No. 326 AUGUST 2013

# T.W.I.T.T. NEWSLETTER

The EFW N-20 Aiguillon (English: Stinger) was Switzerland's first indigenous jet fighter aircraft.
Source: http://upload.wikimedia.org/wikipedia/commons/thumb/0/04/N-20.10_Aiguillon_frontal_view.jpg/300px-N-20.10_Aiguillon_frontal_view.jpg

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

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# 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.

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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

The letter exchange between John Gibson and Bob Michener has reached a lull after a lot of activity. I was hoping we would get some others involved to spice things up, but so far there hasn't been any other participants. It is not too late to join in if you have some thoughts on the subjects.

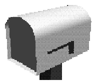
The discussion did produce a link to a 2004 flight test program done on the Pioneer IID by Dave Welles. I have included a shortened version of the report in this issue since the full report wouldn't have left any room for the exciting stuff coming from Al Bowers through the Nurflugel chat group. I have included a link to the full Pioneer tests report so you read the entire thing.

Don't forget the Experimental Soaring Association Western Workshop is coming up over the Labor Day Weekend at Mountain Valley glider port in Tehachapi, CA. Al Bowers has brought together a great list of speakers and topics with the theme revolving around 13.5 meter designs of the past and present. This time of year there is also some very good flying in the local area and up along the Sierra mountain range, so bring your sailplane and enjoy both the programs and the flying.

I am nearing completion on my 1-26 restoration project so there really is a light at the end of the tunnel. Now I just have to keep pushing all aspects of the project and really get it done.

Have a great rest of the summer.

Andy



## LETTERS TO THE EDITOR

*(ed. – The two letters below sort of finish up the discussion between John Gibson and Bob Michener on reflex airfoils and the to some degree how it relates to the Marske Pioneer series sailplanes. I have also included a portion of the Pioneer 2D flight test report done by Dave Welles.)*

Bob,

Your interest in what other aerodynamicists might have to say about reflex aerofoils is easily answered from impeccable sources.

B Melvill Jones, a leading UK scientist, shows that the profile of an aerofoil has no influence on stability, since all have essentially the same lift slope which does (in Durand's multi-volume series on Aerodynamics, ca 1935 - I can't be more precise).

K Wood, Professor of Aeronautical Engineering, Purdue University, shows that an aerofoil requires only that the CG is in the front quarter to be stable and needs a reflex to be balanced (in Technical Aerodynamics, 1935, McGraw-Hill Book Co. Inc.

Robert T Jones, Senior Staff Scientist, NACA-NASA-Ames, shows that for stability of a wing alone the CG must be ahead of the lift centre (1) at the quarter chord when there is no tail, and that to be trimmed for steady flight the centre of pressure (not the same as (1)) must be there too and which is supplied by a reflex (in Comparative Longitudinal Stability of Ultralight Tailless Gliders, Soaring, January 1978).

John Gibson

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Andy Kecskes, Editor

Thanks for the opportunity to respond to John Gibson's remark that "Reflex aerofoil sections...do not influence stability...." I applaud his effort to Google on the web sites associated with Marske or "continuo..."; there is a fantastic array of info in them including a rich history of Fauvel, etc. I suggest that he pore through http://www.continuo.com/marske/ for what he is looking for. When I get time, I will do it myself. [In case readers think I am trying to avoid comment on his remarks,: I have just turned 82, and have a dearth of mental energy to ration on my many current projects, not to speak of the "chore" of retrieving memories completely and/or accurately.]

Some aerodynamicists who have worked with Jim Marske on computerized reflex airfoils are Dave Lednicer or John Roncz with Mark Mangelsdorff, who may have published results with stability implications. As I mentioned previously, Bruce Carmichael of TWITT fame published in SOARING the empirical article on the unexpected "sweet spot" in the AV-36 polar. *(Marske comment: Bruce discovered a kink in the performance curve at high speed providing an unexpected decrease in drag. In the July-August 1953 issue of Soaring Bruce describes this phenomenon quite well and accurately. It is an article well worth reading.)* Also, Dan Somers who has published with Eppler on low Reynolds Number airfoils may have touched on reflexed.

