In The Air

Our modest role in making the world a better place.

Terence C. Gannon

An exciting launch into big air at an F3F event in Taiwan in September of 2008. (image: ©2008 Yusr Wang, all rights reserved, used with permission.)

An essential element of the re-launch of the NEW R/C Soaring Digest was to clearly articulate, through our *Community* and *Social Media Policy* statements, the ground rules for interaction with the RCSD readership and the aspirations for how the readership would interact with each other when using any of RCSD's platforms. In doing this, I more-or-less assumed there would be some push back of some sort at some point. The truth is, there has been virtually none. In fact, the opposite: feedback has been much more on the supportive side of the ledger. Anecdotally at least — and it's early days, I realize — it seems that there is an appetite for a community which simply focuses on its shared interests and, for a while at least, sets aside those things on which we undoubtedly differ in an increasingly fractious world.

That works for me. And I truly hope it works for you too because in my role as Managing Editor, I intend to actively stick at it.

I recently did some data analysis which approximated the breakdown of the RCSD readership by geographic location. Roughly half are based in North America, a third in Europe and about 7% are in Australia and New Zealand. The unfortunately small factor remaining are made up of readers in Africa, South America, Asia and the Middle East.

Going forward, my aspirational goal is twofold: to grow the audience everywhere at every opportunity, of course, but also to grow the audience so that the readership more closely reflects the populations of those various regions.

Growing a global audience is a truly Sisyphean task for a nascent online publication, but at the very least it provides a high level 'prime directive' for selecting the stories for each issue. To that end, I encourage **anybody** from **anywhere** here on this Big Blue Marble to submit *your* story. Everybody has at least one. These articles should focus primarily on any aspect of R/C soaring, of course, but if they can also help others better understand your particular roost on said Big Blue Marble, then you have accomplished something a bit more profound. We are all richer for that. I would even go so far that with a bit more shared understanding we have, indeed, a chance of leaving the world a slightly better place than how we found it.

It is in this spirit that I'm proud to welcome a new RCSD contributor: Mr. Norimichi Kawakami. For those for whom that seems familiar, it was likely in connection with his remarkable 1/3rd scale *Mita* project. The aircraft resulting from this work is magnificent as you will soon see — but in my experience, I don't recall having seen a project which was more meticulously documented. In this issue, we are presenting the first of a number of instalments of Mr. Kawakami's build log — **in the original Japanese**. English-only speakers please don't panic: the author also provides an excellent English translation which we present right along side. But if you **do** happen to read Japanese, the original text is there for you to enjoy.

Furthermore, I encourage any potential contributor who may not be comfortable writing in English to consider submitting your article in whatever language is best for you. We'll figure out a way of getting it translated so we can present both versions to RCSD readers around the globe.

Also in this month's issue we welcome the return of Pierre Rondel who provides his thoughts on the *Orden* from RTGmodel. Like his *MicroMAX* article in the March issue it is lavishly illustrated and features some of the most beautiful flying sites in the world, bar none (one of which graces this month's cover). James Hammond also returns with the second of his four part design series. This time round, James' master class is dedicated to designing a slope 'allrounder': under his tutelage you, too, can realize that perfect design which can float away on virtually no lift at all and yet can give Spencer Lisenby a scare if you take it to the dark side of the slope. OK, I'm totally exaggerating, but that doesn't make James' article anything less than 'must read'.

Stéphane Ruelle writes entertainingly about the *Spring Soar for Fun Aerotow* in Cumberland, Maryland which he attended recently. One of our favourite photographers, Mike Shellim, contributes a great article on *OpenTX*. The affable Peter Scott has a true nugget that unexpectedly connects the Golden Age of Hollywood to the precious avionics on which we all depend. Tom Broeski also returns with another one of his tips each one of which triggers that highly desirable 'but of course!' response. There are a few other bits and pieces thrown in there, so without further ado, here's the April 2021 issue of RCSD. I hope you enjoy it as much as I have enjoyed putting it together. And thank you *so much* for reading.

Fair winds and blue skies!

One of the goals for every issue is to kick it off with a really eye-popping photo and this month's fit that bill to a tee. Joël Marin's composite photo features frequent contributor Pierre Rondel launching his Aerotec Shinto *at Col des Faïsses in the French Alps during August of 2017. Pierre provides the following comments: "Conditions were windy and rather cold temperature for this season. We had very good flying afternoon with good wind and lift in a stunning place!" Yet another place we have* **got** *to go. Thanks Joël and Pierre. Now, please turn to the* ***first article*** *in this issue or go to the* ***table of contents****.*

Orden from RTGmodel, Fly Different!

A top notch and versatile F3F competition glider from Slovakia.

Pierre RONDEL

Green is green! Trying a camera filter to obtain a nice visual effect!

Photo 1: The Orden in the snow during 2020 spring

RTGmodel is a Slovak-based manufacturer that has been producing F3F gliders for many years now, and is synonymous with top notch molding quality and attention to details. Long based on HN profiles, this new glider, the Orden, marks a breakthrough in aerodynamic design to bring it into line with current standards (new dedicated wing profile, thin fuselage, rounded tip, ailerons running all the way out to the wingtip), while marking its difference by making some original choices. I propose with this review to see if the Orden achieves its objective of competing with the best sellers of the moment.

Kit Overview

Photo 2: The kit parts. It is missing part of the ballast on the picture.

With a wingspan of 2.88m, the Orden is rather small compared to the current trend of 2.95 to 3 meters. The choice of a small 230 mm root wing cord and tail cord is giving it a visual aspect ratio so that the glider looks bigger. The first wing panel is almost rectangular so that the wing area is comparable with other gliders on the market. The tips are rounded without being elliptical, and the ailerons run all the way out to the wingtip to maximize roll rate. The wing has a ballast compartment that can accommodate 1.6kg of brass ballast. The wing joiner can host 600gr of additional ballast for a total of 2.2kg. As with the previous RTGmodel gliders, the Orden has its proprietary LDS system, which has the particularity of having the removable control surface axis using a tool supplied with the kit. It is a brass rod with the inside of the threaded tube at one of its ends. Axes also have a thread. The tool is screwed onto the axis and simply pulled. On the servo side, a wooden servo frame receives an epoxy cage for a ball bearing that takes up the forces of the servo output gear. Do not forget to indicate the servos' brand you want to use when ordering.

Photo 3: The servo tray is molded and drilled perfectly, with Kevlar reinforcement toward the nose

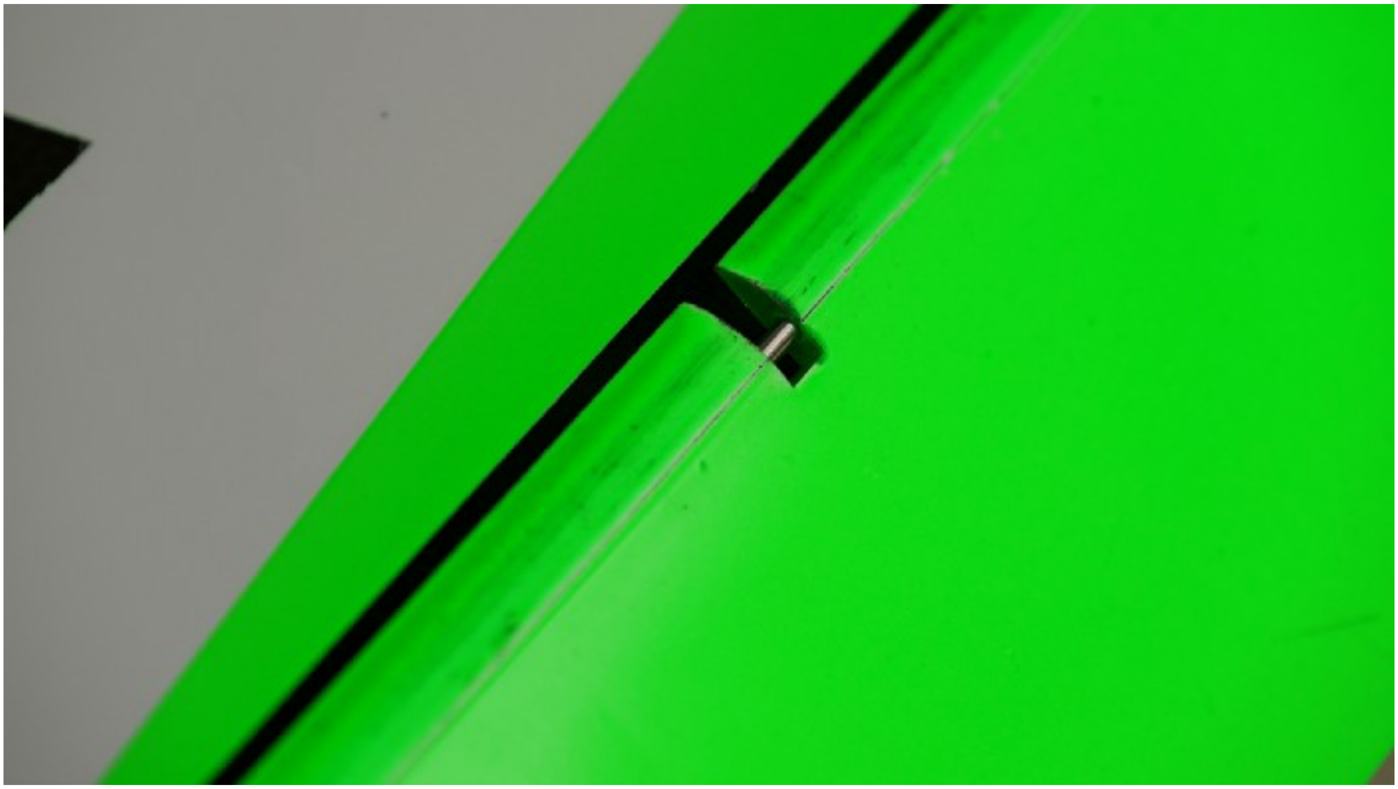


Photo 4: Removable LDS axis on the control surface side

Let’s move on to the fuselage: the diameter is reduced to a minimum on the front part to reduce drag, like the Stribog+. On the other hand, there is no more wing root and the nose is slightly more plunging. As in all RTGmodel productions, the servo tray is molded and drilled, with Kevlar reinforcements: Thus, 2 large Kevlar strips run far enough towards the nose for more strength. This fuselage is closed by a small canopy that offers sufficient opening to access and extract all the radio elements without any problems.

Photo 5: Elevator is using standard metal clevises, easy to remove with a screw driver

Tails are a strong innovation of the Orden: Rather small in size, they are made full with a core in Rohacell and 'spreadtow' carbon fabric, but above all, they are articulated by the middle, i. e. the hinge is inserted between the two half cores, which avoids this hinge to work with time. It is no longer necessary to make sealing wipers, as the gap is reduced to a minimum. Another positive point of these tail planes, they are very light at only 30/31gr including the carbon rod joiner, but still robust. On these tail planes are the usual aluminum horns facing upwards, which receive the 2mm metal clevises (no ball joint clevis). In use, it is very practical to mount / remove tails when travelling.

RTGmodel' s trademark remains the quality of molding and finishing down to the last detail, and the Orden is no exception to the rule, all adjustments are perfect, the surfaces and paint offer a superb shine, deep colors, in short, a very beautiful work. Finally, here are the weights of the various components:

- **Left tail**: 31gr
- **Right tail**: 30gr
- **Left wing**: 602gr
- **Right wing**: 608gr
- **Fuselage**: 275gr
- **Wing joiner**: 95gr
- **Total**: 1640gr before assembly

Straight Forward Assembly

In the more than 25 years I have been doing F3F in competition, I have had the opportunity to fly a large number of gliders. Some require a little more work and attention. This is not the case with the Orden, which has no surprises or particular difficulties. At first glance, I thought that the radio installation in the fuselage would be complicated because of its narrowness, but this is not the case. I even found the assembly more 'spacey' than on the Stribog+. The molded servo plate is perfectly positioned in height and the slight offset in opposition of each servo makes them ideally positioned and the control rods perfectly aligned. The servos are inserted without forcing on the plate, without risk of damaging the output of the servo wire. A little trick on the way to screw the servos in place: I place the servos at the stop of their housing and insert a small custom-made part between the two servos, with two screws. This assembly ensures that the servos are perfectly held without any lack of material for the screws.

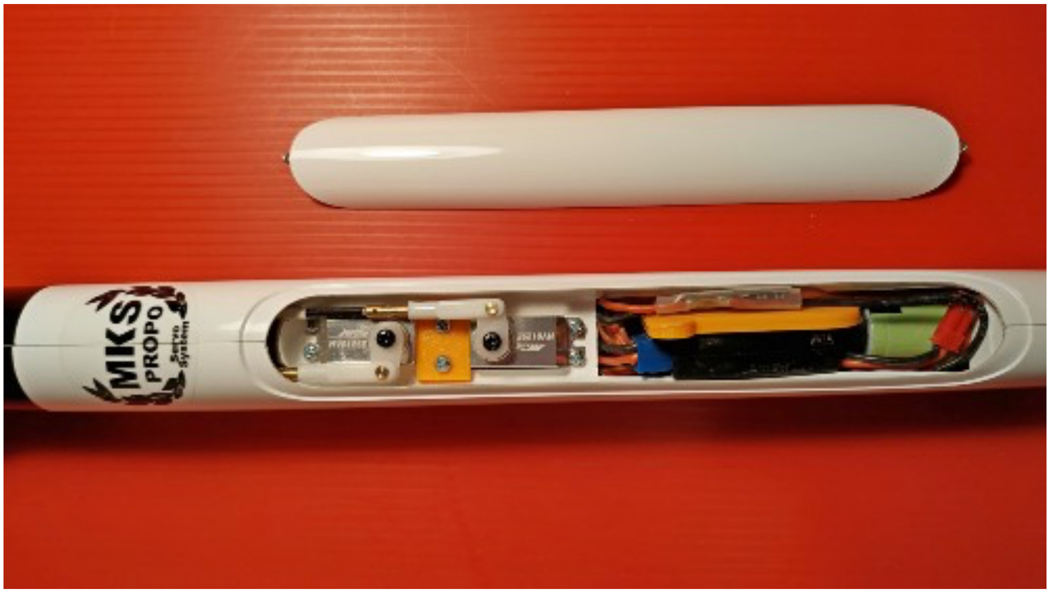


Photo 6: Fuselage is tight but finally components find their place easily

Personally, I mount the female green plugs on the fuselage and the male plugs in the wings. Plug recesses on the fuselage root are perfectly adjusted. Once the wiring is done, I make two small parts in 1mm plywood to serve as a stop to the green plug (with a 2mm shrinkage on the edges), and improve the bonding. First of all, I glue these two pieces with fast epoxy, then I install and glue the green plugs, always with fast epoxy. To ensure that the grips are positioned perpendicular to the root, I have made 3D printing templates in which I block the green grips during gluing, which also allows me to use clamps during drying.

For the wings, the work consists in gluing the wooden servo frames in place, wiring and then assembling the servos. However, I always add a step which is to put an additional piece of carbon fabric to stiffen the skin even more so that the glued frame and its servos do not deform the top surface. A small sanding before gluing the frames allows a better grip.

The LDS system is unique to RTGmodel and includes a wooden frame, an epoxy cage receiving the external bearing, an epoxy arm, and an aluminum servo head with its axis and clamping screws. The arms for the flaps are a few millimetres longer, so I advise you to identify them first.

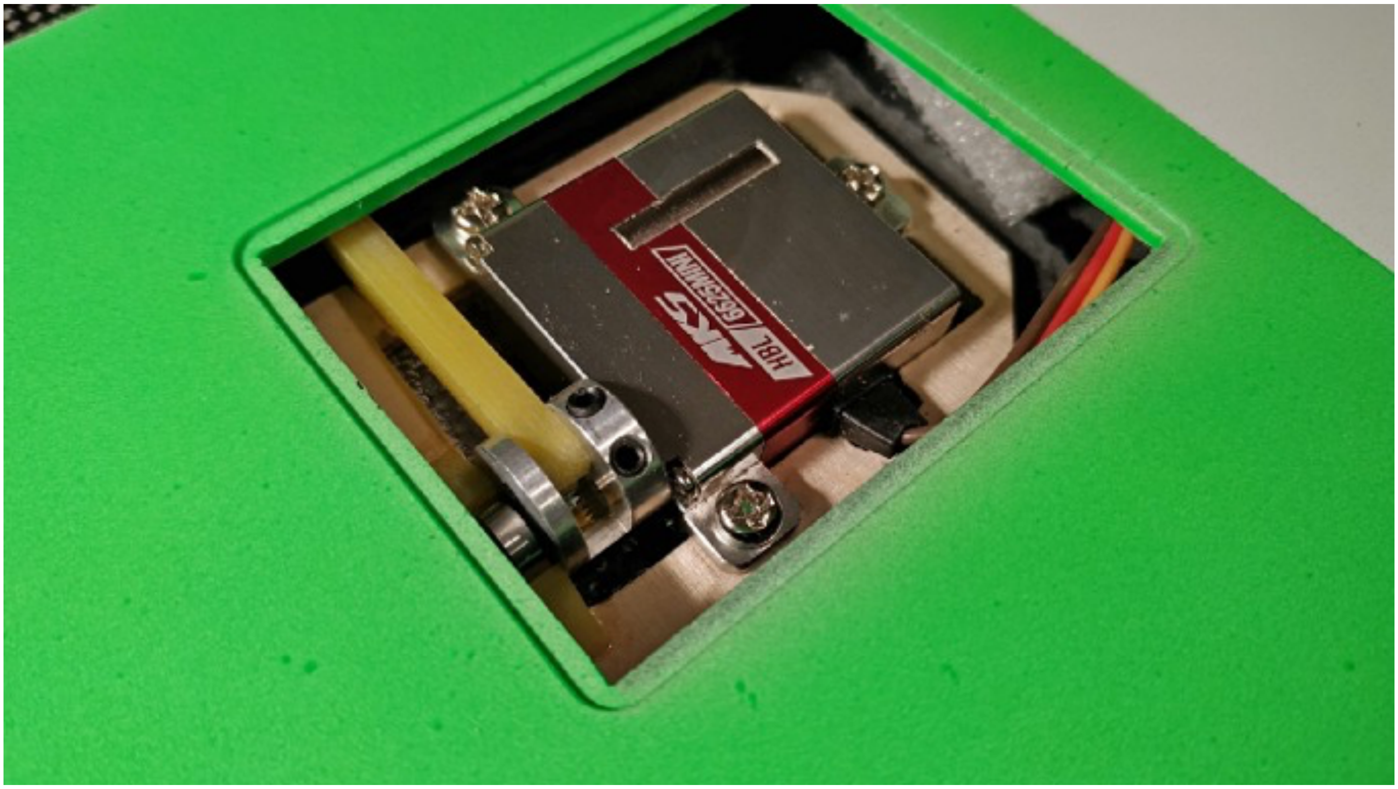


Photo 7: Ailerons LDS mounted on a MKS HBL6625mini. No slop at all, even after a season.

Start by gluing the bearing cage to its wooden frame, and then insert the ball bearing into it. The frame must be glued in the correct position, so it is necessary to start by installing the epoxy arm on the steering side and then connect the roll drive to the arm. This then makes it possible to glue the frames, perfectly positioned, with the roll drive in its housing, and optionally the servos, protected from the glue by a plastic film or thin tape. Do not forget when gluing to put a small piece of 3mm by 3mm paper tape on each frame screw hole so that the glue does not get in.

The green plug is glued to the root rib with the wing in place on the fuselage, all surfaces being protected with fine tape and release agent (polyvinyl alcohol solution).

A picture is often better than a long speech, so you can find all the pictures of the glider assembly here in my RTGmodel Order Assembly Log.

Small check on the scale, 2175gr empty in flying order, it's very good and let oversee a versatile glider!

Let's go to the slope!

I finished assembling the Orden just before leaving for the FAI competition at Col de Tende mid-July 2019. So I stopped on my way, near Gap, to make the maiden flight. Lift conditions were rather light that day, but the Orden perfectly performed its flight, I just moved back the CG a little to help retain energy in turns.

Video 8: Orden maiden flight video

Forty-eight hours later, following a crash where I damaged my primary glider, I switched to the Orden and finished the competition with it, winning three out of seven rounds with the Orden, and winning the competition, so very satisfied with such an introduction!

Photo 9: Onboard picture with a camera attached to the wing tip

What about the glider: in F3F, we don’t only look for straight line speed, but a clever mix between speed and energy retention in turns. The Orden has precisely these two qualities. Able to accelerate and fly fast in a straight line, its turning behaviour is excellent, combining stability and acceleration when exiting the turn, provided that the snap-flaps are well adjusted. Under certain conditions you can even feel a kind of ‘kick in the ass’ acceleration of the glider. According to the manufacturer, the CG range is between 90 and 100mm. I’m personally started at 95mm and finished at 98.5mm.

In light conditions, the low weight of the glider at 2175grs is an advantage. You can then stick to the slope and tighten the turn without any problems. As soon as the lift is becoming stronger, the turn is widened to an ‘energy management’ style turn, i.e. the glider describes a turn away from the ridge with a 45° slope to get grip while on the edge, then return to the ridge and ‘screw’ in front of the pilot to start preparing for the second turn. This turning technique requires heavier flying.

