Radio Controlled

Soaring Digest

March 2016 Vol. 33, No. 3

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Front cover: The weather can change quickly in Iceland. This photo was taken at Helgafell and shows a Seagull K8B flying in front of a crystal clear background. The back cover of this issue shows the same model flying less than an hour before this image was captured.
Photo by Sverrir Gunnlaugsson
Canon EOS 350D, ISO 400, 1/1600 sec., f11, 70mm

Back cover: The Seagull K8B flying at Helgafell less than an hour before the front cover photograph was taken.
Photo by Sverrir Gunnlaugsson
Canon EOS 350D, ISO 400, 1/1600 sec., f11, 70mm

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In the Air

As we write this, it's been two months since the U.S. Federal Aviation Agency, FAA, has required registration of individuals flying an Unmanned Aircraft System (UAS) weighing between eight ounces and 55 pounds. The impetus for this move was and is the rapidly growing number of "drones" being flown by the public.

A look at the FAA UAS registration web page will quickly let you know the FAA sees "drones" as multi-rotor aircraft. See <http://www.faa.gov/uas/registration/>, <http://www.faa.gov/uas/no_drone_zone/> and <http://www.faa.gov/uas/registration/faqs/media/UAS_Weights_Registration.pdf> where no fixed wing aircraft are in evidence.

Between the FAA mandate and the present, there has been much conversation within EFLAPS, our local "silent flight" club <http://www.eflaps.club>. A number of members initially expressed concern over registration and the ideas of failing to register, leaving the AMA, and dropping out of the aeromodelling hobby have all been voiced.

After considerable thought, our own attitude toward registration has evolved, and we now see registration as a form of positive recognition by a federal authority, with equal standing to full size aviation. The fact the FAA took action because of "drones" is becoming of less importance. And the AMA seems to be continuing to influence things in an appropriate direction through a variety of avenues, including confirmation that flying over 400' is OK with the FAA so long as the AMA Guidelines are being followed.

The question as to whether RC soaring will survive in the U.S. appears to be answered in the affirmative.

Time to build another sailplane!

B^2

LilAn Omega Part 2

Chuck Anderson, chucka12@outlook.com

Building the Omega Wings Without Plans

Wing Joiners

Carbon fiber rods don't like shock loads and are notch sensitive so I don't use them for wing joiners or stab rods. I use 2.5 inch long 3/8 inch diameter 7075T6 aluminum wing rods in 3/8 inch ID brass tubes in pine shear webs for wing joiners. Mark Drela uses carbon rods in Kevlar tubes in end grain basswood. If you are trying to minimize weight, then use Bubble Dancer wing joiners.

A 10 inch chord AG35 airfoil is thick enough to use a straight 2.5 inch long 3/8 inch diameter wing rod for dihedral angles up to 10 degrees. I have found that clear, straight grained pine from Lowes whitewood bin to be satisfactory for installing 13/32 inch brass tubes for the 3/8 inch wing rods.

Cut a pine block slightly longer than the brass tubes and drill 13/32 inch hole through the block using a drill press. Lay out a line 5 degree lines relative to the hole almost touching the hole at each end and cut just outside the lines. Four blocks are required.

Bevel one end of each block 5 degrees relative to the hole. Slide two blocks on a 13/32 inch brass tube with the bevel ends joining. Sand the bottom to a 10 degree angle just touching the brass tube at the outboard ends. Mark the bottom as a reference surface before sanding the height to 0.60 and thickness to 0.50 inches. Mark the blocks so they can be used together for either the left or right wing joints. See Photos 1 & 2.

LilAn Alpha had a 10 inch constant chord center wing panel. When I switched from spruce to carbon fiber, the tapered thickness of the carbon fiber spar caps would require that the shear webs vary in height for the constant chord center panel. I measured the height of the shear web for the 10 inch chord tip rib and then calculated the chord length required to use the same shear web height at the center.

The center wing panel wound up with a 11 inch chord at the center and a 10 inch chord at the tip for an 0.60 inch high shear web.

Center wing panel shear webs are cut from ½ inch balsa while the outboard panel shear webs are cut from 3/8 inch balsa. All shear webs are cut with the grain vertical and are 0.60 high.

Bolt Rib

LilAn II originally used a Bubble Dancer bolt beam that passed through the spar to bolt the wing to the fuselage, but the last three models have substituted nose and tail bolt ribs cut from ¾ inch thick pine. The switch to nose and tail bolt ribs was to find an easier and faster way to build the wing. This decision was made after analysis of wing damage after a crash documented in “After the Crash” in January 2014 *RC Soaring Digest*.

The new bolt rib was made by using rib 2 of the center wing panel as a pattern to cut a rib from ¾ inch thick pine. The pine bolt beam was cut into nose and tail ribs during assembly. The bolt rib spar joint was reinforced by 1 inch thick balsa gussets.

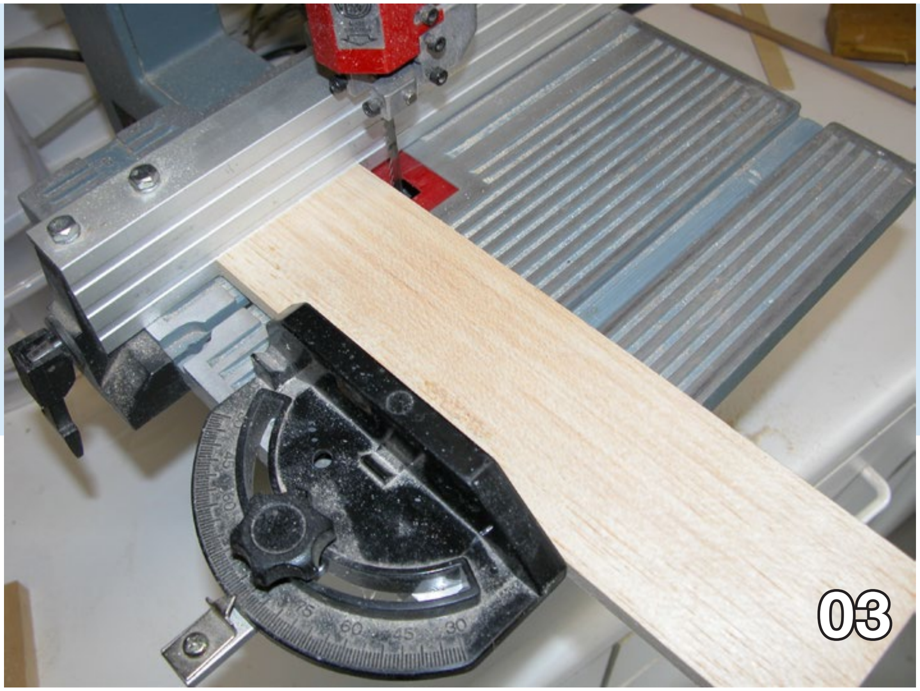
Spar Assembly

I adapted Mark Drela’s Bubble Dancer spar to the wing structure that I have been using for 30 years for all but the tip panels. The short tip panels use conventional balsa construction without spars. The center panel spars caps are ½ inch wide carbon laminate that taper from 0.060 inch thick at the center to 0.014 inch at the tips (CST No. C1952).

The 30 inch outboard panel spar caps are cut from the thick end of a 48 inch long 3/8 inch wide carbon laminate that tapers in thickness from 0.60 to 0.007 inches (CST No C1834). Center wing panel shear webs are 0.60 inch high cut from ½ inch balsa while outer wing panel shear webs are 3/8 inch balsa cut to height after gluing to the bottom spar caps (Photo 3)

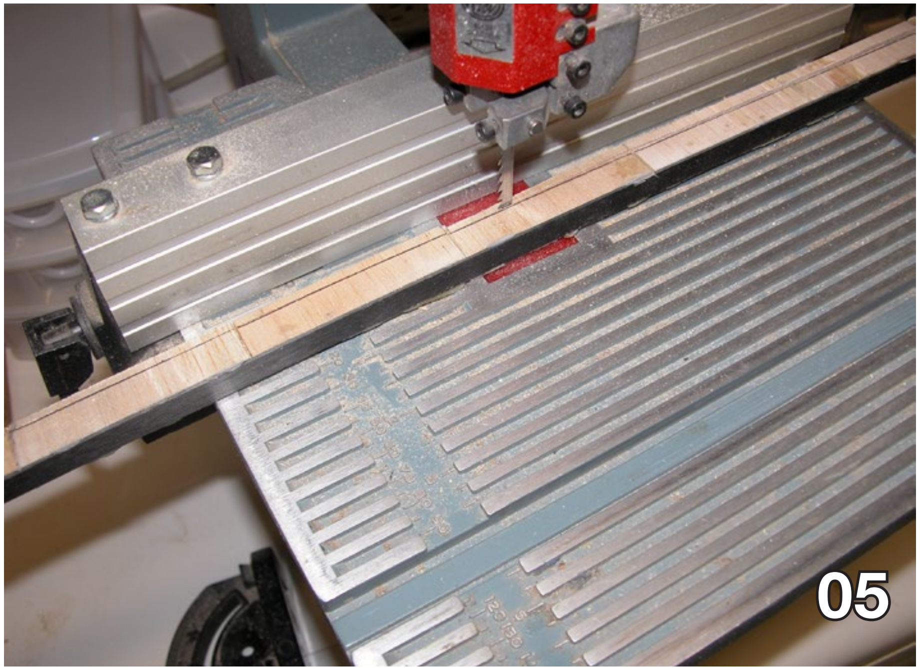
NOTE If any carbonate laminate other than CST No C1952 is used for the center wing panel, then it may be necessary to use tall shear webs and cut to height after gluing to the bottom spar cap as done for the outer panels.

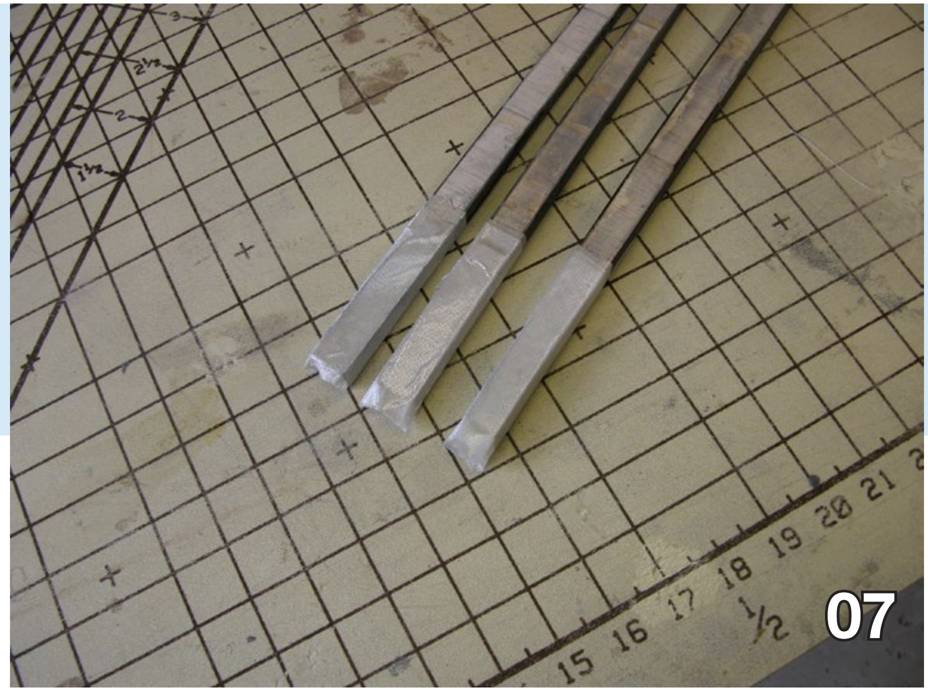
I have several square aluminum tubes that I bought several years ago for long sanding blocks, reference straight edges, and trammeling during assembly. The



shear webs are glued to the spar cap with 30 minute epoxy or laminating resin thickened with colloidal silica adhesive filler and clamped to a square aluminum tube on a flat building surface (Photo 4). After all shear webs have been glued to the spar cap and the epoxy set up, glue the other cap in place and clamp to the aluminum tube until the epoxy has cured.

Constant height shear webs could not be used on the outer wing panels so 0.60 inch high 3/8 inch shear webs were glued to the bottom spar cap. After the epoxy has set, draw a line the height of the root rib minus the thickness of the spar cap at the inboard end to the height of the tip rib minus the thickness of the spar cap at the outboard end. Trim the shear web to slightly over the line on and sand to the required height (Photo 5). Hold the top spar cap in place and measure the height at the root and tip. The height of the spar must be a few thousands less than the heights of the root and tip ribs. Gluing the other spar cap in place with thickened epoxy and clamp to a straight edge until the epoxy is cured.





Round the sharp edges of the spar caps. The joiners are wrapped with two turns of 2 oz bias cut glass cloth before wrapping with kevlar tow. Spray the glass with a light coat of 3M Super 77. Lay the spar on the edge of the glass and carefully roll it over the glass (Photos 6 & 7). After wrapping the spars with kevlar tow, coat the spars with a light coat of laminating resin or thin CA. I have also used carbon tow and Stren fishing lines for wrapping spars but kevlar tow is the easiest to use.

Trailing Edge

The trailing edge is made by gluing a 1/16 inch by ¼ inch bass strip to a standard ¾ inch balsa trailing edge stock and sanding to a knife edge. The September 2015 *RC Soaring Digest* shows two simple tools that make shaping and notching the trailing edges easier

LilAn uses the Drela AG35 airfoil for all wing panels. The first four LilAns were built with stack cut ribs and the October 2015 issue of *RC Soaring Digest* shows how I cut the ribs. Charlie Bair wrote a computer file for laser cutting LilAn ribs and has made it available for down loading from *RCSD*. (December 2015 *RC Soaring Digest*.)

The LilAn Alpha had spoilers in the outboard wing panels to minimize the need for spoiler/elevator compensation. LilAn II moved the spoilers to the center wing panel to get rid of the weight of the servos so far outboard and eliminate the servo connection at the outboard wing joint. Spoilers can be controlled by servos in the wing but I prefer to use pull strings connected to a servo in the nose where the weight is needed instead of outboard in the wing where it isn't. I do not have to remove the wing to transport the model in my van so I only have to tape the outer wings in place to be ready to fly. If I had to remove the wing to transport the model, I would use spoiler servos in the wing because plugging in a servo is easier than hooking up pull strings. Drill the necessary holes in the ribs for

servo leads or string guide tubes before starting assembly.

LilAn Spoilers are large and designed to be used like a throttle to regulate speed and glide slope in the landing pattern; not in and out for spiking.

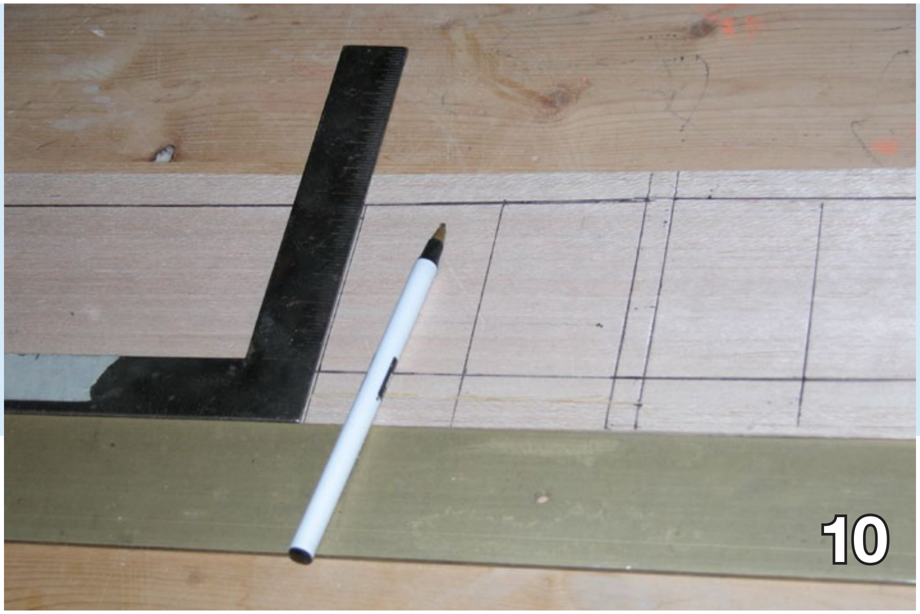
Wing Skins

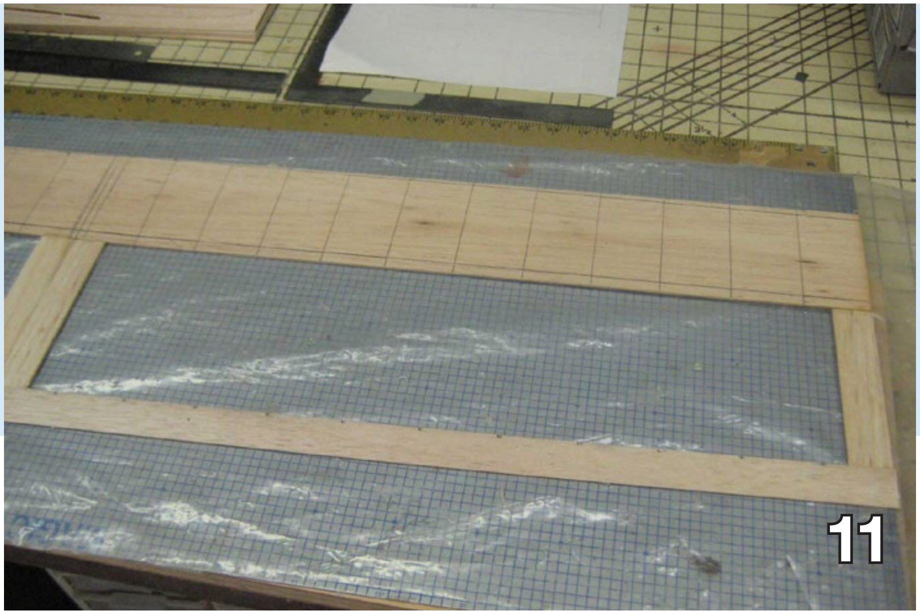
I have found no need order contest balsa for my sailplanes. I just order more standard balsa and throw away any bad sheets. (I usually find a use for all the wood).

