
Radio Controlled
Soaring Digest
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The New RC Soaring Digest

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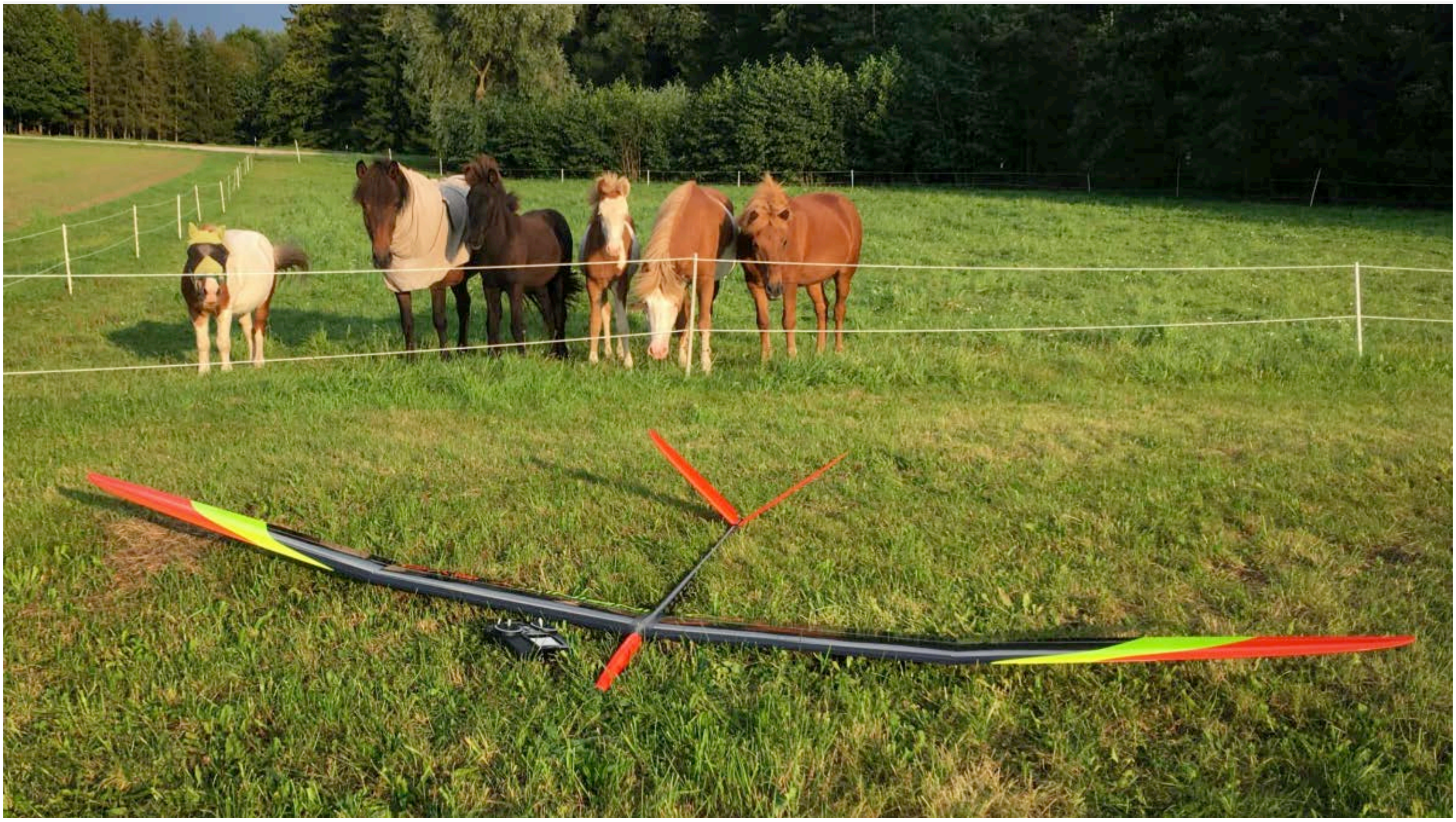

This month's key photo comes to us via Gerald Schauder who wondered whether these gorgeous onlookers are his "biggest fans or his harshest critics"?! In any event, it's a lovely photo and thank you so much for the opportunity to use it, Gerald. The only connection with this month's editorial is that it's perhaps the kind of scenery you would find while "open cockpit flying just four feet off the ground"?

In The Air

Open cockpit flying just four feet off the ground.

Terence C. Gannon · Follow
Published in The New RC Soaring Digest · 8 min read · May 5

I finally managed to extricate myself from my post-pandemic funk — or at least start down that road. One of my great joys in life — cycling — remained on the to-do list for **all** of 2022. I didn't cycle a single centimetre the entire year. But I was determined to get back in the saddle in 2023 and with the aid of a new acquisition — more on that in a moment — I am now happily putting in steady distance once again.

Two legs, two pedals and two wheels is hands down the best form of earthbound transportion. It's open cockpit flying just four feet off the ground. If you spend five minutes doing it, you'll quickly understand how the Wrights 'easily' made the jump from bikes to gliders.

When it comes to cycling — actually, when it comes to most things — I'm a creature of habit. I have a 19km route that I'm trying to ride between four and six days a week. If you have ever heard the hackneyed phrase "make [virtuous thing] a priority in your life!" may I recommend that whatever that thing is, do it first thing in the morning before you do anything else. That's what I do now that the early daylight has returned and I can be out on the road at 6.30am. Also, I like the familiarity of a route ridden often. I can remember most of the spots where the old school Cannondale *M400* 'hardtail' makes its presence known in no uncertain terms, and can avoid them with an almost invisible, subconscious flick of the wrist.

There is one undeniable bug-on-the-windscreen of the whole endeavour. Each ride lands me back in the same place I started except that everything is just a little more worn out than when I began. Make no mistake, it's still the best way in the world of making way for absolutely nowhere — a glorified, exquisite form of going around the same circle over and over again. But I can see how some — not me, of course — might think it all a bit pointless.

All the while when that was happening and also as a consequence of the pandemic-related upset, I took on family grocery duties: every Monday, list in hand, I attacked the local grocery store at 7.00am and made short work of the chore in a, thankfully, nearly empty store. In time I got to know most of the staff on a first name basis — after all, often I was the only customer. I actually began to enjoy and then eventually look forward to my weekly visits. So while the pandemic may have waned — right? — the weekly grocery runs continue.

So finally back to the new acquisition: a sparkling new Burley *Nomad* bike trailer. The plan was to replace my weekly **car** trip with a weekly **bike** trip for precisely the same purpose — to hunt down and haul the weekly supplies back to the house. I'm happy to report that I now have at least a couple of these rides under my belt.

In a word, they're **sublime** and it's for a simple if not peculiar reason. My bike is now being used to do **actual work**. My carbon footprint is just that little bit smaller, having been able to leave the car in the garage from which I pedalled away with the Burley in tow. By making the ride meaningful in a material way, the pleasure of it is greatly enhanced. Now I can hear you say it and you're absolutely right: this makes absolutely no sense. However, the rush is real, without a doubt.

The 30-year-old Cannondale ‘M400’ and Burley ‘Nomad’ undertake their weekly grocery run.

So where’s the glider connection, you ask? It’s a tenuous one at best, but I can’t help but think that gliding around in circles or back and forth across the slope might seem to some — not me or any of you reading, of course — more or less the same thing: the airborne equivalent of riding around in circles. But I’m wondering whether there might be the same rush as and when we put our gliders **to work** in some way as opposed to just wheeling around the sky looking for the next thermal or lift band.

Candidly, I feel this humble journal has so far done a pretty good job of finding at least some of these types of applications. The *Silent Arrow* project is a good example. The latest instalment in this remarkable story can be found in this issue. The *Glider Patents* series has also provided some interesting ideas which employ RC soaring concepts and have solid commercial potential. For example, this month’s *Glider Patent* has a parcel delivery service dropping small cargo gliders out of what looks like a Cessna

Caravan. I'd order the latest *Veg-o-Matic* just to have it delivered in this exciting way.

However I'm quite sure the brilliant hive mind that is the New RCSD readership has lots of fascinating ideas along these lines. After all, our super-efficient aircraft have *so much* to recommend them, not the least of which is they do so much with so little. Surely, there's a commercial angle to these capabilities. Maybe even something that involves staying aloft and going up, as opposed to slowing and controlling their falling out of the sky? Whatever your ideas are let us know so we can share them with the rest of the world. It may provide a different kind of buzz other than that old, reliable staple of coring in on that mid-summer boomer.

Back to the Burley for one last comment. Don't anyone tell Michelle, but it also has another potential use which I'll simply refer to as its 'secret mission' — should I "choose to accept it":

But let's keep that strictly between us, okay?

So long, Twitter

In this month's *Lift over Drag* newsletter, a promise was made there would be a 'substantial announcement' regarding the New RCSD's social media profile. So here it is: we're dumping Twitter.

Perhaps surprisingly it's not primarily over the erratic, bizarre, bafoonish and even dangerous behaviour of the new owner. That said, all of these 'qualities' sure as hell didn't help.

No, it has much more to do with return on the investment of time. Each of the five social platforms we've been on up into now — Instagram, Facebook, Twitter, LinkedIn and the nascent Post News — all take about the same amount of time — which is a lot. However, here's a comparison between Instagram and Twitter, our accounts for which were created **on the same day** just before the New RCSD was launched. In the case of Instagram, we have earned 2,861 wonderful, chatty followers. In precisely the same amount of time with Twitter? Just 169.

With the same energy it absorbs to find one follower on Twitter, that same amount of energy will net us nearly 17 followers on Instagram. Game over.

By thoughtfully pruning our social media presence, I think we'll be able to deliver better stuff on the four remaining ones we will support in the foreseeable future. We'll also continue to make adjustments so we can do the absolute most lift with the absolute least drag. After all, every moment spent on social is a moment less delivering what you, the reader, values the most — that is, the great articles that wind up on the page.

Our last posts on Twitter will be how the great — but so few! — followers we have over there will know where to find us in the future. Unequivocal thanks to all of them. You have been great and hopefully we'll see you soon on one of the other social platforms.

Oh, and let me preempt the near-zero-likelihood of Melon Tusk saying he couldn't give a rat's ass about our toy glider account and its meagre number of followers. I've seen the almost unadulterated rubbish on Twitter including a lot of his. I don't need anybody to validate that it will be a *much* poorer Twitter without the high quality, considerate, attractive posts put up by the New RC Soaring Digest social staff over the past two-and-a-half years.

So happy trails, Twitter. It's been … well … pretty lousy actually.

On with the Show!

As usual I have undoubtedly left readers wanting not more but less so without further ado, click below to get to the first of many great articles in the May, 2023 issue. Thanks to all contributors and a special thanks to you, our readers for your continued support.

Fair winds and blue skies!

Cover Photo

This month's cover comes to us by way of Jonathan Demery, who caught the exact right moment when these four young RC soaring enthusiasts let loose their glider over the bluffs over the Great Orme, Wales. Jonathan, who is a teacher at St. David's College in nearby Llandudno, runs a unique *Silent Flight* program for students, of which these kids are members. Their

Instagram feed (linked in *Resources* below) is well worth following. Thanks for the opportunity to feature your great photo, Jonathan!

You are welcome to download the May 2023 cover in a resolution suitable for computer monitor wallpaper. (**2560x1440**).

Resources

- ***St. David's College Silent Flight*** on Instagram. — Where you can find more great photos like this month's cover.
- ***Burley Nomad*** — "Designed for bike touring, the *Nomad™* bike trailer provides superior handling and stability for navigating the road ahead. With a 100-pound carrying capacity…"

Disclaimer

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All photos in this article by the author. Here's the ***first article*** *in the May, 2023 issue. Or go to the* ***table of contents*** *for all the other great articles. A PDF version of this edition of* In The Air*, or the entire issue, is available* ***upon request****.*

Also, do you have a glider-related stamp you'd like to add to the New RCSD Glider Stamp Montage? By all means, please let us know!

Letters to the Editor

The coming regulatory storm knows no borders?

The New RC Soaring Digest Staff

Published in The New RC Soaring Digest

5 min read · May 4

Listen Share More

The In The Air *piece in the April 2023 issue along with Adam Weston's* It's Time to Raise the 250g Limit *stirred up a lot of commentary. We were fairly sure would be the case. Here's a representative sample of what we received. — Ed.*

Responses to 'In The Air'

Good issue, however I was surprised to read in *In the Air: The trouble with Canada* that the loss of the MAAC exemption was attributed to:

> *As such, it was really just a matter of time before somebody would* **not** *"abide by the organisations rules as to how and where to fly" and went ahead and flew wherever the heck they wanted and in a manner of their sole choosing*

It was very clearly not just 'somebody' but rather people in positions of power within MAAC itself. I just want to slightly argue against the implication that this mess is the fault of average MAAC members and not organisational failures.

I know as little as anyone of what truly happened, though I think it has been basically concluded that the main issue was the authorisation of clubs post-2019 in restricted airspace, which I believe is indicative of a procedural shortcoming rather than individual failures of MAAC members, least of all a failure of Joe Average Model Flyer!

Joshua Mardling
(via Instagram Comments)

Thank you for mentioning the regulatory disaster in Canada which makes 'the way were were' over and done with through the imposition of ridiculously complex regulations which makes it impossible to fly RC sailplanes in Canada.

This especially so for solo flyers who have less than zero interest in flying sailplanes from a 'sanctioned' power flying field.

The requirement for a pilot licence, registration of the model, keeping maintenance logs of work done, flight logs, have an accompanying visual observer, hold a radio operator's licence to operate a VHF radio on aircraft frequencies, obtain the written permission of owners of property being overflown, and the real hoof kick to the head of sailplane flying — nothing over 400 feet.

That's not the worst of it. There are substantial fines associated with things like not deregistering a model if you crash it, the requirement to change your address on file within seven days of moving and a long list of other offences created by the introduction of Part IX of the Cdn Aviation Regulations. The fines are $1,000 per pop!

They are actually issuing those fines, and have served notice that Transport Canada will be briefing police forces and expect them to enforce the regulations, or at least report what they see and take down particulars. Wonderful. I have donated my large two scale models to the local full-scale gliding club to hang from the ceiling of their clubhouse.

I started flying RC model sailplanes in 1971. Because the juice isn't worth the regulatory burden of the squeeze, they have driven me out of the hobby.

A true shame.

Lee Smith
(via Facebook Messaging)

So nice to read your viewpoint which by the way, resulted in me head nodding approval as I worked my way through your submission.

It occurred to me that the new Part IX requirements will affect the soaring enthusiast the most — primarily the 400' AGL limitation. Try keeping your 4m-5m composite wonder compliant whilst in the midst of a thermal boomer!

I like you will be staying under the radar until I have no other choice. I want to see what Exemption 2.0 looks like.

Lyle Jeakins
(via Medium Responses)

Responses to 'It's Time to Raise the 250g Limit'

Adam has an excellent point. Even better would be to eliminate all of this nonsense. It is making it next to impossible to comply when flying off the grid.

How is the FAA going to enforce any of this?

Jeremy Fursman
(via Facebook Comments)

Raising the 250g limit for RC sailplanes would be like a dream come true! However, here in Canada my fear is when the powers to be determine how many pilots are flying under 250g, there may be pressure to lower even that paltry limit!

Historically, the flying of fixed wing RC planes has never been an issue. The majority of us belong to organized clubs with strict rules and fly at approved fields.

I fear there is more at play here that just the use of recreational drones and RC fixed wing aircraft. There is the ongoing development of commercial grade delivery drones systems, that will require exclusive use of our airspace, especially above 400ft AGL.

I wish you all the luck with your endeavours to raise the 250g limit. If you are successful in doing so in the US, there might be hope for us located north of your border.

Lyle Jeakins
(via Medium Responses)

Thanks to all readers who provided such thoughtful and respectful feedback and thank you for allowing us to publish it here for the benefit of others. One informal initiative we are undertaking is to solicit articles from all around the world to understand better how each country is addressing these issues. We'll see if that bears fruit and we'll present the articles as and when we receive them. Speaking of which — why not consider writing one for **your** *country?! — Ed.*

Resources

- ***In The Air: The trouble with Canada*** by Managing Editor Terence C. Gannon. — "It landed in my inbox ironically on Wright-mas, which regular readers of this column will know as December 17th. If email was capable of make the sickening thump of a dead-blow hammer, this incoming email would have made that sound…"
- ***It's Time to Raise the 250g Limit*** by Adam Weston. — "FAA regulations requiring Remote ID (RID) and registration for both aircraft and pilot have exclusions for aircraft weighing less than 250g (8.8 oz). Two model aircraft organizations … have proposed raising the limit from 250g to 1kg…"

*Send your letter via email to **NewRCSoaringDigest@gmail.com** with the subject "Letters to the Editor". Alternatively, you can leave a reply in the* Responses *section below (that's the little 💬). We are not obliged to publish any letter we receive and we reserve the right to edit your letter as we see fit to make it suitable for publication. We do not publish letters where the real identity of the author cannot be clearly established.*

*All images by the author unless otherwise noted. Read the **next article** in this issue, return to the **previous article** in this issue or go to the **table of contents**. A PDF version of this article, or the entire issue, is available **upon request**.*

"The GD-2000 glider is released from a C-27J airplane at Yuma Proving Grounds, Ariz. On February 13, 2023." (credit: US Department of Defense, 1st Special Forces Group (Airborne) in the Public Domain)

Silent Arrow® Successfully Tested by US Special Forces

Recently declassified material reports test program conducted at United States Army Yuma Proving Ground in Arizona.

The New RC Soaring Digest Staff

Published in The New RC Soaring Digest

3 min read · May 3

The US Army's *1st Special Forces Group (Airborne)* successfully tested the *Silent Arrow®*

declassified material released by the US Department of Defense.

A Special Forces detachment commander, whose team tested the glider, said that "what this glider does is give us a much greater [travel distance] and a much greater glide ratio into a target." The commander went on to say "if we are able to get [the glider] up to 40,000 feet we're looking at [travel distances] in excess of 25 to 30 miles. That's a pretty unique capability and not matched by anything we currently have."

This autonomous cargo glider program had its origins in a request from the US Marine Corps to address some limitations of the existing Joint Precision Air Drop System (JPADS) which is based on steerable parachutes. The JPADS system is larger in size and has limited ability to manoeuvre — this makes it less accurate over long distances or in adverse weather conditions and in particular high winds.

Left: "Soldiers from 1st Special Forces Group (Airborne) and the United States Army Special Operations Command Flight Detachment load the GD-2000 glider into a C-27J airplane at Yuma Proving Grounds, Ariz. On February 13, 2023" | **Right**: "Soldiers from 1st Special Forces Group (Airborne) recover the GD-2000 glider after its landing at Yuma Proving Grounds, Ariz. On February 13, 2023." (credit: US Department of Defense, 1st Special Forces Group (Airborne), Sgt. Thoman Johnson in the Public Domain)

Implementation of the *Silent Arrow®* will result in enhanced capabilities of the Special Forces detachments deployed through varied and restrictive terrain. Timely and accurate resupply is imperative to the success of combat operations. Notably, the *Silent Arrow®* is completely disposable once on the ground, allowing it to be left in denied or contested territory without compromising the security of the Soldiers receiving the supplies.

"[The glider] gives us the ability to drop this from a plane outside of controlled airspace into international air space and fly resupply in from an unmanned autonomous craft.

It’s a huge enhancement to the mission” the Special Forces commander said.

In the test program the *Silent Arrow®* delivered a 1,000-pound test payload after being airdropped from a C-27J *Spartan* aircraft. During several drops, the glider landed within 30 meters of its intended target and the hull of the aircraft was still intact and protected the cargo inside.

The New RC Soaring Digest will continue to provide updates on this innovative program as well as other initiatives where RC soaring technology is employed to address both commercial civilian and military requirements.

Resources

- ***1st Special Forces Group (Airborne) Tests New Prototype Glider*** — The primary source of material for this article as provided by the Defense Visual Information Distribution Service.
- ***Silent Arrow in New RC Soaring Digest*** — The complete collection of stories to date.
- ***Silent Arrow*** — The official company website.

*Read the **next article** in this issue, return to the **previous article** in this issue or go to the **table of contents**. A PDF version of this article, or the entire issue, is available **upon request**.*

May 2023 Military Aviation Special Forces Gliders Drone Delivery

Designer Pawel Kohls with the 'Astrid' at the Aero Club of Poznan Kobylnica flying field. (credit: Kohls RC Models)

Cool New Stuff

Three great gliders, a gadget to carry them in and a mug to toast bringing 'em back in one piece.

The New RC Soaring Digest Staff
Published in The New RC Soaring Digest
8 min read · May 1

Astrid F3L

Ease-of-construction using traditional techniques combined with excellent flight performance.

The *Astrid* is a great performing glider for the FAI's F3L class (also known as F3RES) which has ease-of-construction designed in from the start. Even those with little experience will manage to assemble this glider and likely be successful the first time.

(credit: Kohls RC Models)

With a span of 1984mm , wing area of 34dm^2 and an all-up-weight of around 450g, the *Astrid* is lightly loaded at around 13g/dm^2. That makes long flights possible even with small thermals in marginal conditions. The *Astrid* is designed to almost fly on its own given it's stability on all axes.

The flat-bottomed *AG37–39* airfoil makes the wing easy to construct accurately using a simple, traditional building board. Even so, the *Astrid* sacrifices little with respect to performance and provides very good flight characteristics after an easy and quick setup at the field.

(credit: Kohls RC Models)

The wing spar and leading edge are made of carbon tubes and rods, giving them the desired rigidity and strength. The trailing edge is cut from 0.8mm plywood. The *Astrid*'s fuselage is constructed with 2mm plywood for the inner skeleton stiffened with an 0.3mm wall carbon tube. Servo locations are ample, allowing for inexpensive servos of up to 9mm in size to be employed. The kit also comes with the require hardware including many custom, 3D-printed parts.

The fuselage canopy is conveniently retained with four magnets. There is an adjustable tow-hook for hi-start launch. The New RC Soaring Digest was told an electrified version is currently in development, as is a wing with ailerons which will considerably expand the *Astrid*'s flight envelope.

(credit: Kohls RC Models)

The Kohls RC Models' kit comes with these gorgeous, easy-to-follow plans and an instruction manual with detailed descriptions of some of the more difficult steps. You can find additional videos about the *Astrid* in the *Resources* section below, and complete information is available **directly from the Kohls' website**.

Boxer Aircraft Carrier

Tired of all those trips back and forth to the car?

The *Boxer* is a better carrier for your aircraft — fewer trips back and forth between the parking lot and the ridge. It also makes for a convenient place for keeping your gliders off the ground when you get them there. It's sized to carry up to five mid-sized sailplanes — the primary focus being those sized 60" span and smaller.

Aloft Hobbies' proprietor Wayne Flower told the New RC Soaring Digest that they actually designed them for their own use with the goal of a single handle for all the gliders for a day's flying. However, when customers couldn't find them in the shop to buy them, they "knew we were going in the right direction".

In addition to its ample cargo carrying capabilities, the *Boxer* is designed to be anchored down to avoid mishaps like having it fall over and instantly converting all of your conventional gliders into flying wings.

When loaded the *Boxer* remains level when picked up. If you put a transmitter or other heavy items in the optional storage box at the top, the weight will increase the angle of the planes making them more secure in the *Boxer*'s slots. It's ruggedly constructed of laser cut plywood, the handle is made from very strong PVC pipe and there are 3D-printed endcaps. A roll of closed cell foam tape is included and is used to line the five sets of slots to cushion their precious contents.

It's available in two versions: the *Standard* version is the the basic carrier. The *Deluxe* version includes additional storage compartments. The kit comes flat-packed and ready to assemble, all you need to provide is the glue. A link to the manual can be found in *Resources* below, and complete information is available **directly from the Aloft Hobbies website**.

Stellar F5J

A perfect first plane for dabbling in the FAI's electric-assist thermal duration class.

(credit: Ecirtech)

The *Stellar F5J* is a very easy to construct, all-wood, laser-cut motor-glider specifically designed for lowland thermal flying and for light lift days at your local slope. The elegant glider's wing employs the *AG35* airfoil designed by Dr. Mark

Drela and spans 3.12m. It’s lightly loaded at 20.5g/dm^2 and the wing has both ailerons and flaps.

This configuration enable small thermals to be worked easily while the Drela airfoil provides a broad speed range which enables transitioning quickly between areas of lift. We particularly like the look of the geodetic construction for the unusual, shapely wingtips.

Built-up control services are a testament to the designer of the *Stellar*’s attention to detail when it comes to producing a light, stiff, high performance airframe.

(credit: Ecirtech)

An attractive decal package, as shown above, is also available as an option. You can find both the build manual and construction photos linked in *Resources* below.



(credit: Ecirtech)

Complete information is available **directly from the Ecirtech website**.

Cover Photo Mug

The perfect vessel for your morning pre-flight coffee or evening tea, or depending on how your day out went, maybe something stronger.

(credit: The New RCSD Shop)

There's a new product line in the New RCSD Shop that riffs on their *Cover Photo T-Shirt* series: introducing the *Cover Photo Mug*. The inaugural edition features the beautiful photography of Uroš Šoštarič, who captured this gorgeous 5m *DG–1000* at Mangert in the Julian Alps of his native Slovenia. His photograph is custom formatted just for this particular use and wraps all around the hearty 444ml (15oz) mug.

Whether you're drinking your morning pre-flight coffee, evening tea, or maybe something stronger — this mug's for you! It's sturdy and glossy with a vivid print that'll withstand the microwave and dishwasher. Complete information available **directly from the New RCSD Shop's website**.

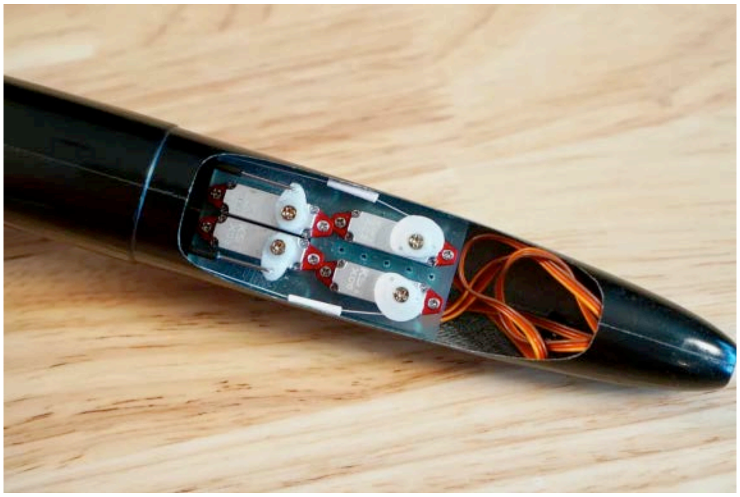
Deviant DLG

Want a glider you can get in the air and start flying whenever the mood strikes?

(credit: ArmSoar)

In that case, as Thomas and Jason over at ArmSoar say, "you need a *Deviant* in your life." Yikes.

The *Deviant* is proof that a large low aspect ratio wing helps boost both the performance and handling of a 1m glider. Even in more rigorous conditions which other 1m models and their pilots will find challenging, the *Deviant* will stay on step particularly when ballasted up.



(credit: ArmSoar)

Manufactured in HAAS machined aluminum moulds, the *Deviant*'s fit and finish are exceptional. Construction is by their crack team based in Ukraine, a hotbed of superior quality composite construction. Unlike other designs which employ XPS foam for the wing cores, the *Deviant* instead uses the superior *Rohacell®* material for better stiffness, ease of construction and repairs, and resistance to hanger rash.

(credit: ArmSoar)

In addition, the nosecone design makes it very easy to handle the model on the field. If it gets damaged — that will never happen, right?! — you can swap it out for a new nosecone helping keep the model looking fresh. We have linked the build videos for the *Deviant* in *Resources*, below. Complete information can be obtained **directly from the ArmSoar website**.

Say you saw it in the New RC Soaring Digest.