Not being an EN of any type---only a 'soft (social ) scientist' I can communicate only my personal experience with my P-2 over 20 years of test-trial flying and 2 semi-rebuilds *(1)*, and what I have seen of Mat Redsell's and Dave Welles' test flights documented by DVD, and instrumented flight tests of both performance and stability. *(ed. – See the detailed report from Dave Welles starting on page 5 below.)*

*(1)* My experience: in my feckless youth when I unknowingly bled off airspeed on cross-wind landing leg, and found my P-2 gently contacting the cornfield in a near vertical descent with the ship horizontal at all times-damage restricted to complete destruction of fiberglass fuselage and canopy with no pilot injury, wings continued flying for many years.

In order to objectively document our subjective performances, I over the years unsuccessfully offered PIONEER 2s to various SOARING performance testing programs: Paul Bikle begged off that he no longer did it on account of age (though he told Jim that the PIONEER was "the Cadillac of the "flying wings" after chasing it around the Mojave Desert), and Dick Johnson *(2)* stated he did not evaluate Homebuilts. I also offered the P-2 to SSA as an entry to the international Sports Class fly-off selection but was summarily turned down.

*(2)* Dick Johnson once published some performance polars ostensibly refuting Jim Marske's claims that waxing wings improved performance. I re-sorted Johnson's data, and demonstrated that in the "-8 deg. Flap" (i.e. reflexed airfoil) condition, the Johnson data did indeed confirm improved performance with waxing. In a flying wing seminar in the late '70s, organized by Mat, Dick seemed to look at me curiously when introduced but said nothing nor commented in print. (So much for social science research methods in the 'hard' sciences?)

So I suggest that the problem is with the "hard science" tradition of Empiricism itself, wherein hard data has had to be consensually measurable in some way. After a couple of millenniums, it is easy to argue to ourselves that "all that needs to be known, is known; and all that is left to science is to 'fill in the blanks' in the tables *(NOTE A)*.

*NOTE A*. Fortunately, this Empiricism had to make way for Karl Popper and a few others to honor systematic speculation about "imaginary" data (which could only be " seen" as statistical artifacts) was called Construct Validity and helped the early particle physicists validate their speculations, modeling methods, and results. So now we have the Bose particle that Empirical scientists seem to prefer to call "the God particle" (to enshrine it in metaphysical concepts instead of validating any alternative to "hard science"?). Other "soft science" areas that have had respectability conferred on them have been Quantitative Psychology through multivariate statistics, and the traditional "black box" phenomena, i.e. the human brain, which Gestalt researchers have theorized about validly for a century before computers and radionuclides existed. Also, speculation about physiological medical models as Acupuncture could be unique applications of Construct Validity.

**WHAT THEN?** A qualified, inquisitive Aerodynamicist---should be 'empirical' to be "safe"---could get access to Matt Redsell's PIONEER 2 which by an act of Fate is being offered for sale in the May issue of SAILPLANE BUILDER. p.3-4; rare in the history of flight has so much been offered for so little (10 G's). When the performance-stability has been confirmed---not IF---then I suggest heavily instrumenting the P-2 and loading the empirical data into a real-time computer program for evaluating specific variables that Marske designed in like forward angle of L.E (which certainly affects/ improves span-wise flow), dihedral angle, tapered wing plan, C.G. Wheel location, "wetted area", etc. And it would be the ultimate practical test and classic contribution to Flying Wing technology: Right down TWITT's alley.....No?

**WHAT NOW?** The ESA could then in good science (not just 'good conscience') 'raise the bar' for all other homebuilt designs for pilot safety and enjoyment, not to mention 50+% improved performance for simplified Homebuilt designs. NOTE: Not all reflexed airfoil gliders are automatically safe designs: the AV-36 in spite of its' thousands hours of safe performance is still noted for its potentially disastrous landing behavior, even ending up inverted trapping the pilot as Ann Welch's inquiry commission found, and the only American Fauvel experienced. (Marske's C.G. Wheel was a brilliant solution, supplemented by my in-flight C.G. sliding weight tube for further research.) Also, a group of 4 Canadian-built AV-36s were scrapped when the first two came apart in the air with fatal results, due to quick glue deterioration.

**TODAY**; Jim is now doing test flying of the PIONEER 3 at the Marion (Ohio) county airport, weather permitting, and I would presume any observers are welcome. Jim is not allowing anyone to fly the Pioneer 3 till he has finished tuning it. However, so far only two other pilots have flown it. He is also marketing plans and furnishing several kit levels for P-3 flyer/builders who want a "hot" competitive 15m soarer. His older P-2 plans are still being sold (no fuselages though *(3)*, and are still a bargain just to see his radical rib assembly from tin-snipping out of fiberglass sheets, etc.

