can also be expressed as

$$m = Q/g$$

Replacing this value in the above formula we find that

$$Fn = Q \bullet an$$

Hence

$$Fn = 2.1 \bullet 90 / 9.8 = 19.3 \ Kg$$

To this should be added vectorially the weight force Q to obtain the apparent weight in turn Pv.

$$Pv = \sqrt{Q^2 + Fn^2} = 19.4 \ Kg$$

P is the lift that the wing will have to develop to match the apparent weight in turn P = Pv:

$$P = ½ \bullet V^2 \bullet S \bullet \rho \bullet Cl$$

Where ρ is air viscosity the average Cl is then:

$$Cl = 2 \bullet P \ / \ V^2 \bullet S \bullet \rho$$

$$Cl = 2 \bullet 19.4 / 900 \bullet 0.39 \bullet 0.125 = 0.884$$

To obtain a similar mean Cl you have to use a profile with a relatively high camber.

At the same time the profile must maintain the characteristic of a “fast profile,” hence have a low Cd at Cl = 0.

It is also necessary that its Cm be close to null or slightly positive in value to meet the requirements of stability of a flying wing. It seems clear that combining all of these requirements will not be easy. We will have to make a choice of compromise between having a low Cd in fast straight flight (small camber and thickness) and low Cd in a turn (high camber and thickness). In any case, the profile must absolutely respect the condition of having a Clmax greater than 0.9, as otherwise when the lift developed will be less than the centrifugal force, the model will widen the turn greatly slowing down because of the high drag that a profile develops above its Clmax.

An adequate solution to this problem is to adopt a variable profile which allows the use of thin profiles with Cdmin very low in straight flight but that, with the lowering of the flaps in combination with the command to pull up the elevator, also allows a desirable increase of Clmax when turning the pylon.

Speaking now of straight flight fast, let's see how you can determine the speed at which occurs the phenomenon of the lift inversion in the twisted version of SiGh. It is useless to point out that in the non-twisted this can not occur.

The speed in question will be at least one to which the lift equals the weight, at an angle of attack equal to the negative wash-out adopted; of course it is assumed that the profiles at the root and the tip have the same angle of zero lift, otherwise we must also take account of this difference.

Zero lift incidence α_0 = -0.6 degrees
Tip wash-out α_s = -0.5 deg

The angle of incidence of the wing root, such as to have an incidence of zero lift at the tip will be:

$$\alpha i = \alpha o - \alpha s = -0.6 - (-0.5) = -0.1°$$

Recall that the formula of lift is:

$$P = 1/2 \bullet V^2 \bullet S \bullet \rho . Cl$$

Placing the lift equal to the weight P = Q showing that the speed is:

$$V = \sqrt{\frac{2 \bullet Q}{\rho \bullet S \bullet Cp}}$$

$\rho = 0.125$
$S = 0.59\ m^2$
Cp = 0.09 found by referring to the importance of the profile curve for incidence -0.1 degrees
Q = 2.100 kg

$$V = \sqrt{\frac{2 \bullet 2.1}{0.125 \bullet 0.59 \bullet 0.09}} = 25\ m/s = 56\ miles/h$$

It may be that the speed will seem low, in which case I would like to point out that for simplicity in the calculation above, we deliberately are ignoring two facts:

(1) All of the wing does not work at the same Cl; the end panel is twisted and works with a lower incidence and then with a lower Cl, consequently the speed at which there is an inversion of lift will actually be higher than calculated.

(2) There is the phenomenon of the induced incidence. This reduces the effective wash-out and this limits, even if only in part, the approximations introduced by the previous step.

The calculation done, however, meets our demand by providing useful information, and in fact shows the lower speed limits at which occurs the phenomenon of the lift inversion and guarantees that the wash-out adopted is certainly good for speeds up to that calculated.

Wanting to get a more accurate result we will have to adopt a more precise calculation method that allows us to eliminate or reduce these approximations, as we will see later, when we will talk about drag and moment.

Reynolds number

If we consider that the lift in a turn is equal to the apparent weight of the model, the wing must necessarily work at high Cl, unless you want to increase the surface area while maintaining the same overall weight. But at that point shape drag will increase too, even in straight flight.

It will then be appropriate to increase the aspect ratio to reduce induced drag. This involves reducing the chord. This is convenient only up to a certain point; in fact, the extent of the chord has a direct influence on the Reynolds number and thus on the profile polar.

How much can we reduce chord ?

Let's try to hypothesize a minimum speed, a minimum Reynolds number - the one below which the polar profile is significantly poorer - and then calculate the minimum chord for our model.

Observing the polar of the profile chosen, we see that there is a big decline for

Reynolds numbers less than 200K.

We also know that the minimum speed of a model during an F3F race, with the minimum dynamic conditions laid down in Regulation (wind 3 m/s), can not be less than 15 m/s.

The formula for calculating the Reynolds number is:

$$Re = \frac{V \bullet C \bullet \rho}{\mu}$$

where
C = chord length
μ = air density
ρ = air viscosity

Hence

C= 0,193 m = 7.6 in

This is the dimension that should be adopted for the smallest chord, or at the tip.

Form Drag

Since one of our goals is to get the highest efficiency (ratio between lift and drag) in turn and the least possible drag in straight flight, we try to calculate the drag of the wing in the various flight conditions. The total drag is made up of induced and form drag. The form drag is calculated in a similar way to what was seen for the lift:

$$R = V^2 \bullet Cd \bullet S \bullet \rho / 2$$

The value of the drag coefficient Cd can be seen on the profile polar for the correct Reynolds number taking its value in correspondence with the Cl required for that flight condition.

Here the problems begin. Because this calculation is quite easy when applied to an elliptical wing with no sweep in which the local Cl is constant all along the span, in this case the angle of attack does not vary because of the induced incidence and the only approximation concerns the variation of the Reynolds number between the tip and root chords.

On a swept flying wing this thing becomes instead more complex, because any of the above-mentioned data do not remain constant, but you must also consider that the profile has been changed along the span in order to generate the desired moment coefficient Cm, hence the polars to consider are different across the wingspan... and the angles of incidence too!

Induced Drag

For the induced drag things unfortunately are no better, although for different reasons. Let us then try to understand why.

To calculate the value of the induced drag it is sufficient to replace, in the above formula, the drag coefficient, using Cdi instead of Cd thus obtaining:

$$Ri = V^2 \bullet Cdi \bullet S \bullet \rho / 2$$

Unlike Cd, the induced drag coefficient does not depend in any way from the airfoil, since it expresses the drag that develops from a wing of finished enlongation due to the vortices which are formed at its tips. The magnitude of Cdi depends instead by Cl (the greater the lift and the greater the intensity of the vortices), by aspect-ratio (the higher the aspect-ratio the lower the magnitude of the drag caused by the vortices) and from the wing load distribution (the more it is similar to elliptical shape the less is the magnitude of the induced drag). A simplified formula (Ref. 1- 6 and 7 of the bibliography) is as follows:

$$Cdi = \frac{2 \bullet Cl^2 \bullet G}{A\text{-}R \bullet \pi}$$

A-R = Aspect-Ratio
G = geometric parameter of the wing

The Cl to be used in this case is the average wing Cl. That is, we do not have the problems related to the variation of the profiles and to the difficulty to "choose" the Cd on the right polar as a function of Cl.

The problem in this case comes from parameter g, which for a wing with a perfectly elliptical distribution of lift can be assumed equal to 1.

But what do we know About how the distribution of lift evolves as a function of the flying aspect on a wing like ours?

We have to consider the phenomenon of the induced incidence and profile variation and wash-out needed to achieve the given aspect to that given speed. We can definitely envy the designers of conventional models who choose a straight wing without wash-out and separate surfaces for pitch control. They may opt for an elliptical planform, thus ignoring the factor G from scratch, or they can simply realize a trapezoidal wing, if in this wing the ratio of taper (tip chord / root chord) is equal to 0.4, it has the best approximation of the elliptical distribution, and it is sufficient to put G = 1.01 to calculate the induced resistance, an increase of 1% of Cdi in reference to the true elliptical wingload shape.

Panels method

The problems related to the calculation of the drag of a wing in which continuously along the span the profile varies incidence, Cl, and Reynolds number, can be solved by dividing the wing into many panels, i.e. into many small segments of lower span. The greater the number of panels, the lower their width and the smaller the differences between the profiles at both ends of the panel examined. In the case of an infinite number of panels (infinitesimal width), the profile of each panel end has differences very small (infinitesimal precisely) with the profile at the root, to the point that can be considered the same profile. This would ensure the most accurate calculation. It is not necessary, however, to use integral calculus, we just need software that calculates the polar profiles (panel by panel) and replace the values in the above formulas, doing for us the work after splitting the wing into a sufficient number of panels. A number of these panels equal to or greater than 30 would result in a sufficiently accurate panelling for our needs.

Pitching Moment and longitudinal stability

In our "wish list" there is also software that can calculate the lift distribution in a turn taking into account the position of the various moving parts. It is necessary, therefore, depending on the geometry of the model, to know the deflection of the elevons / flaps needed to turn - which also depends on the C.G. position - and to calculate the Cm of the new profile and wash-out, together with the data of lift and drag.

It is clear that the need for a flying wing to incorporate different functions - lift, stability and control - on a single airfoil creates a bit of confusion.

Let's proceed with order and look for a starting point: CG position, for example!

In fact, whatever the flying aspect of the model, slow flight, fast flight, normal turn or pylon turn, the conditions of equilibrium and stability have definitely to be respected, so that the model remains controllable.

In order to maintain the path set it is necessary that the model is always in equilibrium condition.

In a flying wing that means that the point of application of the aerodynamic forces (the center of pressure) is located on the same abscissa, with respect to the chord, as the center of gravity (which actually is the point of application of the inertial forces).

To remain constantly in balance all over the flight, it is also required that the model is "stable," meaning that for any intervention that would disturb its equilibrium condition, be it an accidental external event (a gust of wind) or an event caused voluntarily (the actuation of a mobile part), the model is able autonomously restore itself to the equilibrium condition.

The point of application of the aerodynamic force on a profile is usually not known because there are movements to vary its position while ensuring the stability that the model needs. Although its position can be calculated, this is not indicated in the characteristic data of the profiles.

Conversely comes the moment coefficient Cm. It is a dimensionless value that expresses the tendency of the profile to rotate with respect to the neutral point Xn which is conventionally considered to be at 25% of the chord.

There is obviously a relationship between Cm and the position of the center of pressure Xcp, given that the distance of the latter from Xn is the "arm" of the aerodynamic moment, the relation (Ref. 1, 6 and 7 of the bibliography) is as follows:

$$Xcp = Xn - Cm/Cl$$

Let us remember that in respect of the condition of equilibrium, the position of the center of pressure corresponds to that of the center of gravity:

$$Xcg = Xcp$$

If you want to do a check of the moments, know the Cm, we can calculate the total aerodynamic moment. This should balance the moment due to the weight compared to the same point, which is the product of the static margin (distance between the neutral point and center of gravity, i.e. Xn - Xcg) and weight - the weight multiplied by the centrifugal acceleration g of the turn, then the ' equation to be solved to obtain the centering function of speed / weight is:

Ma (aerodynamic moment) = Ms (static moment)

The moment caused by the aerodynamic forces, calculated with respect to the neutral point is:

$$Ma = \rho \bullet Cmm \bullet S \bullet C \bullet V^2/2$$

where
C = the mean aerodynamic chord
Cmm = coefficient of aerodynamic moment of the whole model, to be calculated using the method of the panels applied to the various flight conditions and trimming of the moving parts.

The static moment, with respect to the Neutral Point, caused by the forces due to the mass of the aircraft - weight and centrifugal force - applied to the center of gravity is given by:

$$Ms = (Xn - Xcg) \bullet Q$$

As already mentioned, the distance Xn - Xcg is also called the "static margin" and it is clear that by representing, in the calculation of the moment, the factor dependent on the geometrical characteristics of the model, this distance is also called "stability factor."

Extrapolating the speed value from the combination of the above equations we can easily observe that the speed of flight of a model depending on C.G. position and its weight is:

$$V = \sqrt{\frac{2 \bullet (Xn - XCG) \bullet Q}{\rho \bullet Cmm \bullet S \bullet C}}$$

We give an example with the SiGh in straight flight:

ρ = 0.125
Cmm = 0.0037
S = 0.59 m^2
C = 0.2285 m
Xn = 0.27 m
Xcg = 0.25 m
Q = 2.100 kg

Substituting all in the above formula we obtain a speed of equilibrium:

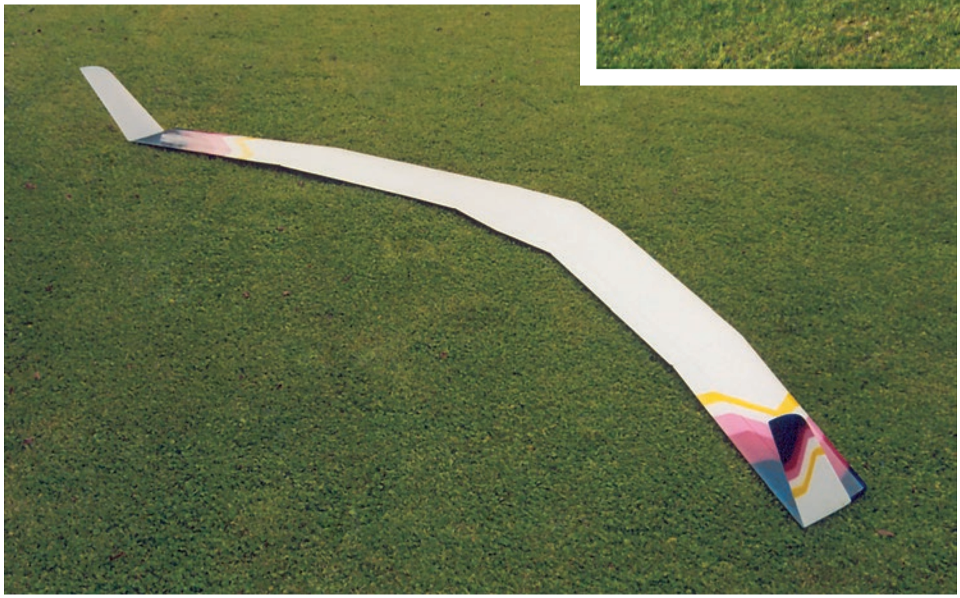
V = 36.7 m/s = 132 km/h = 82 m/h

This example is the only one we can do easily. In fact the value of Cmm, moment coefficient of the complete model, coincides with that of Cm, moment coefficient of the profile, in the absence of deflection of the moving parts and wash-out and assuming negligible effects by the induced incidence (low Cl).

Otherwise is needed a program that analyses the wing by the above described panel method and that computes Cmm calculations as the sum of the moments developed by each panel with respect to the neutral point of the complete model (25% of the mean aerodynamic chord).

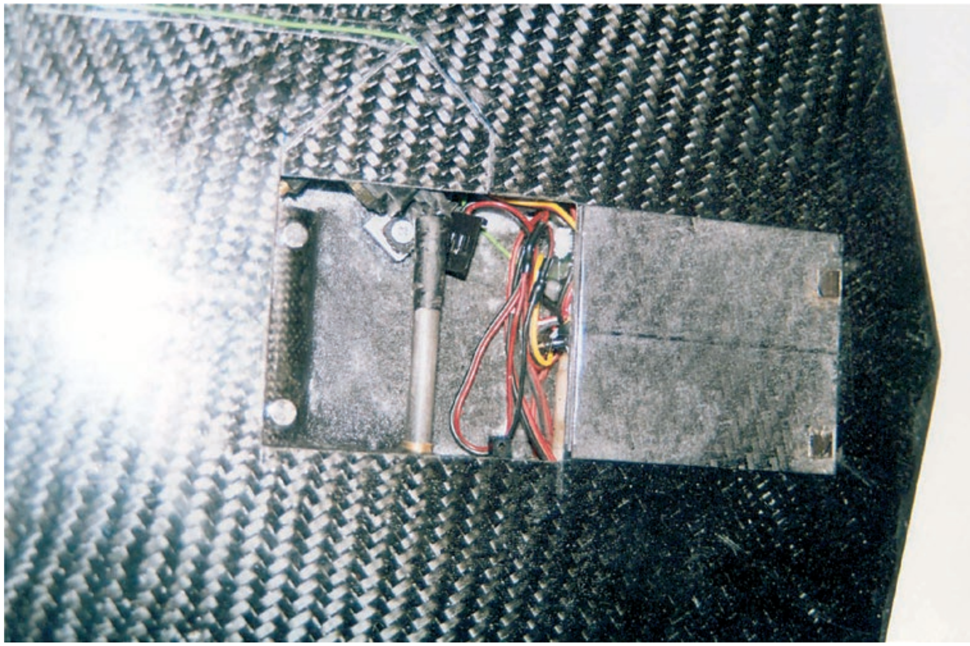
Also note that, in the case of the turn, the equilibrium condition will be sought by substituting in the formula of the static moment, and consequently in that of the velocity, the apparent weight in turn Pv to the simple weight Q.