Resources

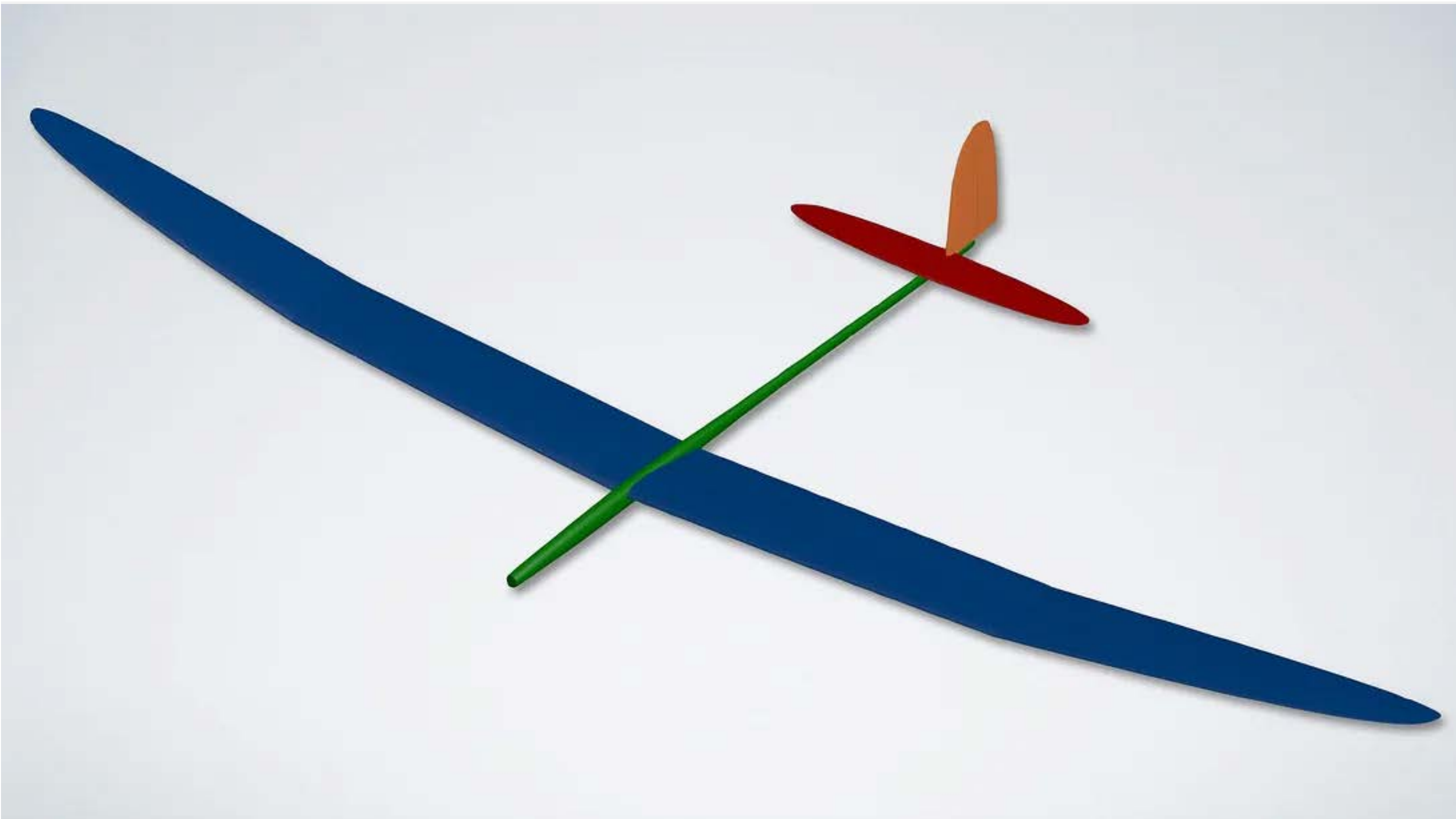
- ***Astrid F3L*** from Kohls RC Models. — Flying Astrid Glider in Calm Conditions (video), Flying Astrid Glider for the First Time (video)
- ***Boxer Aircraft Carrier*** from Aloft Hobbies. — Manual
- ***Stellar F5J*** from Ecirtech. — Manual, Construction Photos
- ***Deviant*** from ArmSoar. — Build Log Part 1 (video), Build Log Part 2 (video)

The Fine Print

All product descriptions in Cool New Stuff *are prepared in collaboration with the product's manufacturer and/or distributor which is/are entirely responsible for ensuring the accuracy of their product's descriptive text and images contained herein. Note also the* New *in* Cool New Stuff *can sometimes mean 'new to us' — the French* nouvelle *as opposed to* neuf.

Would you like your product featured in Cool New Stuff? *Please* ***contact us****. Read the* ***next article*** *in this issue, return to the* ***previous article*** *in this issue or go to the* ***table of contents****. A PDF version of this article, or the entire issue, is available* ***upon request****.*

May 2023 Model Aircraft New Product Launch Hobbies And Interests Gliders



Project ALTius

Part IV: An extended essay to help see the big picture.

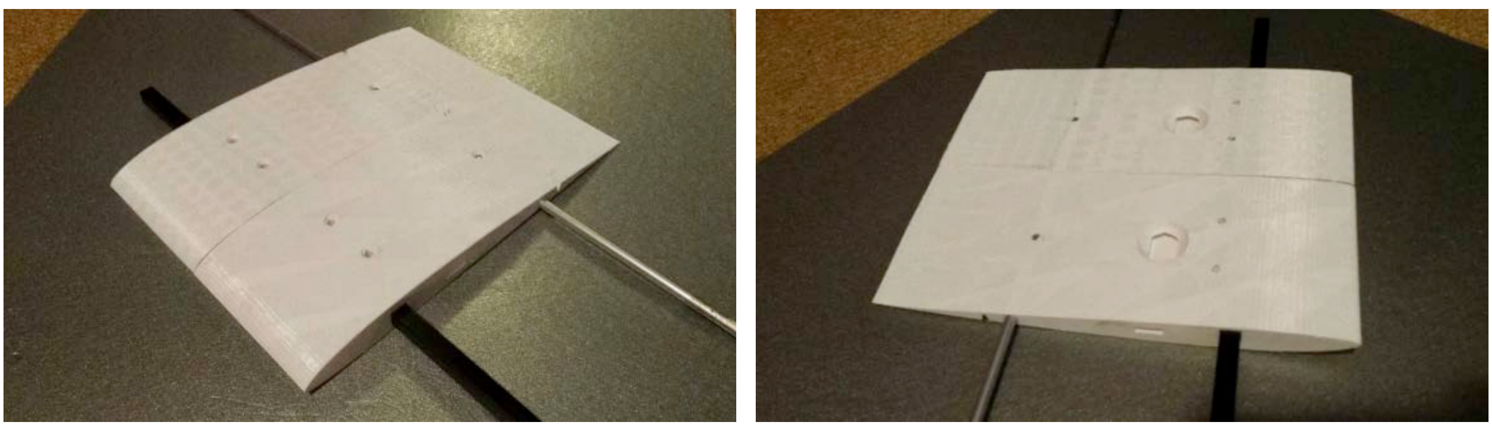
Tiberiu Atudorei · Follow
Published in The New RC Soaring Digest
21 min read · Apr 30

In the ***first three parts of this series*** *the author described performance glider projects as complex with many repetitive operations. The latter can be addressed with CAD software and then automated in standalone SAD (software assisted design) apps and homemade HAM (hardware assisted manufacturing) apps. He then presented some same workflows to illustrate their use. Most recently, he covered working within both weight and financial constraints. —*

P*roject ALTius* is a long story of disappointments, failures, dead ends and above all resilience and hope. As any good drama this saga has its fair share of surprises and unexpected turns of events. Here are a few of them:

Failure №1

In the last part we concluded the easiest way to build this glider was to 3D print it. However the common FDM technology (AKA 'squished molten plastic sausage') is not adequate for this purpose and we need to consider printing with resin instead. I advocated this solution based on an analytical argument — taking into account weight estimations — but in reality the change of direction was due more to experimental results. When I got to the printing tests I found out that my DIY FDM 3D-printer was not adequate for the job: a wing printed with a 0.4mm nozzle was too heavy and printing with other nozzles took too much time and it was not structurally sound.



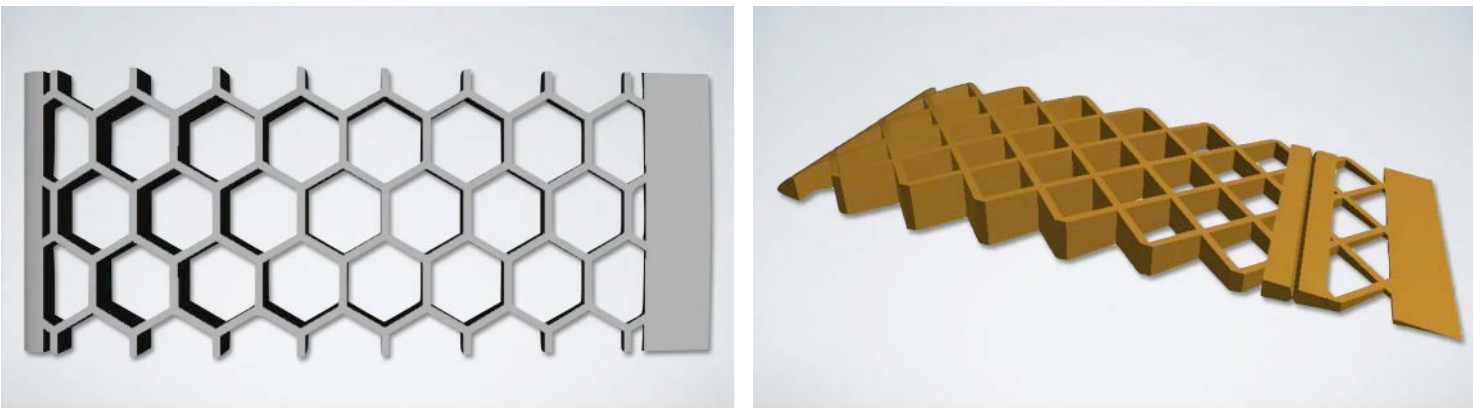
First print test for alignment and continuity between segments.

Failure №2

From my estimation a large part of the weight was due to the foil — that is, the surface of the wing — and I switched my focus on making the wing lighter by using *Oracover®* and some sort of holes and printing without infill. This was done by processing the 3D model in *OpenSCAD* and cutting some hexagon or square shapes. I also needed to make some important changes in `xflrwing` to separate the 'solid' parts, in the leading and the trailing edge and also the hinge area, from the rest.

Incidentally this was similar to Kraga's *Kodo* but the design was different and my wingspan was not a mere 1.6m but a larger 3.8m–4.0m. The hexagon/honeycomb shapes were nice but not possible to print on my DIY 3D-printer without supports due to overhangs of 120 degrees.

I finally settled on a rhombic structure, with diagonals 20mm and 25mm that was easier to print. Good results in printing, bad results in covering with film: the PLA (polylactic acid) print filament and hot air are not very good friends. You can likely guess what happened to the trailing edge. ABS (acrylonitrile butadiene styrene) behaves a little bit better but I had no enclosure for my printer to contain the fumes and therefore I could not print with this material.

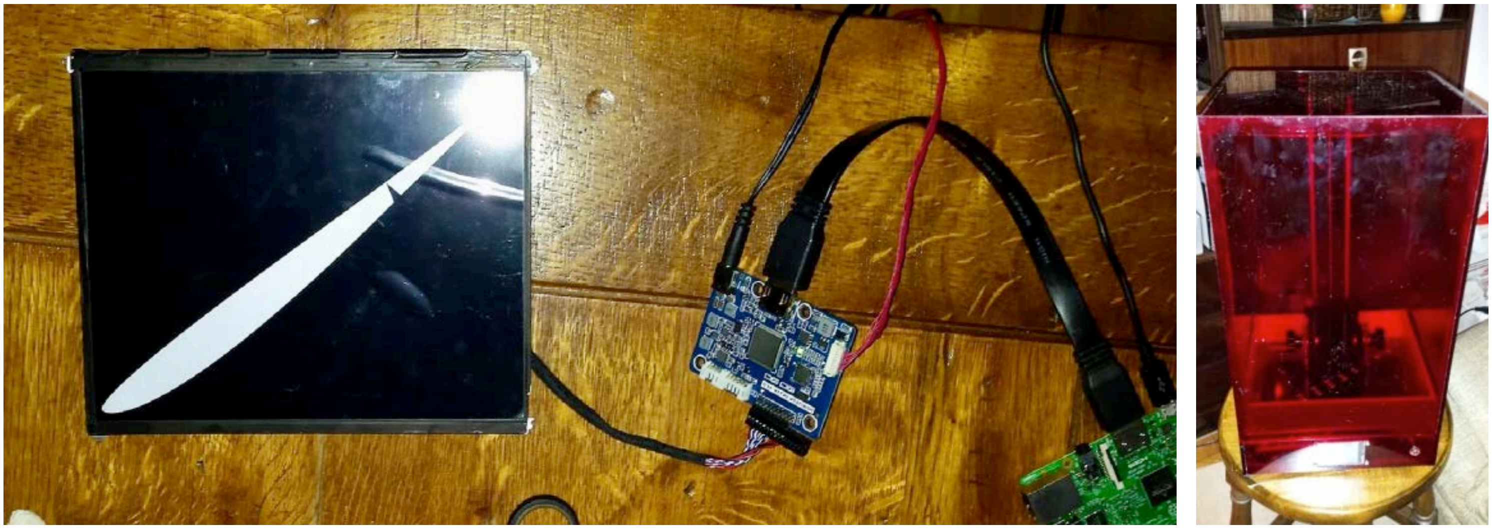


Modeling geodetic wing structure.

Failure №3

And the first U-turn in the project: I am quite stubborn and I decided it was nothing wrong with my idea, only the FDM printing technology was limiting me — so I had to print the wing with resin! The problem was that the resin printers are expensive — similar in cost to a competition glider! — so I decided to build my own resin 3D-printer.

I needed something able to print 250 mm chords: an iPad 10" retina screen was available on eBay as a spare part, some red *Plexiglas*® or *Perspex*® plates, some electronic parts and I was finally able to build the printer. It turned out that the non-UV resin was quite expensive — around €60/kg — and the iPad screen background light was quite weak and I needed longer exposure times. This can lead to all sorts of other problems like 'bleeding'. When I switched to UV resin I found that the iPad screen filtered a lot of 405nm UV light and my LED array, made from flexible strips with 405nm UV LEDs, was not bright enough.



Left: From a Raspberry Pi and an iPad display… | **Right**: … to my first resin 3D printer.

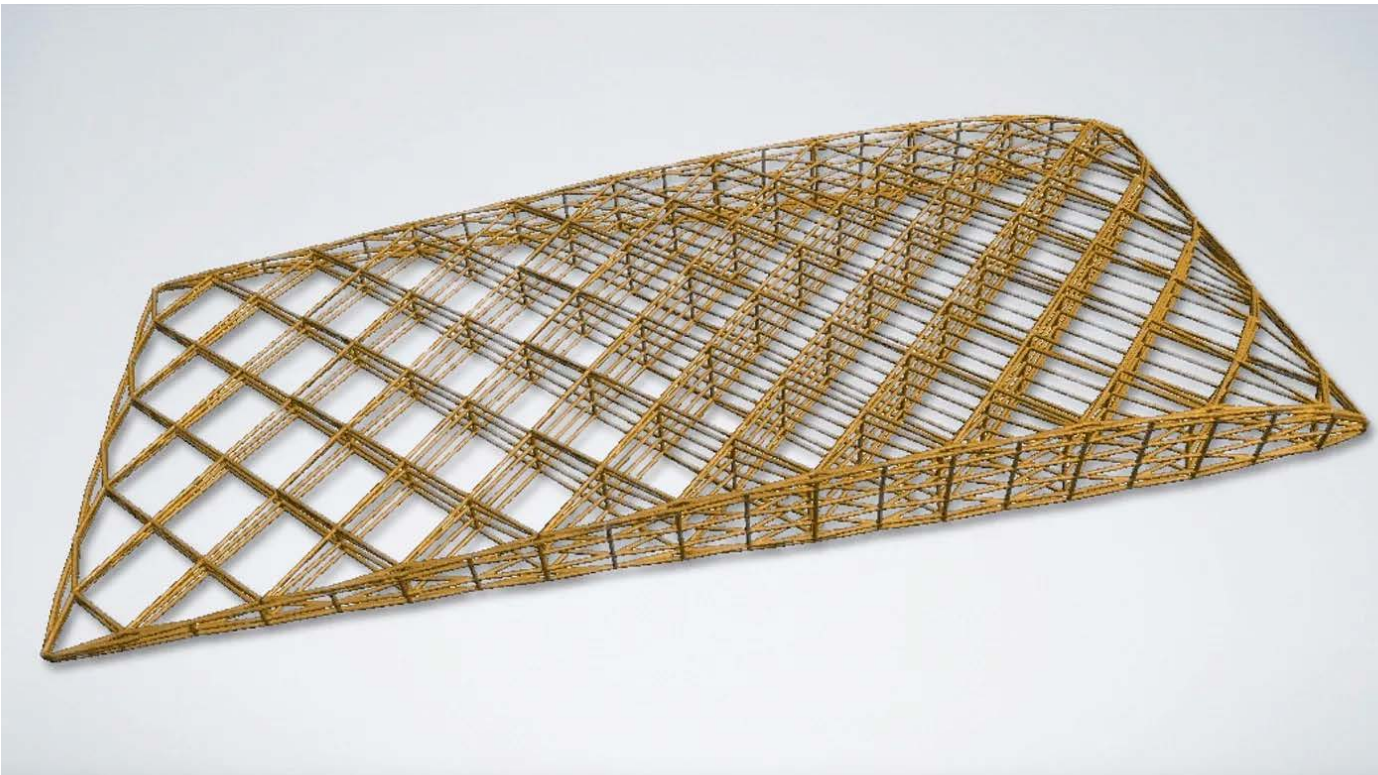
Another problem was with the slicer: the slicers for resin printing were a joke. You either printed it as a solid form — that is, 100% infill — or you had an option to hollow the model in an external app like *MeshMixer* and put a hole in the model to let the resin entrapped inside drain. Or — and I think this happened quite recently — there is the option of an internal structure but that's quite heavy. None of these options was good enough for my needs.

The Core Problem

Rohacell® used for solid-core is very light: 30kg/m^3 or the heavier version of 50kg/$m^3$3. The resin is 1150kg/m^3 and because of the density difference I had to use an infill of 2.5%–4.0%. In addition I also needed a surface foil printed with resin and in order to compensate for this additional weight — actually bigger than the lattice structure weight — I had to use only 1.0–2.0% infill.

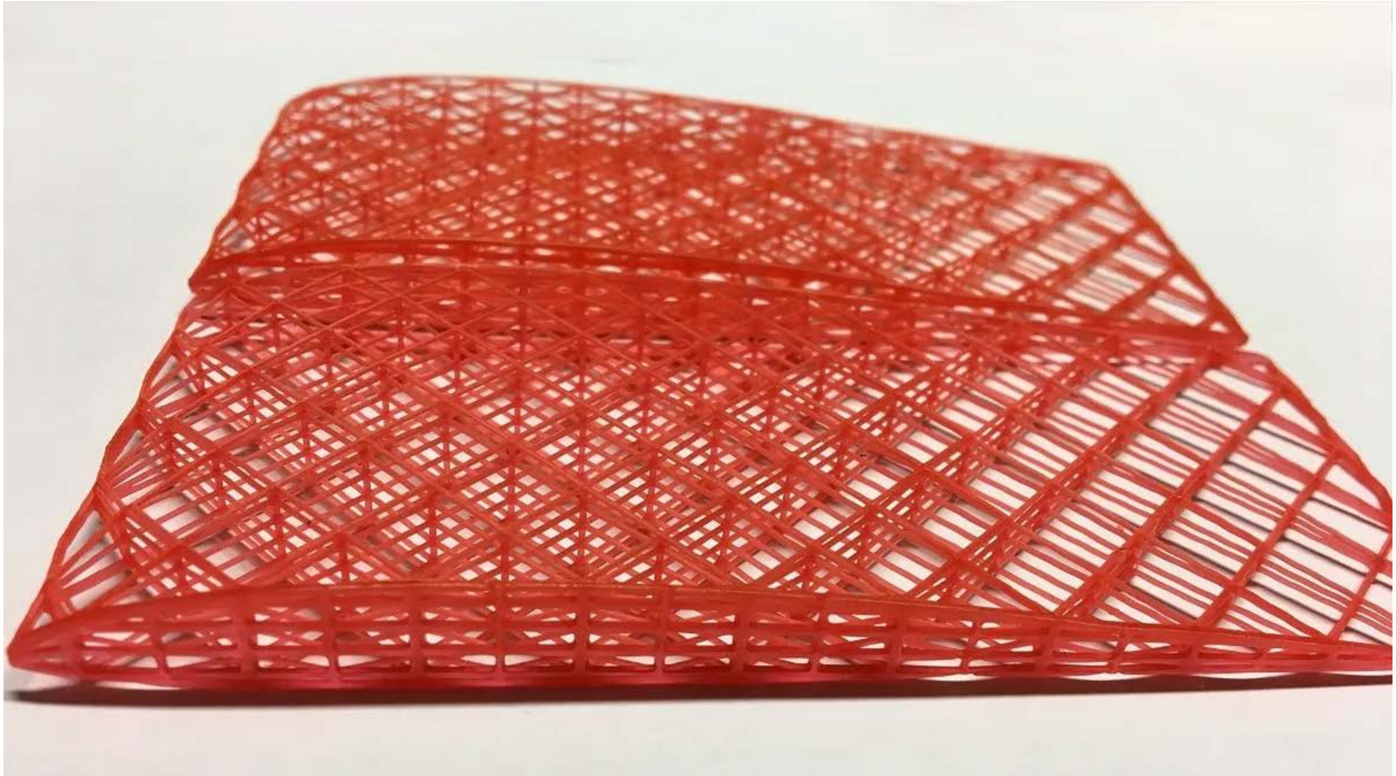
With such a low infill percentage I definitely needed some extra strength and this was only possible with a composite structure such as carbon fibre and resin. I needed molds and plugs and I had to add this feature in `xflrwing` and also I had to figure out the easiest way to make these molds and plugs. I considered 3D-printing them or carving a plug in XPS and adding a mix of resin and mineral filler — but I needed a DIY CNC and probably I would have to write a program to generate the G-code for the CNC.

There was another problem with the infill: all the patterns had closed cells and I needed a 'drain-proof infill pattern'. This light infill had to resist to all kind of loads during the flight. I used a specialised program — *Element Free* from nTop — and I designed a complex structure starting from a geodetic rib or a 3D disser and carving drain hole spawns. Modeling this kind of structure was quite CPU intensive and needed a lot of time. I changed the *OpenSCAD* programs I used before as a starting point to add these additional holes for draining resin.



From rendered 3D model …

At this point I realised it made sense not to over-engineer the geodetic structure and instead of 3D-printing it just cut some geodetic ribs made from balsa which is one-tenth the weight of resin. And I needed an app to draw the ribs. However the idea of this structure was still very appealing and I wanted to test it. The price of resin 3D-printers dropped and now I had a €500 Anycubic *Photon*. The problem was the screen was quite small — it enabled approximately 10cm (L) x 5cm (W) x 15cm (H) printing volume — and I had to print it at half scale. I did a couple of test prints and everything was fine — the structure was sound and light. But it was obvious that this was a dead end. Printing and assembling a puzzle of 100+ pieces was not something I was ready to take on.



...to 3D printed with resin in 1:2 scale.

An Important Trip to Slovenia

Around this time I had another change to the project — maybe the most important change — both in goal and in technology / method. I had the opportunity to meet one of the top composite builders in Slovenia for scale and competition models who was interested in the `xflrwing` app. When I was demoing the program — it was an early version — and explaining how I was doing everything he was very quiet. This made me uncomfortable, as what I was probably doing was very basic for him and it was a waste of his time. But he asked just one question:

“How do you model the hinges?”

This was very important because it was the trickiest part in modeling the wing. I explained about the 30% position for the hinge in the `.dat` files and how this is used for the long axis. I considered this as a fixed point for the washout rotation in order to keep the hinge on a straight line. He told me that I have a good solution — and it was his turn for explanation:

Creating the tooling for a glider is very expensive and time consuming. There is the aerodynamic part, of course, but then somebody has to take this and create the mechanical design — 3D model, molds and plugs. This is expensive and you likely will have to hire an engineer with expertise in using the CAD software such as *CATIA* or *SolidWorks*. Then you take this design and move to the CAM phase which involves machining the molds / plugs in CNC — and CNC time is even more expensive. Then you start polishing which is also very pricey and time consuming. The combined cost of the CAD project and the CAM part will run to thousands or even tens of thousands of euros.

The weakest link in this whole chain is the CAD project because it's very hard if not impossible to verify the results unless you have the finished prototype in your hands. My program was a shortcut for this weak link.

I was quite shocked when he told me he wanted to be a customer for my program but he needed some additional features: IGES / STEP format instead of STL — the de facto standard for professional CAD and CAM programs — and some additional elements in molds and plugs. He showed me the molds for the wing of his next competition glider — it was hidden on a workbench under a soft cloth.

Mirror finish on professional molds … perfection.

It was simultaneously a high and a low moment for me:

- **High** — I knew that my software was quite good, at least for the amateur builder. For pro builders there was some work to be done, but I was on the right path.
- **Low** — In that moment I knew for sure that I will not be able to manufacture these kinds of molds and plugs in a reasonable amount of time and with a reasonable amount of effort: a four-segment wing and two-segment fuselage would need something like 16 different molds.

So, a dead end for molds and plugs. I had to find another way to build my glider. That said, I never abandoned the mold/plug feature in the program and I later added the missing elements. But at least now I had a better understanding of why the competition models are *so damned expensive*: there is a huge effort and a big cost in getting them to the market.

Thoughts on 'The Market' and Its Needs

I also realised that the market for me was not a handful of composite builders interested in my simple app just to save some costs or the glider enthusiasts who can afford an expensive model. My real market was the tens or hundreds or maybe thousands of hobbyists who can't afford an expensive model but are interested in building one. I had to create the simplest method to build the glider in the shortest time using the cheapest materials with a still acceptable final result. Not only this specific glider but any glider similar to this type with wing and tails defined in XFLR. In other words: my goal shifted from a single, commercial-quality competition glider — the market was already quite saturated anyway — to rapid prototyping builds.

After the meeting in Slovenia I worked in parallel on software and hardware. I started working on the fuselage app in order to automate design of a F5J type fuselage. I added a lot of features to the `xflrwing` app and finally when I considered it good enough I had my 'IPO' in RCGroups. I also had to rewrite the whole output section to organise the code better because the number of output files increased a lot and, candidly, the code was a mess. I also wrote the app for the geodetic balsa ribs. After the RCGroups post I was contacted by two builders who wanted to build the glider using my model — the classical path with CNCs.

Tug of War

The pandemic lockdown also had a big impact. No more business-related travel with a lot of time spent in airports, planes and hotels when I could work on the software. My focus now was finding the method and building the necessary hardware. It was clear to me that 3D-printing with resin was the solution but the method — MSLA (masked stereolithography apparatus) bottom-up, projecting the image through a transparent bottom of the vat — was wrong. It was good for printing small figurines or structural parts with 100% infill but not good for light structures.

It was like a tug of war: 'team adhesion on the lifting plate' versus 'team adhesion on the vat flexible film' pulling the 'light resin structure' rope. The game is rigged because 'lifting plate' has an advantage — increased exposure time for first layers. But it's not a sure thing: sometimes 'flexible film' wins. There are also cases when nobody wins and the resin structure is simply torn apart. With the kind of structures I had in mind this was high risk. It was time for another change in direction.

'Bottom-up' was changed to 'top-down' — this solved the adhesion problem on the building plate as there was no more flexible film. MSLA was changed to 'moving laser spot' — which solved a lot of other problems. However, I still had two very big issues:

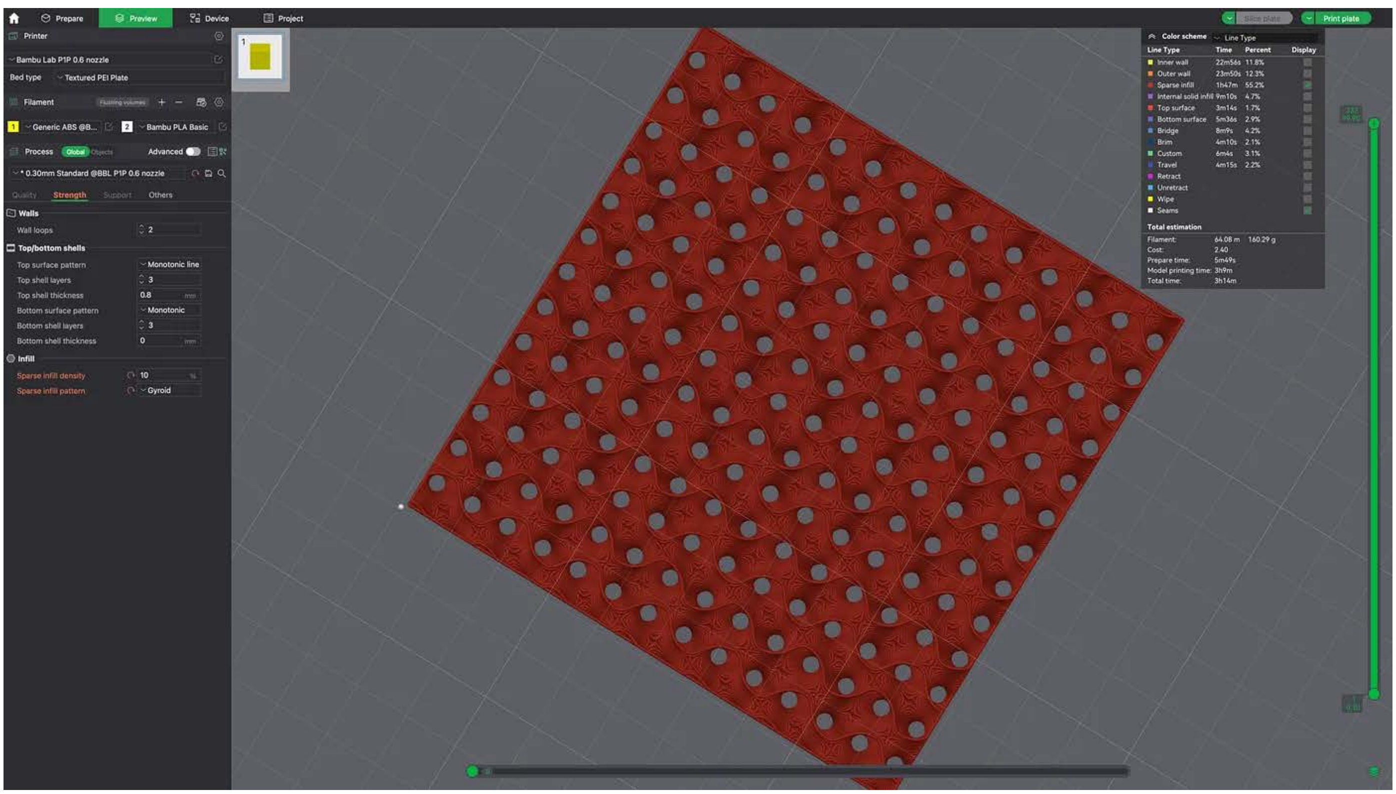
1. The complex 3D model of the structure and…
2. There was no slicer available I could use.