In very strong wind and while flying ballasted around 4kg, I noticed a slight bending of the wings in high G turns, without any consequences. For information, my version is a ‘standard’ version, double carbon, i. e. a sandwich composed of a 90gr/m2 outer fabric / Airex / 60gr/m2 spread tow inner fabric. A strong double carbon version is always available with a sandwich composed of a 160gr/m2 outer fabric / Airex / 80gr/m2 inner fabric.

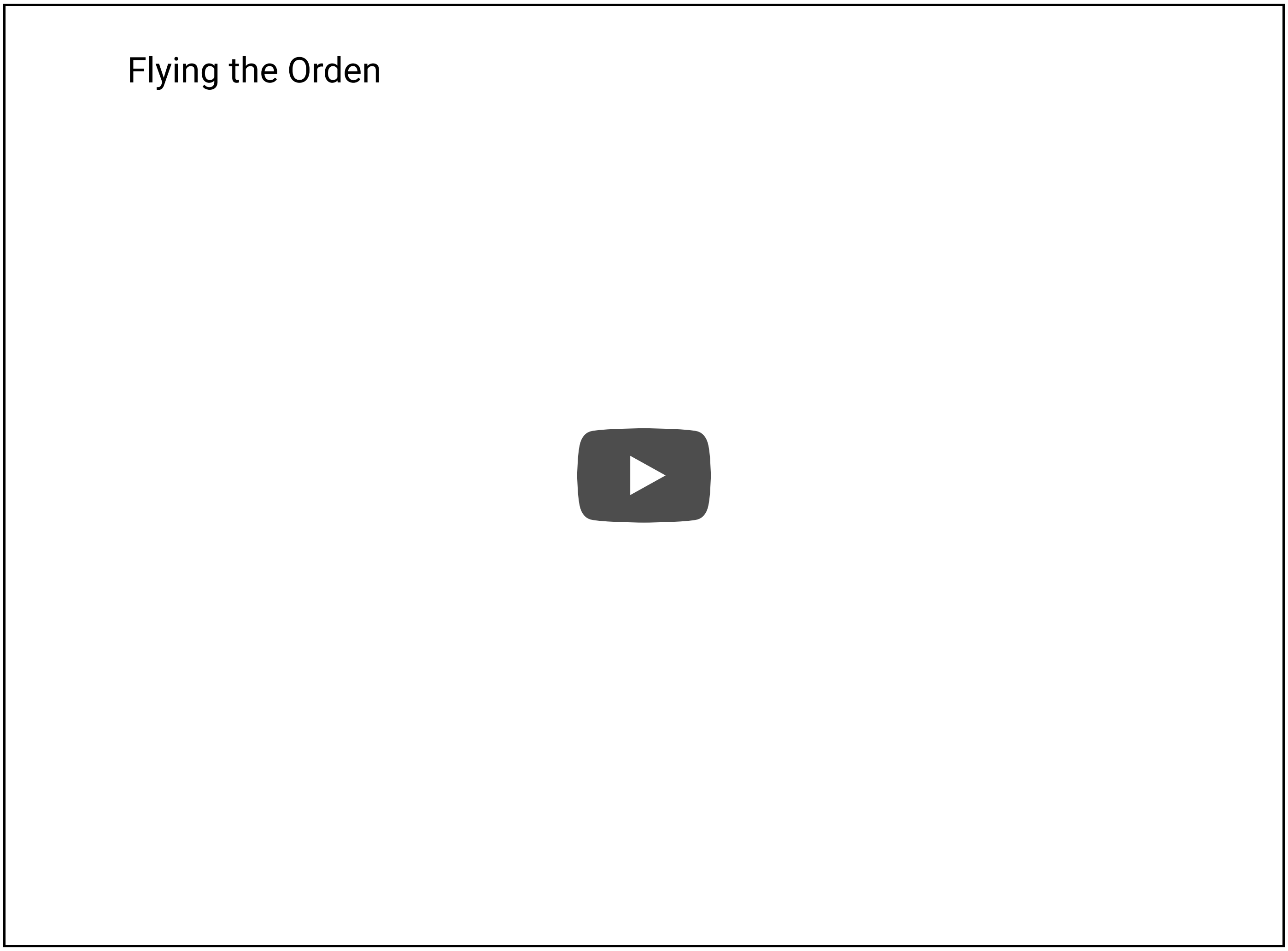
Since then, I have also tested this strong layup wings and could check the excellent stiffness for an empty flying weight around 2350gr only which remains an excellent compromise to cover most of the conditions.

Photo 10 trough 19: Pictures of the Orden in flight. The plane is providing an high level of performance, both for sport flying but for F3F competition too

The Orden accommodates many different flying and turning styles. It is just the amount of elevator that allows you to switch from one style of turn to another; there is no need to change the snap-flaps ratio.

Photo 20: The Orden in good company with the Penguin F3F from Jean Luc Foucher a home designed, milled and molded F3F plane with radical choices

In typical sport flying, the qualities mentioned above make the Orden an excellent companion that adapts to all conditions: Light weather and thermal 'hunting', more dynamic wind or aerobatics, very strong wind and ballistic flight. Circling holds perfectly, helped by the small dihedral of the wing. Transitions to travel from thermal to thermal are a simple exercice and allow you to explore the airspace quickly without losing altitude, and the flaps in the thermal position are effective.



Video 21: Another video with some onboard sequences

All the basic aerobatics goes smoothly even if it is not the glider’s vocation. Quadroflaps bring vivacity and precision. On landing, the ‘butterfly’ mix works perfectly and allows you to land short.

In short, the versatility is there and the Orden will give a lot of satisfaction to its pilot whatever the flying conditions or the flying style!

Photo 22: The author with his Orden few minutes before the maiden flight

The final word

RTGmodel has succeeded in his bet because the Orden offers much more than just an evolution of the Stribog and Stribog+ but is now able to compete with the market best-sellers. It therefore offers a beautiful alternative for those who want to fly different, with an extremely well built glider, and dreadfully effective in all circumstances. To fly without moderation, whether for sport flying or F3F competition. Have a good flight, everyone!

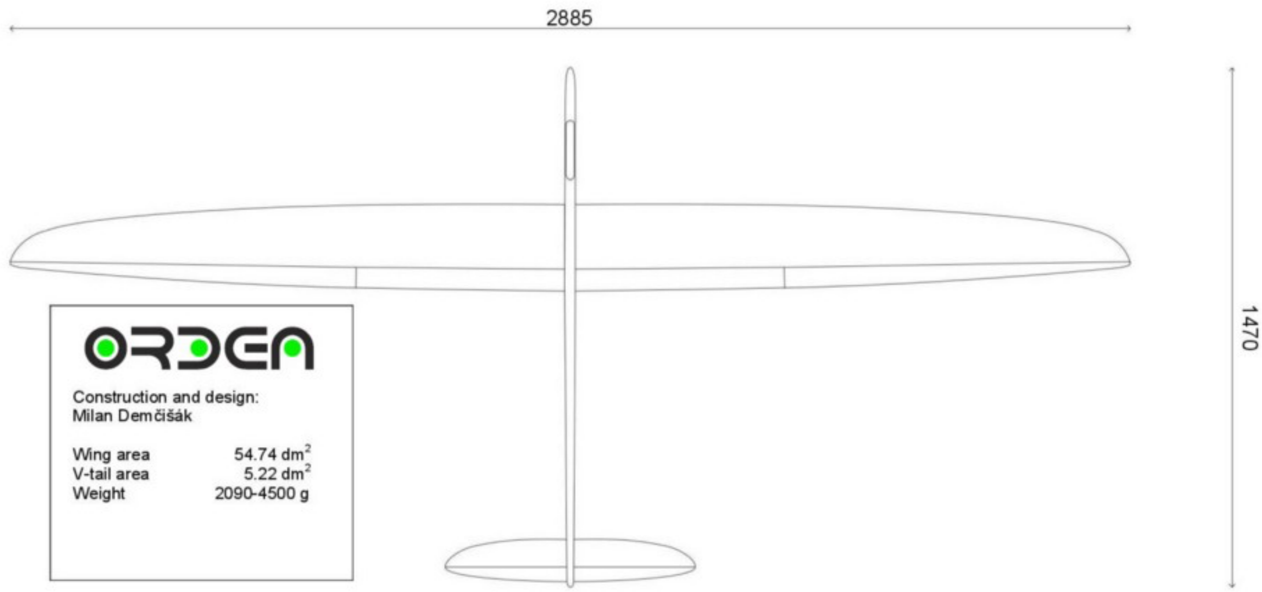


Photo 23: RTGmodel's Orden plan view. (image: RTGmodel)

Characteristics

- **Wingspan**: 2885 mm
- **Length**: 1470 mm
- **Wing area**: 54.74 dm2 (FAI : 60 dm2)
- **Empty weight**: 2175gr (max FAI : 4500gr)
- **Manufacturer**: RTGmodel
- **Contact**: Milan Demcisak, Polna 3174/6, 01001 Zilina, Slovakia

Settings

- **CG**: 98.5mm
- **Elevator** : 6mm up/down
- **Rudder**: 8mm up/down
- **Function ailerons**: Ailerons : 28 up / 14 down, Flap: 15 up / 8 down
- **Function snap-flaps**: Flaps: 7mm down at full elevator, Ailerons: trailing edge aligned
- **Function butterfly**: Flaps: 45mm down, Ailerons: 23mm up, Elevator compensation: 5mm down
- **Thermal position**: Flaps: 4mm down, Ailerons trailing edge aligned

- **Speed position**: Flaps: 1mm up, Ailerons trailing edge aligned

All videos and images by Joël Marin & Pierre Rondel unless otherwise noted.

*Read the **next article** in this issue, return to the **previous article** or go to the **table of contents**.*

Designing for a Slope Allrounder

Insight into the thought processes behind a balanced design.

James Hammond

Typhoon 2M (80″) showing its versatility.

In this article I'm going to go through the basic thinking and outline design process for my Typhoon 2M — still a popular choice and now holding the record as the most produced moulded 2m slope allrounder ever. While you, the reader may not have the skills or maybe lack the right facilities to make your own all-moulded glider, and indeed it's a lot easier these days to just buy one; I hope that this article will help to give you an insight into the thought processes behind the design procedure. — JH

What Do We Want From a Multi-Purpose Slope Allrounder?

Zzzz…cool man, got to be cool looking…I need cool slick looks from my baby…oh boy, I need blistering fast…yeah…whistling fast…I need TOTALLY aerobatic…I need DS…I need STRONG, dude…got to have strong…yeah… getting there…got to be really light to for those really light breezes…Whoa… what time is it?

Damn, is it that time already? But…what a nice dream…

Unfortunately, however hard we try, our dream will remain just that, a dream — a slick looking sloper that does everything really well, in fact to the max, will never happen. But at least, if we are smart, we can actually fulfill large parts of the dream, push back the limitations a bit and turn them into reality. And that can be a lot of fun.

Let's Get Down to It…Decisions, Decisions…

Realistically the very first thing we have to decide before we set out our list of requirements is wingspan: big or small? We all have different spaces and indeed different priorities — it's sometimes a teeny bit difficult to convince 'she who must be obeyed' (SWMBO) to leave the kids at home so you can go fly your stonking 150″ allrounder.

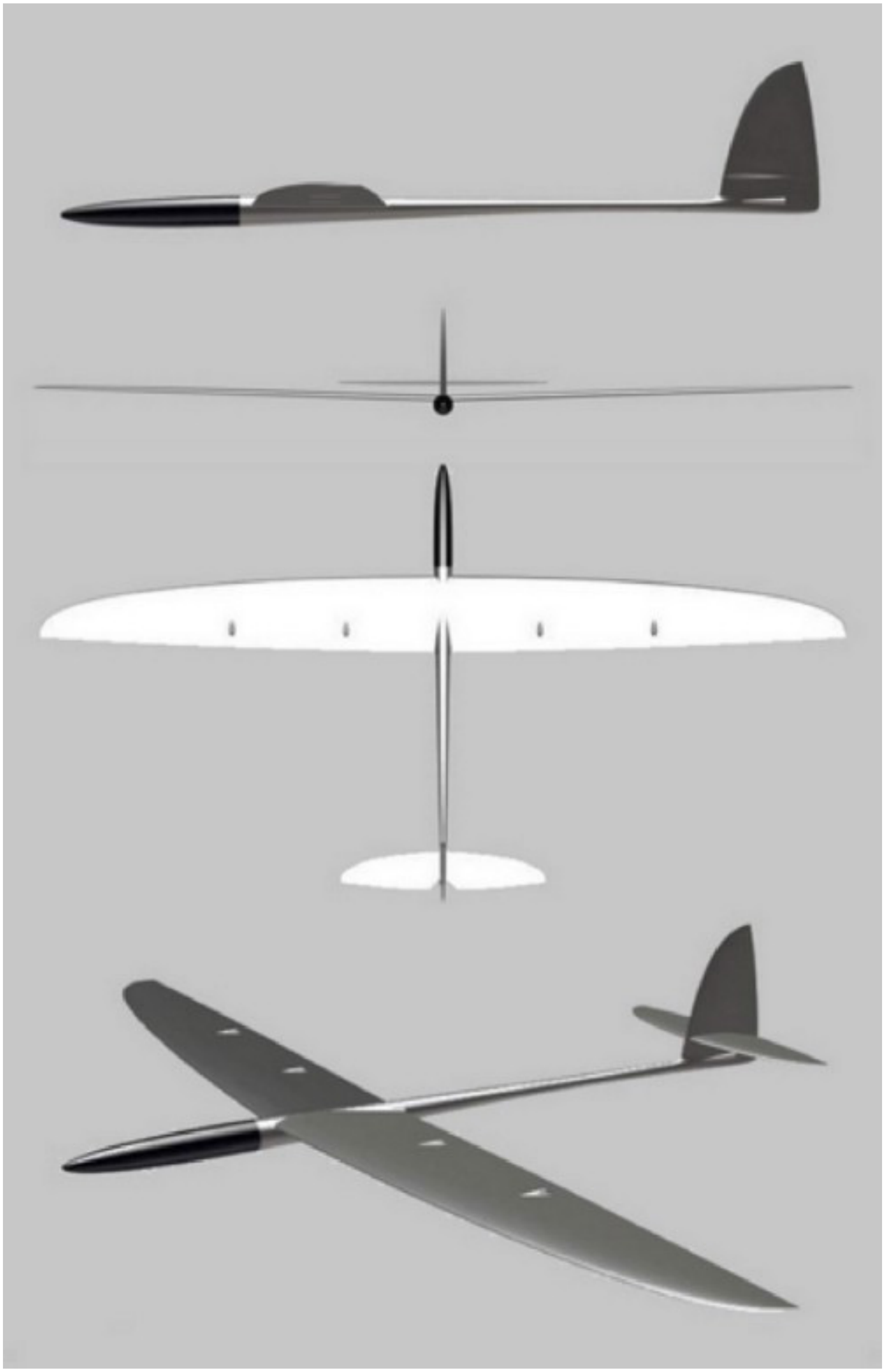


Figure 1: For reference a review of the Typhoon by ace flyer and world champion, Pierre Rondel can be found on his excellent website.

For almost any model aircraft, there is a truism in that the larger it is, the better it will fly and this ‘kinda’ rule also applies to our slope soarers. For pretty much every slope soarer type — and in this series we will be dealing with aerobatic, allrounders, high performance competition types, and alpine soarers — at the correct weight for the type, the bigger the model is, the easier it will be to fly, and the better it will perform the tasks we demand of it — at either end of the design envelope. Though more convenient, possibly less expensive, and certainly easier to transport and store, smaller models are twitchier and more sensitive, and really demand a lot more skill overall to fly well, so it's best not to think too tiny.

> *Takeaway: Big is better than small, so it's best to go as big as we can. But do consider other factors of influence.*

But Hmmm...How Big Is Good For Me?

An average allrounder is the kind of ship that breaks down pretty small with the fuselage normally representing the longest component. If designed conveniently small, when disassembled it could maybe be kept (hidden) in the car most of the time, and flown when the opportunity presents, or maybe could easily be stored in a bag like a set of golf clubs and then quickly put into the trunk with other models in our fleet. Probably for most of us, the width of a standard car trunk, back seat or maybe car windowsill are the most convenient reference measurements for deciding size. This means we need a model with something between 72″ (1.8m) at the small end and 100″ (2.5m), with the sweet spot at 80″ (2m) span… so this is where I started back in 2008, when considering the Typhoon 2M model

> *Takeaway: For the size of the model, try to consider what's a happy medium between performance and convenience for you.*

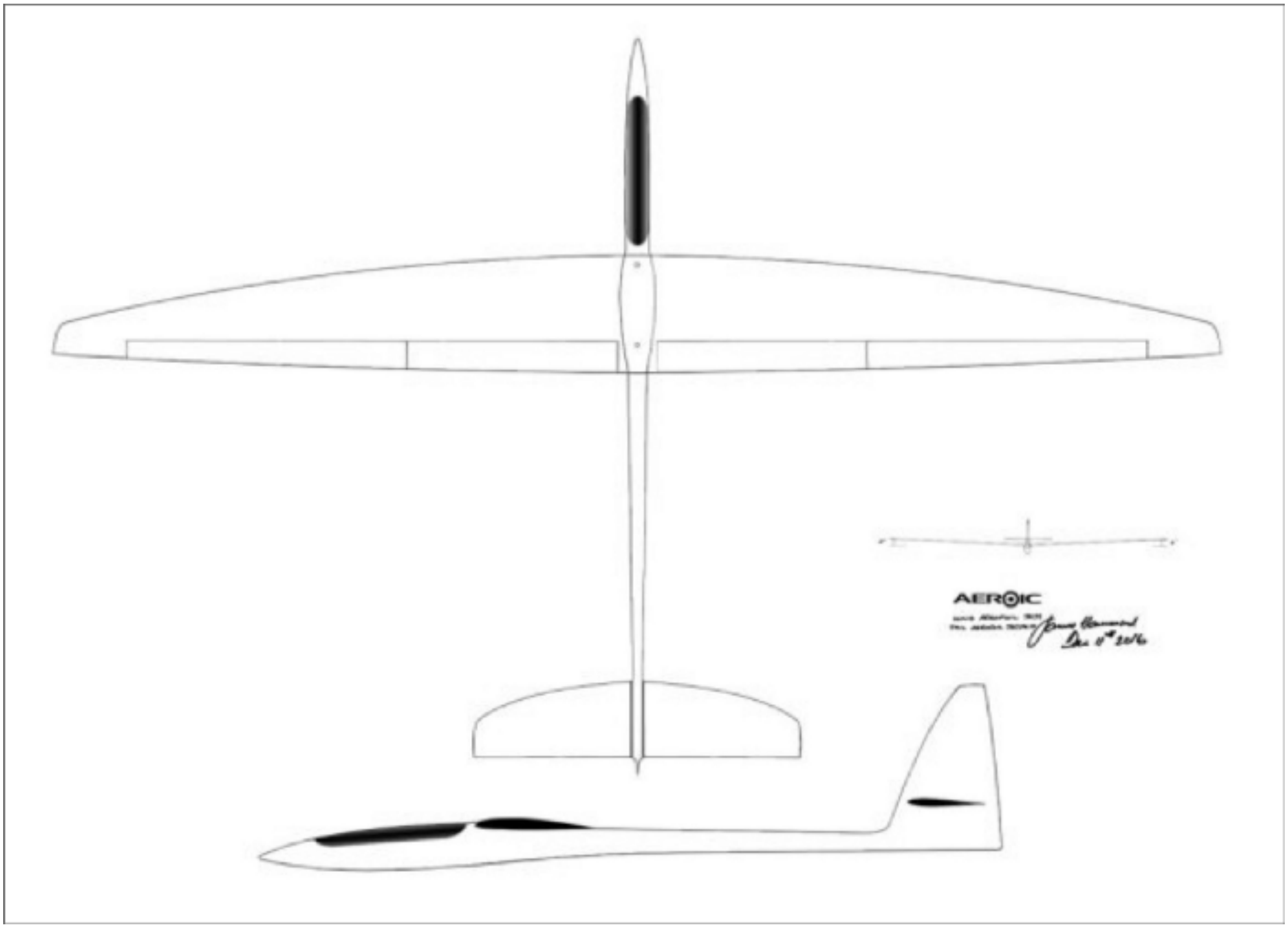


Figure 2: Sessanta 60″ (1.5m) — a smaller allrounder — this time with correct aileron extent.

So Now We Know How Big It Will Be, What Do We Actually Want From the Model — Or at Least What Can We Realistically Expect?

Remembering how I was gathering my thoughts for the Typhoon design back in 2008, I listed my own parameters in probable order of desirability:

Flying parameters: fast, pretty aerobatic, got to fly well in a wide range of conditions, is easy to fly, is easy to land, and looks good. For the most part all of these are functions of aerofoil choice, and wing planform/aspect ratio arrangement.

