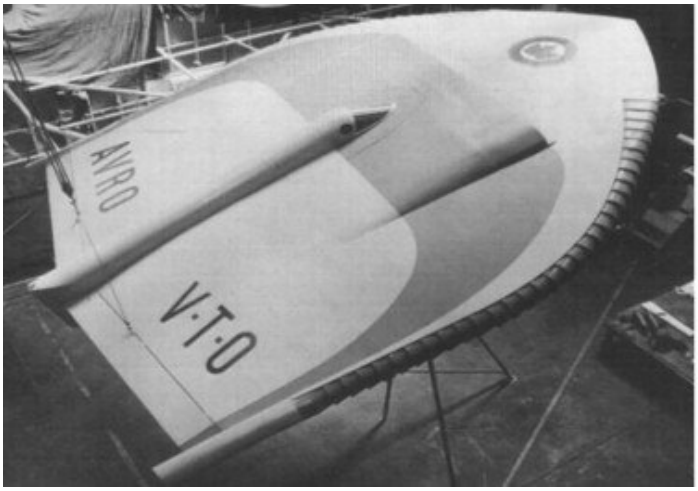
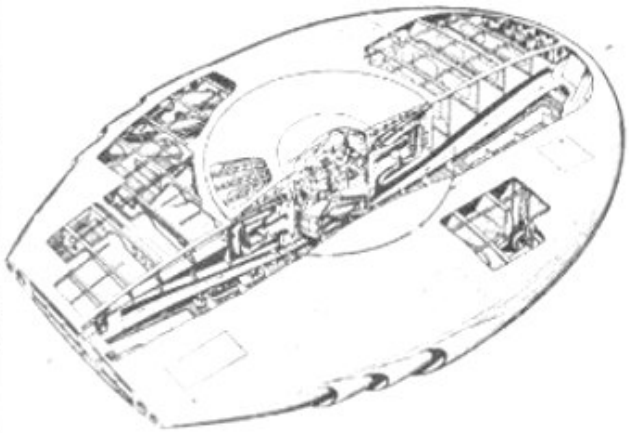
No. 228 JUNE 2005

T.W.I.T.T. NEWSLETTER



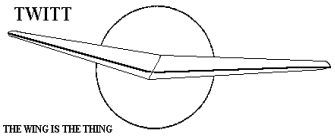


The Avroplane (left) was part of a 1950s "air jeep" project, Project Y, which also produced the Avro-car disc-form aircraft. It was developed by A.V. Roe, a subsidiary of Hawker Siddeley. Diagram (right) referred to as "Avro Disc" which appears to represent a version of the Avroplane. http://www.unrealaircraft.com/wings/avroplane.php

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., **0506** means this is your last issue unless renewed.

Next TWITT meeting: Saturday, July 16, 2005, 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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The **T.W.I.T.T.** office is located at:
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Meetings are held on the third Saturday of every other month (beginning with January), at 1:30 PM, at Hanger A-4, Gillespie Field, El Cajon, California (first row of hangers on the south end of Joe Crosson Drive (#1720), east side of Gillespie or Skid Row for those flying in).

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PRESIDENT'S CORNER

I would like to thank all the regulars who came to the May meeting to hear about the B-58 Hustler. Darrell Schmidt did a very nice job of telling us all about the aircraft and entertained us with lost of good war stories. I haven't run across a pilot yet that doesn't like war stories about airplanes.

I don't recall it, but someone recently mentioned that Richard Miller had passed away some time ago. If anyone can confirm this and provide more information, I would appreciate it. Richard was one of the original founders of TWITT and the first newsletter editor. He had contributed some comments on the future of aviation several years ago we published on the web site, but then he sort of disappeared again.

It's not too early to begin thinking about making plans for the Labor Day SHA/ESA Western Workshop at Tehachapi's Mountain Valley Airport. Bruce Carmichael always pulls together a great line-up of speakers and presentations on all sorts of aviation related topics. The main programs are on Saturday and Sunday, so plan on coming for one or both days and learn more about the art of homebuilding and other neat things.

Also be sure to make a mark on your calendar for the July anniversary party at the hanger. This will be our 19th birthday party and we are looking for many more ahead.

As noted we are looking for a program reference for the July meeting to go along with the party. So please let me know if you have any ideas and/or contacts I could work up into a program.

I hope everyone is getting a good start on their summer flying season whether it is putting a new model into the air or going out to the local soaring site and flying the full size stuff.

Andy

JULY 16, 2005 PROGRAM

The main event for the July meeting will be the annual **TWITT Anniversary** party with lots of cake and ice cream (the latter will go great on what will probably be a hot day). We are still looking for a program to try and keep our 2005 "streak" of programs going but haven't found one yet. Last month's program was suggested by Walt Scott, so dig into your list of friends and acquaintances and see if one of them could do a flying wing or tailless aircraft talk.

So mark your calendar for the third Saturday in July and come join us for the celebration.

