No. 315 SEPTEMBER 2012

T.W.I.T.T. NEWSLETTER

Boeing and NASA have recently looked into tailless aircraft, which they call blended wing-body. Here's public domain image from NASA, of a concept called the N3X: http://www.dieselpunks.org/profiles/blogs/s-a-m-50-alternative-boeings.

T.W.I.T.T.
The Wing Is The Thing
P.O. Box 20430
El Cajon, CA 92021

The number after your name indicates the ending year and month of your current subscription, i.e., **1209** means this is your last issue unless renewed.

Next TWITT meeting: Saturday, September 15, 2012, beginning at 1:30 pm at hanger A-4, Gillespie Field, El Cajon, CA (first hanger row on Joe Crosson Drive - Southeast side of Gillespie).

THE WING IS THE THING (T.W.I.T.T.)

T.W.I.T.T. is a non-profit organization whose membership seeks to promote the research and development of flying wings and other tailless aircraft by providing a forum for the exchange of ideas and experiences on an international basis. T.W.I.T.T. is affiliated with The Hunsaker Foundation, which is dedicated to furthering education and research in a variety of disciplines.

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Meetings are held on the third Saturday of every other month (beginning with January), at 1:30 PM, at Hanger A-4, Gillespie Field, El Cajon, California (first row of hangers on the south end of Joe Crosson Drive (#1720), east side of Gillespie or Skid Row for those flying in).

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PRESIDENT'S CORNER

I hope you enjoy this issue, but please cut me some slack of you find some spelling or grammar errors since I had to throw it together rather quickly. As usual the ESA Western Workshop over the Labor Day weekend got in the way of getting it done on time so I rushed pulling items out of the flying plank bulletin board to supplement the few letters I had.

Max Perrault contributed a lot of the material in the threads I found and he also did a really nice presentation at the workshop. He and Bob Hoey teamed up to cover the flying model of his Pegasus design. One of the things I got out of their talk was the model actually validated much of what had been seen in the simulation program. The only oddity is that the model can't do the high G maneuvers, especially at high angles of attack, due to the high drag of the shape. Hopefully Bob is going to get some edited versions of the flight videos on YouTube to show everyone what it looks like in the air.

The workshop had a lot of very good presentations on a number of subjects. Our own Phil Barnes gave one on a wing planform survey that correlated fifty years of NACA and NASA. As usually it contained a lot of math and formulas, but the graphs helped put it all in perspective. I hope to have him put something together for this newsletter and *Sailplane Builder* so all can learn from it.

One of the key areas discussed during the weekend was how to generate more interest in general aviation and especially soaring among America's youth. Both TWITT and ESA have older demographics so this is important to keep the organizations vitalized and in a position to continue in the year ahead. Think about it and what can do to draw in our youth.

Andy

LETTERS TO THE EDITOR

Hello:

You have pictures of a circular flying wing on you site. The aircraft that first caught my attention is:

http://www.twitt.org/Circular%20Wing%20Photos.html

This is closer to our current design, and the Russian Diskoplan:

http://scienseillustrations.mypage.ru/2317512.html

which uses a similar construction method as we are.

We are build a circular wing glider for the Flugtag competition and would like to talk with the builder of that aircraft. Our primary goal is flying distance. We would like your thoughts/insights on our project based on your experience.

www.facebook.com/sfflugtag

Would it be possible to forward this request to him?

Could you also forward this e-mail tread to it's author as well.

Thank you

Adam Albert
adamalbert@yahoo.com

Hello Adam,

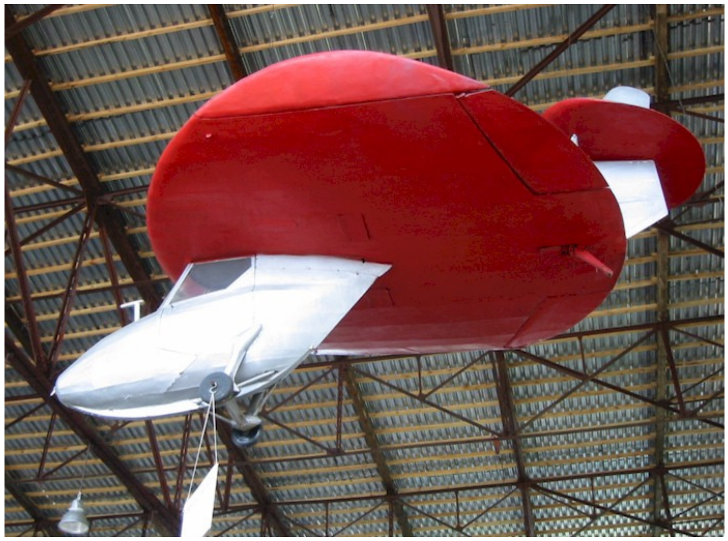
Thanks for your e-mail concerning circular wing aircraft.