Splice two sets of three sheets of 3/32 inch x 3 inch x 25 inch balsa to make the top and bottom skins for the center wing panel. Each sheet is cut into 5 and 4 inch wide sheets for top and bottom skins. Splice two sets of three 1/16 inch x 3 inch x 31 inch balsa for the outboard wing panels. Lay out the ribs and leading edge before cutting the sheets into top and bottom skins. So far, center wing panels of all LilAns have been built on a 48 inch long sheet of 4 inch wide 3/32 inch balsa because I had several sheets that size and only had to splice the top skins of the center wing panel.

Some modelers take the quick way out and use CA to splice balsa and wind up with a ridge at the joint. Titebond is very sandable and gives a much better splice. Photos 8 and 9 shows the way I spliced two sheets of 1/16 inch x 3 inch x 12 inch balsa for the tip panel wing skins. Trim the joining edge with a sharp knife and straight edge if necessary to achieve edges that touch along the full length. Tape the skins together along the joint and drape over a block so the joint will open. Apply a small bead of Titebond to the joint. Pipettes are great for this. (*RC Soaring Digest* November 2015) Move the skins to a flat surface and wipe excess glue with a paper towel. Wipe again with a damp cloth to remove as much glue as possible. After the glue is dry, remove the tape and sand both sides with a large sanding block.

A wing plan is not necessary for building simple sailplane wings with straight or tapered panels and I haven't built wings over a plan in over 40 years. All I need is the span, root chord, tip chord, sweep





angle, rib spacing, and a grid to align the ribs. The LilAn center wing panel has a span of 48 inches, center chord of 11 inches. tip chord of 10 inches, no sweep, and two inch rib spacing. The center wing panel is built on a 4 by 48 inch sheet of 3/16 inch balsa. If using two 25 inch long sheets, the spar carries the load and the bolt rib covers the joint. Top sheeting is two 5 by 25 inch sheets of 3/32 balsa.

The aft edge of the bottom sheeting is used as a reference line and ribs are aligned perpendicular to it. Draw the spar and rib locations on the bottom sheeting with a ball point pen, straight edge, and square or triangle (Photo 10). The bottom sheeting extends ¼ inch aft of the spar.

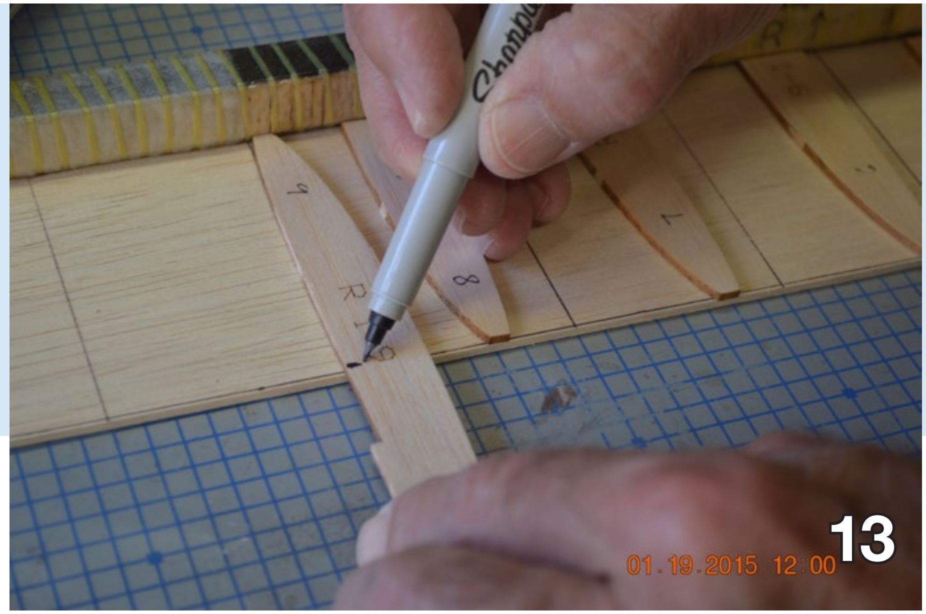
Start by finding the center of a 48 inch long sheet of 4 inch wide sheet of 3/32 inch firm balsa and draw the centerline. Draw a line every two inches either side of the centerline. The laser cut rib set includes extra end ribs for the 1 inch sheeting on the end to support the wing tape used to attach the outboard wing panels

Place rib 2 on the rib 2 location and mark the front of the rib. Repeat with rib 12 and draw a line from the root to the tip and cut just outside the line. Use ribs 2 and 12 to locate the trailing edge and tape it to the building board. Glue the rest of the bottom sheeting between the bottom leading edge sheeting and the trailing edge. If using stack cut ribs, use the root and tip templates to locate the leading and trailing edges (Photo 11).

Anything with a grid can be used to align the ribs. I have a magnetic building board with a grid but I have also used a large quad drawing pad or the cutting pad I use for cutting fiberglass cloth.

Glue the spar to the bottom sheeting with West 105 or 30 minute epoxy that has been thickened with colloidal silica adhesive filler and weighted down until cured. Old laptop and UPS batteries make good weights for construction (Photo 12).

The principle change to my standard building method required by using the carbon fiber spar is one piece ribs cannot be use so nose and tail ribs will



have to be cut from all except root and tip ribs. Place the nose of the rib against the front of the spar at the rib location and mark the leading edge (Photo 13). Cut the nose rib on the mark. A Miter Cut makes a square cut quick and easy. Cutting the nose rib first lets the flat bottom rest against the Miter Cut for a more accurate square cut (Photo 14).

Glue ribs to the spar with 30 minute epoxy thickened with Carbosil. The flat bottom part of the nose rib near the spar is glued to the bottom sheeting with thin CA to hold the rib in position until the epoxy cures (Photo 15).

The trailing edge of the rib is placed against the spar and the length of the aft rib marked against the trailing edge (Photo 16). The spar section of the rib is then cut off with the Miter Cut and glued in place with CA and 30 minute epoxy

Move the wing to the edge of the work bench to clamp the bottom sheeting to the nose ribs and glue with thin CA (Photo 17 and 18). Hack saw blades on top of the ribs distribute the clothes pin loads preventing crushing the ribs. Pipettes make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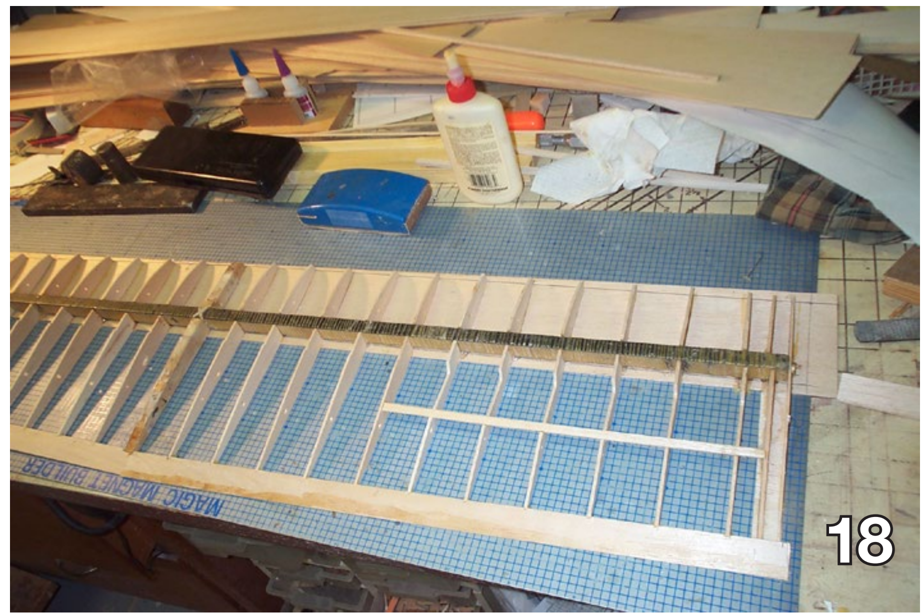
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applying CA in confined places easy. The November 2015 *RC Soaring Digest* shows how to pull generic pipettes to a fine tip for applying CA.

Photo 19 shows installing bolt rib gussets

The top sheeting is glued to the spar with a narrow bead of thickened slow curing epoxy and glued to the ribs with Titebond (Photo 20). I prefer West 105 epoxy because it gives me more time to spread the Titebond on top of each rib and align the top sheeting. Place the wing on a flat surface and place a long weight over the rear of the sheeting. Let the leading edge overhang the edge of the work surface so the sheeting can be clamped to the leading edge with clothes pins and weights (Photo 21). Let the glue cure overnight.

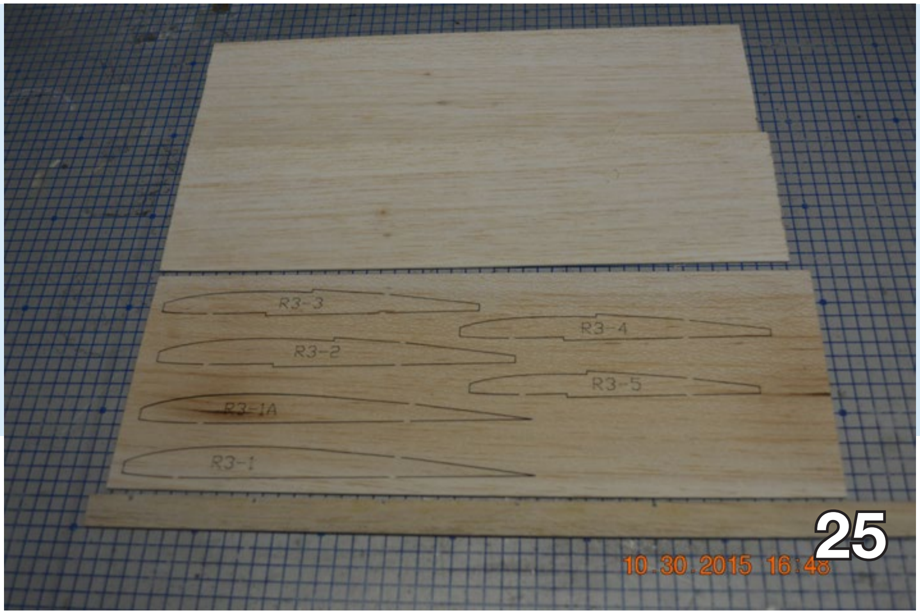
After the glue has completely cured, sand the sheeting back to the ribs with a long sanding block. Inspect the glue joints and re-glue any suspicious joints with thin CA.

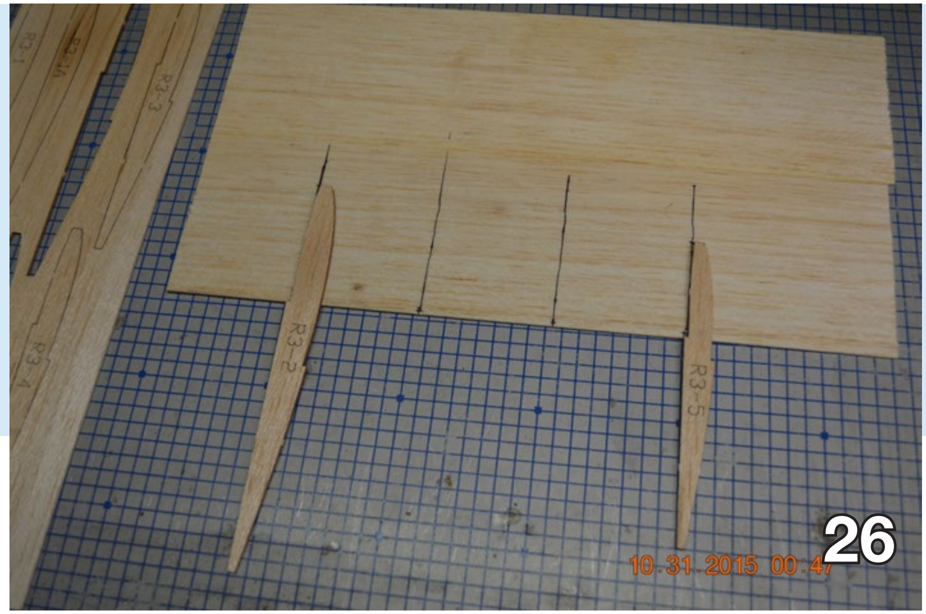
The leading edge is glued with Titebond and held in place with masking tape (Photo 22). At this stage, the wing is quite flexible in torsion so it is easy to add washout. If washout is needed, shim the trailing edge at the outboard end as necessary to provide the desired angle. Use weights to hold the wing to the building board while the glue dries (Photo 23). Once the leading edge is glued in place, the wing is quite stiff in torsion and any twist will be locked in.

Install the spoiler string guide or spoiler servo leads and spoiler well frame (Photo 24). Leave off the top sheeting of the tip ribs until the outboard wing panel alignment pin tubes have been installed.

Outboard Wing Panel

The outboard panels are built the same way as the center panel except that there is no spoiler and the wing sheeting is 1/16 inch balsa. Root chord is 10 inches, tip chord is 7.5 inches, span is 30 inches, rib spacing is 2 inches, and there is no sweep. A 1/8 inch shim is placed under the outboard end of





the trailing edge while gluing the leading edge in place to give 1 degree washout. Install 3/32 inch diameter alignment pins in the outboard panels. Be sure the pin is parallel to the joiner rod. Drill matching holes in the center panel tip ribs for 1/8 inch brass tubes to receive the alignment pins.

Assemble the center and outboard wing panels. Attach straight wood dowels or carbon fiber tubes to the bottom of the outboard ends with rubber bands. Adjust the brass tubes until the rods are aligned and epoxy brass tubes to the center wing panel. Sheet the rest of the top of the tip ribs.

I expect to be flying my sailplanes for years so I reinforce the ends of all joining panels with 1/16 inch plywood ribs. Omit the plywood ribs if light weight is that important.

Heavy wing tips have an adverse effect on handling qualities so I make every effort minimize weight. The tip panel has no spar and a 3/32 inch thick vertical grain shear web is glued between the top and bottom sheeting between the first three ribs. The wing has a raked Horner full sharp tip and is used because it is so light, easy to built and may reduce drag. See *RC Soaring Digest* article on NonPlanar Wing in the June 2013 issue of *RC Soaring Digest*.

Tip panel has a span of 8 inches plus 4 inch raked tip, 7.5 inch root chord, 6 inch tip chord, and ¾ inch wide trailing edge.

Photo 25 shows the ribs, sheeting, and trailing edge.

Construction of the tip panel is like the other panels except that there is no spar and the ribs don't have to be cut into nose and tail ribs. The first three ribs have 3/32 balsa shear webs. The first rib is inclined 20 degrees for the tip dihedral.

Splice two sheets of 1/16 inch x 3 inch x 12 inch balsa. Draw rib locations every two inches for 8 inches. Use ribs 2 and 5 to

mark the leading edge of the ribs and draw the leading edge (Photo 26). Cut the sheeting just ahead on the leading line for the top sheeting. Use ribs 2 and 5 to position the bottom sheeting and trailing edge over a grid and glue with CA. Add ½ inch wide bottom sheeting under rib 1. Install shear webs on either side of rib 2 (Photo 27).

Bevel the inboard shear web 20 degrees for the root rib. The root rib is tilted 20 degrees for the tip dihedral. Trim rib 1a to fit between the shear web and trailing edge and glue with ca. Install ribs 3 and 4 and move to the edge of the building board. Use a hacksaw blade and clothes pins to clamp the bottom sheeting to the ribs and glue with ca (Photo 28).

Glue a 3/8 inch wide 3/32 inch thick tip between the leading edge and the trailing edge (Photo 29).

Bevel the edge of the tip for the top and bottom sheeting and install the top sheeting. Clamp the top and bottom sheeting to the tip (Photo 30).

Sand the tip to a sharp edge (Photo 31).

The tip panel is glued to the outboard wing with 20 degrees dihedral relative to the outboard panel with a simple butt joint without a dihedral brace. The bottom of the joint is reinforced by a 1 inch wide strip of 2 oz glass cloth to handle launch loads. See After The Crash in the July 2014 *RC Soaring Digest*.

Carving the Leading Edge

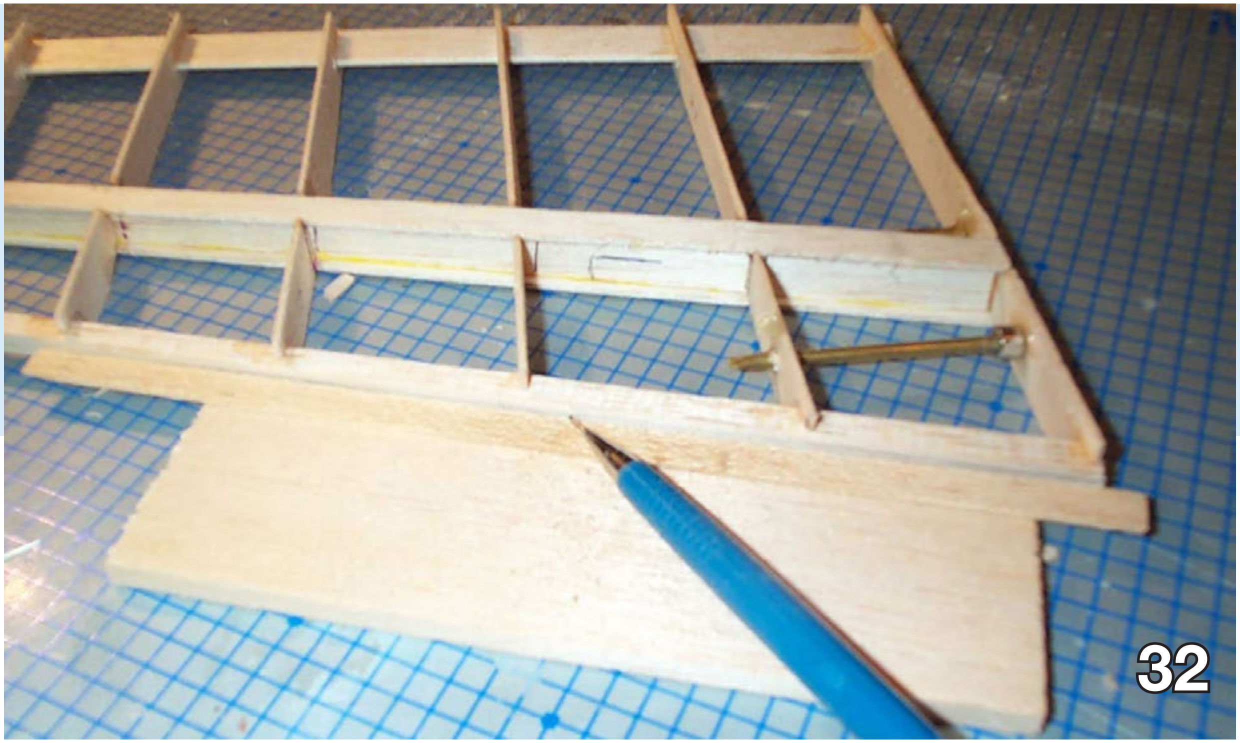
Mark the center of the leading edge to aid in carving the leading to shape.