The increase in the static moment due to the apparent weight Pv in turn gave rise

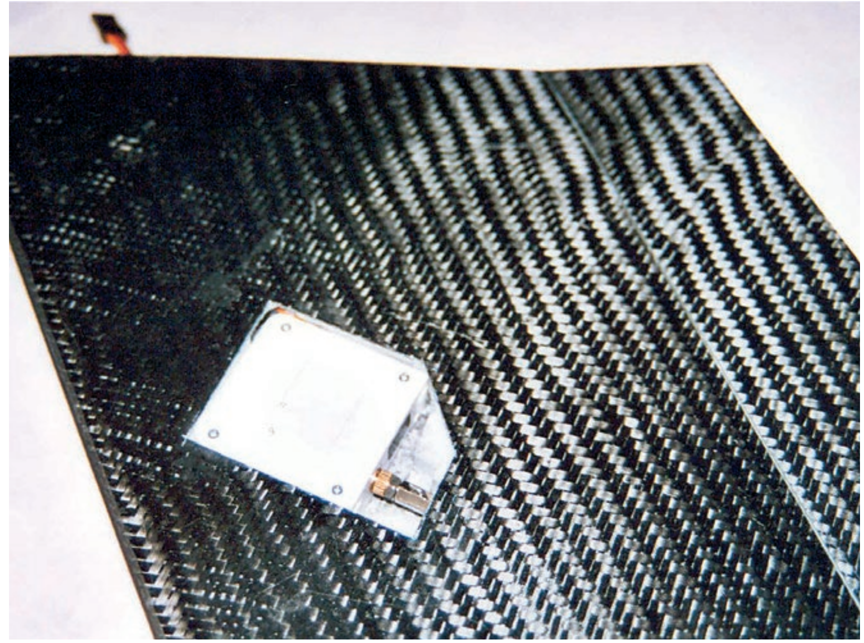


Above: Group photo of the participants at the Italian F3F Series in Valinis. In the middle, Simon Nosi with the SiGh that still does not have the beautiful final livery.

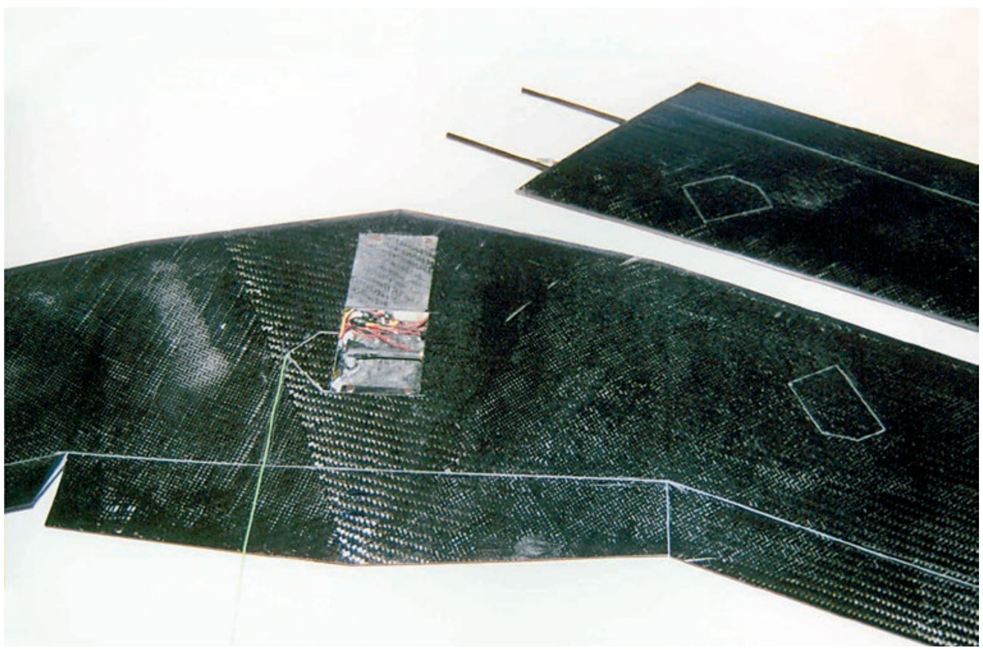
Left: The SiGh in all its glory. Whichever way you look at this flying wing, it is a true "anthem" to aerodynamic efficiency. Painted predominantly white, an absolutely essential item, as the bare carbon surface, when exposed to the sun, could easily fry a couple of eggs!

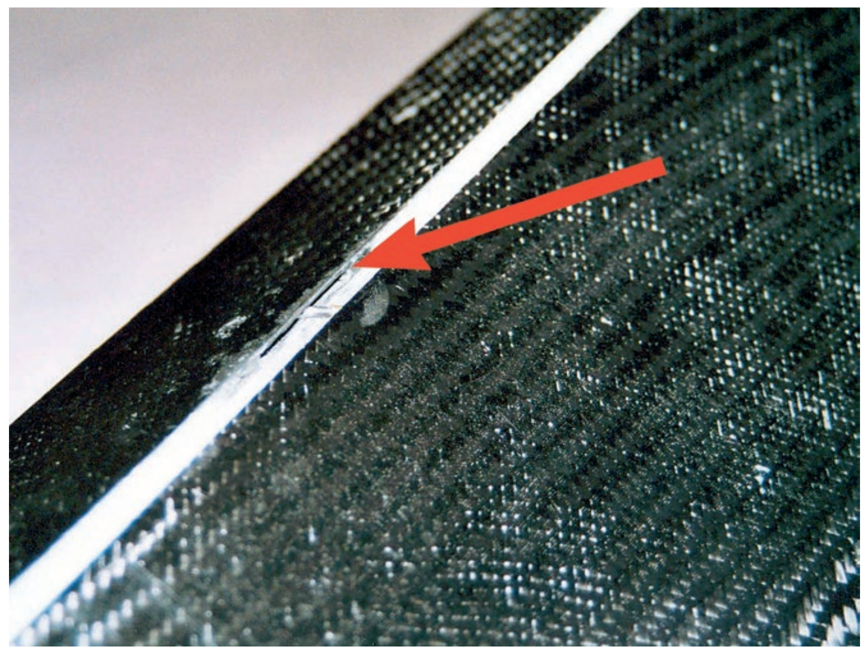


Center section compartment and bayonet wing panel assembly.



And RDS, of course.





to the deflection required for the moving parts to keep the model in a circular path. In fact, in order to keep the model stable in turns at the same speed, you will need to increase the coefficient of the moment of the complete model Cmm.

Computer simulation

We have analysed several of the available software in order to assess what was best suited to our needs. Starting from the most simple, the spreadsheet “Liftroll” by Hazel, that does not provide information on drag and moments, but on the distribution of lift and Cl only.

A coarse evaluation on the form drag can also be done simply by observing the maximum Cl, understood in this case as the apex in the distribution curve of the Cl of the model, and not the Clmax of the profile.

Having in mind this value, simply choose a profile that allows its achievement on the polar curve at the correct Reynolds number, before meeting the “wall” of resistance that identifies the location of Clmax. However, this is a very superficial assessment, which doesn’t allows us to give a measure of performance, but only to understand if a profile is more or less suitable for the use we want to do.

A more complete program, derived from Liftroll fwith permission of the author, was developed by Greg Ciurpita. This software too calculates the drag of the model, using data from precalculated tables containing the polar of various profiles related to the Reynolds number.

This software is adequate for conventional models with or without wash-out and sweep. Unfortunately, it’s not suited to the flying wing because, while calculating the new value of Cm with the trimming of the movable parts (using, I suppose, the theory of thin profiles), it takes the data of the profile Cl and Cd from the static tables and does not calculate the new profile polars.

Therefore it can not take account of the influence of the position of the various movable parts on profile polars, and consequently the shape drag data are distorted.

The only program, among those assessed by us, that performs the “dynamic” processing of the drag data, calculating the polar of the real profile each time and panel to panel (that is, modified by the position of the moving part), is the software Nurfluegel V 2.17 by Frank Ranis, downloadable via the Internet at <http://mitglied.lycos.de/frankranis/>.

It is an amateur program rather accurate (unfortunately only in German) and specific for flying wing, which calculates the lift distribution and drag along with stability, always taking into account the deflection of the various moving parts.

The author used the vortex lattice theory for calculating the induced incidence and then the distribution of Cl, the lifting capacity (Cl • local chord) and the induced drag.

In order to make the software as much as possible enjoyable and fast, the author applied instead the theory of thin profiles for the calculation of Cm, which is used in the stability calculation. Finally used the Eppler Code only for dynamic calculation - panel by panel - of the polar profiles in order to determine the form drag. The calculation of the form drag by means of the Eppler Code is optional, it requires a certain time, which increases with the number of panels and with the age of the computer available.

In place of the form shape calculated, and hence of calculated efficiency, the software can provide an “estimated” value which, however, is quite different from the computed one.

With Beppe we decided to use the most accurate method. This required a longer time for calculation and quite a few problems, because the calculation at the beginning did not want to work.

We referred to the author and the dilemma has solved when he wrote to us explaining that, for reasons unknown, the dynamic calculation of the polars by Eppler Code did not work on Windows2000 or WindowsXP operating systems. It was necessary, therefore, to have a computer with Windows98 or WindowsME.

Before we totally relied on this program, we thought it would be good to do cross-checks to see if calculated data corresponded with those of other software evaluated, which although less adequate for our purposes, however, were more referenced.

We have therefore set up a similar model for all the software and looking at the values of Cl maximum, the highest value in the distribution curve of Cl, we felt that there was some convergence.

In fact the values found:
Liftroll at 12.5 degrees incidence:
    Clmax = 0.971
Ciurpita at 10.6 degrees:
    Clmax = 0.962
Nurfluegel at 10.4 degrees:
    Clmax = 0.96 - 0.97, value inferred from the polar

In Liftroll the angle of incidence is about two degrees higher than in the other two programs, but this difference is simply due to the incidence of zero lift of the simulated profile.

The general operation of the Nurfluegel V. 2.17 software is the following:

- Define model geometry,
- Define flap and aileron geometry ,
- Set the weight of the model,
- Set one of the basic parameters concerning the flight... And the program calculates the rest.

The basic flight parameters are:
- Flight attitude, can be entered as angle of attack in degrees or as Cl,
- Stability, inserted as C.G. position in mm or as stability factor,
- Flight speed (in m/s).

Inserting, for example, the speed, the software will calculate angle of attack, relative Cl, C.G. location and stability factor, relative to the model described having weight and moving parts trimmed as set.

Conversely, setting the C.G. position (or the stability factor), on the same combination of model weight and moving parts trimmed, there will be calculated by the program the flight aspect (angle of attack, Cl) and the speed of the model.

It is also possible to enter the flight aspect, as angle of attack or as Cl, and obtain the flight speed and the necessary C.G.position.

We, Beppe and me, did this consideration: once found, for a given model, the deflection in degrees that elevons should have to make the turn, the program tells the C.G. position and the value of the static margin. Afterwards you try to simulate the use of flaps, modifying wing profiles according to the chosen setting and look for the new deflection of the elevons needed to achieve the same C.G. and static margin.

Obviously wanting to simulate the condition of the pylon turn, compared to the case of straight flight, you should increase the weight by multiplying it by acceleration g.

For simplicity, we have assumed an acceleration of 10 g. The only thing that remains fixed on the model is the position of the C.G.

The hypothesis was therefore to evaluate and set it up so that the C.G. remains fixed during the simulation, then all that remains is to see what happens to the other calculated data. We started trying to optimize the distribution of lift, and therefore the induced drag, for the condition of turn to the pylon to 10 g with a weight (ballast enclosed) of 2150 gr.

One of the first questions we set ourselves was if by chance it is possible to obtain a distribution curve very adherent to the elliptical, and at the same time making sure that this distribution is maintained in the various flying conditions, including that of straight flight, in a way similar to what happens on conventional models.

Adopting a particular geometry of the moving parts, not without some surprise, we saw that it is possible.

The wing planform and the relative distribution in a 10 g turn is shown in Figure 3, the distribution curve is continuous in red color, the dashed curve is the elliptic curve for reference. This result was obtained, as can be seen from the figure, by adopting movable surfaces of triangular shape, so that the “twist” geometric and aerodynamic product at each point along the wingspan is such as to maintain a very regular distribution curve.

Looking at the efficiency of this solution, and comparing the calculated efficiency for the same model with moving parts of a traditional dimensions (such as those of Figure 2), however, we realized that the traditional solution gave a higher efficiency, despite the lifting curve (Figure 2) had a much less regular pattern.

The configuration, and the relative distribution of lift, that gave the best theoretical results in a turn is that of Fig 4, in which the pitch-up needed is obtained only with the lowering of the movable flaps (green and blue).

Analyzing the best results, that is, looking also at the values of form and induced drag in the two situations, it was found that the solution with the tapered flaps had less induced but greater form drag. In an attempt to “adhere” the curve of the lift distribution perfectly to the ellipse, we had forgotten that there is also a drag given by the profile, and that this may increase a lot if the hinge point of the movable parts is incorrectly positioned.

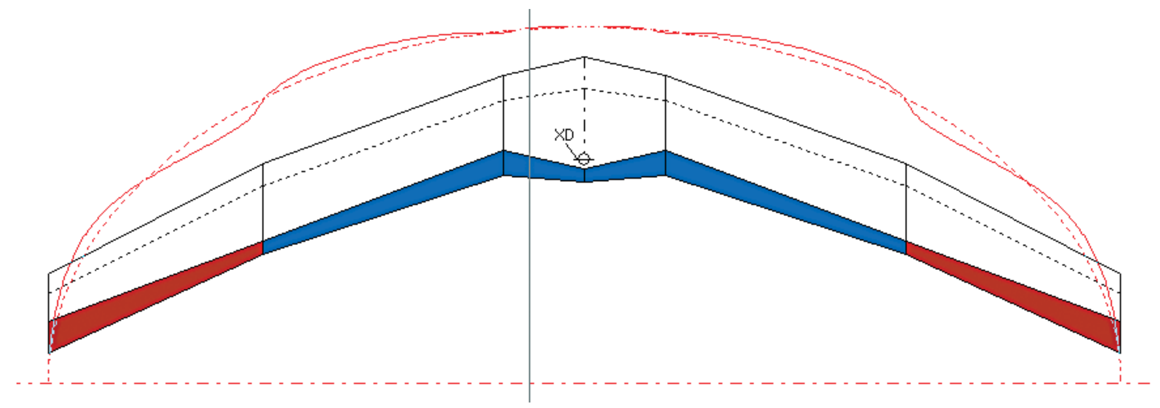


Figure 3

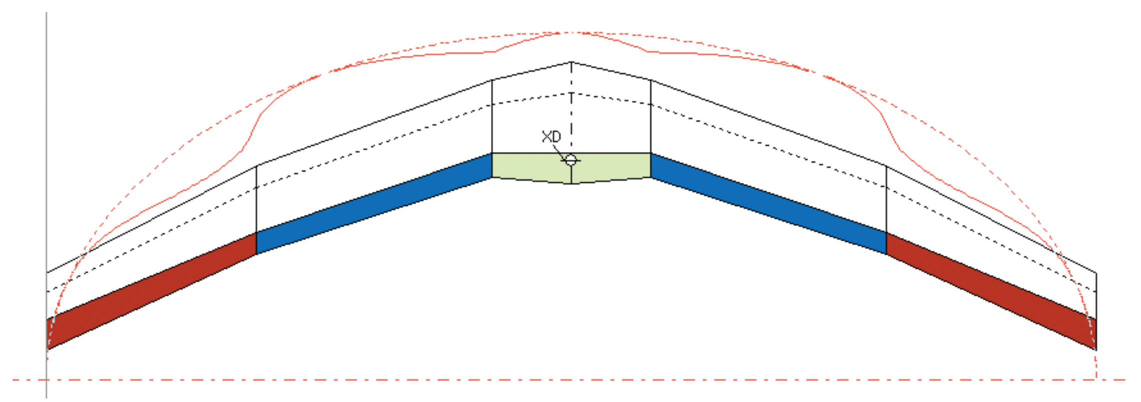


Figure 4

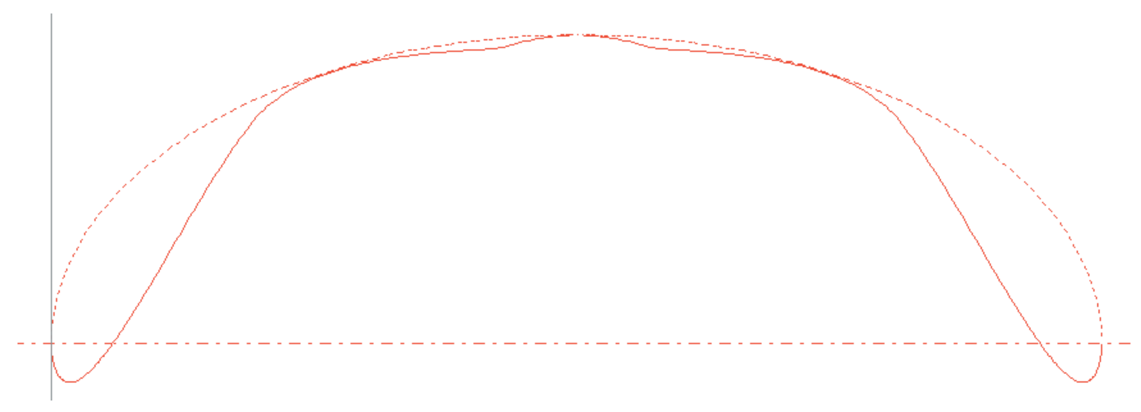


Figure 5

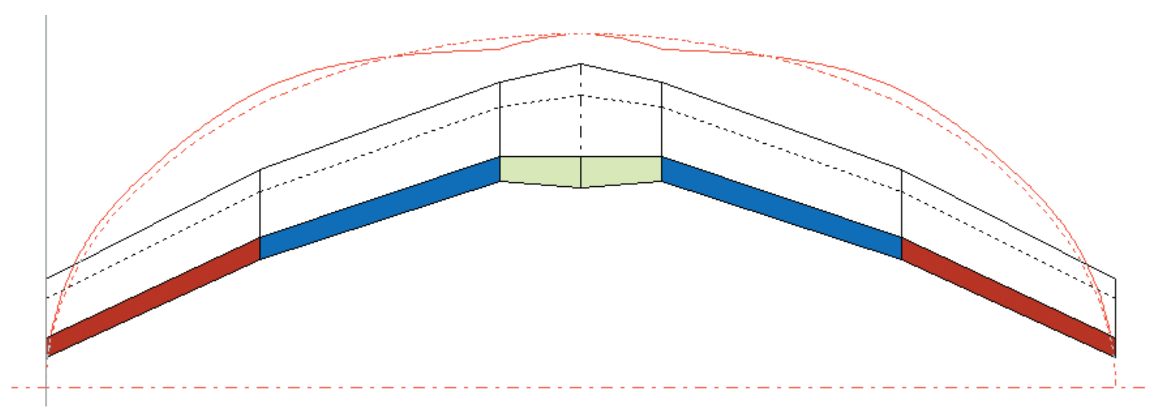


Figure 6

For the straight flight, the ideal was to obtain an elliptical distribution at high speed and, at the same time, avoid lift inversion in the conditions of minimum wing loading and maximum expected speed.