Concerning the Russian circular wing aircraft, i.e.
- Gremyatsky "Disc" (Moscow Aviation Institute, 1969) detailled in the article

(http://scienseillustrations.mypage.ru/2317512.html):

Not much except a 3V drawing.

- Sukhanov "Discoplan" I & II (1958 & 1962): Here-attached photos taken from the Monino Air Force Museum where they are presently preserved.



Discoplan 10

Discoplan II 1

Perhaps more interesting are the aircraft designed and tested by David Rowe in Australia (UFO I, II & III in 1991, 1998 & 2001), especially the last one which is quite successful (David's photo of his UFO II here-attached, below).

But David doesn't have an e-mail address so if you want to contact him by snail-mail, please let me know, I will forward you his postal address.

Best regards,

Philippe Vigneron
retrofitprsp@yahoo.com

(ed. – Originally I misinterpreted Adam's request for information thinking he was talking about the Dehn Ring Wing from the web site, forgetting about the real "circular" wing I had posted just recently. In the mean time I had forwarded the message to Philippe since he had provided the Dehn material. Philippe was gracious enough to add some more information that might help Adam and the pictures are great. I let Adam know he could contact Paul Sallach at paulsallach@gmail.com and see if he has anymore information or can put you in touch with the designer/builder. I am not sure Paul has the engineering information Adam is looking for but perhaps he can get everyone together on the subject.)

Andy,

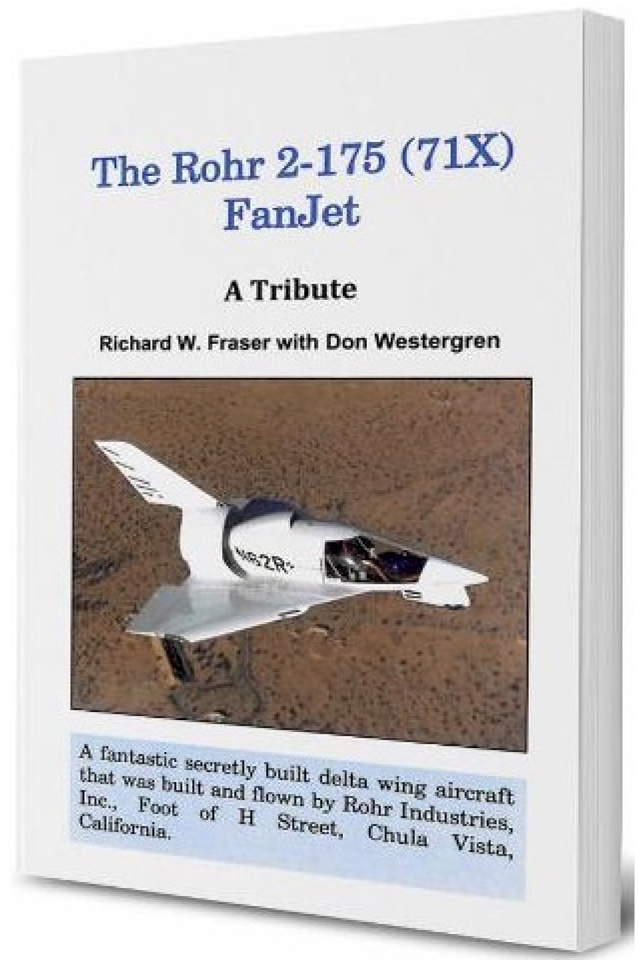
I don't know if you know of Bill Chana, but he passed away the first week of this month. He was 93 and Program Director for the Rohr 2-175 project. He was also President of the Air & Space Museum in San Diego for a while.

This should be of interest,

http://www.fraseraerotechnologycompany.com/Rohr_2-175_71X_FanJet_Book_Review.html

Richard Fraser
rcfraser@pacbell.net

(ed. – Here is an image of the book cover to remind you of what the Rohr 2-175 looked like.)



Hello:

Jim is finally getting some more airtime on his Pioneer 3. I posted some video of his last flight

http://www.youtube.com/watch?v=4QoxSigUdzk&list=UU7cscDUEM4QnZId90F2ki-g&index=1&feature=plcp

He soared for almost 5 hours and landed with a big smile on his face.