Static parameters: good looking! Strong, and durable enough to survive some of my less than ideal arrivals, has standard size ballast capability, is easy to install the radio, is easy to transport, assemble and disassemble, and the cost will not involve limb amputation. These tend to be related to the construction design i.e. what materials and how they will be used, though to a lesser extent the actual shape of the model and the radio access will also have some influence.

One good thing about your own moulded model is that you can change the materials and the quantities used at will, to make a gossamer-light model through to a stonking DS Blaster and anything in between, all using the same mould set. But we also need to remember that more material means more resin which means more weight. Also, its often not the amount of material you use that has the greatest effect, but which kind, and how you use it.

> *Takeaway: With your own moulded model you have complete control over weight and strength.*

Wannahaves

Has standard size ballast capability, is easy to install the radio, is easy to transport, assemble and disassemble, and the cost (don't tell SWMBO!) will not involve limb amputation. Well that's quite a lot of wants and needs, but actually pretty achievable. So, let's kick off with the wing design as this is easily the most important part of an allrounder, or in fact any slope soarer. First of all, we need an aerofoil:

Choosing an Aerofoil

Uh oh — now we could be back to making lists again. Here I may be able to save some time. I have designed at least four very successful allrounder slope models between 80″ (2M) and 100″ (2.5M) and I can tell you pretty much what we need, and why: What's required is a semi symmetrical section (Not flat bottomed) with a thickness of between 7.5% and 8.5% — this is the sweet spot. Why? because at this thickness the camber line of the section will have a good curve, which will create enough lift to carry ballast if needed, and it will be quite aerobatic. At this thickness range the section can deal with a large variety of model weights, yet its thin enough to be low drag, while still being thick enough to be structurally viable and capable of withstanding high aerodynamic loads. There is no point going below a thickness 7.5% because there will be little or no advantage on a slope soarer, and even possibly a loss of performance due to the wings having to be strengthened and made heavier to compensate for the lack of structure. By the same token there is no point in going over 8.5% as the extra lift is simply not needed, while the drag on a smaller 2M model escalates pretty fast with thicker sections. Last but not least. Any modern aerofoil with a decent alpha performance does not need any rigging angle. Repeat: Any modern aerofoil with a decent alpha performance does not need any rigging angle.

> *Takeaway: Choose a nice proportioned aerofoil between 7.5% and 8.5% to get the best overall performance from your model.*

> *Takeaway: Don't design your model with any rigging angle — it will destroy the performance.*

> *Takeaway: Sections like the RG15, MH32, JH25, and JH35, fit the bill.*

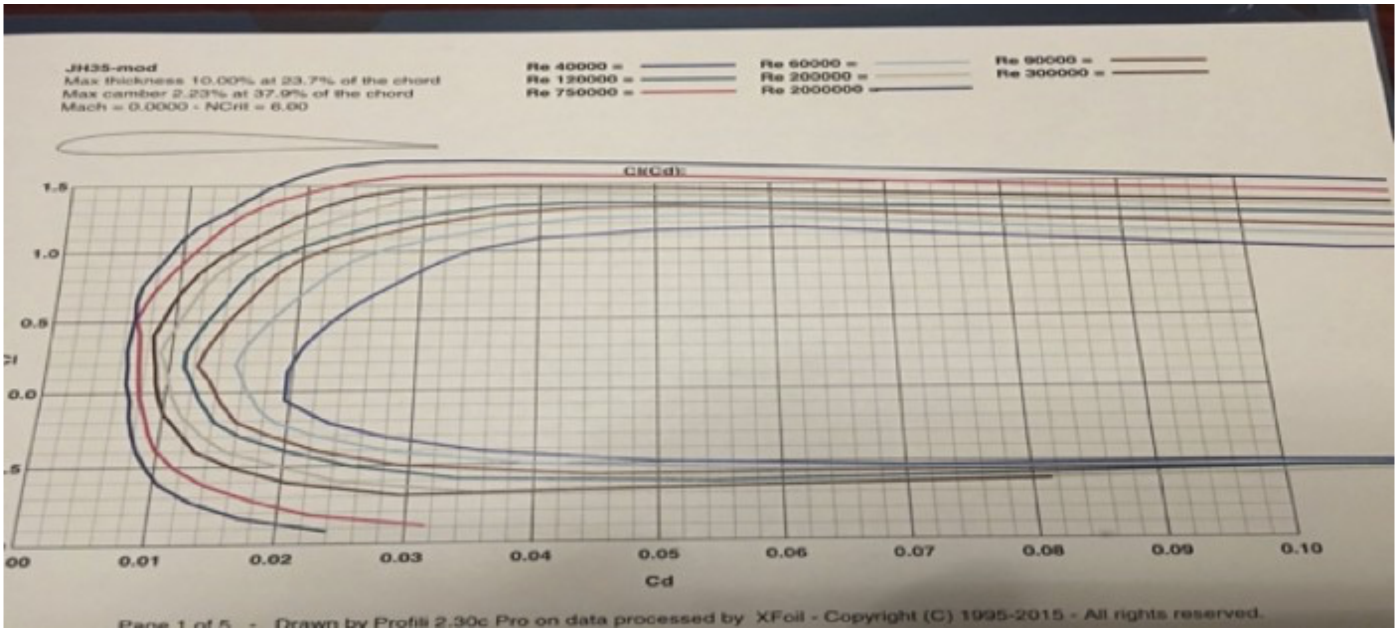


Photo 3: A set of L/D curves for the JH35 Alpine soaring section.

Here are some polars for the JH35, a more “lifty” aerofoil that I designed to give low drag with high response to control inputs, but this time more with Alpine Soaring in mind. For this section, lift has been given priority over out and out speed, yet its still surprisingly fast. I have used this ‘foil on only one of my larger 3.2/3.7M span models so far, and it is surprisingly fast, very well behaved, highly responsive to control inputs, thermals exceptionally well and also slows down safely.” More about this one the next article.

Note the Double Cusped (undercambered and ‘overcambered’) configuration with its nice CL/CD curve with no drag bucket, and also the nice lift curve with little effect on the drag.

Figure 4: Profile of JH25 — an open source 8.25% thick section specifically designed for better control response.

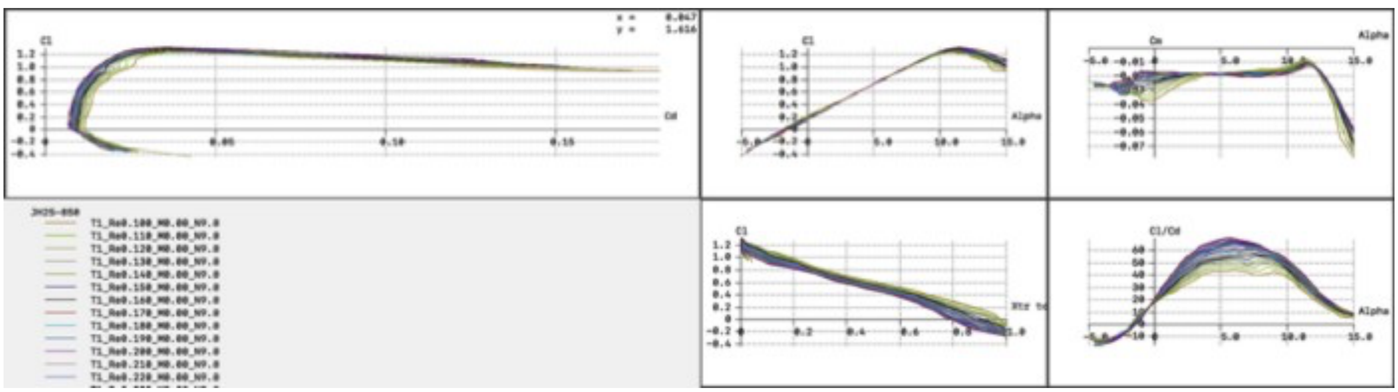


Figure 5: JH 25 polars.

Now for a design point that in my experience is far more important even than the aerofoil section.

The Wing Planform

We all know that we need lift to make our model fly, and we probably know that lift can easily be swapped for speed. Logically though, we don't need a lot of lift out near the wing tips, but we do need more lift closer to the fuselage. In an ideal situation we need to have an elliptical lift pattern span-wise across the entire wing with the most lift close to the fuselage and the least amount at the wingtips. So why not just make the wing elliptical — a true beautiful ellipse just like the WWII Spitfire? Yummy!

Well it turns out that a true ellipse might be great for the lift — at least in theory — but it's actually not so good for model flying qualities. What tends to happen with a true ellipse, is that the Mean Aerodynamic Chord (MAC) and the Centre of Gravity (CG) can find themselves too close together, which can lead to instability and a tendency for the wing to stall if even mildly provoked.

> *Takeaway: Ideally, we want a nice elliptical lift pattern.*

> *Takeaway: It's best to try to modify the ellipse to separate the MAC and the CG as much as possible.*

> *Takeaway: We don't want the problems that true elliptical tips bring.*

Photo 6: Forza 2M shows its plan view in a fast turn.

The other problem with our true ellipse planform idea, is that if carried out to the end of the wings, the air can’t find a good way to leave, and then complex and unstable vortices tend to form which can lead to stall propagation. The reason for this is that the air — let’s say the isobars since we can divide them into waves by pressure — have to be directed to where WE want them to go and not left to their own devices.

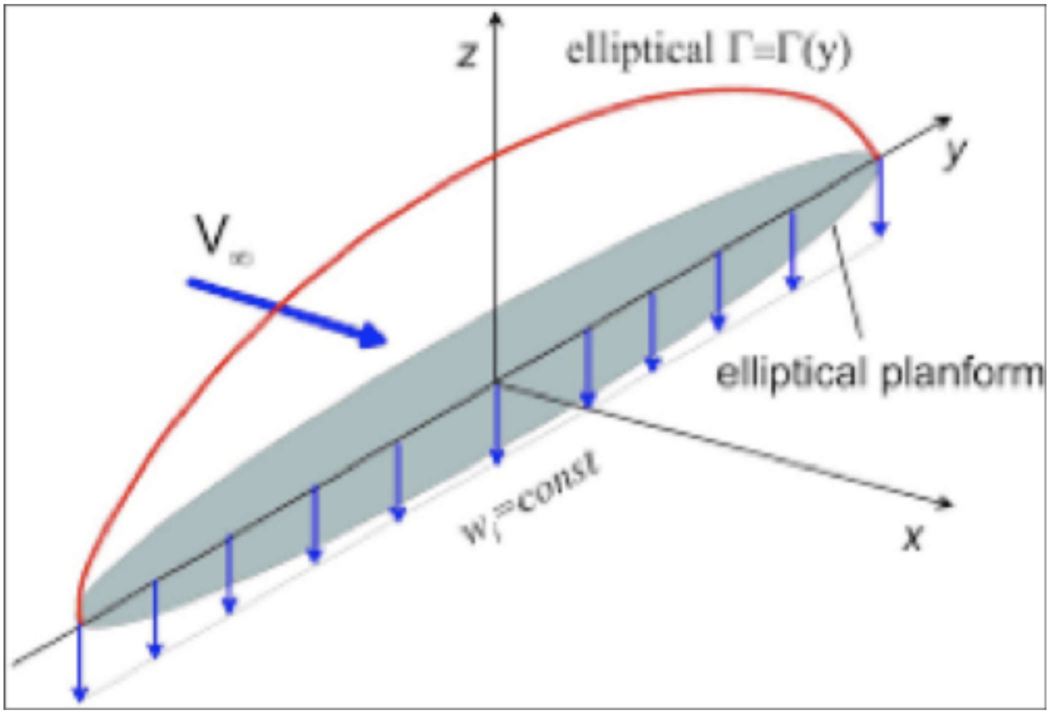


Figure 7: Elliptical lift distribution diagram — note that if the wing really was the same shape as the drawing, then the ends of the red lift curve would be doing some rather strange and unwelcome things.

Remember — the isobars will always find the path of least resistance, which is mostly the shortest path and that can vary a lot with the attitude and speed of the model. This is the seed of the dreaded tip stall, plague of many an otherwise well-designed model, and cause of many heart attacks as its completely unpredictable.

Why Is This so Dangerous?

Wrongly designed tips: Thing is that if the vortices just happen to be departing in the wrong ways — which as they are disorganized is very likely to happen — then this could propagate a stall as the boundary layer becomes suddenly detached from the wing following the path of a vortex. This then starts a stall which rips up the wing and kills all the lift on that wing immediately — but not on the other wing which will mean complete and instantaneous loss of control.

> *Takeaway: tips that are wrongly designed are the*

most common cause of the tip stall and should be avoided at all costs.

Dangerous Liaisons...err, Ailerons

Wrongly designed ailerons: ailerons that end too near the tips on fast slopers, or with too much chord will not give you more control, or if they do you won't notice it. These are not often thought about as stall inducers, but are really dangerous as they can cause stalling if applied in the wrong volume, and/or at the wrong time. This is another phenomenon that often leads to the dreaded tip stall, and it always seems to happen when we are not expecting it — like in a high-speed turn, or when its least recoverable — like on landing.

Takeaway: The tip stall can happen at high or low speed.

Photo 8: A Schwing 2M rests between flights in sunny California.

Actually, there are four kinds of tip stall possibility to be really careful of when designing:

1. *Wrong wing chord profile:* Too much wing area (Chord) too near the tip can cause a stall, as sometimes too much lift is being generated at one time, on one wing only, especially when the wings are travelling at different speeds such as in a turn. The difference in lift is often enough to induce a stall.
2. *MAC and CG too close together:* You could say that the MAC is where the main characteristics of the wing can be seen. It's the centre of lift averaged out over the entire span. So maybe you could imagine it as a kind of inverted pivot point where the hanging wing would go to positive or negative angles. As the CG is also the pivot point of mass balance then if we have MAC and CG too close together they can, and will influence each other, often in an unwanted manner.
3. *Badly designed tips:* In this case the departure of the span-wise flow at

the end of the wing is random and can be stall inducing.

4. *Aileron induced departure:* The outer edges of the ailerons is where we have the least control. Far away from the roll axis — the fuselage — they can however become dangerous as there is the tendency is to give more control inputs, or possibly more control throw than is needed. The ends of the wing are where we have the highest possibility to have unplanned departures from our intended flight path, so it’s best to disturb the airflow in that area as little as possible.

Hmmm…thinking…A nasty bag of problems, especially as I want to do aerobatics as well as high speed and thermal flying. Ho hum…so what to do?

Photo 9: Smiles all round after a successful Schwing 80 maiden — Tick Point, California. Stars of the show are myself — the slim handsome dude with the model, Wayne Flower in the foreground — owner of Aloft Hobbies and chief test pilot that day, and ace flyer Bruce Anderson who probably has more of my designs that anyone else on the planet. (image: Julia Liu)

Compromised or ‘Clipped’ Elliptical Wing Design

My thinking process: I know that I really want an elliptical lift pattern, and since I can use CNC (or even carving if I’m good enough) to make the wing master, then I can really have whatever wing shape takes my fancy — within the constraints of the wing span and chord size. But I also know that a true ellipse that extends to the tips will bring problems, plus I know that the pesky chord distribution might also have an effect too. Aileron size and span problems are OK because I can deal with them after the model is made.

Thinking cap on, and the answer comes. Pondering “control” I know I need to control the chord size to limit it to what is needed to put the lift in the right places. I also need to control what happens at the tips, and not let those random elliptical vortices whistle (yes, they do) every which way they feel like and possibly start a tip stall.

So, putting those together I come out with an elliptical shape but with the rear (trailing edges) pulled back to make the rear curve flatter, and the front part (leading edges) more bowed — so that should sort out the MAC Vs CG problem very nicely, but I’ll still keep my elliptical lift pattern. For the tips I’ll just cut them off and give a more focused and controlled point for the isobars to depart in a more organized manner. A bit like sweeping the wings back on the straight-edged model, I know I am going to give up a bit of pitch and roll maneuverability, but I’ll gain stability and control, and best of all limit the tip stall possibilities.

Example (photo 10) of a non-elliptical ‘legacy’ wing planform on the left, and one of my more modern stretched ellipse designs on the right. i.e. Left side design has too much chord in the wrong places, not enough MAC Vs CG variation, has badly designed tips, plus the ailerons are too close to the ends. Flying slowly, this type of planform might be OK, but as the speed goes up, the problems will show.

Photo 10: Legacy vs more modern wing planforms.

Here is an example (figure 11) of the original Stormbird 2M with pretty much all the features discussed so far. This is the original Stormbird 2M drawing before rendering into CAD. Designed in 2015, this model was really my first excursion into the “dangerous” wing shapes that I now carry in all of my designs. Note the long fuselage — this gives a little more leverage, but also allows the model to be made in 2.5m (100”) form as an alternative — hence the Forza 100 was born.

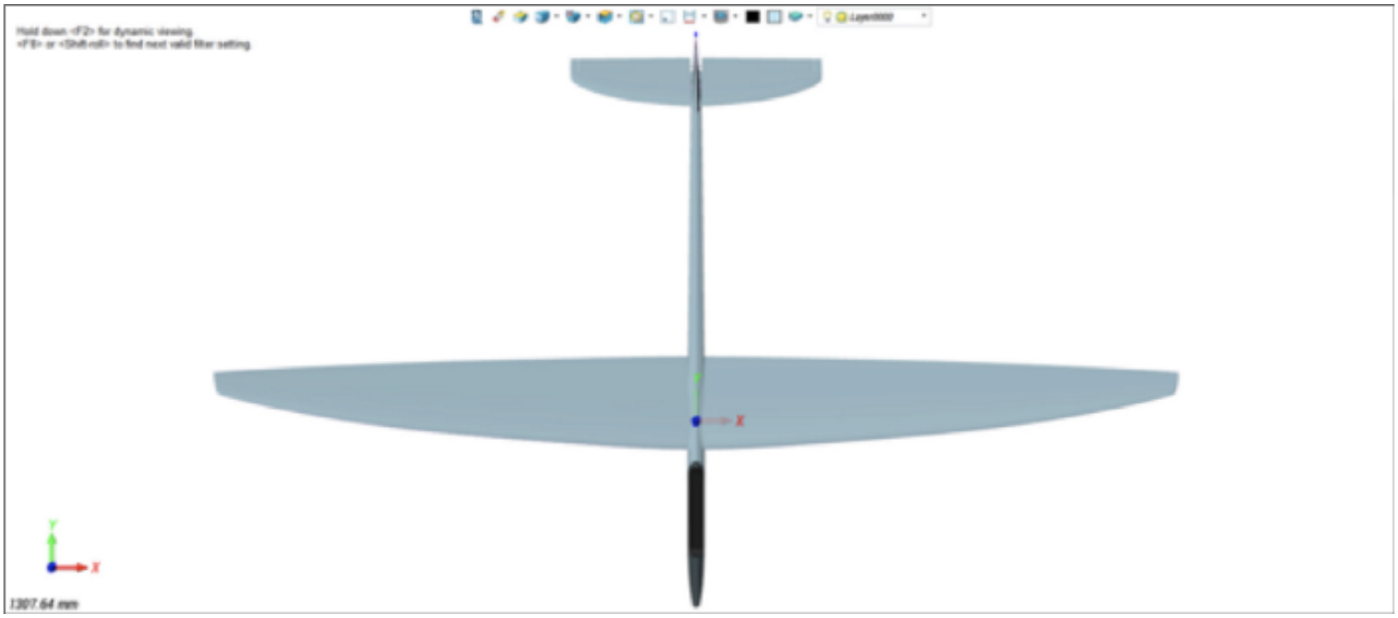


Figure 11: Stormbird 2M plan view — note the ‘dangerous’ wing shape.

> *Takeaway: Many people when they first saw this new wing shape, believed it to be a tip stall nightmare, and said so quite volubly. Well, it has proved to be exactly the opposite. High speed or low speed tip stalls are very, very, rare with this model and also for its larger and smaller brothers with a similar wing shape, thus proving the design philosophy.*

Now How About the Tail Feathers?

V-Tail good points: fashionable, less pieces/joints so theoretically less drag, can be helpful in stabilizing the model in strong winds, less chance of landing damage.

V-Tail bad points: loss of much of the rudder control, less control effectiveness overall, little or no drag advantage in practice as the inputs need to be greater for the same responses, not so good for nice aerobatics as the control forces can be in the wrong directions.

X-Tail good points: better overall control, with little or no actual difference in drag, decidedly better for nice aerobatics.

X-Tail bad points: not fashionable, more pieces so theoretically more drag, more risk of landing damage.

The choice is up to you. I have done both types with success, but if I was asked which is better for an allrounder, I'd go for the X-Tail every time due to the more open and detailed flight envelope that it allows.

> *Takeaway: Both X-Tail and V-Tail have tradeoffs — which one is better for you?*

Photo 12: Schwing looking nice over the Australian Southern Ocean. (image: Adam Fisher)

Secondary considerations are the stabilizer aerofoil to be used, the area and whether to go for an all moving tail (AMT) or a conventional elevator setup.

Stabilizer aerofoil choice is pretty easy: A symmetrical aerofoil of between 7 to 10% is required. I use my JHSYM-10 aerofoil, and recently the JHSYM-9 at a controversial 10% and 9% thickness respectively — more thickness than most people would go for, but there is method in my madness. Through testing the aerofoils **with** elevator movements, I quickly found that the thicker aerofoils actually have less drag and more control response than the thinner ones. This is likely due to the way the air flows around and separates on the thicker section when the elevator is deployed compared to a thinner section where it can have an entirely different separation path.