Shim the outboard end of the panel so that the center line of the tip rib is the same height above the work surface as the center line of the root rib.

Place the middle of the center wing panel on the edge of the work surface and shim the tip 1/16 inch. Use a ¼ inch high marking height guide. Place a pen or pencil on the guide and slide it down the leading edge.

Photo 32 illustrating marking the centerline is from a stab, but the process is the same. Repeat for the other end. This is necessary because the center panel was build on a flat surface giving the center panel a very slight negative dihedral.

Shim the outboard panel 1/16 inch at the tip before marking the leading edge centerline using an 0.22 inch height guide.



Carve and sand the leading edge to shape making frequent reference to the leading edge template (Photo 33).

I use a 10 inch long coarse sanding block for preliminary shaping and a long sanding block made by gluing medium grit sand paper to a 36 inch length of square aluminum tubing for final shaping.

Leave the leading edge mark centerline in place until the final sanding to aid in aligning the leading edge template. The airfoil cord line is marked on the leading edge template ahead of the airfoil before cutting out the template.

Part III of this series will cover building the tail surfaces with rectangular rib blanks and sanding to shape on a sanding board.

Flying Wing Designer

Marko Stamenovic, ftlltf@yahoo.com

For a long time Hortens' flying wings have represented some kind of mystery and if we would to go a little deeper into design, even today, they still present some challenge. Not all related issues are well understood and we still have a thing or two to learn about it.

Compared to standard configurations with horizontal tail or canard, for which we have a huge amount of empirical data and verified rules of thumb, when designing "Horten style" aircraft we have much less information readily available.

Add a requirement for a complex twist and things get even more difficult for the average model maker.

Creating "Flying Wing Designer" (FWD) was my humble effort to make the whole process a little easier, so that different configurations can be tested much faster. The more we test the more we know.

But let's step back a little and start with basics.

In my view there are three basic (and practical) types of flying wings. Some other solutions are possible but they are of a lesser interest. The classification is made by the concept used:

- Flying wings with positive sweep and elliptical (or super-elliptical if winglets are present) lift distribution. These wings correspond to the most modern flying wing concepts. The best example would be the SWIFT. They always require vertical surfaces and offer high performance.
- Flying wings with zero or very low sweep (planks) and elliptical lift distributions. These flying wings also always require vertical tail surfaces, optimum position being usually in the middle of span. Jim Marske's Pioneer series of sailplanes is a good example.
- Flying wings with Bell Shaped Lift Distribution (BSLD) or "Horten style" wings. These are the only ones that can be flown successfully without vertical surfaces.

FWD can be used to design all kinds of flying wings, not just "Horten style" models, but it is made with the BSLD concept in mind.

In the case where winglets are present, the lift distribution calculated in software won't be accurate since winglets influence it considerably. Still, it can help you with geometry of wing.

About the software itself

FWD has been made under the assumption that the user knows the basics of aerodynamics and flight mechanics. Also, familiarity of how Horten's aircrafts were designed would be extremely helpful. Many things have been written on the topic.

It is highly recommended to check the recent work of Mr. Albion Bowers from NASA to whom I must express gratitude for sharing his knowledge for many years. Here is a good starting point: <http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20110003576.pdf>

The main idea behind Flying Wing Designer (FWD) was to make the process from designing concept to CAD model a very fast one.

Due to the complex wing twist this can be a time consuming process since you need to scale, position and rotate airfoils to a required twist angle in CAD software. The twist is not linear, so using just the Root and Tip airfoil and setting the angle between them won't work.

To achieve the desired result you need a lot more sections defined. FWD simplifies this process by calculating coordinates of airfoil sections, scaled, positioned and rotated to the desired angle. You can use these coordinates by copying them into a .dat or .txt file which you can then open in most CAD software packages. Once you do that for all airfoils you should be able to loft your wing.

How to use FWD

We will go through Excel pages, design processes and methods used in FWD for a "Horten style" model. You are encouraged to go over the "READ ME" page as it should help clarify the designing process. I have tried to insert enough comments into the spreadsheet pages. They should help you further.

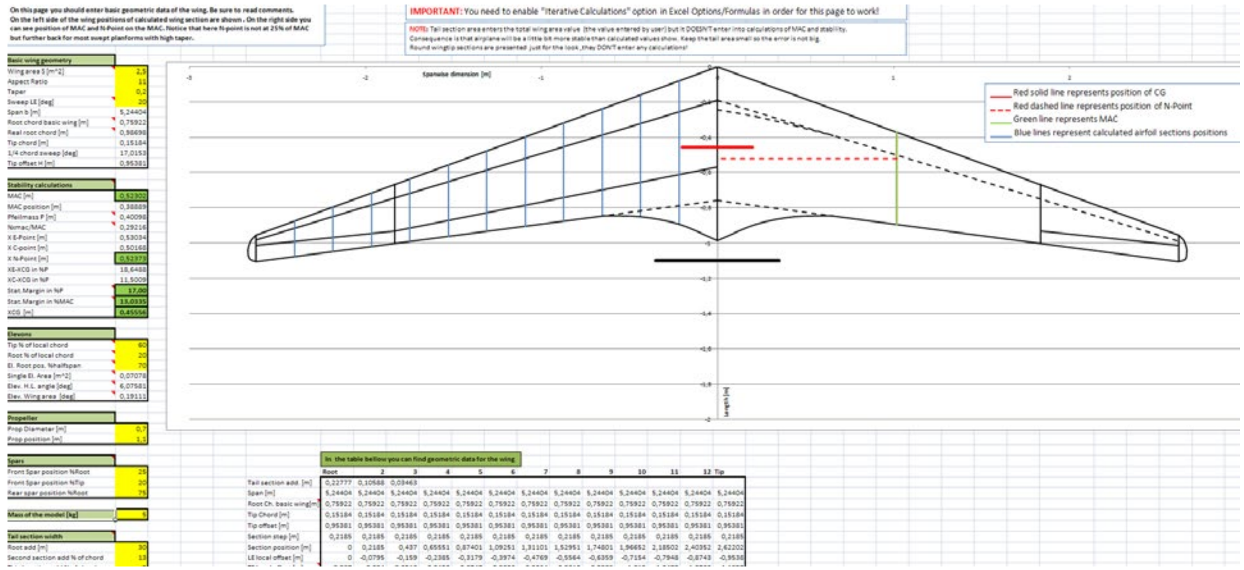


Illustration 1

You start designing on the "PLANFORM GEOMETRY" page. See Illustration 1. As the title suggests, this is a place where you define how your flying wing should look. The planform of the wing has a trapezoidal base, but you can add a so called "bat tail" section in the center. The Horten brothers used the "bat tail" in order to reduce a loss of lift in the center due to sweep effects.

If you decide to use a "bat tail," you should keep in mind that it will be included in the total surface area and twist calculations, but it won't influence the calculations of Neutral Point and CG, nor the trim lift coefficient. The result is that aircraft will be a little more stable and trimmed at a lower lift coefficient than calculated.

The next page is "TWIST AND TRIM." See Illustration 2. Here you define the lift distribution, airfoil data, and the desired Static Margin. You are free to use any shape of lift distribution. The shape is controlled by changing the factor "mi." If it is zero you will get an elliptical distribution and if it is 1.0 you will get a BSLD. All values in between are possible. For more details you should check Prandtl's paper about minimum induced drag.

Twist is calculated using Prandtl's Lifting Line Theory (LLT). The main drawback of the theory is that it doesn't include

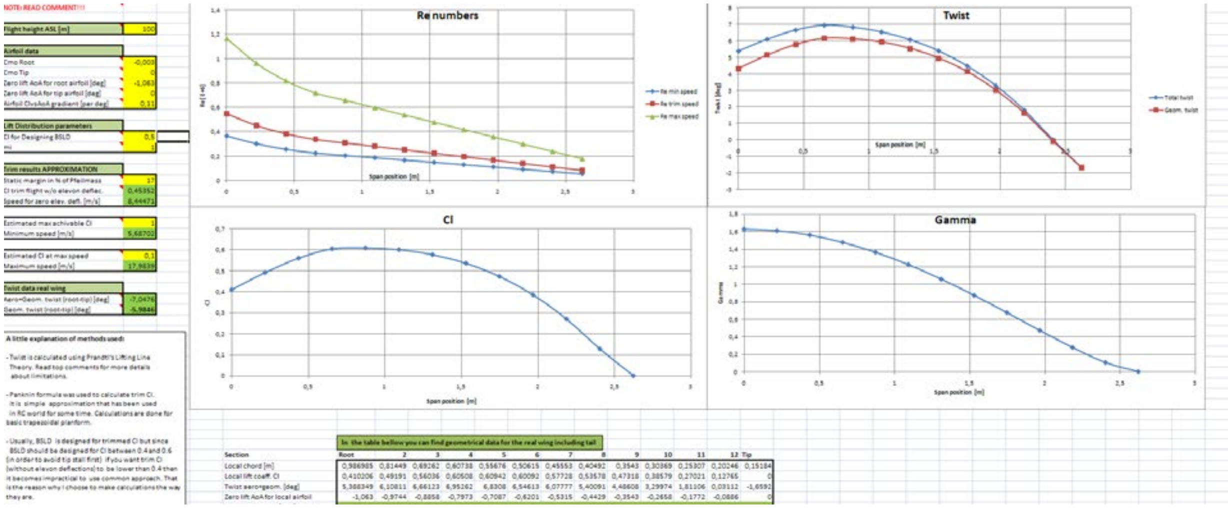


Illustration 2

sweep effects. For that reason keep the sweep small. This theory was applied due to its simplicity and due to the fact that many VLM codes are available today. FWD enables you to decide if you are using twist data from LLT or to enter twist values manually from some other software.

In the case where you have considerable sweep, my recommendation would be to use data from FWD to make a wing model in some VLM software (FLZ_ Vortex would be the simplest solution.)

Use the twist from FWD as a starting point and then correct the twist in VLM software so that you get the desired lift distribution shape. If “mi” is 1 then you should compare it with lift distribution proportional to sin^3. Input the new twist values in the “LOFT VIEWER” page and you will get coordinates of airfoils for new twist.

It might look like it is complicated, but actually this is quite straight forward procedure and should take you to final results quickly. (The “LOFT VIEWER” page will be described in detail in a short while.)

Another adjustable parameter related to the lift distribution is lift coefficient for which that distribution is designed. Usual values should be between 0.4 and 0.6. General experience is that if this value goes below 0.4 then wing tips will probably stall before the center section and your model will have bad handling.

Trimming calculations are done by simply applying the well known Panknin formula.

An important thing to note is that trim lift coefficient (without any control surface deflection) is not the same as the lift coefficient used for generating the lift distribution. Although it might look logical to do so, I decided that it is better to separate these two things. The reason is that you can have the cruise lift coefficient outside the 0.4-0.6 range. Otherwise you would be stuck with a very limited range for designing. If you want your model to cruise at the same lift coefficient used for the lift distribution you can achieve it by adjusting the desired Static Margin.

The “AIRFOIL INTERPOLATION” page is a place where you enter the coordinates of Root and Tip airfoils. The number of points should be exactly 30. You can obtain these coordinates from software like XFoil or XFLR5. Interpolated airfoils will be calculated for all sections between Root and Tip.

“LOFT VIEWER,” See Illustration 3, is a page where you enter values of twist obtained from some other software if you decide that you won’t use the results from LLT as mentioned above.

Another important value to enter is the position of the rotating point along the chord of the sections. If it is zero, rotation will be done around leading edge; if it is 1.0 then rotation will be done around the

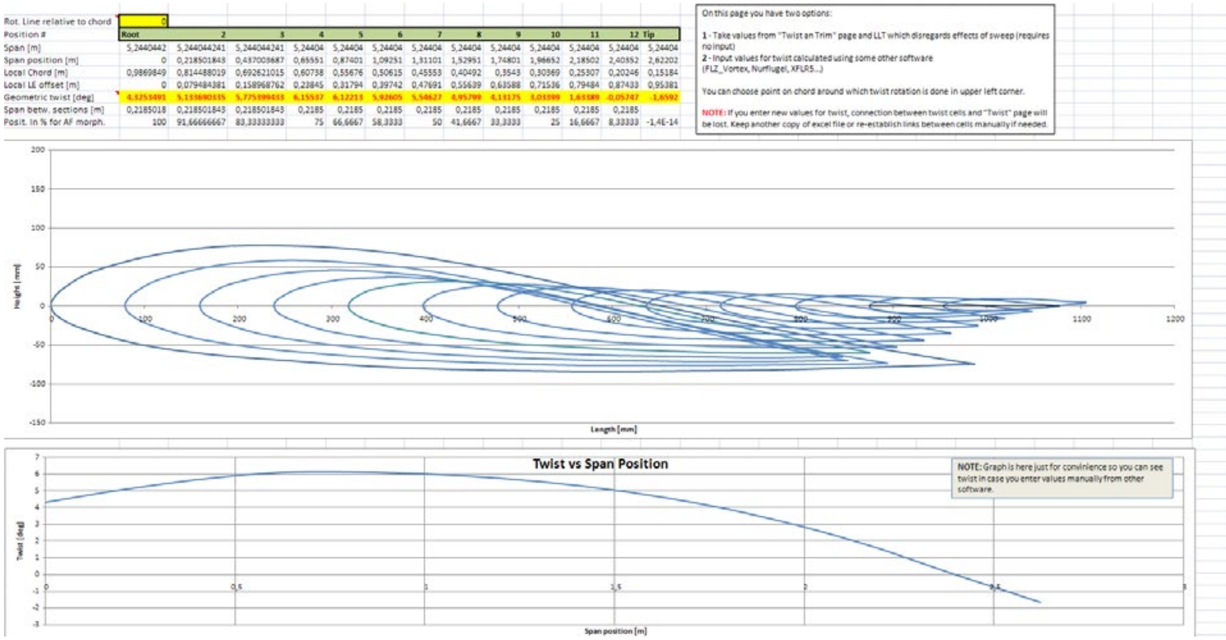


Illustration 3

trailing edge. The first case might make fabricating of the leading edge simpler.

You could place the rotation point on the spar, or if your control surfaces are of constant percent chord you could put the rotation point at the leading edge of the control surfaces. That way they would be easier to design and you will have fewer problems with their geometry when they are deflected. This is especially important when designing low Aspect Ratio wings since required twist is usually greater and it is concentrated on a smaller halfspan.

“ROOT” to “TIP” pages give you calculated coordinates in green fields that you should copy to .dat or .txt files for usage in CAD software.

The “AIRFOIL DATABASE” page, see Illustration 4, offers a few examples of airfoils, but you are surely encouraged to find airfoils that suit your model best according to the design parameters.

Note that the Excel file that designs airfoils using the same methods used by the Horten brothers is available on the same web page as FWD. Compared to today’s modern airfoils these are outdated, but for their time they had good characteristics.

Limitations of the software

As said before, there are a few limitations to the software.

Firstly any “bat tail” section is not used in the calculation of the Neutral Point and the Static Margin.

Secondly, LLT theory has been used which does not take into account effects of sweep. This can be overcome by using some VLM software.

Lastly, trim calculations are made using Panknin formula and in my opinion it will give a trim lift coefficient which is a little higher than in reality.

But overall this simple sheet should make designing flying wing model a little bit easier.

Future work and beyond Horten

I will try to improve the software over the time and implement new features - maybe even apply Lifting Surface Theory in order to take sweep effects into account when calculating twist.

Until then I hope that my efforts to simplify designing process will help you.

In the end I would like to mention a few things related to flying wings in general.

They have always been a controversial topic in aeronautics. The main reason is the fact that flying wings are basically

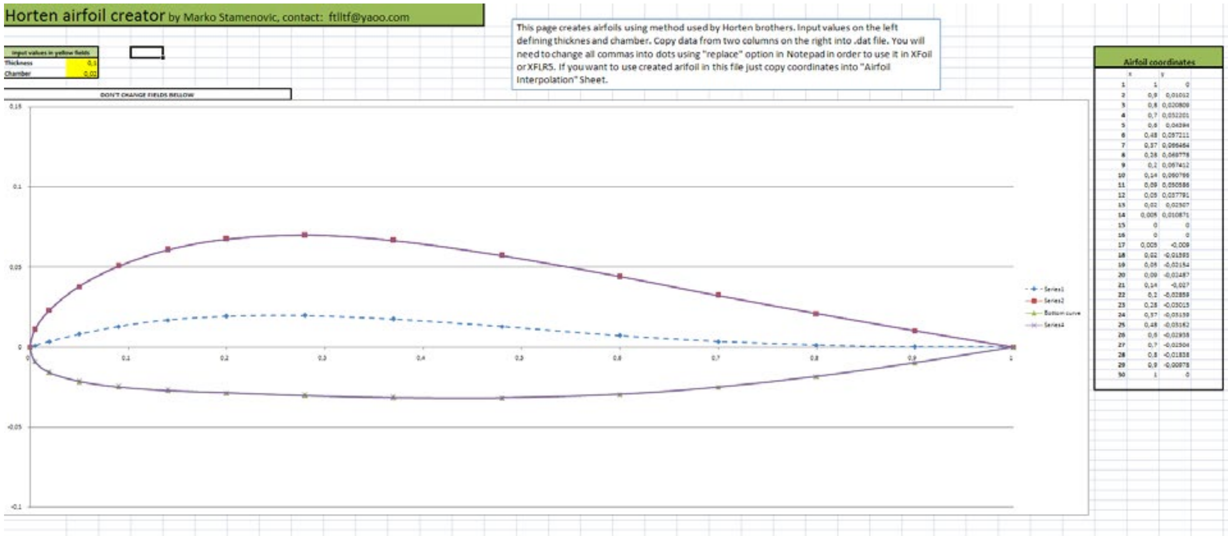


Illustration 3

single point designs. The further you go from that point, the characteristics become worse and worse. Unfortunately, an aircraft has to take off, climb, cruise at high speed, and all things in between. In most cases these requirements contradict each other.

