No. 305 NOVEMBER 2011

T.W.I.T.T. NEWSLETTER

Jim Marske in his Pioneer 3 on takeoff roll. Photo courtesy of Matt Kollman.

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., **1111** means this is your last issue unless renewed.

Next TWITT meeting: Saturday, November 19, 2011, 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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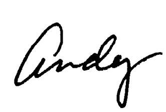
PRESIDENT'S CORNER

First of all I would like to thank Jim Marske for permission to use the picture of the P III for our cover this month. It is an interesting shot since you can see the curvature in the wing as it loads up since the wheel is really off the ground at this point. He included some other pictures that perhaps I can include in a future issue. He has also forwarded a short recap on the P3's performance so far and I think you will find it interesting. Unfortunately, you will have to wait until next month since it came in too late to fit in this issue.

This month's issue contains a lot of information from the Nurflugel bulletin board based on some initial comments by Al Bowers from his recent TEDx presentation that set off interesting follow-on conversations. I have also included some of the slides from Al's ESA Western Workshop presentation on induced drag and thinking outside the box since they fit very well into the material that was being covered in the discussions.

I know I use a lot of material from Nurflugel, but it does help fill in the blank space left when no other letters or other articles are available. However, I wonder how many of you actually subscribe to the bulletin board so this becomes repeat information and dilutes the value of the newsletter to you over time. I would like to hear from you to get an idea of how many do subscribe and whether or not you would like to see a different approach, although right now I don't know what that would be without more material. I guess this also applies to those folks that subscribe to the Mitchell U-2 site since I use that information when there is enough and it has some relevance.

So let me know your thoughts and perhaps we can find another way to generate new material for the newsletter.



LETTERS TO THE EDITOR

October 16, 2011

There was a note on the WIG (Wing in Ground Effect) mailing list that Chuck Bixel died on October 11. I've seen letters and an article from him in the TWITT newsletter so figured you should also get this link to the on-line obituary: <http://www.mclaughlinmortuary.com/obituaries/Charles-G.-Bixel4811529753/ - /Obituary>

(ed. – Chuck was a past member of TWITT and had contributed a number of items related to WIG over the years. I was not aware he was ill since I continued to receive e-mails from him, even recently. I have included his obituary below since it may disappear from the Internet at some point in time.)

Obituary for Charles G. Bixel

Charles G. Bixel Jr. passed away Tuesday, October 11, 2011 at the age of 85. Chuck was born in Los Angeles California on July 8, 1926. He was an Air Force pilot who was privileged to have flown many different Fighters including his favorite, the P-51. During his service, he showed his family different parts of the world as well as the USA. Family vacation travel was often by small plane and usually included high adventure, which will always be remembered and enjoyed by his family. Chuck retired from Eglin AFB in 1966 and continued his interests as an inventor, entrepreneur, creative sign maker and all around tinkerer. He designed and built many different things including dune buggies, boats, a prelude to jet skies, and *his proudest project - a functioning ground effects craft made out of foam*. As one of his fellow enthusiasts put it "His lively and challenging presence will certainly be missed. In fact, it was already missed; he had been quiet lately, no doubt because of his poor health. We had hoped that he was simply busy with other projects".

Chuck is survived by his wife of 61 years Shirley Bixel, his son Gil Bixel (Kathy) and his daughter Cheryl Bixel. He was preceded in death by his oldest son Michael S. Bixel who was killed in Viet Nam.

October 25, 2011

Thank you Andy,

Saw TWITT reference on article on US Pacific website article about Mitchell. Ordered B-10 plans from Pacific. Will get U-2 plans as well. I will build a B-10 ultralight. Been buying plans for 30 years, like many guys. Times up, so need to get going.

Only have student soloist time in a 7Aeronca Champ, a few minutes stick time in a P-51B, and various old biplanes.

I'm a decent welder and small time fabricator. Just finished rebuilding a 5.0 Ford V8. I'm a technical writer.

Ron Fabretti
<ronfabretti@gmail.com>

(ed. – Ron is a new member and this is in response to my welcome message asking how he heard about TWITT and about his general interests.)

(ed. – Below is a cut down version of Al Bower's synopsis of his presentation that sort of started an interesting thread on the Nurflugel bulletin board that I have tried to capture. This also overlapped with his ESA Western Workshop presentation "On the Minimum Induced Drag of Wings –or- Thinking Outside the Box".)