In fact it was quite a regular structure and I could bypass the software to generate this complex 3D model and the slicer and just write `G0` / `G1` / `laser on` / `laser off` commands. The extrusion control is the major part for slicers and it was of no use to me. I actually wrote the app to control the laser for printing this structure. But somehow the structure looked very sparse. I started investigating alternative lattice structures.

Thank You Mother Nature

I started with what Mother Nature already had on offer: carbon, in two variants with one being very strong — diamond — and one being weaker — graphite. The diamond lattice is regular with beams starting in four directions from a central point and repeating in a recursive manner. The graphite lattice is with beams starting in six directions and is weaker but it has parallelism between planes and much easier to code. This led me to a simpler structure with a lattice based on cubes. It was very easy to compute and even easier to ‘slice’ — that is, to write code for the 3D resin printer which is actually closer to a laser cutter. We’ll talk about the HAM part later in this series.

The infill factor formula was similar with the infill for balsa: $(3n - 2) / n^3$ with an approximation $3 / n^2$. When I was researching graphite and graphene I found an MIT research paper about “a new 3D material with five percent the density of steel and ten times the strength, making it one of the strongest lightweight materials known”. While I was not able to replicate some fancy nano-material what really got my attention was “you can replace the material itself with anything, the geometry is the dominant factor. It’s something that has the potential to transfer to many things”. And they had tested it on 3D-printed models! The gyroid surface was the magical solution to my problems and it was time to abandon other lines of research and use it as infill. Not really a new failure but another change of direction.



Top view of a cube with gyroid infill.

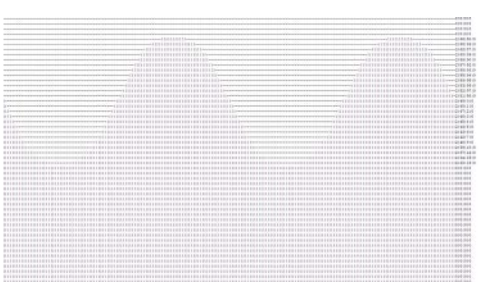
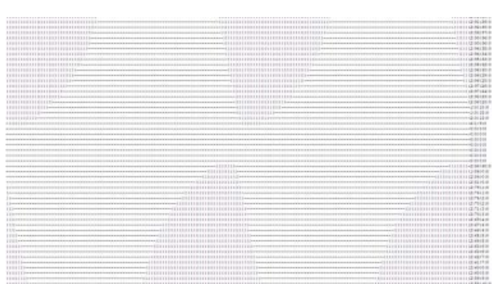
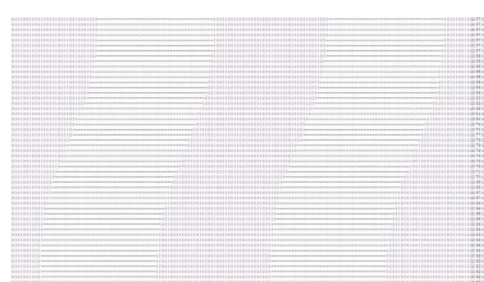
I had to create the algorithm to fill the wing with the gyroid surface. It can be approximated by a simple symmetric equation $(\sin x \cos y + \sin y \cos z + \sin z \cos x = 0)$ and it was symmetric in three directions — good for strength — and also full of holes also in three directions — good for draining the resin. It was not something new

— it was first published in a NASA paper from the 1970s — and one of the properties was a “triply periodic minimal surface”. Also good, “periodic” and “minimal” was just what I was looking for!

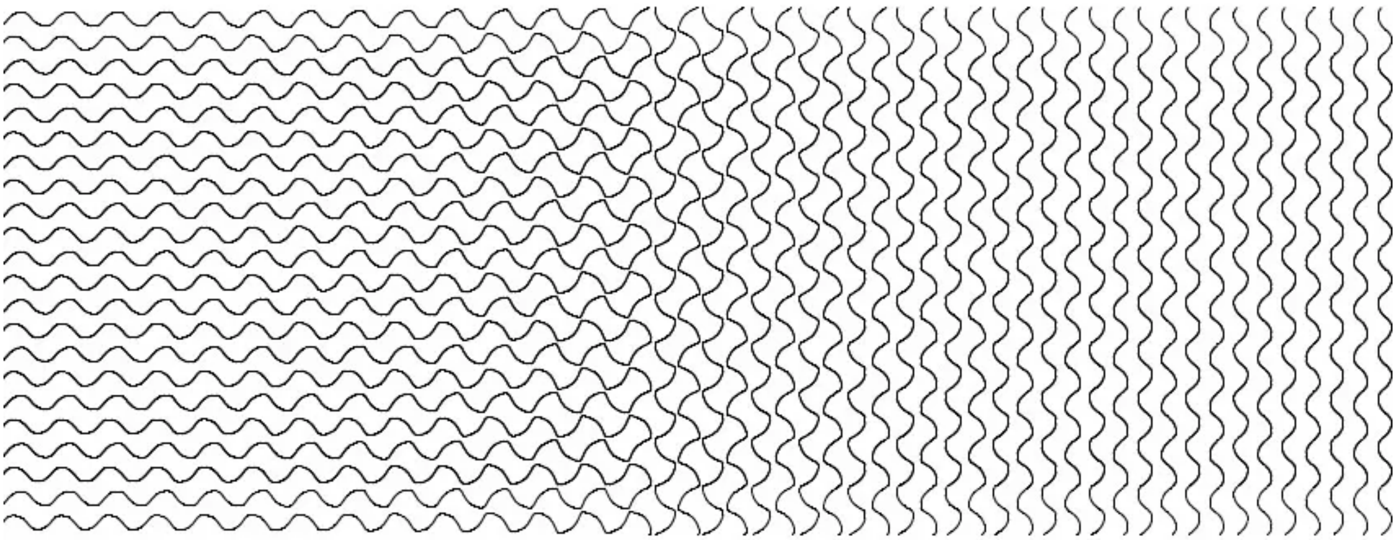
It had another remarkable property: it divided the space in two equal exclusive regions which gave me an idea about how I could use it to create the algorithm for an infill of 1–2%. It was quite simple: let’s consider the typical laser ‘nozzle’ of 0.1mm — which is actually even smaller, around 0.06–0.07 mm. For a 1% infill you need to have a structure with a period of `0.1 mm x 100 = 1cm` The infill line is repeated after 1cm, but this looked dense enough to me. I had to figure out how to draw the laser inside a 1cm x 1 cm x 1 cm cube and then repeat it in every direction needed. I used a 3D matrix of 100 x 100 x 100 cells (later 200 x 200 x 200) and computed the values of the function `f(x,y,z)= sin x cos y + sin y cos z + sin z cos x` . It sounds complicated and time consuming but it’s not — you do it just once and it’s fast. If two cells close to each other — either horizontally, vertically or in diagonal — had values of opposite signs then between them there is a point where the function was zero — so the point was on the gyroid surface — and I could compute the coordinates of this point with a good approximation using interpolation.

I was doing the final adjustments and optimisations, for continuous lines and for compacting the number of travel moves and for limiting them inside the wing, when I had to stop and abandon work. Why? Because I was not the only one interested in using gyroid as an infill and somebody else crossed the finishing line before me, soon enough all major open source slicers had gyroid as the new infill. No need to reinvent the wheel. Another failure? Not at all, it was just a confirmation I was on the right path.

From now on I could use an open-source well-tested slicer. And not only me — every builder could use these free slicers with ease. Almost all of the software pieces were in place and I could focus on the hardware part.

For my gyroid slicer from output text files…



…to QCAD drawing — horizontal waves are morphing into vertical waves.

The project was about a 3.6m–4m wingspan glider. For practical reasons — the T8 lead screws I had at the time for the Z-axis were 100 cm and I also had some 110cm 1204 ball nut screws with a 100cm active travel — I had to settle to a travel of maximum 96 cm on Z-axis. Scratch off the 4m variant for now. I wanted to print a 90cm or 96cm segment in a reasonable amount of time, let's say during weekend days in daylight: 15–16 hour outside the window of eight hours sleep. Fifteen hours for 90 cm, 16 hours for 96 cm, that's `6 cm per hour => 1 mm per minute => a layer of 0.1 mm in 6 seconds`.

I needed a vat big enough for the wing and maybe for printed molds and plugs. A minimum 30cm x 5cm x 100cm but better to make it bigger in order to use some tricks to do some 'mirror printing' — printing a part and the symmetric mirror which is to say the left and the right segment in the same time. In the end I settled for 30 x 15 cm and the whole volume was 50L. Filling it with resin was out of the question — again, the cost was similar to a competition glider! — so we need resin to float on a liquid with higher density — resin is 1.15g/cm^3. A saturated salt solution was out of the question — salts in solution are very corrosive. There was also the possibility of using sugar — I did some experiments and was not completely satisfied. Glycerine (1.26g/cm^3) was a good choice but at €2/L means €100 in the budget for a 1m tall vat which would OK for the moment.

As with liquid, the resin has a significant surface tension. This means that after printing out a layer a ‘small dip / descent’ of only one layer height is not enough and we need a ‘big dip’ of several millimeters, similar to the pop-up in the bottom-up printers but this time with less drama and no ‘tug of war’ game followed by a ‘big rise / ascent’. From the six seconds per layer we need to provision at least one second for this ‘dip and raise’ movement. Better make it two seconds and do it in a smooth move and let the resin rest after this movement — only four seconds left to print a layer. This is like drawing with laser the two walls (that’s `4 x 25 cm = 100 cm`) and the infill lines — at least two times some very curvy lines.

Final Figures

We need a printer able to ‘draw with laser’ two meters in four seconds — let’s call it a ‘500mm/s class printer’ — we need this printer to be robust to sustain 16 hour print sessions, to be easy to build and above all to be cheap because we have a very limited budget. Tough task! In the last part we had left only €200 in the budget for tooling including this 3D-printer. Is it even possible?

> “The best part is no part. The best process is no process. It weighs nothing. Costs nothing.” — Elon Musk

We will use the same principle and simplify everything. No tooling means no complex molds or plugs. We will use the good old vacuum bagging method but with some improvements: household domestic use products like vacuum bags for clothes and using the vacuum cleaner for suction. Even better, use 28cm vacuum film rolls used for food and the associated vacuum sealing machine. Instead of the traditional mylar film we will use a cheap elastic release film made from FEP (fluorinated ethylene propylene), the same polymer used in the flexible transparent bottom of the resin vat in MSLA bottom-up printers. And in order to keep everything in place we will use some simplified 3D-printed molds: a simple contour of the surface with a width of, let’s say, 2mm. I call this simplified mold a ‘bark’ — as in tree, not the sound dogs make. In detail we will vacuum bag a sandwich of:

> breather — ‘bark’ — FEP release film — TeXtreme® — core 3D -printed with resin — TeXtreme® — FEP release film — ‘bark’ — breather

I know it sounds crazy but when you think about it — I did think about it for several years! — and you eliminate all that is not really needed and leave ‘just the bare necessities’ … it feels like the right solution so it must be the right solution. The puzzle is almost complete after the bombshells “the easy way to build a performance glider is to print it with resin using a gyroid infill” and “no special tooling needed, just build a cheap 3D resin printer and borrow the food vacuum sealer from your kitchen”. All the pieces are in place except an essential one: the 3D-printer. But not for long.

Let’s Pause for a Moment for All Recap

In fact this whole part of this series is an extended pause to help you see the big picture. *Project ALTius* is not about the *ALTius* glider, as in ***my*** glider — it’s about the method and the set of software and hardware tools you need to build a glider, as in ***your*** glider. And by choice I’ve set up a set of hard constraints for:

- **Software** — open-source, complex yet easy-to-use, multi-platform
- **Tools —** cheap laser cutter and 3D-printers that are easy to build
- **Materials —** no *Rohacell®*, *CarboLine®* or other exotic stuff but rather just UV resin / balsa and affordable spread carbon cloth
- **Time of Execution** — all these constraints are derived from my initial target of “€500 glider build in a week”

However, let’s be candid: we will never get the perfect looks of a commercial competition glider — at least I know I am not able at this time. But we *can* challenge them in other areas: we can get a similar weight and a similar flight behaviour but with a faster time of execution and much less expensive. When your bird will be up in the sky you will not be able to see its ‘less than perfect’ wing surface. And if we get this right we will pass the ‘affordable’ mark — maybe we will not reach ‘disposable’ yet but we will definitely be near “if I crash, it’s not the end of the world, I can fly it repaired next week or a brand new model in two weeks". An interesting dilemma because repairing the crash will cost €50 to €100 and building a new one €100 to €200 in materials.

An Analogy

Here's a familiar car analogy to compare to F5J competitions: right now on the track there is an exclusive club of Lamborghini / Ferrari / McLaren / Porsche owners. But you can buy (or pimp up your own) Toyota / Hyundai / Ford / Skoda / Renault / Fiat / Dacia / Tata with carbon parts and a super-motor for a tenth of a super-car price. And the brand of the car will not matter anymore but the skills of the person behind the wheel. That person is not just the pilot, they are also the designer of the car and the builder and the mechanic as well.

Makes sense, no?

And a Confession

I'm not a pilot nor a builder — due to my travel and job constraints I could not spend much time in the field or in the shop. I see myself more like a 'technology enabler'. I used my time trying to solve some software or hardware problems. And in the weekends I like to spend time with kids in the local club teaching them CAD or recently writing these articles. There is a famous quote by Ralph Waldo Emerson:

> "It's the not the destination, it's the journey."

For *Project ALTius* it's both, I've set up a desirable but distant destination and I'm prepared for a long but also interesting journey. It's up to you if you decide just to read a travel blog or start to prepare for your own journey.

Next month, it's back to the nuts-and-bolts. For now, if you have any questions feel free to add them in the *Responses* section below. You get there by clicking the little 💬 below. Thanks for reading. Until next time, best of luck with your project.

Resources

- *CATIA* from Dassault Systèmes. — "delivers the unique ability not only to model any product, but to do so in the context of its real-life behavior: design in the age of experience…"

- ***Carboline®*** — "a global manufacturer of coatings, linings, and fireproofing with offices and manufacturing facilities worldwide…"
- ***Element Free*** from nTop. — "The nTop Ed community is bringing together educators, researchers and students … how to access your free non-commercial license of nTop…"
- ***G-code*** on Wikipedia. — "the most widely-used computer numerical control (CNC) programming language. It is used mainly in computer-aided manufacturing to control automated machine tools, as well as from a 3D-printing slicer app…"
- ***Kodo*** from Kraga. — "Kodo is a proof of concept that 3D printing can be used for building RC planes. It was designed as a multipurpose glider that does it all…"
- ***Meshmixer*** — "state-of-the-art software for working with triangle meshes…"
- ***Photon*** from Anycubic. — "LCD-based SLA 3D-Printer … supreme accuracy for highly detailed prints…"
- ***OpenSCAD*** — "software for creating solid 3D CAD models. It is free software…"
- ***Oracover®*** from Lanitz-Prena Folien GmbH. — "our leading product for covering RC model airplanes is patented worldwide … permits re-positioning without fear of colour-layer separation…"
- ***Perspex®*** — "suitable for glazing, furniture and display cases to name a few applications…"
- ***Plexiglas®*** — "the first cast sheet made of polymethyl methacrylate … stable, transparent and impact-resistant polymer…"
- ***RCGroups*** thread for Project ALTius. — "altius, citius, fortius — sounds familiar? That's the Olympic motto where 'altius' means 'higher'. But the spelling (ALTius) is related also to my initials — Atudorei Lucian Tiberiu…"
- ***Rohacell®*** — "For 50 years, Evonik's ROHACELL® structural foam has been offering the aerospace and automotive industries, medical technology, and other markets boundless possibilities for lightweight construction…"

- ***SolidWorks®*** — “SOLIDWORKS® and the 3DEXPERIENCE® Works portfolio unite your entire ecosystem…”
- ***TeXtreme®*** — “spread tow reinforcements are a uniquely adaptable, safe and ultra light supportive solution for your carbon fiber composites…”
- ***XFLR5*** — “an analysis tool for airfoils, wings and planes operating at low Reynolds Numbers…”
- ***xflrwing*** — “STL generator for an XFLR project wing…”
- ***XPS*** from DuPont. — “Since its discovery in 1941, Styrofoam™ Brand XPS Insulation has a long and rich heritage as a sustainable building product…”

*All images by the author. Read the **next article** in this issue, return to the **previous article** in this issue or go to the **table of contents**. A PDF version of this article, or the entire issue, is available **upon request**.*

Written by Tiberiu Atudorei

5 Followers · Writer for The New RC Soaring Digest

“The Prandtl-D makes one of its early flights” in 2015. More information on this photo can be found using the link Resources, below. (credits: NASA / Tom Tschida)

Twist Distributions for Swept Wings

Part 4: The effect of lift distribution and aileron configurations on adverse and proverse yaw, and using bell-shaped lift distribution to reduce induced drag.

Bill Kuhlman · Follow
Published in The New RC Soaring Digest
11 min read · Apr 30

*Readers who have not already done so may want to read **Parts 1, 2 and 3** of this five part series before proceeding with the following. — Ed.*

Defining Lift Distributions

Before describing research results related to lift distributions, another look at the elliptical lift distribution is in order.

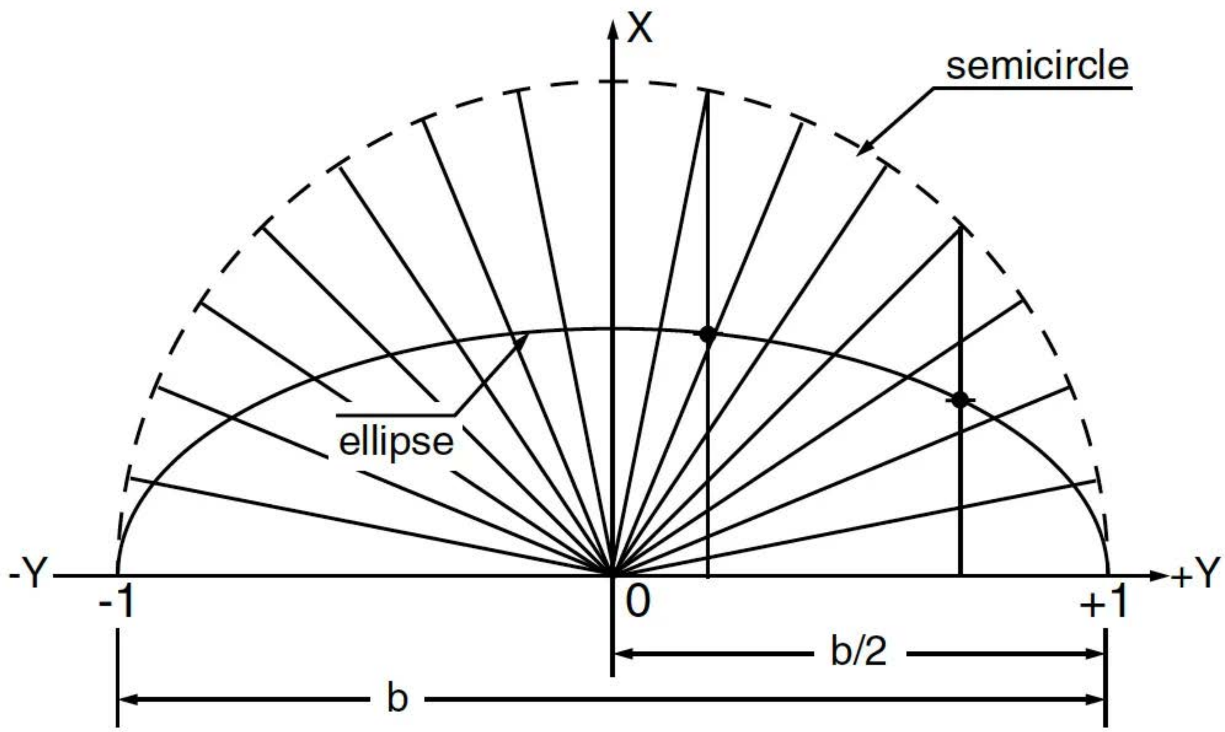


Figure 1. Geometric construction of elliptical lift distribution

In Part 1, the elliptical lift distribution was defined by means of a geometric construction. Figure 1 illustrates this methodology. Simply stated, vertical lines are dropped from a semicircle to the baseline. The center of these verticals are then determined and a curve drawn which connects the determined points. The curve thus defined is an ellipse. This shape is then used as a basis for the lift distribution across the span. The result of such a lift distribution is a constant downwash across the entire span and a minimization of induced drag.

As an extension of the description in Part 1, there is another method of defining the elliptical lift distribution which involves trigonometric functions. In this construction, the point *P* is defined by its *X* and *Y* coordinates as determined by the following formulae:

$$YP = b/2 * \cos \xi$$
$$XP = K * \sin \xi$$

For the construction of the semicircle, $K = b / 2$, the semi-span. For the construction of an ellipse, *K* can be any value less than one. In the illustrated case, Figure 2, $K = 1 / 2$ in keeping with the geometric construction explained previously.

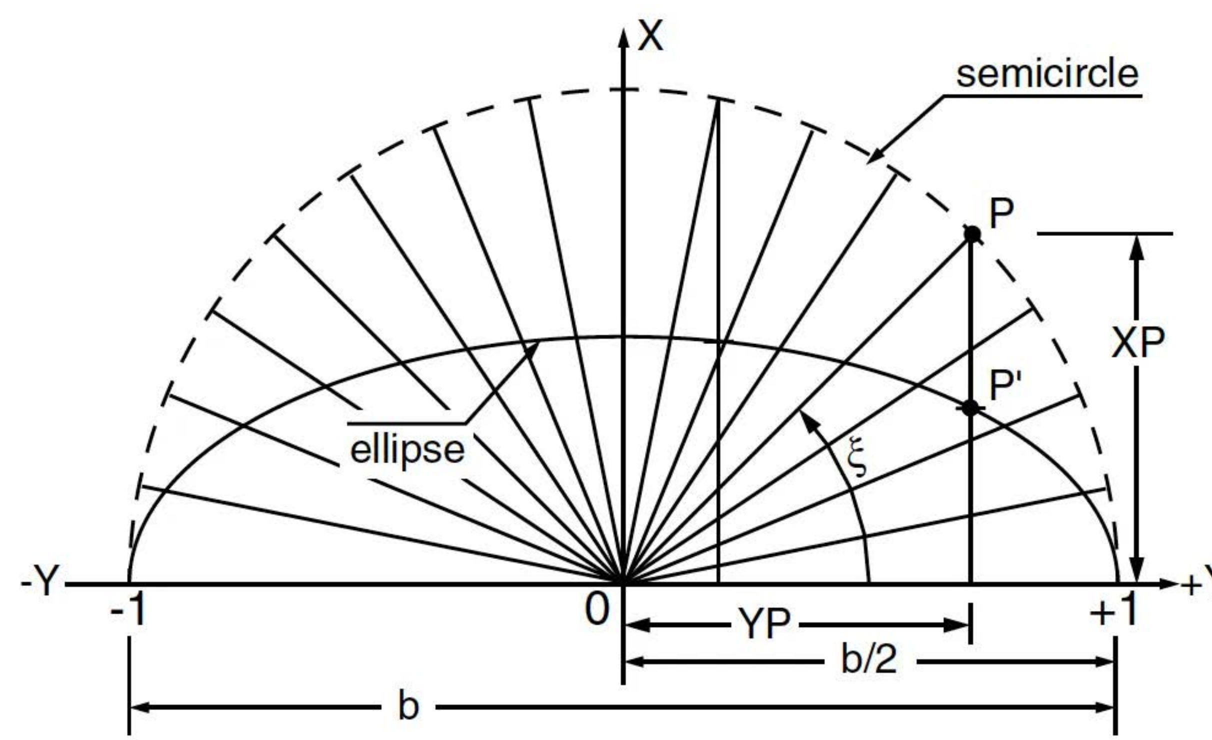


Figure 2. Trigonometric construction of elliptical lift distribution

It should be noted at this point that each point *P'* defines the lift generated by that wing section, the coefficient of lift times the local chord. One way of visualizing this is to consider an elliptical lift distribution and an elliptical wing operating at a coefficient of lift of one. Remember, the lift coefficient is constant across the span; that is, the local coefficient of lift for each wing segment will be one. In this case, the wing chord is directly proportional to the height of the lift distribution curve at that point along the Y-axis.

Taking this trigonometric methodology one step further, we can modify the trigonometric function by adding an exponent *n*. For example, rather than using sin ξ, we use $\sin^n \xi$. See the included Table for an idea as to how various exponents affect the resulting points *P'*.