Matt Kollman
kollman123@gmail.com

(ed. - This is a short video of Jim's takeoff and landing from this great flight. There was some general discussion on Jim's new design during the recent ESA Western Workshop in that it is at the leading edge of being an affordable, high performance sailplane that the homebuilder can produce in his/her garage.)

Flying Plank Bulletin Board Threads

If you were to build a Plank, using your preferred building technique, would you:

1. Foot launch it.

2. Tow it (car, winch, plane or other method).

3. Motorized it.

Tommy

Tow first, probably with a car.

Motorize second as we figure out what works. Motorized paraglider perhaps? There is a lot of development going on there. A 4 cycle single rotor Wankel might work on a light airframe.

I see three separate models coming out of the same design.

The foot launch version would be uber-light with a skid under the nose and perhaps a small wheel. Definitely under ultralight glider weight.

The tow model would be stronger than the foot launch design but related. More ribs? Hard leading edge? Thicker wall tube spar with the same OD as the foot launch version? Plug in tips? Under ultralight glider weight.

The motorized version would be stronger still in different areas. It would be a tow model with a motor mount at the back of the fuselage, fuel tank and wheels that can taxi on a hard surface runway. It could make powered ultralight weight.

I want all three. Uh oh. I'm talking about having more than one. That's going to be some trailer.

PCKing

I would love to make a foot launchable UL version to fly at the NC coast. Aluminum tube spars like used in a hang glider or CGS Hawk wing. Ribs can be 1/2 inch bent airfoils inserted in pockets. Or foam with wood cap strips and covered with 1.8 oz peel ply cloth ($3.95 yd).

Make it with struts. Have the cabin floor open for foot launch'n. Sling seat and a zippered door closure. Use Velcro in case a zipper hangs and you can rip it open for foot land'n. Or land on a skid with a wheel. Like my 1-26 Schweizer use to have.

Cabin would be tube & gussets to and either covered with 1.8 oz Dacron or hang glider Dacron. Mylar windscreen and kind of like the CGS Hawk pod. Flat sided and simple. High mounted wing. Struts to the axle? Or low fuselage point. It'd be light & easy to tow. Plus a smaller engine would power it too.

Kind of like this with no boom or tail

http://www.youtube.com/watch?v=_aS8YJIhB_A

Tommy

Lots of design options, and its worth making sketches. I'm thinking mid wing with a large airfoil, possibly cantilever. Sketches show if a design concept has practical merit.

Of course a re-design is a new design and requires some stress analysis and some attention to the new aerodynamics, wheel placement etc. There is some nice freeware for doing simple stress analysis, and even some finite element freeware if a person is willing to get into the depths. This is where I would think a group dialogue and sharing of specific info would sort of take off, these kinds of important and very interesting design details...

For sure a 9g 65 lb hang glider could be built. My friend developed the Soarmaster power pack of the old hang glider days, and you can easily see that a similar motor solution could be put on a plank hang glider, wheels added etc. Surface finish has potentially a large impact as I've indicated before. Thought should go into it. This is ripe for innovation. The lower surface especially has a good potential for drag reduction, and the first 15% top and bottom is crucial. Not just drag but lift too is affected.

Max

I agree with you that there are endless possibilities for a Plank re-design. Numerous posts have been made about other aircraft on this group. And I don't really think it offends folks at all. Certainly not me. Some moderators will boot you out of a group if you sneeze wrong. But I am not like that at all.

I was in the US Army and still believe in liberty and free speech etc. Like the other groups I'm in, some just seem to be silent about things they don't understand or maybe it does not interest them?

Actually I was pouring over your previous design the other day and was amazed at the one foot cord on a 8 foot wing! For some reason it all reminds me of a hybrid dragonfly? Or the body of the military twin called the Flap Jack?

http://www.fiddlersgreen.net/models/Aircraft/Vought-XF5U.html

In some respects in appears to be a very radical concept but I have seen the Burt Rutan designs and can appreciate such genius imagination. I for one have been very busy in the yard lately. Seed, lime & fertilizer. Plus I've mowed 4 times in the past 10 days. We had lots of rain & warm days here in North Carolina.

I slowed down on my Fokker project 2 weeks ago when I ran a 1/8th inch drill bit into my left thumb. I could not hardly use my hand for a week. And I have been busy out soaring the hang glider on cross country flights. I got in early Sunday morning at 1:30 am! So I think others are away from the PC's and out and about more now that spring has arrived early. Now when I saw your design, I was trying to figure out how to mount those wings on a keel tube and use a control bar to hang glide it or a pod with a foot launch type arrangement for gliding.

