No. 264 JUNE 2008

T.W.I.T.T. NEWSLETTER

The 2007 version of the XRay2 Underwater Flying Wing glider being tested by the Scripps Institution of Oceanography. This could have both military and civilian applications as surveillance and survey vehicle. This view gives it a distorted look, but that is the water refraction effect. This will be the subject of our July 19, 2008 program.

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., **0806** means this is your last issue unless renewed.

Next TWITT meeting: Saturday, July 19, 2008, with the time and location to be announced when it is determined.

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.

T.W.I.T.T. Officers:

President: Andy Kecskes (619) 589-1898
Treasurer:
Editor: Andy Kecskes
Archivist: Gavin Slater

The **T.W.I.T.T.** office is located at:
Hanger A-4, Gillespie Field, El Cajon, California.
Mailing address: P.O. Box 20430
El Cajon, CA 92021

(619) 447-0460 (Evenings – Pacific Time)
E-Mail: twitt@pobox.com
Internet: http://www.twitt.org
Members only section: ID – **twitt2008**
Password – **08member08**

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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

It is a real pleasure to announce a program for July and have a potential program for September. If Al Bowers has the time and desire perhaps we can also convince him to update his Horten presentation material and come down again later this year and do another presentation (see his comments starting on page 8).

I am excited about the July program and am hoping the Scott and his boss will be able to make the arrangements to actually go to the Scripps lab for the meeting. If it happens, I will provide all the driving instructions on how to get there and what will be needed to enter the facility. Fortunately, it sounds like it is not directly on the Naval base so that might make it easier to get the clearance. Stay tuned.

For those newer members (joined since 2002) you will be glad to know that I have now place the newsletters for 1997 to 2001 on the website. There will be more to come over the next couple of months with the eventual goal to have everything from issue #1 available to the members.

I am also glad to see we have picked up some new members including one from Spain. There always seems to be a lot of interest in the European area on flying wings, but the biggest project (PUL-10) still hasn't gotten going again to produce a viable production or kit for the enthusiasts.

That's it for this month. I hope you enjoy the newsletter and my thanks to Phil Barnes for allowing me to publish his ESA presentation.

Andy

JULY 19, 2008 PROGRAM

We have a very special program from July, especially if our speaker and his supervisor are able to get approval to have the meeting at their laboratory on Point Loma.

Scott Jenkins, Principal Engineer, Marine Physical Laboratory, Scripps Institution of Oceanography in San Diego will be making a presentation to the group about the XRay Flying Wing Underwater Glider program. The objective is to develop a fully autonomous, self controlled and self-adapting, underwater glider based on the flying wing design for persistent, novel, unattended passive sensing experiments in the ocean.

2006 Version of the Underwater Flying Wing

Successful, tests of the Flying Wing Underwater Glider could lead to a new generation of gliders that researchers expect to be the largest and fastest to date. They would be capable of traveling thousands of miles under ocean waves, quietly conducting surveillance and gathering data for military and civilian purposes.

The Flying Wing Underwater Glider's likely civilian applications include ocean science research, environmental study and fisheries monitoring. It could map currents or follow marine animals without disrupting their behavior, according to Scott who has spearheaded work on the glider's design.

LETTERS TO THE EDITOR

5/7/08

Greetings. As a new member, I would like to find out what I need to do to let you know my user name etc. I await your reply.

George Bottorf
<plunkettarcher@webtv.net>

(ed. – I wrote to George letting him know the standard user ID and password so he could access the members only section while he waited for the first hard copy newsletter. This is what he wrote back:

Thanks for the prompt reply. I have been "cruising" all sorts of links and am going CRAZY!!! And I thought I was the only crazy nut around. I have many questions that I will ask as time passes. And I have a few bits of stuff from the past that I will pass on.

Has anyone looked into the old model mags from the 40's on up? I have a few things around if I can find them. This gives me an excuse to get busy!

Thanks again. I will be back soon.)

5/22/08

New guy David here. Thanks for all your hard work on the newsletter, well done.

A couple of things, first my expiration date. Not sure, but looks like the month and year numbers have been transposed. Please take a look, and let me know.

Second, I'm considering building a U2, but would like to see one first before I succumb to the temptation. If anyone has one completed and flying that I could come look at and sit in, I'd be grateful. Hopefully the closer to Houston the better with the current fuel situation, but I can travel if necessary.

Andy thanks again for all the work you put into this so the rest of us can enjoy it. I plan to be ordering some of the literature, slide, and DVDs soon,

David Bogart
<dave.bogart@yahoo.com>
El Campo, TX

(ed. - Thanks for the compliment on the newsletter. The expiration date shows you expire in 2009 in May (0905) since I started your hardcopy issues with May. I assume you have looked at some of the on-line back

issues, but if you haven't make sure to take some time for it.

As for a U-2, I am not sure if one is in your area but the best way would be to subscribe to the Mitchell Wing group, put out a request and see what happens. If you don't find something close and decide not to monitor the group you can always just unsubscribe. This link should get you pointed in the right direction: http://groups.yahoo.com/group/U-2Wing/

Just so you know, I can do any of the items shown as a VHS tape as a DVD if that is a better medium for you.