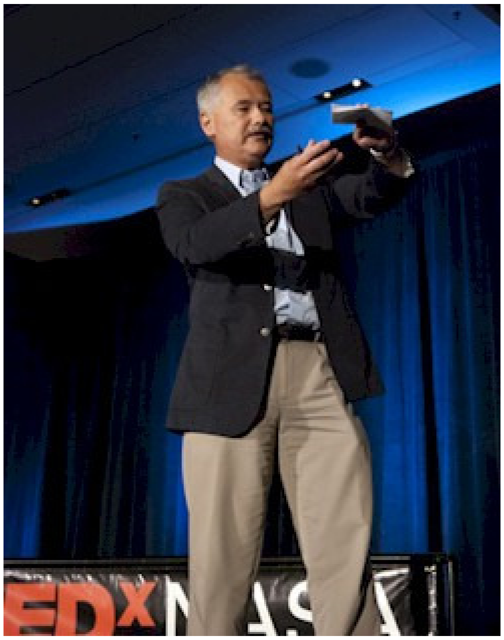
Watch Al's TEDxNASA presentation, "Toward More Bird-Like Flight: Thinking Outside the Box" at http://www.youtube.com/watch?v=223OmaQ9uLY&feature=youtu.be For the full blog on line go to: http://blogs.nasa.gov/cm/blog/Dryden/posts/post_1315426542410.html

By Al Bowers
Associate Director for Research
NASA Dryden Flight Research Center

It has been a couple of weeks since the TEDxNASA@SiliconValley event now. I've had a little time to decompress and reflect. I have some thoughts to share...

An incredible amount of work was done by the NASA Ames folks putting on their first TEDx event, and the

NASA Langley TEDx crew did an equally incredible amount of work in support of the event, helping out and getting everything spooled up. There were a number of NASA Dryden folks helping out as well; many kudos and thanks to everyone who was doing a lot more than pulling their own share.



Al Bowers takes the stage for his 8 minutes of fame at the recent TEDxNASA event in San Francisco. Image courtesy Michael Porterfield.

Wow, TEDxNASA. What an event. In the lecture/conference world, the TED name (stands for Technology, Entertainment, and Design) has huge *gravitas*. And it is well deserved. Some of the most mind-blowing ideas have been presented in a public forum at TED, and to put all those great ideas together in one place like TED does is simply amazing beyond words. TEDx is the way TED shares their ideas worth spreading with a broader audience. Bravo!

So I knew what TED was before I was asked to be a TEDxNASA speaker. And when the question came up of who should speak for NASA Dryden, the fact that my name got mentioned was a huge compliment and honor. So TEDxNASA was an opportunity to share one of the really big ideas that I was able to grasp.

I chose the last paper by Ludwig Prandtl on the spanload of wings. Prandtl was the founding father of the science of aeronautics. His formulas were the first practical tools by which we could calculate lift, induced drag, and spanload - the distribution of load across a wingspan.

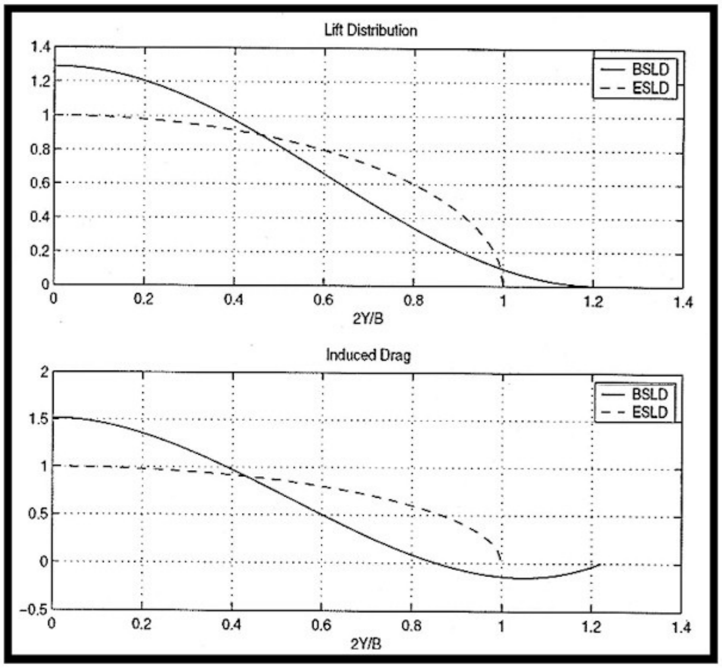
Prandtl's last paper on spanload and induced drag has languished, almost completely unnoticed, and would be not even a footnote were it not for two brothers who used his idea to build a few wooden gliders and sailplanes. These two brothers, Reimar and Walter Horten, built some of the most beautiful man-made aircraft to ever fly - pure flying wings. The Hortens had to integrate all the components of flight into a single unit, and eliminate everything that did not contribute to their singular idea. Prandtl's last paper on spanload was the germ of that idea.

The Horten H VI sailplane, built by Reimar Horten. Image courtesy Doug Bullard.

Many years ago, I had the great honor to listen to Bob Hoey, the retired Edwards Air Force Base engineer. Bob had been studying the flight of birds. And Bob was talking about the spanload of birds and how, if you got it wrong, nothing worked, but if you got it right, everything worked.