This condition - the one to be avoided - is depicted in Figure 5, and is relative to a speed of 30 m/s with 1.5 degrees of negative tip wash-out. The condition of straight flight with 0.5 degrees of negative wash-out is instead that of Figure 6, obtained at 30 m/s.

Simone:

I am afraid that trying to increase efficiency by increasing the wing load will be reflected negatively in the process of turning a 8-9 g; also see what happens in the configuration with -2 degrees bringing the speed to 33 m/s in both the lift distribution and the CG position.

Beppe:

I was expecting an increase in efficiency with increasing weight. I went from 1250 to 1750 grams, not least due to the increase of Re, however, there is no difference. Rightly then we have to bring the weight to turn around in.

Simone:

We should try to define a maximum speed for an F3F model and set to this speed the downwash that does not cause the reversal of lift at the tips. Otherwise we will be in the disadvantageous position of having induced drag (due to the downforce) that increases with speed instead of decreasing as on all other models. Considering that the path is theoretically 1 km (in practice at least 1300 m) and that the "record" seems to me to be little more than 30 seconds, I think the peak speed with exceptional conditions can not exceed 35-40 m/s.

Speed around 20 m/s could also be normal.

What do you think of the whole matter?

Beppe:

When I thought about my F3F (Emmbbè) I asked a friend the time usually set when he was competing; of course he did not remember exactly, but he said "around 35-40 seconds with a good wind."

I think it's too optimistic if the record is around 30. Whereby said 30 the minimum limit and 45 the max we have an average speed of between 28 and 43 m/s, we can further reduce the research and set between 30 and 40 m/s.

Sinking speed should also be similar to the wind speed vertical component; we shouldn't gain or loose height, so no gain can be accepted by an increase in sinking speed, hence we should have high efficiency or low sinking speed, which is the same thing.

Simone:

Given an horizontal speed of 40 m/s what should the ideal sinking speed be?
I computed some numbers with the wing of a model that is still widely used in F3F, the Tragi 702.

Tragi 702 at 40 m/s with the minimum weight (2220 gr - 35 gr / dmq) has an efficiency of 22.6 and Vy = 17.66 m/s, while the maximum ballast (3720 gr - 58 gr / dmq) we arrive at E = 37.8 and Vy = 10.57 m/s .

Considering that this model has a fuselage and tailplane... it seems that the model has too much surface related to the little lift that serves at that speed to be highly efficient.

Beppe:

In fact we are saying the same thing watching different parameters. It can be said that with the increase of the speed the ratio Cl/Cd decreases with the decrease of Cl, or it can be seen that the ratio Lift/Drag decreases for the increase of Drag, or yet the ratio Horizontal Speed / Sinking Speed... we always talk about efficiency, we just only have to agree.

Simone:

Tonight I had fun too. I'll send you the series of models from A to C.
- The A-version includes an increase and extension of the wash out, but it is an advantage that could prove harmful in straight flight, I'd rather err in defect rather than excess.
- The B version has less sweep at the last panel, which is not as huge a constructive advantage wanting to build the model in three pieces and as there is a non-linear wash out at that point. The increase in efficiency is less than 3 and is obtained pulling back the CG 1.8%, i.e. by decreasing the stability.
- The C version instead has a very good idea, to move the flaps with a 2:1 ratio instead of 1:1 with the elevons, the increase of efficiency obtained is combined with the increase of stability.

Beppe:

The current position of the flap seems to me to do much in increasing efficiency. I simulated a ratio of 3:1 in the flap-elevon mixing, seems to me a way to go. In addition, it seems to me, even from the simulations, that big load increases are not useful.

I do not know how we're going to load the model with respect to the base load and for what base load we aim?

Interesting your proposal: don't mind about the accuracy of the lift distribution curve, be rather more careful to put the hinges where they usually give better results; this improves the overall efficiency because the "loss" (induced drag) caused by the non elliptical distribution is largely compensated by the gain on the form drag. It seems to me that the reasoning does not make a wrinkle and also pay the accounts in hand.

Simone:

Anyway... How do we proceed?
If you agree, I would say that before you start to draw a model we need to take stock of the objectives and instruments, and then:

1) We must choose the distribution to be found in the two phases of flight (straight and turn)
2) We have to decide which of the thousand or more parameters that gives us the program we need to take as a reference.

Beppe:

The benchmark should be the main pursuit of least resistance (i.e. maximum efficiency) in the two flying conditions.

Straight flight

Any distribution will do, provided that we have no lift inversion at tips, as you said when the lift is small, its distribution causes a little impact.

Turn

Distribution very similar to the ideal elliptical which means least induced drag for a given wingspan.

Simone

I do not know how simple this will be.

Observing the Emmbbè these are the conclusions dictated by the program, my guess wasn't exactly the same

Straight flight:

At a speed of 33 m/s with a weight of 1.25 Kg there is lift inversion at tips, looks like 1 wash out degree is too much.

Turn:

At the same speed with a weight of 12.5 kg the best approximation of the elliptical lift distribution seems achievable with 0 degrees of flaps deflection (useless?) and 1 - 1.5 degrees of up elevons, which I think are insufficient to ensure the turn at the pylon.

Bringing the elevons to 5 up degrees, the lift curve tends to a bell distribution with sin^1.5.

But on second thought, since you can have elliptical distribution with a non elliptic planform do not you think that the value of the relationship will change?

Beppe:

In fact I get it that way, elliptical distribution means that the development of the product local chord • Cl is elliptic, if the planform does not meet the ellipse then you can take action on Cl (geometric / aerodynamic wash out) to maintain the elliptical form of the product, but the Cl is no longer constant and the above relationship can then be different even with an elliptical distribution.

The difference between elliptical wings (with constant Cl) and other configurations that aim to elliptical distribution with other systems is that they DO NOT respect the same distribution at all angles of attack, but only at a few privileged aspects.

CG position

The model needs 200 gr of lead to get the CG in the proper position. The initial CG was set at 250mm from the leading edge at the root, or 16.2% of the mean aerodynamic chord; it is a good value for the test flight. Then we proceed by removing 5 grams at a time. The limit according to me not to be surpassed is 265 mm, corresponding to 20% of the average chord. Generally, on a flying wing model after due tests I find myself about halfway, at 18% CMA.

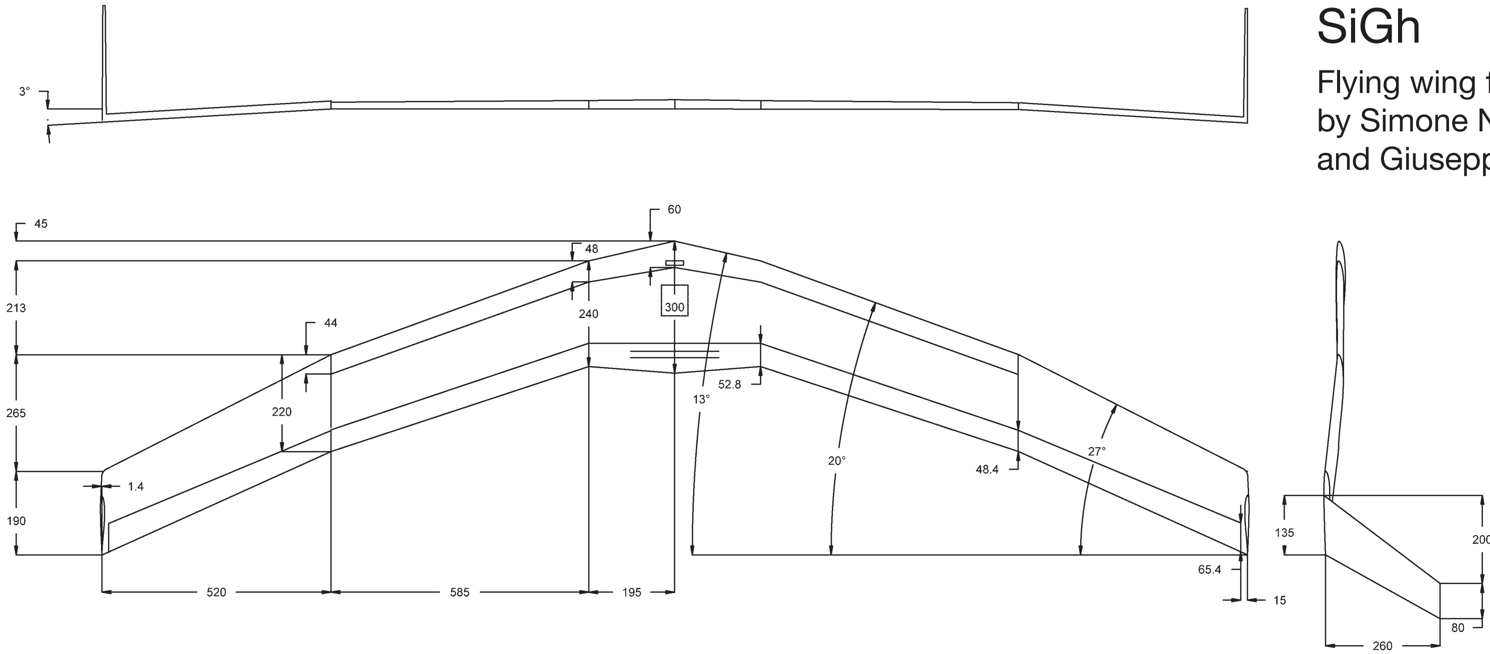
Flight

Battery charged, CG at 250 mm from the leading edge at the root, weight of 1660 g with a load of 28.25 g/dmq (the model is not yet painted). For commands I set two programs for the sake of prudence (first flight), reserving to modify them according to the reactions of the model:

+ means down movement

SPEED
Roll: External aileron + / - 20 mm (mixing with the intermediate flap 50%)
Pitch: External aileron -9 mm, intermediate flap +12 mm, central flap + 18mm

LANDING
Roll: External aileron + / - 20 mm (mixing



SiGh

Flying wing for F3F
by Simone Nosi
and Giuseppe Ghisleri

with the intermediate flap 50%)
Pitch: External aileron -9 mm, all the rest do not move, so I'm sure to have control.

The mode used for the first flight is Landing.

Launch!

It needs a little down trim, then it picks up speed, try to turn... docile as a lamb, there is no need for aileron trim and, after a while, even pitch trim is set back to center. Is it all due to the evenings spent making calculations or pure luck?

I make turns simulating the race course, the model is stable in all axes, it turns very well and is very docile and easy to fly, so that I'm relaxed .

It's time to try the speed mode.

I climb somewhat to gain height and switch the program on, pitch up... All right, I turn the model right and left many times trying flying modes. With the speed mode the model is more sensitive to pitch up control, a sign that actually lowering the internal flap produces a favorable moment to pitch up. In addition, it seems to me that the model exits faster from turns.

It's time to decide what changes to do before the next flight. In the speed mode I'll reduce the elevon movement in relation to central flaps. However, I will not change the center of gravity because the model with this setting flies very well and... you can not try it all together.

The landing is a problem... the model does not want to come down and forces me to do a lot of laps. Once on the ground I would also change the landing

mode, raising all the moving parts together to decrease the efficiency and sink more rapidly.

The new settings are then:

SPEED
Roll :External aileron + / - 20 mm (mixing with the intermediate flap 50%)
Pitch : External aileron -4 mm, intermediate flap +12 mm, central flap + 18mm

The launch is always in landing mode. I fly the model and try the new speed mode. Now there is no difference in sensitivity to the pitch command in the two modes and they generate the same pitch up moment with the same stick excursion.

Instead, I see more clearly than before (no timing, only sensations) that in the speed mode the model comes out faster from turns than before.

I try to stall the model in the two flying modes, slowly pulling the stick. The model doesn't stall, but pushed to the limits of the up command, it starts to jiggle in the pitch axis; the oscillation, however, is less in the landing mode

Feeding a sharp pull-up the model stalls, throws the nose down and resumes flying attitude in less than 5 meters without any attempt to spin. A relief!

Some more changes to surface excursions.

SPEED
Pitch : External aileron -4 mm intermediate flap +12 mm, central flap + 20mm (2 mm more than before)
LANDING
Pitch : External aileron -15 mm, intermediate flap -9mm, central flap -9mm

The test went well, however, because I have done three flights trying different configurations and obtaining a model easy to control. In my opinion, a racing model must fly all by itself so the pilot can focus on the track without having to worry about keeping in the correct aspect.

Despite the low wing loading, even turning into the wind the model did not seem to slow down a lot.

Summarizing the position and movement of the control surfaces:

During straight flight they are set to zero, both in the speed and in the landing mode; the difference lies in the effect that the up stick movement has depending the mode selected.

The lowering of the central flap during the turns (mixed to the elevator), serves both as "variable profile" and to contribute to the pitching-up moment, thus requiring a lower elevon movement.

In the landing mode, the pitch-up stick commands the surfaces so that by pulling it progressively all surfaces are raised, thus decreasing the efficiency of the profile.

In the future, I was thinking of modifying the landing mode and also use the throttle stick command as "brake," looking for the right mix in order to raise all the moving parts with a quantity that does not have an effect on the pitch-up moment, leaving to the pitch-up stick the task of moving only the elevons to control the pitching axis.

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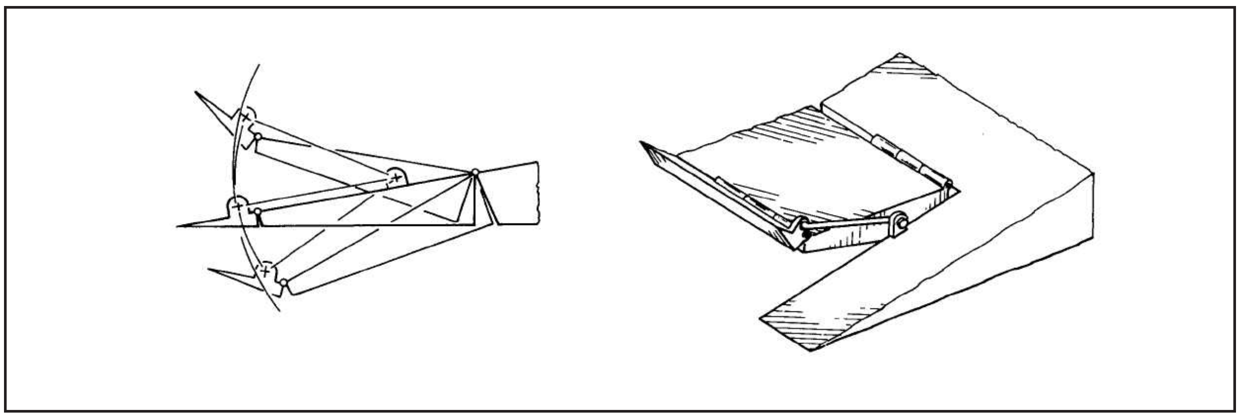
Aileron differential, the Kasper trim device, Frise ailerons, drag rudders and split elevons

John Newton, jhndesign@hotmail.com and Bill Kuhlman, bsquared@centurytel.net

Bill: OK, I've been working on an enlarged Ken Bates' Windlord for a couple of years now. Our original vision, because this version was to have ailerons (contrary to the original), included Frise-type ailerons to compensate for adverse yaw. Because the Windlord is a "plank," differential is not a good solution to this problem.

Luckily, the delayed building process has lately allowed us to begin thinking about other adverse yaw countermeasures.

One of these solutions is the use of the Kasper trim device as outlined in Kasper's book and used on Mat Redsell's build of the Jim Marske Monarch.



The Kasper trim device geometry forces the tab portion of the control surface upward any time the control surface is not in its neutral position

Our uncertainty comes when determining how large this tab needs to be on the Windlord, so we're looking for advice from the group.