I was looking at this earlier too:

http://www.youtube.com/watch?v=_aS8YJIhB_A

Now can you just imagine that without the boom & tail and in a flying Plank configuration? It'd be lighter too. By the way, I mentioned about my wife & I seeing a UFO two years ago driving down the road back from the airport (on another group) and 97% did not reply about it. Two did to me privately sharing their experience and one on the group mentioned it being off topic. Well, you can beat a dead horse to death. So how many questions can you ask about or talk about an engine over the years?

I admire you for your Plank screen savers and the stuff you turn out. I'm just not that advanced on PC's to do that kind of stuff either.

Tommy

Thanks Tommy for the thoughts. Wow, I would love to hear about the UFO.

OK, a long post just for overview, here it is;

You mention the Vought XF5U. In fact there is a lot in common with my Pegasus but in a roundabout way. The tip-mounted props reduced the induced drag in a similar way to the feathers. The Flying pancake was in fact a successful design. The low aspect ratio lifting body gives you cantilever lightness and benign flight. The drag is offset by a larger Reynolds number....which means the large chord helps.

I guess a major idea dovetailing into Backstrom's plank is that you can choose low span and low aspect ratio and still get good performance. But some idea of what the important compromise points are makes all the difference. In the case of the EPB-1, he got better fuselage and airfoil drag than you would expect or even hope for (parasite and profile drag) and this really helped ...it made the design viable. He paid attention to good clean wing construction, and wrote an article on the merits.

On the other hand, he got really poor span efficiency because of separation around the canopy....a good reason to go with high wing as you are thinking....and his lift coefficient was terrible. 0.75 .....like a lead sinker. A lift coefficient of 1.4 with up elevon is possible and this means twice the lift. That is major news for a hang glider design. 1.8 is possible with weight shift or other methods to get the nose up during flare, like his above CG drag rudder idea.

From this observation there are several areas that present themselves, and they need discussion. Namely; Airfoils, building style and the effect on airfoil performance, fuselage design, elevon design and of course span and area. It is not trivial and the video of the feathered machine should have given some insight into the possibilities.

In short, it seems to me that there is a superior flight and foot launch character....even leading to different flight styles....with a reduced span approach. This is very relevant to planks because the EPB was notably short span. But you have to fight for it to make it work. Then it may work spectacularly. The wrong choices and you have a hopeless dog, and maybe a dangerous dog at that.

IF a person is going to build in a fledgling style, or even any regular rag wing ultralight style, this means to me that the span should be kept relatively high, at least 30 feet. You have something that will be very much like an average fixed wing hang glider of old. It may require guys stabilizing for take off and the roll and inertia will be similar. You will always want more span, and more will be added. At some point in that vector, the pilot streamlining will become less important, and I think the Monarch is a good example of this. Long span always solves the sink rate problem.

But the spirit of the plank is a streamlined sports car, even though it looks like a Chinese chopping knife. Drag reduction allows smaller span. Smaller span means better roll and Backstrom said the plank was the only sailplane capable of a good 8 point roll. But compare the plank to my little feathered machine and again were at a new level of control authority. I don't see this discussion of span as being insignificant at all. It leads to a whole different feel and flight style.

The entire point about the Pegasus is a small machine. It's not to be different, tricky or bizarre. But then to see how it flies, wow, you realize there is this whole other pole to glider design, and nobody explores it, except Backstrom and a few others. The reason is designers around the world are stuck in thinking. Specifically the equation for induced drag makes it appear that it is a function of aspect ratio, but this is in fact not true. Once you realize this, you are free to explore design in terms of airfoil drag and span loading. There are only these things; wing loading, span loading, airfoil drag (profile) and then fuselage drag (parasite). The first thing to do is calculate the span loading of the plank and see where you are at. This IS the induced drag. The wing can be fat or slender, it makes no difference. This determines sink rate to a large extent. Then you see where you are with profile drag. This is penetration. You look at the influence of fuselage drag and you see in realistic terms where you are and what you can get away with.

The Archaeopteryx is a beautiful example of the standard way of viewing sailplane design. Its great, but its also hugely expensive and rather large in span. Long span and slow flight means slow motion flying. There's where my video comes in. You absolutely wont see a Carbon Dragon or Archaeopteryx flying like that 21 foot span creature. Maybe that's fine for 90% of the folks, but hang glider pilots have a glimpse of birdman aviator style flight,....you would think they would pick up an eyebrow....

OK, so the points are that the spirit of the plank is super clean and small span. It's an aerodynamics pursuit. Low drag!. Without the willingness to walk that path, and understand the implication, then the plank is not the appropriate inspiration. Aerodynamically, it makes more sense to make a rag nimbus than a rag plank. By my calculations, Backstrom must have been getting really extensive laminar flow. Did anybody ever read about Marske's first plank? It was a real dog and had an unbelievably low LD. He sanded and filled the leading edge D-tube and had miraculous gains in performance. He even added wingspan....everybody does.....and his roll rate was an agonizing 5 seconds ....or was it more, to go from 45 to 45.