Bob didn't know about Prandtl's last paper, or details of the Hortens' work. But I did. And suddenly I connected the dots between them. I could see the connection between Prandtl with his ideas, the Hortens with their sailplanes, and Hoey with his birds, and everything came together.

TEDxNASA@SiliconValley was in San Francisco, near Moscone Center. It was tagged on the end of the IT Summit, so there was a certain amount of teardown activity for the summit and buildup for TEDxNASA going on.   The first few speakers gave their talks. Things were going pretty well. We had the usual GLITCHes (GLITCH = gremlins living in the computer hardware), but the presentation was moving very well. It was time for me to get ready. Now, I have a confession to make. The worst time for me, for any talk I give, is the last five minutes before I walk out to start talking. I am a total nervous breakdown, train-wreck of stomach-churning, introverted, hands-shaking nerves. I know none of you believe that of me, but it's true. And then I walk out on stage, and I start, and suddenly...the moment flows. I can connect with people; I can open their mind's eye to new ideas, to concepts that are really the secret truths of the universe. For a moment, this frail, failing, human mind of mine can do that with others.



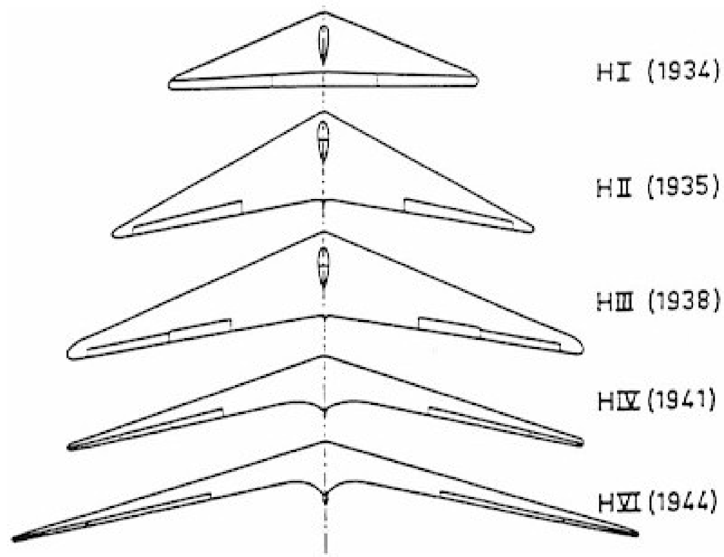
Graphic above: The elliptical spanload (dashed line) and the bell spanload (solid line), with the centerline at the left and the wingtip at the right. At the top are the span loads, and at the bottom are the induced drag curves (note the bell spanload induced drag goes negative at the wingtip).

"Assumptions are a fact of life..." I begin to share what I have learned. The boxes our minds live inside of...the flight of birds...the Wrights and their success...Prandtl thinking the great thoughts... explaining induced drag...Horten figuring out the implementation...and my stumbling into the implementation (with help!)...my disbelief of the analysis, and Mike Allen's unwavering belief that it MUST work...how much we could reduce the carbon footprint of aircraft (about 40%). All of this because of the flight of birds. I glanced at the clock twice, right at the last quarter of my talk (1:24 to go), and again just before the summation with 0:24. "When we distill an idea down to its minimum, it is simple and elegant. Prandtl had to rethink his assumptions to find superior solutions. We, too, must rethink our assumptions to solve the problems of today. And I believe this is an idea worth spreading. Thank you."

The days pass. Life returns to "normal." The video is posted now. The talk is not perfect (not by a long shot). But it's good. I'm glad the idea - Prandtl's idea - is being talked about.

Yesterday afternoon I was working out in the yard, clearing some branches. The sun was hot, and the afternoon breeze was blowing. I watched a raven slope, soaring as he flew by. His tip feathers stretched out against the afternoon's azure sky...

(ed. – This ends Al's blog but we continue with the questions and contributions of others pretty much in chronological order as they appeared in the e-mail bulletin.)



Horten applies Prandlt's theory – Horten spanload (1940-1955) use twist to achieve spanload induced thrust at tips – wing root bending moment.

From Philip:

So the applications are where wing root loading (strength) and weight are critical, and span isn't up against airport limitations? Does this mean applications only to planes with wingspans that could be longer and still get into airports? Or do you see even jumbo-jets benefiting? Are there any gliders or ultralights in the works with a bell-shaped lift distribution?

Birds cheat. They fold their wing tips and wings back when on the taxiway, approaching a concourse. And they have bio-computers that adjust wingtip incidence for thrust under a variety of conditions.

I understand that winglets are very design-fussy and flight condition fussy, to get any performance boost, and are targeted for cruise conditions only. Am I right in guessing that getting thrust from your bell-twisted tips is also sensitive to flight parameters, and that their design would target a single speed and altitude? Is this where some telemetry and computerized control over variable tip twist would be useful? The tip twist could be varied with a control surface, or tiperons?