Our Windlord is a 132% enlargement of the original Standard Class 100" span model. This size gives the maximum wing area allowed by the FAI for aeromodels. On our "cross country" version, the ailerons extend from the outer edge of the elevator to the last wing rib, 30", and have a chord of 5 1/4" at the root and 3 3/4" at the outer end where there is significant curved taper over the last 6".

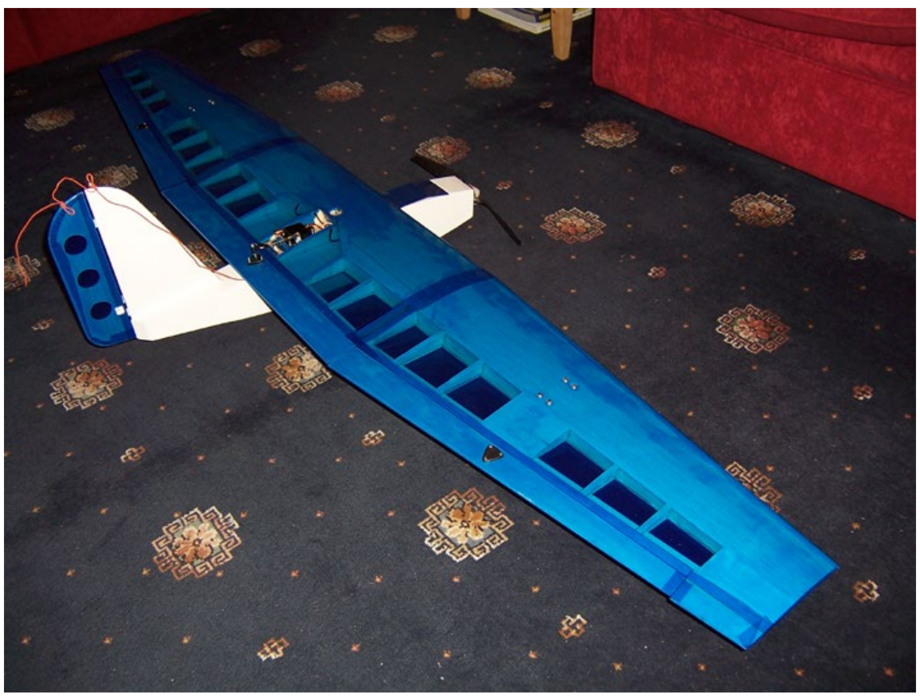
Any Kasper tab sizing recommendations will be eagerly accepted with our sincere thanks.

John: I read with interest your intention to use Kasper flaps to help avoid adverse yaw on Ken Bates' Windlord. I only recently discovered the Kasper flap and it looks like an intriguing solution. Looking at the design I wonder if the

Inset right: Ken Bates and the original 100” span Windlord. Photo from the March 1978 issue of Model Aviation and the Academy of Model Aeronautics web site <http://www.modelaircraft.org/plans/images/1978/215.jpg> where full size plans are still available at <http://www.modelaircraft.org/plans/plans78.aspx> as plan set #215.

Right: Ken and his “new” Windlord at the 2007 AMA/LSF Soaring Nationals. Photo from the Louisville Area Soaring Society web site photo archives <http://louisvillesoaring.org/gallery/main.php?g2_itemId=112400>.

Below: John Newton’s Soaring Fish-E mentioned in the article.

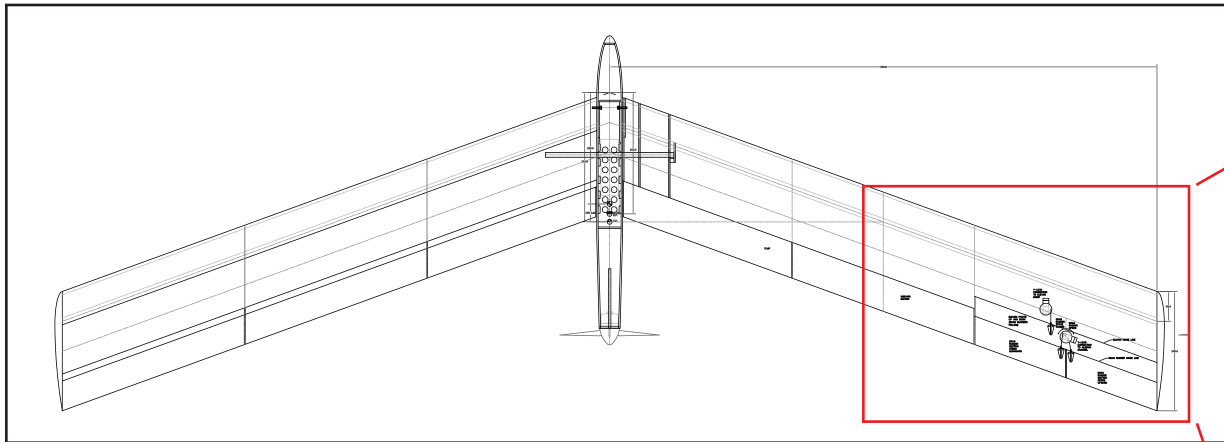


connecting linkage between the flap and the main control surface could be moved inboard more centrally relative to the flap to prevent the flap twisting under load. You would not normally want to have a linkage at the extreme end of a control surface, makes me wonder if this contributed to the flap coming adrift on the full size Kasperwing?

Before I became aware of the Kasper flap I had been trying to come up with somthing that would increase drag on the inboard wing when the model was rolled to produce a coordinated turn and remove the adverse yaw.

Attached is what I came up with. The drag rudder sections are connected to the main outboard elevon and move up and down with it, they are linked to the aileron control in such a way that they deploy on the inboard side of the turn when the model is rolled to increase drag, they could also be mixed in with the rudder channel to use as a conventional rudder control.

On the model wing I am currently flying which has two elevons per side (inboard and outboard) they are mixed to open in opposite directions on the inboard side of the turn when the rudder stick is used, as per Jurgen Haas suggested. This worked well in practice and I found I could counter the adverse yaw the model suffers by applying rudder along with



aileron to get a coordinated turn.

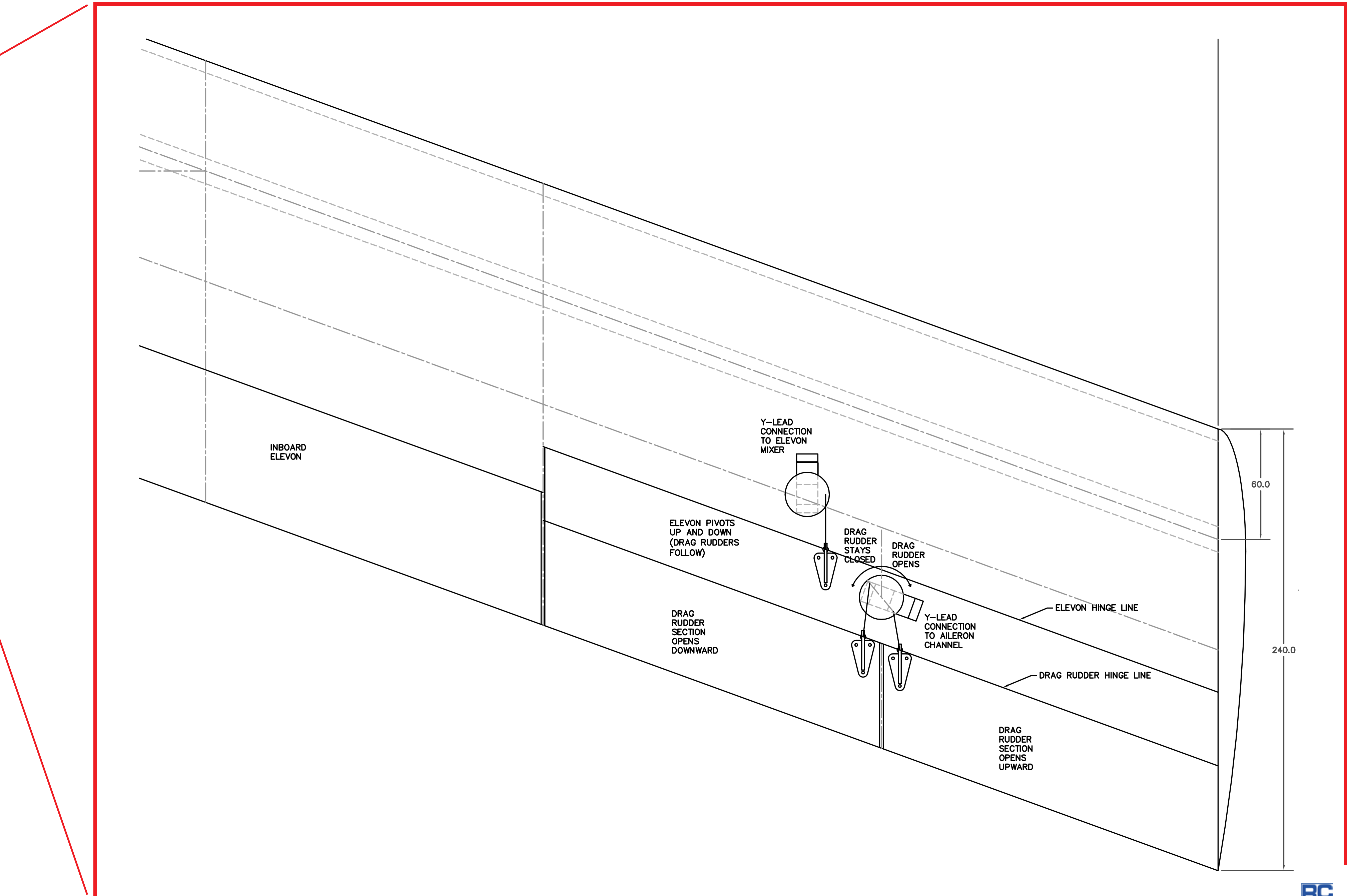
I hope the above is of interest.

I have been thinking some more regarding the Windlord based model you mentioned and I think it may not suffer from any noticeable adverse yaw if you retain the fin. I designed a model with a similar layout called the Soaring Fish-E (see attached photo), this featured a central elevator and outboard ailerons, turns were fine using aileron control alone without any rudder application being needed, and I did not notice any adverse yaw.

A word of caution, my model would tip stall if turning tightly at slow speeds using aileron alone, due I suspect to a combination of high taper, outboard ailerons with no differential (as required) and no washout.

Bill: We have the aileron cutouts constructed and all of the aileron ribs manufactured.

After looking at what's already been done, incorporating the Kasper flap is going to be complicated as the aileron cutout has too large a chord for a standard aileron. Rather than reconstructing the outer wing panels, we've decided to go ahead and use the Frise ailerons originally envisioned. Having said that, a modification is in order - building the full Frise leading edge over only the last third of the aileron span. We haven't put the sheeting on the wing yet, so that outline can be configured to accomodate the modified aileron leading edge. We always use mylar gap seals as well, so everything should fit OK despite the rather extensive unplanned modification.



Y–LEAD CONNECTION TO ELEVON MIXER
INBOARD ELEVON
ELEVON PIVOTS UP AND DOWN (DRAG RUDDERS FOLLOW)
DRAG RUDDER STAYS CLOSED
DRAG RUDDER OPENS
60.0
ELEVON HINGE LINE
Y–LEAD CONNECTION TO AILERON CHANNEL
240.0
DRAG RUDDER SECTION OPENS DOWNWARD
DRAG RUDDER HINGE LINE
DRAG RUDDER SECTION OPENS UPWARD

over the edge

Ken Stewart, kenmstewart@gmail.com

The alarm chirps, eyes open, the day starts.
Pilots meet and breakfast hastily eaten.
Wind and weather are discussed and a slope chosen.
With Thermoses filled and trucks loaded, it's off to the hill.

Into the valley they travel, then a turn up a steep road.
The trucks climb with swiftness and ease.
From the valley floor, morning fog climbs out of hiding. Questions are asked then answered advice is given and noted.
The summit is breached, the trucks are parked and planes are readied.

The morning brightens, cool and calm
Hand launches are tossed, sink, and then quickly land.
Pilots quietly discuss an alternate site.
Voices shout, kids chasing, and cameras click
A hawk glides near, and then dives away.

Wind out of the west, and building.
Lift, light, but steadily growing.
A gentle toss, fragile wings dip, and accept the strain of flight.
Faces smile and beam, as altitude is gained.
Everything with the world is all right.

Altitude quickly gained, is suddenly lost.
Planes begin to sink below the horizon.
Thoughts of making it to the top again, disappear, as the lift dies.
Down, deeper in to the abyss the plane floats.
Twisting, turning and searching for the elusive lift, all the while shrinking.

Lost for eternity or just eaten by trees?
The descent begins, legs are strong and breath is sound, easy going.
Where the slope the steepest, the bush the thickest, the plane is rescued.
With shins bleeding, thin air the ascent begins.
A rest stop, legs burning, breaths gasping, push on.
Time passes, climbing endless, the summit is sighted, then breached.

Sunnier, warmer, breezier, fore noon
Lift is back but sketchy.
Cooling coffee is sipped and snacks eaten.
Pilots chatter as electrics whine around.
Heads turn, eyes strain, faces smile
Swans gracefully and silently pass overhead.

Clouding, warm windy afternoon
Lift strong and settled.
Pilots hoot and holler
Wings locked in combat flail about
Binoculars out, necks strained, standing in awe,
as cranes noisily thermal by.

Darkening, cooling fore eve.
Lift strong and stable as Ninjas gracefully ply the skies,
zooming, turning, spinning in effortless flight.
Geese loud and shrill and an ever-changing V quickly pass.
Batteries are running low.

Dark, cold, calm, night.
A silent ride to dinner, still in awe
Pilots eat, brag and joke.
Then back to the room, charge batteries, and make repairs,
Check morning weather, and then retire for the night.

Glacier Ridge, Colorado,12,280’. Photo by Rocky S. Stone

Little Plank III

Chuck Clemans, ChuckClemans@msn.com

A little about the Little Plank III

The first Little Plank was the result of collaboration with Dave Jones. Dave ran Western Plan Service which specialized in flying wing designs, most of which were planks with zero sweep-back. Dave and I built and flew models together in high school and after stints in the Air Force and college we resumed model building and exchanging ideas. Dave lived in Torrance California and I had settled in Bellevue, Washington.

In 1971 Dave sent me a sketch for a small 54" span plank for high start or winch launch which he called the Little Wing. Based on his concept, I drew plans and built the Little Plank. It was very simple with two servos, one for each elevon. The elevon servo was mounted on a sliding tray which was moved fore and aft by the elevator servo. No electronic mixers in those days! Despite having no dihedral and a span of 60", it was easy to control on high start or the 6V winches of the day. It was fun on the slope and would thermal in light lift. I also flew it with a TD .049 in the tail.

In October of 1971 we submitted the design to *RC Modeler* and it was accepted for publication. That was a first for either of us. Getting paid for doing something we would do for free was great. The Little Plank appeared in the May 1972 issue of *RCM*. Plan #492 is still available from *RCM* Plan Service.

Left: Chuck and the original Little Plank in 1971.
Right: A more current photo of Chuck with the Little Plank III.

Left: The pusher configuration with twin fins, outboard ailerons and inboard elevators. Right: The tractor configuration with full span elevons. Full size plans for the Little Plank III are available at <http://www.b2streamlines.com/Clemans/Little_Plank_III.pdf>.

Don Dewey was editor of *RCM* at the time and apparently had doubts about the design. He built a Little Plank for himself and put more than 100 flights on the model. He was so impressed that he wrote nearly half a page extoling its virtues which appeared at the start of the article. Heady stuff indeed!

In 2007 I finally got around to designing the Little Plank III. Dave Jones developed plans for the Little Plank II, but as far as I know it was never built. Dave passed away in 1991, but left us the Raven and numerous other designs for flying wings. Thanks Dave! While I couldn't improve on "Cute," "Simple," and "Fun," there were a few things that I wanted to try; a better airfoil with less reflex and drag, tow hook closer to the wing, and electric power.

I've been flying my Little Plank III since 2008 and it looks like it's going to be around for a while. It penetrates much better than the Little Plank. It has four degrees of dihedral which means you don't have to watch it all of the time, just most of the time. The tow hook is much closer to the wing which eliminates that nasty pitch up at the start of a winch tow. I think it's easier on the eye than the Little Plank.

I stayed with the pusher configuration and used twin fins to provide prop clearance without having to extend the aft end of the fuselage. Separate surfaces were provided for elevators and ailerons.

It took only a few flights to convince me that changes were in order. The pusher configuration that worked fine with the 6" diameter prop on the tail of the Little Plank turned out to be not such a good idea with a 12" diameter prop. I quickly discovered that hand launching under power was risking a bite on the arm from the prop. The alternative was to launch with the power off and try and get power on and things under control before touch down. That was a little too exciting for an old guy like me, so the two rudders became one and the motor moved to the nose. The change was made to full span elevons which eliminated a couple of servos.

When building Little Plank III use medium to lite balsa. The spar with webs is very strong and should handle moderate to strong winch loads. With the elevator at the trailing edge of the wing I doubt it has enough authority to break the spar while on the winch.

'Glassing the fuselage with 0.75 oz. cloth adds little weight and adds a lot of strength and ding resistance.