Table 1: Sin^n values for the construction of lift distributions

ξ	90°	78.75°	67.5°	56.25°	45°	33.75°	22.5°	11.25°
$\sin \xi$	1.0000	0.9808	0.9239	0.8315	0.7071	0.5556	0.3827	0.1951
$\sin^2 \xi$	1.0000	0.9619	0.8536	0.6913	0.5000	0.3087	0.1465	0.0381
$\sin^{2.5} \xi$	1.0000	0.9526	0.8204	0.6304	0.4204	0.2301	0.0906	0.0168
$\sin^3 \xi$	1.0000	0.9435	0.7886	0.5748	0.3536	0.1715	0.0560	0.0074
$\sin^4 \xi$	1.0000	0.9253	0.7285	0.4780	0.2500	0.0953	0.0214	0.0014

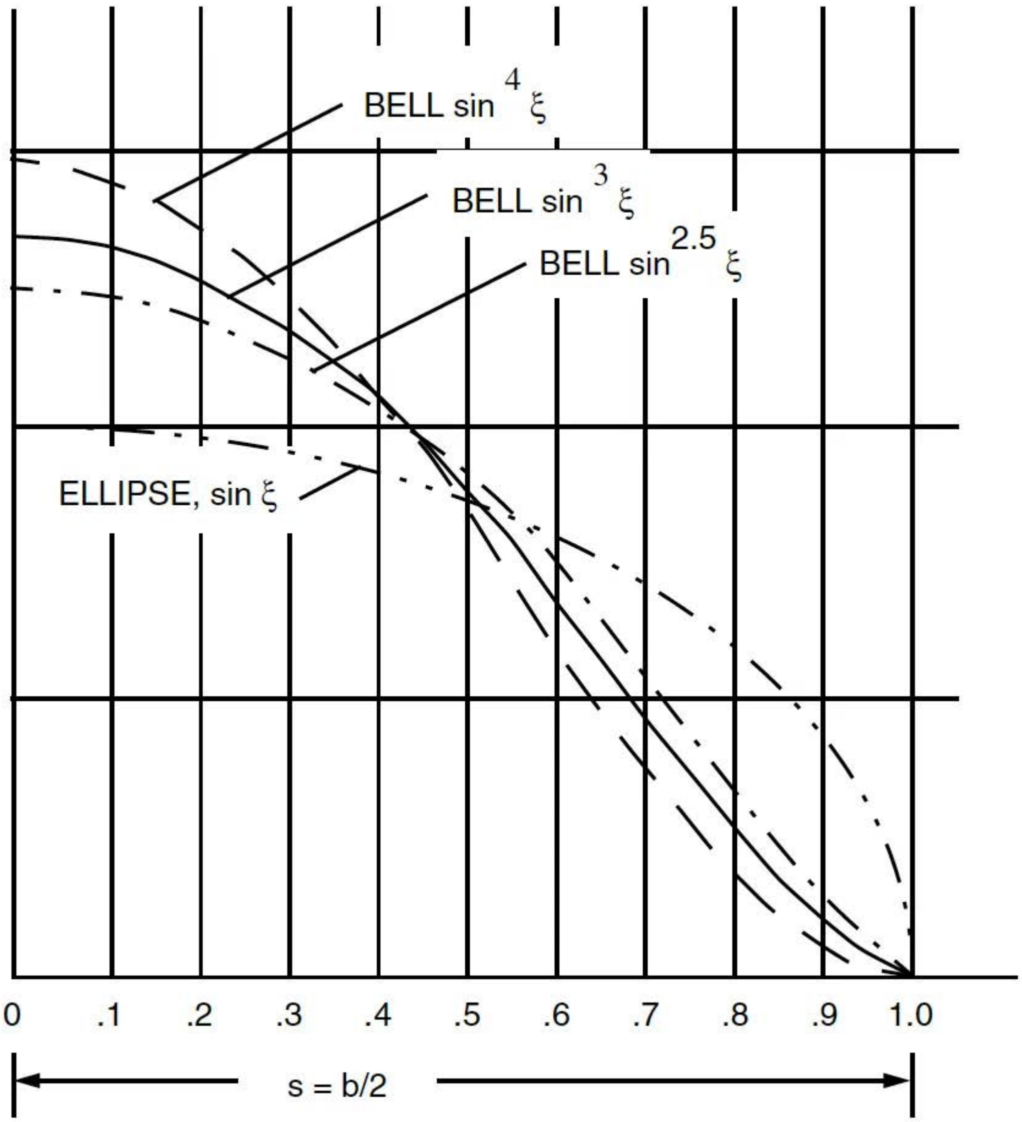


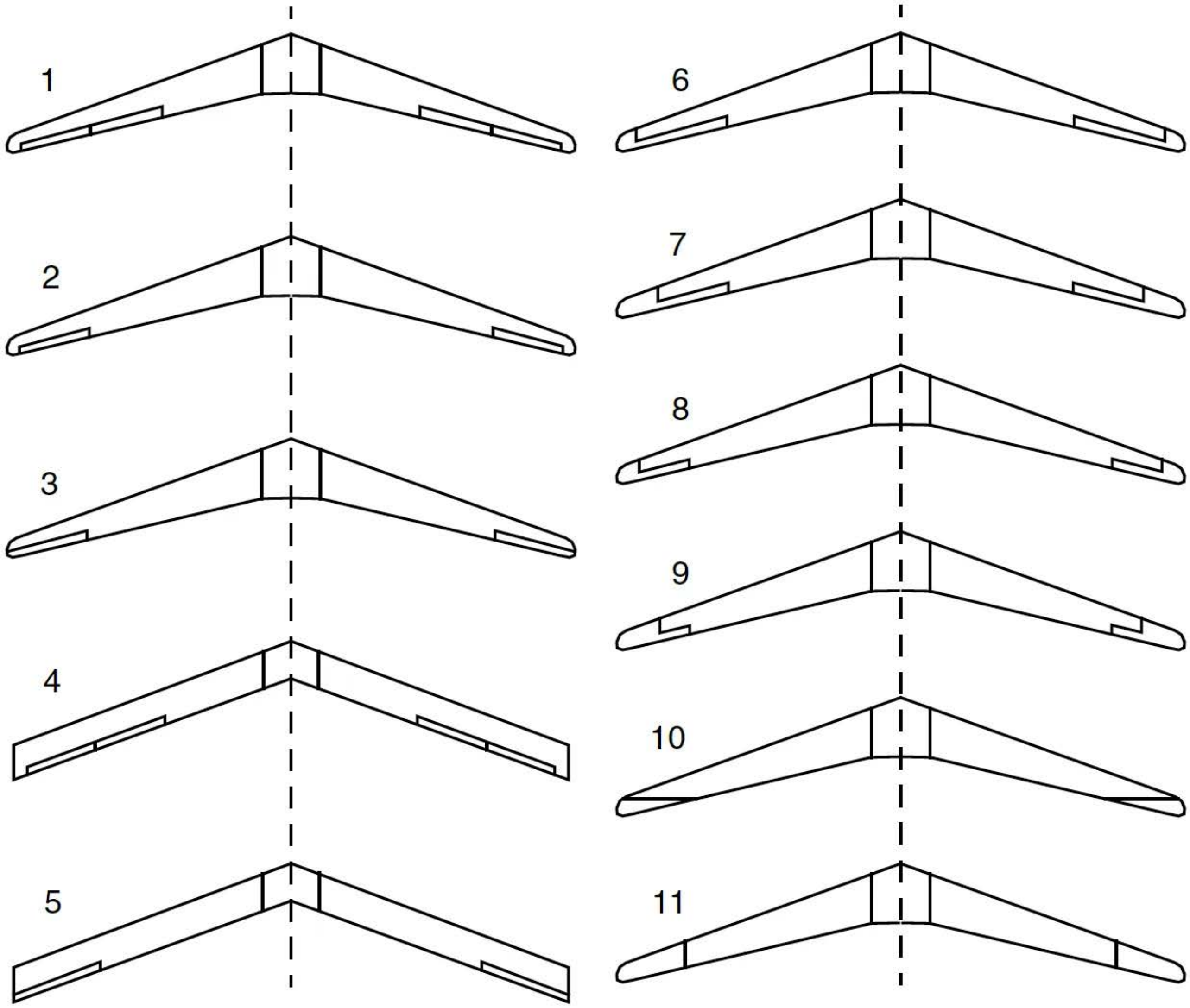
Figure 3. Lift distributions for $\sin^{n}$ functions.

Figure 3 shows the elliptical lift distribution, $\sin \xi$, and three other distributions, $\sin^{2.5} \xi$, $\sin^{3} \xi$, and $\sin^{4} \xi$. Because the aircraft weight is held constant, the area under each curve is identical. The latter lift distributions which utilize the *n* exponent are termed bell-shaped for obvious reasons.

When the bell-shaped distribution is applied to moderately swept back wings, the following generalizations apply: when the exponent n is two, the lift distribution is bell-shaped but there is no induced thrust at the wing tips. When $n = 2.5$, the adverse yaw disappears and proverse yaw begins to appear. As *n* approaches three, the induced drag begins to increase rapidly. The designer should therefore use the lowest value of n in keeping with his/her objectives. The Hortens used $n = 3$ for most of their designs, but $n = 2.5$ may be sufficient for use on models where both adverse and proverse yaw are undesirable and induced drag should be as low as possible.

Yaw Moment, Lift Distribution, and Aileron Configuration

Dr. Edward Udens analyzed the yawing moment of two swept wing planforms with differing lift distributions and control surface configurations. Figure 4 shows the various configurations, notes their lift distributions, and presents the yaw moment for each. The elliptical and $\sin^3 x$ bell-shaped lift distributions were evaluated. Negative yaw moment values indicate adverse yaw, positive yaw moment values indicate proverse yaw. Both of the wings with elliptical lift distributions demonstrate adverse yaw regardless of control surface placement. Proverse yaw can be generated by using the bell-shaped lift distribution and by keeping the elevon control surface well outboard.



Elevon Configuration	Cn∂a	Span Load
1	-0.002070	bell
2	0.001556	bell
3	0.002788	bell
4	-0.019060	elliptic
5	-0.015730	elliptic
6	0.001942	bell
7	0.002823	bell
8	0.004529	bell
9	0.005408	bell
10	0.004132	bell
11	0.005455	bell

Figure 4. Relationship of control surface configuration, span load, and yaw moment.

Dr. Udens' results demonstrate an increasing adverse yaw moment as the elevon control surface is moved inboard. This is an important consideration. The roll control surfaces must be placed in the area of the wing which has a concave lift distribution curve; that is, outboard in the case of the bell-shaped lift distribution. Although the Hortens used the $\sin^3$ lift distribution, they included inboard elevons which may have significantly reduced the proverse yaw moment and in fact created an adverse yaw moment.

A Relevant Example

There are a number of readers who at this point desire some sort of practical example of the bell-shaped lift distribution generating proverse yaw as elevon control surfaces induce a roll moment. Ideally, we would look for a swept wing tailless model without winglets which exhibits very strong adverse yaw as an example. Those who have built and flown a Klingberg wing know well this model meets the ideal. Don Stackhouse of DJ Aerotech had the following to say about his Klingberg wing:

> *"My stock Klingberg, with its horrible adverse yaw and a yaw-roll coupling that essentially negates the roll response to any but the smallest elevon deflections, is essentially unsafe to fly in any place with maneuvering space restrictions or in any kind of turbulence."*

Don goes on to say that the addition of any aileron differential severely affects the aircraft in pitch. The application of down elevator to inhibit the nose up pitching reduces the differential, so it's a *Catch 22* situation. Don has not flown his Klingberg wing in several years, and in fact only takes it out of storage to serve as an exhibit model.

Michael Allen, a student at Embry-Riddle Aeronautical University and an intern at NASA Dryden Flight Research Center under Al Bowers, decided to build a Klingberg wing using a bell-shaped lift distribution. See Photo 1.

Michael Allen and his “Hortenized” Klingberg ’wing.

The taper ratio and other planform parameters of the two meter Klingberg wing closely match those of the Horten Xc, an advanced ultra-light glider designed by Reimar Horten while he was living in Argentina. Al was able to get the twist values for the modified Klingberg wing from Reinhold Stadler, and Michael built the model using the defined twist distribution. Additionally, Michael used an elevon planform, illustrated in Figure 5, in keeping with the results of Dr. Udens (Figure 4 No.6). This elevon planform is calculated to give a small amount of proverse yaw, $C_n \partial a$ = 0.001942.

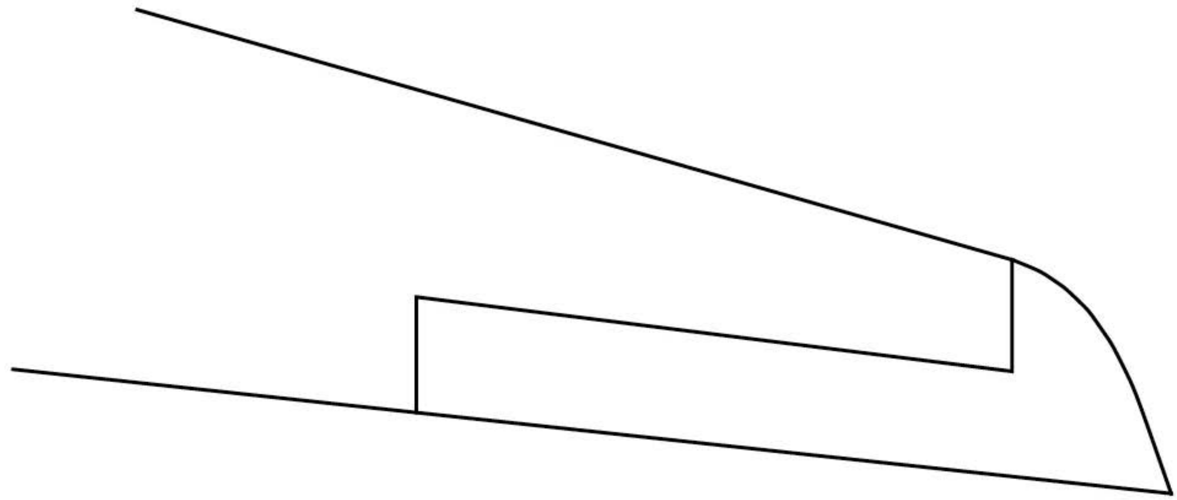


Figure 5. Elevon planform for Michael Allen's "Hortenized" Klingberg 'wing.

Al says the wing looks very 'organic' in the air, and while flying directly overhead and giving full right or left stick, there is not even a hint of adverse yaw in evidence.

Reducing Induced Drag

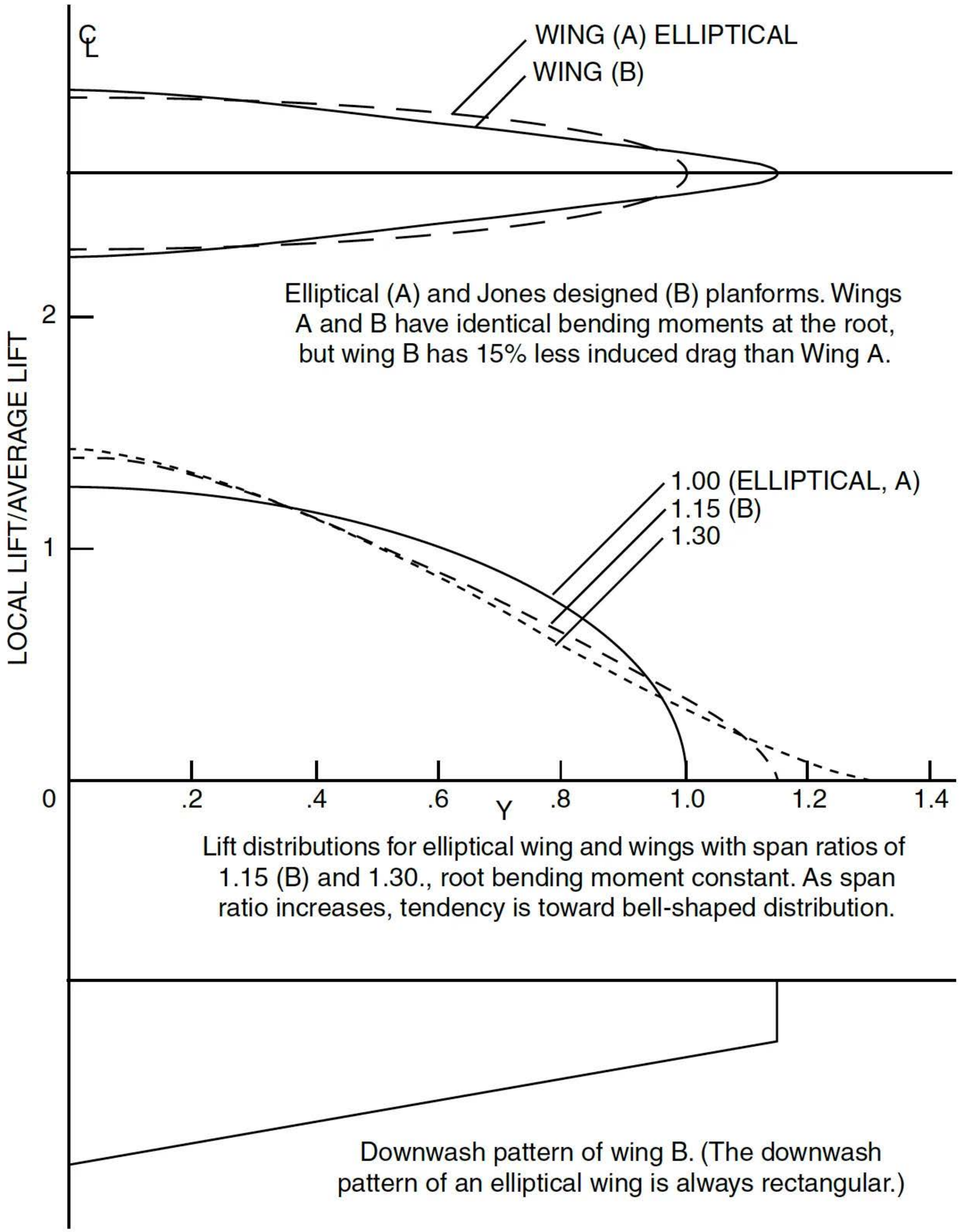
"The elliptical lift distribution is the most efficient." We have heard this statement often over the years. Recently we've come to discover it is not entirely true simply because it is incomplete. More accurately, "the elliptical lift distribution is the most efficient for a wing of given lift and span." The qualifications may not seem to be of much importance at first. But consider a wing of a given span with an elliptical lift distribution. Is there a way to reduce the induced drag of this wing, making it more efficient, while keeping the root bending moment the same?

If you simply add span and maintain an elliptical lift distribution, the wing will be more efficient because you've increased the aspect ratio. But the spar will need to be strengthened because the bending moment at the root will have been increased with the larger span. So the question becomes a matter of finding a means to increase the span without increasing the load at the wing root. Enter the bell-shaped lift distribution.

Ludwig Prandtl came up with the elliptical span load around 1908, but did not formally publish his work until 1918. In 1933, Prandtl published his paper *On the Minimum*

Induced Drag of Wings in which he presented the bell-shaped lift distribution. Prandtl's solution provided an 11% reduction in induced drag with a 22% increase in span and no increase in the root bending moment. In 1950, Robert T. Jones looked at the same problem and, unaware of Prandtl's work, came up with a similar solution by a different means.

Jones' computations show a 15% decrease in induced drag with a 15% increase in span when using a bell-shaped span load. Figure 6 illustrates Jones' planform, a comparison to the standard elliptical lift distribution, and the trapezoidal shape of the produced downwash.



Elliptical (A) and Jones designed (B) planforms. Wings A and B have identical bending moments at the root, but wing B has 15% less induced drag than Wing A.

Lift distributions for elliptical wing and wings with span ratios of 1.15 (B) and 1.30., root bending moment constant. As span ratio increases, tendency is toward bell-shaped distribution.

Downwash pattern of wing B. (The downwash pattern of an elliptical wing is always rectangular.)

Figure 6. Comparison of various aspects of Jones' low induced drag planform to an elliptical wing.

Also included in that illustration is a diagram showing the lift distribution for a wing with a span ratio of 1.30 and a root bending moment identical to the span ratio 1.0 elliptical wing. Jones states that while the span can be increased further, the near maximum benefit comes with a 15% increase in span.

Other investigators, notably Klein and Viswanathan, have looked at the same constant root bending moment problem but also included other constraints, such as shear. The results point to a bell-shaped lift distribution and similar reductions in induced drag.

Back to Winglets

In Part 3, we described how winglets can be a source of induced thrust. We also drew a parallel between the action of winglets and the effects of generated upwash on the outer portion of a swept wing. Consider a wing with a bell-shaped lift distribution which is producing induced thrust at the wing tips to be equivalent to a wing with winglets which is operating at its design speed.

While researching this series of articles, we ran into a document produced by Boeing as part of their publication *Aero* dealing with blended winglet design for various passenger and cargo aircraft. Briefly, the addition of properly designed winglets which extend the wing between ten and 16 percent can substantially increase payload and range and decrease takeoff runs, particularly near maximum gross weight. This is parallel to the effects predicted for the span extension proposed by Jones. According to the article, maximum payload increases, takeoff runs are shortened, cruise drag is decreased by four to more than five percent, and range is increased by approximately four percent.

This is evidence that, when properly designed, winglets can improve performance over a wide speed range. Additionally, blended winglets improve directional and pitch stability and longitudinal and lateral trim stability. There is no change in stall speed or Dutch roll damping. One of the interesting points covered in the article involved the toe angle of the winglet. Initially, the toe out angle was set for zero degrees. While this minimized induced drag, it imposed very high loads on the wing. A toe out angle of two degrees reduced the bending loads on the wing but did not adversely affect the drag reduction except in the flaps down position. Boeing determined this was an acceptable trade-off for reducing required structural modifications.

It's important to realize that commercial aircraft have span limitations based on constraints imposed by airport architecture, so vertical winglets are a much more attractive option than increasing the wing span. Boeing's blended winglets aerodynamically increase the wing span without imposing a greater root bending moment and without increasing the actual wing span.

Discussion

The following discussion recently took place on the *Nurflügel Mailing List* the link for which can be found in *Resources*, below. We think the exchange may be enlightening, particularly for those readers with some doubts as to the efficacy of the bell-shaped lift distribution as applied to reducing induced drag. Al Bowers is Chief of Aerodynamics at NASA Dryden Flight Research Center.

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From: Al Bowers <al.bowers@dfrc.nasa.gov>
Date: Wed, 18 Jun 2003 07:58:24 -0700
Subject: [nurflugel] NASM and Hortens…

Just a quick FYI: Russ Lee is in a blurb about the Hortens at: <http://
www.airandspacemagazine.com/ASM/Mag/inthemuseum.html> The blurb is
mostly right. The part about a drag penalty isn't quite true (but I
made that mistake in the past, so I can't complain too much). Nice
photos…

Al
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From: Russell Lee <russlee_99@yahoo.com>
Date: Tue, 24 Jun 2003 10:37:51 -0700 (PDT)
Subject: Re: [nurflugel] Digest Number 1143

Al, when the author of the A & S piece asked me about Horten's bell
distribution, I recalled that you had reported fiending less drag than
with the elliptical distribution. I wanted to mention that fact but I
have no idea how this occurs, so wanting to err on the cautious side, I
recited the standard litany about the drag penalty with bell.

Would you have time to explain why the bell drag is less? I would sure
like to give Reimar full credit when people ask about his work.

Russ Lee
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From: Al Bowers <al.bowers@dfrc.nasa.gov>
Date: Wed, 25 Jun 2003 15:33:46 -0700
Subject: Re: [nurflugel] Digest Number 1143

Hey Russ,

The question is actually pretty complex. But the problem boils down to one issue: is span constricted or not? If span is constricted, then the lowest drag is elliptical (unless winglets are allowed). If span is not constricted, then the bell shaped is lower drag.

Let's assume we design a wing elliptical. Now, given that wing, what is the size of the spar we have to build to support that load (this is the wing root bending moment, hereafter the WRBM).

Now, as a thought experiment, ask the question: Is there a span and a span load that results in SAME WRBM but has less drag? If the answer is yes, then what is the optimum span and span load for the same WRBM? (This was Prandtl's question in 1933.)

The answer is yes, it is the bell shaped load distribution. The BSLD has the same WRBM as the elliptical and the same lift (so the same wing spar), but it has 22% MORE span and 11% LESS drag. It's the optimum drag for a given wing spar (which makes it of interest to birds; why haul around more bio-mass than necessary?).

By the way, this is also the subject of R.T. Jones 1950 paper, as well as being developed a bit more with Klein and Viswanathan's 1975 paper. The other piece of the puzzle is the induced thrust at the wing tips (ala winglets). This allows the defeat of the adverse yaw part. But that's another story.

Does that help?

Al

From: “DavidRSw” <DavidRSw@bdumail.com>
Date: Wed, 25 Jun 2003 16:57:18 -0700
Subject: Re: [nurflugel] ESLD vs. BSLD

Hi Al,

So after listening to you give at least three lectures on this subject, talking to you in person an equal number of times, and reading your posts here, finally I may be beginning to understand what you are saying. ;-)

So, if we take two aircraft with the same weight = same lift = same WRBM = same wing spar, then we have two aircraft with different spans and different drags?

One hang glider with an elliptical lift distribution (ESLD) wing that weighs 245 lbs. ready to fly, has a 40 ft. span and a glide of 22:1. Does the other hang glider with the bell shaped lift distribution (BSLD), weigh 245 lbs. ready to ßy, have a 48.8 ft. span, and a glide of 24:1? Have I got it right yet?

Disregarding the weight, what would the glide be of a 48.8 ft. span hang glider with an ESLD? If we have two hang gliders of 48.8 ft. span, the one with the ESLD will have a better glide but weigh more? About how much more?

Thanks,

Dave Swanson

From: “Albert Robinson” <arobins1@midsouth.rr.com>
Date: Thu, 26 Jun 2003 02:34:47 -0500
Subject: Re: [nurflugel] ESLD vs. BSLD

Or with the BSLD are we are driven to a longer span to make up for the losses incurred? How else would you have the same WRBM with a greater span? I thought one premise of BSLD was an increase in stability but with a small loss in total efficiency. Would not ESLD for a given span have to be more efficient? For that matter, were any of the Horton designs ever tested and demonstrated as “pure” BSLD? Or perhaps a blend of both.

Sorry, just old and stupid, I don’t understand.

A-n-P

From: Al Bowers <al.bowers@dfrc.nasa.gov>
Date: Thu, 26 Jun 2003 08:28:46 -0700
Subject: Re: [nurflugel] ESLD vs. BSLD

>So, if we take two aircraft with the same weight = same lift = same WRBM = same wing spar, then we have two aircraft with different spans and different drags? RIGHT!

>One hang glider with an elliptical lift distribution (ESLD) wing that weighs

<snipped>

>ready to fly, have a 48.8 ft. span, and a glide of 24:1?

Close, it's only the INDUCED drag we reduced a bit (~11%), we didn't do anything to the profiledrag (remember, we changed the wing area, so the balance of drag would be different, but profiledrag changes would be "insignificant"). So the "real" L/D max would probably only go up to a little over 23:1 (not quite to 24:1). And I would imagine the weight would rise a little as well (we did not consider the shear required to carry that load further out, Prandtl's original solution didn't consider shear, but Klein's & Viswanathan's solution DID).

> Or with the BSLD are we are driven to a longer span to make up for the

<snipped>

> and demonstrated as "pure" BSLD? Or perhaps a blend of both.

BSLD gets less drag than ESLD, that's not a "making up for losses" in my mind. The reason BSLD has the same Wing Root Bending Moment (WRBM) as ESLD is because BSLD carries less load out near the tips as ESLD.

It's like trying to pick up a 40 lb. tool box and turn it around vs. picking up a 40 lb. ladder and turning it around. The ladder has more mass out further away than the tool box, so you have to apply more load to turn it. BSLD is the tool box and ESLD is the ladder. There is no loss in efficiency, BSLD is BETTER than ELSD. It minimizes the structure to carry the load (or you carry more payload as a fraction of total weight), it gets less drag, and it also solves the adverse yaw problem (you don't NEED a vertical tail, for even less weight).

It is the bird flight solution.

> Sorry, just old and stupid, I don't understand.

No, I'm just not explaining it well enough. When you get this one, a HUGE light bulb will turn on in your head and you'll suddenly get it, in a BIG way! I get chills just thinking about this, it is so completely right, elegant, and simple.

It HAS to be the bird flight solution.

From: Al Bowers <al.bowers@dfrc.nasa.gov>
Sent: Thursday, June 26, 2003 10:28 AM
Subject: Re: [nurflugel] ESLD vs. BSLD

OK, OK, I think I am getting it now, but one more pass for us "aerodynamically impaired":

So to get simplistic (it's more than this, I am sure) the BSLD it is a function of airfoil selection and of course washout (type and style of twist). You said that the WRBM would be less with BSLD because the tips are carrying less load than if it were ESLD. (Am I doing OK so far?) In order for it to be "less" something had to go away, i.e.: total lift in the wing tip sections correct?

But the trade off is worth the loss in that the lift vector at the tips is now forward (from the washout and the airfoil selection) and provides yaw stability plus less bending moment. Hooowee,do I got it?? :) or maybe a little??

From: Al Bowers <al.bowers@dfrc.nasa.gov>
Date: Thu, 26 Jun 2003 10:07:45 -0700
Subject: Re: [nurflugel] ESLD vs. BSLD

Albert Robinson writes:

> OK, OK, I think I am getting it now, but one more pass for us

<snipped>

> I got it?? :) or maybe a little??

BSLD is a function of twist, design point (lift coefficient & wing sweep), and airfoil. But ESLD is also a function of airfoil selection as well. And we traded the lift at the wing tips and moved it inboard a bit relative to ESLD.

ESLD BSLD

center load: less more

tip load: more less

total load: equal for both

I think you've got it now…

Al

For AMA RC models outside of the Unlimited class (RC-HLG, 2m, Standard), span is limited. Designing a tailless model with a bell-shaped lift distribution in an attempt to improve performance beyond that of a conventional tailed aircraft of the same span is therefore problematic, as Al Bowers explains.

Still, for the Unlimited class, where the only limitations are wing area ($2325in^2$), mass (5kg, 11.02lb), and wing loading ($3.95–24.57oz/ft^2$), a competitive swept wing tailless model is certainly in the realm of possibility, and in fact, may be the best choice.

A tailless model utilizing the bell-shaped lift distribution is a particularly enticing proposition when such considerations as ground handling and construction costs are removed and modern low Reynolds airfoils, vortex-lattice computer codes, and high-tech materials and fabrication methods can be so easily added to the design and construction processes.

Our sincere appreciation goes to Al Bowers for providing substantial guidance and positive reinforcement, as well as a number of printed references, for this installment. Thanks are also due to the members of the nurflugel e-mail list for their informed questions regarding the elliptical and bell-shaped lift distributions.

What's Next?

The next and final installment in this series will provide a summation of the Horten, Culver, and Panknin twist distribution methodologies.

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Resources

- ***NASA Armstrong Fact Sheet: Prandtl-D Aircraft*** published on March 30, 2016. — "NASA's Armstrong Flight Research Center engineers in Edwards, California, are working on an increasingly complex aircraft called the Preliminary Research Aerodynamic Design to Lower Drag, or Prandtl-D…." This article is the source of the key photo above.
- ***Nurflügel Mailing List*** — "This mailing list serves as a discussion forum for fans of flying wings. Pretty much anything that pertains to this subject is welcome. The title *Nurflügel* is the German word for what in English is called a flying wing…"

All images, figures and tables by the author unless otherwise noted. Read the ***next article*** *in this issue, return to the* ***previous article*** *in this issue or go to the* ***table of contents****. A PDF version of this article, or the entire issue, is available* ***upon request****.*

May 2023 Gliders Aeronautical Engineering Aviation Flying Wings

Calculating Laminate Thickness

Figure it out before you start unrolling carbon cloth and mixing resin.