Yeah, tiplets, winglets, my brain will call anything anything. Not quite as bad as a friend who had brain damage, and had full-blown aphasia, but...

So it sounds like you are single-handedly pulling a hot 80-year-old topic into the mainstream. You wrote: "And yes, the design of this approach is for one particular design point. You can adjust the design point some with full span trailing edge control surfaces."

Thinking again, when trailing surfaces increase twist they decrease camber, lift, and therefore thrust. A leading edge control surface might match changing conditions better, but is a tougher design. Rotating twisterons or wing warping are hard to do for a whole wing.

The problem is getting an ideal angle of attack in relation to the induced angles of up flow in the outer parts of the wingtip vortices--so the outer wing will gain optimum thrust as it glides 'down' that up flow. The outboard flow will spill up more steeply at lower speeds. So at lower speeds, more twist would be ideal.

Sweep in the outer wing must also be critical--we need the thrust-producing, twisted, outer portion of the wing to be in the strongest wingtip vortex up flows. Too far forward or back and the up flows must be weaker. Gulls often pivot their outer wingtips forward or back.

I could see a solution to a discouraging argument. A designer says, 'Wow. I can get better performance by going bell, with just some longer span!' And then she says, 'But as long as I'm increasing span, I'll just use a longer elliptical lift distribution, for minimum drag per span. Sure, it increases root loading, but I'll make it up with composites.' Under some conditions, she'll be right. Other conditions, the BSLD will still win, or some compromise.

One compromise might be to do what the birds do--equip a fairly standard wing with twisterons that stick out into wingtip vortex up flows, and that are designed to fold either up or back, while taxiing or parking.

Or maybe some leading edge warping could increase effective twist and camber, at lower speeds. I could see a leading edge designed to rotate downwards a bit, with the rotating part having wider percentage of chord toward the tip, to make stronger effective twist out there.

Such leading edge variable droop could be on its own, right out to wingtips, or could be combined with folding twisteron tiperons.

The ultimate solution, of course, is morphing wings, but until then...

More from Al:

I just figured out why bell spanload is so strong on directional stability!!!

Holy cow. How did I not see this before!!! Its the TWIST! Seriously, its the way the washout couples with the spanload...

I could never figure out why a bell spanload on a swept flying wing is rock solid directionally, yet the elliptical spanload on a swept flying wing yaws all over the place. It never made sense to me.

Keep in mind this is a lateral directional mode, the dutch roll. This is a coupled yaw-roll or beta-phi mode. Its stronger in beta (yaw) than phi (roll). So the beta-to-phi ratio is above 1. This is why we see the aircraft yawing back and forth, the phi (roll) is small.

So for elliptical as we yaw and get a little beta. To refresh, remember the spanload is elliptic, and because we have constant downwash, we get elliptical induced drag distribution as well. As we yaw, there is a small change in the lift at tips (upwind increases). Ditto the induced drag. The overall effect is very slight in lift (phi ratio is small) and the effect in drag is also small. So with little differential change in drag, there is little differential to straighten out the wing. Hence we get a constant dutch roll.

Bell shape: remember we have a part of the wing with induced drag, and tips with induced thrust. The induced thrust is because of the TWIST!!! As we yaw, the amount of tip that gets induced thrust changes a considerable amount. Small changes in induced thrust at the tips locks the wing in directionally. It’s the

TWIST or WASHOUT that provides the directional stability!!!

I've known this 14 years, and I only realized this today...

Man I'm dense...

Mike Allen with his twisted Kingberg wing.

From Rich Nunn:

Al: Don't beat yourself up too much-you've probably got other things in your life-so it got pushed aside into a corner. On another note, I see that many of the Nurflugel group are really into sailplanes, as was Horten himself. Are these calculations/ relationships necessary for powered wings as well with shorter spans, such as 30-35 feet? Hortens really had very long wings, which lightened their wing loading appreciably, and left much of their load carrying capability unused. Comments please.

From Chris Bryant:

Down here at vegetable level I am getting another idea from what you wrote: what happens to the yaw and roll damping of a wing with bell shaped lift distribution. It seems obvious that the damping should also be stronger than for an elliptical lift distribution, but is it? If I have it right you have been talking about forces but not about damping. Also, how does this compare to tailed aircraft?

From Andre Martins:

Al, I believe you pretty much got it!
Just for understanding: in yaw, the trailing wing loses lift, therefore the twist (the "basic lift distribution" in classic NACA jargon "kicks in" more in relation to the "additional" one, so the SPANWISE extent subject to thrust increases, favoring restoration of zero yaw... Right? Perfect!

Actually, it rings yet another bell: the low taper ratio on the Hortens should lead to a quite triangular, tip-unloaded "additional" (NACA again...) lift distribution, maybe reducing its play in the game even further!...