Stabilizer area choice not a problem either: On a smallish 2m model, if you make something about 17% to 20% of the wing area, you'll be on safe ground. In this range, the Stabilizer will be big enough to be effective, but not needlessly over large.

The third decision is more controversial: to AMT or not to AMT? For control effectiveness I can tell you — through many long hours of wind-tunnel and practical flight testing — that the elevator setup is more effective in every way than the AMT. On the other hand, the elevator type can be a bit trickier to make with its hinges, and to actuate — but I'm assuming that if you do actually get to making a model then this is well within your capability. The AMT works well enough for most people, and is a lot less work. Your choice, but for me it's always the elevator type. The elevator chord should be suitable for the aerofoil section but normally 25% is good.

Stabilizer shape? Follow the wing shape that you have used as much as possible — this is not only for looks, but also effectiveness as the things that we have discussed for the wing shape are all valid for the Stab too.

> *Takeaway: Thinner aerofoils do not necessarily have less drag, and may actually lessen control response.*

> *Takeaway: A tail volume of between 17 to 20% of the wing area will work well.*

> *Takeaway: Elevator setups work better than AMT type.*

> *Takeaway: V-Tail or X-Tail, make the Stabilizer shape similar to the wing shape — the same rules apply.*

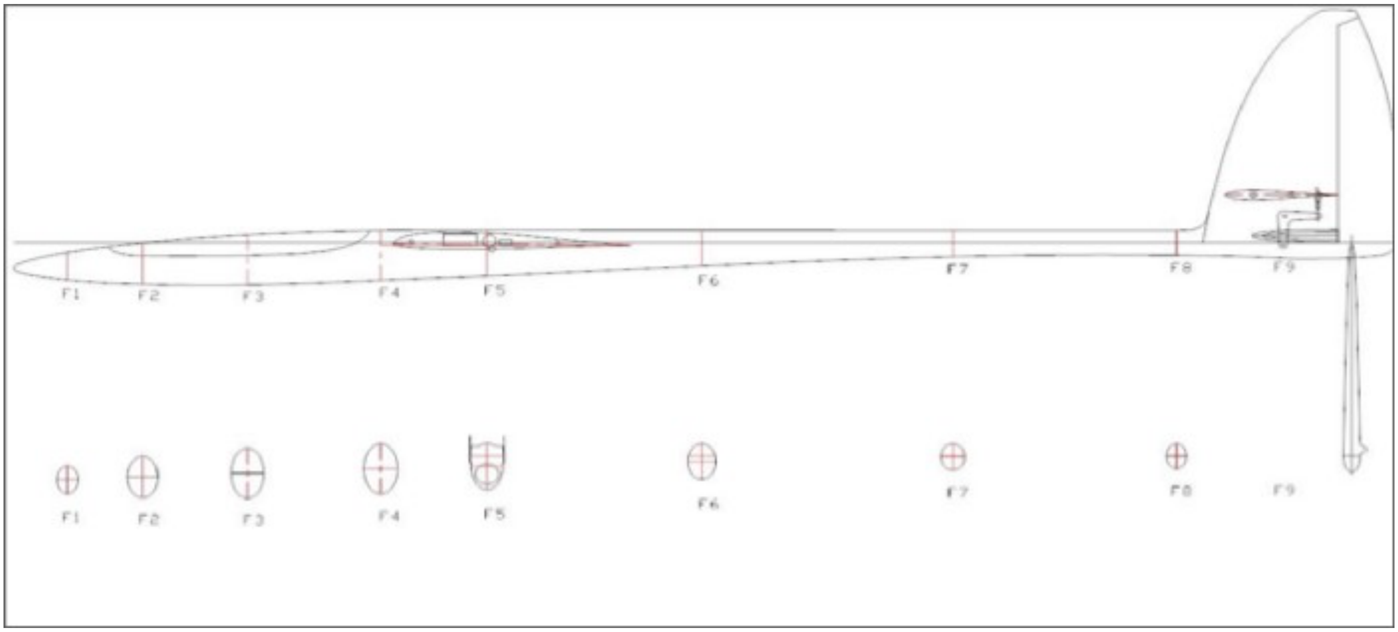


Figure 13: Corsa fuselage drawing — note the downward pointing nose…gives a nice predatory look.

The Fuselage

Finally! I guess the first thing to be considered for the fuselage is the moment arms. By this I mean the distances between the wing and tail, and the wing and nose. Think of these measurements in the same way as levers, but remember the weight considerations too. The longer the lever, which is the distance behind the CG, the easier it is to move the load which is the area in front of the CG. These are pretty critical as if they are too short you will need big control movements to change the pitch and yaw, but too long and they will add unnecessary weight which will need to be counterbalanced by adding weight in the nose.

So here, without going into it too much, I'll give some moment arm references based on my own experience and using the wing root chord as the yardstick:

- Nose moment length to wing leading edge: 1.5 to 1.7 x wing chord
- Tail moment Stabilizer leading edge to wing trailing edge: 2.75 to 2.8 x wing chord.

Corsa 108″ (2.75m) a larger allrounder. Note that on this test flight model the ailerons have been set too close to the tips. Some tape, a ruler, a sharpie pen and hacksaw soon had that sorted!

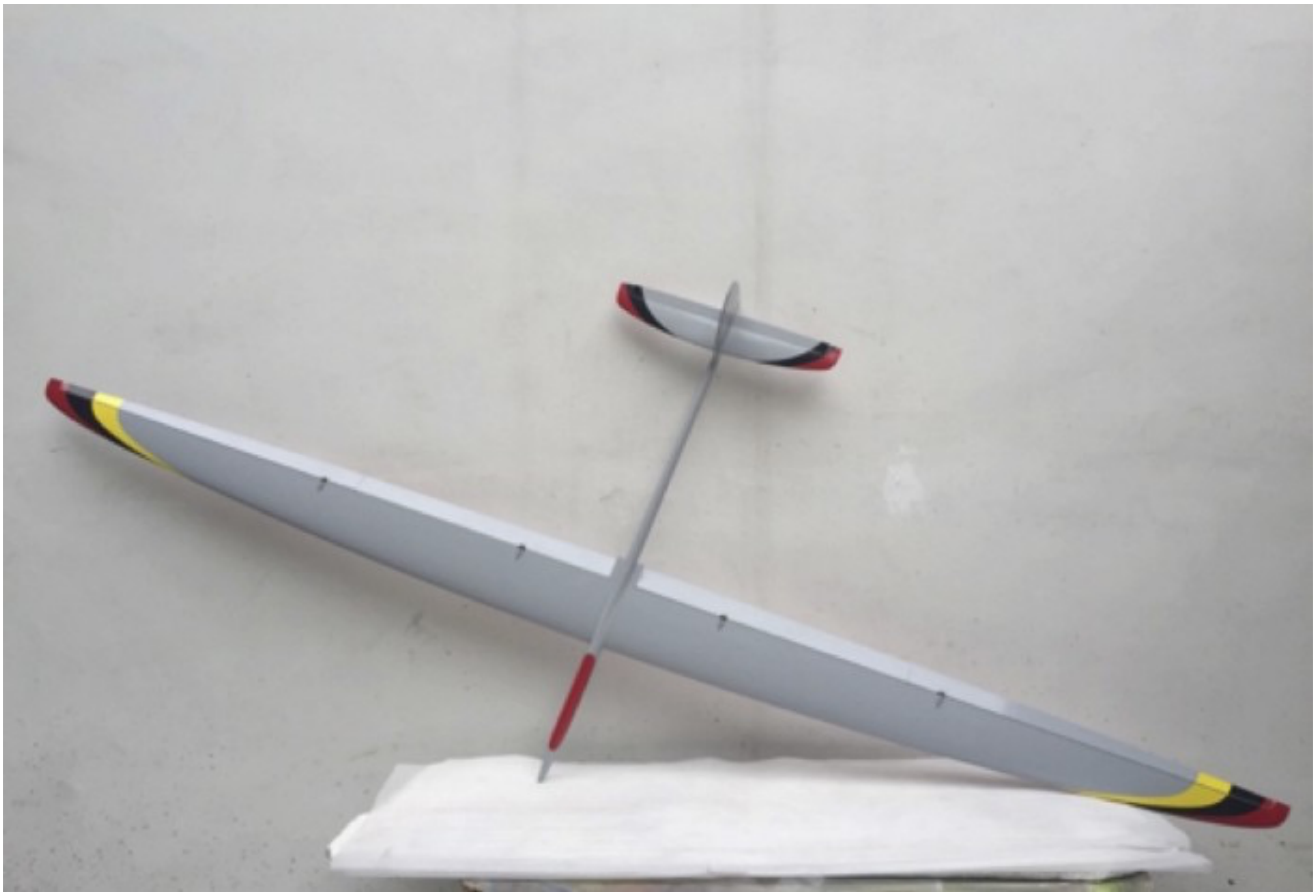


Photo 14: Corsa 108 prototype — not the incorrectly cut ailerons…the hacksaw soon came out…

Fin Size

For an X-Tail a good start point is go to 2 to 2.5 the size of the total horizontal stabilizer area and allow a good-sized rudder. Frankly any aerofoil section can be used from 7 to 10% The reason for the greater volume here is that we are not doing the work of the Horizontal Stabilizer that is working against the MAC and the CG, here we are trying to force large amounts of wing to yaw — which it usually does not want to do. With the advent of smaller, lighter, but super strong servos you may decide to put both of the servos' rudder and elevator in the fin — remember to make the internal fin area large enough plan access hatches.

2.75M Corsa in its OEM guise showing what you can expect of a well-designed slope allrounder, fast, aerobatic and easy to fly. (video: Composite RC Gliders GmbH*)*

One last parameter for the fuselage: make it look good! Mess about with it — especially the fin which defines the fuselage to a large degree — until you have something that not only looks good, but also has large enough — but not too large — cross sections that will handle landing whiplash — especially before and after the wing positions. The strongest cross section is the round shape.

Overall folks, there is a lot of value to the saying that "if it looks good, it flies good" — especially for allrounder slope soaring models.


© Jógvan Hansen

Photo 15 and **Photo 16**: Corsa 108 flies its magic over the Faroe Islands. (images: Jogvan Hansen)

This is the second part of a four part series. Coming up in the May issue of RCSD, author James Hammond provides his take on designing for high performance 3M ships. Don't want to miss it? Best subscribe to our mailing

list! All figures and photos are by the author unless otherwise indicated.
*Read the **next article** in this issue, return to the **previous article** or go to the **table of contents**.*

Never Trust the Weather!

The Spring Soar for Fun Aerotow in Cumberland, Maryland never fails to please.

Stéphane RUELLE

Overview of the pilot pit, with the main building in the background. SH Minimoa and Baudis Antares on the foreground.

After a winter frantically spent building, the spring fever started to build in me for our fist aerotow of the 2021 season, the 12th edition of *Spring Soar for Fun Aerotow* near Cumberland, Maryland. This event is usually taking place end of March, close to the first day of spring. And in the past 12 years we have known all kind of weather, from snow cold to T-shirt hot, it has been a quite interesting exercise to predict what next year will be! the only thing I can say is I always looking for the event — the season starter — as it is always good to do some aero talking if flying is not available.

As always, a week before you look the forecast and try to judge what weather will be. This is where the roller coaster of emotion is going on as every day in that end of winter, beginning of spring the weather changes radically, going this year to a total wash down with snow mix to beautiful sunshine. At some point you need to commit and walk away from forecast, last that I saw was nice on Wednesday, rain on Thursday, maybe snow mix on Friday and sunny on Saturday to Monday. I committed to leave Michigan very early on Wednesday to be able to grab a piece of Wednesday afternoon weather.

Photo 1: Early departure with the trailer to arrive in time for the afternoon.

After the drive to Maryland (flying site is in actually in West Virginia at the border with Maryland), the weather gods kept their promises, and allowed for some flying Wednesday afternoon, a bit overcast with lower ceiling but very flyable weather with some light thermals. We have been able to fly until dark and stored the plane in the hangars that Jim D the owner of the place installed couple years back.

Photo 2: Diner on the deck around a pit fire, how better end a day of flying.

Once this done most the people stayed for a diner at the field grilling and picnicking until pitch dark to watch the International Space Station moving in the sky over us. This is one of the positive effects of 2020, people try avoiding hotels and restaurants, going to a more authentic experience very similar to the spirit you find in Europe for that type of event. I hope it will last as the best memories are after the flying of the day is over, storytelling about the day or previous experiences.

Photo 3: Pilots (left-to-right) Len, Kevin, Bert, Steve K and Steve P.

Thursday the weathermen played against us with low ceiling and drizzle that allowed some of use to proceed with the necessary repairs on retract or other mechanical devices or bring back some improvements to the radio programming. The aerotowing community is always here to help putting back everyone in flying condition when so usual snags are showing up, and as a fact Len’s trailer is always a key of success on the east coast, as he has always something that could help you getting back in the air!

Photo 4: One of the two hangar, that hosted the repairs and fixes of Thursday.

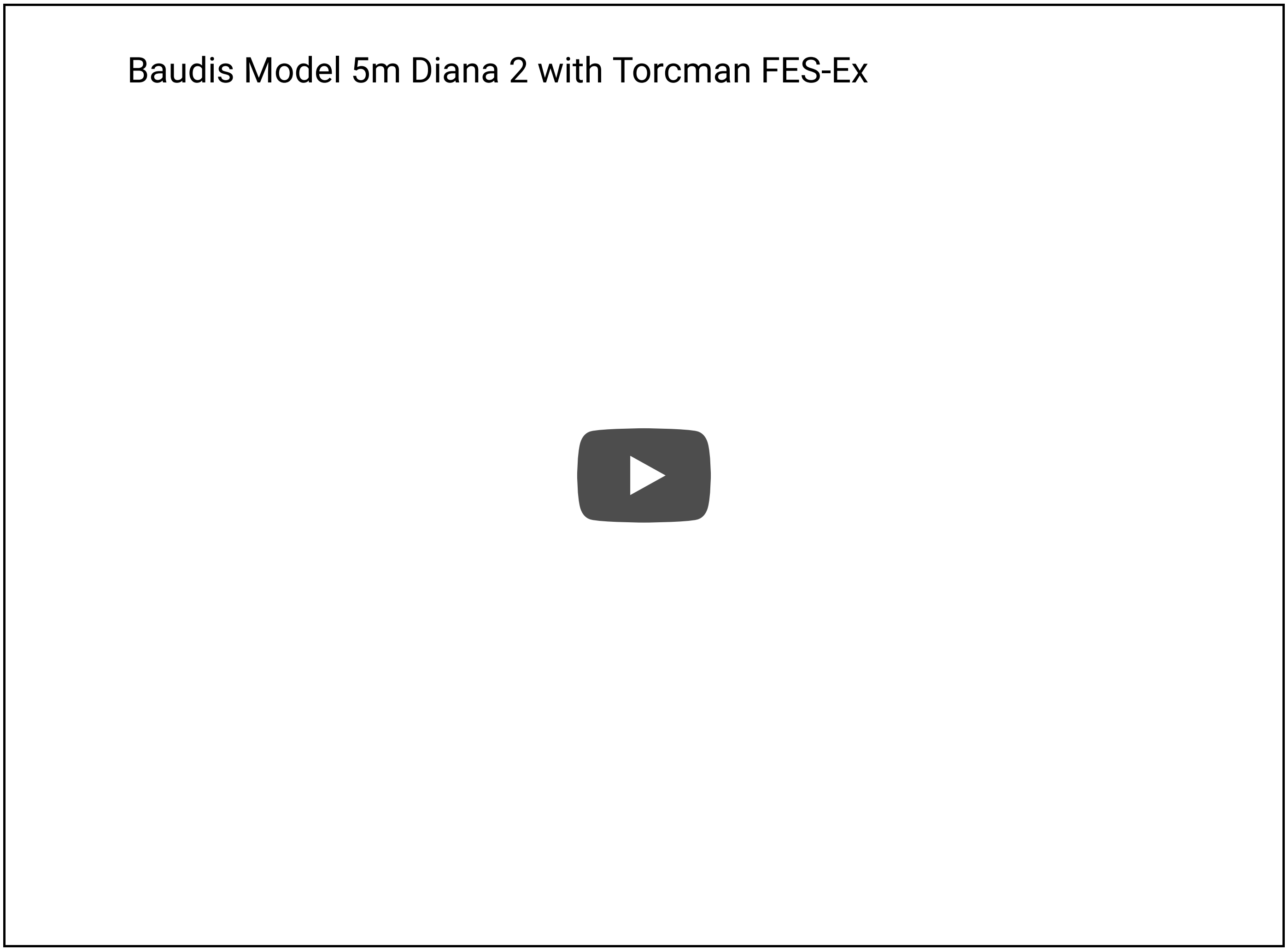
Friday that originally was calling for snow mix, showed up with a totally different face, when I woke up a beautiful blue sky was there without any clouds, clouds that did not showed up during the rest of the weekend. Temperature progressively rises to 70F (20C) making up of some very pleasant spring days spent on the top of the mountain! Thermals have been present every day, very weak but flyable until noon, giving a very nice training to improve your circling and thermal hunting skills. About lunchtime to 2:30 some very pleasant condition took place with some more robust thermals (and some very noticeable sink!, I clocked +5m/s and -7m/s on my vario that day!) that allowed some of the participant to train their skill on GPS triangle racing (30 minutes work time on a 2.4km course, forcing you to travel on every sides of the flying site, I will be back on a future article on how it appeal to me).

Photo 5: Kevin K getting ready to take of with his 6m KV model Shark for an initiation to a 30mn session of GPS triangle, he will come back from this hooked.

Photo 6: Peter and Caroline G assembling the Peter Goldsmith Design L-19, one of the tug on duties during this week end. Foreground, Slingsby Swallow Caroline's personal model.

This weekend has been for me like other the occasion of maidening the winter built aircraft, in my case a 6m ASG 29 kit. The conditions where perfect for maidens, light lift light wind, very adequate to get a good feeling on how is answering the plane. As all my sailplanes now (most of) I have taken the habit to install and electric motor in the nose, it appeals to me as it is an insurance (some airframe can be pricy or in regard the time invested to build the airframe) on the sailplane to be able to bail out of a bad situation, like a crowded landing, of flying lower than the landing area on a slope without finding lift. The other big advantage been able to fly much more often by yourself, either as the sailplane can ROG (rise off ground) by itself or like this one, use a bungee to get necessary prop clearance to be able to start the motor. On this particular sailplane as the nose was quite round with difficulties to use a matching nose cone, I decide to use the Torcman FES system, that is on my view a very good solution also for safety as you connect the prop just before taking of, no risk to hit a switch and get sliced!

Photo 7: First flight for my winter project, a 6m ASG29. Powered with Rimfire 1.2 (Kv 450), 6S 5000mA and RFM 16x10 mounted with a Torcman FES system



Video 8: Video of my Diana 2 taken the day after the even enjoying the emptyness of the place

this edition has been quite a success, and I can only encourage people to come and join us, the event is organized three times a year for each of the flyable seasons. All events are held at the Highpoint Aviation Airfield:

Figure 9: Where you will find the Highpoint Aviation Airfield. (image: Google Maps)

The next event on the calendar will be the 9th annual *Summer Soar for Fun Aerotow* will be held on July 15th through 18th, 2021 (registration). After that, the 55th edition of *Fall Soar for Fun Aerotow* will be held November 4th through 7th, 2021 (registration).

See you there and don't forget **not** to look to the forecast!

All photos and videos are by the author unless otherwise noted. Read the ***next article*** *in this issue, return to the* ***previous article*** *or go to the* ***table of contents***.

I’ve Got the Power: OpenTX

An open source operating system with the Lua progamming language.

[Michael Shellim]

Some OpenTX-compatible transmitters. Left to right: FrSky TX12S, X9D, X9 Lite, RadioMaster TX12.

Few topics generate more noise and hot air than OpenTX, the popular open source operating system. Some love it. Others hate it, and for the rest OpenTX remains a mystery. In this article I’m going to explain the background to OpenTX, as well as its unique approach to programming.

I will also show how, with the aid of the built in Lua facility, you can do some pretty advanced stuff — like a continuously variable trim system!

Humble Beginnings

OpenTX’s popularity is remarkable when you consider it started life as an obscure operating system for cheap Chinese transmitters. It finally hit the big time in 2013, when FrSky chose it for their first transmitter, the Taranis X9D. Thanks in large part to OpenTX, the X9D became a huge hit.

Part of the appeal of OpenTX is the free Companion software. This provides a model editor, and a simulator for testing your setups. It's also a great way to familiarise with the OpenTX before purchasing a transmitter.

OpenTX also incorporates a Lua interpreter. This allows users to create powerful extensions in the form of *scripts* — we'll look at an example later in this article.

Designing a Setup

As with any serious pursuit, knowing the lingo is key. Architects use lines and curves. Mathematicians use symbols. And OpenTX'ers use *interactions*. An interaction expresses the relationship between one stick and one servo.