The Backstrom plank is really a different design approach. A small span, lightweight minimum drag thing. That is why the feathered Pegasus is so appropriate to the discussion. Feathers reduce induced drag more than anyone's dreams. Now you have a span of 21 feet. You feel like you can almost touch the wingtips. Just use the imagination to compare foot launching that or a Carbon Dragon or Archaeopteryx.

In plank terms, it means perhaps keeping the tip fins, but making them efficient for drag reduction and adding a central fin for directional stability and control....for example. Or no tip fins, tapering the tips, optimizing the planform and elevons for elliptic lift distribution. Making a really streamlined fuselage. He says this in his article a plank for today. First get on board with the concept of the machine. The only way to even approach a longer span thing let alone swift or Archaeopteryx is to really go for laminar wings (lower surface) and maybe a lifting body fuselage.

At the end of the video I put a photo of Lilienthal. I have seen that glider hanging in the Balboa museum. It's really small. And it had feathers. Man, he almost had it, and its appropriate he was the first guy, the father of aviation.

Max

I have uploaded a DAT file of the EPB-1 airfoil to the group files in the airfoil folder. This was traced using a drawing program from the plans that Tommy sent
out and then input into Profili to change the format into a dat file which is an xy coordinate system commonly used by airfoil analysis programs

There was some loss of fidelity in the process so I don't claim this is totally accurate.

A handy program is Concorde from Martin Hepperle which converts many different airfoil coordinate systems include a dxf file which can be used in drafting programs

An excellent freeware program that will analyze airfoils and determine performance and stability of an aircraft layout is XFLR5.

I had coordinates for the EPB-1 as well as Fauvel. They may have come from the UIUC database. Judging by the analysis of these coordinates in Mark Drelas excellent freeware X-foil (no relation to x-plane that I keep referring to), I thought they could be well updated. This sent me on an endless development quest using x-foil.

I finally got around to tracing the airfoil from the plans and to my surprise, the performance was much better than the old coordinates I had. In fact the airfoil is very good with a very nice low drag coefficient of under .005, which if you deduce the profile drag from the data Backstrom gives, he must have been achieving pretty close to this. The airfoil is so good that its quite a testament to some ones airfoil design skills back in the day of slide rules and NASA mean line curves.

The only issue that stands out is the low lift coefficient of .75 that he mentions. The lift coefficient is a direct indication of the amount of lift that can be produced and thus wing area that is required, so obviously a wing with twice the lift coefficient requires only half the wing area. The maximum lift of the EPB-1 is close to 1.45. The amount of reduction in lift from elevon deflection is related to the static stability. The static stability in flying wings is simply the distance from the aerodynamic center to the center of gravity in percent of the chord. This is often called static margin. RC models often use a very small margin of 2 to 3% of the chord. In full size aircraft it appears that a greater margin is required to be safe from tumble. At least 5 if not 10. Once the static margin is decided, it's easy to calculate the required airfoil moment to hold the nose up at any given lift coefficient.

It looks like the EPB-1 airfoil would be capable of a lift coefficient of around 1 which was also the number given by Backstrom. This reduction of about Cl 0.4 is a rough estimate of how much lift one would lose due to elevon deflection. It's a significant hit. The additional loss down to Cl= 0.75 is probably from separation around the canopy and loss due to aspect ratio and the planform and elevon geometry.

A flat plate flat to the wind has a coefficient of force (drag) of around 1.28. Its one of the neat things about wings that they can produce this much force and more, perpendicular to the wind with a mere 15 or so degrees of inclination. It would be nice to get at least this much lift, if for no other reason the satisfaction of it.

One of the many airfoils I came up with is this fat 19% airfoil that gets a Cl of 1.9 or 1.5 with elevons deflected. The drag seems quite low for a thick section like this.

Something to consider is how much laminar flow one is shooting for. A more laminar section will have less lift. This is a valuable trade off however. But the reality is that most build techniques won't allow this, so its probably better to go with a higher lift airfoil.

Experimenting with the idea of specialized elevon geometry produced this unique form which gets a Cl of over 1.6 with elevons deflected. Something like this may be a consideration on the elevon section of the wing. At a cruise moment coefficient and higher speed, the lift coefficient x-foil gives is over 2. This is optimistic but still, that's very high lift for a positive moment airfoil.