On a side note: it is interesting how all that seems to give a background to history, with for example Northrop nobly but constantly struggling with lateral issues (e.g. YB49 or XP56), while reports from the Horten side seem to spell: "problems? What problems?"... Fascinating.

From Rich Nunn:

Dear Al and others:
Perhaps it is my neophyte understanding of the span wise flow of air toward the wing tip that encourages tip stall . (Sabre dance). Sometimes the aerodynamicist/ engineers use a fence on the wing to prevent this so that tip stall is prevented. However, that was a long time ago-(I.E Mig-15's for instance).

Now we have vortex generators that can be attached to wing surfaces-both top and bottom. Could the correct positioning of vortex generators be added to a wing that would not only provide better yaw control, but also eliminate tip stall? They might also be able to redirect the airflow to add tip thrust. This might simplify construction of future wing aircraft. Just wondering.

From Don Stackhouse:

Al, first of all, that was a truly spectacular talk.
One thing I think is getting the "short shrift" in this whole discussion is your comments at the beginning about assumptions, and how they box in our thinking.
I have often referred to those as "engineering sacred cows", things we accept without challenging, but that might not be entirely accurate, or that might not apply in all cases. It pays to read the fine print. I've

personally had a few "breakthrough" events in my own design career, and usually it has been the result of questioning what everyone else was just taking for granted.

One example I can think of was some very impressive-looking analysis of the question "what's the optimum aspect ratio for an R/C sailplane?" There were a number of highly respected designers chiming in on this on the Internet forums a while back, and with some very thorough-looking analyses they were coming up with numbers around 15:1. The problem was that they started with a baseline design, but did not re-optimize the overall design for each different aspect ratio they looked at. As a result, they came up with the optimum for that baseline design, NOT the overall optimum. Meanwhile, we allowed all the parameters in the design to float, re-optimizing the overall design for each aspect ratio, including re-optimizing things like the airfoil shapes for the different Re's, and came up with design with a higher aspect ratio that outperformed the supposedly "optimum" 15:1 designs.

Likewise, there were many discussions of the "optimum" weight for a hand-launched 1.5-meter model, with the consensus that the optimum was around 9 ounces or so. Meanwhile, by re-optimizing the other all parameters in concert with the weight, we came up with designs in the 5-6 ounce range that would outperform those supposedly "optimum" 9-ounce designs in all regards, including launch height.

The bottom line is that you must consider the "big picture" including all of the ways that the individual parameters of the design and of the mission profile interact with it, and with each other.

I agree entirely with you regarding the benefits of the bell-shaped lift distribution, both in terms of induced drag and adverse yaw, but I have some problems with it when we try to insert it into the "big picture".

There are several issues.

First of all, the bell distribution requires a 22% span increase. Never mind that some competition classes include a span limit, even if we're looking at something like the Unlimited class (no span limit), we still have problems. Yes, the bell distribution gives us the same root bending moment, so the "beef" in the spar at the root is the same, the increased span still gives us a higher overall spar and wing weight.

In addition, the greater span means that either our area is greater (which means more skin friction and parasite drag), or if we keep the area the same we get lower chords, and therefore lower Re's, with higher drag and lower Clmax. Or, we go for some compromise on these and end up with a piece of both of those negatives.

This suggests that the true optimum from a performance standpoint is likely to be something in between the elliptical design and the 22% longer bell design.

Handling wise, the longer span generally means greater inertia about the yaw and roll axes, as well as more aerodynamic damping in roll. For cases where maneuverability is important (for example, the precision landing tasks in R/C sailplane competition), again, the true "optimum" might be something intermediate between the bell and elliptical distributions.

So far, so good, as long as we're talking about a single-operating-point design. However, most airplanes have a variety of operating points where they have to deliver good efficiency. A typical sailplane has to perform well at thermalling speeds, but also at best L/D, and at speeds needed to penetrate upwind, and even at near zero lift coefficient during portions of launch.

This is where the bell distribution with it's relatively heavy reliance on comparatively large amounts of twist gets in serious trouble. Twist is particularly sensitive to flight condition. It's easy to come up with a twist distribution that's optimized for, say, best L/D speed, but that twist quickly becomes excessive at higher speeds, with corresponding penalties.

Yes, it is possible to improve this by using multiple control surfaces along the trailing edge to create the effect of an altered twist, but that's only an approximation. The airfoils are distorted by the control surface deflections, effective twist within each segment is still incorrect, and now you also have the drag created by the sheared airflow between the adjacent ends of each pair of control surfaces.