If we want to develop flying wings further into the future we need to address these problems in detail.

In the past years new technologies that can remove some of the limitations that flying wings suffer from are becoming available. Artificial stability, shape morphing, 3D printing of complex parts, active boundary control and many other things… What was once a technology reserved for top secret projects nowadays is available to the "common man." A lot can be said and imagined about future possibilities.

So think big, explore new concepts and please share your results with us.

"Flying Wing Designer" and "Horten Airfoils Creator" Excel apreadsheets are available for free download at Koen Van de Kerckhove's "Nest of Dragons" web site: <http://www.nestofdragons.net>

Follow the links to Weird Airplanes > Flying Wings > Flying wing Designer. Horten Airfoil Creator is near the bottom of the page.

Simine Short, editor of the Vintage Sailplane Association magazine Bungee Cord, has just notified us that a "movie" of Otto Lilienthal flying one of his creations is available for viewing on YouTube!

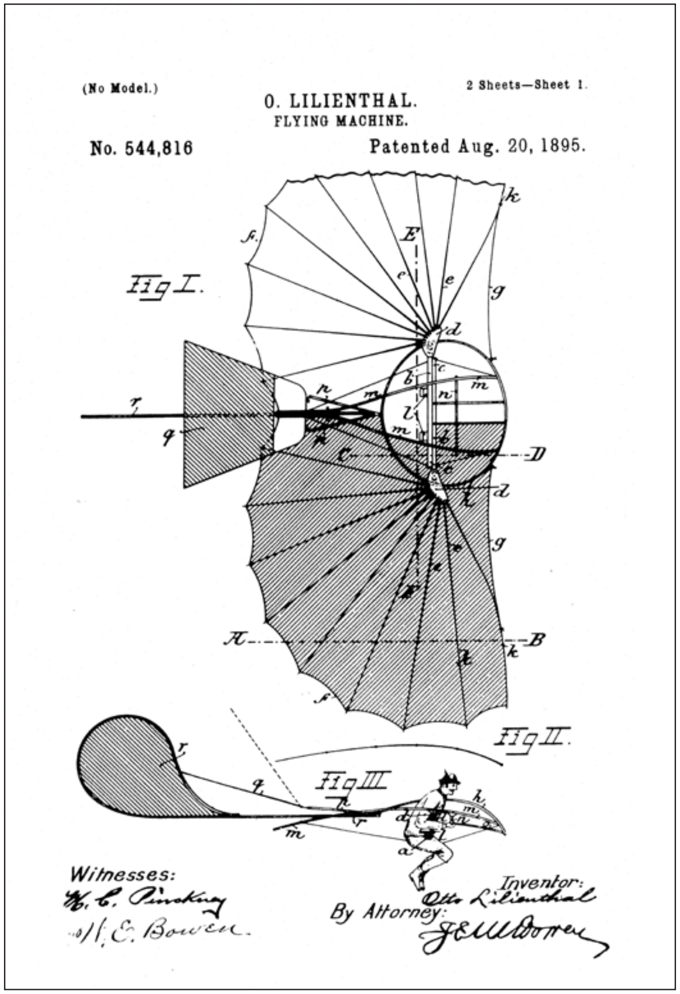
Johannes Hogebrink received permission to use the complete photo archive held by the Otto Lilienthal Museum in Anklam. Putting the photos in an appropriate order, he was able to create a film which represents a complete flight.

<https://www.youtube.com/watch?v=qLuIiwmu3OE>

This film parallels both the DLR material presented on the following pages, as well as the most recent edition of *Bungee Cord*, Volume 41, No. 4, Winter 2015, which focuses on the "roots" of soaring.

<http://www.vintagesailplane.org>

DLR to build replica of the world's first series-produced aircraft



Lilienthal's 1895 patent for a 'flying machine'. Credit: Otto-Lilienthal-Museum Anklam.

11 February 2016

The German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) plans to build a realistic replica of the world's first series-produced aircraft and study it scientifically. The project intends to honour the work of aviation pioneer Otto Lilienthal who, 125 years ago, became the first person to pilot an aircraft. In addition, the researchers hope to acquire insight into the cause of Lilienthal's fatal crash.

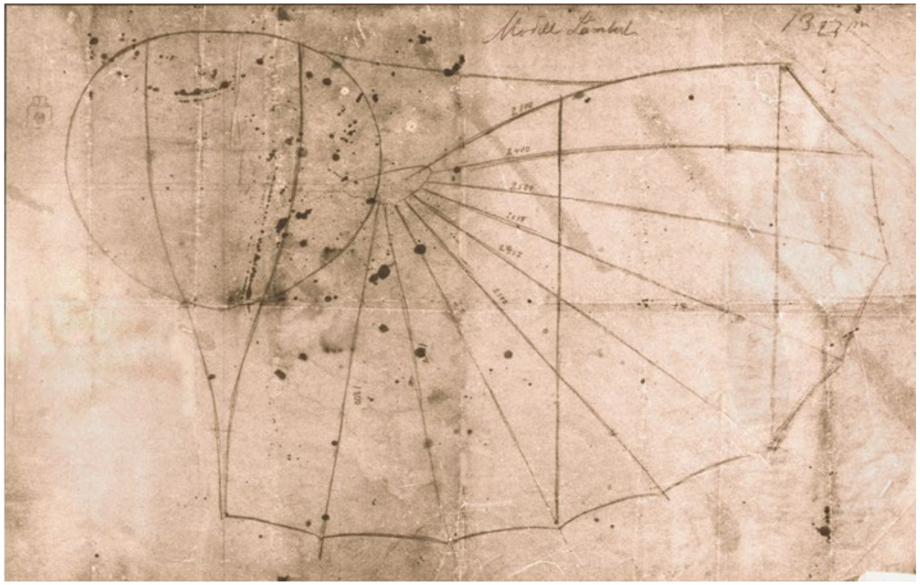
First human to fly

Lilienthal is considered 'the first human being to fly'. The flights he conducted in 1891 with his self-built glider are considered to be a pioneering achievement in aviation. Balloons that had previously taken people up into the air are not considered aircraft, as they are lighter than air.

Lilienthal's endeavours formed the basis for the first motorised flight by the Wright brothers in the United States and for the work conducted later on by aviation pioneers such as Hugo Junkers and others. This was enabled by Lilienthal's scientific publications and by his – at times – sensational photographs, which received considerable attention both in Germany and abroad.

Investigation in a wind tunnel

"This project, which will involve constructing a historically accurate replica of the world's first series-produced aircraft as it was built by Lilienthal and using it for wind tunnel testing, was initiated not only in order to conduct scientific research into the early days of aeronautics, but also to commemorate and honour one of the world's most renowned aviation pioneers," says Rolf Henke, the DLR Executive Board Member responsible for aeronautics research. "We are the leading aeronautics research organisation in Germany, so this project takes us



Workshop drawing of the world's first series-produced aircraft. This drawing shows the 'normalsegelapparat,' or conventional glider, the first series-produced aircraft in the world, which is to be rebuilt by DLR in cooperation with the Otto Lilienthal Museum in Anklam. The sketch was made for an aviator named Charles de Lambert, who is one of nine known buyers of Lilienthal's 'normalsegelapparat.'

Credit: Otto-Lilienthal-Museum Anklam.

back to our origins. Our work is based on Lilienthal's scientific legacy."

Paradigm for contemporary aeronautics research

The DLR Institute of Aerodynamics and Flow Technology in Göttingen will conduct the scientific analyses. Andreas Dillmann, Head of the Institute, sees Lilienthal as the father of all modern aeronautical research: "Lilienthal was the first aerodynamic researcher to proceed according to scientific principles. Until then, there had only been hobbyists."

Search for the cause of the crash

The analyses are intended to demonstrate that Lilienthal built an aircraft that was stable about all three axes. Moreover, the wing profile will be closely examined to determine how similar it is to its modern counterparts. Finally, it is hoped that the analyses will provide information about the cause of Lilienthal's fatal crash on 9 August 1869.

Of all the designs that Lilienthal left behind, the 'normalsegelapparat,' or conventional glider, is the one that will be reconstructed. This was the world's first series-produced aircraft, of which nine were sold worldwide. It was in this type of aircraft that Lilienthal suffered a fatal accident.

The replica will be built by the Otto Lilienthal Museum in Anklam, using Lilienthal's original design drawings. Lilienthal gliders have frequently been replicated, but this is the first time that a historically accurate replica will be constructed. A series of preliminary analyses and research work will be conducted for this purpose. For example, rigorous testing will be carried out on the fabric covering of preserved, original Lilienthal gliders to determine its properties. Once the replica is complete, it will be tested in one of Europe's largest wind tunnels, located at the German-Dutch Wind Tunnels (DNW) facilities in Marknesse in the Netherlands. "Our aim is to comprehensively understand its flight mechanics and aerodynamic performance," says Dillmann. "How far could he fly, depending on the take-off elevation? In which areas was he able to maintain stable and safe flight?"

URL for this article: <http://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10081/151_read-16705/year-all/#/gallery/21944>

Lilienthal taking off from the Maihöhe. In 1893, Lilienthal erected a 'flying station' on the Maihöhe in Steglitz, which served as a launching platform and glider storage facility. Ottomar Anschütz, a pioneer of photographic technique, took the photograph. Credit: Otto-Lilienthal-Museum Anklam.

Lilienthal in flight during 1894. The image shows Otto Lilienthal flying from the Fliegeberg near Berlin. He constructed it specifically for launching gliders; it is thus one of the first artificial airfields. Ottomar Anschütz, a pioneer in photography, took the photograph. Credit: Otto-Lilienthal-Museum Anklam.

Links:

DLR at a glance:
<http://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10443/637_read-251/#/gallery/8570>

DLR Institute of Aerodynamics and Flow Technology:
<http://www.dlr.de/as/en/desktopdefault.aspx>

Otto Lilienthal Museum:
<http://www.lilienthal-museum.de/olma/ehome.htm>

Akaflieg Karlsruhe AK-X

via <https://translate.google.com>

June, 2015

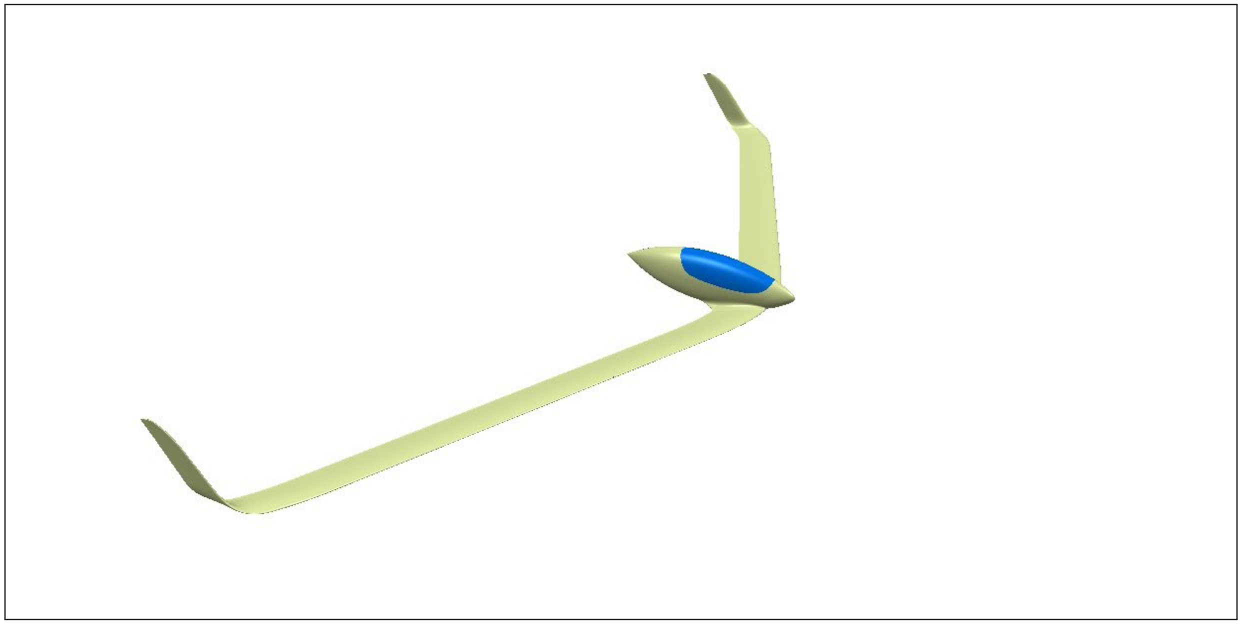
After the AK-8 is in flight testing, we deal some time intensively with the question of what we want to take the next plane project in attack. It quickly became clear here that the conventional aircraft concept is already very mature and further improvements in our facilities, can only be achieved even in detailed areas.

We extended our considerations from hence, and came to the conclusion that the draft tailless glider has a great potential increase in performance.

Objective

The objective of the project is to explore the flight mechanics of the flying wing and derive a draft, which aims not only at good flight performance, but also has so good-natured and easy flight characteristics that even less experienced pilots to fly without problems. In addition, attention should be paid also in the construction of the prototype on creating a practicable design. Here, for example, pay attention to a robust design of the suspension, so this sometimes ungentle landings survives. (A weak landing gear plagued the SB-13 throughout its test flying schedule. - ed.)

Development approach at the beginning of the project the previous Nurflügelkonstruktionen were first analyzed in gliding range. Here we put our focus on the flying wing of brothers



CAD model of the AK-X design

Horten, which were built during the Second World War and the SB-13 Akaflieg Braunschweig. Here, an attempt was made to understand the design process and having trouble figuring out the constructions, which showed in the later flight.

In the section “Aerodynamic design” a couple of these problems will be explained as an example. Subsequently, a preliminary draft was created, has been tried in which to solve these problems. Parallel to the work on the flight mechanics and aerodynamics is also working on the structural design of the prototype. In the section “Structural design” the procedure thereof is explained in more detail.

Before we begin the construction of the prototype, we want to check our design comprehensive and optimize them. Therefore we decided to perform with remote-controlled model aircraft flight tests of our design. The construction and flight testing of the models are in the sections “testing model” and “flight model testing” explained.

Chassis design

As part of a bachelor thesis was constructed from October 2014 to January 2015 the suspension of the AK-X and designed. The task was to integrate both the bow and the main landing gear in the 3D CAD model and to perform the necessary strength tests. A special requirement for the construction was about the ground clearance required for the flying wing due to the strong Rückpfeilung (rearward sweep - ed.). Therefore, the concept of choice was a main landing gear with a double verknieten landing gear struts, which allows a long extension path.

The use of treatable steel 25CrMo4 for the tubular frame of the main landing gear permits a slim design. The stress analysis for the main landing gear was performed with the aid of FEM calculations, the static overdetermination of the system, take better account of the analytical method.

The nose landing gear should be designed to be steered to give the pilot the opportunity at a low drive track to correct as at the start behind a tow plane. This demand has led to a construction with a steerable fork, which can be retracted by means of a rotatably mounted steering head via simple drag struts.

For the critical components of the nose gear evidence were conducted against fatigue failure and violent rupture to take into account both the high swelling strains, and the strong landing shocks. also all assembly and detail drawings were made for the production and installation of the landing gear.

<https://www.youtube.com/watch?v=evD8UXXFfWU>

Control

This year began with the completion of a bachelor thesis at KIT. With it a concept study for the design of the control of the AK-X was performed. Work focused on the study of ways to allow the mixture of three control signals. In this context, a mechanical concept was developed that represents the structure of a respective mixer. In addition to this research on construction materials held in the controller. This work forms the basis for the further development of the control.

To promote the development of the AK-X even faster, since an entire team is engaged in the further development of the control. Four students devoted their joint 2014 semester work the mixer of the AK-X control.

In addition to the preparation of a detailed CAD model created impressive kinematic simulations of control mechanism. The design of the mechanical components carried with the aid of FEM simulation tools.

Next year, the entire mixer unit is constructed in a mock-up. For this purpose are rapid prototyping process for rapid manufacturing of components available.

Two team members devote themselves intensively to the development of components for power transmission in the wing. The focus is on innovative new materials and design principles.

Conventional gliders traditionally use mechanical components made of steel or aluminum. The disadvantage of these materials affects addition to the high density of the thermal behavior of the material from. The structure of modern gliders is constructed of glass and carbon fiber reinforced plastics. These have a very different temperature behavior as steel and aluminum, so it comes with temperature changes inevitably cause undesirable interactions. Unfortunately, such temperature changes during ascent and descent of an aircraft are unavoidable.

For this reason, the possibility of using carbon fiber rods combined with new management unit investigated with great effort. To this end, attempts are being prepared.

To develop the rudder control, the team is in frequent contact with engineers of SB13 (Akaflieg Braunschweig <http://www.akaflieg-braunschweig.de/prototypen/sb13/>, the unofficial predecessor of the AK-X.

The experience has, where possible, already use the destination proven design elements of SB13 in the AK-X.

Also in this section CAD-based models have already been created.

Next year, tests are initially planned with carbon fiber rods. After the completion of the detailed design is to begin with the construction of mock-ups. The aim is to construct the control and test.

Aerodynamic design

At the beginning must be a basic aerodynamic design, which determines the outer shape of the aircraft, with a predominant effect on the later flight performance and characteristics. In the draft Nurflügels pay attention to other things than in a conventional aircraft in the aerodynamic design of course.

Anticipation was determined that for our project only developing a rückgepfeilten Nurflügels (rear sweep only wing) with winglets comes into question, as other configurations, such as a Brettnurflügel (“plank”), a stronghold design or even a flying wing Vorgepfeilter (forward sweep, as the Akaflieg Berlin B-11) have for our application to serious disadvantages.

To get an overview at the start and to be able to draw on the experience already gained previous flying wing, such as the SB-13 and the Horten aircraft were initially analyzed. In this context, some simpler model aircraft were built in order to explore Basic Flight Mechanical Problems. Following this attempt was the problems that this turned out to dissolve and thereby create a first draft. Below a small insight into the design work should be given by the account of any major problems.

Bob(bing)

From the flight tests of the SB-13 is known to be a flying wing in flight can tilt through turbulent air to pitching. This phenomenon has been studied in more detail during the flight testing of the SB-13. It was found that these pitching is caused by an overreaction of the aircraft on malfunctions.

Each statically stable aircraft flying tries a failure of the flight path by an offset directed counter moment. Normally, the attenuation of the pitching motion now ensures that only the disturbance is compensated. In the SB-13 is a high static stability leads to a strong disturbance compensation ending moment.