Continuing the subject of airfoils and flying wing wings, I thought I would reiterate this interesting thing about drag and aspect ratio. Induced drag is the well-known leak of air around the wing tips that makes the wing tip vortex. The drag is due to the fact that the downwash from the vortex tilts the lift vector backwards a little bit. Otherwise, if it weren't for this wing tip leak, the upwash in front of the wing and downwash would be equal and the lift vector would be perfectly perpendicular to the wind. So that's the basis, but an interesting thing is that there is an equation for induced drag that includes the aspect ratio and this apparently gives the impression that high aspect ratio wings have less induced drag.

Here are two wings, a low and high aspect ratio and the planes have the same span and the same weight and are flying at the same speed. Which one has more induced drag?

Of course the induced drag is the same but somehow we have been led to believe that the high aspect ratio wing gets less. This has a bearing on the airfoil choice. Its not correct thinking to choose a higher lift section just to allow a higher aspect ratio, expecting lower induced drag. In fact if you can achieve laminar flow, it would be better to have a lower aspect ratio planform, given the same stall speed. A program like XFLR5 shows the results of airfoil choice clearly. Construction technique is a main deciding factor on airfoil choice. An old NASA study showed that long EZ wings got extensive flow, despite sweep and owner built technique. It doesn't seem like one could get laminar flow past a D-tube. Its interesting how far back the Planks D tube extended, and he may in fact have gotten laminar flow past them on the bottom surface.

I know it's a rudimentary point for all you aerodynamics guys, but it's curious how widespread this is conception is, along with its cousin, that downwash is the source of lift.

Max

Not being an aerospace engineer, can you give some background on why this is so Max? I would have guessed right the opposite.

Tommy

First, I'm not an aerodynamicist or expert. So the appropriate question is why would I venture any comments in the first place!....

Stall is a boundary layer phenomenon. High-pressure air starts to creep forward into the low-pressure region of the airfoil via the boundary layer. At some point this will cause separation. This actually happens readily as laminar flow encounters a higher-pressure gradient. The result is the so-called laminar separation bubble most evident on low speed airfoils. (low Reynolds number more specifically) This will usually reattach as a turbulent boundary layer. A turbulent boundary layer has the ability to forge into the high pressures toward the trailing edge because it is mixing the fast, high momentum air outside the boundary layer. it is the momentum that carries the boundary flow into high pressure regions. Boundary layer theory is extremely complex. Tollmein Schlicting instability waves, or cross flow from swept wings, of course any boundary layer protrusion will trip the laminar layer. The resulting hairpin vortices have been visualized by computer animation. This has a field of worms look and one can easily imagine the higher drag condition. Worth a YouTube look.

The longer the air travels on the airfoil, the thicker the boundary layer gets. The boundary layer loses the ability to go against the pressure gradient as the air is slowing down and regaining atmospheric pressure. If you start this recovery from low pressure to atmospheric soon, the boundary layer is thinner and can take more of a pressure gradient. That means you can achieve lower pressure and still return to atmospheric pressure without stalling. The optimum location of the beginning of this pressure recovery region, ...where the boundary layer will become turbulent, differs depending on the airfoil design, but may be from around 20 to 35 percent.

If you trip the boundary layer too soon....not enough laminar flow, then as you say, lift is reduced. A turbulent boundary layer loses energy faster than a laminar one.

The excellent Genesis airfoil gets laminar flow close to 45% even at high angles. The maximum lift is about Cl = 1.3 with cruise elevon setting. The thick airfoil I had posted the image of became turbulent at about 18% at maximum lift which is close to Cl=1.9. A longer laminar flow occurs at lower angles so penetration is actually quite good.

One must consider the construction technique when deciding on an airfoil. It would be better to have a lower aspect ratio wing and use the genesis than a higher aspect ratio wing and a higher lift but higher drag airfoil.....IF you could build very clean wings. This is because laminar flow is quite a bit better than turbulent and the higher wing area is more than compensated by the lower airfoil drag. But if you use standard rag wing methods, or have a little discontinuity at the D-tube, then it may be better to use a high lift section. The most important part is the first 15% or so, as is well known. Some effort should be made to get laminar flow that far.

Backstrom did a great job with his construction and the airfoil looks really good to me. Amazing for the times and the airfoil holds up to today's airfoils. It was before Stratford came up with the low-pressure plateau, concave pressure recovery theories.

Max

To be honest, I would have guessed the higher aspect had less induced drag.

"Its interesting how far back the Planks D tube extended, and he may in fact have gotten laminar flow past them on the bottom surface."

So did Al Backstrom and his friends stumble into the right idea or were they actually super smart before the computer age?