We have had some success with that last problem by using control surfaces with some torsional flexibility, then anchoring one end and driving the other. For example, on our "Spectre 120" ten-foot span open-class sailplane design, we used only two control surfaces on each side (one flap and one aileron per panel) instead of the three that were becoming fashionable at that time, but the outboard end of the aileron was anchored to the tip. The aileron was torsionally flexible, so that it twisted nearly linearly between the servo linkage at its inboard end and the anchored tip. Because it was effectively anchored at both ends, the overall torsional stiffness and flutter resistance was as good as a conventional arrangement anchored in deflection only by the control linkage. The deflection needed at the inboard end of the aileron to maintain an elliptical lift distribution over a wide range of airspeeds was a fairly close match to the deflection needed at the outboard end of the flap, so there was very little penalty from the gap. We were able to provide a more elliptical lift distribution over a wider range of airspeeds, with less parasite drag as well, using only a four-servo wing, without flutter problems, than the others were getting from a six-servo wing with torsionally rigid control surfaces.

Whether this or some similar approach might be a viable way to help solve the bell distribution's problems with off-design-point performance is a good question. However, finding a practical and effective solution is necessary if we want to fully realize the bell distribution's potential.

From Al:

Constraints don't necessarily push the optimal solution towards elliptical. Aero constraints push the solution towards elliptical, all other constraints push you towards bell. And bell results in the same weight spar (spar weight is correlated to load, and spanload).

I think that's where Prandtl was pushing us. Aero pulls one way, and everything else pulls us the other...

From Rich Nunn:

Dear Al and others: Perhaps a happy compromise could be reached between the two thought processes?

On another note, today I was considering a technique that could possibly be used to damp the yaw on a wing-type aircraft. As the rearward wing slices into the airstream, and accelerates to become the leading wing, a type of hot-wire sensor could be used to determine the increase/decrease in airflow, or airspeed of that particular wing. If this were coupled to a feedback device that would deploy a surface device to retard that wing yaw, equilibrium of some sort could be achieved. The dampening of the yaw would be constant, but would have to be much more sensitive than a human could detect. There would have to be two airspeed detection devices, one on each wing, to detect the acceleration rates of first one wing, then the other. Just a thought...Perhaps you know of a better way.

From Chris Bryant:

Hi Rich, just a thought …

Your idea for an air speed sensor on both wingtips might have to sense dynamic pressure rather than temperature. This assumes that the pressure effects of thermals would be less than the thermal changes, which might not be true!

I can remember a particularly clever gliding colleague who used wing tip sensors to detect a temperature gradient across the aircraft that told him where the centre of a thermal was. Long before GPS arrived he built himself a tiny CRT display for the top of his instrument panel that showed a plan view of the path of his Open Class glider and the predicted centre of the thermal. I think there was another sensor on the tail of the glider to give a two-dimensional plot and a computing box behind his head. He said the device only worked well when he flew the glider very smoothly and accurately and did not yaw around. It was designed for weak conditions but, of course, was not necessary if lift was strong. He flew with it a lot in weak conditions. I suspect that a rough day would have been its undoing. How would you separate out atmospheric gradients from those caused by the glider?

All this makes the birds look even smarter!!

From Rich Nunn:

Current automobiles use a device called a mass airflow sensor, which is usually a hot wire device. By knowing the resistance of a certain type of wire and how airspeed affects the resistance in the wire, the computer senses the change in air velocity flowing through the engine air intake. It then changes the fuel requirements accordingly to make the engine run faster or slower. If such a device were to be mounted on each wingtip and differential airspeeds noted by the computer, perhaps it could feed back to an airflow altering device to dampen the yaw. Just thinking…

I am under the impression that a swept wing in straight and level flight, yaws in it's flight path. This would be a reason for computer control in the current B-2 and was the death knell for the Northrop wings. If I remember correctly, Horten also had a problem with this on some of his wings. No extra fancy dials, just a possible, lightweight, automatic solution for this problem, without pilot intervention. Just a hypothesis.

From BILDAN:

I am not sure this actually works.

When I worked for Paul MacCready at MRI, we had a lot of thermal traverse data on paper charts. The charts had a line for vertical velocity, temperature and dew point among other data. There was a clear NEGATIVE correlation between temperature and vertical velocity but a less clear positive one with dew point. Whatever the reason, thermals were consistently COOLER than the surrounding air by about 1 degree C. The analog data were on paper charts so probably never got digitized for computer analysis.

The temperature anomaly was never completely explained but there was speculation rising air cooled along the adiabatic line while the ambient air did not and was therefore not quite as cool. Wingtip temperature sensors seem doomed to failure as thermal detectors.

After a lot of experimental data, it seems the one consistent characteristic of thermals as they are rising air. That's what we need to detect remotely.

From Jeremy Moore:

Think what Rich described is called a 'Mass Flow Sensor' and guess you are all driving around in a slightly more efficient and clean vehicle due to these things! (Part of the typical fuel injection system.)

I am not really an engine man but believe that it does, indeed, sense 'air mass'!

The cooling effect on the electrically heated wire should be influenced by a) flow rate b) density (therefore pressure) c) temperature of ambient air.