I hope you continue to enjoy your membership.)

5/15/08

The Horten's bell shaped curve is often spoken of in layman's terms. Is it the negative wash out at the trailing edge? Is it a constant mathematical calculating of each rib? Can one just get a main chord and a tip chord and just draw lines from one to the other? I build radio control gliders. I love the Horten's center tail section. Is there a simple way to explain the bell shaped curve? (No phone, no computer.)

Eugene F. Turner
847 East Main Street
San Jacinto, CA 92583

(ed. – I sent Eugene's question to Al Bowers since he is the Horten expert. Al wrote back with the following:

I've attached a PDF of Mike Allen's former web page. He explains how to build the right curve for a Klingberg Wing (above) with a Horten twist. It's not a straight line, and it's not a constant twist. Mike built the "fixture" as described out of foam core poster board. Then as he built the wing, he pinned the main spar to the fixture, and the trailing edge was pinned to the building board straight (really you want the elevon hinge line to be straight, but this was close enough). The airplane flew very well.

Al

I sent a printout of Al's explanation and Mike's article to Eugene, but if anyone has more information that you think might help him, please forward it to his mailing address.

If anyone would like a copy of Mike's article, please let me know and I will attach it to an e-mail for you.)

5/26/08

This is fascinating stuff (underwater flying wing). I have been sort of following this effort for a while, and am intrigued by the potential application to hot air balloons. If they can make envelopes that look like wine bottles, trucks and Mickey Mouse, they should be able to make one in the shape of a blended wing body, and do the same thing in the atmosphere!

Please keep me posted on any changes to the meeting.

Bob Hoey
<bobh@antelecom.net>

(ed. – Before reading a little more about the uses for an underwater flying wing my first thought was using them for moving large quantities of material across the oceans underwater in the massive center section of a BWB. It would avoid the surface storms and perhaps be more efficient at the L/Ds they are getting. Don't know what kind of power system would be necessary. I also ran across a website that was talking about underwater dynamic soaring that look like just the inverse of the diagrams seen for regular dynamic soaring. You are right, fascinating stuff.)

6/1/08

Hope all is well! The July 19 meeting looks interesting!

If you have any openings in your speakers schedule, I'd love to come down and talk to the group about my latest flying wing development. I have completed another season of SAE aero design and we had success with another flying wing. We got 2nd place in the micro class in SAE East using a blended wing body model with a 5' wingspan. It had a 'belly flap' installed under the wing which was integral to the design, allowing the aircraft to rotate at takeoff. I can bring the fully functioning competition model for display if you're interested.

Here's a link to an article on our achievement:

http://karl.papubs.csulb.edu/news-events/story.cfm?hackid=955

Thanks and hope to hear from you soon!

Dan Dougherty

(ed. – I wrote back to Dan about perhaps doing the September meeting, but haven't heard back yet. Mark you calendar for September 20, 2008 as another good program on a flying wing.

Unfortunately, the website article didn't include a picture of their wing for this year.)

(ed. – Both Norm Masters and Walter Scott have sent in messages concerning developments from the Atlantica group at Wingco. Most of the material is associated with some other projects that the company is pursuing in order to stay in business, but some of the research data apparently will transfer over to the Atlantica. I have included some of the material in the message traffic from Wingco and some of the links. The power systems being used are probably of the most interest.)

4/26/08

From: "Alan Shaw" <AlanShaw@cfl.rr.com>
To: <Atlantica@list.wingco.com>
Subject: 35% Atlantica

Friends,

Flight video is on U Tube under Wolf UAV. The span is close to 14'. Until further testing is done I will put the
endurance at 6 hours. with modest telemetry, RF and optical surveillance packages on board.

Testing of the 1/6th scale Atlantica RC model has be limited. We would prefer to work with a 35% scale model using the same power system as the Wolf. This $2,000, 5KW power system was not available when we built the smaller models. The Wolf project is providing great experience in construction, equipping and operating large RC airframes. It was good to start a new scale with a more conventional design. Now we are ready to move on and build the large scale Atlantica RC. This will provide valuable data on the new wing design that is needed before moving back to full scale OPS.

I got some news about Atlantica today. Here's the video that Mr Shaw mentions:

http://www.youtube.com/watch?v=JstlinSrz5I

We recently built with FIT students (www.fit.edu) a 12 foot wingspan UAV, with a 7 hp elec. motor and 3 pound "a123" nano Li-ion battery. Flies 1 hr with 30 # payload or 12 hr if battery is increased , with a 5 # payload.

5/1/08

From: Alan Shaw
Subject: Lighter is Better

Friends,

The Eclipse and D-Jet single fans are a step in the right direction but they are still too heavy and complicated.