Here's how you might write an interaction representing a simple elevator function.

```
Elevator stick → CH3/elevator (pitch)
```

The first step in designing a setup is simply to make a list of all the interactions required. Here's an example, for a 4-servo glider with twin aileron servos. Note that the aileron stick generates two interactions, one for each servo:

```
Aileron stick → CH1/RtAil (roll)
Aileron stick → CH2/LtAil (roll)
Elevator stick → CH3/Elev (pitch)
Rudder stick → CH4/Rudd (yaw)
```

The beauty of this approach is its simplicity: this four-line table completely describes the basic operation of the model.

Implementing the Design

While the design is concerned with interactions, the implementation is all about *mixers*. And a mixer in OpenTX is very simple — it takes an input, applies a transformation, and assigns the result to a channel.

The similarity with interactions is obvious, but it gets better... to implement your design, simply reverse the interactions and enter them into the Mixes menu:

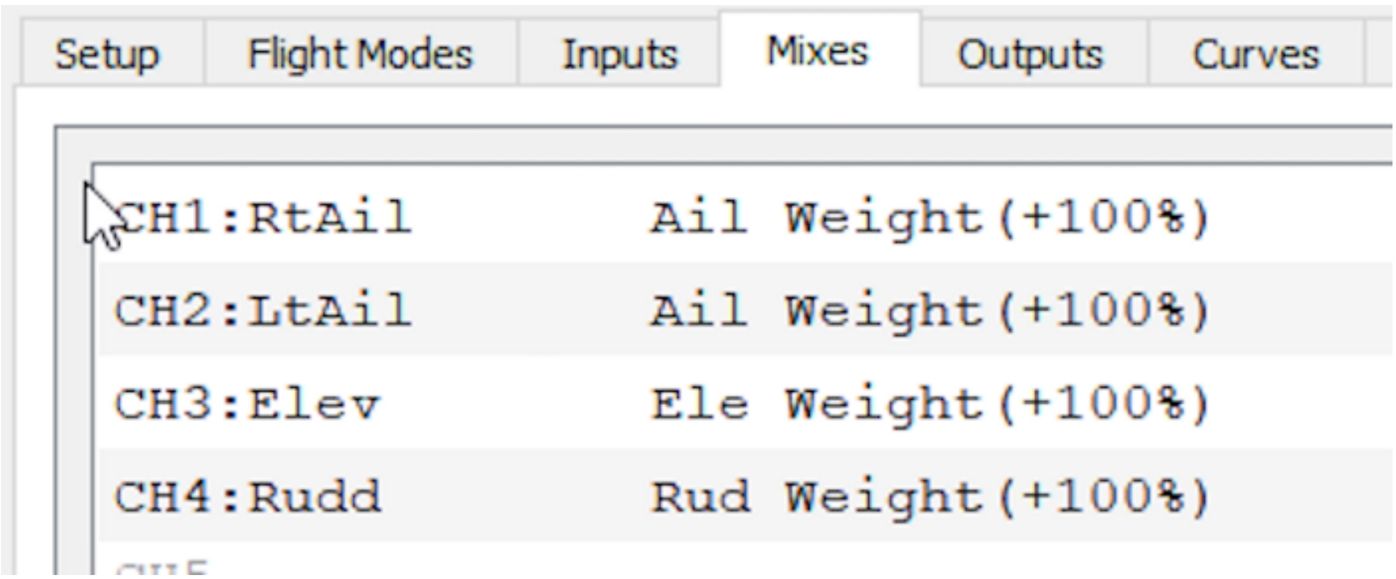


Figure 1: Mixers for a 4-servo glider, shown in OpenTX Companion software.

Want to add snapflap? No problem — just add two interactions:

```
Elevator stick → CH1/RtAil (snapflap)
Elevator stick → CH2/LtAil (snapflap)
```

... and again, those translate into a couple of extra mixes.

The 1:1 relationship between interactions and mixes makes it easy to design a setup. And because your work can be expressed as a list, it's easy to browse and document.

The Beauty of Lists

Mixers are just one aspect of OpenTX. Others elements include:

- *Inputs* — flight controls with rates and expo
- *Logical switches* — combine switches using AND/OR operators… and much more.
- *Outputs* — set servo end points and centres
- *Gvars* — define integer variables
- *Special functions* — trigger actions like telemetry logging, timers

All these elements are shown as simple lists.

It should be clear that OpenTX is very simple at heart. Yet it's also extremely powerful. Part of this is due to its simplicity — building complex systems is easier if you start with small building blocks. However, a large part is also due to an embedded Lua interpreter. What follows is an example of a powerful Lua based extension for a continuous trim system.

The Power of Lua: A Crow Aware Trim System

Anyone who has used crow brakes will know that they can wreak havoc with pitch trim. The usual antidote is a crow-to-elevator mix with a *compensation curve* to deal with any non linear behaviour.

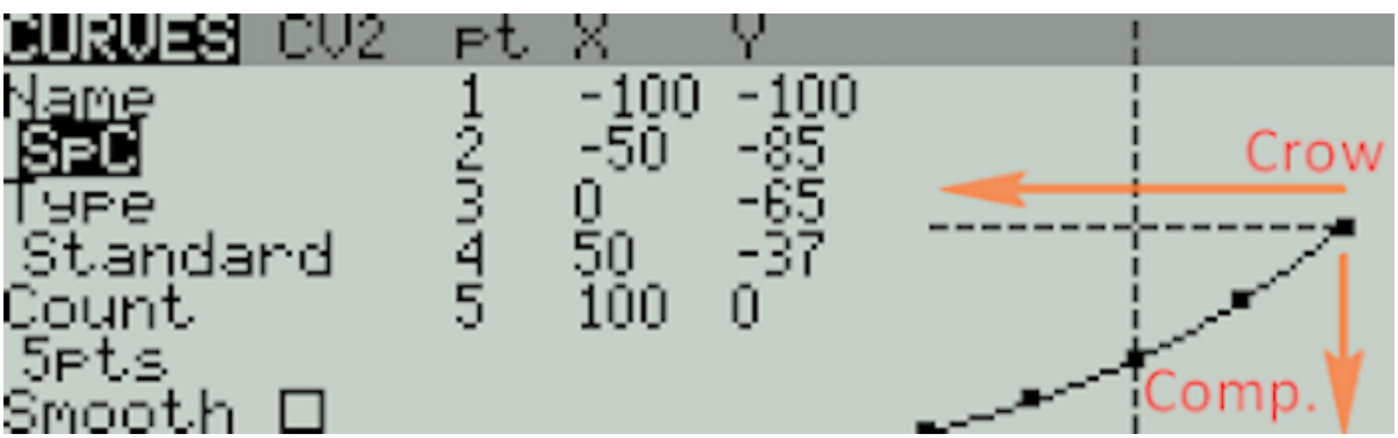


Figure 2: Crow compensation curve on author's Stribog F3F model.

The problem is that adjusting the curve can take several flights to get right. But hey, why not just *use the trim to bend the compensation curve*? For such a system to be useful, it would need to be completely transparent.

Turns out that with the help of Lua, a practical solution is possible. I call it the 'crow aware adaptive elevator trim'. A bit of a mouthful, I admit, for what is essentially a continuously variable trim system!

The solution, in three parts

There are three parts to the solution. The first is to decouple the elevator trim from the elevator stick — easily achieved in OpenTX. Once freed from its normal duties, the trim behaves like a dumb (double-throw) switch.

The second part is getting the trim to bend the compensation curve. This is where Lua comes in…

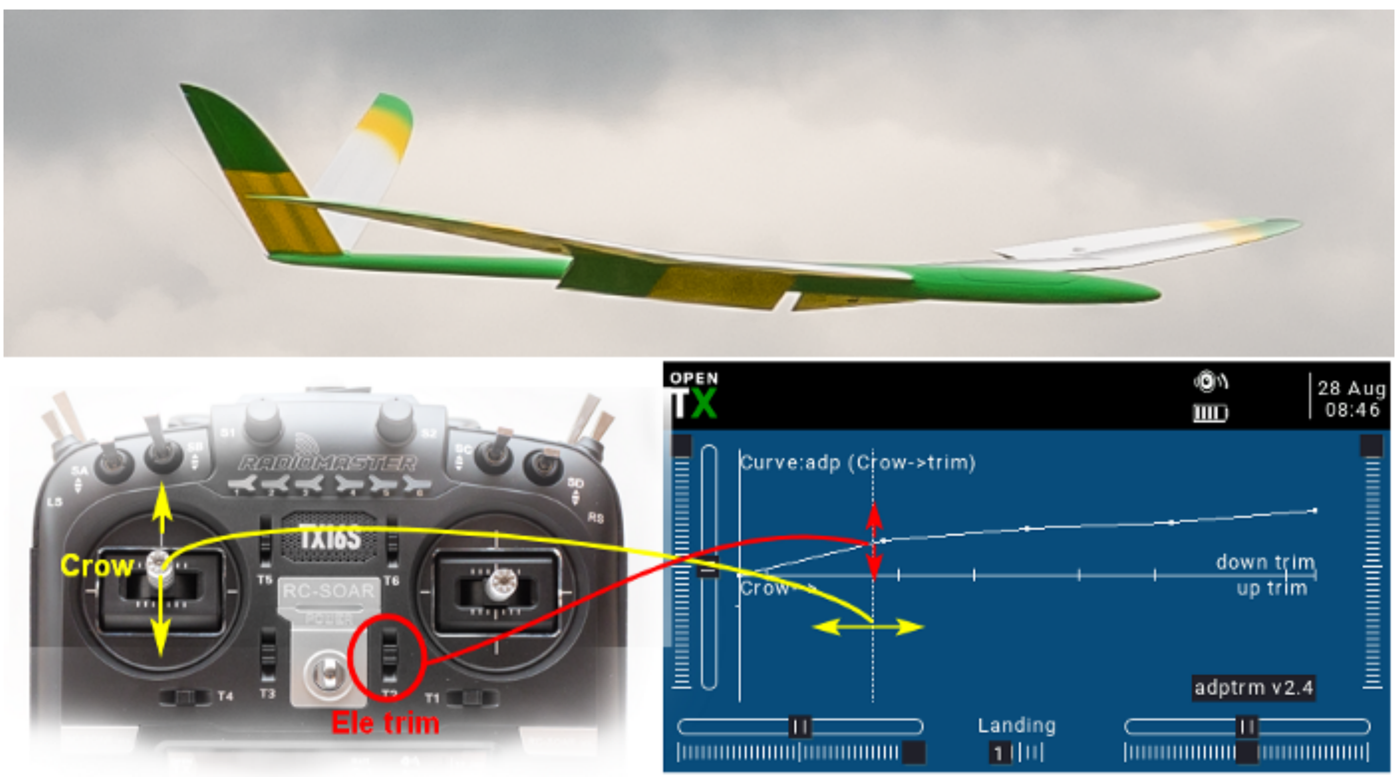


Figure 3: Crow aware trim system. Bottom right shows live view of compensation curve.

The script runs in the background under the control of OpenTX. When a click is detected, the main part of the script springs into action; it determines the crow setting, recalculates the compensation curve, then writes back the updated curve. The key API call is:

```
model.setCurve (cv_idx, {name=cv.name, smooth=1, y=pt_y})
```

As far as I'm aware, there's no equivalent to the `Model.setCurve()` function in other systems, so this is an application where OpenTX has a unique advantage.

The third and final part is to assign the compensation curve to a crow-to-elevator mix. The output of the mix is the crow compensation.

Using this script it's possible to optimise the crow trim before a new model's first landing. The script in use by several pilots and is available for download from my website OpenTX Clinic (see links).

Summing Up

I hope this has given you a flavour of OpenTX — both its simplicity and its power. I won't pretend that it's all roses — the overview I've presented has of necessity been greatly simplified. However, if you're technically inclined, you'll find it a uniquely capable and satisfying operating system.

Finally, I'm eternally grateful to the developers for their continued commitment to this project. OpenTX has been the mainstay of my soaring activity for almost eight years — as it has been for thousands of modelers around the world controlling everything from drones to competition F3X models. Long may it continue!

Additional Resources

- OpenTX.org — home of OpenTX
- OpenTX Clinic — author's site, with sailplane templates and tutorials:
- Crow Aware Trim Script

- List of Interactions for an F3F Model

All photos and figures by Michael Shellim. Read the ***next article*** *in this issue, return to the* ***previous article*** *or go to the* ***table of contents****.*

1/3rd Scale Mita Type 3 Production Notes

The first part of a multi-part series.

Norimichi Kawakami

This article was translated from the original Japanese by the author.

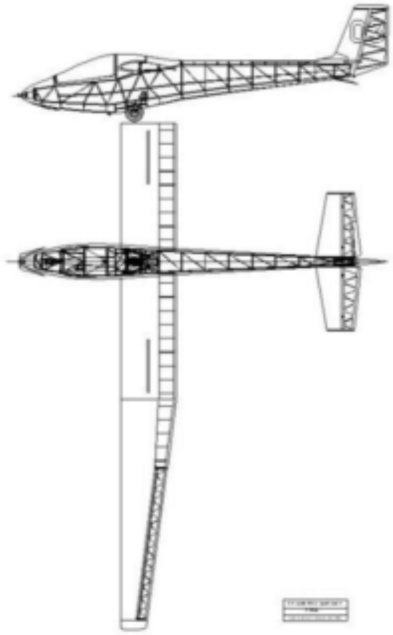
Utsunomiya City, Tochigi Prefecture, Japan

Nowadays, the mainstream to enjoy radio-controlled aircraft is to assemble a ready-made semi-finished aircraft (so-called ARF aircraft) , but one of the best parts of the RC hobby is to design your own aircraft, cut out the parts from the materials and assemble it by yourself. Collecting the aircraft's data and studying them, making drawings and revising them until you are satisfied, cutting parts and assembling them through overcoming many obstacles and unexpected mistakes, you can finally build your favorite aircraft. You will be satisfied with a sense of accomplishment that you can't experience with ARF aircraft and you will be attached to the aircraft.

He may used to enjoy building toys when he was a kid, but as grew up, he doesn’t have the opportunity to do so anymore. What is more, as many ARF products are readily available today at a reasonable price, there are many people who hesitate to start building their own products. Although there are many articles of self-made aircrafts on RC magazines, they usually do not describe how they dealt with the many considerations that arise in the design and building process and how they overcame the inevitable mistakes in the project. Therefore, the readers tend to think that it was made by a person who is very good at craftsmanship and it is far away from them.

It was the same with me. I had been away from model making for several decades since junior high school. I started my hobby of RC airplanes just after I retired. At first I enjoyed assembling ARF and building balsa kit airplanes, but a strong desire to design and manufacture my own airplanes from scratch has gradually grown. So, for the first time in decades, I took up the challenge of making drawings with a 2D CAD and cutting parts from materials with cutters, saws, and files and assembling them. There were many things to consider in the design stage, and I made many mistakes in the fabrication stage. I believe that reporting the process without hiding would be helpful to those who are interested in making their own products. This is the reason I am writing this article. I hope you will enjoy reading this article, even if it is a bit long and I hope it will give a push to those who are hesitant about building their own RC.

The subject of this article is a 1/3 scale Mita Type 3 revision 1 glider that was introduced in the November 2019 issue of Japanese RC magazine “RC Technology（ラジコン技術）”. It is a large plane with a wingspan of over 5.3 meters, and is the second plane that I designed and built completely by myself.



How It All Started

After retiring, I took up RC airplanes as a hobby. There are many types of airplanes, but I am particularly fascinated by the elegant flying style of gliders. Among the many different types of RC gliders I have built, the 1/5 scale Mita Type 3 revision 1, which I built from a kit from Thermal Studio, has become one of my favorites.

The photo below was taken on her first flight just before landing. As I was so impressed with its graceful appearance I wanted to buy a larger 1/3 size. Because no kit was available, I decided to make it by myself.

Photo 1: 1/5 scale Mita Type 3 rev 1 made from Thermal Studio's kit.

Aircraft Survey Part 1

I immediately started a survey of the actual Mita Type 3 at the end of 2017. I found that the owner of JA2103, which was the original aircraft of the 1/5 kit of Thermal Studio, lives in my city Utsunomiya. I contacted him, Mr. Kimura, and visited his house at the end of the same year. Unfortunately, he had donated the aircraft to the Shizuoka University of Science and Technology's Aviation Museum, so I was unable to see it. However, he gave me a CD with valuable photos of each part of the aircraft taken during the time he owned it, which helped me a lot in the design process.

In parallel with this survey, I began full-scale two-view drawing of the 1/3 scale using CAD, based on the 1/5 three-view drawing. Its purpose was to clarify any unclear points that needed to be surveyed. Unfortunately, I am not able to use 3D CAD, I used 2D AR_CAD, a free software.

Aircraft Survey Part 2

At the beginning of the year 2018, the Kanto region was hit by a rare heavy snowfall. 3 days later, I visited the Shizuoka Aviation Museum near Shizuoka Airport to investigate the actual aircraft. As expected, there was no snow at all. I was able to see the actual Mita Type 3 rev 1 for the first time.

Photo 2: The actual Mita Type 3 rev 1 JA2103 at the Shizuoka Aviation Museum (borrowed from the internet aviation magazine HIKOKI-KUMO)

My first impression was that it was smaller and slimmer than I had expected. I imagined the diameter of the steel pipes used for the fuselage to be about 30Φ, and started drawing with that dimension, but when I compared it with the photo on the CD that I received at the end of the last year, I had the impression that it must be smaller. By seeing actual aircraft, I was surprised to find that the biggest longitudinal longeron was 20Φ, and others were 15, 12, and 10Φ.

Thanks to the kindness of the museum staff, who took time out of their busy schedule to help me, I was able to understand how the center and outer wings are connected, how the wing is attached to the fuselage, and the leading edge shape and hinge positions of the ailerons. Nowadays anything can be found on the Internet, but I felt again that it is important to see the real thing and appeal to my senses.

I was greatly encouraged by the museum’s willingness to examine the actual object if there would arise unclear points in the design process and ask him through e-mails.

Photo 3 shows the connection between the outer and center wings. It was taken from the wing leading edge. The two wings are connected by big fittings protruding from both wings at a distance of about 10 cm. The connection is made by two shear bolts located at the height of the upper and lower spar flanges. The upper bolt is visible in this photo. The gaps between the wings are closed with a plastic cover.

Photo 3: Joint of the center and outer wings of the actual aircraft.

Photo 4 shows how the wing is connected to the fuselage. There are two fittings, front and rear, but this is the front one. Two bolts protruding from the square fuselage frame penetrate through the holes in the tongues of the two fittings which are attached to the wing web and are tightened with nuts. Lift and drag forces and rolling moment are efficiently transmitted to the fuselage.

Photo 4: Wing-fuselage joint of the actual aircraft (front side).

I was able to take a number of other valuable photos.

Actual Aircraft Data

Here, the actual machine data of Mita type 3 revision 1 is summarized as follows.

Form		Double-seat glider
First flight		March 26, 1966
Number of production		32
Structure	Fuselage	Steel tube truss covered with cloth
	Wings	Wooden single-spar covered with cloth. Consist of three parts: 1 center wing and 2 outer wings.
Main Characteristics	Wingspan	16m
	Overall length	7.96m
	Overall height	1.57m
	Empty weight	300Kg
	Gross weight	450Kg
	Wing area	15.87m2
	Aspect ratio	16.3
	Dihedral angle of the outer wing	3.45°
	Twist	Twist is provided on the outer wing, but its magnitude is unknown.
	Airfoil	NACA 633-618
Performance	Best glide ratio	30.8
	Best glide speed	78Km/h (single-seated) 82.7Km/h (double-seated)
	Minimum sink rate	0.72m/sec (at MaxGW)
Flight Limitations	Excess prohibition degree	180Km/h
	Stall speed	62.5 Km / hour (double-seated)
	Limit load factor	+5.0~-2.5
	Allowable center of gravity range	30% MAC ~ 40% MAC (312mm ~ 416mm from the front edge of the main wing)

These data will be used as a reference to determine the specifications of the 1/3 model.

Basic Concept of the 1/3 Model

Now that the basic survey of the actual model is complete, it is time to solidify the basic concept of the 1/3 model. As a policy, I decided to preserve as much as possible the image of the actual model and if necessary omit or simplify without destroying it. There are five items that must be defined as the basic concept as follows.

1. *How to divide the model?* How to divide the body and wings so that they can be carried by my Subaru Forester?

2. *How to make the fuselage structure?* The fuselage of the Thermal Studio's 1/5 model is made of laser cut plywoods, but I don't have a laser cutter.
3. *How to join the center and the outer wings?* The joining method of the actual aircraft is as described above, but should it be faithfully modeled or should a different method be used?
4. *What airfoil should be used?* Since the Reynolds numbers in flight are different between the actual aircraft and the 1/3 model, the aerodynamic characteristics of the airfoils such as lift and drag will change. Therefore, there is a concern that the performance of the actual airfoil will be degraded.
5. *How much is the target weight?* Weight control is important In the development of airplanes. Target weight must be set and the weight and center of gravity must be monitored during each process of design and building, otherwise overweight may result in unsatisfactory flight performance.

Above five basic items have been sequentially solidified as follows.