Rachael Geerts · Follow
Published in The New RC Soaring Digest
7 min read · May 3

We are delighted to present the third in our series of selected articles from Gougeon Brothers, Inc. excellent in-house publication Epoxyworks. *See* Resources *for how you, too, can become a subscriber which is what we are and highly recommend you become as well. Continued thanks to Logan Gougeon for her tireless support of this initiative. — Ed.*

Have you ever wondered how laminate thickness can be determined without breaking out the epoxy and reinforcement fabric? The answer is simple — use math. While some of you may have just lost interest because you think math is too difficult, I can assure you that this math requires nothing more than some basic multiplication, addition, and division. Let's get to it.

Here is the equation we'll use to calculate the average thickness for a single layer of laminate:

$$t_L = \frac{W_F}{\rho_F} + \frac{\left(\frac{W_F}{X_F} x \, X_R\right)}{\rho_R}$$

In This Equation:

- ***tL*** represents the total composite laminate thickness.
- ***WF*** represents the aerial weight of the woven or knit reinforcement fabric you are using in your composite laminate.
- ***ρF*** represents the density of the reinforcement fibers.
- ***ρR*** represents the density of the resin system you are using. In this instance, the resin system is West System Epoxy.
- ***XF*** represents the fiber weight fraction, which is determined by the process you are using to create your laminate.
- ***XR*** represents the resin weight fraction. Like the fiber weight fraction, this will be determined by your processing technique and can be calculated as *XR* = 1 — *XF* .

Now that we know what our variables represent, we need to determine their value.

Reinforcement Aerial Weight (WF)

The aerial weight is given by the fabric supplier, but it's also what you typically call the woven fabric you buy. Ever wonder why fiberglass was called 10oz or 17oz or maybe why carbon might be called 200g/m^2? These are the aerial weights of the fabrics (exact aerial weight is typically given on the spec sheet). 10oz is referring to 10oz/yd^2. The same is true for 17oz. Now, weights like 200g/m^2 carbon may confuse those of us in the US a little, but g/m^2 stands for grams per square meter. This is a common unit of measure for carbon fiber.

This brings up a good point — check your units! For these equations to work properly you need to make sure you are using the same units — inches to inches or mm to mm, etc. I could go into great detail here about how to convert between different units, but with all the resources available today, you hardly need to do the conversions by hand (although you can if you like math that much!) There are plenty of apps or websites that will do these conversions for you in a matter of seconds, so I would recommend using one of them (or checking your work with one of them).

Fabric and Epoxy Density (ρF and ρR)

While you can find the densities of different fiber reinforcement types in various reference materials, we typically use the values given in this table:

Fiber type	Average density in oz/in^3	Average density in g/cm^3
Fiberglass	1.47	2.55
Carbon Fiber	1.04	1.80

The average density of the West System® 105/20x is about 0.68oz/in^3 or 1.18 g/cm^3. Specific densities can be found on our technical datasheets on our website, the link for which you can find in *Resources* below.

Weight Fraction (XF and XR)

Through much research and experience, the composites industry has agreed that the processing technique you use impacts the weight ratio of each component. This means that, if you hand lay up your laminate, the weight fraction (*X*) values will be different than if you vacuum bag your laminate. This second table contains the *X* value ranges that are typically accepted in the composites industry. Since the only components of your reinforced laminate are the fibers and the epoxy, *XF* + *XR* should always equal one.

Processing Technique	X_F Fiber Weight Fraction	X_R Resin Weight Fraction
Hand Lamination	0.45-0.55	0.45-0.55
Vacuum Bagging	0.55-0.7	0.3-0.45

The hand lamination technique is suitable for a wide range of applications, however there may be certain times where you need to optimize your laminate for higher performance. Since the laminate fibers carry the majority of the load, it is often best to increase *XF* and decrease *XR* to maximize the composite's strength.

The most common way to increase *XF* when using epoxy is to vacuum bag your laminate. This means that, after you have thoroughly wet out your reinforcement fabric, you would follow the directions outlined in our *Vacuum Bagging Techniques* manual which can also be found in *Resources*, below. For a flat laminate, you would want to apply a vacuum pressure of 5–12″ of Hg (inches of mercury). For a more complex shape, you would want to apply 12–25″ of Hg to get an even vacuum pressure across the entire laminate. This vacuum pressure helps remove entrapped air and excess epoxy, consolidating the laminate. Again, this is a great way to optimize your laminate, however, it may not be practical or needed for every project. Make sure to consider the full scope of the project before determining which processing method you are going to use.

The Formula in Action

Let's put our new knowledge to the test. We will calculate the thickness for a fiberglass, hand layup panel made with one layer of 10oz fabric and *105 Epoxy Resin®* with *205 Fast*

Hardener® :

- *WF* — If we use one square yard of 10oz/yd^2 fiberglass then = 10oz/yd^2. We'll convert this to 0.0077oz/in^2 which will help with units later.

- and — We can use 0.5 for our and (right in the middle of the ranges) since our panel will be made via hand lamination. *Note: This amount of epoxy will allow you to thoroughly wet out the fiberglass by hand.*

- *ρF* — From the density table, we know the average density of fiberglass is 1.47oz/in^3.

- *ρR* — We also know that the density of *105/205* is 0.68oz/in^3.

If we start putting all of the known values into the equation, we get:

$$t_L = \frac{W_F}{\rho_F} + \frac{\frac{W_F}{X_F} x\, X_R}{\rho_R}$$

$$t_L = \frac{0.0077\ oz./in^2}{1.47\ oz./in^3} + \frac{\frac{0.0077\ oz./in^2}{0.5} x\ 0.5}{0.68\ oz./in^3}$$

$$t = 0.0052\ in + 0.011\ in$$

$$t = 0.016\ in$$

(Using 2 significant figures)

A Few Last Thoughts

While the laminate thickness equation may look a little intimidating at first, you now know exactly how to fill it in and solve it. This is a great tool to help you in calculating your laminate thickness, but keep in mind that this equation only gives you an average single-layer thickness. The average takes into account the high spots and low spots in the fabric from the weave. If you were to take some calipers and measure the thickness of a panel made with a single layer of fiberglass, you would likely get a slightly higher number than the calculated thickness because the calipers would rest on the high spots of the fabric.

Remember to double-check your units! They are slippery little fellas and can sometimes get away from you. Make sure to always keep them in check (you should never end up with a single-layer thickness even close to an inch or more with a standard woven or knit reinforcement fabric).

Short Cut

If you're steadfast in your aversion to math, I've got a shortcut for you. This chart has the approximate single layer thickness for all of our WEST SYSTEM fiberglass for a hand lay-up laminate.

Product	Fabric Weight	Single Layer Thickness*	Product	Fabric Weight	Single Layer Thickness*
740	4 oz.	.006" - .008"	733	9 oz.	.013" - .017"
742	6 oz.	.009" - .011"	745	10 oz.	.014" - .019"
702	11 oz.	.015" - .018"	727	17 oz.	.025" - .032"
729	9 oz.	.013" - .017"	737	17 oz.	.025" - .032"
731	9 oz.	.013" - .017"	738	23.8 oz.	.039" - .053"
732	9 oz.	.013" - .017"			

The table above is extracted from the WEST SYSTEM User Manual & Product Guide, Reinforcing Materials which is linked in Resources.

Disclaimers

We do not engineer laminates and therefore cannot recommend a final laminate thickness for builds or repairs. During repairs, we generally recommend replacing the original laminate thickness to maintain or exceed the strength of the original laminate that was designed.

While this equation is accurate, it is still based on some average and nominal values. We do not guarantee that your laminate will be the exact thickness as calculated using this equation.

I hope this makes you feel a little more confident heading into your next composite application. If you have any additional questions feel free to contact our technical staff.

Resources

- ***WEST SYSTEM® and PRO-SET®*** — While these likely need no introduction to our readers, these are "marine-grade epoxies used around the world in the commercial, marine, aerospace and industrial composite markets."
- ***Epoxyworks*** — The excellent quarterly magazine published by Gougeon Brothers, Inc. of Bay City, Michigan which produces the WEST SYSTEM® and PRO-SET® lines of epoxies. You can sign up for your own free subscription with this link.
- ***Epoxyworks in the New RCSD*** — The complete compendium of *Epoxyworks* articles which have appeared in the New RC Soaring Digest.
- ***Calculating Laminate Thickness*** — This article as it originally appeared in *Epoxyworks* magazine.
- ***Vacuum Bagging Techniques*** in PDF format. — "A guide to the principles and practical application of vacuum bagging for laminating composite materials with WEST SYSTEM® Epoxy."
- ***User Manual & Product Guide*** in PDF format. — "This manual is designed to familiarize you with WEST SYSTEM products and help you use them effectively."

*All images provided by the author. Read the **next article** in this issue, return to the **previous article** in this issue or go to the **table of contents**. A PDF version of this article, or the entire issue, is available **upon request**.*

Mark Treble returns to the pits. (2018, Pentax K70)

F3F—in Black and White

Michael Shellim · Follow
Published in The New RC Soaring Digest
4 min read · May 3

Ever since I started competing in F3F, I've always carried a camera — it just feels a natural thing to do, thanks to the beautiful slopes that we're blessed with in the UK.

Since those early days, I've attended more than 150 F3F events — yes, it seems incredible looking back on it, but F3F offers so much that I think I can be excused. The result is a sizeable collection of images, many of which are included in the competition reports which are available on my website (see *Resources* for link).

Earlier this year I decided to embark on a new project — the idea was to post a selection of my favourite images to Instagram. What follows is an account of how I approached the project, together with some of the images chosen.

Choosing a 'Look'

Rafael Sajardo at La Muela, Spain after the F3F comp. (2007, Pentax *istDS)

A key decision was to concentrate on the pilots rather than the models — after all, F3F ships all look pretty much the same. It's the pilots who are the soul of F3F and that is what I wanted to express.

To achieve a consistent look, I decided to display the images in black and white. Stripped of colour, the images would have a timeless feel — I thought it rather appropriate, given that F3F as a class has changed little in 30 years. Finally, all the images would be cropped to a square.

A trawl through the archive provided a set of candidate images. These were then edited, and the final versions stored in a folder ready for transfer to Instagram.

An Image a Day

Joel West launching for Pete Gunning, at the Welsh Open. (2019, Panasonic G9)

I've developed a love/hate relationship with Instagram! On one hand, it's home to a vibrant RC community, and there's a lot of good content. On the other hand, Instagram is a beast which needs constant feeding. To stay relevant — especially if you don't do video — you have to keep posting images.

So I try to post an image a day. It requires some discipline, but that's no bad thing. One day the pool of decent images will dry up, and that day will mark the end of the project.

Camera Kit

Mike Evans tests the air, at the Hole of Horcum. (2022, Ricoh GR II).

My current slope kit consists of a Panasonic *G9* with two lenses: an Olympus 12–45 f/4 and a Panasonic-Leica 55–200. Together these cover a focal range of 24–400 mm (35mm equivalent). The complete kit is weather resistant, and weighs around 1500gm.

I also take along a Ricoh *GR II*. This has an APS-C sensor and an excellent lens, yet fits in a coat pocket. Some of my favourite shots have been with this camera.

Processing

Before PayPal. (2014, Ricoh GR)

For photo management and basic editing, I use an older version of Adobe *Lightroom*. The monochrome treatments are done with *Silver Efex Pro,* also an old version.

The older software is more than adequate for my needs, and avoids the treadmill of annual subscriptions and hardware upgrades.

It’s a Wrap!

Eric Heine, at the Welsh Open (2016, Ricoh GR)

Slope soaring and photography go together beautifully, so I hope that this article has stimulated both your aeronautical and photographic interest.

To view my Instagram images which are the subject of this article, visit the link in *Resources* below. *Note:* an Instagram account will be needed to view the full set and if you want to follow the feed in the future.

Resources

- ***F3F — in Black and White*** on Instagram. — The feed which is the subject of this essay, although note my handle on the Instagram platform is *@mikeshellim.rcsoar*.
- ***RC-Soar.com*** — My full archive of F3F competition reports and photos.

*Read the **next article** in this issue, return to the **previous article** in this issue or go to the **table of contents**. A PDF version of this article, or the entire issue, is available **upon request**.*

May 2023 Photography Instagram Gliders Photo Essay

“Jonker JS1” (credit: Condor)

Condor Corner

Glider flight simulation–for safety’s sake.

Scott Manley · Follow
Published in The New RC Soaring Digest
6 min read · May 3

Listen Share More

The fourth of this series to appear in the New RC Soaring Digest. *The original version of this article first appeared in the May 2022 issue of* Soaring *magazine. — Ed.*

Each year the Soaring Safety Foundation (see *Resources* below for link) publishes a Safety Report citing both fatal and non-fatal glider-related accidents and comparing the year's accident rates with longer term trends. To focus attention on the issues bringing our sport and its participants to the greatest grief, accidents are categorized by phase of flight. The report also offers valuable analysis and recommendations designed to help reduce the number of glider-related accidents, ideally to zero.

As I read through the most recent report — Nov. 1, 2019 through Oct. 31, 2020 — I was again reminded of the potential that flight simulation has for contributing to flight safety.

Experience

Based on nearly 50 years of flying light aircraft and my 15 years as a flight instructor, I have concluded that the safest pilots are those with the most experience; not just as a function of total time, but more importantly related to the breadth, depth, relevance and recency of that experience. Consider the following excerpt (shown below in italics) from the most recent SSF Safety Report. Note: the bold text in the excerpt is my edit.

> *To continue reducing all accidents and to eliminate all fatal accidents, ALL glider pilots must realize that this is not a problem with individual pilots. These accidents are typically not caused by pilots ignoring the rules or taking incredible risks. Instead, we must recognize that* ***pilots are responding to situations in the manner in which they were trained. These Human-Factors errors are symptoms of a deeper systemic problem with our training environment*** *…*

I would like to suggest the "deeper systemic problem" is that aircraft-based flight training is inherently inadequate. Pilots cannot be expected to properly respond to situations they have not realistically and repeatedly experienced, and by extension learned to avoid. In other words, "what would you do if" is a poor substitute for actual situational experience, and a single actual in-flight experience (for example, one pre-solo PT3 at 300 ft AGL) is a poor substitute for a multitude of related, varied experiences. Either because it would be unsafe or because it is too time-consuming and/or expensive, aircraft-based flight training fails to adequately expose rating candidates to the situations we know routinely result in accidents and, in so doing, not only leaves them without the flight skills needed to mitigate these situations, but more importantly leaves them without the motivation and judgement skills needed to avoid these situations in the first place.

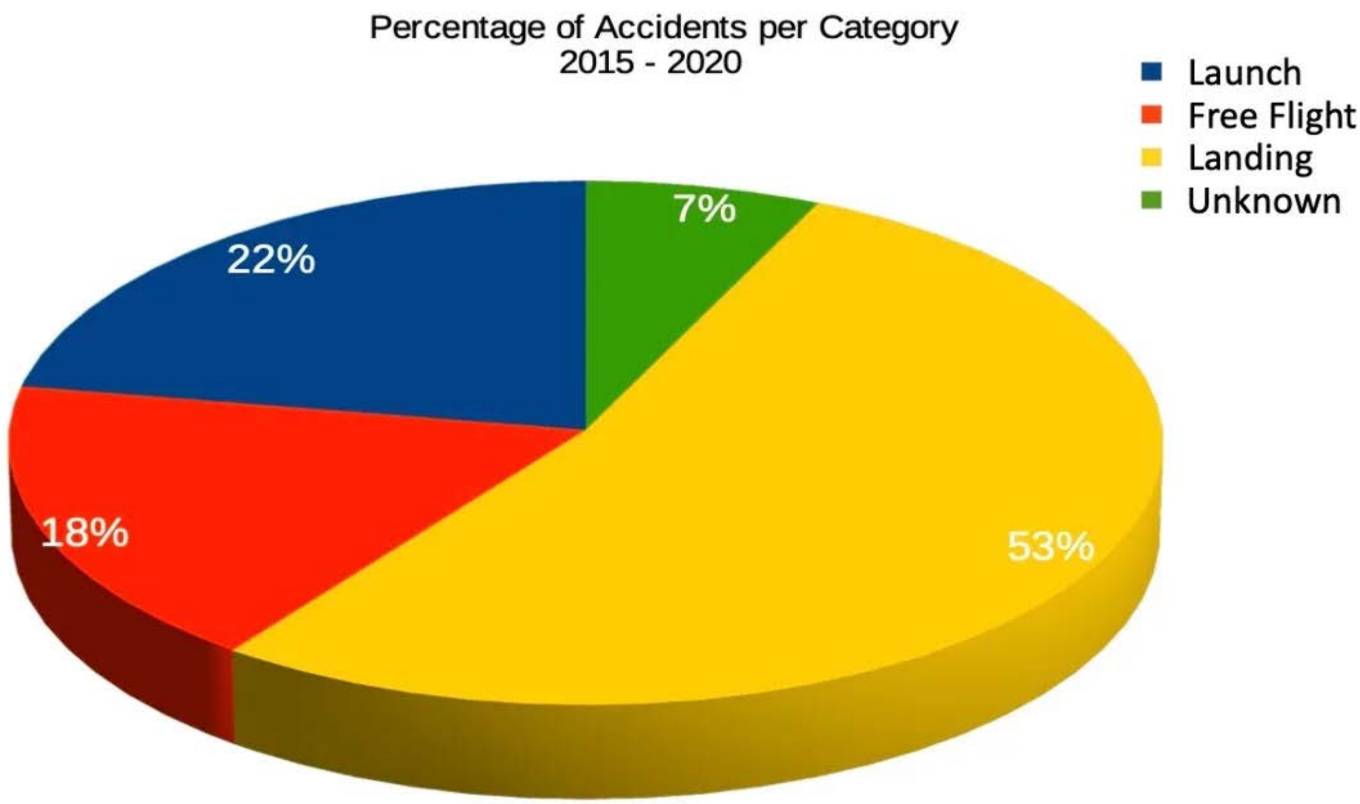
For example, one of the accidents cited in the SSF report resulted from a stall/spin in the landing pattern, likely the result of being so low and slow as to render physically impossible a landing on the intended runway. Another accident involved the glider kiting on the towplane. Clearly these situations cannot be safely replicated on an actual training flight. It is however possible to safely place pilots in these situations using flight simulation; allowing them to realistically 'experience' the tragedy, futility, and inevitable consequences of trying to stretch their glide to the runway or losing site of the towplane. Flight simulation allows for the development and testing of mitigation tactics (for example, an abbreviated approach or safe off-airport landing), and more importantly affords the opportunity to make and evaluate the in-flight decisions that paint us into these corners in the first place.

The advantage of simulation-based flight training is that all glider pilots can be realistically, repeatedly and safely exposed to these and other high-risk situations, gain invaluable experience dealing with them and more importantly develop the judgement and decision-making skills to avoid them altogether. I am reminded of Frank Paynter's *Condor Corner* article entitled *Learning from Your Own Fatal Mistakes* (link in *Resources*) where he related the results of mistakes made in simulation that later prevented him from making the same mistakes on actual flights.

Lack of Total, Relevant and Recent Experience

The chart below, taken from the 2019–2020 SSF Safety Report, shows that 78% of all glider-related accidents over the past five years have occurred in the Launch and Landing phases of flight, with the majority occurring during landing and approximately half of those off-airport.

From the perspective of total, relevant and recent experience, this should come as no surprise. Launch and Landing are the phases of flight in which nearly all glider pilots have the least experience. Consider that, even on a typical 20-minute training flight, a combined time of only three minutes — 15% of the flight — will be spent taking off and landing. Expand that thought to the typical three hour cross-country flight and the experience gained in these critical phases of flight shrinks to less than 4%. Consider then the amount of actual experience most glider pilots have landing off-airport and you begin to see my point. Why would we expect glider pilots to be any good at taking off and landing?



(credit: Soaring Safety Foundation)

Glider flight simulation provides the opportunity to dramatically expand the breadth and depth of our physical and, more importantly, our mental flight experience. One hour on Condor can provide more total experience, and a greater variety of launch, launch failure and landing experiences than most certificated glider pilots will experience in a year, and it's a great way to maintain those critical skills in the off-season, thereby helping to mitigate the 'Spring Stupids'.

This image shows a pilot using Condor's Flight School function to practice making as many as 30 crosswind landings in an hour. (credit: Condor)

SSF Trustee Actions and Recommendations

The SSF's Annual Safety Report concludes with a list of Trustee Actions and Recommendations including Scenario-based Training, Stall Recognition Proficiency and Goal-Oriented Landing Approach, all of which could be dramatically enhanced using simulation. I'll have to save these topics for future articles.

Next Month

The next article in this series is subtitled *Kato and the Ghosts*. I hope that intriguing monicker will bring you back to learn that, despite best laid plans, unexpected things can still happen.

For now, then, thanks for reading! Please leave any questions you have in the *Responses* section — you get there by clicking the little 💬 below.

Resources

- ***Soaring Safety Foundation*** — "the Training and Safety arm of the Soaring Society of America (SSA). Our mission is to provide instructors and pilots with the tools needed to teach/learn both the stick & rudder skills and…"

- ***Learning from Your Own Fatal Mistakes*** — "What kind of a title is this … Obviously if the mistake was fatal, there's not a whole lot of opportunity for learning afterwards, at least not on this mortal coil…"
- ***Condor Corner*** in the New RC Soaring Digest. — The complete set of articles as they have appeared in this publication.
- ***Simulation-based Glider Flight Education***, the author's website. — "to provide you with the information and resources you need to self-manage the flight training and aeronautical knowledge development required to qualify for a Private Pilot Certificate with a Glider Category…"
- ***Condor*** — "simulates the complete gliding experience on your computer. With it you can learn to fly gliders and progress up to a high level of competition skill. The core of the simulator is the state of the art physics model and advanced weather model aimed at soaring flight."
- ***Soaring Magazine***, the official publication of the Soaring Society of America. — "each issue brings you the latest developments on safety issues, delightful accounts of individual soaring accomplishments, a sharing of ideas and experiences, tips from the great soaring pilots of our times, and…"

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May 2023 Flight Simulation Aviation Gliders Safety Training

Soaring the Sky Podcast

E064: Soaring In Paradise With Aerobatics Gliding Team Member James Alaggio

Chuck Fulton · Follow

Published in The New RC Soaring Digest

2 min read · May 4

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Our twelfth instalment of this ongoing series where we select and present episodes from Chuck Fulton's highly regarded soaring podcast. See Resources*, below, for links where you can find* Soaring the Sky*, or simply click the green play button below to start listening. — Ed.*

On this episode James Alaggio talks with Chuck about his adventures soaring in a place where you can get a 1000 foot tow and stay in the air for hours. James has been flying gliders since he was 13 and since then he has flown all over the world. James is a member of the US Aerobatics Gliding Team and Hawaii makes a great place to practice his programs. When he is not in the glider he finds himself in the cockpit of an Airbus A330 flying all over the globe for Hawaiian Airlines. Join Chuck now to hear about James' adventures soaring the sky!

Resources

- *US Glider Aerobatic Team* on Facebook. — "The US Glider Aerobatic Team represents the United States each year at the FAI World Aerobatic Championship…"
- *Soaring the Sky* — "an aviation podcast all about the adventures of flying sailplanes. Join host Chuck Fulton as he talks with other aviators around the globe". You can also find Chuck's podcast on **Instagram**, **Facebook** and **Twitter**.

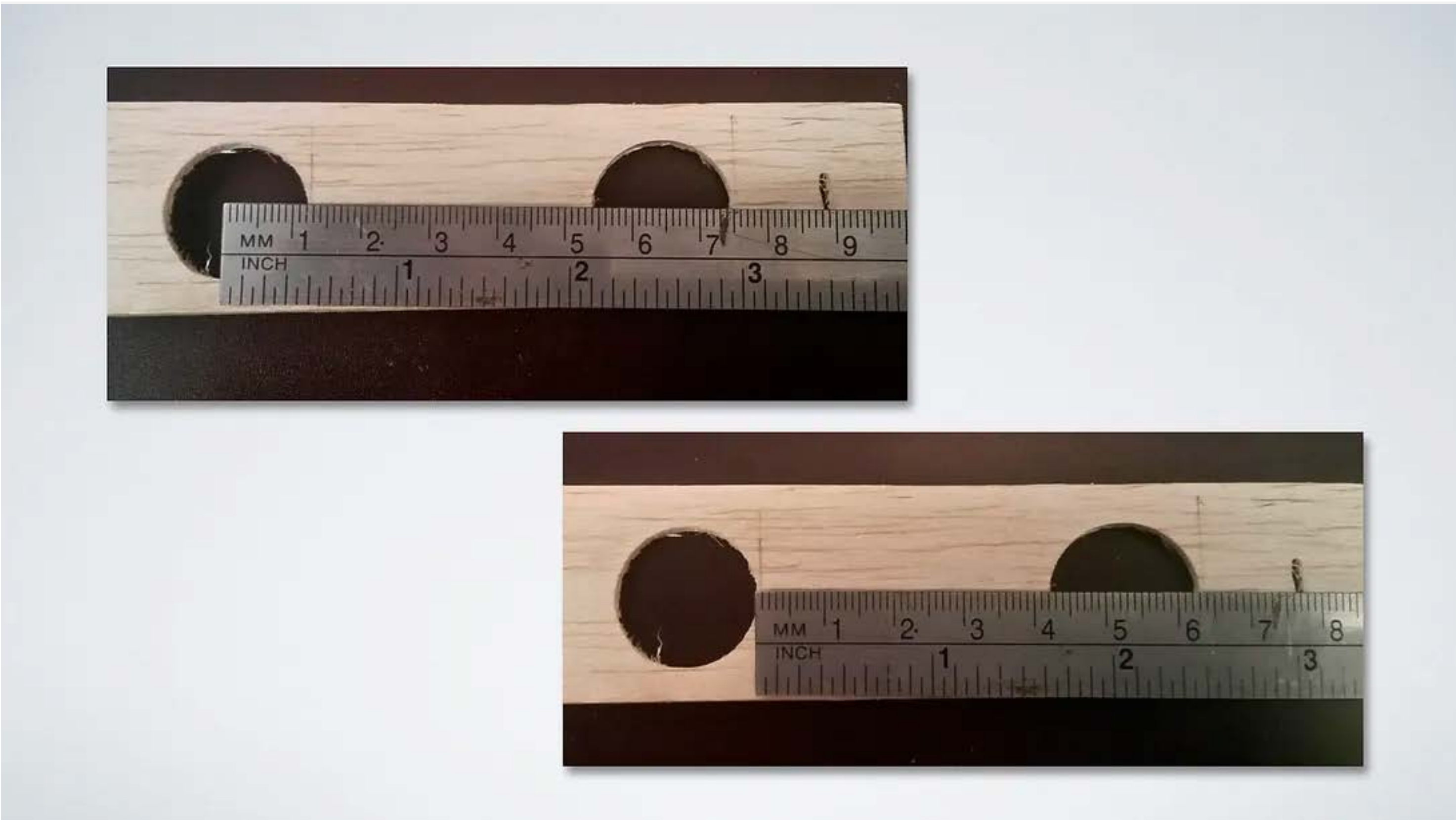
Subscribe to the Soaring the Sky *podcast on these preferred distribution services*:

- *Podbean*
- *Apple Podcasts*

*Read the **next article** in this issue, return to the **previous article** in this issue or go to the **table of contents**. A PDF version of this article, or the entire issue, is available **upon request**.*

May 2023 Aviation Gliders Podcast Air Sports

Written by Chuck Fulton



Instead of doing the top left, trying doing the bottom right.

Center Between Two Holes

Here I am stuck in the middle with you.