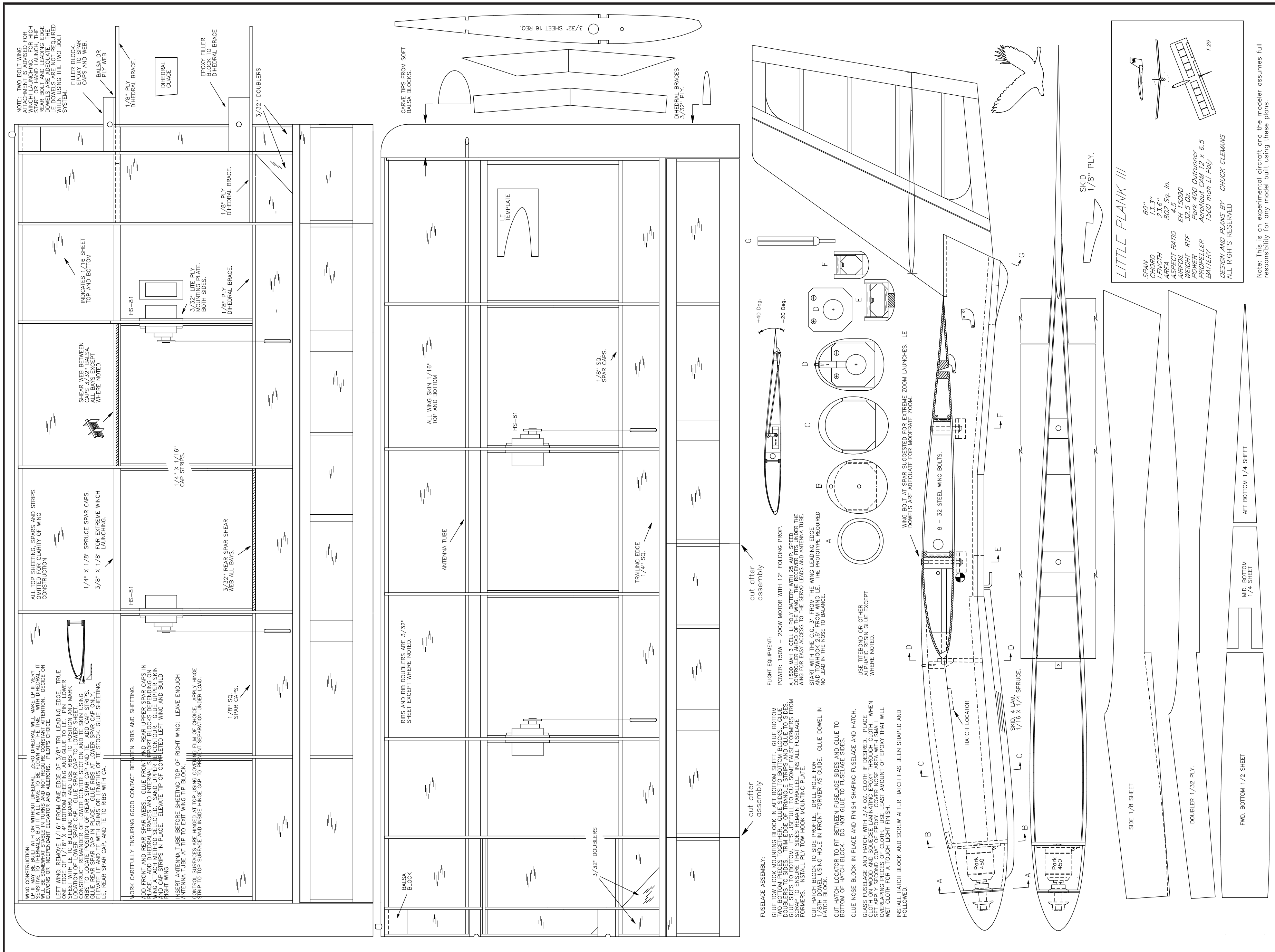
While the Little Plank III is pretty docile in the air it is definitely not a beginner's model. For the first flight the CG should be at the front of the range with full up trim and full power. If possible have someone else launch the model. Get a few hundred feet and then sort out the trim and power setting. I use 30% - 50% exponential to soften the stick around neutral.

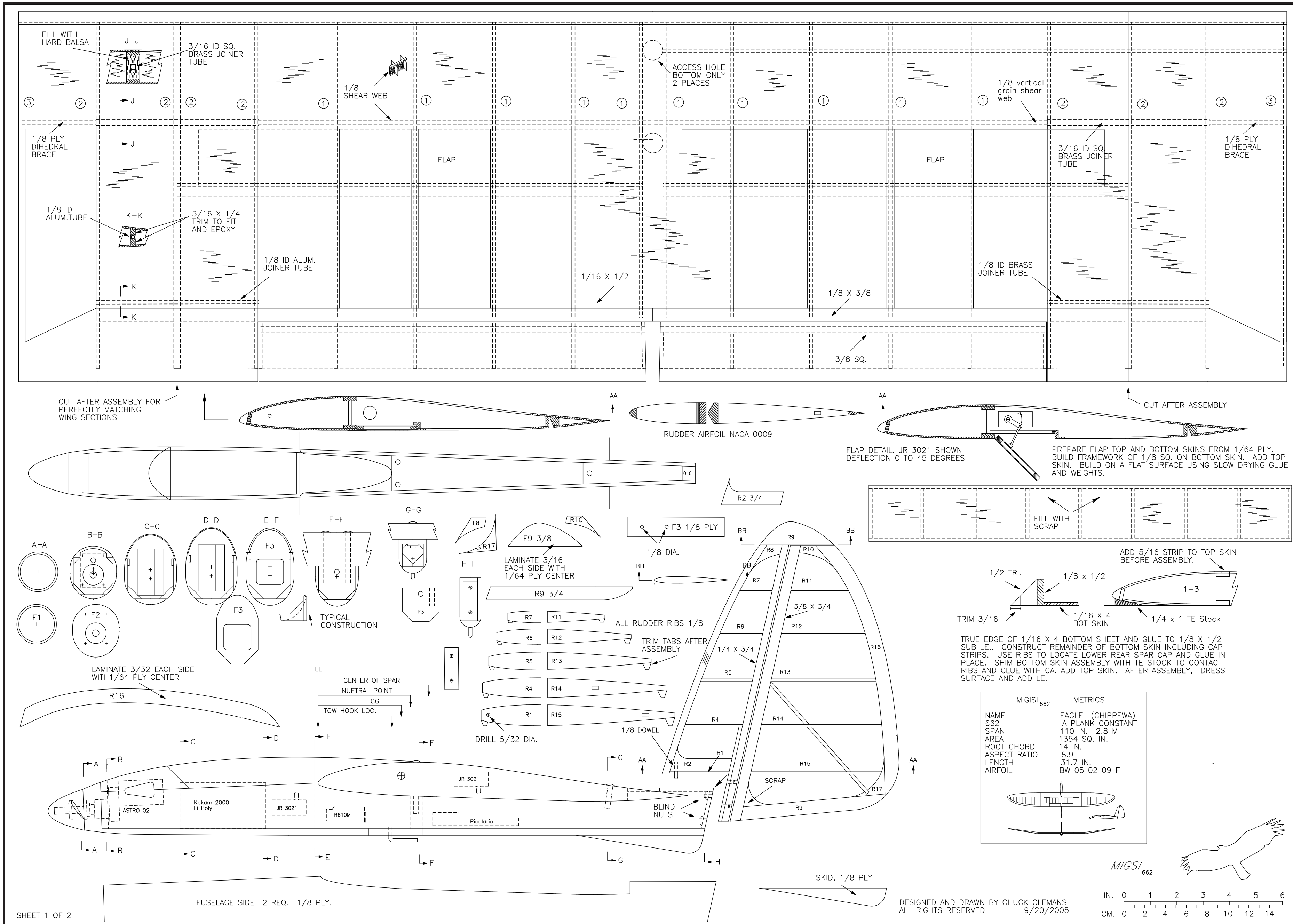
I think the plans for Little Plank III are available at <http://www.b2streamlines.com/Clemans/Little_Plank_III.pdf> and are pretty descriptive, but if you have any questions feel free to contact me at ChuckClemans@msn.com.

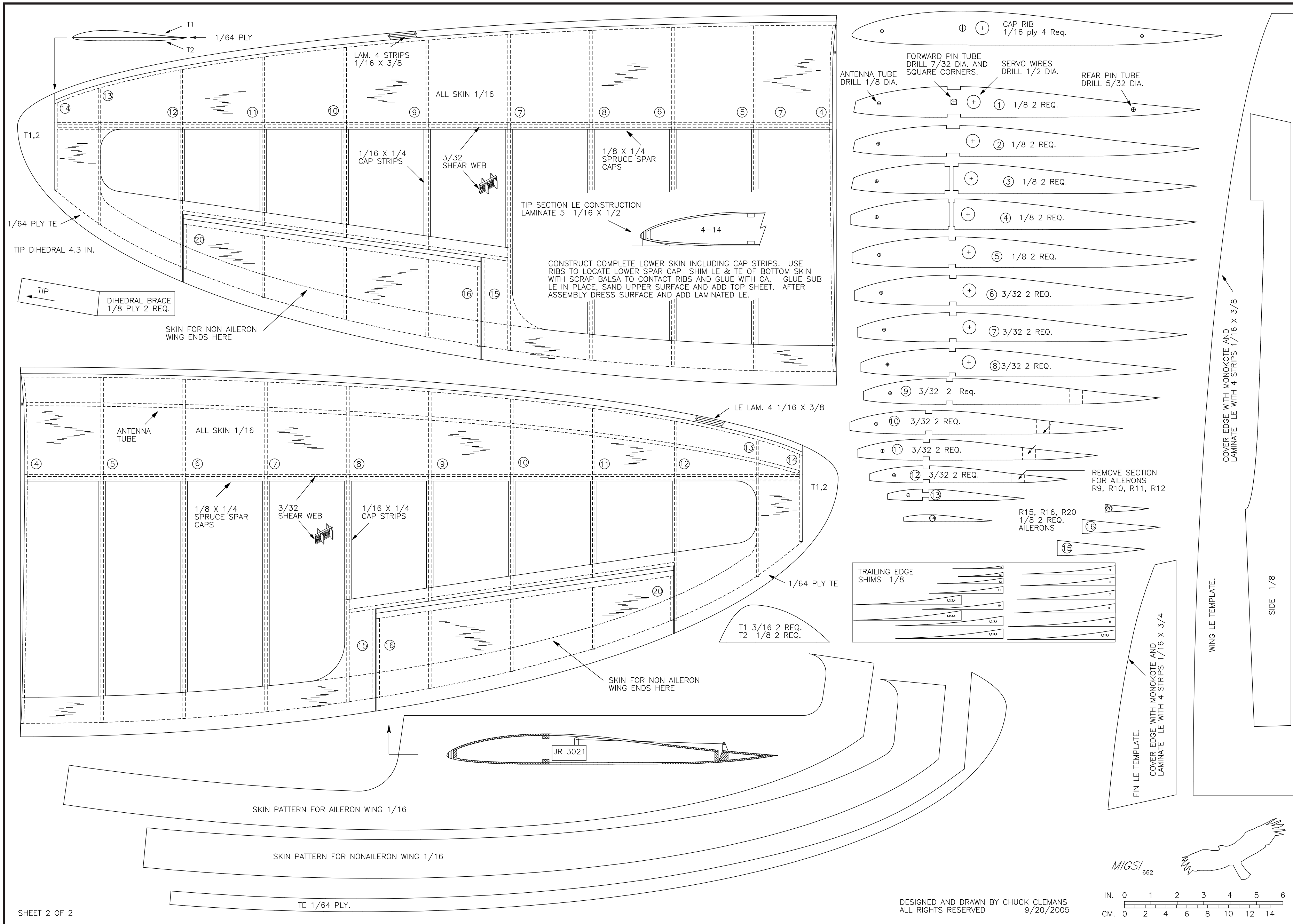
Remember that the Little Plank is a Woodie and "Woodies Rule!"

The plan for another of my designs, the Migisi, is available at the B^{2}Streamlines web site as well <http://www.b2streamlines.com/Clemans/Migisi_662.pdf>. The Migisi design was heavily influenced by a Dave Jones Plank, the R2*. I've long wanted to build a larger higher aspect ratio plank with elliptical wing tips. No prototype yet. Someday I hope to build the Migisi, but for now it's second in my build queue.

* Editor note: The R2 has to be our favorite Dave Jones design. The open structure is an incredible sight in the air and the parabolic wing outline is a visual masterpiece, especially if transparent covering is applied. We made several changes to the basic design while building ours, including using the Raven MB fuselage, adding ailerons, and exchanging the polyhedral for simple dihedral built into the wing center section. The newer CJ-25^{2}09 airfoil is a vast improvement to the original undercambered section shown on the plans. (Chuck is using the BW 05 02 09 section, a definite improvement over the CJ-25^{2}09, on the Migisi 662.) The added airfoil depth of the CJ-25^{2}09 makes for a deeper stronger spar system and near full pedal winch launches are straight and result in very good height upon release from the line. Strong digital servos are recommended for all of the wing control surfaces. The wing loading is about six ounces per square foot, giving it a relatively slow flight speed and a low sink rate. We really lucked out on the dihedral angle, as very little attention is needed during thermal flight and it can climb with the best, often gaining height faster than some of the F3J 'ships in the same thermal. With a large chord and a 100" span the R2 is easily visible at distance. Our R2 has made two appearances at the Visalia Fall Soaring Festival with Dave Beardsley at the controls. It is an attention getter and always attracts questions and comments after putting in a flight.




FILL WITH HARD BALSA
J–J
3/16 ID SQ. BRASS JOINER TUBE
1/8 SHEAR WEB
ACCESS HOLE BOTTOM ONLY 2 PLACES
1/8 vertical grain shear web
1/8 PLY DIHEDRAL BRACE
FLAP
3/16 ID SQ. BRASS JOINER TUBE
1/8 ID ALUM.TUBE
K–K
3/16 X 1/4 TRIM TO FIT AND EPOXY
1/8 ID ALUM. JOINER TUBE
1/16 X 1/2
1/8 X 3/8
1/8 ID BRASS JOINER TUBE
3/8 SQ.
CUT AFTER ASSEMBLY FOR PERFECTLY MATCHING WING SECTIONS
AA
RUDDER AIRFOIL NACA 0009
CUT AFTER ASSEMBLY
FLAP DETAIL. JR 3021 SHOWN DEFLECTION 0 TO 45 DEGREES
PREPARE FLAP TOP AND BOTTOM SKINS FROM 1/64 PLY. BUILD FRAMEWORK OF 1/8 SQ. ON BOTTOM SKIN. ADD TOP SKIN. BUILD ON A FLAT SURFACE USING SLOW DRYING GLUE AND WEIGHTS.
R2 3/4
FILL WITH SCRAP
A–A
B–B
C–C
D–D
E–E
F–F
G–G
H–H
F1
F2
F3
F8
R17
F9 3/8
R10
LAMINATE 3/16 EACH SIDE WITH 1/64 PLY CENTER
F3 1/8 PLY
1/8 DIA.
BB
R9 3/4
TYPICAL CONSTRUCTION
ALL RUDDER RIBS 1/8
TRIM TABS AFTER ASSEMBLY
R7 R11 R6 R12 R5 R13 R4 R14 R1 R15
DRILL 5/32 DIA.
R8 R9 R10 R16 R2 R17
3/8 X 3/4
1/4 X 3/4
1/8 DOWEL
SCRAP
BLIND NUTS
ADD 5/16 STRIP TO TOP SKIN BEFORE ASSEMBLY.
1/2 TRI.
1/8 x 1/2
1–3
TRIM 3/16
1/16 X 4 BOT SKIN
1/4 x 1 TE Stock
TRUE EDGE OF 1/16 X 4 BOTTOM SHEET AND GLUE TO 1/8 X 1/2 SUB LE.. CONSTRUCT REMAINDER OF BOTTOM SKIN INCLUDING CAP STRIPS. USE RIBS TO LOCATE LOWER REAR SPAR CAP AND GLUE IN PLACE. SHIM BOTTOM SKIN ASSEMBLY WITH TE STOCK TO CONTACT RIBS AND GLUE WITH CA. ADD TOP SKIN. AFTER ASSEMBLY, DRESS SURFACE AND ADD LE.
LAMINATE 3/32 EACH SIDE WITH1/64 PLY CENTER
R16
LE
CENTER OF SPAR
NUETRAL POINT
CG
TOW HOOK LOC.
Kokam 2000 Li Poly
ASTRO 02
JR 3021
R610M
Picolario
MIGSI 662 METRICS
NAME EAGLE (CHIPPEWA)
662 A PLANK CONSTANT
SPAN 110 IN. 2.8 M
AREA 1354 SQ. IN.
ROOT CHORD 14 IN.
ASPECT RATIO 8.9
LENGTH 31.7 IN.
AIRFOIL BW 05 02 09 F
MIGSI 662
SKID, 1/8 PLY
FUSELAGE SIDE 2 REQ. 1/8 PLY.
DESIGNED AND DRAWN BY CHUCK CLEMANS
ALL RIGHTS RESERVED 9/20/2005
IN. 0 1 2 3 4 5 6
CM. 0 2 4 6 8 10 12 14
SHEET 1 OF 2