In addition, the SB-13 has the missing elevator only weak damping of the pitching motion. Now these reasons there is an over-reaction of the aircraft to a disturbance which causes the above-mentioned pitching.

Since this vibration is very distracting for the pilot has to be avoided in the case of a new construction in any event.

After the above statements one can conclude that this vibration would not occur in reducing either the static stability or increases the pitch damping. Since the static stability at a flying wing can not be reduced without causing other disadvantages, it remains only to increase the pitch damping. This can be achieved by increasing the Rückpfeilung (rearward sweep) of the wing.

So it was calculated that one needs a Rückpfeilung the wings of about 25 ° to suppress the pitching. In comparison, the SB-13 had only one Rückpfeilung of 15 °.

Slow flight behavior

Both in the SB-13, as well as the Horten flying wings, showed that under certain influences the flying stability can be lost, the onset of stall.

In the literature, this situation is clearly explained to them by the Rückpfeilung (rearward sweep) the wing caused tends to flow to tear down first on the outer wing. Since the outer wing is through the Rückpfeilung behind the center of gravity means a stall there, a loss of lift behind the focus. This in turn causes a tail-heavy moment, whereby the flying wing rears, the onset of flow separation and thus the flow completely torn off and flight stability is lost. To avoid this effect, it is necessary that a stall has to be behind the focus on the outer wing necessarily prevented.

To achieve this the wings will receive a special, almost rectangular plan and the profile on the outer wing with negative angle (twist) to be installed.

This could be calculated that the flow first, tearing on the inner wing before the shear point. This then sets the opposite effect. The result is a top-heavy moment, the onset of stall, which leads to a Anstellwinkelverringerung (reduction in the angle of attack). Thus, a progression of stall can be prevented.

Longitudinal control

Nurflügel do not, like conventional airplanes via an elevator, which is housed in the tail, allowing control of the pitching motion. When flying wing control of the pitching motion by flaps (here “flaps” means control surfaces - ed.) must on the wing, which as far as possible from the center of gravity (= pivot) away are to be achieved.

Previously this was done by flaps on the outer wing, behind the center of gravity. If you now wish to fly more slowly, as a tail-heavy moment must be generated. This can be achieved by reducing the buoyancy behind the center of gravity, so the flaps must deflect up.

This lined up rudders are in slow flight unfavorable because it raises the profile generates less lift and higher resistance.

To reduce this effect, to be attached to the inside wing of focus in our design additional elevators are. These have exactly the opposite effect and thus devalue the disadvantages of the proposed elevator.

Aileron response

Some of the planes showed almost no reaction to a predetermined aileron: The flight tests with the simple models at the beginning of an effect, which in previous flying wings, to our knowledge, not yet made its appearance showed.

After extensive literature review and salaried recalculations following facts emerged: An aileron deflection produces the so-called adverse yaw, which ensures that the flying wing in the “wrong” direction rotates around the vertical axis.

Due to the low side of a stability Nurflügels creates a sideslip state with a large angle of sideslip. Now a wing with sweep and dihedral has an additional sliding roll moment. This produces, as the name implies, at a sideslip condition, a rolling moment. The roll moment thus generated acts contrary to the original by the ailerons, thereby increasing the effective aileron response is significantly reduced.

Recalculations showed that the models partially oppose to the rolling moment was even larger than the original, which explained why this part does not respond to aileron.

To prevent this effect, one can only try to minimize the shift roll moment, because you can not reduce easily the adverse yaw with a flying wing.

As mentioned above, the shift roll moment of the V-shape (dihedral) and the V-shape of the blade depends. Since you can not reduce the sweep, there remains only the reduction of the V-shape. The design calculations showed that exists in a V-shape of less than 2 ° yet sufficiently effective aileron effect.

Ground clearance outer wing

Use the arrow shape of the wings, this clearly droop at high angles of attack. This is especially when landing unfavorable, since they would then first side touching the ground and that could result in a rotational movement, which endangers the directional stability.

One could, to prevent this, reduce the sweep or increase the V-shape of the wings, which the above mentioned reasons can not be reviewed.

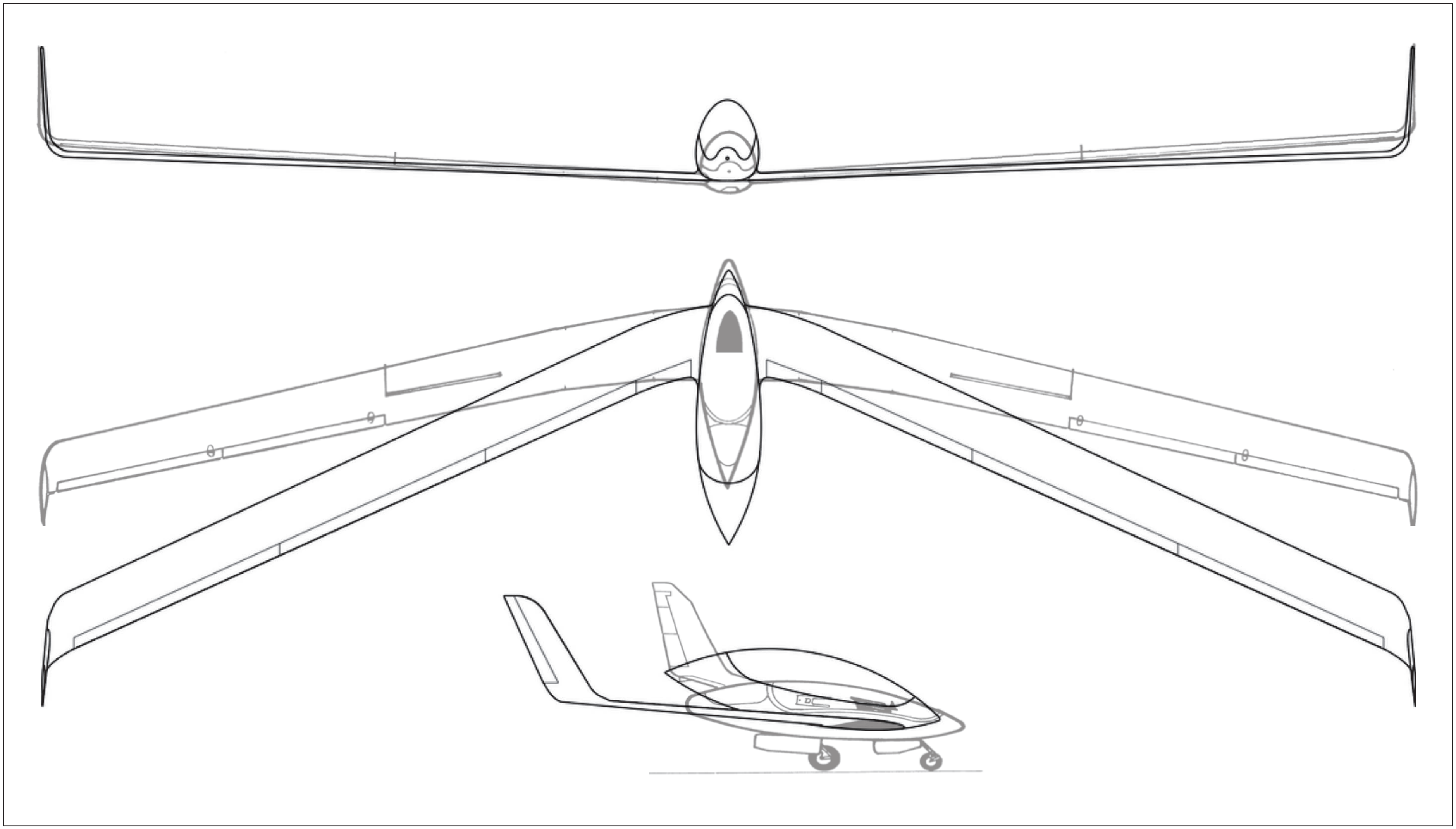
Thus, only the angle of attack on landing remains smaller. This will be achieved through the use of flaps in our design. Flaps are at low speeds down to worn flaps which upon landing enable the buoyancy of the profile thus increasing smaller angle — the invoices showed that with a special damper position for the landing approach only one angle of 3 ° is required to intercept. Suffice it therefore to ensure sufficient ground clearance of the outer wing.

Lateral control

Finally it should be mentioned that the lateral stability is to be achieved in our design by particularly large winglets, as with the SB-13. This has the advantage that the winglets offer little resistance especially at low speeds and assure laterally stability in flight. To control the lateral movement and flaps are attached to these winglets, which act like a normal rudder.

In summary, results of preliminary shown above for a flying wing with 25 ° Rückpfeilung to prevent the “rockers”, the almost rectangular wing plan form for a good-natured stall characteristics and the 2 ° V-shape, which allow even sufficient aileron response. The longitudinal control is resistance optimal with one flap on the inner and outer wing and there are additionally used flaps which exclude a ground contact of the outer wing during landing.

Looking ahead, we would like to mention that still need to be done further investigation until the final draft is. For example, it is still uncertain how much of the mid-mounted wing fuselage affects the aerodynamics. This will probably adversely affect the lift of the wing and thus also affect the torque balance of Nurflügels. Since it can not experience calculate bad this effect, we rely here on measured values of model flight tests.



3-view of Akaflieg Karlsruhe AK-X (c. 2015) over 3-view of Akaflieg Braunschweig SB-13 (c. 1988).

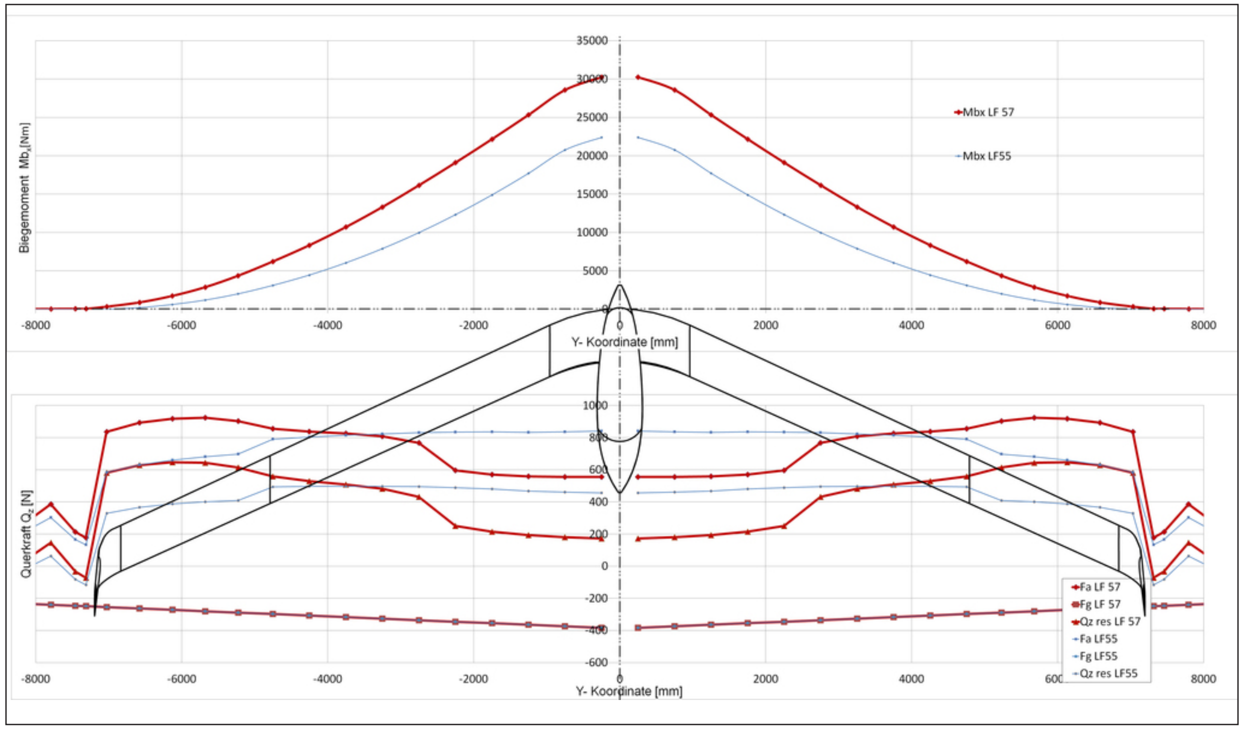
Structural Interpretation

In addition to the aerodynamic design we worked also strengthened with the structural design of the airfoil. Basically it can be said that the design of AK-X due to the particular geometry wing special demands are placed on the structure. Besides the usual detected load cases covering the expected in flight loads due to gusts and interceptions, among other things, it is expected that the interpretation with respect to the strength of the wing flutter will shape the structure design significantly.

Outlook In the future, modern design for the structure computerized calculation and optimization methods are used. First, however, a designed and manually recalcutade preliminary is needed. Based on this draft calculation models to be created, which can reflect the complex laminate construction. In addition, various configurations to be compared, in order to explore the optimal structure design with the given boundary conditions.

Design load

At the beginning of work on the structure design a series of load cases was based on the JAR-22 defines and determines the unbearable under these conditions loads. The observations have been limited to the interception and gusts load cases, since on one hand the maximum loads to be expected. On the other hand the current state of the interpretation is not all load cases required by JAR-22 are comprehensively dealt with, since not all the parameters necessary for this have been set.



Qz & Mbx LF55 vs.LF57

Because of the control system used by the aircraft lateral axis (elevator) incurred particularly high bending moments in our design. This is because while pressing the elevator occur on the outer wings increased by the flap value buoyancy forces that have a large impact on the resulting bending moment by its large lever arm to the wing root.

This situation is clearly shown in the picture Qz & Mbx LF55 vs.LF57.

In the lower part of the image, the transverse forces in the Z direction (by mass, floating and resultant forces) and in the upper region are plotted the resulting bending moments Mbx for the two load cases. Both load cases make the flying into a vertical, upward gust speed 15 m / s. Also the mass configuration in both load cases is identical. It corresponds to the maximum mass of not wearing parts.

This means the body is loaded maximum and no water ballast is housed in the wing. By different flap position, however, results in a different distribution of lift. In LF 57 (pressed down elevator), the forces on the outer wings are higher and therefore the bending moments shown in the top graph, significantly larger.

CAE

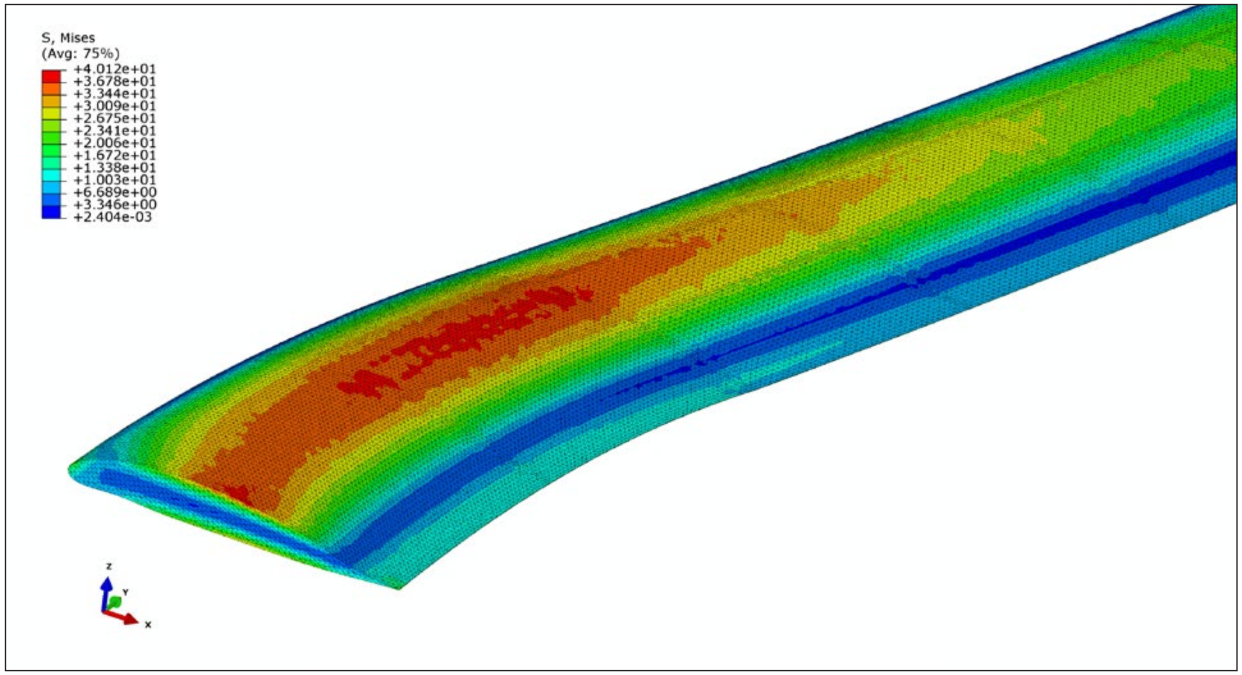
In a study at the Institute of Product Development (IPEK) was investigated in addition to the loads already described, how to modern finite element method applied in the design of gliders. During this work, a method has been developed which makes it possible to represent the forces acting air as pressure distribution over the surface of the airfoil.

Using this method, and the wing geometry of the aerodynamic design, a simulation model was created, which can reflect the loads acting a particular load case.

Based on this simulation model, a topological optimization was conducted in order to gain first evidence of a structure draft.

First results are already available, the parameters of the calculation, however, must be adjusted in order to verify and refine these results.

The figure Simulation Result shows the equivalent stress profile during the calculation model in the wing root.



Simulation Result

It was first simulated isotropic solid material to validate the method for calculating the pressure loads and to check the plausibility of the results.

Test Model 1: 3.75

Before we begin with the construction of the prototype, we have decided, with remote-controlled model aircraft to check our design and optimize. This will be tested in particular the following:

Slow flight behavior

As explained in the "aerodynamic design" section, slow flight behavior must be considered as flying wings tend to lose flight stability during stall. Full stall speed and spin attempts (Spin is an undesirable flight condition, which can occur during stall, while the airplane will turn quickly to themselves and fall uncontrolled.) should therefore show that our design has a good-natured slow flight behavior.

Controllability and turning flight behavior

These will be checked and the fine flap fittings if necessary adjusted to assure

Model with 4m span built in our workshop

the authority of the rudder. Furthermore, it is checked whether the testing model has sufficient aileron effect and the sufficient lateral stability of the winglets.