*(3)* Though a few second hand ones can probably be located, including mine (TT=<200hrs).

Bob Michener, Laramie, WY.
(www.rbmichener@gmail.com)

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## FLIGHT REPORT

by Dave Welles *(Provided by Mat Redsell)*
Marske Pioneer 2D @ Marion OH, on 6/22/04

*(ed. – The test program below is only a part of the entire text available at the link below. I have removed some of the details for the various tests to conserve space in the newsletter for other things, but still be able to give those members who don't use the Internet the ability to read the core information.)*

http://www.continuo.com/marske/ARTICLES/Flight Testing/Dave Welles June 2004 Pioneer IId.htm

**CHANGES**

Since I last flew this aircraft (See 9/28/03 Report) a number of changes and improvements have been made:

1. The main wheel has been replaced with a larger diameter wheel (with a drum brake) to improve rough field operations capability. The nose skid was replaced with a nose wheel. Both wheels are faired to the fuselage with fairing skirts. Appearance-wise this gives the aircraft forward fuselage a 'PW-5 look'.

2. A 'moveable weight' trim system has been added that is controlled by a small crank / cable drum arrangement located on the L/H side of the cockpit below the spoiler handle. This mechanism has a cover that is slotted to accommodate the trim position indicator. A very tidy, functional arrangement.

3. The old 'removable' canopy has been replaced with a 'forward hinging' version. It contains an emergency release that is activated by a 'T'-handle located on top of the glare shield.

4. The fillet between the wing and fuselage was reshaped to correct an apparent wing root (airflow) separation problem. Additionally, a fence was installed at the inboard end of the 'elevator' for the same reason.

5. Mylar seals were added to the wing / aileron gap, top surface.

The aircraft empty weight is now 432 lbs.

**TEST OBJECTIVES**

In the two days available the consensus was to come up with a plan to improve the handling qualities (read improve roll rates and turning ability). This puts the focus on the lateral – directional qualities of this aircraft, as the longitudinal stability / controllability is really quite good.

Modified Pioneer used in testing.

The tests and objectives are as follows:

a. Determine if the aileron differential is optimum. The original design called for a 3:1 ratio (30$^o$ up / 10$^o$ down, I think, at maximum stick deflection); this had been changed to 3:2 (approx.) to improve roll authority and fix a perceived 'proverse yaw' problem. The plan was to fly the current set-up then put the aileron rigging back to 'standard' and re-fly the tests (Roll rates and Dutch roll characteristics)

b. Evaluate the turning qualities by looking at the 'Spiral Stability'. This was to be measured by placing the aircraft in a coordinated turn (30 o degrees to be documented) than releasing the controls (stick and rudder) and timing the interval until the bank had reached either 50oor 10 o; or, record the bank angle after 30 seconds.

c. Evaluate differential spoilers for roll control. This was to be done by disconnecting a spoiler and quantifying what the roll (and yaw) responses are with single spoiler operation.

d. Conduct a 'tuft study' with both wings tufted; and for air-to-air videoing, the wing root, aft fuselage, and rudder.

**TEST INSTRUMENTATION AND SET-UP**

**WEIGHT & BAL:** 5 lbs. fixed ballast was added at the rear anchor point of the 'moveable weight trim system' (Sta. not available) to yield a (almost) 10 inch balance dimension (Marske system) with the trim weight cranked fully aft. The flying weight was 620 pounds. Because of decreased cockpit space (the larger main wheel and the tube for the trim system (sliding weight) along the bottom of the aircraft) I no longer fit with a

parachute. Because of the ‘low risk’ nature of the proposed testing the decision was made to fly W/O a chute.
Reference marks were made on the lower edge of the instrument panel to indicate aileron stick positions of ‘neutral’, ½, and full stick throws (left and right).

For bank angle(s) marks were added to the canopy sides that, when aligned with the yaw string tape (parallel with the horizon), yielded a 30 degree bank (left or right).

The tuft pattern, applied to the wings, was spaced at (about) 2.5 feet apart along the 60% chord with another line of tufts (mid spaced with the above pattern) at the 90% chord line. For the ‘air-to-air’ flight, additional tufts were added to the wing root (in the area that was unobservable from the cockpit) continuing the described pattern inboard and including the fuselage, and fin and rudder (right side only).