The last few weeks I have been on the drawing board with a four seat single fan similar to the UAV we built and another that is an Atlantica derivative. Both are roomier than the original Atlantica and with a lot more baggage space. By simplifying with streamlined fixed gear and only 4.2 psi pressurization (FL25) we can keep the dry weight down to 1800 lbs. This means we can use the PWC 610 instead of the larger hungrier PWC 615. The fixed gear is little drag above 10,000'. Our big drag factor is the long thin 14 to 1 aspect ratio wing that is needed for take off, landing, climb, payload and altitude performance with the modest 900 lbs of thrust. We won't need as much fuel or structural weight with the smaller turbine and lighter airframe. Weight and costs savings are made with my unique co-molding of structures. The mostly wet wing has a geodetic structure. Less is more. We can out perform in range and payload plus the lightweight is key to good speed too. We should be able to carry 500 lbs payload with 1000 lbs of fuel a long way or 1000 lbs. payload and 500 lbs. of fuel for shorter trips.

Our initial and operating cost should be similar to a turbo charged piston Cirrus….but without piston maintenance.

The fixed gear and FL25 limitation will keep the development, certification, *insurance* and pilot requirements down.

Although it is intended as a turn key airplane the business model does not exclude a kit plane version as a developmental stepping stone.

Always good to hear from you Anthony.

Alan Shaw

From: Anthony Liberatore
Subject: Eclipse Aviation Introduces Eclipse 400 Single-Engine Jet (and other things...)

Go here:

http://www.eclipseaviation.com/index.php?option=com_newsroom&task=viewpr&id=1378&Itemid=52

Alan, your instincts have been correct IMHO.

Tangent to this, did anyone see the article in Air and Space Mag a couple of months ago? The gent from Arizona I believe with a concept of a small Turbofan that would have very good fuel specifics?

Did anyone catch this week Boeing kind of halting the 737 follow-on for re-evaluation?

http://www.aero-news.net/index.cfm?ContentBlockID=525aa36c-1d31-41ec-b4d8-c5603cd6ba70&Dynamic=1&Range=NOW&FromDate=05%2F26%2F2008&ToDate=05%2F31%2F2008&Category=%2Findex.cfm

To Quote "Aero-News" and Boeing from the article: The manufacturer announced Thursday the study team has been absorbed into the broader product-development unit and has shifted focus away from the goal of specific airplane designs after the manufacturer decided the effort to replace the 737 was premature. "We've reduced our airplane-design effort and are focusing more on the technology breakthroughs," said Boeing spokeswoman Sandy Angers. "We need technology breakthroughs in engines, aerodynamics, materials and other systems." To justify the launch of a new jet, Boeing determined it needs to find technologies providing performance improvements of 15 to 20 percent as currently demanded by airlines.

Boeing states such improvements can't be accomplished by merely scaling down an existing next generation airliner such as the 787. "You can't simply shrink the 787 and expect the same benefits for the narrow-body market," Angers said. "We've got difficult challenges." Angers said Boeing is not pinning down a target date for the 737's replacement beyond "the latter half of the next decade."

Ok.... Is it me or will what was just said above lead them down the road to a BWB?

Will it be powered by Pratt's new Geared TurboFans?

Nurflugel Bulletin Board Threads:

Swift Airfoil

Does anyone know which airfoils are used in the Swift light?
Best regards,

Miquel Angel
<marpbcn@hotmail.com>

Try this link:

http://www.glide.net.au/flyingwing/vern/index.htm

I have just built this model, flies great. I don't know why there's the caveat on the 'foil. Vern Hunt is active on rcgroups.com if you need to contact him.

p_westrup
<p_westrup@hotmail.com>

(continued on page 8)

Computer Graphics Study

Phil Barnes gave this presentation at the ESA Western Workshop in Tehachapi over the 2007 Labor Day weekend. In his presentation, "***Trigons, Normals, and Quadragons - New Solutions for the Classic Problems of Computer Graphics***," Phil shared his excitement at finally learning how to "render" a 3D object on a computer screen. After studying the topic on-and-off for a decade, but never progressing beyond the "wireframe" level, Phil decided to live dangerously and give himself a deadline by which he would have the method working. Along the way, he developed newer, simpler, and faster methods, some of which are outlined here (all are well documented in his graphics theory package soon to be available at the ESA website). Many ESA members are engineers, mathematicians, or scientists, any of whom can easily follow everything herein. But Phil hopes also that the non-scientific ESA readers will find interesting what goes into the making of a computer graphics image. Here we go!

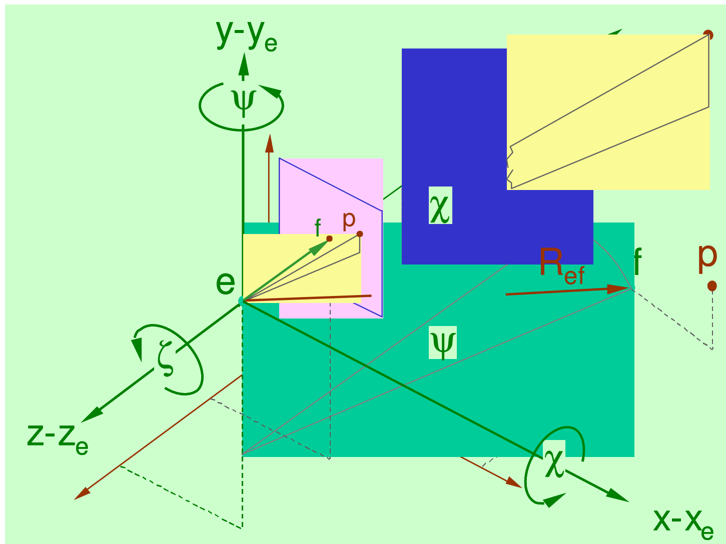
A computer graphic (CG) image displays a 3D object, as realistically as possible, on a 2D computer screen. Although the classic problems of computer graphics were solved thirty years ago, here we'll follow some good advice:

> "*If you look for the answers yourself, you will find that you can do better.*" - Paul MacCready

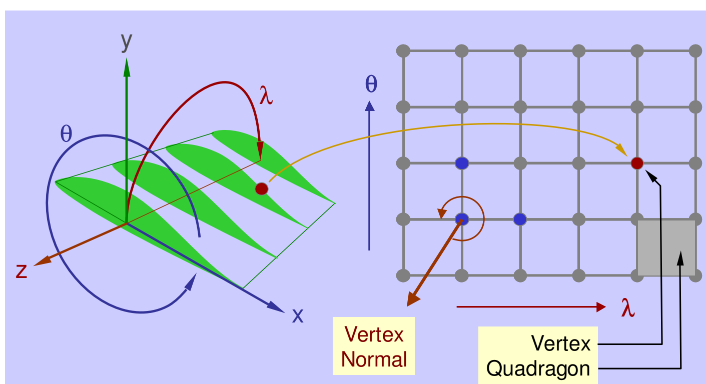
Our computer screen has an array of some million or so "pixels," each assigned a light intensity and color. Amazingly, modern computers can refresh the screen with a new image, including myriad computations, at perhaps 100 times per second. Our chosen task here is to skip the $79 off-the-shelf CG software, re-visit the theory, and render our own graphics at the individual pixel level. Rendered graphics herein are programmed with Visual Basic 5, using only the VB5 "set pixel color" command.

We can imagine a 3D object as a collection of "points" in space. The first challenge of CG is to place a given point on the screen, given the coordinates of the eye point (e), focus point (f), and the point (p) itself. This task is highly simplified if we imagine the observer to see the world through a hole in the apex of a "viewing pyramid" turned on its side. Let's say the viewer initially looks due east, but now intends to focus on some point (f), which resides to the southeast at some different elevation. The observer could "pan" and then "pitch" the pyramid until the point (f) were centered on the "screen" (pyramid base). However, a much easier alternative (mathematically) is to leave the viewing pyramid fixed as the "viewing globe" of radius (Ref), centered at (e), is twice rotated to obtain the same result (see next figure).

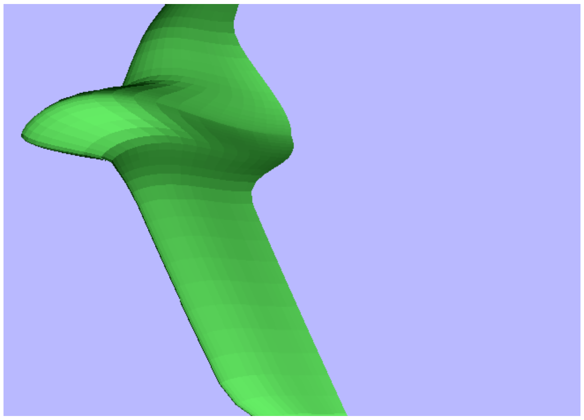
Relative to the textbook "***world-to-screen transformation***" methods, this approach reduces the required number of rotations, while also eliminating all translations, by carrying out the two or three rotations about axes through the point (e). This means the rotations operate on the coordinate differences ($x-x_e$, $y-y_e$, $z-z_e$), not the (x,y,z) coordinates themselves. The third rotation is optional for "cockpit roll."



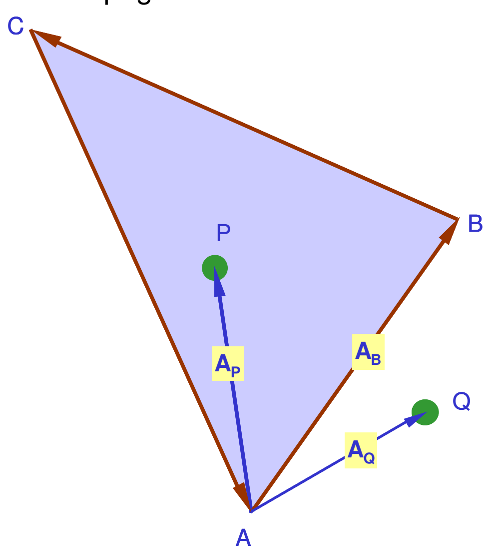
Now that we can display a single point on the screen, we next define the 3D geometry, in this case for a wing, with coordinates fully determined by equations. Phil showed that a 3D surface, whether a wing, fuselage, or sphere, can be mapped as a flexible "distorted cylinder."