T1
T2
1/64 PLY
LAM. 4 STRIPS
1/16 X 3/8
ALL SKIN 1/16
T1,2
1/16 X 1/4
CAP STRIPS
3/32
SHEAR WEB
1/8 X 1/4
SPRUCE SPAR
CAPS
TIP SECTION LE CONSTRUCTION
LAMINATE 5 1/16 X 1/2
4-14
1/64 PLY TE
TIP DIHEDRAL 4.3 IN.
CONSTRUCT COMPLETE LOWER SKIN INCLUDING CAP STRIPS. USE RIBS TO LOCATE LOWER SPAR CAP SHIM LE & TE OF BOTTOM SKIN WITH SCRAP BALSA TO CONTACT RIBS AND GLUE WITH CA. GLUE SUB LE IN PLACE, SAND UPPER SURFACE AND ADD TOP SHEET. AFTER ASSEMBLY DRESS SURFACE AND ADD LAMINATED LE.
TIP
DIHEDRAL BRACE
1/8 PLY 2 REQ.
SKIN FOR NON AILERON
WING ENDS HERE
CAP RIB
1/16 ply 4 Req.
ANTENNA TUBE
DRILL 1/8 DIA.
FORWARD PIN TUBE
DRILL 7/32 DIA. AND
SQUARE CORNERS.
SERVO WIRES
DRILL 1/2 DIA.
REAR PIN TUBE
DRILL 5/32 DIA.
1 1/8 2 REQ.
2 1/8 2 REQ.
3 1/8 2 REQ.
4 1/8 2 REQ.
5 1/8 2 REQ.
6 3/32 2 REQ.
7 3/32 2 REQ.
8 3/32 2 REQ.
9 3/32 2 Req.
10 3/32 2 REQ.
11 3/32 2 REQ.
12 3/32 2 REQ.
REMOVE SECTION
FOR AILERONS
R9, R10, R11, R12
R15, R16, R20
1/8 2 REQ.
AILERONS
COVER EDGE WITH MONOKOTE AND
LAMINATE LE WITH 4 STRIPS 1/16 X 3/8
WING LE TEMPLATE.
SIDE 1/8
LE LAM. 4 1/16 X 3/8
ANTENNA
TUBE
ALL SKIN 1/16
1/8 X 1/4
SPRUCE SPAR
CAPS
3/32
SHEAR WEB
1/16 X 1/4
CAP STRIPS
T1,2
1/64 PLY TE
TRAILING EDGE
SHIMS 1/8
T1 3/16 2 REQ.
T2 1/8 2 REQ.
SKIN FOR NON AILERON
WING ENDS HERE
FIN LE TEMPLATE.
COVER EDGE WITH MONOKOTE AND
LAMINATE LE WITH 4 STRIPS 1/16 X 3/4
JR 3021
SKIN PATTERN FOR AILERON WING 1/16
SKIN PATTERN FOR NONAILERON WING 1/16
TE 1/64 PLY.
MIGSI 662
IN. 0 1 2 3 4 5 6
CM. 0 2 4 6 8 10 12 14
DESIGNED AND DRAWN BY CHUCK CLEMANS
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SHEET 2 OF 2

Back to basics

Fling 2m22

Rene Wallage, rene_wallage@yahoo.com

All but two of the models in my hangar have that whirly thing either in front or in the back, producing the forward urge. So no matter what, I can always count on a motor to pull me out of trouble. Apart from that one time (or two, or three) that I overextended my stay in the air, and had no motor power left...

It's nice to have that peace of mind, but more recently my mind had been ticking over: "What if..." Especially now that I am slowly dipping my feet into F5J (or ALES) territory. "I must learn to fly without having in the back of my mind that I can rely on a motor to pull me out of trouble..."

With that in mind, I slowly started to set up a list of "wants".

The glider had to

- be cheap (I am always short of cash)
- break down into about 1 meter long pieces (for easy storage and transportation)
- be controlled by R/E and spoilers or flaps
- be able to launch with a hi-start
- be a reasonably good thermal glider
- be easy to repair
- quick on site setup

A few gliders came to mind, including the Great Planes Fling 2 meter, but the whole idea got put on the back burner for various reasons, lack of funds being one of them.

And then came my birthday and a birthday gift from my brother consisting of a PayPal fund transfer with the express instructions "… buy a plane with it…" Needless to say that the funds did not stay long in the account, especially since OmniModels.com had temporarily reduced international postage! (Dank je wel Marcel!)

In due time the box arrived. It clearly had been bashed about somewhat, but all contents were damage-free. The double boxing and carton separators inside the box surely attributed to that.

Even before arrival, I knew I was going to take the original Monokote covering off and replace it with Solite. A) Out of weight considerations, as Monokote is one of the heavier covering materials available, and I do want to thermal as well as possible. B) Because past experience has taught me that yellow is not a good color for a glider in the – mostly- bright blue Israeli skies. And C) because I was going to install spoilers, which would mean some major covering surgery.

(For the un-initiated; if you modify your ARF you forego all warranties. Be warned!)

So I wasn't too bothered with the absolutely abysmal covering job they had done at the factory. Clearly, the Monokote had been slapped on carelessly, showing uneven seams. I expected some wrinkling due to temperature fluctuations during transit, but this was out of all proportion.

Some of the wrinkles could probably be removed by some judicious use of a covering iron, but in some places the covering had shrunk, shriveled, and was hard due to overheating; whoever did the covering apparently overheated the Monokote in some places in an attempt to get rid of some of the wrinkles.

At least the pod and boom and all other bits and pieces were solid, good ol' Great Planes quality.

There were some very nice piano wire pushrods (guiding tubes are already in the fuselage), proper control horns with the correct bolts and backplates, a large sheet of decals (including something I have never seen before; a sticker to put your name, address, phone number, AMA number, etc. on, in case of a fly-away), and some very comprehensive instructions, complete with clear black & white pictures and a nice section about thermal and slope flying.

My only "complaint" is that the servo tray is made of way too thick ply. Never mind, I'll deal with that later.

Wrinkled Monokote everywhere, but modifications to the underlying structure required recovering anyway.

The elevator was made of very light (and soft) balsa. I'll replace this with some of my own. The top of the rudder was made of the same quality balsa, so I'll cut this out and also replace. But I'm keeping the best (or worst) blunder for later...

Not a very good start.

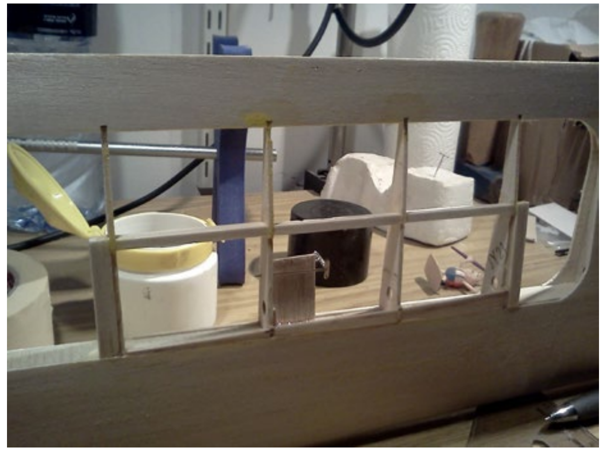
A few drops of thin CA for the ribs, and some light weight balsa filler (i.e. wood glue mixed with micro balloons) for the gaps saw me on the way.

First order of business: spoilers. I cut two 3-bay long 1.5" wide 3mm thick balsa plates. I applied some carbon fiber cloth at both ends, and then covered the whole surface with lightweight fiber glass cloth. I covered the D-box with grease proof paper, and placed the spoilers, buttered side down, on the D-box. I covered that with grease proof paper, and weighted it down with magazines. This way I hope to get the slight bend of the wing profile in the spoilers while the carbon/fiber/epoxy cures. Worked great for my Bird of Time. When cured, I temporarily covered the top side of the spoiler blades with "Zagi" tape, to prevent hangar rash while trial fitting etc.

I made balsa "boxes" for the spoilers, so the covering would have something to hang on to, and sanded the ribs down so the spoilers will be flush with the wing surface. You may notice that the LE of the spoilers is not parallel with the wing's LE. That is because the LE is slightly swept back, and I prefer to have the spoilers at 90° to the flying (wind) direction for maximum effect.

I made small servo trays for the spoiler servos. I intended to use some cheap 5g Hextronics servos I had in my spares drawer. Trial fitting them showed the wing was too thin. So some (slightly less) cheap 4g 9mm wide servos where sourced (digital!). As the arms of both servos will be pointing out, towards the wing tip, and I plan on using a Y-lead from the spoiler servos to the Rx, I also ordered a servo reverser, so the arms will move in the same direction. The little digital servos fitted perfectly, so I cut the wiring, and soldered extension wiring on them. When trial fitting again, I noticed that the servo arm wouldn't push the spoiler open very far so I made some simple servo arm extensions by gluing a piece of 1mm lite ply on top, and one on the bottom of the arm, with a thin piece of soft balsa in between. When the glue (thick CA) had cured, I drilled two 1mm

Spoiler blades.



Built-up spoiler frame.

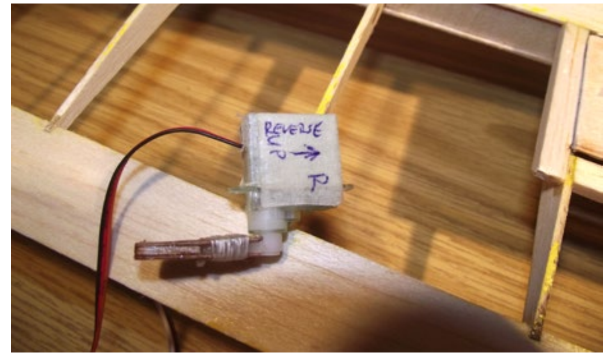
holes in each servo arm, and wrapped some dental floss through and around the arm, fixing it with medium CA. I then sanded the extensions to equal shape and length. Now I could screw the spoiler servos in place.

I made a small hole in the underside of the wing's center balsa sheeting, as close to the root rib as possible (after soaking the area with thin CA). After some fiddling about, the servo extension wires were pulled through the lightening holes in the wing ribs, and through the CA hardened opening in the wing.

I put the wings aside and cut a new elevator from some hard balsa. I also removed the soft balsa top of the rudder and replaced it with the same grade balsa as the elevator.

A gentle rub with 600 grit sandpaper, brushed with the soft brush from the vacuum cleaner (vacuum cleaner attached, duuuh), a wipe down with some alcohol over all surfaces, and we were ready for a new covering job; this time using the Solite I had sourced in the UK, and my dear, long-suffering wife had brought back with her after visiting family over there. Transparent red, and solid white (the Solite, not her family.)

As I had never used Solite before, I did some heat tests. I cut a small piece of material off, and placed it on the upturned covering iron, noting the heat setting; see what happens, take it off, raise the temperature, wait a few minutes, and put on another small piece of material. I continued that until the material shriveled immediately, indicating



Top: Servo arm extensions.

Middle: Reversed servo.

Bottom: Spoiler installed in frame with mounted servo pushing it to open position.

too hot. I did the same procedure for both colors. Experience has taught me that sometimes different colors work at different temperatures, even if they are from the same factory, but this time, if there was any difference, I couldn't detect any. If I had a digital iron maybe, but my current iron has been functioning just fine for the past eight years...

I also removed the tape from the spoiler blades, and ironed on covering. However, when applying sufficient heat to activate the glue and shrink the material, obviously, the blades curled up. I had a brain wave, and wrapped the upturned blades with elastic bands around one of my wife's pastry rolling pins (late at night, she was already asleep, shhhh) (Did you forget I was going to proofread this for you honey? Your wife.), and carefully heated the covering with a heat gun. The next morning I had blades that had too much curve, but I had expected that. Some judicious ironing with a slightly hot iron, cooling, trial fitting, ironing, cooling, trial fitting, ironing, cooling... well, you get the idea. Anyway, half an hour later I had two perfect spoiler blades, taped to the wing with hinge tape, in place. To keep the spoilers closed in flight, I went high tech. A small rare earth magnet and a bent piece of paperclip...

I then had to solder plugs back on to the servo extension wiring, and decide which decals I would put on. I cut out a few decals, taking care to have only rounded corners (pointy ones are likely to pull up). I mixed some liquid dishwashing soap with lukewarm water, and applied that to the area I wanted the decal to be. I pulled the backing paper off the decal, placed the decal on top of the soapy water, moved the decal around a bit, until it was just in the right place, and then squeezed the water out from under the decal with an old credit card. No bubbles, no wrinkles, no worry.

Gluing the metal spar pieces together.

Mismatched wing chords!

The instructions tell you to glue the two wing halves together. I didn't like the idea of a one-piece-two-meter-wing, so I am going to leave the wings as is and tape them together for flight. On RCGroups I read of a few pilots who've done that, without any problems.

The wings have a center dihedral spar, consisting of two pieces of aluminium that I had to (epoxy) glue together, and two pieces of light ply I had to glue on the outside of the aluminium spars. After the glue had cured it took a bit of sanding to have the spar fit properly (not too loose, not too tight). As I wasn't going to glue the wing halves together, I wanted to insert a short 2mm carbon aligning pin halfway between the center spar and the TE. To measure and mark the right spot on both root ribs, I trial fitted the wing halves together for the first time.

Now, seeing as this is originally an ARF, I did not expect that I should have checked this before starting work on the wing. The root ribs were not of equal length! One was 5mm shorter than the other! Measuring both wings, I found that at the dihedral break the difference tapered off to only 2mm, and by the one-before-last rib they were equal. That means that effectively, one wing has less surface then the other! Clearly someone at the factory screwed up here.

I wrote a very nice email to Great Planes (no, really), explaining the whole thing, including the changes/additions I had already made, and that I understood that they might reason that, because of this, the warrantee was no longer valid. I also noted that, had I not made the modifications, I would never have found the loose ribs and bad glue joints, which would have easily caused wing failure at the first high start launch.

Now, stand back in amazement. I got an answer within 24 hours, with apologies, "the message will be forwarded to management," and could I please give my address so they could send me a replacement wing! I did, and the next day I got an email that a new wing would be on the way.

Take note well_known_Hong_Kong_internet_shop_not_known_for_its_after_sales_service... and many others)

Meanwhile, I will continue and see if I can fly with this wing. It's done now, anyway.

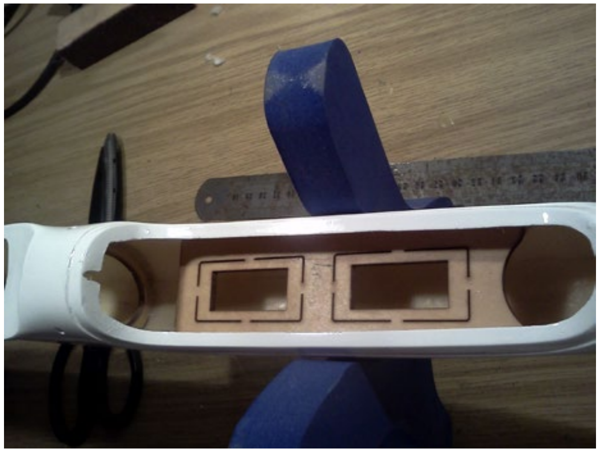
Before putting the wings back in the box for storage, I put some white "Zagi" tape around the root section. When taping the wings together, this will protect the Solite from lifting while removing the tape after a flying session.

Finally, I put the wings on the scales and found that with all the mods I'd done, I got the exact same weight as wings were on arrival: 144g and 142g, including servos, servo wires, servo trays, spoilers, and a spoiler box! I am pleased.

So, on to the fuselage.

The pod and boom are already glued together, so there's nothing to be done here. The tailgroup is designed to be bolted to the boom, and the boom is already prepared for that. The top half of the boom is cut and filled with light (soft) balsa. As I am contemplating keeping the tail group removable, I soaked the area of the balsa - where the bolt holes were - with thin CA and then applied some lightweight fiberglass cloth on top of the flat balsa.

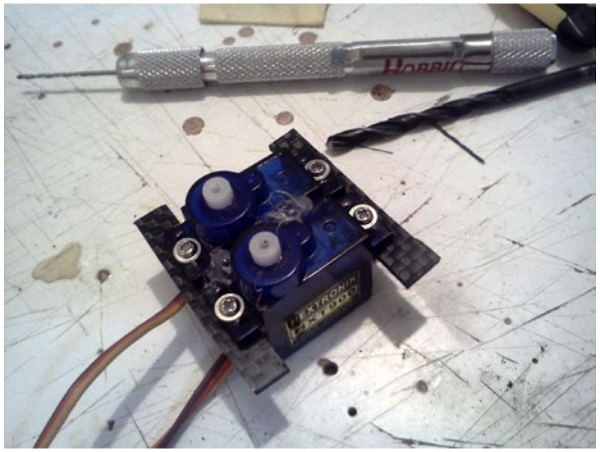
I am going to use a pull/spring system to move the elevator and rudder, so I will not need the supplied pushrods. And



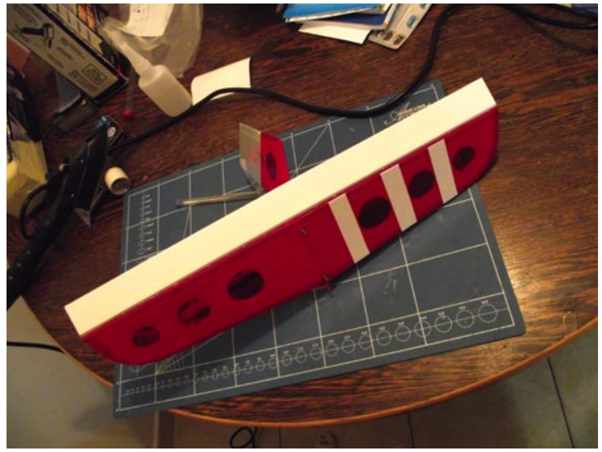
Servo tray in place. Too thick.