Marks were made (using a protractor) to indicate yaw string positions of neutral, and 15 degrees left and right.

Dave Welles in the cockpit prior to a test flight.

**RESULTS**

The first flight was made on 6/22/04 from a 3000’ AGL tow in moderate soaring conditions. The first half of the flight was in air too turbulent to get much meaningful data. Eventually things smoothed out with thermals still good until well after 7:00 PM.

The first impressions / comparisons with the September 03 flight were that at slow / minimum airspeeds the wing behaved differently. Its propensity to slice (yaw) to the left, or if turning, in the direction of turn, were largely gone. The tuft pattern on the wing showed no separation inboard as was previously observed; but the R/H wingtip was separating (stalling) before the left. (Later measurements showed the L/H tip as having about 1.9 degrees of incident less than the R/H side)

The moveable trim system worked very well. The minimum trimable airspeed was an indicated 40 - 42 mph (trim weight full aft) and, with the weight forward, the trim speed was 65 IAS. The T/O and landing were made with the trim in a ¾ aft position. On tow the weight was moved to approximately the middle, to trim out the forces and ‘zero’ the elevator position. (Zero = the trailing edges of the wing and elevator are ‘even’.)

The minimum flight speeds / stall: with the weight aft was 32 IAS, and weight forward, about 1.5 MPH greater. With the trim weight fully aft (worst case) the static longitudinal stability was positive over the speed range of ‘minimum’ to 80 MPH IAS.

**RECOMMENDATIONS**

**SAFETY-OF-FLIGHT**– The following (first three items) should be addressed ASAP:

1. Replace the “VNE=130 MPH” Placard with an airspeed indicator ‘red-line’ (piece of red tape) appropriate to the ‘operational’ never exceed IAS.

2. Modify the spoiler system to allow safe opening / closing (with controllable pitch changes) close to the ground. Maybe reinstalling a ‘smaller’ lower spoiler door (or adding big holes to the ‘original’ lower door) is the easiest way to go.

3. Change the Aileron leading edge / wiper seal from an open “C” section to a closed “O” or “D” section to preclude the previously described ‘jamming’ problem. (See 9/28/03 Report). And / or add aileron stops (wing) to insure that no ‘over-travel’ / jamming can occur.

**IMPROVEMENTS** (General)

1. Replace the nose wheel with a semi-retractable nose skid that would give the higher (nose up) attitude desirable for the take-off; and for landing, be in the retracted position to allow for greater ground clearance to minimize premature nose / ground contact.

2. Add an ‘UP-Aileron only’ segment to the wing tip section. To be ‘lifted’ (driven) by the UP motion of the existing aileron. Depending on results, an

inboard portion of the existing aileron(s) could be removed to lighten aileron forces. These segments could also serve as tabs to trim out, or minimize, the effects of the warped L/H wing.

3. Redesign the aileron bell cranks (in the wings) to optimize them for the (existing) 3/2 differential, and, in rigging, 'even up' the aileron travels. The redesign should include a "rig-pinning" feature and, "aileron stops".

4. Recommended testing: To measure the Pioneer against other sailplanes, ridge running would be an efficient, fun way to go. The sailplane should be cleared to airspeeds of, at least, 120 MPH IAS* first (with mass balanced ailerons). The test comparison is to go with other sailplanes (one at a time) at a series of speeds, with the sailplane with more performance flying higher (in weaker lift) as required to maintain equal speeds. This altitude delta becomes a measure of the performance difference between the sailplanes, at that speed. The other measure would be for each sailplane to carry a recording 'g' meter and compare the max. reading / run for each sailplane. The ability of the Pioneer to 'unload' the vertical gusts quicker (because of the much lower mass moment of inertia / pitch axis) the smoothness of the ride, as measured by the max. 'g' recorded, should be equivalent to sailplanes with much higher wing loadings. Here again, maintaining the same speed / run is critical for comparison purposes. *At Harris Hill, in good ridge lift, a 2-33 can maintain 80 MPH.

**CONCLUSIONS** (Not set in concrete)

The Pioneer is a much-improved sailplane from what I flew a year ago - except in two areas- the nose wheel (replace W/ a skid) and, poorer fit (for my 6'-3" frame). The hinged canopy and the trim system, from an operational standpoint, are welcome additions.