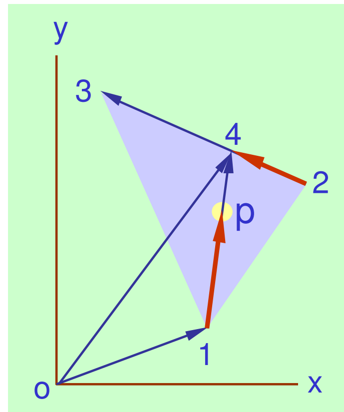
For our CG image, the surface is approximated as an arrangement of "quadragons," each having ranges of "latitude (λ)" and "longitude (θ)," and each having vertex *normal vectors* pointing away from its surface.



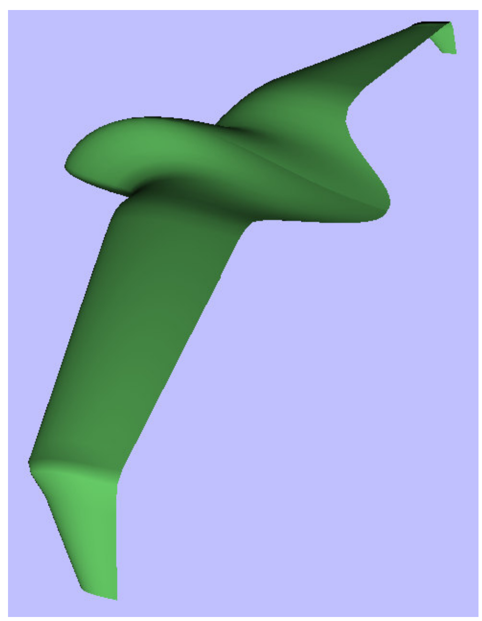
To "shade a polygon," we need to know if a given point (p) resides within a quadragon or trigon. The next figure illustrates Phil's new, vector-based solution for the classic "***point-in-polygon***" problem. We see that the cross product $\mathbf{A_B} \times \mathbf{A_Q}$ points into the page, whereas the cross product $\mathbf{A_B} \times \mathbf{A_P}$ points out of the page. Thus the point is *outside* if, for any of three or four vertices, we obtain $(\mathbf{A_B} \times \mathbf{A_P}) \bullet \mathbf{k} < 0$, where the unit vector (**k**) points out of the page.

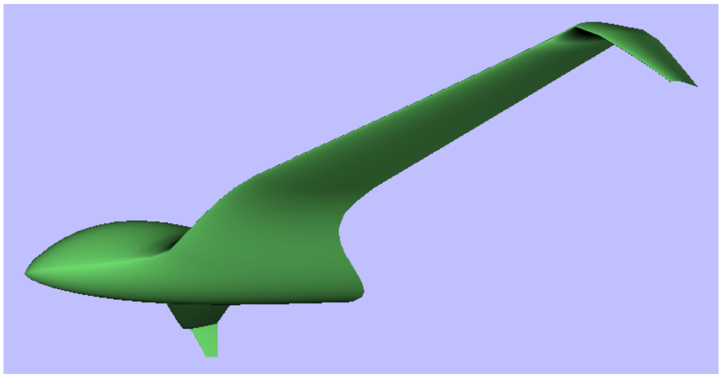


Taking a closer look at our "flat-shaded" wing on the previous page, we see that each *quadragon* has a fixed light intensity, the latter determined by the dot product of the polygon-centroid *normal vector* and *centroid-to-eye* diffuse light-reflection vector. A more pleasing image would assign each *pixel* its own intensity, with such varying smoothly between the vertices. This is accomplished with inter-vertex interpolation. Relative to the traditional "scan-line" method, Phil's new **vector-based interpolation** replaces the computation of *distances* with *differences*. Only the latter avoid computationally-intensive square-root operations. The next figure illustrates the vector approach to obtain any property (z-coordinate or light intensity) at the point (p), given that same property at each of the three vertices of the trigon. With the aid of vector-scaling, the method solves two simultaneous equations to yield the answer in terms of the (x,y) differences between vertices.



Applying vector-based interpolation to determine the light intensity at each pixel yields the smooth effect of the figure below, representing Phil's *Render Raptor* blended wing-body aircraft. Clearly this design was selected to illustrate the graphical principles here, but there is no reason why it shouldn't fly. Indeed, at least one rail-launched "uninhabited air vehicle" (UAV) in production has downward-pointed winglets. Whether up or down, winglets develop thrust because the winglet lift vector points somewhat forward.





The next step is to add a background and to animate the scene. Phil's vision is to create a realistic dynamic rendering of a wandering albatross soaring over the waves. Anyway, we hope readers at least take away from this article a greater appreciation of what our personal computer has to do to display a computer graphics image.