After grinding with a Dremel. Still enough left to strengthen the fuselage.

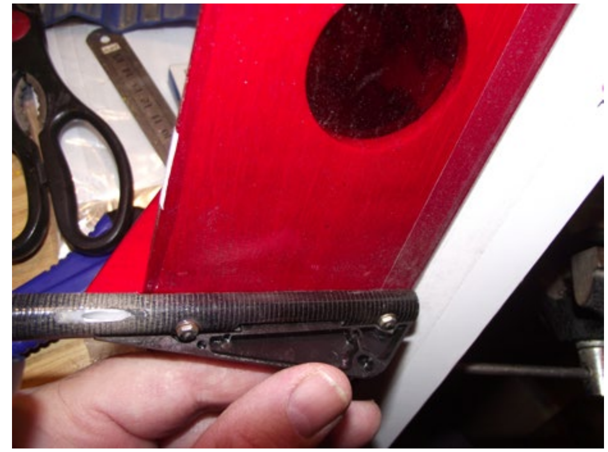
Tow hook block mounted.



Servos mounted on carbon fiber rails.



Bottom of the tail group, two mounting bolts on the stab centerline.



Tail group mounted to aft end of tail boom. Note the plastic skid.

because I will not use the pushrods, I do not need the installed pushrod sleeves. Some not-so-gentle pulling got the sleeves out easy enough.

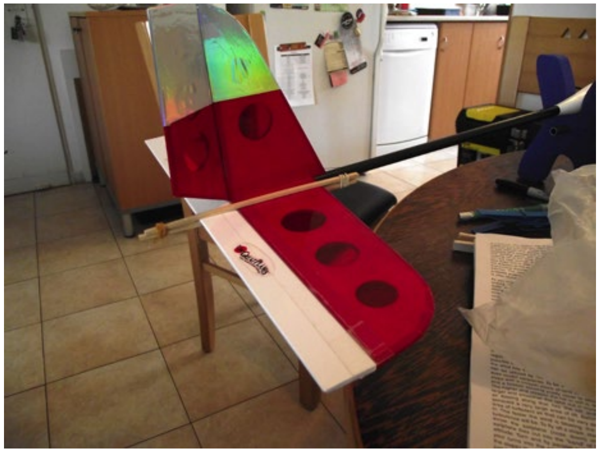
Inside the pod is a thick-ply servo tray, and towards the rear, a pushrod guide of the same thick material. With the cutting disk of my Dremel I removed most of the servo tray, leaving only the sides and the rear part, for fuselage rigidity. Then with my Dremel sanding attachment I sanded the servo tray sides further down, and reduced the pushrod guide to a few millimeters wide.

To prevent wear and tear on the pull cables I inserted a short piece of pushrod sleeve in the boom's openings, and fixed with thick CA. While the CA was curing I taped the excess tubing outside to the boom, to put pressure on the tube inside so it would cure pointing as much as possible parallel with the boom and not pointing inwards, towards the tube center. Once cured, I sliced the excess tubing flush to the boom with a fresh X-acto blade.

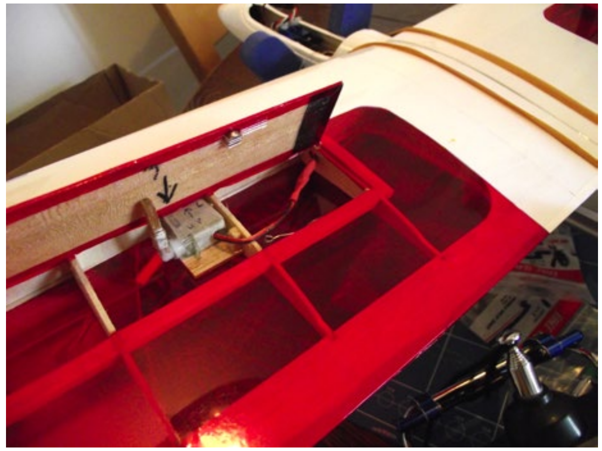
Moving to the front again, I glued some Velcro in the nose for the 4 cell 150mAh battery. I made a sort-of-servo tray of two pieces of 2 mm carbon fiber bars (with some balsa glued on the underside, so the servo screws have something to bite into). Trial fitting, I placed the servos (5g Hextronics) as far forward as possible, while still being able to remove the battery. The "servo tray" was glued on top of the remainder of the original servo tray with thick CA. I centered the servo arms, and cut them down so they could move freely inside the pod, with the canopy in place.

Going back to the tail.

The vertical stab has two bolts embedded in the bottom. These go through pre-drilled holes in the horizontal stab, through the boom, and fastened with tiny nuts. I opened up the Solite covered holes in the horizontal with a warm soldering iron. Fitting the tail group was a no-brainer: perfect fit. My only complaint: those tiny nuts and washers are a pain to get in place. This should be done over a table, preferably with a towel covering the area, so falling nuts and washers will not roll away. Do not try this in a cluttered building shed, with the pod and boom on your knees, the only proper lighting right over the work bench and the



Sticks keep the elevator in neutral while setting up the pull-pull system.



Left spoiler operation.

Name and telephone number inside canopy. Always a necessity.

rest of the shed in permanent twilight. 20 minutes on hands and knees on a dusty, dirty floor is not good for one's patience. But I did find those grey nylon bolts I lost last summer...

The instructions show the exact length the bolts should be cut down to for the tail skid to fit over. The hard plastic tail skid comes in two halves that need to be glued together. Before doing that, test fit a half over the tail bolts. I had to cut mine down way back to the nut, a good 2mm more than instructed. And a drop of Locktite wouldn't go amiss here. You don't want the elevator and rudder to go all wobbly on you on a fully loaded high start!

For the springs I made two 90° bends at a 90° angle of each other in two pieces of 1mm pushrod wire, and inserted them into the TE of the horizontal and vertical stabs, and the LE of the rudder and elevator, fixing them in place with a drop of thin CA. I fashioned control horns from a 2mm thick carbon fiber (*bling*) plate. I drilled a 1mm hole in each, and made a tiny cut in the horn from the back to the hole. This way I can remove the pull wire without un-knotting it. I then cut slits in the rudder and elevator, and glued the control horns in place with thick CA.

The best way to fit the pull wires (I found), is first to immobilize the moving surface at dead center. I do this with two scrap pieces of any hard wood on either side of the surface, held in place with rubber bands. Then knot a small loop in the pull wire (I prefer a bowline knot), and pull it over the control horn (hence the slit). I then move to the servo side, pull the wire taught, hold it over the servo arm, and mark the position on the wire with a marker. Pull the loop of the control horn (to take the tension off) and tie the wire on the mark at the servo-end. Then put the wire back over the control horn and release the moving surface. A dot of thin CA on all knots, and we're done!

The wing is held in place with rubber bands, looped over carbon fiber rods. The holes for the carbon fiber rods are pre-drilled and according to the instructions I should glue them in place with thin CA. I prefer to use thick CA for something like this (it'll strengthen the area around the hole and doesn't flow away like...umm...like thin CA). Also, there is no mention in the instructions of lightly sanding the carbon before using glue.

The front carbon rod was a perfect fit. But the holes for the rear one were not straight. The rod is slightly off kilter, but negligible so.

And last, but not least, I inserted the self-tapping tow hook. Inside the fuselage you can see that there are three positions prepared, but only the middle one is drilled through. So that's where I placed the hook, securing it with the provided self-locking nut on the inside, with a drop of Locktite.

Trial fitting the wing on the pod showed a good fit, so I connected the Rx to all surfaces and programmed my Tx. I am using a Berg4 stamp Rx with Ch1 and 2 for rudder and elevator resp., and Ch3 (throttle) for the spoilers. Works a treat! For starters I have the spoilers at maximum 80° open, with 5% down mix dialed in.

Next stage, balancing. I found I had to add 45g of lead fishing weights to get to the recommended CG. I taped the little weights together, and taped the blob to the front of the battery. And finally; a sticker with my name and phone number on the inside of the canopy.

The maiden was done on a perfect windless early Friday morning. As this was going to be my first time launching with a high start, to keep things calm I only packed 10 meters bungee elastic and 20 meters pre-stretched wire. I left another 10 meters bungee, and another

Above: Final set-up at home.

Left: Launch equipment on the field, Fling 2m in the background.

60 meters wire at home. I didn't want to be tempted...

I laid out the high start, hammering a tent peg into the ground with a 4Kg hammer, and then wrapped the elastic twice around the hammer. In the unlikely event that the peg gets pulled out, the hammer will prevent it becoming a deadly missile (I hope)...

Before anything else; a range test – fine. A hand test throw; hmm, another 10g of lead added. Another test throw – fine. I had run out of excuses.

Pulling the elastic 1/3 its length, I attached the Fling to the ring, a last wiggle of the sticks, wind check (there wasn't any), and off she went.

The first few seconds no Tx input was needed. She just lazily traveled up to maybe 15 meters. I leveled her, and continued straight. The high start detached itself, and I was on my own!

Three clicks up trim had her float hands off. A gentle, wide circle had her lined up for landing again, and I deposited her in some high grass. BIG grin!

Walking through the high, wet grass I made a mental note: "I need to mark the peg with a flagpole or something, and some bright colored material to the end of the high start line". I'm sure I read about this before I started this high start lark.

Luckily, as the grass was high I quickly found the track I made when laying out the line, so in no time I was ready for launch #2. Pulling the line to ½ the elastic's length, I launched. Again, a steady rise, nothing dramatic, with plenty of time to grab the controls. Again, hardly any input from me. The Fling released the line slightly higher this time. This time I managed to circle around for a minute or two before setting up for another landing. Coming in a bit high, I had a chance to try the spoilers. WHOOAA!! With 20/20 hindsight they probably are far too big and could be half the size I made them. But boy, are they effective!

The Fling acted as if a handbrake was pulled. First she ballooned, then practically stopped in mid-air, and dropped like a stone. "Note to self: easy on the left stick..."

A thorough inspection after this hard arrival: no damage, the wing had shifted a bit under the 4 elastic bands. Moving everything back in place, I went to search for the line again, cursing myself for not putting a mark at the peg, or something highly visible on the line's end...

Flying Lin

Launch #3 was as before, only this time with the elastic pulled out the full 10 meters (another note to self: “put the fish scales in the case with the high start”). She whisked off with an audible “whoosh”. Feeding in a bit up elevator near the apex of the launch, I got a bit more altitude, and managed a nearly 5 minute flight. That early in the morning there was very little thermal activity, but I could see the wing twitch now and then. However I decided to leave tight thermal turns for another time, when I could get to some safer altitude first.

The landing was again a non-event, especially now that I have seen the full effect of the spoilers. I will need to mix some more down elevator with the spoilers.

I did two more launches, reaching about 20 meters altitude each time. Just enough for 3 to 5 minutes air time. I think I’m going to like this glider. She flies slow, but is relatively quick to respond to Tx input. The high start launch I was somewhat worried about turned out to be easy. That could be also a testament to the stability of the Fling of course. The fact that one wing is a smidge smaller than the other does not seem to affect flight at all. And she looks gorgeous in the sky.

Would I recommend the Fling 2M?

Absolutely, yes.

Is she for a beginner?

Hmmm, were it not for the wing problems, I’d say yes; provided that an experienced RC’er does a thorough pre-flight and does a proper full force high start launch.

If you don’t go mad like I did, and build the Fling out of the box as is, with all the supplied parts, you’ll maybe spend 3 or 4 hours assembling (including time for the epoxy to cure). And you’ll end up with a more than decent glider. For that price.

Ah yes, Great Planes’ technical support department; wow! My first contact with them was 11 February, on 13 February I emailed them my home address. True to their word, on 19 February a new wing set was dispatched to me via USPS Express.

I have a few projects to finish, and then I will mod the new wing, with narrower spoilers.

After all’s said and done, I am really looking forward to many, many lovely flights in silence. Can’t wait for full high start launches!

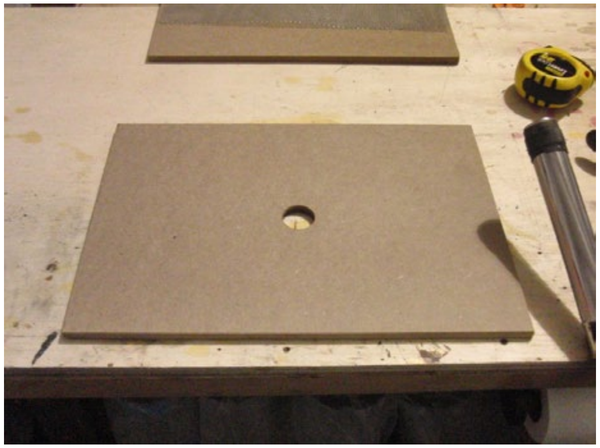
Shimon Hirschhorn used his ’phone to record one of the early Fling 2m flights. My daughter and I did some editing and titling, and the resulting video can be seen on Vimeo at <https://vimeo.com/61978110>.

step-by-step

Building a Vacuum Forming Table

a simple and great working system

Tom Broeski, tom@adesigner.com
http://www.adesigner.com

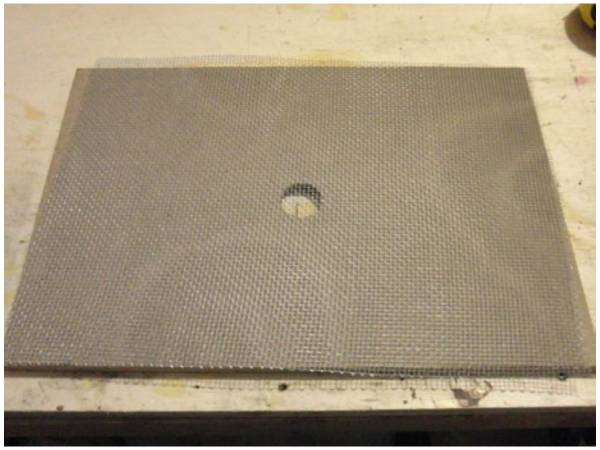


Take a board and cut to the size you want. (I get free 1/2" board from the local tile installer. It is used as inserts in boxes of vinyl tile — these were in Congoleum tile boxes and are usually thrown away.)

Drill a hole to fit your vacuum.

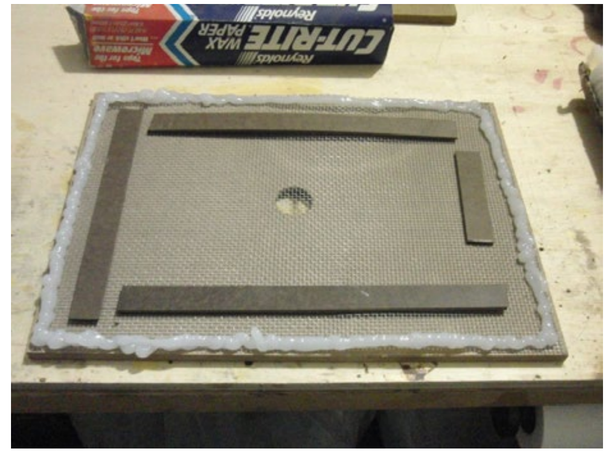
You can get a good vacuum at Goodwill or Salvation Army for under $10. I really like this little Mighty Mite.

Cut a piece of 1/8" hardware cloth to fit board. I get hardware cloth cut at Ace Hardware. It is important to use 1/8" to keep pattern small. You can't use regular window screen as it won't let the air through properly.



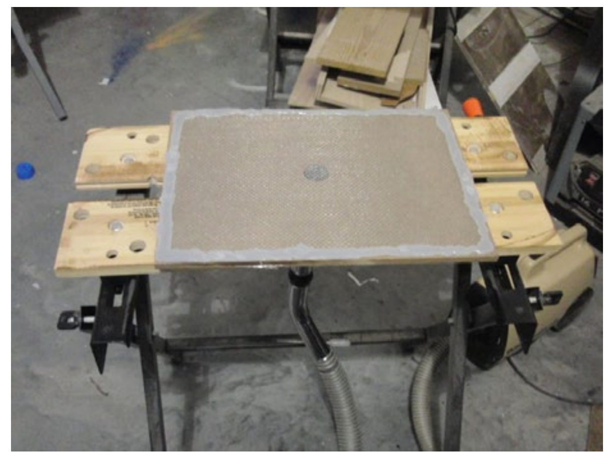
Take and place 1/8” spacers on the hardware cloth and board.

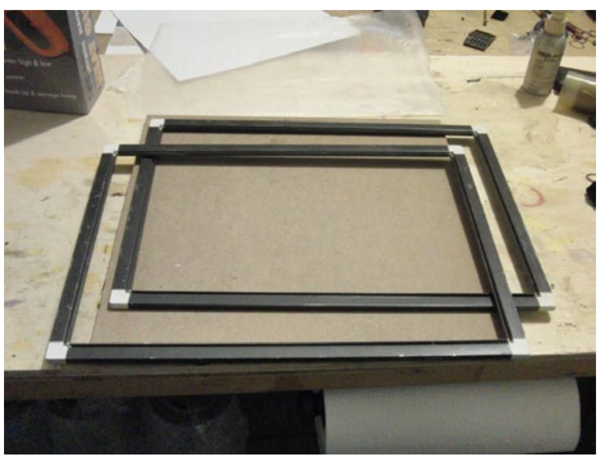
Put a nice bead of silicone around the edge. This keeps everything in place and makes a good seal.