We probably won't ever know just how big an improvement the new wing root fillet is, but based on the observed tuft patterns and changes in handling qualities (from last year), I think its contribution is large.

I think an improvement in roll-rate / maneuvering capability can be easily accomplished by a rework of the aileron system. I would wait until after modifying and mass balancing the ailerons to fine-tune aileron travels and differentials. I don't think the 'anti-servo tab', installed on the outboard end of the aileron (ala. Monarch) is as good a direction to go, compared to the additional (recommended) 'tip' aileron segment; for the following reasons:

1. Harder to mass balance and may (possibly) contribute to aileron flutter.

2. Does nothing to keep the airflow attached, on the wing tip segment, during rolling. The 'tip' aileron segment, deflected UP, would. (See 'Roll Rates' for problem description)

3. May create a 'proverse yaw' prone aileron system – Of the two I will take the 'adverse yaw' first. (Either system will require some tuning – less so I think for the 'tip aileron' concept.)

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### Nurflugel Bulletin Board Threads

So I've been debating how to tell all of you something pretty important. This is a pretty big deal, and we can talk amongst ourselves, but outside our group I'd like to keep the info a little limited just yet.

So all of you know I'm a Reimar Horten fan. I've expounded on how his solution was ideal in solving multiple problems optimally at the same time. If you want the optimal airframe structure for a given payload, AND the minimum drag, AND the correct flight mechanics response to turns ALL without a tail, then the Horten solution is the optimum. And that's not just opinion, that's the analytical answer from no less than Ludwig Prandtl (if anyone can top that I'd LOVE to see it). And given Prandtl's solution, and given the subsequent work by Horten and R T Jones to support it, it had to be the correct answer for the flight of birds as well.

The problem is, for the last 20+ years, I've said that despite ALL the analysis, there was NOT ONE SECOND of flight data to PROVE that any of it was correct.

That all changed yesterday. On Thursday, a small group of NASA interns and an even smaller group of NASA engineers flew a small RC controlled UAV at Edwards AFB. On Thu we got about 6 minutes of data. And today we got about 10 more minutes of data off the little wing. It's an all flying wing, there are NO surfaces to control yaw, none, zip, nada. No verticals, no drag rudders, nothing. It's a flat flying wing with only two elevons.

It's a glider, about 12 ft span, weighing about 12 lbs. at present we're only using a rudimentary system that only records 3 accelerations and 3 rate gyros. The important parameters are the rate gyros. If Prandtl/Horten/Jones are right, then the two parameters of most interest are the roll rate (labeled "p") and the yaw rate (labeled "r"). Right roll is defined as positive, and yaw to the right is defined as positive.

For those who have a physics or engineering background, I know you're thinking about the right hand rule. Positive x is forward, positive y is out the right wing, and positive z is DOWN (I know, it sounds weird, but to make the right hand rule work, you have to do it this way). So the accelerations around those 3 axes are ax, ay, and az. And the rates around each of them are p, q, and r. And the moments around those three are Cl, Cm, and Cn. And the angles are phi, theta and psi. And it all works out with the right hand rule.

The glider is called "PRANDTL-D" and it stands for Primary Research AerodyNamic Design To Low Drag, but its a Horten. It's got 36 flights on it now, with four different pilots, and 15 data flights.

If Prandtl/Horten/Jones are correct, a right roll command will result in a large right roll (positive roll) and a small right yaw (positive yaw). If the yaw is negative, it's adverse yaw, and the experiment is a failure. Positive roll must have positive yaw.

The first data flight (flight 27) we did two roll doublets and one pitch doublet. These are done roll, pitch, roll with a short time in between each to allow the natural response to damp and then retrim, and we call this an Integrated Test Block or ITB. We launch off a high start (about a 4G launch, peak speed about 80 mph and peak altitude about 160-180 ft) trim off the top of the zoom, make a right turn (downwind) execute the ITB, then extend out the downwind, make a right turn back upwind and land at the launch point to recycle.

The very first roll doublet showed moderate proverse yaw. We have about 25 yaw doublets and about 12 pitch doublets. Only under the most rigorous abuse can we get the proverse yaw to go away (but still no adverse yaw). The results and the data are still preliminary. But the data looks good. REALLY good.