Tommy

This statement that the two wings of equal span but differing areas have the same induced drag is not correct. The formula includes the coefficient of lift squared. The wing with more area will have less induced drag because of the lower CL. Unfortunately it will also have higher form drag due to the larger wetted area. But the longer chord also gets a boost from the higher Reynolds number. The 2D lift to drag ratio is good to know but the actual airplane's best L/D will be closer to the 2D minimum drag angle of attack usually at cl=0.2

Norm

Norm....first, take two wings with equal span and equal weight and equal speed and calculate the induced drags. It is non controversial that it is span loading that determines induced drag, not aspect ratio, even though you find the aspect ratio or as you say the Cl in the famous induced drag equation. Most people think that the lower aspect ratio wing has higher vortex drag, but you say the opposite. The truth lies somewhere between.

Al Backstrom was pretty on top of his game I think. Definitely did not stumble into the right idea. The span and parameters came out of analysis, and then he was able to carry it into reality. The problem was of course separation around the canopy, interference drag at the wing juncture and low span efficiency, partly due to the separation. It appears from all that I've read and the simulation also, that more fin area or fin further aft could have helped, and Backstrom had suggested extending the elevons for more "leverage", using drag brakes on the fin for glide path but also to bring the nose up without losing lift from elevon deflection and of course increasing the span. All in all, the Fauvel was the sweeter machine, but I think the simplicity of the plank and an ongoing philosophy of span minimization through weight reduction, high span efficiency and general cleanliness is still a good path for exploration. I would think of blended wing body approaches.

Max

Well yes Induced drag is proportional to span squared divided by weight. However it also increases with angle of attack or inversely with speed. Near the stall b^2/w is the number to use to get an idea of the minimum sinking speed of two sailplanes but at penetration speed it becomes less important. Then the plane with the lower CL will have the flattest glide. See this link for an extreme example of what I'm talking about:

http://www.twitt.org/FarrarWing.html#top

Norm

I have always wanted to know more about the Farrar wing. The span and wing loading are right in the plank category, and as one can see, the performance was expected to be good.

The idea behind showing the two plan forms of different aspect ratio and pointing out that they have the same induced drag was merely to ping against the common notion that lower aspect ratio wings have higher vortex drag. It's a subject pertinent to the plank design. I thought it was a useful, simple global concept.

Speed is certainly a factor for induced drag, and a plane flying twice as fast will have something like 1/4 the "vortex drag". This is good to realize because it shows the outstanding contribution of airfoil profile drag at penetration speeds. This is true of course for every aircraft and is not an aircraft geometry question. Span loading and span wise lift distribution...the fidelity to elliptic, are the important ideas regarding plan forms and induced drag. Wing loading, thus area and aspect ratio, are chosen for the desired stall speed and penetration performance. Airfoil performance and other things also enter into the aspect ratio question.

Backstrom had an article titled something like "a different approach to high performance" where he touches on the next generation low drag plank. Tests indicated that a Cd0 of 0.007 was possible and that you could achieve an LD of 20 at over 100 mph with relatively low wing loading. Cd0 means to me all the drag except induced. The majority of this will be airfoil drag, the rest from the fuselage, interference and fin drag. Its really an extraordinary low drag figure and relies on extensive laminar flow. Remember this was in the 1950's. Backstrom was a young whippersnapper at 27 years old when he worked out the EPB-1.

The test sailplane that was used in the university test program had no vertical fin and was very cool looking. I never understood why they scrapped it instead of simply adding a fin. John Powell was behind the high performance plank that used the NACA 8-h-12 airfoil. It was also really neat looking. It's notable that it failed because the airfoil had the reflex in the elevon region and this gave reverse stick force gradients. An all-important point when choosing airfoils. The other problem was high sink rate in turns which was thought to be a combination of high airfoil drag at high lift and a poor span wise lift distribution due to elevons.

This is an important thing to consider when thinking of elevon control. A major improvement toward elliptical span wise lift distribution is to use a long center body...the bird tail or the lifting body approach and put either trim or simply elevator function on it. Another approach would be to use full span elevons. In addition to better span loading, this has the advantage of faster roll, narrower elevon chord, perhaps simpler control lines since the elevon can be its own torque tube and plug directly to a socket or link in the fuselage.

Wortmann has a good-looking airfoil that has positive camber in the elevon section and I think it was used on the Pelican flying wing. Somehow, the elevon should be aerodynamically and mass balanced.