Tehachapi 2008, Sunday Morning

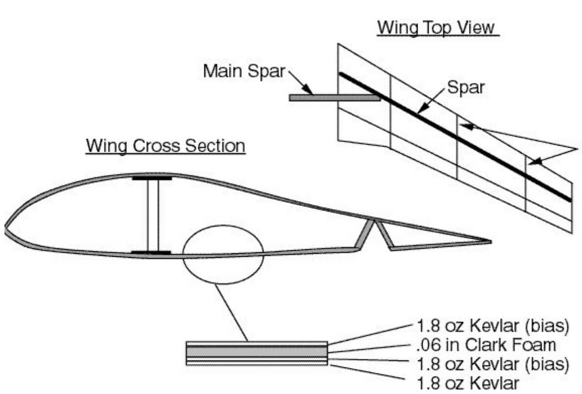
Taking a break from all this theory, Phil's 2008 Western Workshop presentation is titled "*Shooting Birds Digitally*," where time permitting, Phil will share his best photos of soaring birds, explain smart "shooting" and sharpening, and with the aid of the photos, discuss the aerodynamics of pitch trim, ground effect, and formation flight. Is that pelican in front really working harder? See you all there!

(ed.- My thanks to Phil for providing this great synopsis of his presentation. This is the type of thing that makes putting the newsletter together so much easier.)

Nurflugel Threads (cont.)

The airfoil was designed specifically for the Swift at Stanford. There is a sketch in this paper.
http://aero.stanford.edu/Reports/SWIFTAIAA004336.pdf

Rick Page
<rick-page@shaw.ca>



A question for the more knowledgeable: Larry Mauro's "Easy Riser" electric powered ultra light. I do recall he had solar cells on it, but did it also not have battery power too? As I recall, Larry didn't have enough solar to fly on solar alone.

Can anyone out there in the ether confirm or deny?

Thanks!

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

Hi Al!

I found this article:

http://www.airventuremuseum.org/collection/aircraft/UFM-Mauro%20Solar%20Riser.asp
<http://www.airventuremuseum.org/collection/aircraft/UFM-Mauro%20Solar%20Riser.asp>

Happy flying!

Mark "Boreger" Balogh
<boreger@toons.hu>
HUNGARY

From Al Bowers in reference to a discussion on Horten 1b/c plans:

There was a question about the control system. And the question was about differential. I guess it's probably time for the full explanation again (apologies to all who get tired of my going on about this, but its important to understand the differences).

I often say that a Northrop flying wing has more in common with conventional tailed aircraft than it has in common with a Horten flying wing. I imagine that shocks a few people (though none ever says anything to me about that claim). It's related to the span load and what happens when you change the span load AND the control system that goes along with it. So I hope you'll all indulge me.

In 1903 Prandtl came up with the first calculation method that allowed calculation of lift, induced drag, and span load. It was revolutionary. 1903 was a good year for aviation. :-) So once you have a calculation method, it's only natural to figure out, well, what's optimal? that is: what is the minimum induced drag for a given lift with that wing? Prandtl figured that out by about 1908. Oddly enough, he never published that calculation (as important as it is, it is still quoted in ALL aerodynamics textbooks). We would have never known that Prandtl came up with that if it were not for one of his students, Albert Betz (who is no slouch aerodynamicist either!). Betz figured out how to measure the profile drag of a wing (the "other half" of the drag problem). This solution is the ELLIPTICAL spanload. Elliptical span load gives the minimum induced drag of a wing with a given span AND a given lift. Simple, right?

Now the next part is conjecture on my part, but the end result is not in dispute. Apparently, the solution of the minimum induced drag still bothered Prandtl. he continued to work on the solution for the minimum induced drag. Now normally, incredibly smart people (notably those with letters after their names, like PhD) don't try to shoot holes in their own theories. In fact, the people who would like you to think they are great usually do the opposite, they try to convince you that their theory is SO important they can't understand why you don't think they are the smartest person you ever met! but in 1932, Prandtl threw out his old optimum minimum induced drag theory (the one that is still in all the textbooks), and came up with a new one (which almost nobody pays attention to).

Prandtl asked the question: If I take an elliptical span load wing, and I try to BUILD that wing, I need a certain size wing spar to carry that load. If i constrain that load (called the wing root bending moment), and I need to develop the same lift as the elliptical, and I don't constrain the span, IS THERE A SPAN LOAD THAT WILL GIVE LESS DRAG? got that? Same moment, same lift, unlimited span, MINIMIZE DRAG. Prandtl found the answer was, yes there is. The new optimum is 22% MORE span with a bell shaped span load (a young kid named Reimar Horten was the first to call it "bell" shaped), gives 11% less induced drag for the SAME lift, and the SAME wing root bending moment. And Prandtl published it in a paper the title of which translates as "On the Minimum Induced Drag of Wings." Two pages, two figures, two tables, eleven equations. Classic, simple, elegant, and fantastic. [NB: Can you tell I'm a great admirer of Prandtl?]

Nobody uses his idea except for two young sailplane builders who had a little trouble with their first sailplane, but embark on a building spree of sailplanes like none before or since: Reimar and Walter Horten. Lippisch comes in a distant second, and Northrop isn't even in the same league, IMHO. BTW, both Lippisch and Northrop used the original ELLIPTICAL span load ideas of Prandtl, and nearly all aircraft builders today use elliptical span load for their designs.