Fuselage influence

The fuselage, which can accommodate the pilot in the prototype, affects the buoyancy in the wing center. Now that the wing center is located in front of the center of gravity, this results in a nose-down moment (less lift before the center of gravity). This ensures that the flying wing has a higher speed flying, as provided in the interpretation. This influence can be due to the 3D flow, difficult to calculate accurately or with great effort. Therefore, this is measured by the model aircraft.

Neutral point measurement

The neutral point is an important point for the determination of the flight stability. In the model the position of the neutral point is to be measured in order to verify the calculated position.

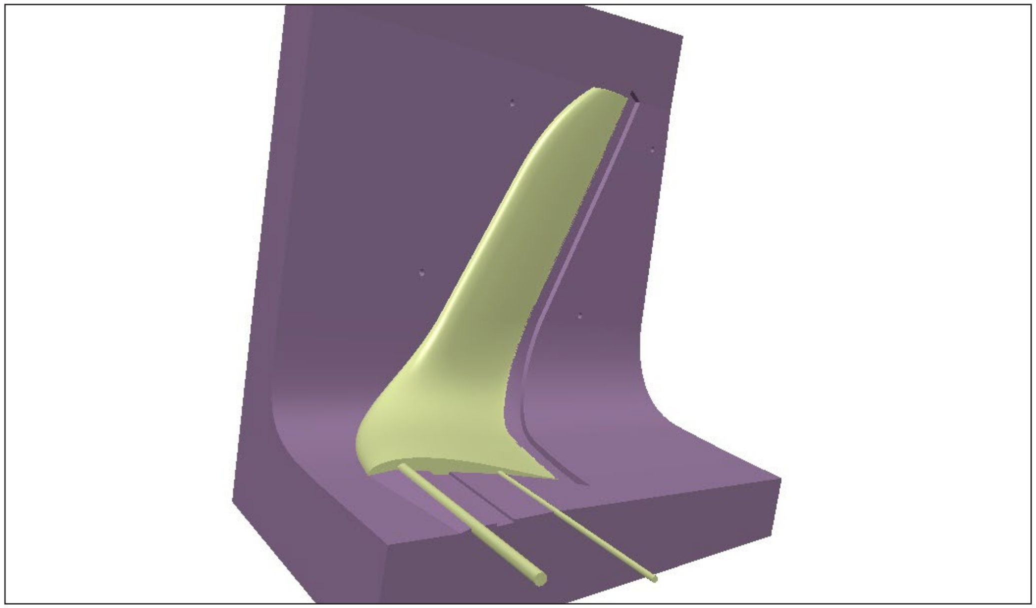
Ground start attempts

See also “aerodynamic design.” It has been shown that a particular flap setting for take off and landing is necessary to stand out with a sufficiently small attitude angle. This is important for the clearance of the outer wing of the swept Nurflügels.

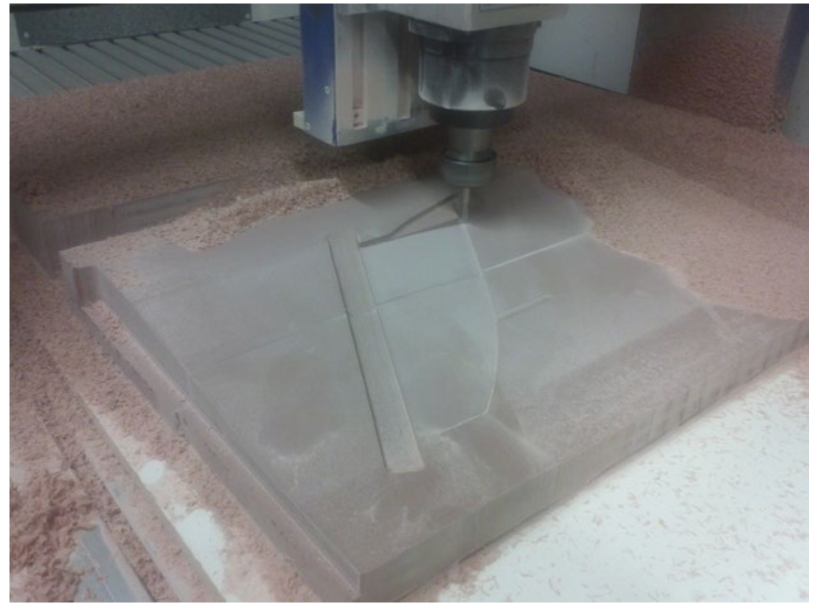
Starts and landings with a “to scale” suspension should show whether the calculations are accurate and no problems can occur during the landing.

First, we have to chose a model aircraft with wingspan 4m, a scale of 1: 3.75 corresponding to the build. The given geometry was scaled. New profiles were made specifically for the model. It was in this case ensured that the profiles have comparable properties, such as laid down for the prototypes.

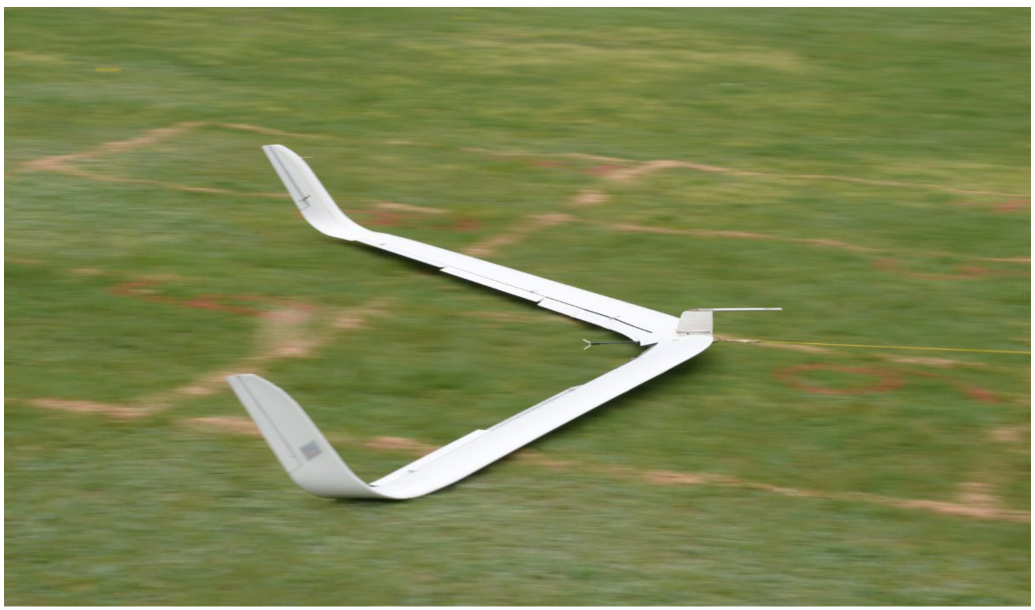
In order to obtain sufficiently precise results of this test, the models, as well as the prototype later, are created from milled shapes constructed in CFRP. For this, a CAD model was created and then the forms and thus the milling codes were derived.



Winglet in virtual shape



Winglet mold being milled



Already for the testing model with 4m span a retractable landing gear is constructed, it is necessary to test the takeoffs and landings flying behavior. It must be particularly ensured that on the ground the wing is at the same angle of attack as the prototype.

Flight testing model 1: 3.75

The following presented tasks have already been completed with the test model:

At the start of flight testing the reaction of the test model to the various control surfaces has been tested in several flights. It was found that the model responded as desired, and the aileron response is sufficiently available. As the model was first flown without the fuselage, the lateral stability still had to later be specially investigated because the body is highly unstable with its side surface prior to focus.

1: 3.75 model in a left turn during a test flight.

Paint is used to determine the airflow over the wing-winglet junction

Next was begun to investigate the slow flight behavior of the test model. For this stall tests was systematically carried out in level and turning flight at different centers of gravity.

Results revealed not quite the desired good-natured behavior and testing to determine the cause was carried out. Among other things, paint images of the so-called winglets were made. Here, a special paint is applied before the flight. This then passes through the flow of air. Thus, the flow around can be made visible and can be seen, for example, regions of separated flow.

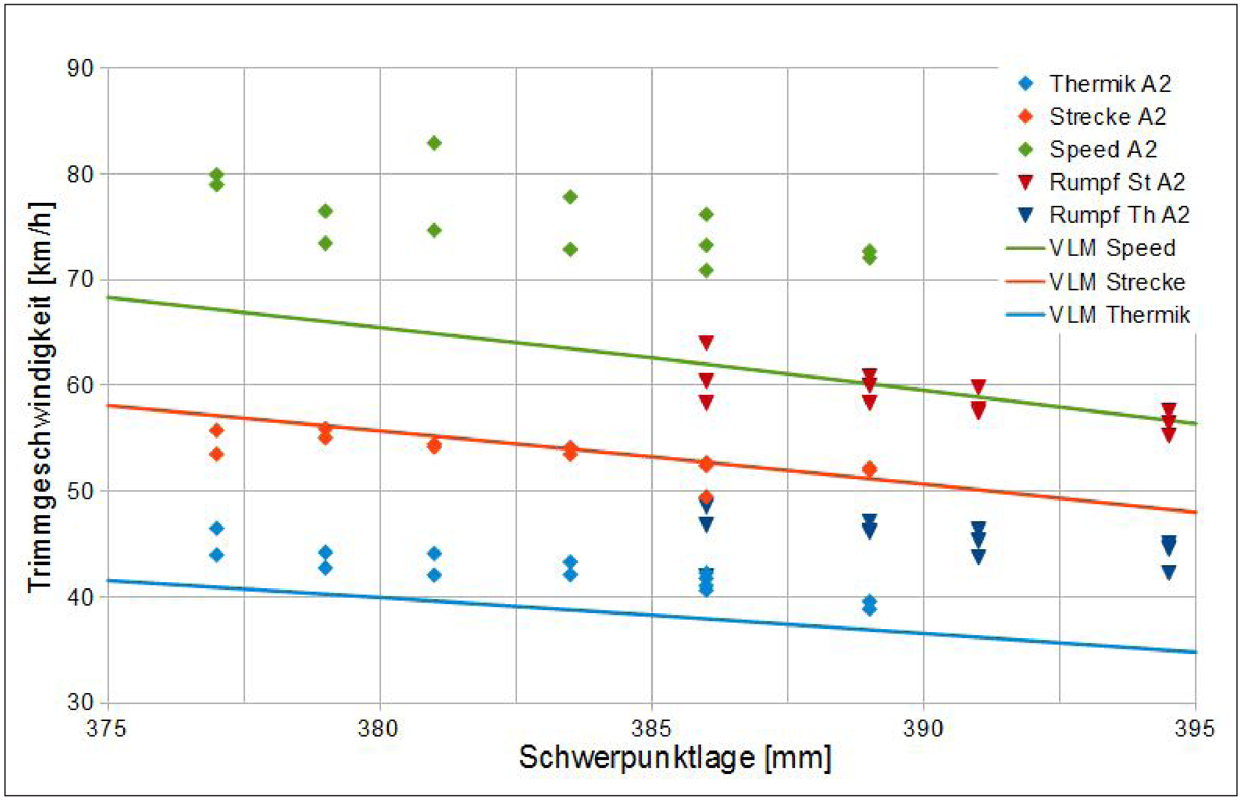
It has been found that the transition region between wing and winglet is prone to early flow separation. For this reason, currently new winglets are built with a different interpretation.

The most expensive item in the flight testing of the test model has been the measurement of the fuselage influence.

As already explained, the body produces a nose-down moment which changes the trim speeds for given flap positions. It is very important for optimal flight performance, knowing this moment for the design of the prototype, so the flap settings and the optimal airspeed can be matched without additional control surface trim. This would in fact create additional resistance.

It was in so doing, that the model was first flown without the fuselage to determine the trim speeds of the pure wing. Given at various centers of gravity, the speed of the three exemplary flap settings were measured with a series of flights each. The same was then repeated with the built fuselage installed. It was found that the nose-down moment of the hull is not as big as feared, and the trim speeds increase by only about 15% compared with the pure wings.

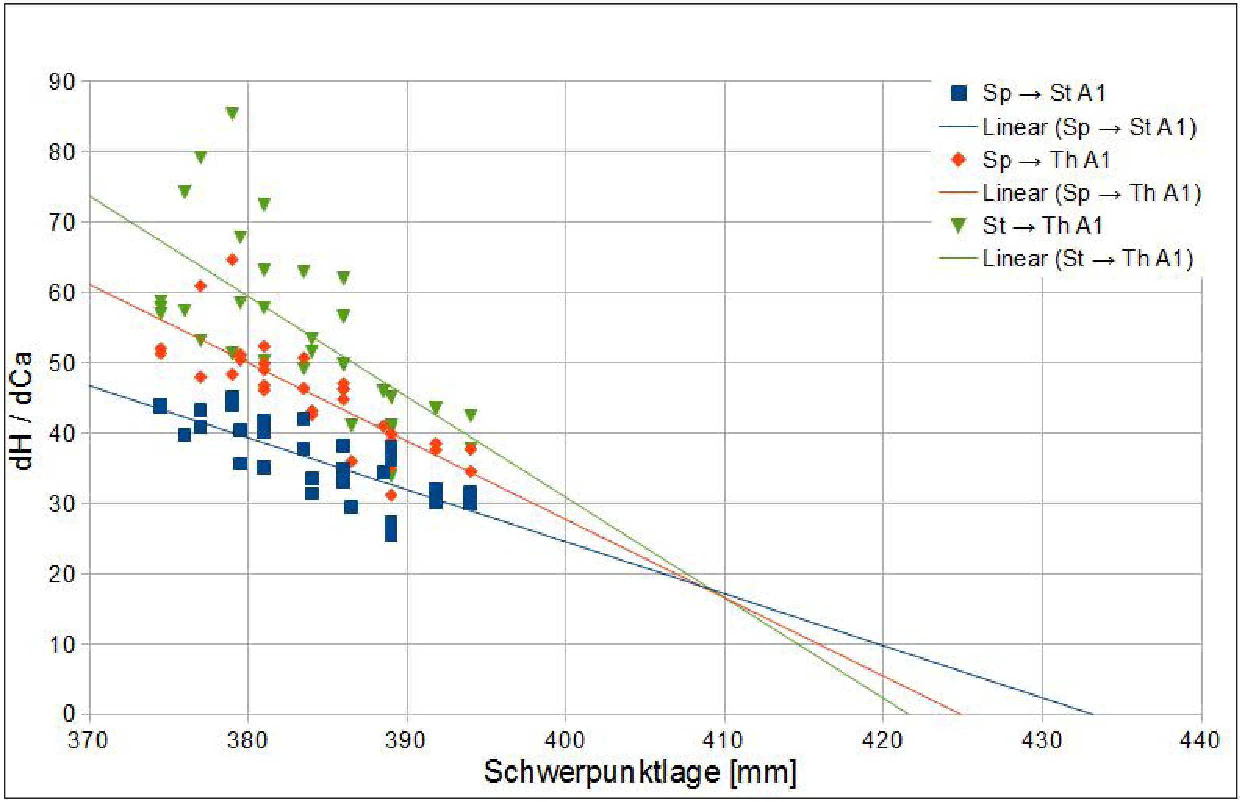
In the following diagram “thermals,” “distance” and “speed” are respectively the designations for the various flap settings.



Trim speeds of the various flap settings applied through the center of gravity

The trails in the brighter colors represent the measured values without fuselage. The triangles in the darker color filters the measured values with the fuselage. The solid lines represent the calculated values.

As explained above, the exact position of the neutral point is important for calculation of stability. In principle, the neutral point of the measurement flights was evaluated for fuselage impact by addition of measured flap deflection. One can read the neutral point position from a chart when plotting the change in the Ca-out about the center of gravity as related to the Delta of the control surface deflections. (The Ca value is a normalized value of the wing lift and can be calculated from the airspeed and some other variables.) The neutral point to read now from the point of intersection between the linear



Neutral point measurement

interpolation of the measured values and the x-axis. Here, then, the neutral point is between 422mm and 433mm behind the reference point. This correlates well with the calculated neutral point of 435mm behind the reference point. The routes, triangles and squares represent the measured values, and the thin lines the linear interpolation.

Construction of test model 1: 2

Testing model 1: 2 emerged

Within a year, the 1: 2 model was with us in the workshop. The model was built to hide details, such as the rudder control by servos, analogous to a manned prototype. This ensures a good agreement with the original design for the structural testing and allows testing of the design.

The following is an insight into the construction to be given based on selected images:

After the design in CAD all started in spring 2014 with the milling of negative molds. As with the 1: 4 model, Ureol was used as material as it is optimal for this purpose.

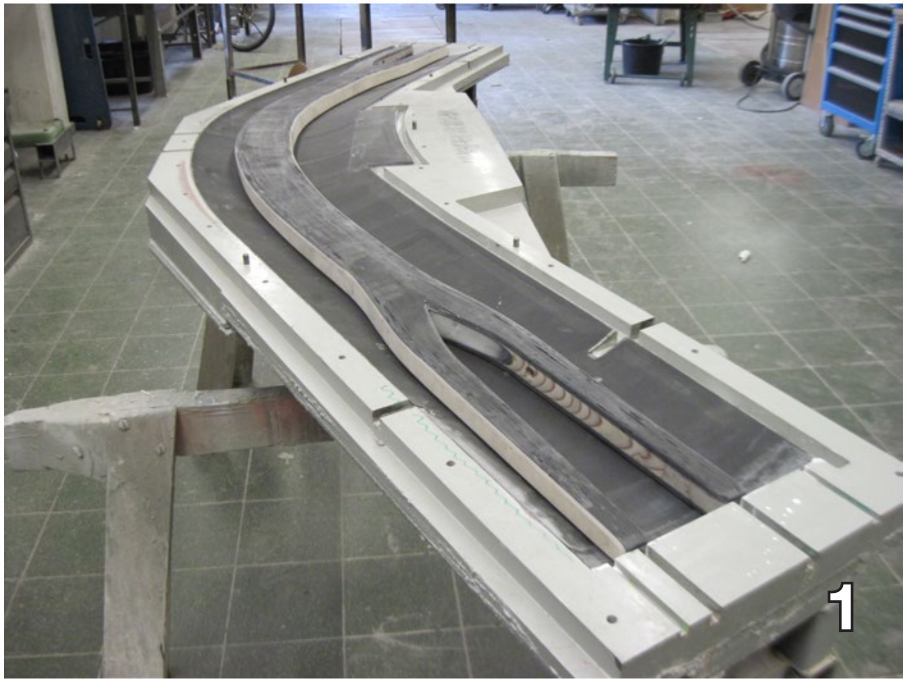
For stiffening of the molds they have been glued on a specially designed steel substructure.