We've tested two different data systems, one works well (motion pack only) and one which is junk (but it had a lot of other useful parameters, but wasn't reliable so it's useless). We're going to try another system next week, and add more parameters. We'd like to have angle of attack (alpha), angle of sideslip (beta), static pressure (altitude), total pressure ( for airspeed), and the control surface deflections. Those plus the motion pack will give us enough data to fully characterize the aerodynamic coefficients and validate (or repudiate) the analysis that's been done by Uden, Stadler, and some guy named Bowers (maybe that should have been Bauer?).

The interns are over the top, they work hard, they're motivated, and they believe in what we're doing. They're awesome. And they're making me run so hard, I'm too old to be doing this.

But we've got data. And it's proverse. The glider looks like a workhorse, not very pretty. But it's reliable like a rock. If only the data system will come through now...

It's exciting seeing the data. It reminds me of the Orville Wright quote to his brother Wilbur: "Isn't it amazing that after all these years, God has hidden all these secrets just for us to find!" The interns and I are thinking the same thing...

Al Bowers
<Albion.H.Bowers@nasa.gov>

Very exciting work Al!! I would love to see the shape of the elevons. Do they extend into the airflow below the wing to aid in yaw control, or is the proverse yaw doing all the work.

Mike

If you are familiar with the somewhat famous Edward Uden chart, it is elevon VI (6). So we have a balance at the tip that extends forward to reduce the hinge moment of the elevon.

And no, we do not run a Frise nose at all. It's not allowed. The proverse yaw is a result of the induced thrust at the wing tips only.

The reason I went looking for proverse yaw, it was the last thing that would happen on the wing. And proverse yaw would only happen if all the other characteristics were present: the bell shaped lift distribution, the induced thirst, the beneficial minimum structure loading of the span load, and the minimum induced drag aerodynamics. Proverse yaw would ONLY be present with plain elevons if all those other prerequisites existed.

I designed the experiment to produce the maximum stress to the concept and only if everything worked would we get proverse yaw. We have proverse yaw.

At the end of the day, I printed up a small banner with a picture of the wing flying, and the name of our technician/pilot, Red Jensen. The sign reads "Red's Lab: Home of Prandtl Wing & Proverse Yaw"

The students printed up about 30 of the data plot of the first maneuver, showing the proverse yaw. They all made me sign them and many of them are framed and hanging on cubicle walls around NASA...

Al

Very cool. I'm assuming then that the balance has little effect that can be easily calculated out.

Mike

There is nothing to calculate in or out. The balance is exposed in both up and down deflections. So it's net effect would be zero were it not for being present in the induced thrust part of the wing.

Uden's work was designed to show that control surface area in the induced thrust area of the wing was favorable to proverse yaw. And control surface area in the induced drag area of the wing would result in adverse yaw. In fact his analysis showed exactly this. If you do not have his chart showing this I would be happy to send it to you.

Our experimental data is following very closely the analysis that was done...

PS. Our launches are about 160-180 ft high (42-54 m). Our glides are about 3500 ft (~1 km). It seems our L/D is about 22:1 on our little glider, even with the test instrumentation taped on the outside and the test maneuvers.

Not bad. Analysis indicates max L/D for the little glider should be about 27:1 if it were completely clean (though I did create custom airfoils for it, so that might be a little low even at this lift coefficient)...

Al Bowers

I would love to have the chart, a Google search failed to produce it. I see the net effect being zero as long as no differential is used. I assume there is none on your model.

This is great research. I look forward to hearing much more as you go along. Thank you for sharing this with us.

Mike

Al, is proverse yaw present at all airspeeds in the envelope?

Bill Daniels

Bill,

GOOD QUESTION my friend!

The analysis says this design should lose the proverse yaw characteristic at high speeds (low lift coefficients). We have tested that, but haven't had time to analyze the data yet.

All this said, because we understand what creates the proverse/adverse yaw characteristic, we can design for perfectly coordinated turning flight in ALL conditions.

And I should also add, this can work for planks as well as aft swept wings. It will not work as nicely with forward swept wings.

Very perceptive question...

We have ZERO differential.

I have lots of people who wish to add winglets or differential to these designs. I try to remain patient (but will admit to losing my temper sometimes!) in answering...

Symmetric aileron deflections always. And NO vertical winglets.