Perhaps this would be a shortfall as even with consistent flow and pressure heat loss is proportional to the fourth power of the temperature difference and therefore thermal gradient could upset it!

It seems that the group is mostly aero-modelers (some also aero professionals and accomplished pilots)
If this yaw stability needs attention, it should be reasonably easy to use the mass of some installed object (LiPoly cell for example) as a wing tip located pendulum that would activate drag flaps! The 'art' would be in eliminating the activation during acceleration and deceleration, I guess a central pendulum could 'lock out' the others! It would also be possible to compound the effects by having the two tip located pendulums coupled!

On a new issue, could Al (VSAERO/FliDyn) or anyone else offer any advice concerning a Nurflugel with a 5m length (regulated, IMO) 6m (limited only by 'user/social friendliness') span and MTOW of about 1550kg (plank or near zero sweep/Lippisch Inverse Delta, presently 3.5 degrees of anhedral)

My lifting area (plan area) is presently 28m2, with the trailing edge gently curved to minimize yaw moment during heavily pitch take off and landing by placing contact near root trailing edge!

I have evaluated several foils in 2D (JavaFoil/FoilSim/FlowWorks 20011) and four in a 3D (FlowWorks 2011) configuration as above.

At present my belief is that the large diameter ducted fan (high thrust line, pivoting at the 6 o'clock position) will adequately counter variations in craft CofL.

I may have but believe I do not need a 3 axis control system, as cross wind landings etc. are not relevant: (sheltered water landing take of and modest low wave height operation!)

With Re=6M-12M, the foil I am focused on has a Cl=1.8-2.0 Cd=0.0177-0.0171 Cm=-0.141 (standard 25%C Moment Reference Center)

I achieve MTOW take-off (according to FlowWorks!) at about 94km/h and this should be readily achievable with 122kW (165hp) at 2.35m diameter!

At present I do not have any twist and FlowWorks (me??) are slow when it comes to analyzing for different angles of attack and getting yaw torques!

I am hoping the 'slabby' thick sides of the (very) low aspect ratio wing and the 2.35m diameter x 0.5 long duct will be enough to ensure yaw stability!

Any advice welcome! Particular areas I am concerned about are:

* foil optimization for high lift at Re of 6M-12M
* foil/prop design for counter rotation within a duct (Javaprop does not cover cr! Back to Flowworks!)
* foil/duct profile optimization
* yaw stability
* pitch stability (believed OK under power and engine out)

From Al:

Several people have e-mailed me off-line and we're having conversations about bits of Prandtl, Horten, elliptical and bell span loads. And after having talked this out, a few additional thoughts are in order (Don Stackhouse, Rich Nunn, Phillip and Koen all make my head hurt!).

1/ Prandtl bell spanload is NOT the same thing as Horten bell spanload. Horten adds a few things. So while Horten fits into Prandtl, Prandtl is a much LARGER set than Horten. I was challenged on this and I must agree, Horten is a smaller subset of Prandtl bell spanload.

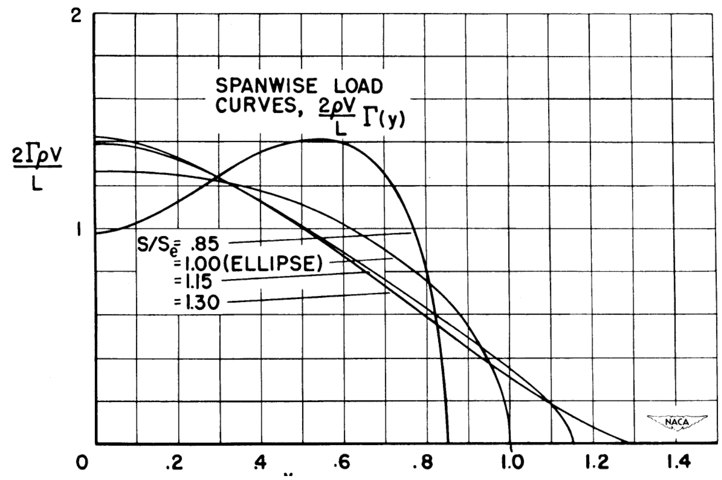
2/ You can do bell without sweep, taper, or twist. It can be done with planform alone (in fact, RT Jones always thought of it this way). In this case, you still reap the benefits of superior aero performance AND minimum weight structure. But I don't think you don't achieve the proverse yawing moment and coordinated control during maneuvering flight. It still works in straight flight and in constant turning flight, but not in the maneuvering transitions. Hmmmm, a Marske plank with bell spanload (high performance AN minimum weight)...

So decomposing this a little more:

3/ Bell with sweep, little or no taper, and twist (LOTS of twist): this works, but doesn't reduce the structure as much as a strong tapered wing. But this still has the strong directional stability that appears to be due to the twist affecting the amount of induced thrust of the wingtip.