Basic Concept #1: Division of the Model

The actual aircraft is divided into 5 parts: center wing, outer wings (2), fuselage, and horizontal tail. In addition, the rudder can be detached relatively easily, so the fuselage length can be reduced slightly. The 1/5 model of Thermal Studio is divided basically the same way as the actual model

Now, the dimensions of each 1/3 model are as follows.

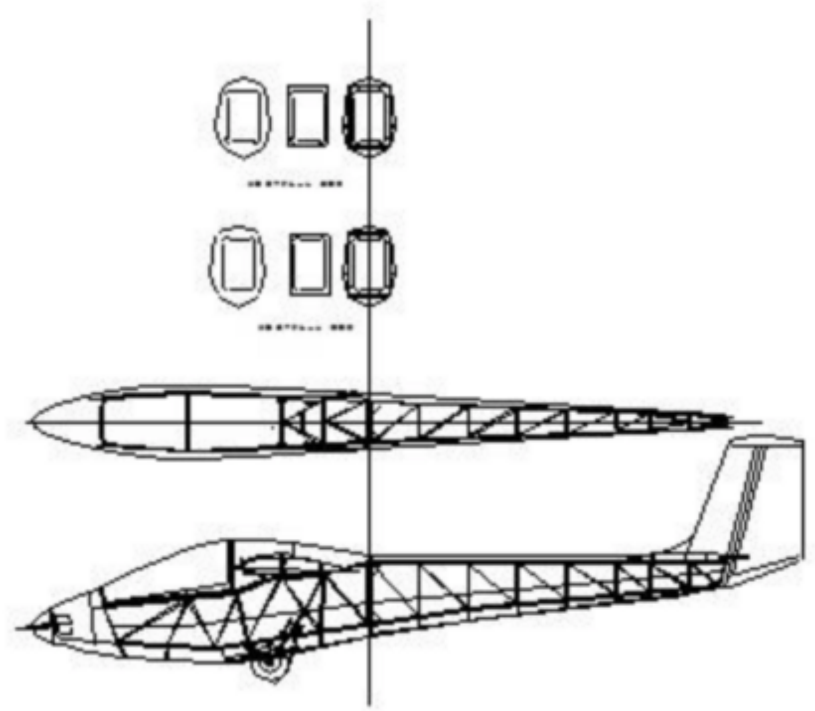
Central wing	2,000mm
Outer wing	1,670mm
Body	2,654mm (With ladder attached)
	2,526mm (With the ladder removed)
	2,394mm (With the vertical stabilizer removed)
Horizontal stabilizer	996mm

On the other hand, the carrying capacity of my Subaru Forester for long objects is as follows.

With the back seat down	1,600mm
When passing through the gap between the driver's seat and the passenger seat as above	1,700mm
When the passenger seat is knocked down and hits the dashboard	2,600mm
When hitting the windshield as above	2,800mm

Above conditions were used to determine the division method, but I worried a lot and went through many changes. The outer wings can be carried easily if they are placed through the gap between driver's and front passenger's seats. The problem is the center wing and the fuselage. In the beginning, I decided to simply fold down the front passenger seat to make the same division as the actual aircraft. However, it is best to carry the plane without folding the front passenger seat. If the center wing is split in two, it will not look bad and the length will be reduced to 1 meter. It is relatively easy to assemble by placing 2 or 3mm thick aluminum plates on the front and back of the webs and tightening them with bolts.

The problem is the fuselage. The fuselage is still too long even if the vertical fin can be removed, so it needs to be divided into two parts. If you divide the fuselage into two parts just behind the trailing edge of the main wing, the front fuselage will be about 1,200mm and the rear fuselage will be about 1,200 to 1,300mm. Drawing 1 shows how to split the fuselage in this way.



Drawing 1: Fuselage split plan

The idea is to make two frames of almost the same shape at the end of the front body and at the leading edge of the rear body, using 4mm and 5.5mm thick plywood respectively, and connect them with four M4 bolts at the four corners.

The 5.5mm plywood will provide the strength, and the 4mm plywood will maintain the outer shape. I decided to go ahead with this for quite a while, but the main disadvantage of this method is that the beautiful cloth covered fuselage will have a clear dividing line.

Furthermore, no matter how flat the plywood frames are, the tension force of the cloth will cause their distortion and a gap will appear in the dividing line. This is a big disadvantage to a scale aircraft. Also, weight of the rear fuselage will increase by a little less than 200g due to this division. Even if this is not the case, I was worried about the aft center of gravity, so I decided to avoid this idea.

Finally I decided to give up the idea of dividing the fuselage into separate sections. Giving up the idea of dividing the fuselage meant that the front passenger seat would be folded down, so I also decided not to divide the center wing. In the end, I went back to my original plan and decided to divide the model into seven parts: center wing, two outer wings, fuselage, horizontal tail, vertical stabilizer, and rudder.

Basic Concept #2: Fuselage Structure

The fuselage structure of the 1/5 model of Thermal Studio is a complex and elaborate combination of laser cut panels of plywood. The structure is light and has high rigidity. However, I don't own a laser cutter and even if I were to rent a cutter by the hour, it would take a lot of time and cost a lot due to the complex structure.

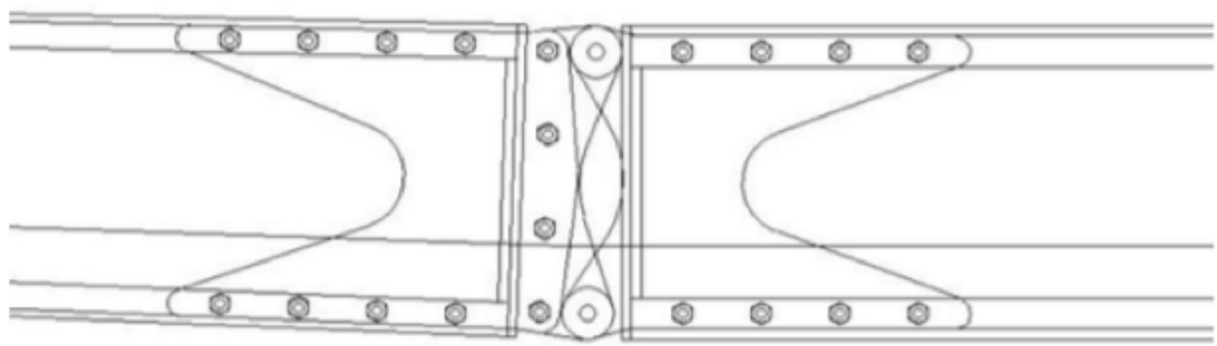
So this time, I decided to use carbon pipes to build a truss structure similar to the actual aircraft. Initially I thought about using aluminum pipes, but I chose carbon because it is lighter, more rigid, and available in various diameters. Another advantage of carbon pipe is that it can be easily glued with CA or epoxy adhesive. However, it may be a little difficult to cut, but preliminary experiments with a diamond cutter obtained from a hundred-yen store (one-dollar store) attached to a mini-router showed that it was rather easy to cut!

I hoped this would allow me to reproduce more realistically the image of the actual steel pipe truss structure.

After the completion of this model, I submitted an article to the Scale Soaring UK (SSUK), and this carbon pipe fuselage structure attracted a lot of attention. It was also evaluated as a breakthrough if this method can withstand landing loads. So far, there have been no cracks or peeling of adhesives, and the structure is fully usable.

Basic Concept #3: How To Connect the Outer and Center Wings

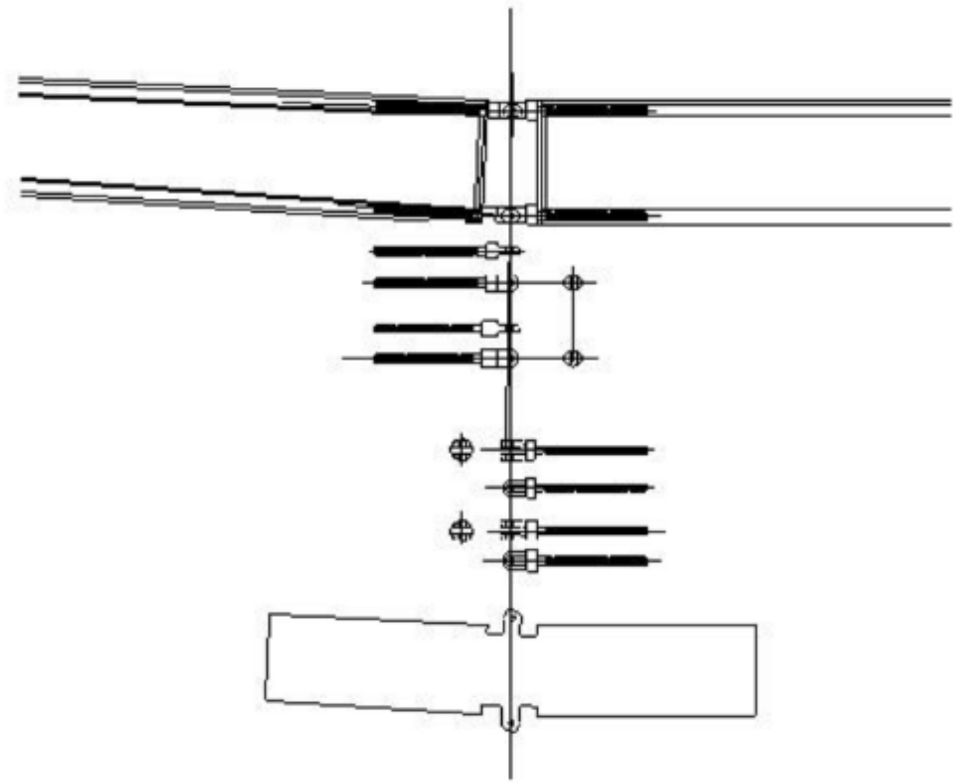
In the actual aircraft, there is a gap of about 10cm between the outer wing and the center wing, as mentioned earlier. The joint fittings extend from the both wings and are fastened with two shear bolts. Initially, I thought that since I was building a large 1/3 scale model, I would try to make it as similar as possible to the actual aircraft and planned a similar joining method. Drawing 2 is the first model I came up with to simulate the actual aircraft.



Drawing 2: Initial concept of the connecting method between the outer and center wings.

The fittings bolted to the flanges of both wings are stretched out and connected with two coupling bolts. This is the most typical method of joining the two wings, but a milling machine is required to make these fittings. One of my RC friends is good at metal processing and I sometimes ask him to make special fittings, but he only has a mini-lathe. I could ask a metal fabrication shop to make the fittings, but it would be quite expensive.

So, the next idea was to use the metal fittings that can be made only with a mini-lathe, as shown in Drawing 3.



Drawing 3: Connecting method of outer and center wings that can be made only with a mini-lathe.

The flanges of both wings are made of carbon square pipes, and four bolts are inserted into the pipes and glued into place. The plate at the bottom is a jig to accurately set the dihedral angle of the outer wing during assembly. With this method, although the flat part of the bolt head needs to be filed by hand, it can be made with a mini-lathe. At first, I thought it would be a good idea to proceed with this idea. The problem, however, was the plastic cover to close the wing gap. As I have no experience in making plastic parts, I am not very good at making a cover that fits perfectly into the sharp curve of the leading edge and figuring out how to attach it.

Finally, I decided to connect the two wings with carbon pipe, which is a common practice in RC airplanes, for the sake of appearance and ease of assembly and disassembly. Therefore, the two wings are perfectly aligned without any gaps. However, the metal fitting method has a high quality appearance that sets it apart from ordinary RC models, I was left with some regrets.

Basic Concept #4: Airfoil

The actual airacraft's airfoil is the NACA 633–618 developed by NACA, the predecessor of NASA. I had forgotten the nomenclature of the 6 series, so I reconfirmed it here.

The first 6 means that it is a 6 series (laminar flow airfoil series). A laminar airfoil series shifts the position of the lowest pressure on the upper surface backward by placing the maximum thickness of the airfoil relatively back. By doing so, the airflow from the leading edge to the maximum thickness is accelerated, and the air flow in that area is maintained as laminar flow (neatly organized flow) to achieve an airfoil with low drag. The next 3 means that the minimum pressure is set at 30% of the wing chord length from the leading edge. The next number 3 is a counterpart to the 6 that follows. In other words, the fourth number 6, means the design lift coefficient and the 3 in front of it tells us that the drag is low in the range of ±0.3 around the design lift coefficient. In other words, the design lift coefficient of this airfoil is 0.6 and the drag is low in the range of 0.3 before and after the design lift coefficient, that is, in the range of 0.3 to 0.9. The last two digits 18 refer to the wing thickness which means that the wing thickness is 18% of chord length.

In general, the aerodynamic performance (maximum lift coefficient and drag coefficient) of an airfoil becomes better the longer the chord length and the higher the flight speed. In other words, the greater the product of wing chord length and flight speed, the better the aerodynamic performance. The value of this product is called the Reynolds number Re, which is the product of the wing chord length and the flight speed divided by the kinematic viscosity of the air, written as $Re=(C*V)/\nu$, where C is the wing chord length, V is the flight speed, and ν is the kinematic viscosity of the air, with a value of 1.50E-05 m2/sec. The Reynolds number Re is the ratio of the inertial and viscous forces of the air on the airfoil. In other words, the larger the Re, the less the effect of viscosity and the better the aerodynamic performance of the airfoil.

The problem that arises is the difference in Reynolds number between the actual aircraft and the 1/3 model, so let's examine this next. The wing chord length C of the actual model is 1.2m in the center wing, and the outer wing tapers from 1.2m to 0.54m. The typical wing chord of such a tapered wing is called Mean Aerodynamic Chord (MAC) and in the case of the Mita, the MAC is calculated to be 1.04m. In contrast, the MAC of the 1/3 model is 1/3 of that, or 0.347 m.

Next, let's consider the flight speed V as the best glide speed. The best glide speed of the 1/3 model is not yet known, but the approximate value is estimated as follows. The lift force L acting on the wing during glide is balanced by the weight W of the aircraft. The lift force is given by $L=1/2\rho V^2*S*CL$. where ρ is the air density, S is the wing area, and CL is the lift coefficient. Since the lift force L is balanced with the weight W, we can replace L with W and transform the equation to $V=2*\sqrt{}(W/S)/(\rho*CL)$

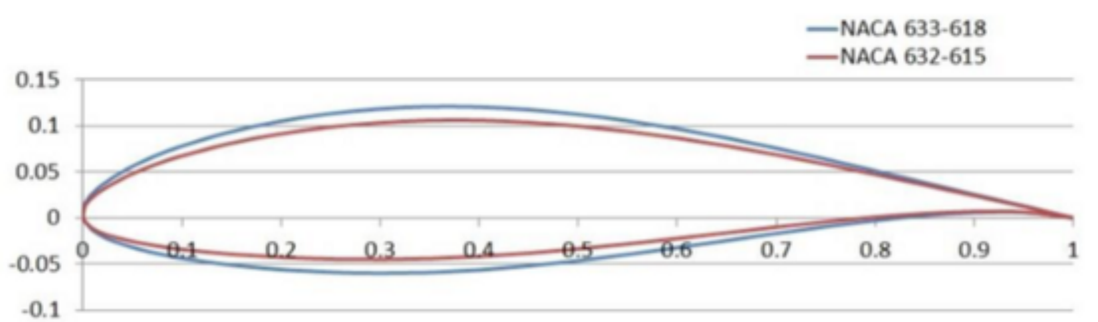
The air density ρ is the same for both the actual aircraft and the 1/3 model. The lift coefficient CL is also not so different. Then, the flight speed V is proportional to the square root of W/S, that is, the weight per unit area (wing loading). The wing loading of the actual aircraft is W=450Kg and S=15.87m2, which gives W/S=28.36. The weight of the 1/3 model is still not exactly known at this stage, but it should be less than 10 kg, as will be discussed in the next section, "Basic Concept #5 Target Weight". Let's assume W=10Kg, and S=1.76m2, so W/S=5.68. Therefore, the square root of the wing loading of the 1/3 model is 0.445 of that of the actual aircraft, and the best glide speed is about 0.44 times that of the actual aircraft, or about 10 m/sec.

Based on the above, the Reynolds numbers of the actual model and the 1/3 model are approximately as follows.

Actual machine Re = 1.04 * 23.0 / 1.50E-05 ≒ 1.6E + 06 = 1,600,000

Model Re = 0.347 * 10 / 1.50E-05 ≒ 2.3E + 05 = 230,000

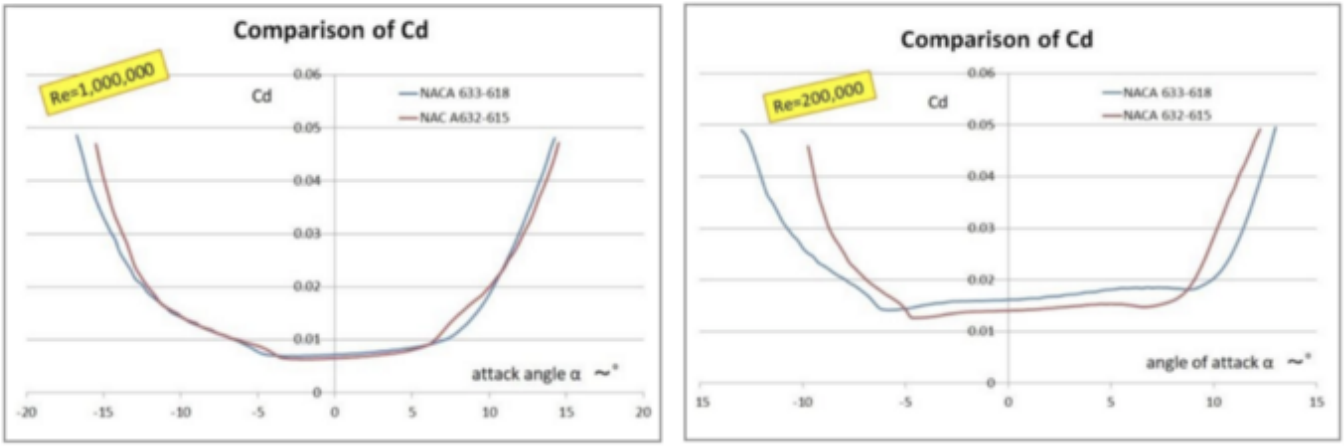
In other words, the aerodynamic performance of the airfoil is expected to be much worse than that of the actual aircraft, since the model has a Reynolds number of 230,000 compared to the actual aircraft's 1,600,000, which is about 14% of the actual aircraft. Therefore, I wanted to adopt an airfoil that has good aerodynamic performance as much as possible with the Reynolds number and does not destroy the silhouette image of the actual airfoil. It's the NACA632–615. Both airfoils are shown below.



Drawing 4: Airfoils comparison

The difference in silhouette is almost imperceptible when the cross section is not visible.

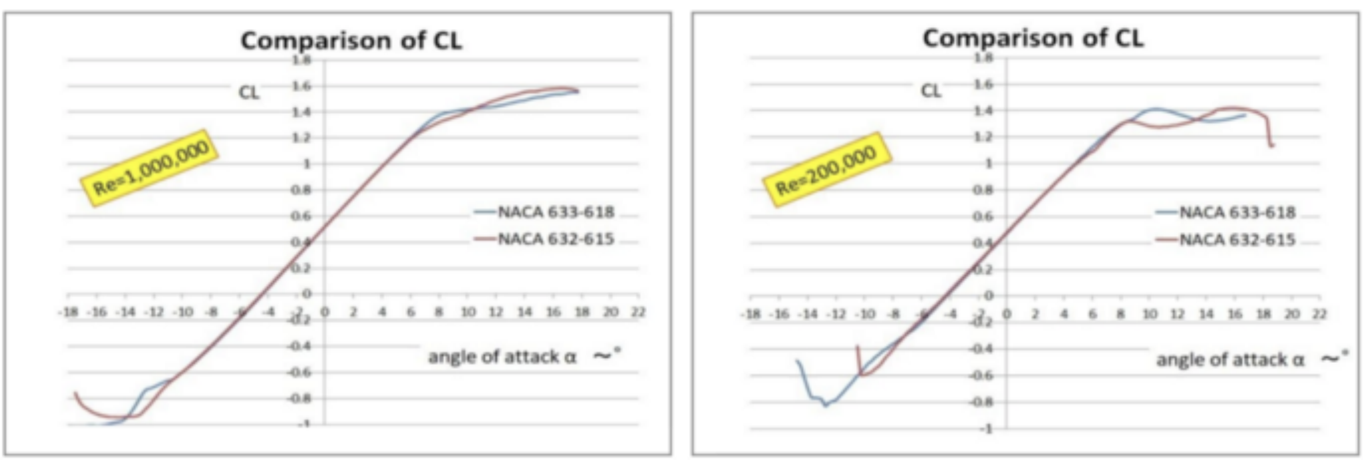
Next, let's compare the aerodynamic performance of both airfoils. The data I had at hand was 1,000,000 and 200,000 Reynolds numbers, so I use 1,000,000 as the actual Reynolds number and 200,000 as the 1/3 model Reynolds number. First, let's compare the drag coefficient.