Prandtl's 1932 spanload solution which I call the Prandtl/Horten/Jones solution already has winglets, but they are simply FLAT winglets. Prandtl/Horten/Jones use induced thrust at the wing tips exactly the same way that Whitcomb does...

Al

Thinking our loud...after a fashion.

If the inboard airfoil section were chosen very carefully to produce a slight nose down pitching moment at low Cl, the elevons would have to remain raised to compensate thus retaining proverse yaw at high speed.

Bill Daniels

Bingo. In fact you'd make the whole trailing edge a control surface for pitch, but only the tips would be used for control.

By doing this, you maintain the bell shaped lift distribution at a wide variation of lift coefficients. Perfect.

Again, very perceptive Bill...

Al

-----------------------------------------------------------------

I am from Poland. I'm looking for plans of Flying Wings named " HAI-3 " and " Only Wing II " and too other plans for Flying Wings (span: 2500-3000 mm). Maybe anyone have plans that are no longer needed and will want help me ???
If so please write to me off list.
My e-mail: mnazimek@op.onet.pl

Sincerely

Martin Nazimek

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Does anyone have any specifications or images of the low aspect ratio Martin Amphibious Air Car ? It presently static displayed at the Forney Museum near Denver. Available image shoes a left side view with what looks like folded up outboard wings. The cabin appears to be the interior of the wing like the Wm. Horton Wingless prototype. Please send or post any links or images.

Stephen Sawyer
<s-sawyer@sbcglobal.net>

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Rules of Thumb:

For those of you not on Facebook (if you are you can hit delete now):

The density of air drops about half for every 18,000 ft of altitude gain. So 18,000 ft is 1/2 sea level density, 36,000 ft is 1/4 sea level density.

A Reynolds number of 1,000,000 is about a 3 ft chord at 40 knots indicated at sea level. Reynolds number is proportional to airspeed and length. So a model with an 8 inch chord at 20 knots is about Re 100,000. And an airliner with an 18 ft chord at 120 knots is about 18 million. For a constant indicated airspeed, Reynolds number varies with the square root of density, so a 3 ft chord at 40 knots indicated at 36,000 ft is about 500,000 Re.

300 knots indicated is 300 PSF in dynamic pressure. So a sailplane indicating 60 knots is about 4 PSF qbar. Using this rule makes it easy to estimate lift coefficient, all you need is wing area and lift/weight.

When flying at maximum lift to drag ratio (max L/D) the profile drag and the induced drag are equal. Cdi is the CL^2/(pi AR). For the most part you can ignore "e". Unless you're building a Horten, then e = 0.8 for Hortens. Using the above rule for CL, ou can estimate Cdi, simply double it and you have a good estimate for total CD, and then you can estimate L/D.

#rulesofthumb
#sevretsoftheuniverse

Al

Thank you Al. Very succinct and easy to understand.

Where did you get this or did you derive the concept yourself?

Back in my late '50s, early '60s Miss State days, Gus Raspet had worked out a similar gross estimate, which he called his "Dart Board" equation, which he'd illustrate using a set of concentric circles of varying sizes to arrive at target/expected performance figures for L/D, min sink, and what he called his "penetration index" which was to be used to estimate cruising speed ... either light plane or sailplane.

He used the test studies done on the PJ-1 Tiny Mite, the Ross-Johnson RJ-5, his well used and abused Schweizer TG-3, a cleaned up and stall cuff modified Stearman PT-17, and the BLC Super Cub (unfortunately, the a/c he was killed flying) as his "sacred cow" proof of concept examples. Somewhere I have his process recorded, but he never had simple concepts, although he often had some elegant statements and expressions.

We'd have long discussions at the flight center, consuming lots of Royal Crown and Nehi sodas and fried and cornbread items from the little market down the road. He would defend his ideas like a tenacious tiger, but loved it when someone convinced him of a flaw or mistake.

Gad, I loved those days, and heady stuff for a teenager.

Cheers,

Bob Fannum

Bob,

I agree that the community lost a great asset when Raspet died.

The rules are all mine except the "300=300" rule, which is from my NASA mentor Alex Sim. He's not a name you'll find very many places, but a young engineer could not ask for a finer mentor. He knew Whitcomb, Jones, Karman, and a host of others on a first name basis. He is still my friend...