In the next step, the molds were treated with a release wax, so that the wings also could be demoulded later. In addition, wax sheets were bonded at certain locations to form an indentation in the subsequent component. This is used to sink reinforcement plies which are placed after the removal to the leading edge to reinforce the fuselage attachment.

For larger laminations it is very important to prepare everything well as by the limited pot life of the resin, it can quickly become very stressful else.

The wing shells are to be able to accommodate inserted ±45 ° fiber orientation to resist torsional forces.

Heavily loaded sites, like in the middle section of the wing at the wing fuselage connection, unidirectional carbon fiber strips are incorporated into the laminate. This transfers the forces of the body connecting bolt into the spar.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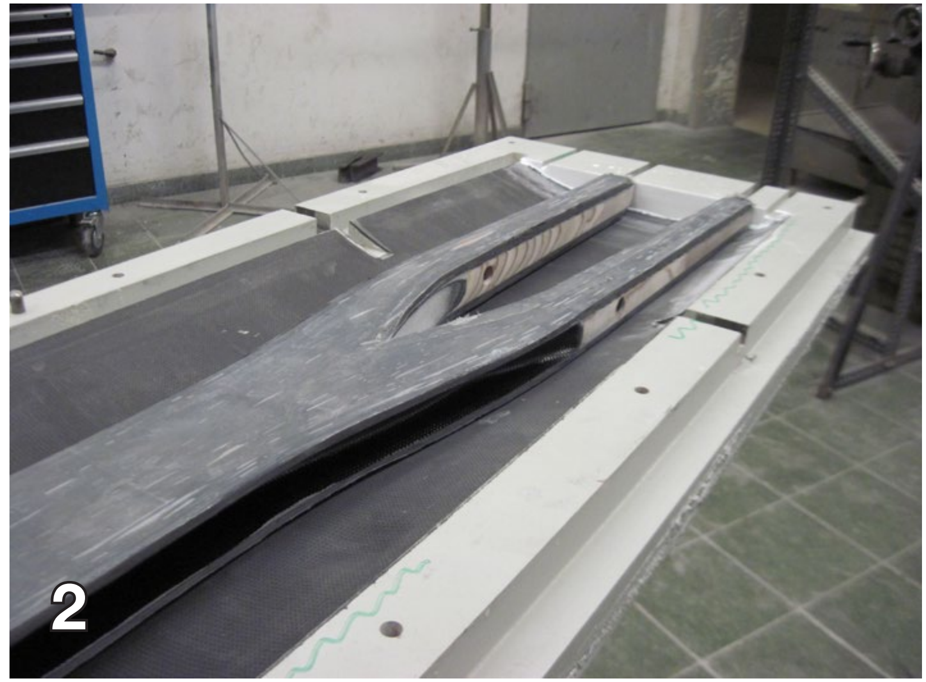

2


3


4

The finished 1: 2 model

Opposite:

1. The curved center section spar

2. Center section spar fork detail

3. Outer wing panel spar bars

4. Winglet molds

During resin curing, the laminate is compressed by vacuum. For this, a special peel ply is placed on the laminate which can be removed after the cure. This is followed by a soft material so the pressure is evenly distributed and finally by an airtight membrane.

In parallel to the wing building, the winglets had to be manufactured. These were also prepared in milled negative molds. However, not so expensive, only with a supporting shell with only a web without spar or support material.

The 1: 2 test model is ready to fly!

Adventures in 3D Printing

Brian Ford, bananaman@bigpond.com

Why is this article in a magazine about R/C soaring? What relevance do consumer 3D printers have to the reader?

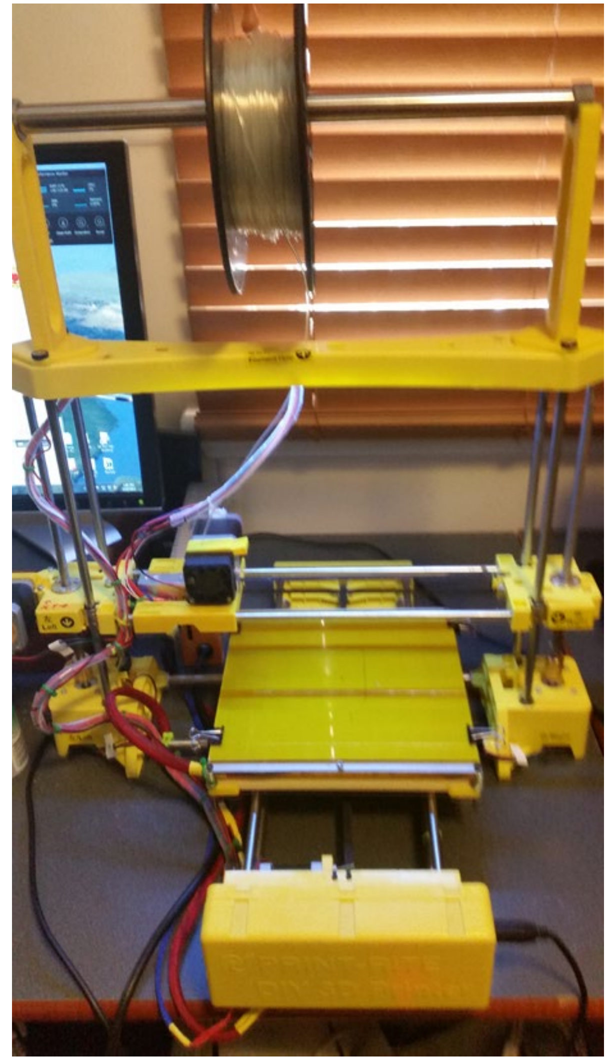
First, my background. I like flight of all kinds and machines; my career is based around both and so is my free time. I'm also interested in learning the allied skills we use to fully explore this great hobby/sport of ours. When I'm not flying I like to build and use some of those skills with lathes and mills. I made my own F3B winches, I like computer tech, 3D modelling and CNC routing, so it may have been inevitable that when I first heard about 3D printers, one might one day find its way into my workshop.

However, I couldn't justify the time to learn and cost for a result I couldn't really define, and wondered if it was just a fad gadget.

Along came some orthopaedic surgery that put me out of action and immobile for many months. My workshop was placed off limits. Now you can only watch so many movies and read so many books. So I revisited 3D printers, if I should I get one and how I could utilise one effectively.

I decided to learn the new skills needed and brush up on my amateur CAD abilities. Research took a few weeks and my home office was converted into a small work area before I went in for surgery. It would become my recovery area.

My first printer was a relatively cheap unit that luckily served me well initially, but ended up extensively modified and it has now been replaced by two larger and more precise machines.



Budget Print-Rite DIY3D printer

So… the first tip is to do very good research before you buy anything. This article should help you make a better decision by listing some questions to consider.

What are they?

Basically FFF (Fused Filament Fabrication - the open source terminology) or FDM (Fused Deposition Modelling – trademarked) extrude hot plastic.

There are variations that do ceramics, even sugar paste. The technology was invented in the late 80s in the US with Stratasys taking the commercial path. The many variations of consumer printers have their roots beginning with the RepRap project in the UK in 2005. Simply, it's a machine that lays down lines of a heated material to build an object representing a 3D drawing.

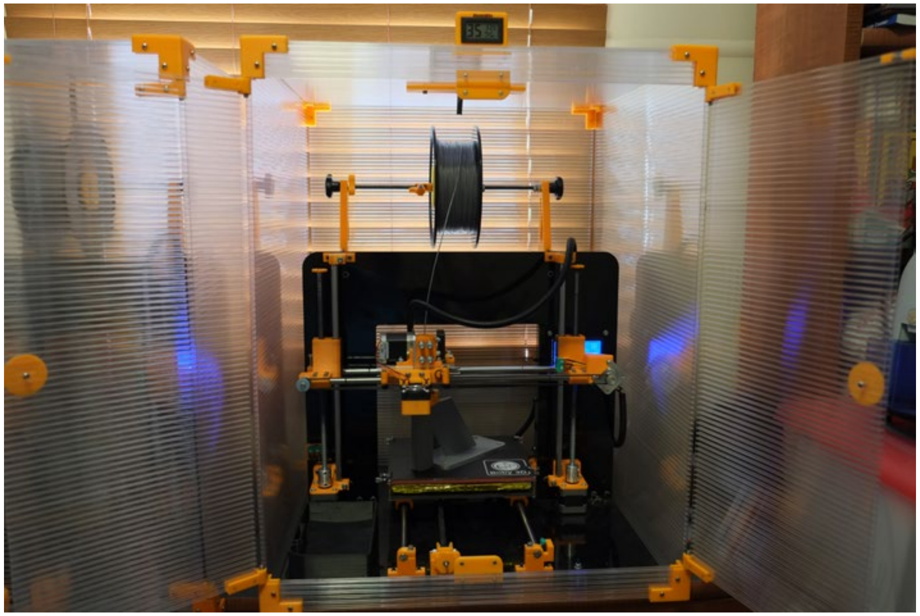
What are you going to do with it?

Really, what do you need it for? The hype? Keeping up with your buddies? The medium used to manufacture is plastic. It is far from the best structural material for a high performance sailplane wing, but it is very good for making accessories like cockpit detail in scale models and some servo mounts for example.

Used the right way it can make you a nice flying model, but existing construction methods are better options for larger models at this time.

Do you like to tinker?

If you can't say yes to that last one then wait a few more years for the technology to evolve. What do I mean by tinker? You can go two paths for the machine itself. Buy one ready-made or build a kit. Both will still need some hands-on time to get nice consistent prints. However, expect the kit machine to take a bit longer to produce a good result. In all cases it is vital the machine is true, square, has slop minimised and is rigid enough to give good precise prints. Printing small test pieces might lull



Mendel90 Dibond

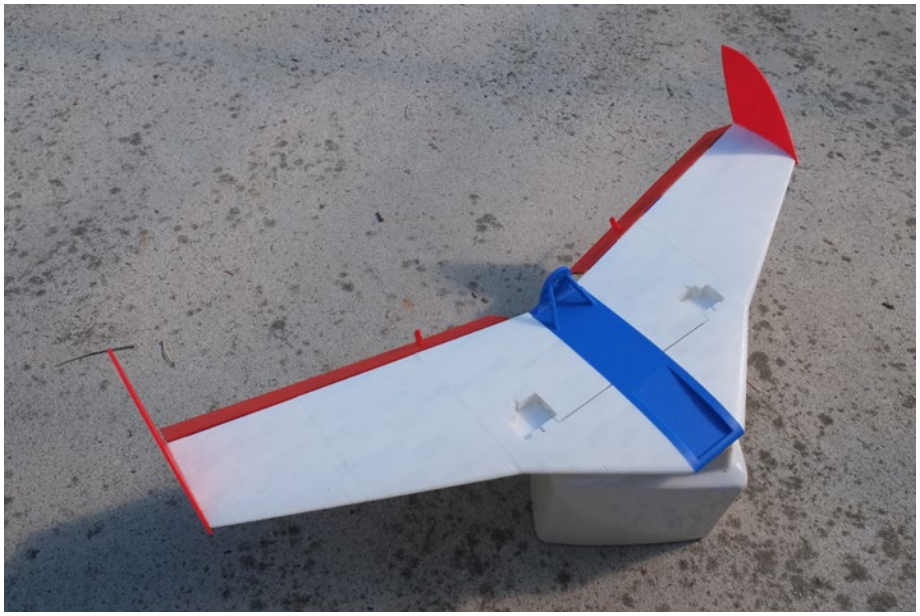
you into thinking all is good but as you print larger objects, poor rigidity and untrue, inaccurate frames will affect the print quality.

What materials can you use?

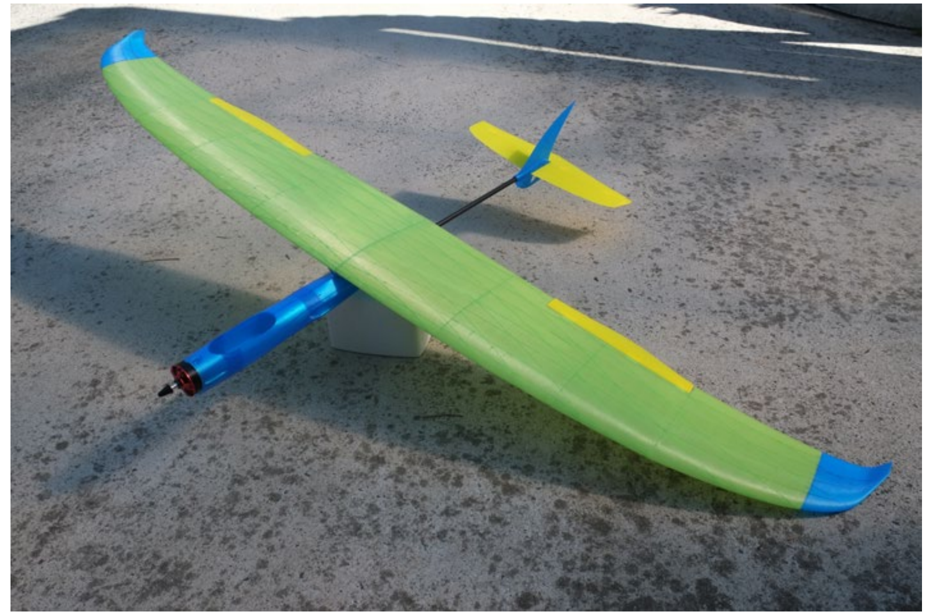
The filaments are in 1.75mm or 3mm diameter. 1.75mm is taking over as the more popular filament size. Filament mostly comes in 500g or 1kg spools. The common ones (in order of difficulty to use) are:

• PLA (Polylactic Acid): somewhat biodegradable and smells like burnt waffles when printing. Easy to use, warp resistant, strong but brittle and will go soft at 60degC. Many colours.

• ABS (Acrylonitrile butadiene styrene): strong pungent smell when printing, so need to ventilate. Tough, fairly easy to use, but will warp when printing larger pieces. Doesn't soften until 110degC. Needs special care in humid environments. Needs a heated build bed. Many colours.



Tau flying wing



EasyMax001

• Nylon: almost no smell, flexible, harder to print as layer bonding can be a problem. I have successfully used F3B winch line to print small items. However, it was a smaller diameter than normal - 1.35 instead of 1.75 - and luckily my machine's extruder could handle it.

There are some other materials, but PLA and ABS are the usual ones to start with.

What skills do I need?

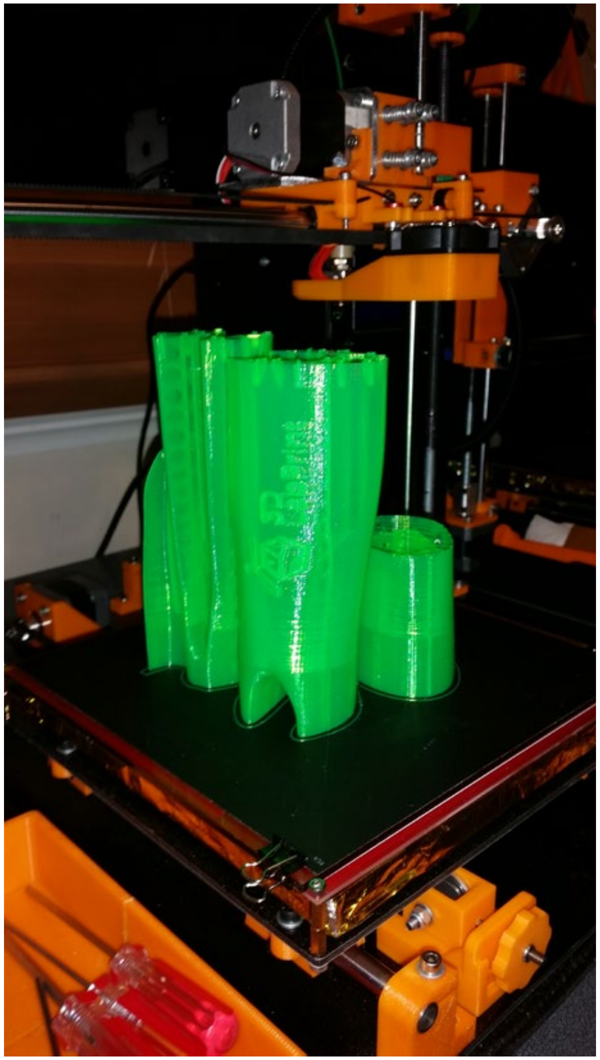
The learning curve can be steep. To be proficient and to justify getting one to support your workshop, you need to be able to drive a computer well and learn a few related programs. Being able to draw with CAD is desired and in reality you won't get the most value out of the printer unless you can use a CAD program.

You must be happy to tinker. There are some basic processes that need to become second nature so you can print consistently well.

You will need to be patient.

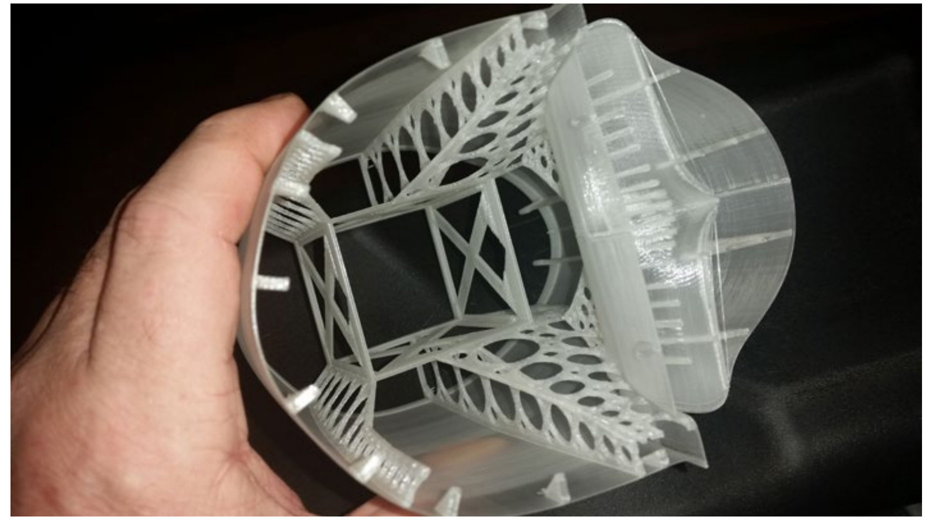
What software is required?