Tom Broeski · Follow

Published in The New RC Soaring Digest

2 min read · May 4

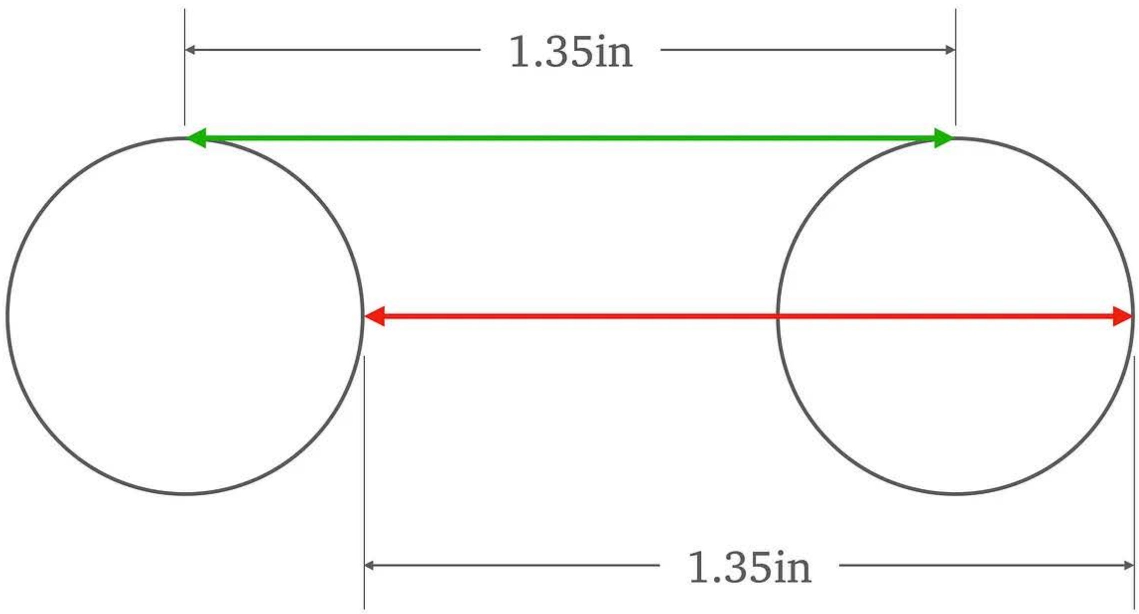
Listen Share More

On more than one occasion, I've watched someone trying to measure the center between two holes by eyeballing the empty space and guessing the exact center. The other day this happened again and he was a millimeter off when we measured it. So…

I have decided to go ahead and mention this for the 10% (or more?) that don't realize this simple fact:

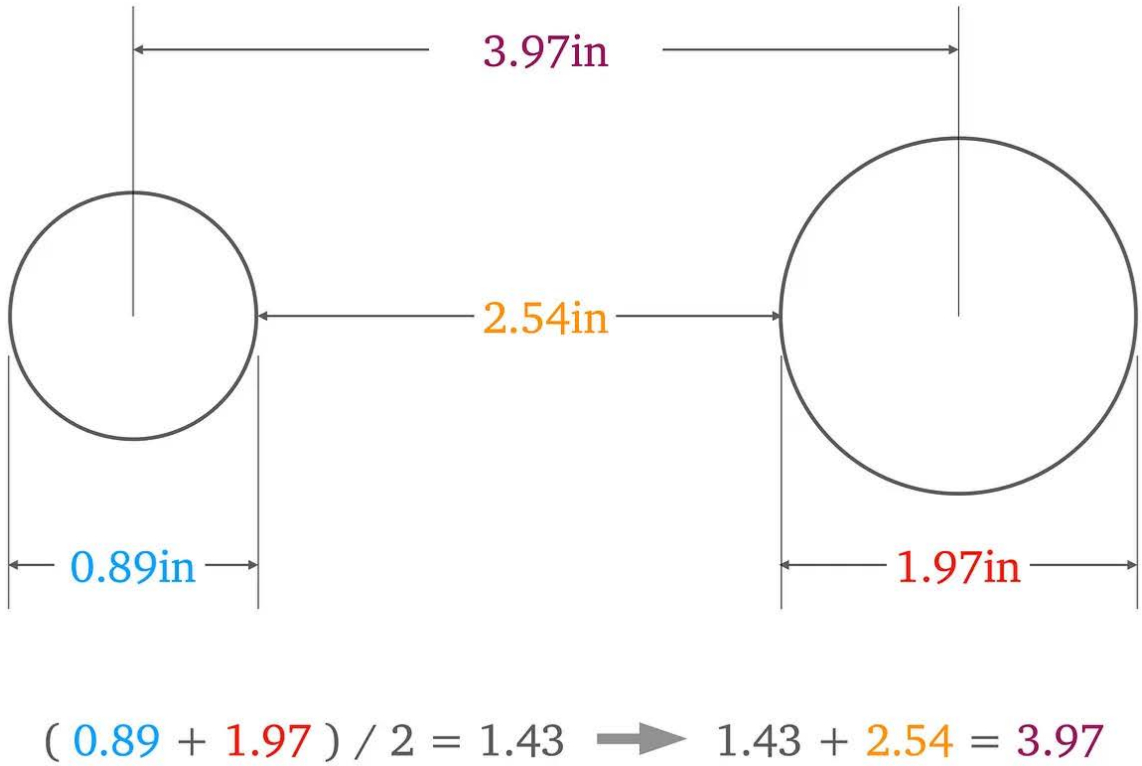
> The distance between the centers of two like holes is the same as the distance between the like edges.

To further illustrate, check out this not-to-scale sketch:



The red arrow and the green arrow are the same length. This is further illustrated in the two photos in the montage at the top of this tip.

An only slightly trickier problem is finding the center between different-sized holes. A great example are root ribs where the two holes are often of different diameters. But it's still not that difficult. All you need to do is sum the diameter of each hole (blue and red), divide by two and add the distance between inside edges (orange) to get the exact distance between centers as shown (purple).



That's it. The shortest, easiest and maybe most useful tip yet! Thanks for reading and if there is a particular tip you would like to see, please consider leaving a comment in the *Responses* section. You'll find it if you click the little 💬 below.

Resources

- ***Stuck in the Middle with You*** by Stealers Wheel (1978) — If you know, you know.
- ***Tom's Tips*** — The complete compendium as presented on the pages of the New RC Soaring Digest.

*All images by the author. Read the **next article** in this issue, return to the **previous article** in this issue or go to the **table of contents**. A PDF version of this article, or the entire issue, is available **upon request**.*

Manfred Derschug launching his Brillant V in June of 2012 at Oberdiebach. (credit: Stefan Hürter)

Manfred Derschug

A retrospective on the designer and his legendary Brillant V.

Jan Sime · Follow
Published in The New RC Soaring Digest
7 min read · Apr 28

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In 1972 the *Brillant V* RC glider was introduced and soon became a legend. It was sold for over 30 years. The latest version I could find is from 2020. With a wingspan of 2760mm and a weight of 1300g, it was one of the lightest gliders in its class. Combined with the E385 modified airfoil it was used by many glider pilots and entered in many competitions in neighbouring countries sometimes, according to Herr Derschug, almost without competition.

Manfred Derschug is known as the man who builds gliders — full-size as well as RC models.

Manfred Derschug's full-size Melos 3000 motor-glider. (credit: flying-directory.com)

According to the website *flying-directory.com* Manfred Derschug developed the *Melos 3000,* a true cross-country motor-glider which incorporated a lot of clever design and many detail refinements. For example, the neat way the engine is aerodynamically integrated into the fuselage. Also, the propellor unfolds automatically as rotation is initiated, and folds back again when the engine stops, an arrangement which avoids the disadvantages of a retractable pylon. The fuselage is composite with wooden wings covered with fabric.

Brillant V through the decades. (credit: Beat.J / RC-Network.de)

In the photo above, starting from the right:

- ***Brilliant V*** (1975) — A representative of the first type. E385 airfoil, wing slightly swept forward, leading edges perpendicular to the longitudinal axis of the fuselage, 4mm wing rods, fuselage with a short, blunt nose, fishing rod tube as tail unit carrier.
- ***Brillant Vz (***1975) — Wing with a new 'faster' profile, flat bottom up to the spar and rotating brake flaps. Geometry, wing joiners and fuselage like version 1972.
- ***Brillant V*** (circa 1985) — Wing straight, spar perpendicular to longitudinal axis of fuselage, leading edge slightly swept back. Wing joiners 2 x 5mm and 2 x 4mm. Profile and surface depths as version *Vz*. Longer nose, a little more pointed, more elegant. One-piece fibreglass hull, no resin-coated 'fishing rod' tube.
- ***Brilliant V*** (2019) — Fuselage construction by Manfred Derschug.

The comparison shows that Manfred Derschug was a master of rolling planning! Incidentally, the *Brillant Vz* shown was actually built in 1977. It is still flying and even now can occasionally be found flying at the Wasserkuppe.

The old and the new: a comparison of two Brillant Vs. (credit: speedy573 / RC-Network.de)

In the photo above, the *Brillant* on the left was built in 2020 and was finished by the master himself, Manfred Derschug. The yellow one on the right could be from the 1980s — the exact details are not known because it was bought second-hand from a colleague.

The fuselages are definitely of different shapes. The conical tail booms also differ significantly. The old version has a tail boom diameter of 19mm to 17mm at the rear. The current *Brillant* is 25mm tapering to 22mm.

The differences in the wings are much more obvious: the span of the new version is 2550mm down from the old version which was 2670mm. However, the chord at the root is similar for both variants, with that being around 230mm.

(credit: speedy573 / RC-Network.de)

The chord of the new wing is 115mm where as the older version was 140mm at the tip. The wing profiles look very similar.

According to Manfred, the new wing was a little better in the wind. It's possibly due to the slightly higher wing loading due to the smaller wing area.

Also a significant change are the wing joiners. New at the front 5mm, with the old *Brillant* being 4mm. Both versions were 4mm at the back.

Take-off weight new 1385g with approx. 180g of lead in the nose of the fuselage and battery — an *Eneloop* AA 4S. Weight of the old version 1520g with the nose-weight unknown since it was permanently glued in place.

(credit: speedy573 / RC-Network.de)

In the early 1990's Manfred couldn't get any fishing rods so he created a mold to laminate the entire fuselage from front to back. Some of these were available with the wing kit, and there was already a brass sleeve for 5mm wing rods glued in at the front.

Fishing rod tail boom in the back, laminated version with integrated tail boom in the front. (credit: Abbakus / RC-Network.de)

Parts, moulds and other documents for Manfred Derschug's other designs such as the *Brillant T*, *Jargon* and *Zirkon* are no longer available. However, there are still some *Brillant T*s on the used market in Germany. As they are no longer made they have become very rare.

Herr Derschug is now long retired and does some work with schools in the community. He also still produces aeroplanes to stave off boredom.

I think it's nice to be able to throw yourself back a little into the time 30–40 years ago with all the modern high-tech models with an aged jewel. Reminiscences of youth — very relaxing!

The Brillant Meeting

The Brillant V establishes a positive climb shortly after launch. (credit: Stefan Hürter)

In June 2012 there was a 'Brillant Meeting' in Oberdiebach attended by Herr Derschug.

The ‘Brillant Meeting’ in June of 2012 at Oberdiebach. (credit: Stefan Hürter)

Manfred Derschug became a legend in the German model plane sector with his two-axis controlled *Brillant*.

Click any image for a more detailed view. (credit: Stefan Hürter)

All versions were at the 2012 event, starting with the classic *Brillant V* with a fishing rod boom, through the full fibreglass fuselage that arose from delivery problems, to the *Brillant T* with a T-tail you can see in the middle photo above.

According to Herr Derschug, by producing the *Brillant* he realised his potential, enjoyed building and traveled a lot, attended competitions and events and got to know many people. He was often in Belgium and Switzerland. He says “you can still see today that I did everything right with the *Brillant V*”.

(credit: Stefan Hürter)

The South African Connection

In my youth I heard a lot about the *Brillant*. I saw a wizened man with a gruff attitude fly this striking, graceful plane with aplomb. He often out-thermalled the latest hot-shot pilots and planes. He was Johan Steyn, called by the brave *Oom Zoom* (Uncle Zoom). He was one of the first pilots to zoom off the top of a winch launch.

He also produced the *Brillant V* with a fibreglass fuselage and a set of plans for the wings and empennage. My late uncle, Sieger Lampen, bought and built the *Brillant V*, flew it for a number of years, and today I am the owner of that aeroplane. It still flys majestically through the South African Highveld thermals.

The author with his Brillant V built by his late uncle Sieger Lampen. (credit: Jan Sime)

As we use powerful winches you will see that the South Arican *Brillant* has two 6mm wing joiners.

Here you can see the heavy duty 6mm wing joiners in the South African version of the Brillant. (credit: Jan Sime)

Epilogue

Since this article was originally written, there have been quite a few updates to the story:

In 2016, Manfred set up a handicraft corner in his new little house over the winter while helping his son Kai build a *Melos*. Quite often he could be found in Friedrichshafen at the airport but unfortunately we missed each other when I was there.

In 2023, I heard in a roundabout way is that Herr Derschug is hale and healthy but still averse to modern communications. If you would like to get in touch with him, please contact me and I'll do my best to put you together with him.

Thanks for reading!

Acknowledgements

This article would not have been possible if not for all the detail provided by *Speedy573*, *Holzwurm59*, *Abbakus*, *Beat.J* and *StefanHürter* who can all be found on RC-Network.de. The link for the main thread can be found in the *Resources* section immediately below.

Resources

- ***Brillant-Treffen in Oberdiebach*** on RC-Network.de. — "Three days ago I heard from a model pilot colleague about a 'Brillant Meeting' nearby. I was informed that Herr Derschug also wanted to come…" (translation by Google Translate)

Read the ***next article*** *in this issue, return to the* ***previous article*** *in this issue or go to the* ***table of contents****. A PDF version of this article, or the entire issue, is available* ***upon request****.*

May 2023 Aviation Aeronautical Engineering Gliders Germany

The History of Electric Flight

Part I: Pioneers Colonel H. J. Taplin and Fred Militky

Mike Goulette · Follow

Published in The New RC Soaring Digest

11 min read · Apr 29

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Prologue

Electric power is increasingly important to the model soaring world these days, from the front end sustainers and 'up-and-go' systems on scale gliders to the proliferation of competition classes for electric powered gliders and also to the RTF foamies that we see every weekend at our local flying field. A couple of years ago I wrote a series of articles about the history of

SAM35 in the UK. These days the UK Chapter of the Society of Antique Modellers is not just about old timer and vintage models but embraces all of traditional aeromodelling and electric power is often substituted for the noisy and smelly sparkies and glow motors of the past — we still love British diesels and Japanese four strokes though!

I mentioned the electric flight series to Terence and he suggested that I contribute a version of it to New RC Soaring Digest and here is the first part of that. Before we start I have a couple of caveats. Firstly, this is a personal view of the history of electric flight. It is not scholarly or definitive and it would be very interesting to hear other views on how the technology developed. Secondly, it is not just about gliders and sailplanes although they are a very important part of the story. So with background and caveats out of the way, let's begin:

Colonel H. J. Taplin

Apart from a few unsubstantiated reports of electric powered free flight models from the early 20th century and some control line experiments with power fed down the lines, the first documented electric model aircraft flight was with an RC model on June 30th, 1957. The model was designed and built by Colonel H. J. Taplin of *Taplin Twin* (twin cylinder classic British diesel engine) fame. The story of the model and its first flight at Chalgrove airfield in Oxfordshire is well documented in the September 1957 *Aeromodeller* magazine. Incidentally, Chalgrove airfield is still active and currently home to the Martin-Baker Company who design and make most of the western world's ejection seats.

Left: Aeromodeller reported the first electric flight in September 1957. (credit: Aeromodeller) | **Right**: Colonel Taplin outside his house with the pioneering electric model. (credit: British Pathé)

The Colonel used a 24V American electric motor from the Emerson Company. Emerson are still in business making a wide variety of electric and electronic products which, unfortunately, do not include motors for RC models! The electricity was provided by a bank of Venner silver zinc cells with a nominal voltage of 1.2V per cell. The 20 cells used initially did not provide enough power for flight so a further five were added to give a nominal 30V at 8A which was, reportedly, enough to take off from a smooth surface. The model weighed 8lb so would have been marginally powered by 240W — a bit less than a third of a horsepower — input to the motor or 30W/lb, particularly as the motor was being overdriven so would not have been very efficient. Nevertheless this was a magnificent achievement for the time and a tribute to the vision and engineering skills of the Colonel.

Twenty-five silver zinc cells powered Taplin's 'Radio Queen'. (credit: British Pathé)

The *Aeromodeller* demonstration was not a one off. There is an interesting British Pathé Pictorial colour film showing Taplin demonstrating the electric model aircraft and an RC boat powered by a 10cc four stroke engine. I have included some screen shots from the film which is in colour and is a fascinating record of a pioneering project.Unfortunately there is only a brief glimpse of the model in flight but it does seem to be climbing away well from a hand launch by the Colonel and is under the control of (presumably) Taplin junior. You can find the link to the entire film in *Resources*, below.

The 'Radio Queen' flies away from a hand launch. (credit: British Pathé)

The model used by the Colonel was a variant of his *Radio Queen* design that dated back to 1950. There is a plan of the model on Outerzone and can find the link in *Resources*, also. The design became famous in 1954 when it was used for the first UK Channel crossing by an RC model. The channel-crossing version was powered by an ED diesel engine and controlled by ED three channel reed radio. The British *Daily Express* newspaper provided sponsorship and publicity, something that is unlikely to happen these days!

Fred Militky

The next key chapter of the history moves to Germany and revolves around the famous Graupner model company's chief designer and a not-so-famous inventor of electric motor technology.

Throughout his time as editor of *Aeromodeller,* Ron Moulton was always keen, through his network of international contacts, to bring the cutting edge of aeromodelling technology to the readers of that esteemed journal. The bumper December issues of the magazine were always eagerly awaited and the December 1959 issue was no exception, not least because it included the story of (presumably, as there is no author credited) Ron's trip to the Graupner factory in Germany to witness pioneering electric flight in action.

Ron reported that Fred Militky, Graupner's design and development engineer, had been researching electric free flight since 1941 but had only begun to have success around 1957 with a 'special motor' presumably hand built by himself. The advent of a new commercially built motor in 1959 had transformed the performance of Militky's models, however, and Ron witnessed a 22 minute out-of-sight flight of Militky's *Elektroflug 251* model from a three minute motor run. Ron didn't report if the model was ever found! *E 251* was Militky's 251st model so he was clearly a prolific designer and builder. After Ron's return to the UK, a flight of 23 minutes, witnessed from a Jodel lightplane, was recorded from a one-to-two minute motor run in *Elektroflug 248,* an earlier version of the model.

Fred Militky launching his 251st model on its 22 minute OOS (out-of-sight) flight powered by the highly efficient 'Micromax' geared, coreless motor. (credit: Aeromodeller)

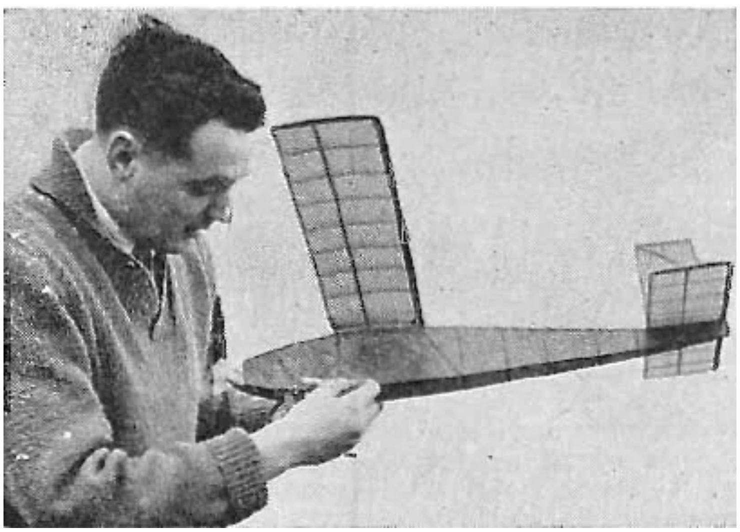
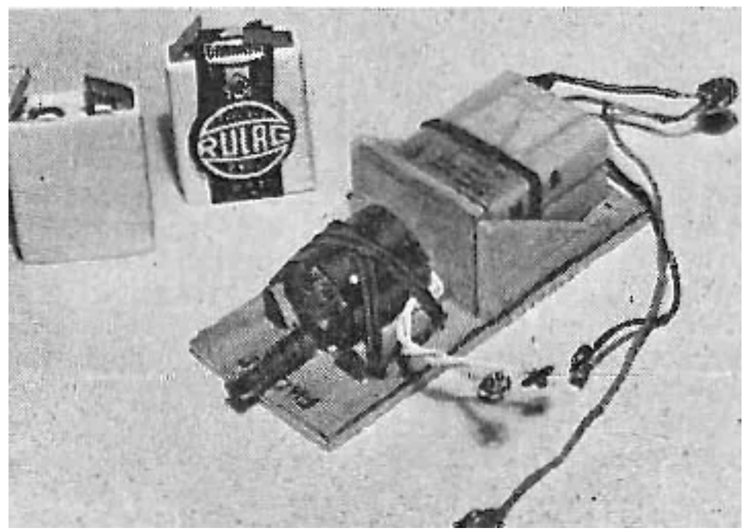
The motor that made all the difference was the invention of Dr Ing. Fritz Faulhaber who walked in to the offices of the German *Modell* magazine in February 1959 to see if his new invention could be of use to the modelling world as a servo motor. The *Micromax* motor was of coreless design with a self-supporting armature winding rotating around a static magnet. This avoided the 'cogging' of typical DC motors and gave both high efficiency and the ability to run on low voltages. The same type of motor construction is used in high quality RC servos today. Faulhaber went one step further by integrating the motor with a miniature gearbox which was available in a number of different ratios. The geared motor only weighed 0.9oz! Militky's experiments showed that the 15:1 ratio was ideal for free flight on 4–6V driving a prop between 10 and 14 inches. The story of the motor was described in detail in an article in *Aeromodeller* in March 1960.

The *Micromax* motor was also used in the servos for the Graupner *Bellaphon* RC system. The large advertising model for the radio can be seen on top of the Graupner company bus in one of the photos of Militky with his pioneering *FM 248* model. The Faulhaber company is still very much in business these days and still produces high precision DC motors based on the original Faulhaber design.

Fred Militky holding his E 248 model in front of the Graupner tour bus which had an advertising model of the Graupner Bellaphon radio on top! (credit: Aeromodeller)

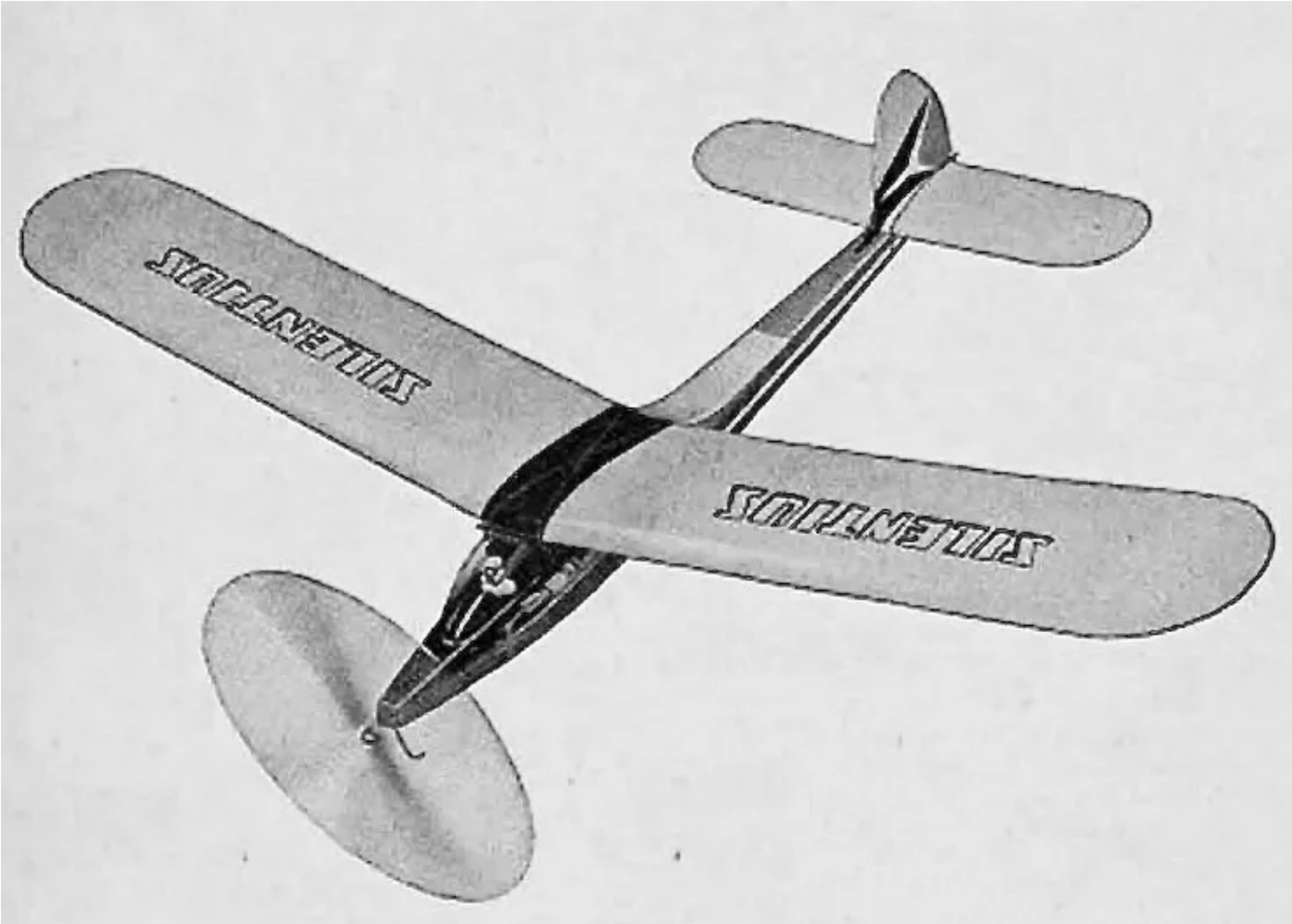
The other key issue, as always for electric flight, was battery power. Again technology developed outside the modelling world was adapted in the form of miniature sealed lead acid cells originally developed for cigarette lighters and intended for a single use without recharging. These were known as *Rulag* batteries in Germany and *Magnatex* in the UK. A 350mAh version weighing 0.875oz was the one chosen by Militky and a pair of these in series this gave 4V and enough power for a dozen or so flights. Militky found that the cells could be recharged but there was no fast charging in those days, however. The recommended charge was at 15mA overnight and, if overdone, the cell casing would blow up like a balloon! It was also possible to use three 'high performance', non-rechargeable (early alkaline?) pencells at 4.5V but with lower performance.

The March 1960 *Aeromodeller* article also described the *Aeromodeller* staff experiments with the new motor and the lead acid cells. After an initial failure with a polystyrene delta which flew too fast for the propulsion system they modified an Aeromodeller Plans Service *Rubberdub* rubber model which was about the same weight and size as the German models. This was immediately successful and showed that good performance could be obtained by the average aeromodeller.

The power module used in the 'Aeromodeller' test airframe based on the Aeromodeller Plans Service 'Rubberdub'. The lead acid batteries can also be seen here. (credit: Aeromodeller)

The 1960–61 *Aeromodeller Annual* had an article repeating much of the two magazine articles but also introducing the first commercial electric flight model in kit form, the Graupner *Silentius*.

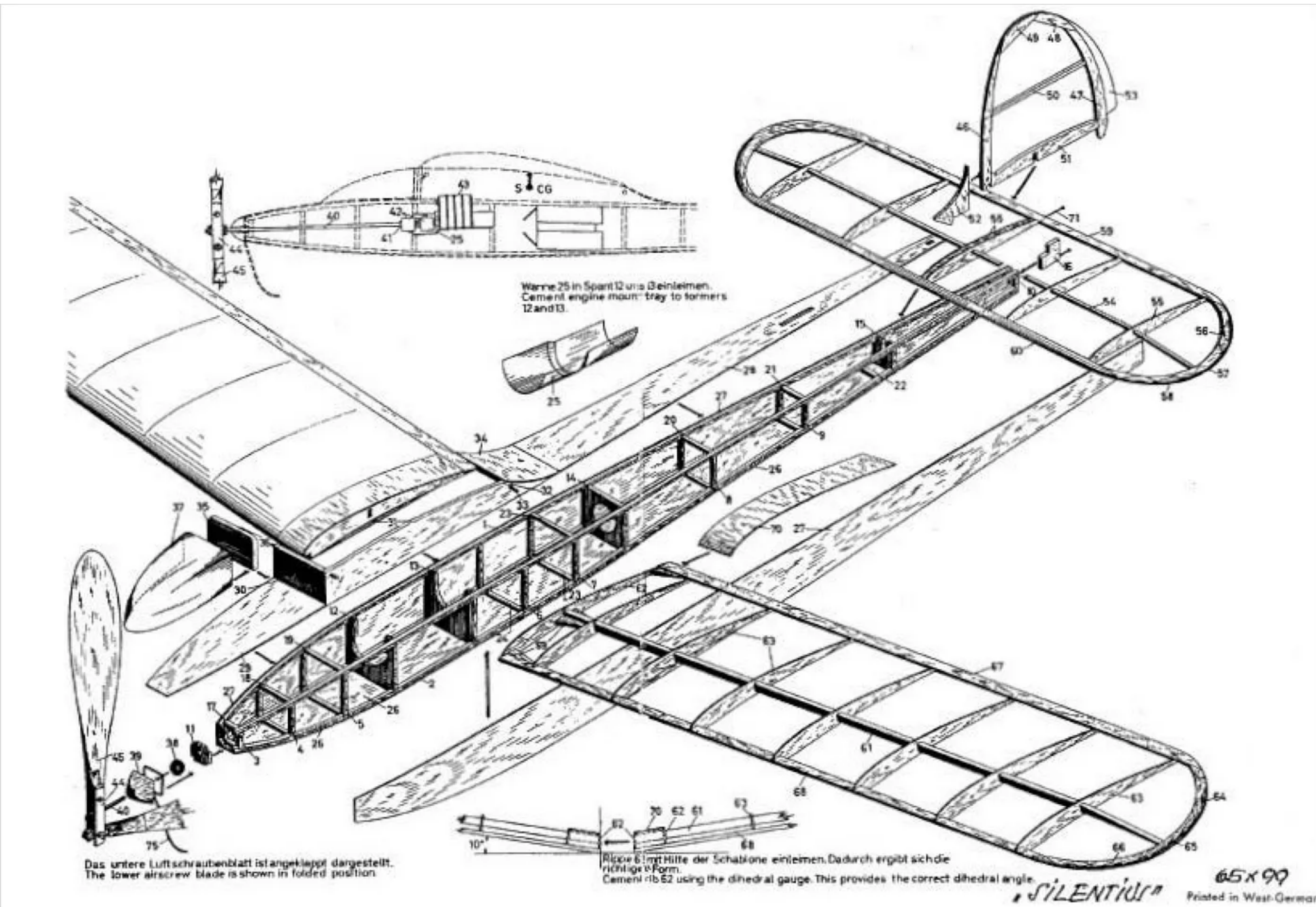


The new ‘Silentius’ model featured in the 1960 Graupner catalogue. (credit: Graupner)

This was clearly a refined and productionised version of Militky’s experimental models and, in typical Graupner fashion, was highly engineered with excellent plans and instructions. The catalogue stated that the kit was for experienced modellers, however, the box art now sported a canopy and pilot!