Al

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If I take the wing Center line as 90 deg, and the tip as One deg, and make a plot of Sin(90 deg)^3 to Sin(1 deg)^3 : If that is a plot of the lift generated along the span, that is a Very inefficient wing loading...

Is there an explanation understandable by an non aeronautical specialist?

Rodger

I was lead to believe that the Sin^3 distribution is more geared towards pitch stability than to outright performance.

Hans Zwakenberg

Yes. Sin^3 is almost as inefficient as elliptical. Both are inefficient use of spanload...

Al Bowers

It depends on your criteria.

If you are looking at it assuming a fixed wing span, then yes, it is far from elliptical, and for a given SPAN the elliptical distribution has the lowest induced drag. However, is that the best criterion?

As Al Bowers so beautifully explained here: <http://www.youtube.com/watch?v=223OmaQ9uLY&feature=youtu.be>http://www.youtube.com/watch?v=223OmaQ9uLY&feature=youtu.be

there are other ways to look at the problem. If we assume instead a constant wing root bending moment, that equates to a constant wing weight. Since the wing structure is typically one of the major items in overall aircraft weight, this is important.

Prandtl in 1914 first determined that the elliptical lift distribution has the lowest induced drag FOR A GIVEN SPAN. That's the answer in all the textbooks. However, he spent the next 18 years asking himself whether that was the right question. In 1932 he finally determined that for a given wing root bending moment ( and therefore a given wing weight) the SIN^3 lift distribution was better. By increasing span 22%, he could get the same wing root bending moment and wing weight, but an 11% decrease in induced drag.

In 1950, NACA's R.T.Jones, who was not aware of Prandtl's work, independently derived that same answer, although in his case he arrived at a 15% span increase.

What's happening is that those lightly loaded wing tips are acting like horizontal winglets, "surfing" on the upwash of the vortex generated by the inboard portions of the wing. This means that they produce induced thrust, just like a winglet does, and that reduces the overall induced drag. They are still producing positive lift that helps support the airplane, so there is no crossover velocity (unlike a winglet, which produces a net drag at higher airspeeds), but that lift is less than what the tip of an elliptical lift distribution would produce, so the wing root bending moment is reduced.

The Hortens found that when properly applied, a Bell-Shaped Lift Distribution ("BSLD") can also be used to eliminate adverse yaw, which then eliminates the need for a rudder in normal turning flight, for a further improvement (Prandtl and Jones were just looking at induced drag benefits, not the effects on control). The key seems to be to keep the ailerons limited to a little more than the portion of the tip that is producing induced thrust. The induced thrust causes proverse yaw, and running the aileron just enough into the induced drag portion of the span produces a zero net yaw.

I have a project in the works that uses a BSLD and no rudder, and it does indeed roll without adverse yaw when aileron is applied. I have found some interesting quirks in certain corners of the operating envelope (primarily at higher alphas and lift coefficients) that I am presently sorting out, but overall what I've seen seems to confirm the work of Prandtl, Jones and Horten. It does roll beautifully, with very crisp aileron response and no adverse yaw when the ailerons are deflected.

The BSLD does tend to involve a fair amount of taper in its implementation, although the reduced lift at the tips does seem to avoid most of the tip stall issues that could normally be expected with that much taper. However, it does mean some potential issues with low Reynolds numbers ("Re") at the tips, particularly with model aircraft applications. You'd better be fairly good at designing low-Re airfoils to take full advantage of the concept.

However, this is to some extent also a problem for elliptical lift distributions. Especially at model aircraft sizes and speeds, a perfectly elliptical planform will NOT have an elliptical lift distribution, due to Re effects on those narrow tips. It will also have issues with tip stalls. You can tweak a non-elliptical planform to have an elliptical lift distribution through washout and airfoil tailoring, but generally only at one operating point, the lift distribution will be non-elliptical at all other operating points. Thanks to Mr. Reynolds, model designers frequently face a number of challenges that make life more complicated than for full-scale aircraft designers.

Don Stackhouse
<djaerotech@windstream.net>

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## 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 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

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## FLYING WING SALES

**BLUEPRINTS** – Available for the Mitchell Wing Model U-2 Superwing Experimental motor glider and the B-10 Ultralight motor glider. These two aircraft were designed by Don Mitchell and are considered by many to be the finest flying wing airplanes available. The complete drawings, which include instructions, constructions photos and a flight manual cost $250 US delivery, $280 foreign delivery, postage paid.

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