4/ Bell with planform, but no twist or sweep. Benefits for performance and structure. But I suspect the area of induced thrust at the tips doesn't change with sideslip. It would be interesting to see a model built like this and see how strongly the dutch roll is damped.

Jones Spanload



- *Minimize induced drag (1950) Constrain wing root bending moment 30% increase in span with 17% decrease in induced drag.*

- *"Hence, for a minimum induced drag with a given total lift and a given bending moment the downwash must show a linear variation along the span." y = bx + c!*

5/ Bell with planform and sweep, but no twist. This one would be interesting, but I suspect it would be quite dangerous. Without the twist, the potential for tip stall would be very prominent. I suspect it too would have a problem with dutch roll.

6/ Bell with taper, twist, and sweep = Horten. I think this one is analogous to birds. But I could be convinced one of the other solutions is also analogous to bird flight...

I think...

From Rich Nunn:

Al: Just wondering if you have seen the U-Tube video about "Robotic Bird" that was presented at a TED conference in Edinburgh, Scotland. Apparently the Germans built a robotic seagull with about a 2-meter span, out of carbon fiber, is electric, and has a two piece wing with LOTS of twist in the outer panel. Watch it, if you haven't seen it before. It's neat!--Thinking of you and your bird comments.

Here are some links for viewing:

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

http://www.youtube.com/watch?v=nnR8fDW3Ilo

http://www.youtube.com/watch?v=kA7PNQiHT1Q

From Al:

A few clarifications. And I promise to keep the American slang to a minimum in an attempt to reduce misunderstandings through the use of the American English language (which has enough troubles of its own, as evidenced by the differences in the way translations are done either word for word or by meaning/paraphrase). Let's be VERY precise here.

1/ From my talk: we all make assumptions. These assumptions create barriers and walls to our point of view, understanding, and ultimately our reaction to perceptions of the world.

2/ That flight was achieved in a very mechanical way has affected us all (apologies for the slang but this is very true: "we've always done it this way!"). This is the CUSTOMARY way we view the problem, so the solution is this...

3/ The solution is by Prandtl, in BOTH cases. Prandtl was in the extreme incredibly brilliant. He created the Lifting Line (and I do not refer to this as a "theory" as it has strong evidence in formulation as FACT), the elliptical spanload, and the bell spanload.

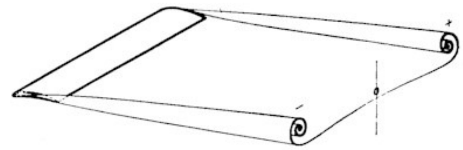
Look at that again. Prandtl formulated both elliptical AND bell span loads. Why did he abandon elliptical for bell? Because elliptical is the MINIMUM induced drag for a wing. This is a fact that CANNOT be disputed! The mathematics is precise on this point! Why did Prandtl change?

This is the point on which it took me 11 years to realize. Note: I had ALL the data for both, Prandtl had to reformulate the problem (it took Prandtl 14 years ;-). The problem lies within the definition of the word "WING."

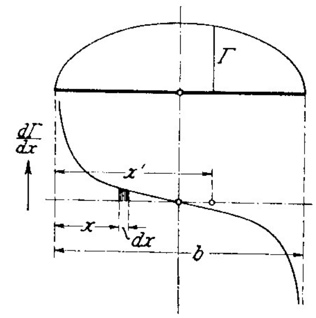
The elliptical definition of the word "wing" is only aerodynamic. With NO regard for any realistic structure. It is pure aerodynamic formulation.

The bell definition of the word "wing" is aerodynamic and also INCLUDES the structure. With bell spanload we are attempting to find the minimum drag with the same amount of structure as the elliptic spanload (and the same lift). This is why the two solutions are the "same.

Prandtl Lifting Line Theory



- *Prandtl's "vortex ribbons"*



- *Elliptical spanload for a given span (1920)*
- *"the downwash produced by the longitudinal vortices must be uniform at all points on the aerofoils in order that there may be a minimum of drag for a given total lift." y = c!*

But the ULTIMATE test is in nature. If the solution doesn't work, the animal will go extinct. The albatross (which I chose intentionally as the greatest soaring bird) would go extinct if it were out-competed by another bird. So what spanload do birds use?

Feathers are soft at the tips. This means the bird spanload must taper to zero at the tips.

Birds show no adverse yaw. Elliptical gives adverse yaw, but bell has proverse yaw because of induced thrust at the wingtips. [This solution was due to Horten developing the bell.]

Birds have no undamped dutch roll. Elliptical has undamped dutch roll. But bell (with twist) has strong damping of dutch roll. [This solution was due to Horten developing the bell, but nowhere can I find his taking credit for this. This may be a recent realization.]

So what are we to conclude?

Was Prandtl right?

YES!!! But which time, elliptical or bell?

What is a "WING"? Is it just an aerodynamic math theory? Or is it a real physical structure to carry aerodynamic load?