The ‘Silentius’ box showed the model in a very colourful scheme and had a pilot in the cockpit! (credit: Graupner)

The plan included a very nice isometric view that I have included here to show how it all fitted together. The plan and supporting articles are available on Outerzone and linked in *Resources*.

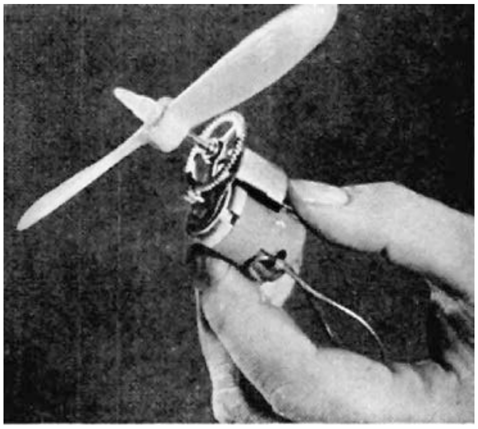


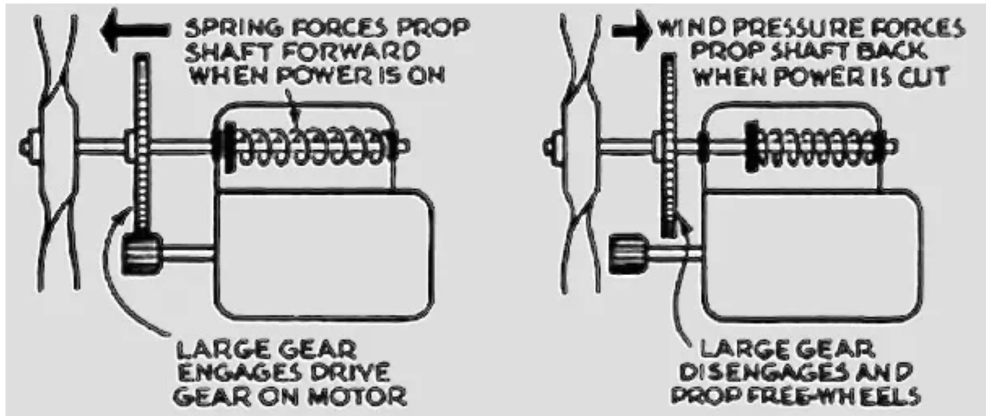
The ‘Silentius’ plan had a very nice isometric drawing of the model. (credit: Graupner)

The model was reviewed by the famous USA modeller Bill Winter in the American *Popular Science* magazine in March 1961. Interestingly he compared it with a Japanese model that was available in the USA at the time that used a very simple conventional geared motor. Winter was impressed by *Silentius* and its motor but concerned that it was expensive at around $15 complete. He said that by comparison the Japanese motor:

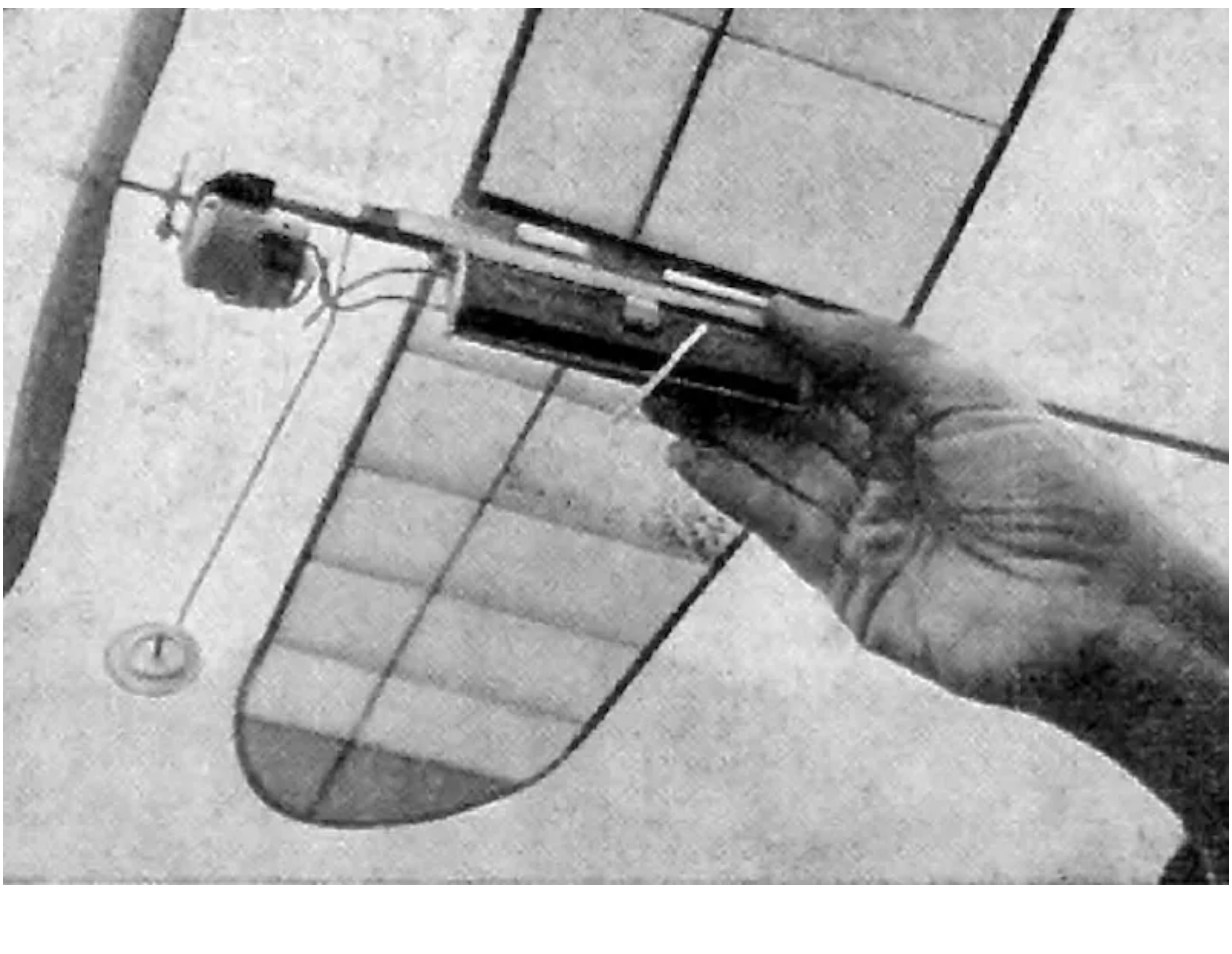
> *“the AP 35, has a gear reduction of about 7:1 and spins a shorter 9–1/2 in prop a little faster, at about 1,500 rpm. It’s somewhat less powerful than the German motor, but it has sturdy bronze bearings and modem ceramic magnets. The model, known as the* TK-1*, is bigger, with a 38 in wingspan, but has a more primitive stick-like fuselage reminiscent of early rubber-*

> *band models. This, however, makes it considerably cheaper — less than $6 including motor — and also simplifies assembly. It weighs about 6–3/4 ounces ready to fly. The parts in the … kit are already cut out for you; those in the German kit aren't. Both kits come with complete instructions in English."*





The motor for the Japanese TK-1 model used simple spur gears and a clever freewheel device. (credit: Popular Science)



The Japanese TK-1 model was very much simpler and less expensive than the more refined 'Silentius'. (credit: Popular Science)

The Japanese model used four pencells for power and was clearly much less refined than *Silentius*. It did, however, have a neat freewheel device on the motor. Unfortunately Winter did not report on the performance of the Japanese model so it is not clear how practical it was. I do not remember the *TK-1* being available in the UK at the time. It would be interesting to hear if anyone had any experiences with one.

Fred Militky continued to pioneer electric flight and his work was recalled in a presentation at the *AVT-209* workshop in Lisbon, Portugal in 2012 by Dr. Martin Hepperle of the DLR Institute of Aerodynamics and Flow Technology in Braunschweig, Germany (and famous for his *MH* series aerofoils, see link below in *Resources*). Hepperle discussed the seminal work by Militky, who as chief engineer at Graupner, a model aircraft firm, went from designing small electric models to the *MB-E1*, the world's first person-carrying electric aircraft. Hepperle wrote:

> *"[t]here is nothing new under the sun … One of the Pioneers of Electric Flight, Fred Militky began with 1940 first trials, and after 1945 became chief engineer at Graupner"*

His electric motor glider *MB-E1* — a Brditschka *HB-3* with a span of 12m and a weight of 440kg — flew on October 21, 1973. The flight lasted about 11 minutes and reached an altitude of 360m piloted by Heino Brditschka. Its Bosch 13hp motor was driven by Varta nickel-cadmium batteries. The two-seater had become a one-seater with a large energy storage compartment behind the pilot. There is a video of this flight which you can find linked in *Resources*, below.

Fred Militky with his pioneering man-carrying motor-glider and his twin electric 'Hi-Fly' model that he designed for Graupner.

Next time, more about Fred Militky and the RC electric gliders he designed for Graupner. As I mentioned above in the Prologue, I would be very interesting to hear other views on how the technology developed — please leave those thoughts in the *Responses* section below, which you can access by clicking the .

Thank you so much for reading and see you next time!

Resources

- ***Electrically Powered Model Planes*** from British Pathé Ltd. — "This is Colonel H. J. Taplin, a man who builds these radio controlled electrically powered models..."
- ***Radio Queen*** plans from Outerzone. — "Famously the first RC model to fly across the English Channnel in September 1954. ... Both old and modern construction is shown on the plan..."

- ***Silentius*** plans from Outerzone. — "Free flight sport model, for electric power. Wingspan 780 mm. Wing area 140 sq in … Silentius was … the world's first kit for an electric-powered free flight model airplane…"
- ***MH Airfoils*** from Martin Hepperle. — "This is a web site about model aircraft, airfoils, propellers and aerodynamics…"
- ***World's First Electric Flight 21st October 1973*** on YouTube. — "First manned electric powered flight in Wels, Austria on 21st October 1973…"

*Read the **next article** in this issue, return to the **previous article** in this issue or go to the **table of contents**. A PDF version of this article, or the entire issue, is available **upon request**.*

Written by Mike Goulette

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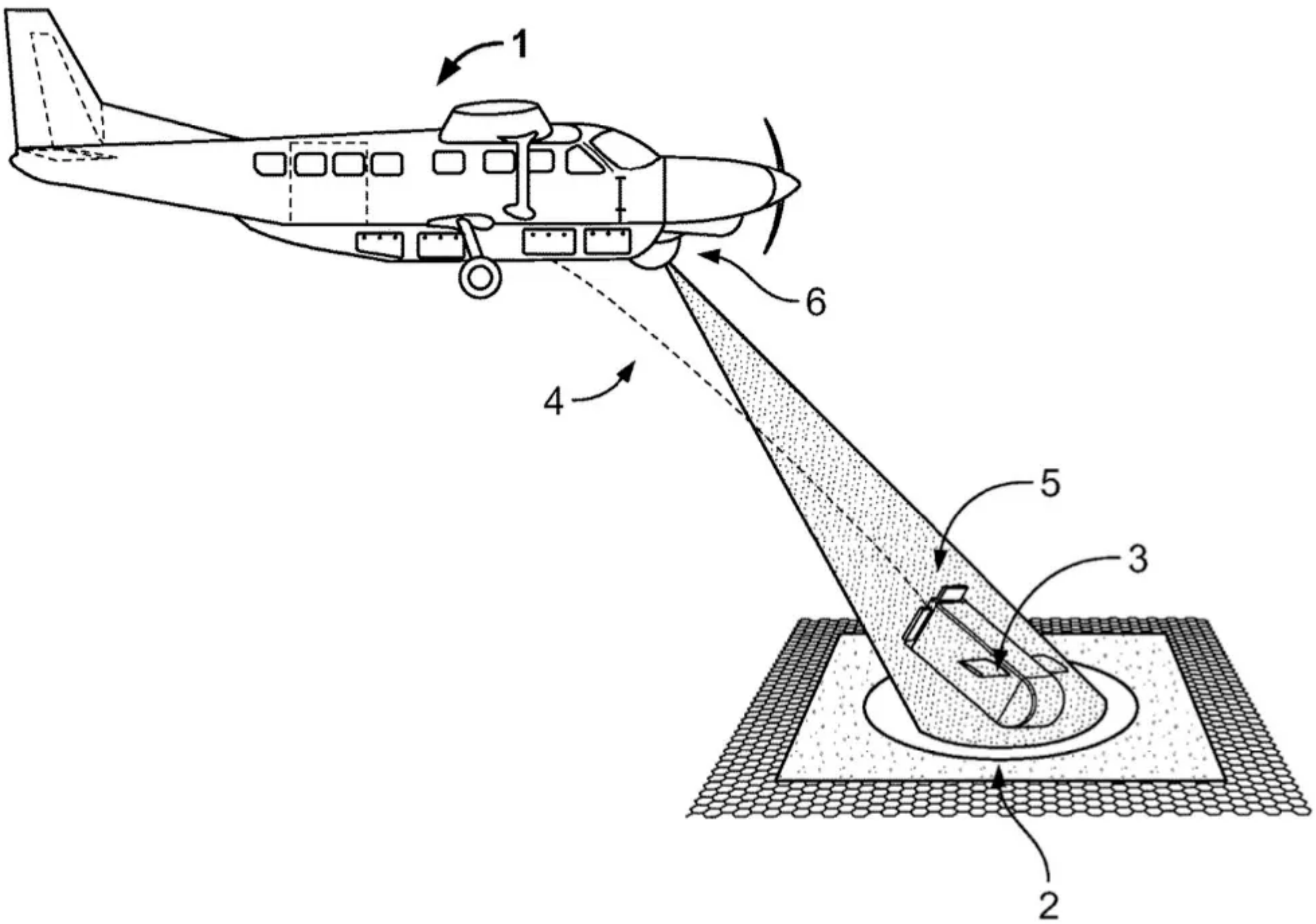

Fig. 1

Glider Patents

US 2019/0318296 A1: System and Method for Performing Precision Guided Air to Ground Package Delivery

The New RC Soaring Digest Staff
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21 min read · May 3

This is the eleventh in our series of glider-related selections from the files of the US Patent and Trademark *office (see* Resources*, below). They are presented purely for the interest and entertainment of our readers. They are not edited in any way, other than to intersperse the drawings throughout the text. Disclaimers: a) Inclusion of a given patent in this series does not constitute an expression of any opinion about the patent itself. b) This document has no legal standing whatsoever; for that, please refer to the original document on the USPTO website. — Ed.*

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Ifill (43) **Pub. Date: Oct. 17, 2019**

(54) **SYSTEM AND METHOD FOR PERFORMING PRECISION GUIDED AIR TO GROUND PACKAGE DELIVERY**

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Abstract

Described is a method of delivery for cargo or goods from an aerial vehicle (mothership) to a designated ground delivery location via the use of a direct air shipping (DASH) package. For example an aerial vehicle may be an airplane or helicopter that remains at altitude with a DASH packaged stowed for deployment. As the mothership travels in the vicinity of the designated location the DASH package flight control computer (flight controller) calculates a preferred travel trajectory based upon the aerodynamic properties of the package and location relative to the designated delivery location such as a small delivery pad located on a patio of a home. When the

mothership transits through a calculated release point the DASH package disengages the mothership. As the DASH package descends it may increase accuracy relative to the designated delivery location by altering aerodynamic properties to maintain the preferred travel trajectory and decreasing landing zone size requirements and increasing precision of delivery. To reduce the impact force at landing the designated delivery location and/or the DASH package may contain a net, airbag, parachute or similar device to provide a suitably soft landing suitable for commercial home delivery.

Field of the Invention

[0001] The present invention relates generally to the air delivery of goods from an airplane or helicopter, or other aerial vehicle, to a ground location by means of an autonomously guided package. Specifically the present invention relates to a system and method for a guided aerial delivery package to provide high accuracy package deliveries regardless of external atmospheric or ground conditions. Depending on the fragility of the cargo, the autonomously guided package may be directed to land on pre-placed landing gear.

Background of the Invention

[0002] Airdrop systems have been use for many decades to perform delivery from airplanes. In its simplest form a package is dropped from a moving airplane such that forward momentum carries the package towards the intended ground location. This simple solution has long been used to provide humanitarian aid in areas plagued by famine, natural disasters or war.

[0003] Alternatively some slightly more advanced systems make use of parachutes, airfoils, or gliders or the like. Those devices reduce landing impact forces, and allow for “soft landings” in order to protect the dropped cargo. Still more recent configurations include electronic flight controllers that may be used to calculate or predict the flight path of a parachute or glider in order to increase precision of the flight path or to provide feedback and control of flight surfaces to steer the package towards the designated landing location.

[0004] Air drops have need to deliver goods as close as possible to the end user in order to reduce secondary transit modes such as truck or hand delivery, and may take place in congested locations where buildings, persons or vehicles may be present in the vicinity of air drop operations. Therefore it is critical that air dropped packages land within a designed landing sites and do not accidentally hit uninvolved structures or persons. Landing zones must therefore be large enough to account for the inherent inaccuracy of parachute or glider approaches, and clear of tall obstructions on approach path.

[0005] Conventional Air drop systems today attempt to address the need for delivery accuracy through the use of parachute or parafoil structures with an underslung load commonly consisting of a pallet, box, or bag.

[0006] The main drawback with parachute structures and other comparable structures used in the art today is that such devices are not able to provide sufficient guidance or control in all weather conditions such as high wind. Accurate landings cannot be guaranteed in such adverse conditions. In addition to landing inaccuracy, parachute and comparable structures are fragile and can be damaged in adverse conditions. For example, a controllable parachute with a low forward airspeed is also subject to collapse or loss of lift from a tailwind.

[0007] Another drawback to existing systems in the art is that parachute or comparable systems require large surface area chutes relative to the package size. The result is that the parachute or similar device may become entangled in trees, power lines, light poles or other ground obstructions near the landing location.

[0008] Yet another drawback is that parachutes are designed for a specific wing loading range and thus may only operate in a narrow performance window for minimum and maximum payload capacity. This limitation requires the use of multiple parachute sizes or ballast weights in order to cover a broad range of package weights.

[0009] In addition, parachute performance characteristics also require the use of secondary systems or multi parachute deployments in order to operate at the cruising speed and altitudes common to commercial cargo aircraft. The reason being that parachutes are designed for a target wing loading and cannot adapt to a wide range of load capacities while maintaining acceptable performance. These problems with parachute and parafoil performance increase the weight of the deployed system overall, and moreover decrease accuracy. The result is also increased cost and complexity. Moreover, the inherent inaccuracy and inability for controlled parachute systems to reliably land in all weather conditions requires the use of large landing zones generally relegated to fields of several acres or larger and to take place away from structures, or ground personnel that may be inadvertently struck by landing parachutes or packages.

[0010] Alternatively, powered or unpowered gliders may also be used to deliver cargo airdropped from airplanes. Similar to parafoils, gliders employ aerodynamic lift in order to reduce vertical descent rate and control surfaces to increase precision of landing. However, gliders require a large wingspan in order to maintain a suitable glide ratio generally greater than 10:1, and also require strong materials in order to maintain structural rigidity at launch speeds typical of cargo aircraft.

[0011] Conventional airdrop systems moreover have the drawback that they are not suitable for performing routine commercial delivery in developed or urban regions in which a heightened need for precision landing accuracy and flight during adverse weather conditions may exist. In addition, conventional airdrop systems are expensive, inaccurate and complex to integrate into traditional air cargo operations and thus are primarily used to support military operations, or relegated for special use cases away from ground activity. The present invention solves these and other problems.

Brief Summary of the Invention

[0012] The device and system of the present invention provide an efficient and accurate way to accomplish air to ground shipments in a variety of settings including urban areas. The present invention can be accurately deployed in adverse or extreme weather systems. In addition, the present invention is capable of safely accommodating fragile cargo. For those reasons and others discussed herein, the device of the present invention substantially departs from the conventional concepts and designs know in the prior art. The improvements disclosed in the present invention allow for a low cost apparatus that provides accurate airdrops suitable for all commercial flight conditions and delivery to all locations.

[0013] The deficiencies of the prior art as described previously are substantially overcome by the use of a guided direct air-shipping package in conjunction with a flight controller. According to one aspect of the present invention, a direct air shipping system consists of a direct air-shipping package that encases a payload to provide a vehicle of known aerodynamic properties. Specifically the aerodynamic shape is designed to be high drag relative to traditional flight vehicles such that forward velocity and terminal velocity are reduced. The intention of the aerodynamic shape is to diminish all foreword airspeed such that the package falls vertically, similar to the trajectory a shuttlecock might take.

[0014] The aerodynamic properties of the direct air-shipping package of the present invention may be numerically modeled in a manner that predictively estimates the resulting ground location based upon conditions at time of release from the aerial vehicle or “mother ship.”

[0015] According to another aspect of the invention, the package that is deployed from the mother ship (the direct air-shipping package, or “DASH” package), may contain fins, wings or deflectable surfaces to alter flight path sufficient to maintain heading towards the designated ground location. Such surfaces may be folded or stowed before or during launch to increase the packing efficiency of the DASH packages in the mothership.

[0016] According to another aspect of the invention a flight controller determines position of the DASH package system using GPS signals and other sensors to determine location, orientation and velocity relative to the designated ground location.

[0017] According to another aspect of the invention the flight controller executes the predictive model to calculate in real time an acceptable release window such that the natural trajectory will coincide with the target ground location.

[0018] According to another aspect of the invention, after launch, the flight controller continuously monitors the flight path of the DASH package based upon the numerical model. The flight controller may deflect aerodynamic control surfaces such as fins to further reduce error and maintain a trajectory of the DASH package towards the target ground location.

[0019] According to another aspect of the invention, the flight controller includes a transceiver, such as a radio modem or cellular modem. During flight, the transceiver is used to transmit position, altitude, orientation or other information regarding the DASH package to a base location. The base location may be located on the ground, in the deploying mothership, or in another location. The information from the flight controller may be used to monitor operation of the system in real-time. Additionally, the transceiver may receive information from the base location. Such information may include manual override control of the system or change in target coordinates, or external sensor information such as atmospheric conditions like ground wind speed.

[0020] According to another aspect of the invention, a designated landing location may contain a net, airbag, or low density foam matting or similar system to slow the decent of the DASH package and enable soft landings of the stowed cargo. The designated landing location may also include, lighting, navigation beacons, anemometers or other devices to aid in the delivery and navigation of the DASH package.

[0021] According to another aspect of the invention, the nose of the DASH package may be constructed of material configured into an energy absorbing crushable impact zone. This zone may be used to further reduce landing force experienced by the cargo and may provide a suitable soft impact for commercially shipped goods. To further cushion the landing, the nose of the DASH package may also include an inflatable airbag. That airbag could be compact when not in use, and would inflate upon impact in order to protect fragile cargo on landing.

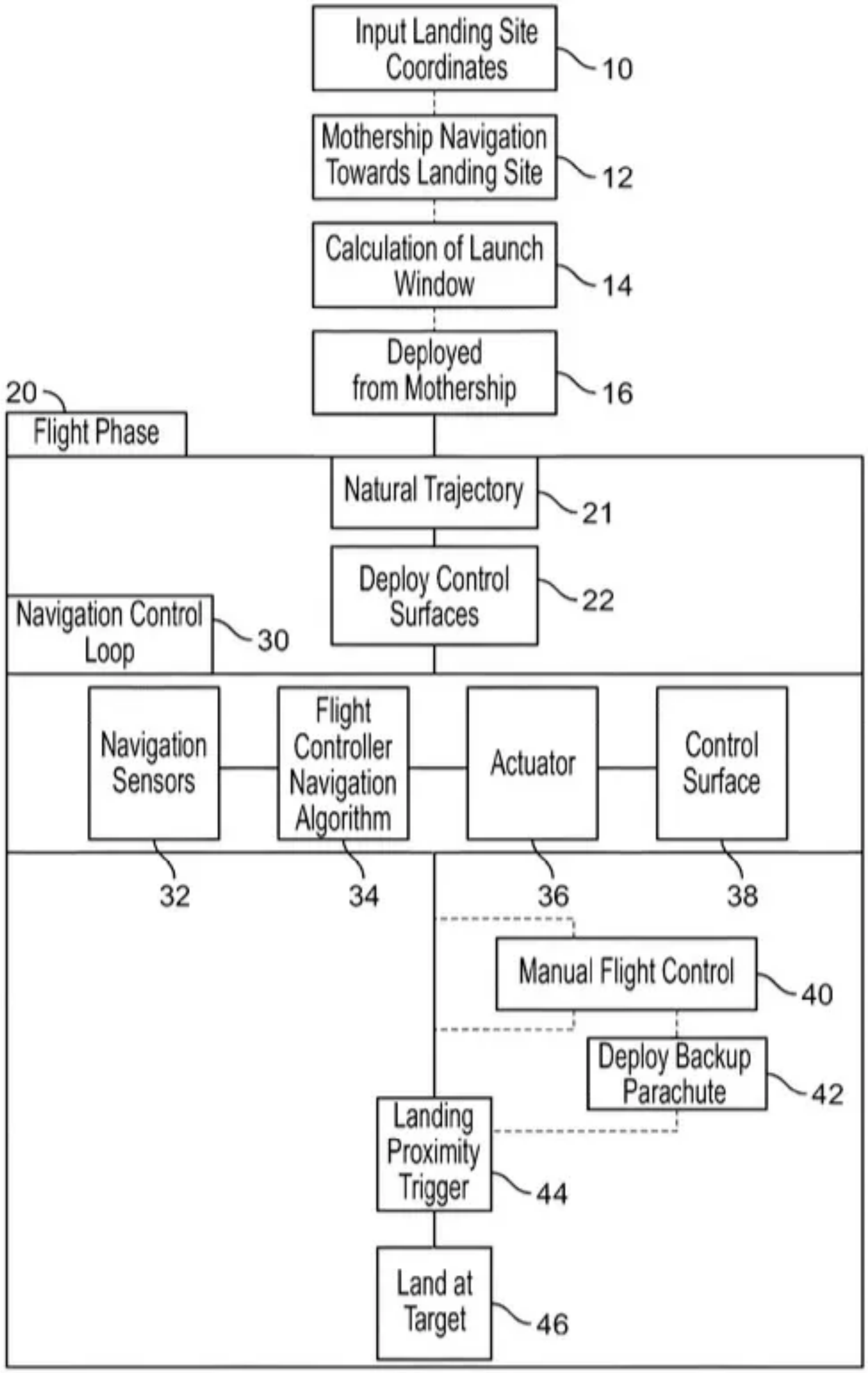

FIG. 2

Brief Description of The Drawings

[0022] FIG. 1 depicts one embodiment of a mother ship and a DASH package being deployed form that mother ship.

[0023] FIG. 2 is a flow chart showing the sequence of deployment operations.

[0024] FIG. **3** is a block diagram depicting flight controller functions.

[0025] FIG. **4** depicts the DASH device and its cargo.

Detailed Description of the Present Invention

[0026] The device of the present invention will now be described with reference to the figures. As disclosed herein, the DASH package system enables the unique capability of delivering goods or cargo to a designated landing zone with several advantages over current airdrop platforms. The present invention possesses numerous advantages over current airdrop systems.

[0027] As shown in FIG. **1**, the system and method of the present invention possesses the unique capability of delivering cargo to a designated landing zone. In the present invention a mother ship **(1)** flies in the vicinity of a designated landing zone **(2)**. Mother ship **1** may preferably be a fixed winged manned aircraft. In one embodiment, mother ship **(1)** may be an airplane. In that embodiment, the airplane may be a cargo plane, a military plane, a personal jet, or other plane. In other embodiments mother ship **(1)** may be other types of flying vehicles including helicopters or any other manned aerial apparatus. In an alternate embodiment, the DASH package may be launched from autonomous unmanned aerial vehicles. For example in that embodiment, a large drone could be employed as mother ship **(1)**.