You should get a CAD program. While many are available, Fusion and Sketchup are free, aren't too difficult to learn, work well and have various add-ons to help you to generate the .stl files needed. You'll need a "slicer" program and perhaps a printer controller. A "slicer" like Slic3r or Cura cut the drawn object into horizontal layers and apply the build and support processes you define into the g-code the machine can use. A controller is the interface between the computer and the machine and lets you manually control the printer. Some



Electric sailplane fuselage nested print

Fuselage structure detail



printers run off USB, some can quite easily run as standalone units using a SD card.

In some cases these are combined into one, like Simplify3D (paid) and Repetier (free). There are others out there – look around and ask questions to get software that suits your needs and pocket.

Can I get ready made files?

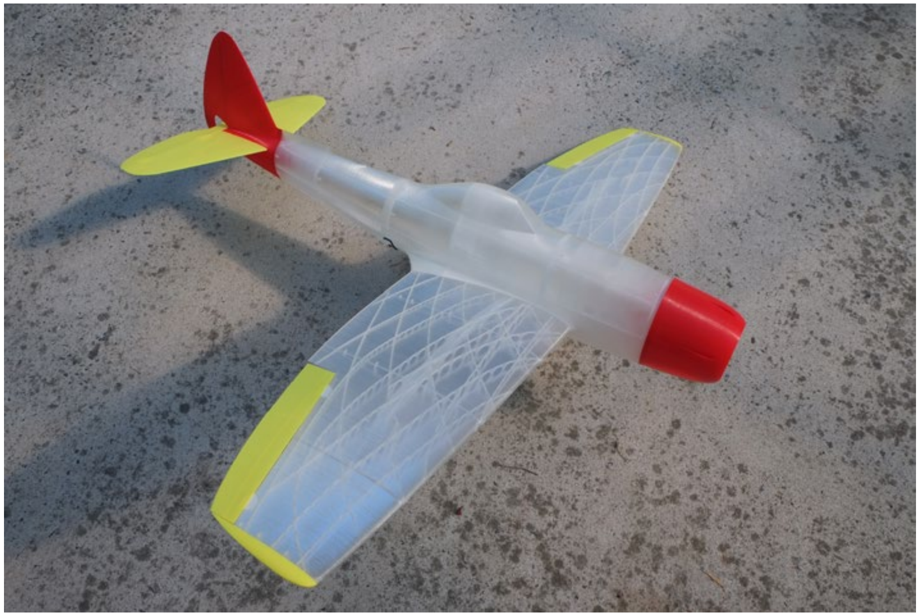
Yes you can. You can also purchase .stl files or go online to Thingiverse or Yeggi where they have large free libraries of files. There are conditions to use. You could spend a year making egg cups alone. Luckily some modellers publish their work for all of us.

Important point! 3D object files may look OK from the outside and be fine for other CNC work where material is taken away to get to the final product. HOWEVER, 3D printing is additive so the CAD model must be good BOTH inside and out and be "manifold." That basically means it would be waterproof, so no holes between the inside and outside of the "shell." Some free files may not be "manifold" and cause problems. There are some programs that can fix these to make them printable if the issues aren't too great.

There are large online communities out there that are very helpful for almost every flavour of software. These communities are a valuable resource.

What type of printers are there?

The printers we are discussing lay down molten plastic from an extruder. There



P-47N structure

P-47N nose

are also resin printers and laser sintering printers too. These last two types are more commercial and are expensive. Of the filament style printers there are "open source" and proprietary designs, either as kits or prebuilt. To complicate things more, there are sub groups of Delta printers (fastest, have swinging arms) and Cartesian (open frame and box style are more common) printers. Each has pros and cons, research this well so you don't end up with an expensive paper weight on the desk.

What bed size do you need?

A common size now is around 200x200x200mm. To go much smaller than this limits you to smaller pieces. Around this size is a good place to start. There are larger ones out there, but larger objects take longer to print and aren't really needed unless you want to print dishes, vases and sculptures. It is certainly possible to join sections together and to nest them on the bed during the build. This gets around the smallish build volume limitation to an extent and is used very effectively to build larger items.

Some machines have heated beds, why?

If you are only going to print with PLA and print small items you can do without a heated bed. However, it is advisable to get one for other filaments, particularly ABS. The heated bed significantly reduces warping and corners lifting due to shrinkage as the layers cool.

How long does it take?

A fairly standard layer height is 0.2mm, so five passes per mm. Nozzles are mostly around 0.3 to 0.5mm wide. If you need a thicker wall and lots of infill

Monitor mount

it adds to the build time. A hi-resolution print at 0.1mm layer height will take twice as long.

A small object like a chess piece might take less than an hour, a large one like a vase, 12 or more. It's slow! The P-47N model in the picture took 12 sessions over 5 days.

What are the limitations?

Patience, skill level and imagination come to mind! An item like a scale glider joystick printed vertically will be difficult to print and be easily broken. A flat instrument panel would be easy. A set of wheel pants for a tug will need support material printed as well. This can affect the finish, so some rework may be required. The strength of a part is also dependant on how well it prints. If you haven't got good layer bonding the item may look fine but be too fragile for use.

While there are multi color printers, they often have a smaller build volume and require a lot of tweaking to get a satisfactory result. So one color is the most common.

What would it cost to set up?

A reasonably sized kit printer could be had for less than USD300.00 and using free software you would pay only for filament. A prebuilt printer could be from $500.00 to $3000.00. If you buy a CAD program it could be hundreds of dollars. Other software can be in the hundreds. As mentioned before, there are a lot of good free ones to try first.

Ongoing costs?

Good filament costs around $20.00 to $35.00, but can be up to $90.00 per kilogram depending on the type and brand. It is worth shopping around. Just be aware that cheap filament is cheap for a reason. For reliability and decreased frustration you need consistent diameter, no inclusions or voids, no oily residues from manufacture, and the filament should come vacuum packed with desiccant.

Spares may be needed as 3D printers are machines that move a lot, so belts and bearings can wear and nozzles can clog. Components do fail. Mostly they are readily available, can be changed by the user and aren't too expensive. Any printed parts can be reprinted.

The wattage depends on the printer, but 20W to 50W per unit is common so this is a cost if used often.

How safe are these things?

The heated beds commonly run up to 110 C°, the extruder nozzles up to 250 C°. Some house fires have been proven to have been caused by a 3D printer. To counter the risk, firmware developers have made some changes like thermal runaway of the extruder and shut down power. However, be safe, don't leave them unattended. Have an extinguisher handy. Avoid printing overnight while sleeping. Keep the machine clean and clear of flammable material. Keep the room it is in well ventilated.

I have had some minor finger burns while removing crud from my extruder nozzle. Plus I have cut myself getting stuck objects off the build bed.

The future?

Truly reliable single action printers are not quite there yet. Multi-color print heads are in development. New materials for filament are being tested. Higher print speeds will be possible soon enough. Given time they will be very handy and reliable tools with a massive library of files to print - whatever someone's imagination has come up with. For an interesting read search for the history of consumer 3D printing.

So how can I use one for RC modelling? Can I print a sailplane?

Yes you can. 3DLabprint offers files for various models including a basic 1.5m sailplane. I have printed them all and they aren't too heavy, look good and fly fine if printed correctly. If you bingle it you can just print another part.

I have printed a monitor mount for my Jeti radio that is small and strong. You can print servo trays for F3X models, camera and servo mounts for tow planes, hatches and covers.

Has it been worthwhile, these six intensive months of 3D printing?

Yes, I've made a lot of mistakes and learnt a lot. I can now produce objects I can use. I must be hooked because I now have three active printers making everything from RC airplanes, trinkets for family, to products for full size aviation research.

There is a lot more I could put in this article. Depending on feedback from readers, maybe I'll write a part two about setup, finishing and some basics to help avoid bad prints.

Tom's Tips

A simple glue holder

Tom Broeski, T&G Innovations LLC, tom@adesigner.com

It seems that it takes a long time for the glue to get to the end of the bottle once it gets below half full — especially when it's cold.

I've dealt with this for years and used to just stand and wait.

I figured I'd share what I finally came up with that works great and saves a lot of time waiting for glue to get to the nozzle.

I just took a scrap block of wood and drilled some holes in it. This was a really well used scrap.

I ended up with a cup holder, a place for sticks, and places to keep glues pointed down for ready use. For a photo of this specific holder with items in place, see the next page.

These glue holders are really very handy if you are a builder.

Another "glue holder" filled with all of the items necessary for a bit of composite construction.

I have a couple different "glue holders" around the shop, all made from scrap.

Design your own and make building easier — or just a bit faster.

Note: Make sure your glue tops are on tight. I don't store glue this way. I just use it when I'm working on something.

In the next issue...

Using XFLR5 version 6 and learning a lot

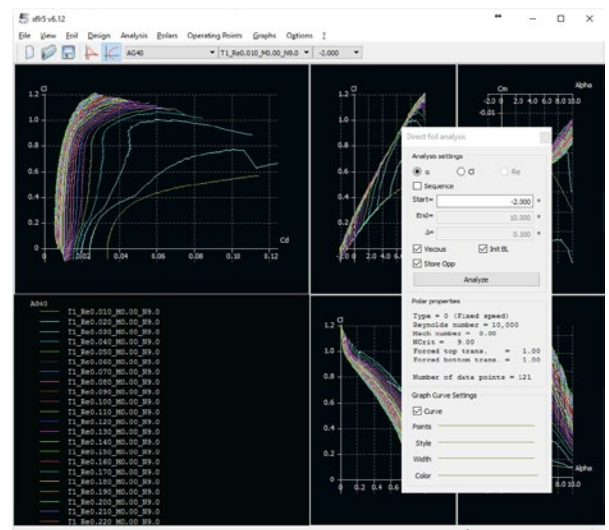
XFLR is a very powerful tool for RC glider design, but it comes with a hefty learning curve that is exasperated by crashes when the data you enter hit boundary conditions.

But once you learn how to run it and interpret the results it is an invaluable tool.

In this article I will start with a simple tutorial that hopefully will get you through the learning curve quickly.

After that I will show you some of the useful insights you may gain from its use.

— Anker Berg-Sonne



ALES

the letters
the Class name
the switch choices

Gordy Stahl, gordysoar@aol.com

We are all using ALES switches and it's also interesting that there are so few choices in them these days. There are three that I am aware of. The Cam, the Altitude Permit, and the Altis4.

So I thought it would be interesting to all of you to take a look at the choices, since we can't fly North of Florida due to the cold temps (well maybe in Denver, too).

"ALES" never was an actual acronym! (There are no dots after each letter.) It's ironic the letters don't actually represent anything that applies to the event or the launch. ALES is "Altitude Limited Electric Sailplane."

At the time the "class" was created apparently the glee of the idea got in the way of the founders' actual thinking about the name or its format.

Let's take a quick look at the name, then take a few seconds to let your brain come on line.

First off, Altitude Limited - Except for in the dreams of FAA Reps, the class has no "altitude limit." Neither ALES nor F5J has an altitude limit, so pilots can fly as high as they can see.

Second, "Electric Sailplane" - The fact that there is a battery inside the model to run the control system or the launch motor, Electric Sailplane doesn't mean anything, so that fact describes nothing about the event or the model of value to either.

Third, the class does not include Electric Powered Sailplanes. If the model is "powered" then the flight score for that round is Zero.

ALES, the "Event"

Saddled with that weird four letter name, it is in fact a Thermal Duration RC Sailplane Class in which the Task Start Altitude is gained not by throwing, not by bungee or winch, not by man-towing, but via an electric motor with propeller. (Hence the descriptor: E-launch RC sailplane.)

What is ALES Class really?

So, in fact, ALES is a contest class where RC thermal sailplanes (fitted with an electric motor and propeller) are launched to a uniform, predetermined start altitude.

The launch motor altitude/time run limit switch then interrupts the “on” signal from the transmitter causing the motor speed control to shut down the motor and the timed flight task “should” begin.

But again the rules were created without much experience and likely by pilots with very little competition experience, so instead the Flight Task Time begins after the motor is started and the model leaves the pilot’s hand.

That predetermined launch height starting point is done via the electronic shut-off switch commonly referred to as an “ALES Switch.”

Here’s a quick look at what’s available and being used from simplest to most features and best value:

Low End Devices

Two Devices Sold by Soaring Circuits

Soaring Circuits <http://www.soaringcircuits.com> makes two Altitude devices and is the most popular because... well it was the only thing readily available in the beginning of the Altitude Limited Electric Launch Class. The CAM unit is their only actual motor shut off device.

The other unit is the smartest and best electric launch “limiting” device created to date for Task RC Soaring Pilots. It doesn’t limit altitude, but it does shut off the motor after 30 seconds motor run.

Device #1

The CAM Programmable (3 Altitudes) Shut-off Switch (about $45 shipped <http://www.soaringcircuits.com>

- This has been the go-to unit for ALES, as it is super functional and simple.
- Only three altitude settings - 100 m, 150 m, 200m
- Standard automatic 30 second motor shut off, motor restartable at any altitude is the default
- No ‘visible’ display to read the set up.
- No programmer needed. Setting and checking altitude is done via a simple set of beeps. (However, if down the road clubs go to a modified F5J or Modified F5J format where each meter of altitude cost points, you have to pre-report which of the three launch altitude setting you have decided to use.)

Device #2

The CAMF5J Altitude Reporting Device (approx $64 shipped) <http://www.soaringcircuits.com>

The right choice for RC sailplane pilots who want to be in charge of their motor shutoff altitude!

- Can not be programmed to shut off the launch motor — period.
- Does shut off the launch motor run after 30 seconds.

If an anacronym were to be used it should have been Alitude Limited Electric Motor Launch Thermal Duration RC Soaring – ALEMLTDRS. So you can see why the shorter meaningless group of letters stuck!

The CAM Programmable (3 Altitudes) Shut-off Switch

The CAMF5J Altitude Reporting Device

• Can not be programmed for lazy pilot motor restarts, or emergency motor restarts, either. An RC sailplane pilots altitude device!

• FAI-F5J Legal!

• The display shows at which altitude the launch motor was shut off and holds that display for recording at the score table. Points are deducted at 1 point per 2m of launch altitude. Again, the motor shuts off automatically after 30 seconds and can not be restarted in flight.

• The tiniest lightest weight FAI-F5J legal device in existence today! (Yup, good ole American ingenuity strikes again!)

• One more time, if you want a switch to determine your model's motorized launch height to a pre-programmed altitude, this one won't do it. You'll need one of the others.

Two AerobTec Altis Models Sold by Esprit Models

Esprit Models <http://www.espritmodel.com> is a large importer and distributor of model aircraft, RC electronics and accessories.

Device #1

Competition Recording Altimeter Switch Altis Micro (F5J/ FAI) (approximately $65 shipped) <http://www.espritmodel.com/aerobtec-competition-recording-altimeter-switch-altis-micro-f5j-fai.aspx>

• The "economy" model – lots of features, but not very field user friendly

• Tiny

• Programmable but must be connected to a computer with Aerbotec software program

Competition Recording Altimeter Switch Altis Micro (F5J/FAI)

Altis4 Plus FAI F5J Competition Recording Altimeter

Competition Recording Altimeter Switch Altis Micro (F5J/FAI)

• Uses small LED lights to indicate ALES setting or F5J altitude shut off.

• Does flight detail logging that can be viewed on a computer with Software.

At the Top End of the Selections

The Altis4 Plus (approximately $85 shipped) <http://www.espritmodel.com/aerobtec-competition-recording-altimeter-switch-altis-v4-fai-f5j.aspx>

• Lots of features, lit display offers information about settings, altitude at motor shut off, etc (manual available on the the sales page at Esprit)

• Needs the Altis4 Keypad Programmer device if programing is needed at the field.

• Extremely accurate telemetry graphing when connected to a computer with the Aerobtec software.

• Also needs a USB cable to connect to the Keypad Programmer.

The Altis4 Keypad & Cable (approx $25 shipped) <http://www.espritmodel.com/aerobtec-...v4-keypad.aspx>

• Needed to change ALES altitude settings at the field

• Not quick to use in a rush between rounds

• Needs a cable to connect to the Altis4Plus

• With the Altis V4+ total cost of about $100 makes it expensive to outfit multiple sailplanes

In the Middle of the Group (price-wise, but near the top feature-wise)

The Fly Dream Altitude Permit (about $59 shipped) <http://www.fd-rc.com/Showcpzs.asp?id=918>

No longer available from HK; the reasons are so far a mystery to both HK Customer Support and Fly Dream, the actual manufacturer. Soon to be available from Kennedy Composites! <http://www.kennedycomposites.com>

The Fly Dream Altitude Permit

This is the unit our club uses. I did extensive testing and did an article on it, as well as communicating with the manufacturer.

When you consider the price, the features, and the ease of use, you'll see why it's likely the best possible value available today.

• Visual display Programmer doubles as a LiPo motor battery cell voltage checker (Yes, it has a balance port on its edge so you can plug your motor pack in to see a quick check on its charge status.)

• Logs your flight altitude for display on your computer if you'd like to see your flight. (This is a fun feature if you don't have a Taranis which does all that.)

• You can program it to compensate for zoom

• You can have the motor restartable; restartable only from under 15m

• For F5J, non-restartable.

• You can set any motor run time... Any.

• You can set any altitude shut off limit... Any.

• The programmer will show you (display) the maximum altitude of any flight, too - for fun or FAA.

• You can set any motor run time...any.

• It's tiny — about the size of a postage stamp — and extremely easy to use.

• Nothing extra to buy to use it, program it or to use any of its features.

• Take a look at the manual: <http://www.fd-rc.com/pdf/Altitude%20permit.pdf>.

I own and use six of them myself and our club has been using them for a couple of years.

When I found that HK didn't seem to be planning on bringing them into the USA, I contacted Fly Dream by email and asked if I could order direct. "Yes" was the answer. Funny thing is they came in HK packaging! They may be still available through HK in other countries.

At about $59 each, it's way worth it if you consider the features.

The **Altis4 Plus** is the premium unit and you pay for that, almost twice as much as the **CAM** or the **Altitude Permit**.

The **Altis4 Plus** doesn't come with a programmer, and its programmer isn't a handy quick-battery-checker.

One feature of multiple pilots on the field having an **Altitude Permit** is that they can share a programmer with each other or friends, if needed.

I suspect Kennedy Composites <http://www.kennedycomposites.com> will have inventory in about two weeks(ish).

Got questions or feedback? You can reach me at GordySoar@aol.com... or at the flying field!