Graph 1: Comparison of drag coefficients for both airfoils

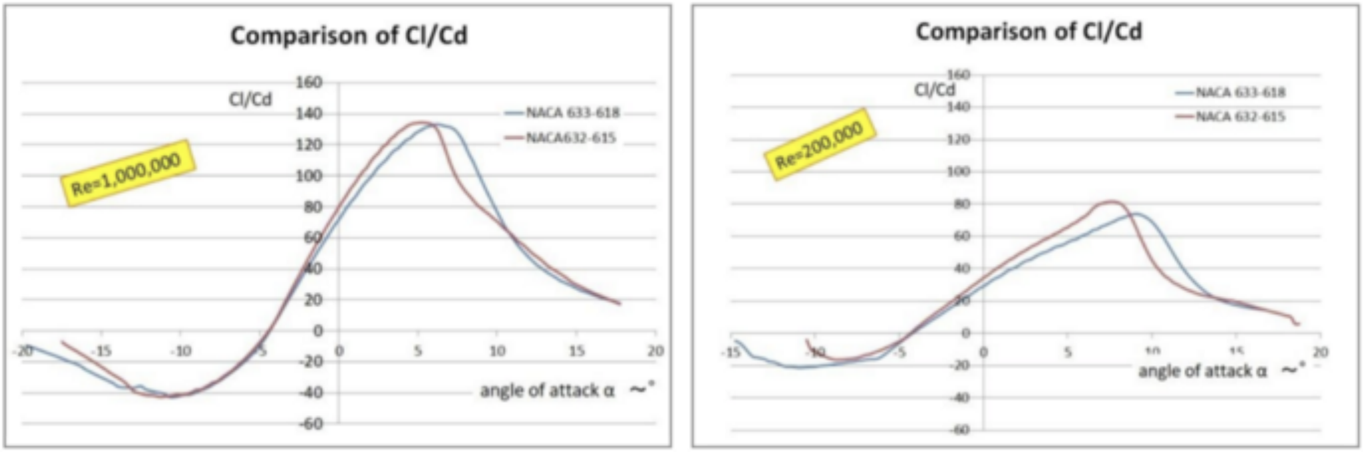
At the Reynolds number of 1,000,000, the drag coefficient of the two airfoils is almost the same, and it keeps a very small value of about Cd=0.007 between -4° and +6° angle of attack. On the other hand, at the model Reynolds number of Re=200,000, the drag coefficient of the actual airfoils 633–618 is 0.016 to 0.018 even at the low angle of attack which is more than double the value at Re=1,000,000. On the other hand, for 632–615, the value is only doubled to 0.014–0.015.

On the other hand, the lift coefficient is almost the same for both airfoils, whether Re = 1 million or Re = 200,000, as shown below.



Graph 2: Comparison of lift coefficient for both airfoils.

From these data, the lift-drag ratio (CL/Cd), the ratio of lift to drag that is important for gliders, is as follows:



Graph 3: Comparison of lift and drag coefficients for both airfoils.

At Re = 1,000,000, the lift-drag ratios of both airfoils are almost the same, and the maximum lift-drag ratio is over 130. At Re=200,000, the 632–615 clearly shows better characteristics up to the stall angle around 7.5° angle of attack due to the difference in drag coefficient. The maximum lift-drag ratio of the 632–615 is 81.6 and that of the 633–618 is 72.2, with the former being about 13% better.

From the above, it is clear that there is almost no difference in performance between the 18% and 15% airfoils at the actual aircraft's Reynolds number. The thicker the wing, the easier it is to secure structural strength and rigidity, so it is easy to understand why the actual aircraft adopted the 18% wing section. On the other hand, since the maximum lift-drag ratio of the 1/3 model is drastically reduced to 72.2/132 = 0.55 of the actual one, I decided to use a 15% airfoil to keep the glide performance deterioration as minimum as possible.

Basic Concept #5: Target Weight

The last item in the basic concept was to determine the target weight. I intended to set the target weight by estimating the weight of the 1/3 model from the weight data of the actual aircraft and the 1/5 model I had.

Square/Cube Law

In the real world of aircraft development, when developing a new aircraft, the weight of the aircraft is sometimes estimated roughly at the very early stage of planning, where many things have not yet been decided, using a law called the "square/cube law". This is a method of estimating the weight of a new aircraft based on data from similarly shaped aircraft of known weight, where the area is proportional to the square of the size ratio (dimension ratio) and the weight is proportional to the cube. For example, the wing area of a similar aircraft of half the size would be 1/2 x 1/2 = 1/4, and the weight would be 1/2 x 1/2 x 1/2 = 1/8.

It is obvious that the area is reduced to 1/4, but the fact that the weight is reduced to 1/8 means that we assume both aircrafts have the same construction of the same material but length, width, and thickness are halved.

Initially, I used this square/cube law as a starting point and made the necessary modifications to predict the weight of the 1/3 model.

Points To Keep In Mind When Estimating the Weight of a Glider

When estimating the weight of an ordinary prop plane, it is enough to estimate the empty weight, but the situation is different for a scale glider. The empty weight of the Mita Type 3 rev 1 is 300 kg, but with no pilot on board, the center of gravity is too far back and of course it cannot be flown as an unmanned aircraft equipped with R/C equipment. 450 kg is the maximum full load weight with two pilots on board, so the weight (payload) is really half of the empty weight. This is a situation where the center of gravity is aligned. Therefore, to estimate the weight of a model glider, you need to consider both the empty weight and the payload.

All of my model gliders have a motor and foldable propeller in the nose. This is to make it easy to enjoy flying even on level ground. Naturally, the weight of such equipment, which is not included in the actual model, is treated as payload. The weight classification of the equipment on the model glider is as follows.

Payload treatment	Motor, folding propeller & hub, LiPo for power, amplifier, receiver, power supply for receiver & S / W
Treated as empty weight	Servo, extension cord for servo

The servos and extension cords are treated as empty weight because the links and cables of the control system are also included in the empty weight of the actual aircraft.

Weight Data of the Actual Aircraft and the 1/5 Model

The empty weight and payload weight of the actual machine and the 1/5 model are as follows:

	Actual Machine	1/5 Model
Empty weight	300Kg	2.10Kg
Payload	Up to 150Kg	0.665Kg
Flight Weight	Up to 450Kg	2.77Kg

The materials and construction style are quite different between the real aircraft and the 1/5 model, but if we forcefully apply the square/cube rule to the real aircraft, we get:

1/5 Model Predicted Empty Weight = 300 × 1/5 × 1/5 × 1/5 = 2.40Kg

Maximum payload = 150 × 1/5 × 1/5 × 1/5 = 1.20Kg

It is surprising that the empty weight is close to the actual measured weight of 2.10 kg. The actual empty weight of the model is finished at 87.5% of the predicted value. The payload is only a little over half of the maximum payload prediction because of the heavy motor mounted in the nose. In this condition, the center of gravity is O.K. without additional weight.

Predicted Weight of the 1/3 Model (Initial)

Initially, using this square-cube law, I predicted the weight of the 1/3 model as follows.

1. Empty Weight

Predicted from the data of the actual machine	300Kg×1/3×1/3×1/3=11.11Kg
Considering the difference in structure and materials between the two, and assuming 87.5% of the above predicted value in accordance with the actual results of the 1/5 model	
	11.11×0.875=9.72Kg
Based on the 1/5 model, estimated value	2.10Kg×5/3×5/3×5/3=9.72Kg
Of course both estimated values are the same	

2. Payload

Payload without weight is estimated from the actual value of 1/5 model 0.665Kg × 5/3 × 5/3 × 5/3 = 3.08Kg
Assuming that the maximum payload is half the empty weight like the actual machine, 9.72Kg x 0.5 = 4.86Kg

From the above, the flight weight is as follows.

During normal flight without weight	9.72+3.08=12.80Kg
At maximum full weight with weight	9.72+4.86=14.58Kg

Revised Estimated Weight of the 1/3 Model (Target Weight)

In the beginning, I predicted the weight as above, but in the process, I noticed the following. When I drew the wing plans, I found that the thickness of the materials in the 1/3 model and 1/5 model did not need to be much different. The ribs, planks, etc. are almost the same as in the 1/5 model, 2 to 3 mm thick balsa is needed. The covering material, which is relatively heavy, will be the same since it will be covered with the Oratex. This means that the weight of these materials will increase by the square of the dimensions, not the cube.

Furthermore, the weight of the fuselage structure of the 1/3 model will not increase as much as the cubic law, since it will be assembled with carbon tubes as opposed to the plywood of the 1/5 model.

Based on the above, the weight of the 1/3 model is estimated by multiplying the 1/5 model by the square of the scale ratio. Since there is weight data of the main components of the 1/5 model, the values below are the weights of the main components of the 1/3 model estimated by the square law.

	1/5 Actual Weight	1/3 Estimated weight
Left outer wing (including aileron servo)	242g	672g
Right outer wing (same as above)	244g	678g
Central wing (including spoiler servo)	585g	1,625g
Fuselage (including tail wings and servo for it)	1,029g	2,858g
Total (empty weight)	2,100g	5,833g
Payload (motor, LiPo, etc.)	665g	1,847g
Remeasurement (normal flight weight)	2,765g	7,680g
Maximum total weight (empty weight x 1.5)		8,750g

After rounding, the target weight of 1/3 Mita type 3 rev 1 was set as follows:

	Target Weight
Left outer wing	700g
Right outer wing	700g
Central wing	1,600g
Body	2,800g
Empty Weight	5,800g
Payload	1,800g
Normal Flight Weight	7,600g
Maximum Total Weight	8,700g

> ***Mistake 1:*** *Unfortunately, as will be shown later, the finished weight has reached about 10 kg due to the installation of equipment such as landing gear shock absorber, instruments panel, seats, tow line release mechanisms, weights for aileron flutter prevention, wing tip wheels, etc. These were not equipped in the 1/5 model. There also applied material changes (e.g., the spar webs were made of plywood instead of balsa).*

> *From this painful failure, I keenly realized the necessity to develop a method for accurately estimating the final weight of a model airplane at the initial stage where only three views were available*
>
> *Later I developed a formula for estimating RC aircraft weight as below:*

$$W = 2151 L^{-0.11400} b^{-0.76204} S^{1.75388}$$

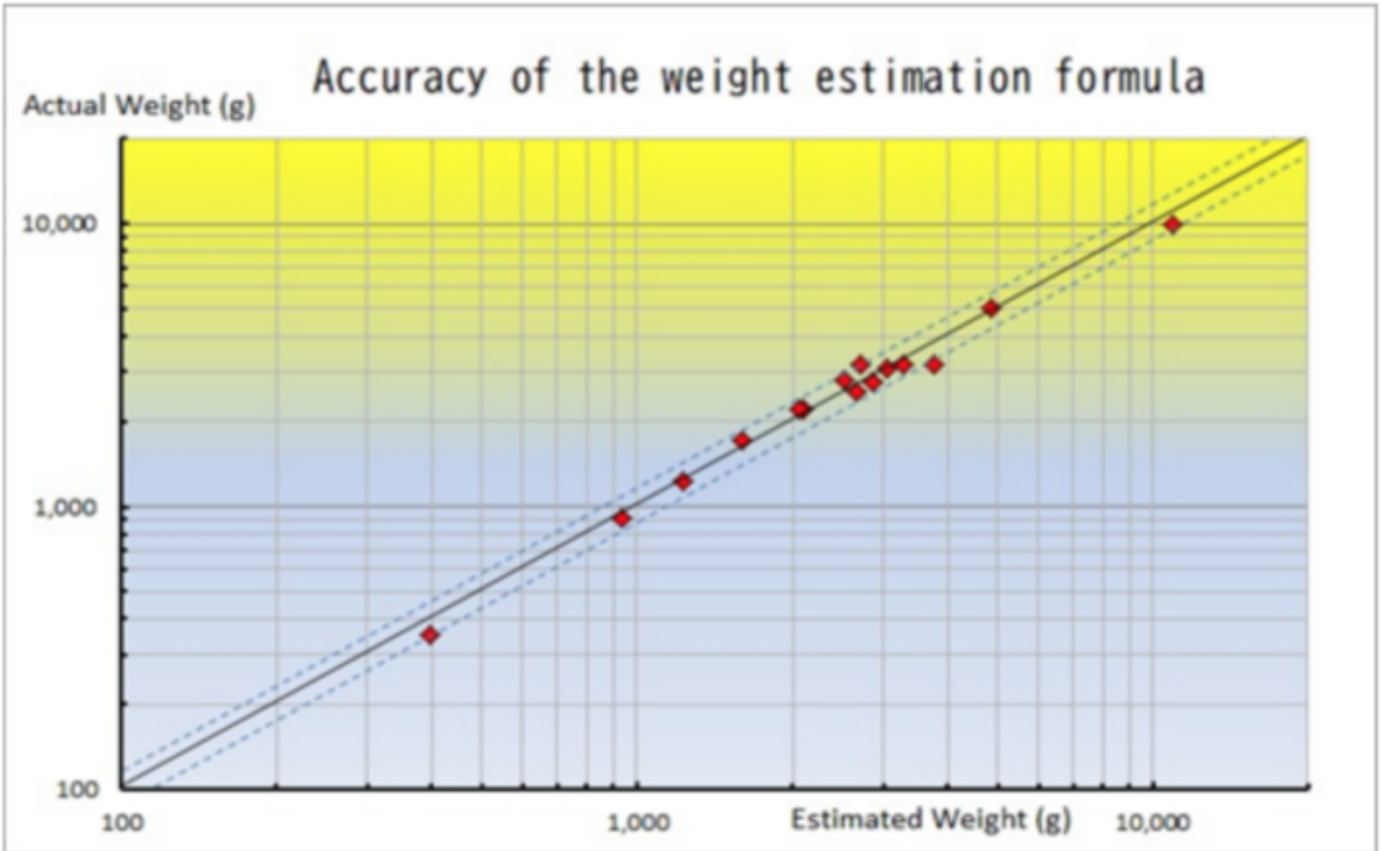
where, L is fuselage length in mm

b is wing span in mm

S is wing area in dm^2

W is weight in g

This formula estimates RC aircraft's total weight(all-up weight) with mean error of 8.7%.

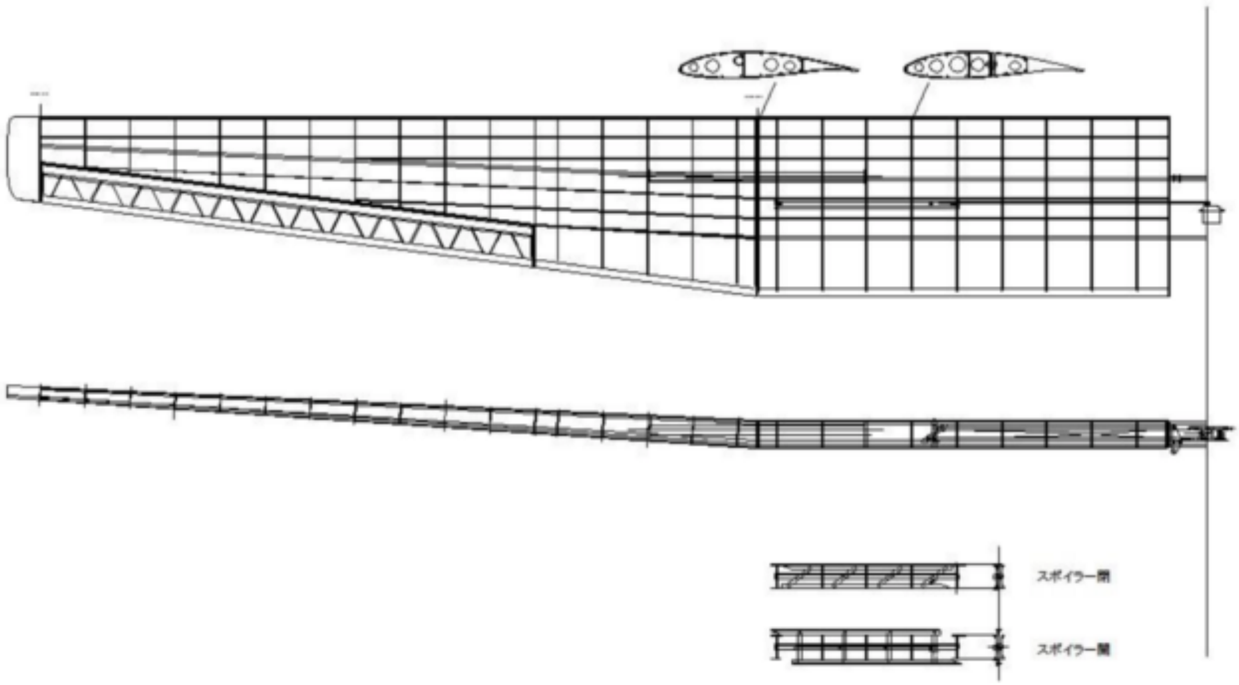


Start Of Design and Manufacturing

The basic concept is also settled, and it is the actual detailed design and production stage.

Main Wing Structure

This is the main wing composition of the 1/3 model designed in Figure 5.



Drawing 5: Main wing structure

The main wing consists of a center wing and two outer wings. They are connected by a carbon pipe with an outer diameter of 20mm, an inner diameter of 16mm, and a length of 480mm. The carbon pipes are supported by thin aluminum tubes with a thickness of 0.5 mm. At first, I could only find aluminum tubes with a thickness of 1 mm, so I bought them and proceeded with the work. However, when I was looking around my workshop, I saw a spare part for the tail boom of a RC helicopter. I measured the inside diameter and it was exactly 20mm! The thickness is also 0.5 mm, which is perfect for this design. This cut the weight in half.

The main spar passes through the thickest part of the wing, about 35% from the leading edge. The center wing has 6×4 carbon square pipe (6 mm square in outer dimension with a 4 mm diameter cavity inside) as the flange and 1.6t plywood web, and the outer wing is made of 5×4 carbon square pipe as the flange. These spars take most of the bending load and the shearing force. The strength calculation which will be shown later told that the main spar could be made of thinner flange, but slightly thicker one was used to ensure rigidity.

The auxiliary spar runs at about 67% of the wing chord. The structure is the same as that of the main spar, but the flanges are slightly thinner, and the center wing is made of 5×4 and the outer wing is made of 4×2.8 carbon square pipe. These auxiliary spars are paired with the main spars and transmit the torsional load of the main wing to the fuselage. The area in front of the auxiliary spar is fully planked with 2t balsa to secure torsional rigidity.

The rib spacing is 100 mm, which is rather wide, so to prevent the plank from yielding, four stringers (two on the top and two on the bottom) are used between the leading edge and the main spar, and same numbers of stringers are used between the main spar and the auxiliary one to increase the rigidity of the plank. The stringers are made of 2×5 balsa bars. In the actual model, auxiliary ribs are placed between the ribs between the leading edge and the main spar, instead of stringers, to maintain the critical wing shape around the leading edge. The reason why I did not adopt this method is that I had installed auxiliary ribs on a previous model, but it was difficult to accurately position them within the short distance between the spar and the leading edge. I had a hard time securing the parallelism of the upper surface of the wing with the auxiliary and main ribs. Unless a positioning jig is provided, it is difficult to accurately position the auxiliary ribs.

Most of the ribs on the center wing are made of 3t balsa, while the outer wing is made of 3t and 2.5t balsa. The mating surfaces of both wings are made of 2t hard balsa, and the innermost ribs of the center wing are covered with 1.6t protective ribs made of plywood.

The outer wing is tapered, so the ribs become smaller as they move outward. At first, I thought it would be easy to draw this proportionally because of the CAD system, but when I actually drew it, I realized that it would be troublesome. The theoretical airfoil has a sharp trailing edge, but if it is left as it is, it will easily dent when the model is hit, so it is necessary to add about 2 mm of thickness. This thickness must be constant regardless of the taper. This means that the airfoil must be modified for each and every rib.

In addition, the outer wing has a twist of 1°. Since the size of the twist on the actual aircraft is not known, this angle was set for the time being. The ribs have to be twisted gradually, but the troublesome part is the spar. If the spar is twisted at the same time as the ribs, the flange made of carbon pipe will be twisted. The carbon pipe has high torsional rigidity, so when the wing is removed from the jig after the assembly is completed, it is expected to be twisted back and the wing will be distorted. In order to avoid this, the ribs are placed in a gradual twisting pattern, but the spars don't. This required a lot of work. I was reminded that I should not underestimate anything.

Production Part 1: Spoiler

I started fabrication at the end of March 2018, starting with the parts for which drawings were ready. The first part to be fabricated was the center wing. This is because it is easy to fabricate since it has constant chord without taper, and also because I wanted to see how big the center wing with 400mm chord length and 2,000mm span actually is.

The spoiler is built into the center wing, so I started with the spoiler. The photo below shows the spoiler parts before assembly.