[0028] Designated landing site **(2)** may be any designated area intended to the land DASH vehicles. The landing site may consist of any area cleared of overhead obstructions such that a clear path from the mother ship to the landing site may be traced. In the preferred embodiment, the landing site may contain a net, foam pit, airbag or similar device to slow the DASH package at deceleration rate, which does not harm the shipped goods or cargo. Ground sensors such as anemometers, GPS base stations, or similar may be used to update the flight controller on conditions in the vicinity of the landing site. This data may be communicated to the mother ship or Flight controller by means of two-way radio modem, cellular tower, Wi-Fi or similar wireless communication technology. Navigation lights, markings or symbols may also be used to visually designate the landing site or create an improvised landing site. As the DASH vehicle may have high precision to a specific landing point the designated ground location may be much smaller than traditional helipads, runways or other landing locations further enabling more options on suitable landing locations and lower cost in the construction and maintenance of landing zones.

[0029] FIG. **1** depicts the DASH package **(3)** being deployed from mother ship **(1)**. As shown, DASH package **(3)** maintains a preferred flight trajectory **(4)** toward the landing zone **(2)**. DASH package **3** maintains flight trajectory **(4)** by deflecting control surfaces **(5)**. Mother ship **(1)** includes two-way communication and sensors on a sensor pod **(6)**. The communication devices and sensors on sensor pod 6 may preferably include GPS tracking devices and cameras. Other tracking and communications devices known in the art may alternatively be used.

[0030] In one embodiment, mother ship **(1)** may be a Cessna **206**, or other cargo aircraft. Mother ship **(1)** stows the package during flight operations and travels toward the general vicinity of the designated ground location. The ground location may be programmed into a flight controller onboard mother ship **(1)**. That programming may be achieved by uploading GPS coordinates in advance of the flight. Alternatively the programming may be achieved by identifying a ground location during flight and using Lidar, Cameras, GPS, triangulation or other sensors to determine precise ground location. Navigation towards the ground location may be aided by the flight controller acting as a secondary navigation aid by means of tablet computer or similar display device that may provide directional guidance toward the designated ground location.

[0031] Sensor pod **(6)** may preferably contain a plurality of sensors such as GPS, infrared and/or visual cameras, altimeters, air speed sensors, and laser range finders. Other sensors and aids known in the art may alternatively be used. The devices in sensor pod **(6)** aid the flight controller in determining location, velocity and atmospheric conditions in relation to the desired ground location. In an alternate embodiment, a base station at the landing site may provide additional telemetry by means of a two-way radio modem or similar communication standard. The sensors are discussed further in connection with FIG. **3**.

[0032] The flight controller located in mother ship **(1)** uses the telemetry and sensor information in order to calculate a release trajectory that will result in DASH package **(3)** landing at the designated landing site **(2)** with minimal to no external energy or need to modify this natural trajectory. This preferred trajectory and release window may optionally be displayed on the secondary navigation aid (laptop or tablet screen) as a three dimensional volume, 2D or 3D approach for the pilot to follow in order to reach their designated ground location.

[0033] Once the release window has been transited the flight controller signals to a release actuator to drop or launch DASH package **(3)** on the preferred trajectory beginning the flight phase. In an alternative embodiment, the DASH package may be manually released from mother ship **(1)**. In that embodiment, an operator on board mother ship **(1)** may open a hatch or other portal. A computing display such as a tablet or other computing device would display a countdown to release, at which time the operator would deploy the package. After release DASH package **(3)** may fold, inflate, or deploy aerodynamic features such as tail fins, wings or nose section. The purpose of this is to increase packing factor and ease of launch in the as-stowed configuration and to protect control surfaces from harsh conditions during the launch phase. Increasing packing factor allows a larger number of DASH vehicles to be stowed within a given cargo aircraft volume allowing for increased operational efficiency and lower cost per package compared to fixed wing gliders, multi rotors or parachute based systems.

[0034] Reference will now be made to FIG. **2**. FIG. **2**, depicts a block diagram of flight operations. As shown in block **10**, prior to launch from mother ship **(1)** ground GPS coordinates are placed into the flight controller memory by computer interface. The ground coordinates may be placed into the flight controller memory prior to or during flight.

[0035] As shown in block **12**, mother ship **(1)** is piloted towards the location of the designated landing site **(2)**. The flight controller may optionally output secondary navigation information to a computer interface such as a monitor to aid in navigation to the designated landing site. As shown in block **14**, the flight controller continuously calculates a preferred trajectory based upon sensor inputs such as GPS, altimeters, and accelerometers in order to calculate a release window consisting of a bounded volume of space in which the as-released flight trajectory will intercept the designated landing zone. Other equipment known in the art may alternatively be employed.

[0036] Block **16** shows that when the release window is reached, the flight controller actuates a release servo or similar mechanism to detach DASH package **(3)** from mother ship **(1)**. As shown in Block **20**, Dash package **(3)** begins the flight phase of the operation in which the DASH vehicle is traveling on a ballistic trajectory towards the ground. DASH package **(3)** then begins the natural trajectory phase of flight in which the forward momentum and aerodynamic properties impart a trajectory. Control surfaces or the vehicle may be optionally maintained in a stowed configuration until forward air speed or other triggers are met.

[0037] As shown in Block **22**, in the preferred embodiment DASH package **(3)** may deploy, wings, fins or other similar structures in order to transit from an aerodynamic or volumetrically efficient configuration to the maneuverable flight form. The deployment may be trigger by the flight controller due to preset altitude limits, or sensor inputs such as air speed or attitude.

[0038] As shown in Block **30**, the navigation sensors continuously calculate error from the preferred trajectory based upon input data from sensors **(32)**. The input data is interpreted by the flight controller navigation algorithm **(34)**. That algorithm determines the deflection of control surfaces to continually reduce error in the positioning of DASH package **(3)**. The flight controller may then output commands to actuators **36** in order to move control surfaces such as fins or wings **38**. Error calculation and correction is then continuously performed until terminated by the flight controller or manual override.

[0039] In one embodiment, the operator may manually override navigation and actuate control surfaces by communication via radio modem or other wireless communication devices. Control override may consist of altering the preferred trajectory or GPS coordinates of the designated landing site or by manually manipulating control surfaces.

[0040] As shown in Block **42**, prior to the time at which DASH package **(3)** impacts the landing area, landing triggers may be set by crossing a altitude threshold, minimum distance trigger, or similar sensor inputs. The landing trigger may be optionally used to perform deployment of a drogue chute, stowage of wings or control surfaces or orientation of the vehicle into a preferred landing configuration. DASH package **(3)** then lands at the designated landing site as shown in Block **46**, and ceases flight operations.

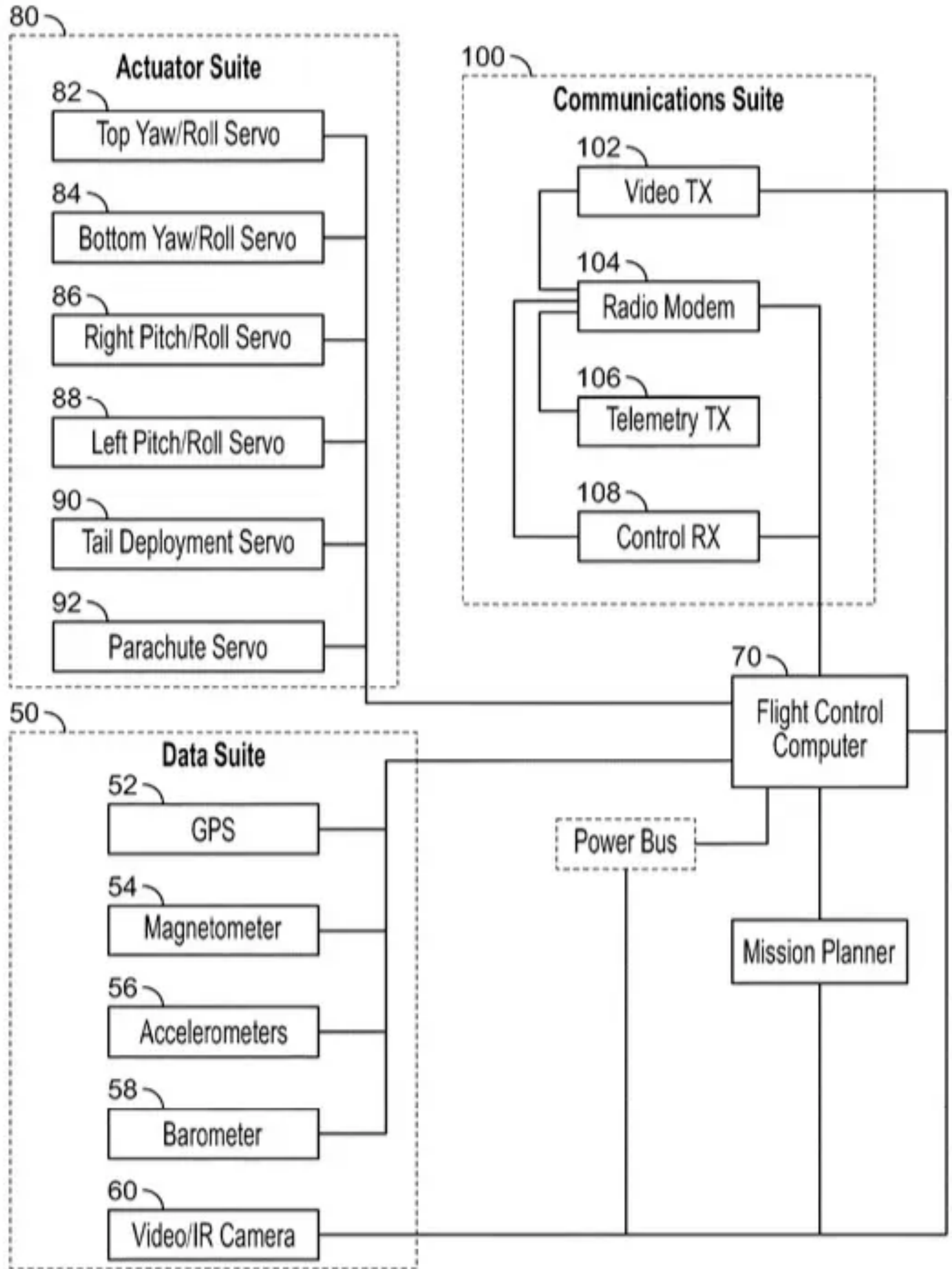

FIG. 3

[0041] Reference is now made to FIG. **3**, which depicts the flight controller functions. As shown in FIG. **3**, the DASH vehicle flight control and telemetry system may preferably be a flight control computer (FCC) consisting of components necessary to provide location, guidance and control of surfaces. That computer allows for an accurate determination of the current location of the mother ship relative to the designated landing location. It further deflects control surfaces to maintain precision on a flight path towards the designated landing location.

[0042] A suite of sensors **(50)** such as GPS **(52)**, Magnetometer **(54)**, 3-axis Accelerometers **(56)**, barometer **(58)** and Video Cameras **(60)** gather information sufficient to provide telemetry and information to determine the location, orientation, heading and flight conditions of the DASH package. The sensors may be self-correcting and error rejecting such that the particular sensor providing the highest fidelity is weighted for use within the Flight Controller **(70)** Navigation algorithm. The FCC **(70)** processes the measured flight information then commands a suite of actuators **(80)** to deflect the corresponding servos **(82–88)** to maintain or modify the flight path. Additional servos may optionally be used to perform other tasks throughout the flight phase such as control surface deployment **(90)** or backup parachute or landing device deployment **(92)**.

[0043] A suite of communication hardware **(100)** maybe used to transmit data from the mother ship or from a ground operator to obtain the status or impart commands after the DASH vehicle launch. A video transmitter **(102)** maybe used to deliver video data from the camera sensor **(60)** and may be transmitted via a radio modem, analog radio or similar **(104)**. Telemetry data **(106)** from any of the sensor suites may also be optionally transmitted via the radio modem. Servo Control data may optionally transmitted or received via the radio control transceiver **(108)**. Such data may be used to send override commands or manually command the DASH vehicle servos.

[0044] Reference is now made to FIG. **4**, which is a depiction of one embodiment of a DASH vehicle **(3)**. In this preferred embodiment, the DASH vehicle includes a vehicle body **(120)**, a tail kit section **(130)** and a shipping box **(140)**.

[0045] The vehicle body **(120)** may be made out of Styrofoam, plastic or similar material that can be fabricated at low cost. The vehicle body is designed as a rectangular prism to maintain a high packing efficiency of traditional shipping boxes **(140)**. A nose section **(122)** may be preferably made out of a material such as Styrofoam that compresses upon impact with the ground to act as a crumple zone, and aiding in the suitably soft landing for the shipping box **(140)** inside. In one embodiment, the nose section may contain an inflatable airbag, which is deployed upon landing in order to further protect the cargo. Wings **(124)** may be optionally installed or deployed to provide increased lift or modify the aerodynamic performance based upon package weight.

[0046] The DASH package is designed such that the aerodynamic properties are known enabling calculation of the trajectory during flying. Compared to a Sail plane or para-wing, in the preferred embodiment the DASH package has a very low lift to drag ratio such that it cannot provide adequate lift to soar long distances or maintain a straight and level flight path. In the preferred embodiment the flight path is straight down, similar to a skydiver, accomplished by using the high drag body and control surfaces to remove all forward airspeed and instead drop vertically at terminal velocity. The purpose of the straight down trajectory is to enable landing in areas with nearby ground obstructions like trees, tall buildings, vehicles or persons, and also to reduce the effects of vertical error in GPS sensors. In the straight down trajectory a landing is possible as long as the landing site has an unobstructed view of the sky. This is in contrast to sailplanes or parachutes that may have in excess of a 10:1 glide ratio and require a clear approach path. The secondary benefit is that there is no need to accurately measure height above ground level. GPS is known to be inaccurate in the Z-axis, a gliding approach path requires a longer landing site or additional sensors to account for inaccuracies in the height above ground level. As the DASH package is coming straight down guidance only needs to be provided continually in the X and Y axis regardless of altitude above target. This vastly simplifies the navigation requirements and complexity of the control process and increases repeatability of landing operations, as no complex flare control flaps or similar device are needed during a touchdown phase.

[0047] Control surfaces **(132)**, depicted as grid fins in this embodiment, may be deflected to modify the attitude of the DASH package and thus alter the flight path. The grid density, pattern and arrangement may be modified to increase drag into an optimal range. In conjunction the aerodynamic drag of the vehicle body **(120)** and grid fins may be used to maintain a specific terminal velocity range to reduce vertical descent rate during the flight phase. The FCC is mounted in the tail kit **(130)** of the DASH vehicle. In this configuration the vehicle body may be made low cost and disposable while the tail kit may be optionally recovered to reduce the cost of repeat package shipments. This allows for the optional recovery and reuse of the tail kit and disposal or recycling of the DASH package body **(120)**.

[0048] The package **(140)** may consist of a standard commercial cardboard shipping box typical of commercial deliveries. The package is inserted into the dash vehicle. The location of the package may be shifted along the length of the vehicle or rotated to improve the location of the Center of gravity relative to the aerodynamic center of lift and thus increase static contrability and flight characteristics.

[0049] All examples herein are to be construed as being without limitation to such specifically recited examples and conditions. Moreover, all statements herein reciting principles, aspects, and embodiments of the invention, as well as specific examples thereof, are intended to encompass both structural and functional equivalents hereof. Additionally, it is intended that such equivalents include both currently known equivalents as well as equivalents developed in the future, i.e., any elements developed that perform the same function, regardless of structure.

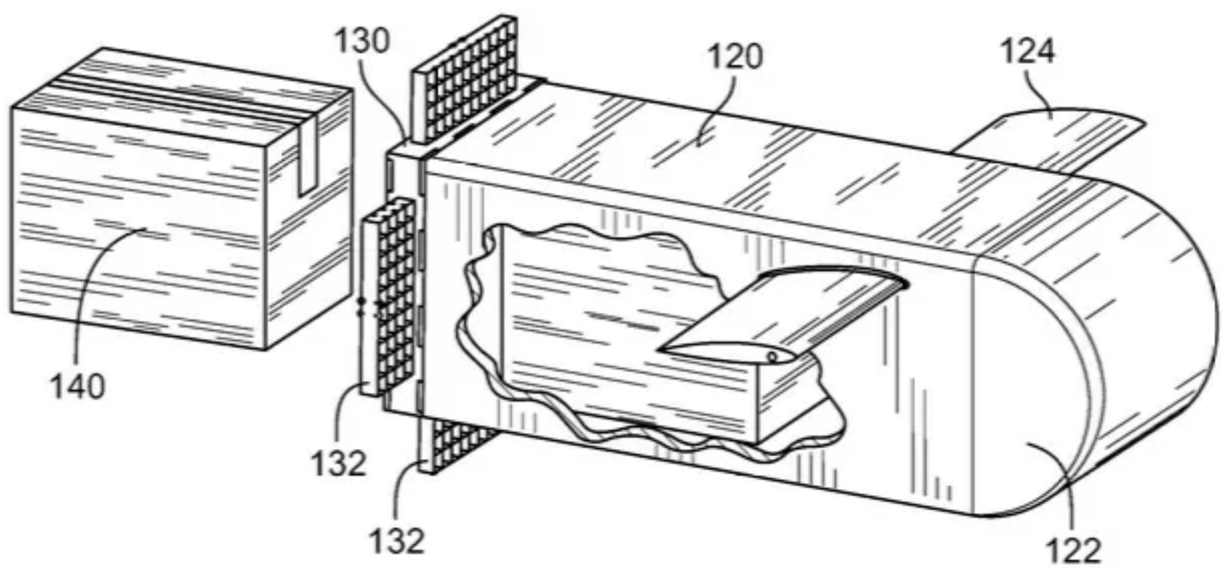

FIG. 4

Claims

1. A system for delivering goods to the ground from an aerial vehicle, including: cargo to be delivered; ¶ and an outer delivery package configured to house said cargo; ¶ and a flight controller located inside said aerial vehicle; ¶ and a designated landing site.

2. The system of claim **1** wherein said outer delivery package includes deflectable surfaces capable of altering the flight path of said outer delivery package.

3. The system of claim **1** wherein said outer delivery package includes location sensors that communicate with said aerial vehicle.

4. The system of claim **1** wherein said outer delivery package includes aerodynamic features wherein: ¶ said aerodynamic features may be in a retracted position when said outer delivery package is not in flight; ¶ and wherein said aerodynamic features may be deployed upon launch from said aerial vehicle.
5. The system of claim **1** wherein said flight controller is programmed with the location of said designated landing site.
6. The system of claim **1** wherein said aerial vehicle includes a sensor pod with two-way communication and sensors which provide communication between said aerial vehicle and said outer delivery package.
7. The system of claim **1** wherein said designated landing includes site material configured into an energy absorbing crushable impact zone.
8. The system of claim **1** wherein said outer delivery package includes an inflatable airbag.
9. The system of claim **1** wherein said outer delivery package is released via an automatic trigger when the aerial vehicle reaches a pre-determined spot.
10. The system of claim **1** wherein said outer delivery package is released manually when the aerial vehicle reaches a pre-determined spot.
11. The system of claim **1** wherein said outer delivery package takes a vertical trajectory from the time of release to the time of landing.
12. A method for delivering goods to the ground from an aerial vehicle including the steps of: ¶ Inserting the cargo to be delivered into an outer delivery package; ¶ storing said outer delivery package in an aerial vehicle; ¶ programming a desired landing location into memory onboard said aerial vehicle; ¶ releasing said outer delivery package from said aerial vehicle; ¶ deploying aerodynamic features on said outer delivery package; ¶ controlling the direction of said outer delivery package while in flight; and ¶ allowing said outer delivery package to land at said designated landing spot.
13. The method of claim **12** wherein the outer delivery package follows a vertical trajectory from launch to the ground.

14. The method of claim **12** wherein said designated landing spot includes site material configured into an energy absorbing crushable impact zone.

15. The method of claim **12** wherein said delivery package is cushioned by an airbag on landing.

16. The method of claim **12** wherein said aerial vehicle and said outer delivery package are in communication after said outer delivery package has been launched from said aerial vehicle.

Resources

- ***US Patent and Trademark Office*** (USPTO) — The USPTO provides an outstanding search engine which enables digging through (seemingly) every patent in their archive. Proceed with caution — you could easily spend **days** of your time digging through their utterly fascinating files.
- ***US 2019/0318296 A1*** — A PDF of the original patent as downloaded from the USPTO website, on which this article is based.
- ***Glider Patents*** in the New RC Soaring Digest. — The complete compendium of articles appearing in this series.

Thanks to Editorial Assistant Michelle Klement for her invaluable assistance in preparing this article. *Read the **next article** in this issue, return to the **previous article** in this issue or go to the **table of contents**. A PDF version of this article, or the entire issue, is available **upon request**.*

May 2023 Intellectual Property Aviation Drone Delivery Logistics

Top Left: "15th World Gliding Championships, Räyskälä" was the title of the stamp which featured the PIK-20 prototype. It was issued on January 13, 1976 in Helsinki, Finland. | **Top Right**: The envelope used by Eiri Avion for their company mail. | **Bottom Left**: The PIK-3 design on a vignette produced in the late 1950s. | **Bottom Right**: The glider mail sponsored by the Australian Airmail Society was carried by Raino Nurminen on the last day of the 12th Internationals at Waikerie, Australia in January, 1974. | **Middle Right**: The postcard issued to commemorate the 15th World Gliding Championships at Räyskälä.

Stamps That Tell a Story

Philatelic Finland.

Simine Short · Follow

Published in The New RC Soaring Digest
4 min read · May 4

This article first appeared in the March, 2003 issue of Gliding *magazine. Temporal references have been retained as originally written. — Ed.*

The Finnish Department of Posts issued a postage stamp showing a yellow high performance sailplane over the lake regions in conjunction with the upcoming World Championships.

This sailplane was the *PIK-20* prototype. First Day Covers were postmarked both in Finland's capital Helsinki and in Lahti, the home town of Eiri Avion which produced the *PIK*. Until the postage rate went up, Eiri Avion used 'their' postage stamp on all outgoing company mail.

According to a company flyer, the *PIK-20* — the Soaring Finn — surpassed all previous Standard Class sailplanes in performances figures. And many of today's pilots still agree with this statement.

PIK — what do these letters mean? Polyteknikikkojen IlmailuKerho RY, or translated into English: The Aeronautical Association of the Students of the Helsinki University of Technology. The abbreviated name is pronounced as *pea-eye-kay,* not *pick*.

Additional Background Information

PIK serial numbers were introduced in 1946 and initially it was thought they would be given to designs used for Masters degree theses at the University of Technology. This changed later with planes being built away from the University community.

The first serial produced ship was the *PIK-3,* a "small club high performance sailplane," the thesis work of Lars Normen. Work on the *PIK-3* began in 1942 and the prototype was completed in 1950. This conventional wooden structure was redesigned in 1957 and as a *PIK-3C,* the prototype took second place in the OSTIV Standard Class type competition in 1958, in conjunction with the Internationals held at Lezsno, Poland. It was a robust and reliable 15m sailplane. SIL, the Finnish Aviation Association, started serial production of this type, naming it *Kajava*.

The label in the montage shows this *PIK-3C* sailplane. It has a very special place in my own collection because for a long time I had no idea what the sailplane was and which country it came from. When Finland hosted the Internationals Eiri Avion produced several picture postcards and one shows the SIL logo in the lower left hand corner, the same symbol as was shown on my stamp. Now I knew!

In the early 1970s, the design work on a composite Standard Class high performance sailplane was begun at the Laboratory of Light Structures at the University. The new competition regulations permitted trailing edge flaps and waterballast which was incorporated into the thesis work of Pekka Tammi.

A new epoxy was used in the construction that allowed the ship to be painted nearly any colour. From the yellow prototype which had its first flight in October 1973, the *PIK-20* evolved as the first notable export success of the Finnish Aircraft industry. Until the end of 1980, a total of 416 *PIK-20*s of different versions were built, prior to the production rights being sold to the French company Siren.

The second prototype, was flown at the 12th Internationals at Waikerie in January, 1974 by Raino Nurminen. He placed 13th in the competition. The glider mail shown in the montage above, sponsored by the Australian Airmail Society, was carried by Nurminen on the last day of the competition. The task was a triangular flight: Waikerie — Alawoona — Karonda, and he finished in 7th place on that day. According to a search of the internet, *Fox November* or OH-425 is now in the Finnish Aviation Museum at the Helsinki-Vantaa airport (see *Resources*, below).

Left: Picture postcards distributed by Eiri Avion before the Internationals were held in Finland. | **Right**: Picture postcards distributed by Eiri Avion after the Internationals: the PIK-20 took the top places in this World Championships.

A total of twelve *PIK-20*s were entered in the 15th Internationals Standard Class at Räyskälä, Finland, in June 1976. The 1st, 2nd, 3rd and 5th place were taken by this design (and its pilots). This all glass-fibre high performance ship, now covered with a white gel coat, showed the world how good it was: Ingo Renner (Australia) flew his own personal ship to first place.

References

- *PIK–20* Advertising Flyer, published and distributed by Eiri Avion, Finland.

- Raunio, Jukka and Erkki Soinne, Risto Oikarinen (1981) *Aircraft Designs with a PIK Serial Number*. Extracts of the book were translated into the English language by Jouko Vallikari and distributed by the Aeronautical Association, Helsinki University of Technology.

Resources

- ***Finnish Aviation Museum*** — “an exciting visiting destination for the whole family, located in the heart of the Aviapolis area in Vantaa. Our collections include dozens of aircraft related to the history of Finnish aviation…”

- ***Stamps That Tell a Story: The Series*** — Catch up on your missing instalments of this excellent, informative series of articles presented previously in the New RCSD and of which this article is the most recent part.

Simine Short is an aviation researcher and historian. She has written more than 150 articles on the history of motorless flight and is published in several countries around the world as well as the United States. She is also the editor of the Bungee Cord*, the quarterly publication of the Vintage Sailplane Association. Simine is currently working on a biography of aviation and soaring pioneer Octave Chanute.*

*Read the **next article** in this issue, return to the **previous article** in this issue or go to the **table of contents**. A PDF version of this article, or the entire issue, is available **upon request**.*

May 2023 Gliders Philately History Finland

Written by Simine Short

3 Followers · Writer for The New RC Soaring Digest

Our good friend and New RCSD contributor Raymond Esveldt recently captured his 'Alien' from OA Composites at sunset over the legendary Wasserkuppe in Germany. Thanks so much for the opportunity to use your exquisite photo Raymond. The 'Alien' was reviewed in the April 2023 issue by Pierre Rondel and you can find the link in Resources, below.

The Trailing Edge

So when do new issues come out, anyway?

The New RC Soaring Digest Staff

Published in The New RC Soaring Digest

4 min read · May 5

Listen Share More

Okay, okay we know — the May issue didn't hit the streets until the 5th of the month. In addition, readers will likely have noticed that as each month goes by, product of the ever-increasing workload associated with getting new issues out the door.

We are taking steps to try and get the schedule back on the rails. First, we're bumping ahead by five days the 'new issue window': that's the point in the month where we switch over from mostly working on the current issue to mostly working on the next issue. That will mean having to make our marketing programs associated with issue release more efficient. Part of the way we'll do that, as *The Ed* mentioned in his *In The Air* piece this month, is by officially giving Twitter the boot effective immediately.

Next, we'll be encouraging contributors to write more of their stories right on the publishing platform as opposed to using other tools. That can greatly impact the amount of time each story takes to 'process' and make it ready for the new issue.

More photos of Raymond Esveldt's 'Alien' on his recent trip to the Wasserkuppe in Germany.

Finally, we'll be looking at some additional automation tools which will whittle away at all the highly detailed, potentially error-prone administrivia required to make a given issue 'click together'.

We're hoping these things will once again inch the new issue release forward with our longer term goal of getting the new issue out at 12.00am of the first day of month in every timezone around the world.

Wish us luck and thank you for your patience!

New in The RCSD Shop

Featured on the May 2023 *Cover Photo* merchandise is this remarkable photo by Jonathan Demery, who caught the exact right moment when these four young RC soaring enthusiasts let loose their glider over the bluffs at the Great Orme, Wales. Jonathan, who is a teacher at St. David's College in nearby Llandudno, runs a unique *Silent Flight* program for students, of which these kids are members. Order the beautiful **t-shirt** or **the mug** today.

All items in the Shop are made especially for you as soon as you place an order, which is why they are fairly priced and it takes us a bit longer to deliver them to you. Making products on demand instead of in bulk helps reduce overproduction and waste. Everybody wins. Thank you for making thoughtful purchasing decisions!

Make Sure You Don't Miss the New Issue

You really don't want to miss the upcoming June, 2023 issue of the New RC Soaring Digest when it's out — closer to the beginning of the month, this time. Make sure you connect with us on **Facebook**, **Instagram**, **LinkedIn** and **Post News** or simply subscribe to our **Groups.io** mailing list. Please share the New RCSD with your friends — we would love to have them as readers, too.

That's it for this month…now get out there and fly!

Resources

- ***Alien: A Carbon Encounter of the Bird Kind*** by Pierre Rondel in the April, 2023 issue of the New RCSD. — "The new flying wing designed by Christophe Bourdon and manufactured in Ukraine by Anton Ovcharenko (OA Composites) is aptly named as the concept goes off the usual track…"

*Read the **previous** article or go to the **table of contents**. A PDF version of this article, or the entire issue, is available **upon request**.*

May 2023 Gliders Aviation Sunset Germany