Then there was the ugliness of WWII, in which anything that was Japanese, Italian, or German was obviously a bad idea (and I accept that militarily there was much to dislike, though Stalin is still no favorite of mine). Prandtl's idea was forgotten.

Another very smart and incredibly talented young man was musing over the exact same problem as Prandtl did. And he came up with the same solution completely independent of Prandtl. The young man was Robert T Jones, or RT as his friends called him. I was GREATLY privileged to work with RT Jones on one of his ideas, the oblique wing, when I was a young man. Jones came up with the same solution Prandtl did, and published his findings in an NACA report in 1950. Jones was working at the NACA Ames Aeronautical Lab at the time. Again, the bell shaped lift distribution, or bell shaped span load.

In the meantime, Reimar Horten finished his PhD, and moved to Argentina to pursue a teaching career in aviation. And while there, he perfected the control system that would allow the solution to one of the greatest questions of aeronautics. the question that all aeronautics is founded on is the FIRST question: how do birds fly? The trouble was, after the Wrights figured out how to fly, people just solved it the same way Wilbur and Orville did (and we're still doing it that way over 100 years later). The trouble is, we forgot the first question that we started with. And it isn't until you think about it, that we realize, we never answered the first question correctly or completely. So let me ask only a part of the question again, in a way to make our current failures more clear:

When was the last time you saw a bird with a vertical tail?

How can birds fly without adverse yaw? They have no verticals to control adverse yaw, so how do they do it? Remember, that was the GREAT advancement that Wilbur and Orville came up with that allowed them to build their first airplane (and also to control their whole "bank to turn" idea of flight).

What do birds know that we don't?

A corollary thought: if birds had elliptical span loads, those primary feathers at the tips would be deflected a HUGE amount upwards. we all know how soft the tip of a feather is, it can't carry much load at all. Yet if the span load was elliptical, there would be large loads right at the tip. And the best soaring birds are diomedae, the albatross'. And they have almost no tail at all. And there is no evidence of adverse yaw in their flight.

As an aside, the B-2 is probably the most advanced flying wing in service today (at least until Diego Roldon Knollinger went and rebuilt one of the old Hortens!). And note that though the B-2 does NOT have a vertical tail, is uses split elevons TO CREATE DRAG for control in yaw. Now that idea should just be HUGELY offensive to everyone. We use an elliptical span load (for minimum drag) and then to control it we have to use DRAG. Dumb, dumb, dumb...

Another short aside: there has been only one development to the Prandtl/Jones bell shaped span load since, and that was done in 1975 by Klein and Viswanathan where they also added the shear load as a constraint to the spar as well. the end results SHOULD give the minimum structure for a given lift, and given wing root bending moment, with minimum drag. Think about that optimization.

Along comes another young guy with a brilliant mind (we've already talked about Prandtl, Betz, Horten, Jones, Klein and Viswanathan) named Richard Whitcomb. He has an idea, where span is constrained, but if you place a VERTICAL airfoil into the presence of the tip vortex on a wing, you can extract energy from the tip vortex as thrust. induced thrust on a "winglet". Whitcomb finds that you get a drag reduction of about half the "span extension". So if you folded that winglet out flat, you'd get an 11% decrease in drag from a 22% increase in span, right? Wait, didn't we already see that somewhere?...

Now the problem with adverse yaw is more subtle. With a elliptical span load, you get an almost elliptical distribution of induced drag. So if you INCREASE the lift on one side, you increase the induced drag there as well (more lift more drag). So the wing that you are lifting when you bank is being dragged BACKWARDS. This is adverse yaw.

Now imagine the case of Whitcomb's winglet. The winglet is cool, because it has INDUCED THRUST. That is NEGATIVE induced drag on the winglet. Now imagine the winglet folded out flat (like a span extension, call it a tiplet ;-). So if you increase the lift on the winglet/tiplet, it will also increase it's negative drag (ie: it will increase induced thrust). NO ADVERSE YAW. Prandtl's bell shaped span load gives induced thrust on the last 30% of the wing tip, just like it was a winglet. So if you put ALL of the elevon in the last 30% of the span towards the tip, you'd get NO adverse yaw.

It isn't until the last few Hortens that the full roll control authority was put on the very tip of the wing. I have a photocopy of a very badly written Spanish three page note from Reimar that explains this idea. It's only the H Xb, H Xc, the H XVa/b/c, the H XIV Colibri, and the H Ib that use this idea. All other Hortens (even the beloved H IV and H VI!) distribute the roll control inboard, which creates adverse yaw. This all happened about 1950, about the same time RT Jones published his report (1950 was also another good year for aviation.

So if you do this, you get minimum structure for the payload you are carrying, you minimize induced drag, you don't need a vertical, you don't get adverse yaw, and you maximize performance. All at the same time. Now allow me to say, if evolution were to push an animal into fitting perfectly into it's ecological niche, OR conversely an animal were perfectly created to fit into it's ecological niche: isn't this the result you would expect to get?

This is what birds know that we don't.

And this is what Prandtl, Jones, Horten, Klien and Viswanathan have been trying to tell us for years.