While these three aspect ratios (image below) have the same induced drag- at a given speed- and thus could be expected to have similar (but not the same) sink rates, the low aspect ratio can fly slower and thus smaller circles. It lands slower, has a larger CG range, has a larger spar height. It will have more benign flight character. The main problem is penetration. By choosing clean construction technique and low drag fuselage this can be somewhat offset. Auxiliary power is also an alternative to good glider penetration. There is a paper on wind milling the prop during thermal to charge batteries and using the stored electric energy to power between thermals. I have a friend doing just that in his electric canard ultralight. How about solar?. A design analysis program like xflr5 shows the trade offs well and would be the thing to use when finally settling on a layout.

Looking at the young Backstrom and these nostalgic developments, one is struck at the passage of time, and the limited amount of it. Collaboration could help.

Max

I like what you mentioned here Max,

"Another approach would be to use full span elevons. In addition to better span loading, this has the advantage of faster roll, narrower elevon chord, perhaps simpler control lines since the elevon can be its own torque tube and plug directly to a socket or link in the fuselage."

Tommy

That would be another interesting number, wetted aspect ratio, span square decided by total whetted area. Basically what it comes down to is the ratio of wing surface to total aircraft surface. The less non-wing surface you have the more efficient the airplane can be. That's the reason that all modern sailplane fuselages look like a curved corndog. The aft fuselage is just parasite drag so as quickly as possible, after making room for the pilot, they choke it down to get rid of as much surface area as possible. The next step is, of course, to get rid of the tail entirely. The only problem is that to accommodate a sitting person in the wing you need a root chord of 9 or 10 feet and if you want an engine that chord jumps to over 13 feet (that's the length of a BD-5). It is worth noting that Dr. Farrar lost part of his face trying to test fly that glider

http://en.wikipedia.org/wiki/Wetted_aspect_ratio_%28wing%29

http://www.homebuiltairplanes.com/forums/aircraft-design-aerodynamics-new-technology/9161-triple-tandem-wings-future-2.html#post88745

Norm

AVAILABLE PLANS & REFERENCE MATERIAL

Tailless Aircraft Bibliography

My book containing several thousand annotated entries and appendices listing well over three hundred tailless designers/creators and their aircraft is no longer in print. I expect *eventually* to make available on disc a fairly comprehensive annotated and perhaps illustrated listing of pre-21st century tailless and related-interest aircraft documents in PDF format. Meanwhile, I will continue to provide information from my files to serious researchers. I'm sorry for the continuing delay, but life happens.

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Books by Bruce Carmichael:
Personal Aircraft Drag Reduction: $30 pp + $17 postage outside USA: Low drag R&D history, laminar aircraft design, 300 mph on 100 hp.
Ultralight & Light Self Launching Sailplanes: $20 pp: 23 ultralights, 16 lights, 18 sustainer engines, 56 self launch engines, history, safety, prop drag reduction, performance.
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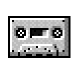
VIDEOS AND AUDIO TAPES



(ed. – These videos are also now available on DVD, at the buyer's choice.)

VHS tape containing First Flights "Flying Wings," Discovery Channel's The Wing Will Fly, and ME-163, SWIFT flight footage, Paragliding, and other miscellaneous items (approximately 3½+ hours of material).
Cost: $8.00 postage paid
Add: $2.00 for foreign postage

VHS tape of Al Bowers' September 19, 1998 presentation on "The Horten H X Series: Ultra Light Flying Wing Sailplanes." The package includes Al's 20 pages of slides so you won't have to squint at the TV screen trying to read what he is explaining. This was an excellent presentation covering Horten history and an analysis of bell and elliptical lift distributions.
Cost: $10.00 postage paid
Add: $ 2.00 for foreign postage

VHS tape of July 15, 2000 presentation by Stefanie Brochocki on the design history of the BKB-1 (Brochocki,Kasper,Bodek) as related by her father Stefan. The second part of this program was conducted by Henry Jex on the design and flights of the radio controlled Quetzalcoatlus northropi (pterodactyl) used in the Smithsonian IMAX film. This was an Aerovironment project led by Dr. Paul MacCready.
Cost: $8.00 postage paid
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VHS of Paul MacCready's presentation on March 21,1998, covering his experiences with flying wings and how flying wings occur in nature. Tape includes Aerovironment's "Doing More With Much Less", and the presentations by Rudy Opitz, Dez George-Falvy and Jim Marske at the 1997 Flying Wing Symposiums at Harris Hill, plus some other miscellaneous "stuff".
Cost: $8.00 postage paid in US
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VHS of Robert Hoey's presentation on November 20, 1999, covering his group's experimentation with radio controlled bird models being used to explore the control and performance parameters of birds. Tape comes with a complete set of the overhead slides used in the presentation.
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