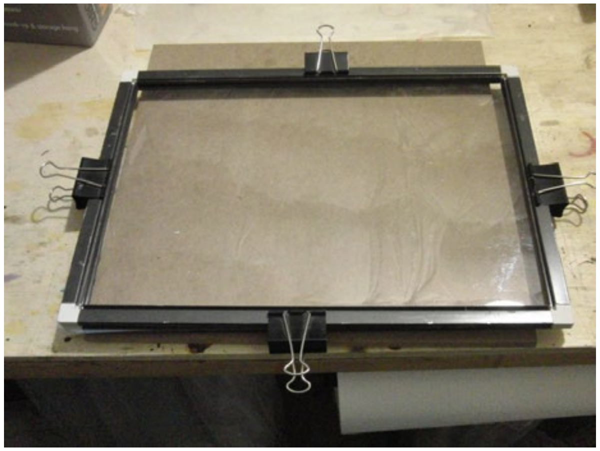
Place a piece of wax paper on and put a weighted board on top. I let it set for 3 hours, then take the board and wax paper off and put it in the oven for one hour at 180 degrees. Or you can just let it set for 24 hours or until fully cured.

You can make a box if you want. I just stuck the vacuum hose in a WorkMate and set the board on top.



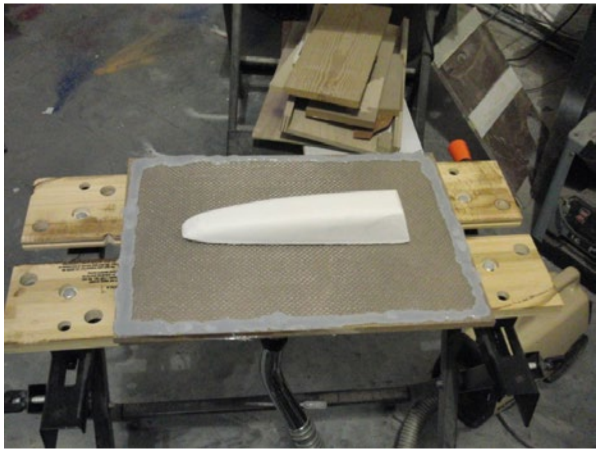


Take and make a simple (2-piece) frame from metal screen frame parts from hardware store. You can make one out of wood or whatever, but I found this really simple. I made it 1/2" larger than the board, so I don’t have to be as precise when placing it on the table.



Use clips to hold the plastic in the frame. You can get various thicknesses and types of plastic in rolls, or cut to size from Piedmont Plastics or your local supplier. I get both styrene (white or colors) and clear PET for most projects.

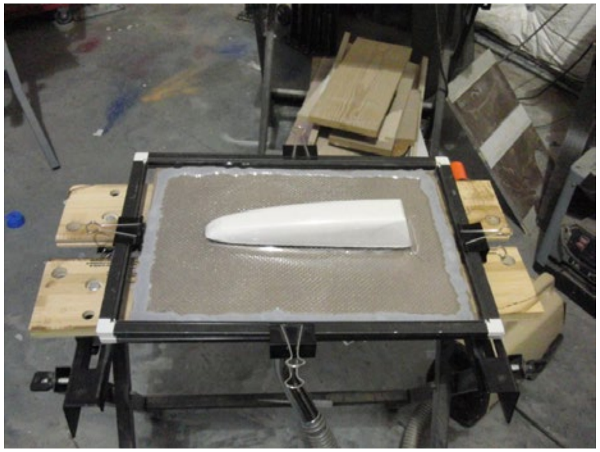
I make my molds by pouring molding plaster in a well waxed original, or just shape one out of wood.



Heat the plastic in your oven or with a space heater. You can use a good heat gun if you are skilled, but it isn't easy. Okay if the part is small.

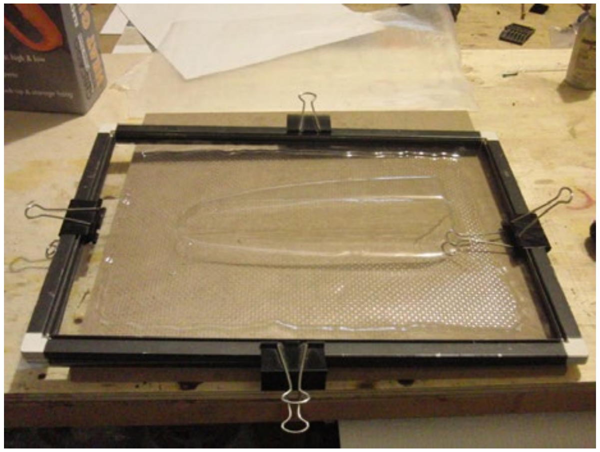
This will take experimentation for some people. I learned that with styrene you want the sag to equal the depth of the part. Anymore, and you'll get wrinkles around the edges of the pulled part. With PET, I just tap on it to make sure it is soft enough.

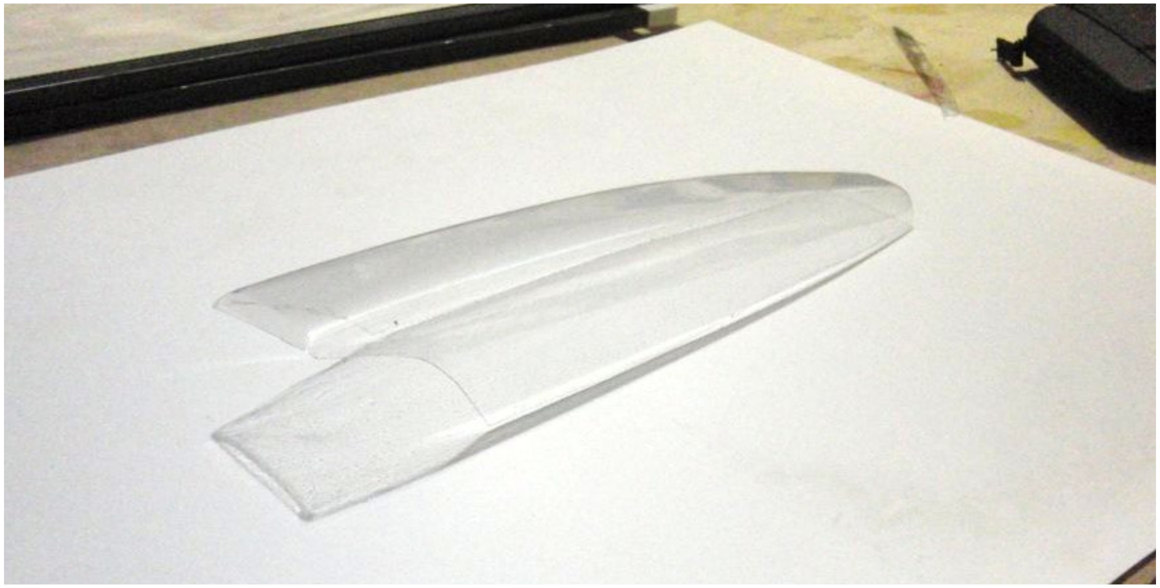
I have an oven heating element in a metal box. (Besides the two professional vacuum forming machines in the shop) The point here is to show something that anyone can make and use.



Put the mold on the table, turn on the vacuum and quickly take the part from heating source (gotta be quick on cold days) and pull it down over the mold and onto the silicone seal.

You'll be amazed how well this works.





Trim out your canopy and that's that. This is a Sovereign canopy.

The Mighty Mite is 3.5 HP and can pull a Duo Discus canopy just fine. It is more getting the right sag on the plastic before pulling. It really doesn't take that much suck once you get it right. I have a 24" board that works fine with the little vacuum. You can make more of a rectangle than a square for canopies. The small vacuum does fine. It's the oven and proper heat needed for the thick sheets. I just tested a 1/4" sheet and it worked fine. In most cases the sheet needs to sag the depth of the part.

Costs:

Board - free

Hardware cloth - $3.79/ft x 36" so about $1.50

Silicone - $3

Spacers - scrap

Window frame parts - $6

Clips - $1 for 4 at a "dollar store"

Vacuum - $8 at Goodwill

Plastic - variable, depending on material and thickness, etc.

Andy McKittrick, amck11@verizon.net

Catch Some Air... Going Up!

Putting together my Sting DS, I could hear the wind ripping through the trees above my head. I knew it was going to be a great day on the hill. As I walked up the path to the top, I watched as a red tail hawk soared up the hillside and high up into the air, riding the lift to the top. I remembered how I wondered what it would feel like being in a glider, riding the lift and soaring out over the countryside instead of flying it from the ground.

It was the impetus to learn to fly. Yes, RC soaring was what got me to go to the glider port for my first ride. It was also a great help in understanding the dynamics of soaring and helping me recognize what to do, just starting out, when I was put in certain conditions that called for decisive and positive action.

We have all had those days when we first began flying RC and crashed a number of times because we weren't use to controlling a glider that was now coming at you and the controls were reversed and BAM, hit the ground, fence or tree! But learning to fly my RC gliders gave me a leg up on understanding what was happening in full scale gliders when I first began. And it will for you.

Being inside the glider provides you with a completely different perspective of flying as well as many challenges you can't get flying from the ground. Obviously, just like model soaring, you start out in something that won't get away from you. Modern fiberglass training gliders like the Schleicher ASK-21 or the Grob 103 are great beginner gliders, however the venerable Schwiezer 2-33 is what the majority of people fly when

starting out for a glider license. Either way, one learns the fundamentals of flying, because when you fly a glider, it's all about "Stick and Rudder plus Energy Management."

Your introductory flight will have you sitting in the front seat after a full walk-around of the glider learning about all of the safety items that need to be checked before flight... just like you do with your R/C glider. Control surfaces are securely attached and working (a positive control check is always a must), batteries charged, tires have pressure and the instruments are working (substitute a range check for your radio here). Your pilot will explain how all of the controls work and what the instruments in the cockpit do, along with the spoiler controls and tow release knob. And don't forget the trim system and emergency procedures. You won't need to worry about the gear since all trainers have fixed gear. You will nod knowingly to yourself as you understand how most of them function already because you fly the same way. In other words, your radio has a stick that moves the elevator and ailerons, and instead of the foot pedals for rudder in a full size, you use the left stick for rudder (right and left) and the spoilers or flap stick (up and down) produce the same results.

There is, however a special high tech device that you have never seen before. It provides a tremendous amount of

The new 21 meter span Jonker JS-1 on tow. Photo by Andy McKittrick information. It's called the yaw string - a little piece of yarn attached to the front of the canopy with a piece of tape! It indicates which way the air is moving over the front of the glider and helps you keep the glider flying cleanly through the air. If you are slipping or sliding, the yaw string will be on one side or the other but not down the middle where it needs to be. The yaw string helps you make coordinated turns where the application of rudder helps correct adverse yaw induced by the ailerons.

As you get in and get the safety harness hooked up around your person, you become aware that your heart rate is starting to increase as you are about to find out what it is really like to fly in a full size glider. It reminded me of throwing off a newly built model on the slope for the first time. Exciting! But it won't compare with what you will learn on your first ride in the air!

The pilot checks your belts and runs you through the instruments again, pointing out the altimeter, airspeed indicator and the variometer and tells you to keep your feet off the pedals and stick until he tells you to put them there. Oh yes, and make sure when the stick moves you do not impede it in any way!

Okay, the tow plane pulls up as the canopy is lowered into position and you are asked to lock it by moving the lever forward. The line boy reaches out for the tow line and the tow plane taxis up in front of your nose and moves down the runway until the rope is almost tight. Next, the line boy opens his hands indicating that you must pull open the tow release as he hooks up the tow line from the tow plane while giving the line a firm tug. You are ready to go. The pilot, sitting behind you, gives the line boy a quick thumbs up after moving the controls through their full cycles and your wing is leveled. You see and hear the rudder pedals moving back and forth which is the signal for the glider is ready to go. The tow plane pilot answers back with his rudder wags and you hear the power being applied to the tow plane.

The glider starts to move and suddenly you are headed down the runway at a good clip and just like that you are two feet in the air, staying in position with the tow plane, careful not to get too high behind him. That could raise his tail and put his prop into the concrete.

The big news is that the wind is making a lot of noise and you are getting higher. The tow plane banks and your glider follows him, staying slightly outside of his turn in order not to turn inside of him causing the towline to bow. This you notice this since you have done that while aero towing your scale glider with less than positive results. Soon you have climbed to 3000 feet and you are asked to pull the tow release and bang, you see the rope fall away and you are off climbing and turning to the right. It gets much quieter and you can relax a little. Your pilot asks, "What brought you out to the glider port today?" And of course you tell him your story about RC and that you want to learn to fly full scale. "Oh, that's great. I am an instructor here as well and if you want, we can treat this like an intro with intent to learn! How's that?" "Great," you say. Your new instructor asks you to read the airspeed indicator and look out the front and see where the horizon is in relation to the view over your instrument panel.

He says, "Take a look at where the horizon is in relation to the top of the instrument panel. That is the sight picture you want to remember since it means that you are in level flight." Let me show you," he says, pushing the stick slowly forward. "If you see that much land above the panel, you are diving so try and remember what the correct site picture is to stay in level flight for now. Let's try a bank. Are you ready?" And there it begins with the words "Are you ready to fly it?" Really?

"Keep your speed at about 55 mph and the horizon level with the top of the instrument panel."

OKAY! Now you have your hands on the stick and feet on the rudder pedals. He says fly straight at that cloud in front of you. As you do, you begin to get a feel for

The Concordia, piloted by Dick Butler, on tow. Photo by Andy McKittrick

the controls and you notice that it's not easy to keep the speed at 55 or keep the horizon level with the panel. Concentrate. Okay, now where is that cloud, oh, it moved off to the right. Wait, the cloud didn't move, your glider moved, wait, we both moved. Welcome to the wind aloft. It's different than winds on the ground. Different direction and speed. And it's in layers, going different directions at different altitudes.

You are drifting away from the cloud again and the instructor says "My glider" and he banks you back towards the target cloud.

"Okay, your glider" he says, "Let's try it again."

And you do, this time determined to fly right to it.

"Just try and keep it straight" he says, "nothing else."

And you do, save for going too fast as all of a sudden you are seeing way too much ground above the panel.

"You are diving, pull back a little, okay now keep going."

Whew, there is more to this than I thought. Then you hear a growling sound and the instructor says, "I have turned on the audio variometer and you will notice the sound. That is the sound of sink and we are in it. So we will need to speed up and fly out of it." More to consider but as you are thinking about it, you feel his hands on the stick as it moves forward

and your airspeed increases as you near the cloud which is now up above you and then the vario growl becomes an insistent “beep, beep, beep,” getting faster and faster and he says, “That is lift and we are in it. I’ve got it.”

And suddenly the glider banks into a seemingly impossibly steep turn and you feel as though you are being pushed down into your seat and going up towards the bottom of the cloud, all at the same time! Those are G’s you are feeling.

Welcome to soaring, instead of gliding! You think about thermalling your RC model and it never looked that steep! And, whoa, you are starting to carve big circles under the cloud and the altimeter is indicating that you are now at 4500 feet and climbing. So this I the feeling of really flying like a bird! Finally after all of those years wishing you could just try it, it’s really happening and you love it.

The glider wants to climb right up into the cloud and it would except your instructor says that the rules don’t allow cloud flying in this country and you need to stay below the cloud bottom at all times so other aircraft can see you.

It’s time to head back to the glider port and your instructor gives you control again as he aims you towards the runway. You have always been able to land your RC glider with skill and now it’s time to learn how it’s done in full scale.

“Fly right over the center of the runway at 1000 feet at a 45 degree angle over it” he says. “This is the IP or initiation point for your landing and depending on the wind direction and speed, you will need to decide how much altitude you will need to make a safe approach. I will demonstrate.” As he flies over the runway he says, “I am now going to test the spoilers. Once I unlock them, I will not lock them again until I have stopped rolling on the ground.” I feel them opening and they are very effective, just like the ones on my scale RC glider. He feathers them almost closed as we turn downwind. I notice that he has increased the speed to 60 and we are starting to turn towards the runway while getting lower. As we turn to face the runway he opens the spoilers halfway and we begin to come down quickly. As the runway comes up to meet us, the wheel chirps on the surface and we roll along. The spoilers are opened all the way engaging the brake and stopping us in perfect position for another tow.

“What do you think”, he asks, “do you want to go again?”

I think about landing my RC glider and I know all I want to do is get it back into the air. Same thing here.

“Absolutely” I say. “I can’t think of a better thing to do than to learn how to fly.”

He answers, “It’s one of the best decisions you will ever make.”

So come out to the glider port closest to your home and see what all the excitement is about. We call it your ticket to freedom and so will you.

Check out <http://www.letsgogliding.com> for more information about learning to soar as well as the Soaring Society of America site at <http://www.ssa.org>.

Get off the ground and “Catch Some Air... Going Up!

Present your AMA license and receive a discount for your intro flight at all of the LGG sites across the US.