The only thing I can figure out is that no one has rolled the whole story up into one ball of wax all together. So we keep missing the bigger picture. And BTW, it took me 11 years to figure all that out because I'm pretty dense...

Andy, maybe we need to update the talk and do it again. *(ed. – Maybe we can do another program with all on this subject.)*

Again, sorry for being so long winded...

Al Bowers

From Mark Hills
<markhills@clara.co.uk>

Your reply about spanwise lift distribution got me thinking and I downloaded the reports your mentioned, (apart from Prandtl paper, still waiting on this, my company does not have a copy of it and it has had to be ordered in from outside).

I was looking through your presentation "on the minimum induced drag of wings." upon looking through this I came across the 2 pics of the albatross and thought how can they get away with such marked anhedral? The only answer I could come up with was their active controls. would a non elliptical lift distribution be irrelevant to this question but it would make the control easier?

On the weekend I flew a buzzard, (purposeful raptor), and an eagle owl, (big fluffy shag pile carpet with wings). if you look at each of these birds, with wings outstretched you will see that there is appreciable 'camber', (curvature & large leading edge radius), on the inner portions of the wing close tot he root compared with the outer part of the wing, (small leading edge radius and a flat chord wise section). all of which makes me surmise that there is more lift production happening close to the root, which lines up with what is being talked off.

To add to the idea that the lift produced by the outer wing is minor i also thought that this must be true from a mechanical point of view because it would be hard for a joint approx half way out the semi span to transmit much moment from the outer wing.

On the note of birds not having any vertical surfaces can't the head and the beck be lumped together as vertical surfaces? if they are, then their area is forward of the aero center, which all the textbooks say should be de-stabilizing. is this another area where active control, i.e. bird brain, makes sure things go in the intended direction?

Mark

I had many conversations with Paul MacCready about this. He and I differed on this one. Paul maintained that birds were unstable. I thought they were slightly stable and still do. Paul would always point out that people, when they walk, are unstable. Yet in every other mode, people are stable. So I allow that shorter periods of instability are probably okay. Birds MIGHT be unstable, but I don't think so (I could be otherwise convinced with the right data).

I've worked on enough unstable systems, with artificial stability, I know what they look like and birds don't look like that. A couple of examples:
I worked the X-29A Forward Swept Wing. It was about 33% unstable sub sonically (about 17% stable supersonic). It had a time-to-double of about 200 milliseconds 9that is: any disturbance, if left unchecked, would double in amplitude in 0.2 seconds). Some aircraft have gone more unstable than that, but it is hard. At 80 frames/second to stabilize the airframe (and this is MUCH faster than a biological system can stabilize itself) there is a "jitter" in the system as the aircraft tries to stay stable.

I observed closely the automated aerial refueling on the F-18 SRA, and have extensive experience from the F-18 HARV refueling. The HARV was a real handful to try and refuel. The CG was slightly aft (still stable though) and it had very poor mass properties. most of the mass was in the ends of the aircraft, the thrust vectoring system added about 2200 lbs to the aft end of the aircraft, and it was counter balanced with 894 lbs of lead in the radome (there is just something wrong with adding lead to an airplane to make it perform better...). The pitch and yaw inertias were HUGE for an F-18. As a result, the aircraft took a LOT of input to get it to respond, and once it did it took a LOT of input to make it stop. But it was stable. To refuel, because that requires fairly fast response, the aircraft was terrible to refuel. We ran a conservative "bingo" fuel when refueling to improve our chances. But if the pilot was tired or fatigued at all, we had many missions cut short because we could not refuel, it was simply too difficult a task for the pilots. And ours were THE BEST! One of them was the President of the Society of Experimental Test Pilots association. Yet in the auto refueling work we did for DARPA, the SRA (albeit, without the handicap of the poor inertias) was almost graceful in the way it would approach and plug. Pilots were always much less elegant. Our pilot for the experiment was and old Vietnam era vet (he flew with the 555th "Triple-Nickel" out of Thailand in F-4s). His comment was it was uncanny in how smooth that artificial system was. The human can only update at about 2.5 frames/second (reaction time is about 400 milliseconds) and artificial systems can update about 80 frames/second (12.5 millisecond frames).

So my conclusion is that, in this regard, artificial systems are better than biological systems. Birds, with their extremely low pitch inertias, would have very RAPID divergence if they were unstable, beyond what most biological systems can react to. Birds show a very smooth motion in flight. I have seen no evidence of any instability (except for very brief periods of time such as flare for landing).

Al Bowers

Whilst birds don't have a vertical surface, the action of their tail and other parts make up for it.

In normal, level, un-disturbed flight, it can be horizontal and used as tailing edge of a lifting body. However, they are able to twist it and hold it at different elevations, thereby able to achieve a similar effect to that of a vertical surface. Remember, they can also change the wing geometry on either side to achieve the same effect also.

If you were to watch said albatross in anything other than still conditions, the wings do differing things on either side to achieve stability including changing the dihedral/anhedral and also those outer sections tend to move more, being small and lighter, they can be used more responsively.

Veronica Merryfield
<veronica.merryfield@shaw.ca>