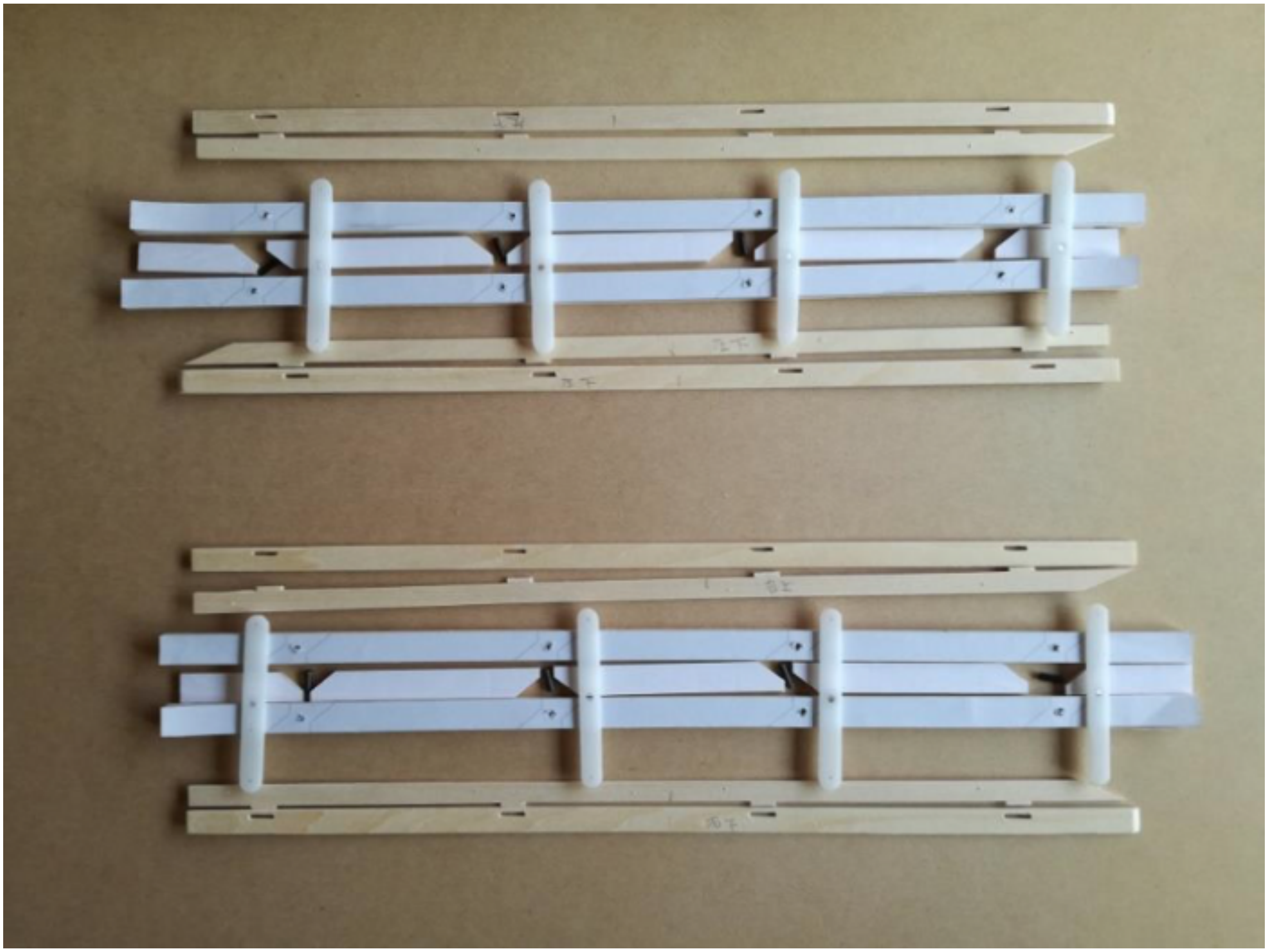


Photo 5: The spoiler parts that I started to build first.

The spoiler protrudes from the upper and lower wing surfaces of the center wing. 1.6mm plywoods are attached to the top and bottom of a 2mm thick acrylic stay to form a T-shaped drag plate, and the center of the stay is sandwiched between two 4mm balsa bars to make the entire structure move in a linkage fashion. The short bars cut diagonally are glued between the 4mm balsa bars to define the working range of the spoiler. Two pull-pull wires are attached to the innermost stay, with that the spoiler is operated by a servo.

> ***Mistake 2:*** *Actually, the structure is so simple that I underestimated it and made a mistake right away. I tried to move the assembled spoiler by hand, but it would not retract at the designed height. It protruded slightly from the upper and lower surfaces of the wing. I tried to fix it, but the*

> *structure is not accessible for modification.*

As I was trying to figure out the cause of the problem, I realized that the width of the acrylic stay was not accurate. In the process of making the acrylic stay, the width of the stay was not accurate by a few tenths of a millimeter. The working range of this spoiler is determined by the contacts between the acrylic stays and the short balsa bars cut diagonally. I was able to cut out the balsa bars accurately in one shot, but I had to cut the acrylic stays a little larger due to the nature of the material, and then file them down to get the right size. I ended up filing the acrylic stays a little larger than the drawing dimensions, so they came into contact with the balsa bars at a smaller angle than on the drawing, and could not be stored properly.

This was a shameful mistake because I drew the plans myself. I ended up rebuilding the spoiler.

> ***Mistake 3:*** *The design of the spoiler turned out to be the biggest failure in the development of this aircraft, as I found out in the flight test after completion. The amount of protrusion of the spoiler was insufficient.*

I thought if the spoiler protruded even a little from the surface of the wing, the air flow would be disturbed and the drag of the main wing would increase significantly, which would have a spoiler effect. Therefore, I didn't pay much attention to the amount of protrusion, and designed the spoiler protrusion of less than 12mm without measuring the actual aircraft's protrusion.

In fact, I learned later that the spoiler not only increases the drag of the main wing, but also acts as a brake with its own drag to reduce the speed of the aircraft. In order to do this, the spoiler needs to protrude far from the wing surface, out of the boundary layer. The spoiler I designed worked well to adjust the descent angle due to the increased drag of the main wing, but it turned out to be insufficient to control the landing speed due to the poor braking effect .

When I presented this model to Mr. Kimura, who owned the actual model, after its completion, he immediately pointed out the lack of spoiler protrusion. I regretted that the spoiler protrusion should have been twice as large as it was, but it was too late.

> ***Lessons Learned 1:*** *Eliminate your own assumptions and do thorough research if you lack knowledge.*

*This is the first part in a series. Read the **next article** in this issue, return to the **previous article** in this issue or go to the **table of contents**.*

Contour Gauge

The shape of things to come?

Tom Broeski

Assembled contour gauge ready to use.

I needed a contour gauge a bit deeper than what is available (for a reasonable price) at Home Depot, Walmart or Harbor Freight. Most have a measuring depth of around 2". Soooo...I made exactly what I needed.

Photos 1 and 2: The part required and the configuration of the strips used to hold the sticks.

Materials

- A bunch of sticks.
- (2) 1 inch to 1.5 inch x 1/4 inch strips. Whatever length you want the gauge to be.
- (2) Machine screws with nuts.
- (2) Plastic tubing cut to width of sticks. These slip over the screws, but are not needed for skewers or small sticks.

Photos 4 and 5: Just one potential use of the finished contour gauge in use.

You can use skewers, popsicle sticks, stirring sticks, tongue depressors, etc. I found that tongue depressors are thinner than popsicle sticks, so decided they would be best for my application. I use it mostly for woodturning, but figured it would come in handy for copying other profiles.

Just cut your strips to length, drill holes for the screws, add the tubes and screw together. Then you can stack your sticks in and adjust the tightness. You want it loose enough that the sticks will move, but not so loose that they fall out.

Photo 6: That wing saddle is going to fit absolutely perfectly.

Need to get the airfoil shape for a specific part of a wing? Not many other ways to do it. The thinner the sticks, the smoother the contour. Really nice if you need to get the shape of a rib for a built up plane when you don't want to rip the wing apart or don't have the plans.

*All photos by the author. Read the **next article** in this issue, return to the **previous article** or go to the **table of contents**.*

A Torrey Pines Puzzle

Never miss an opportunity to ask your folks a question.

Terence C. Gannon

One of the four tantalizing clues that Dad left behind. (image: Dr. R. Patrick Gannon)

My father was an institutional physician, which is to say that while our family never lacked for any necessity, we were in no way wealthy. Dad prized time with his family above all else and he was going to be damned if some high paying, private practice position was going to keep him from that. He made professional choices in the 1950s which would look positively modern in the 2020s. I'm eternally grateful to Dad for that because it meant that I, along with my mother, brother and sister, got the lion's share of Dad's attention over the decades we shared here on this planet.

"the magnificent Torrey Pines bluff which tumbles down to the sea" (image: Dr. R. Patrick Gannon)

The one exception to Dad's 'family first, everything else tied for last' life philosophy was the very occasional professional requirement to attend medical conferences. Remember those? When a bunch of people got together in the same room at the same time separated by way less than the now normal two metres? Yep, Dad would head off on his own to some exotic location for a couple of days to attend what we call today a face-to-face. He would complain about it a lot before he left, but I have a suspicion that he actually enjoyed those trips, particularly when the destination was somewhere he really wanted to go.

Dad wound up in San Diego at one of these conferences in the early 1970s — that is, judging from the mud-brown Pinto he rented. Undoubtedly inspired by its cameo in Disney's *The Boy Who Flew With Condors*, he must have ditched one of the scintillating but undoubtedly stuffy seminars on noise-induced hearing loss (yes, that was his specialty). In his suddenly free afternoon, he must have then sneaked out to Torrey Pines to indulge his intrinsic passion for all things that fly — particularly those without a motor. How do I know that, for absolutely sure? In a recently resurfaced family photo album, four tantalizing clues emerged: four pictures Dad had obviously taken when he was there.

If you look closely, you can clearly see the cylinder of the engine, but no prop. (image: Dr. R. Patrick Gannon)

Looking at the photos, I began to remember him telling the story of the sole occupant above the magnificent Torrey Pines bluff which tumbles down to the sea. It was an old timer, a description which applied equally and aptly to both the pilot and the plane. Dad, who loved to chat with people he found interesting, most certainly would have struck up a conversation with the gentleman while he improbably removed the prop from his gas-powered model. Yes, it turns out the old guy's plan was that lacking a true glider, he was prepared to turn the one plane he had on hand into one. There is photographic evidence to indicate that the 'glider' must have done pretty well.

"photographic evidence to indicate that the 'glider' must have done pretty well" (image: Dr. R. Patrick Gannon)

If you have made it this far, there's a question I want to ask you, dear reader, particular if you are local to Torrey Pines: do you remember this elderly gentleman and his equally elderly model? If so, is there anything you can tell me about him? I would love to know. I'm pretty sure Dad would have extracted all of those details at the time but, sadly, with Dad's passing a couple of years ago, I'll never know for sure. For reasons I am not able to fully explain — which is to say, I don't understand why it matters but it does — I would really like to know.

I know somewhere Dad is looking down from that amazing thermal he caught on his way out of here, and laughing a little at the little puzzle he left behind, and shaking his head a little that I didn't think to ask when he was still here.

Miss ya', Dad.

Know something about the elderly gentleman and his plane? Write a response to this article and let the world know! Or, maybe considering writing a brand new followup article. Or, if you prefer read the ***next article*** *in this issue, return to the* ***previous article*** *or go to the* ***table of contents***.

Thanks to Hedy Lamarr

Inspiration and innovation in the Golden Age of Hollywood.

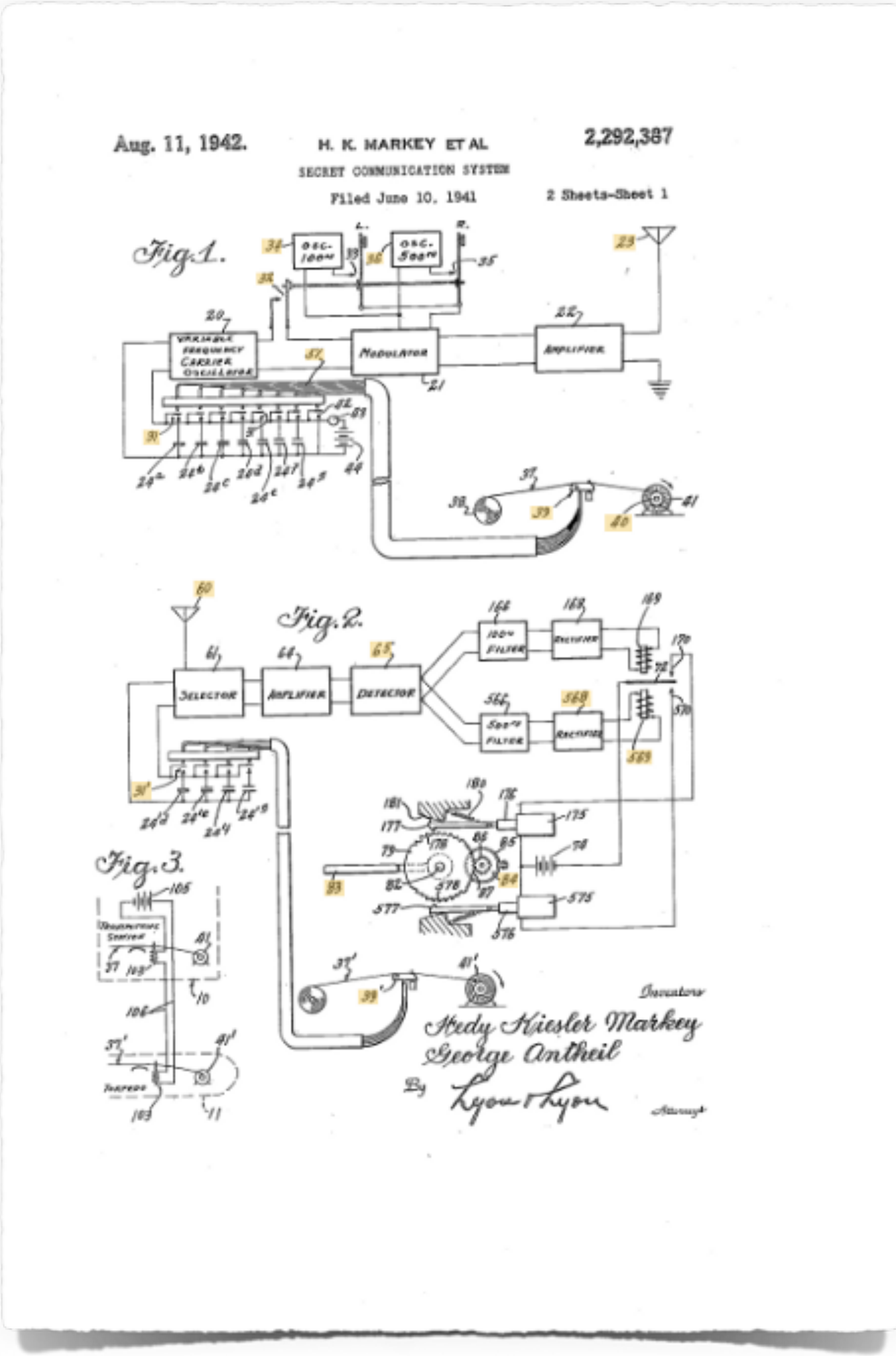
Peter Scott

Promotional photo of Hedy Lamarr from the 1944 MGM film '*The Heavenly Body*'. (image:)

On my transmitter I have put a printed strip saying 'Thanks to Hedy Lamarr'. For those who don't know the reason I thought it would be good to describe this remarkable woman.

Born Hedwig Keisler in Vienna in 1914, she made a name as a beautiful and talented film and stage actor. In the late 1930s, she fled an oppressive husband and, having a Jewish background, the Nazis, ending in the US.

But that isn't why her name is on my transmitter. She was also an inventor. She worked with Howard Hughes and suggested he change the shape of his aircraft from square to a more rounded streamline shape. However it isn't aviation that put her on my transmitter either.



Hughes was so impressed by her talent that he gave her a team of scientists and engineers and free rein to do what she wanted. During World War Two a new generation of radio controlled torpedoes was being developed, but the Germans found that they could jam the signals. Lamarr devised a system for changing transmitter frequencies using a device based on a piano roll player that she patented in 1942 (US Patent 2,292,387). The system became known as frequency hopping.

As is so often the case, establishments, in this case the US Navy, are resistant to ideas from outside and did not take it up until the early 1960's. Her achievement was eventually recognised in 2014 when she was inducted, after her death, into the US National Inventors Hall of Fame.

Frequency hopping allows transmitter and receiver to switch frequencies when connection is lost due to interference or a block. This is why we never worry about switching our transmitters on when others are flying. Ours will simply not connect using frequencies currently in use.

For those who have never used 27, 35, 53 and 72 MHz equipment, the large frequency channel board sometimes found on a flying field will be a mystery. Switching on your transmitter without checking whether someone else was already on your frequency was the greatest crime. Transmitters were often kept in a pound. Each frequency had a colour. You put a coloured ribbon on your transmitter aerial and had to register that you were using that frequency on the board. You could change frequency by changing crystals in the transmitter and the receiver.

Want to hear Hedy Lemarr in her own words? Here's the trailer for Zeitgeist Films' 2017 film 'Bombshell: The Hedy Lamarr Story'

Frequency hopping goes by a number of names depending on the manufacturer, most centring on FHSS (Frequency Hopping Spread Spectrum). FrSky calls its version ACCST (Advanced Continuous Channel Shifting Technology). Hitec is AFHSS (Advanced FHSS). Futaba has FAAST (Futaba Advanced Spread Spectrum Technology). Multiplex has M-LINK which is FHSS. In the European Union all systems must also check for a clear frequency before transmitting using LBT (Listen Before Talk/Transmit). The technology is also found in Bluetooth connections and many other radio-based wireless networks.

And all ‘Thanks to Hedy Lamarr’.

Read the **next article** in this issue, return to the **previous article** or go to the **table of contents**.

The Trailing Edge

Some timely thoughts as March turns into April.

The NEW RC Soaring Digest Staff

1/4.5 scale, 4m wingspan ASH26 from F. Deffner in Germany. It's perched on a slope in the Lavaux area above Lake Geneva. (image: Alexandre Mittaz)

We strive very hard to keep RCSD a COVID free zone. Don't get us wrong — it's one of the defining moments of our collective lifetimes — but we're also quite sure that you're getting all the information you need from sources much better than us. So that's the last we'll mention it. That is, other than with at least some vaccine-enabled relief in site, the various restrictions which have been in place around the world are either beginning to ease off, or will be in the predictable future. Without for a moment forgetting the tragedy which has befallen so many and the attendant, incalculable loss to their friends and family, the end finally being in sight is wonderful news for all of us. It also means…**time to get outside and fly!**

This one minute video shows how to make RCSD available for offline reading — yes, you can still enjoy RCSD even when travelling where the internet **isn't**.

More than ever, some fresh air and camaraderie is just what the doctor ordered and we're fortunate to participate in an activity which promises both. The slope or field awaits. But that doesn't mean you have to leave RCSD behind in the shop. Did you know you can take it with you and enjoy RCSD offline as this short video illustrates?

The beautiful image for *The Trailing Edge* this month is provided by Alexandre Mittaz. If that name rings a bell it's because Alexandre also provided the magnificent 'Springtime in Switzerland' photo which graced our March cover. We'll let Alexandre tell the rest of the story:

"*The picture was taken on Sunday the 7th of February, 2021 a few moments before sunset. The slope is located in the Lavaux area, above Lake Geneva (or Lac Léman as we say it in French). The model is a 1/4.5 scale, 4m wingspan ASH26 from F. Deffner in Germany. Deffner is well known for his 6m DuoDiscus, now produced by RC Flight Academy. He makes these from his private molds. Flying weight is about 4.7kg unballasted, around 6kg* *ballasted with a steel joiner. Airfoil is HQ DS, layup full carbon Hardshell wings. Great model, very fast in high dives, a pleasure to pilot and to watch."* Thanks, Alexandre, it's a great photo and an inspiring story to go with it.

Heartfelt thanks all the contributors to this month's issue. Readers, please don't forget to add a few *Claps* for those stories you really enjoyed. Writing *Responses* to articles is also a great way to interact with the authors. And please consider contributing a story of your own — everybody has a least one ripping yarn to share, right? The May deadline is **2021–05–16** and it will be here before you know it.

Our Managing Editor Terence C. Gannon kicked off this issue talking about his aspiration to grow a global audience for RCSD. Another way of doing that is our *Events* page. You can find it right up there on the menu bar. Please add your event no matter where it might be here on Planet Earth. Just send us your details and we'll make sure your listing goes up promptly. We support new listings with our social platforms, so it will really help get the word out.

The RCSD Cover Photo T-Shirt for March is now available in the RCSD Store.

As always, we are obliged to peddle a little merch — it's one of the ways we use to help keep RCSD free for all. We have *RCSD Cover Photo T-Shirts* for January, February and now March on sale. The latter has that beautiful

'Spring in Switzerland' photo by Alexandre Mittaz mentioned above. All proceeds support the operating costs of RCSD. Don't like black t-shirts? Let us know and we'll create one you want in one of a range of colours almost bound to include your favourite.

If you don't want to miss the May issue when it comes out, please subscribe to our mailing list. Also, follow us on Instagram and Twitter for even more complementary content.

That's it for now — how did we do? Let us know your thoughts. Thank you all so much for reading and until next time…fair winds and blue skies!

*Read the **previous** article or go to the **table of contents**.*