Don't forget that the TWITT hanger is a designated vintage aircraft display venue, so if you need display credit to support a tax exemption make sure to fly in and taxi to Hanger A-4 on the southeast corner of the field.

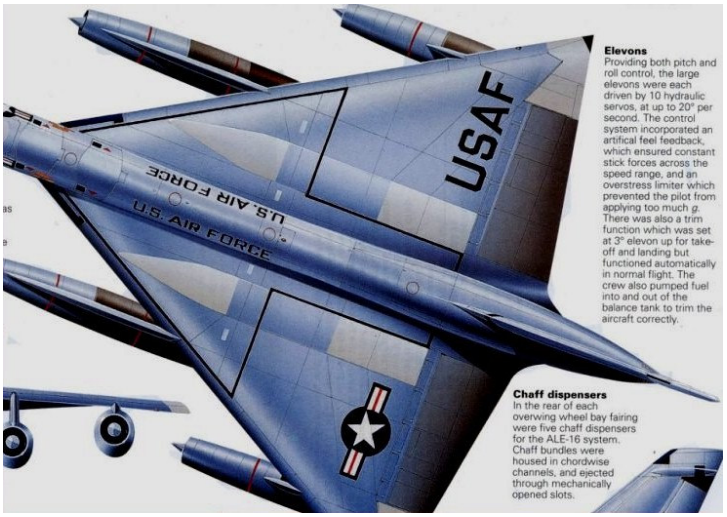
MAY 21, 2005 MEETING RECAP

Andy opened the meeting by thanking the usual regulars for coming so our speaker had someone to talk too. Bob Chase noted that he now had his ultralight trike back in the air with a new engine, so he was happy. Bruce Carmichael asked the group to keep his SHA/ESA Western Workshop program in mind if they run across anyone who could make a presentation relating to aviation and homebuilding.

Andy then introduced Darrell Schmidt who was going to tell us about his experiences with the B-58 Hustler supersonic tailless bomber. (Note: The pictures and illustrations included below came from Darrell's website – http://members.cox.net/dschmidt1/)

Darrell began with a quick overview of his flying history that included a wide range of aircraft over the years. He started in Super Cubs, T-6s, T-28s and T-33s going through Air Force pilot training and then moved into B-47s & B-52s before his transition into the B-58. Toward the end of his career he did his tour of duty in Vietnam and ended up flying the C-7A Caribou, a twin piston engined cargo hauler. So he went from the very fast to the very, very slow.

After "retirement" he had several non-aviation jobs while the pilot positions were hard to find, but he eventually ended up as a Captain for American Airlines. This led to his second retirement at the mandatory age limit enforced by the FAA and he now works as a ground school and simulator instructor for a subsidiary of Boeing.



At this point he was going to show his video, but wouldn't you know it the videotape machine decided to malfunction and not play the tape. Darrell recovered by going on through the material he had while we obtained another machine and eventually were able to view his production.

He gave a few statistics on the B-58, which included:

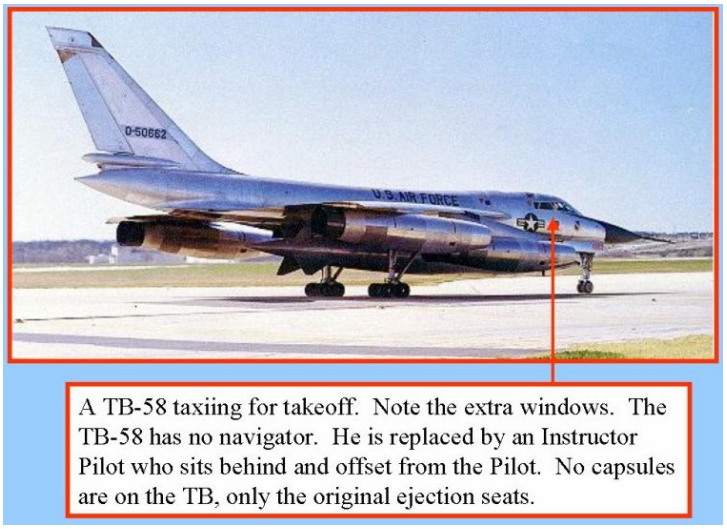
- First Flight - November 11, 1956
- 116 Built – Last one delivered October 1962
- 26 destroyed in accidents
- Maximum speeds – Mach 2.0 or 600 KIAS or RAT 115º C
- Momentary Limits – Mach 2.2
- Combat ceiling – 63,000'
- Record height – 85360' (2nd Harmon Trophy)
- Thompson Trophy – 1,284.3 MPH, January 13, 1961
- Bleriot Trophy – 1,302.07 MPH – May 10, 1961
- Harmon and McKay Trophies – New York to Paris in 3 hours 40 minutes – average ground speed 1,089 MPH, May 26, 1961

Darrell noted that one of the initial problems with the B-58 was getting it through the transonic area. The one thing that helped solve this was incorporation of the area rule or "coke bottle" effect in the fuselage section where the major portion of the wing is attached. This is quite noticeable in top views of the aircraft.

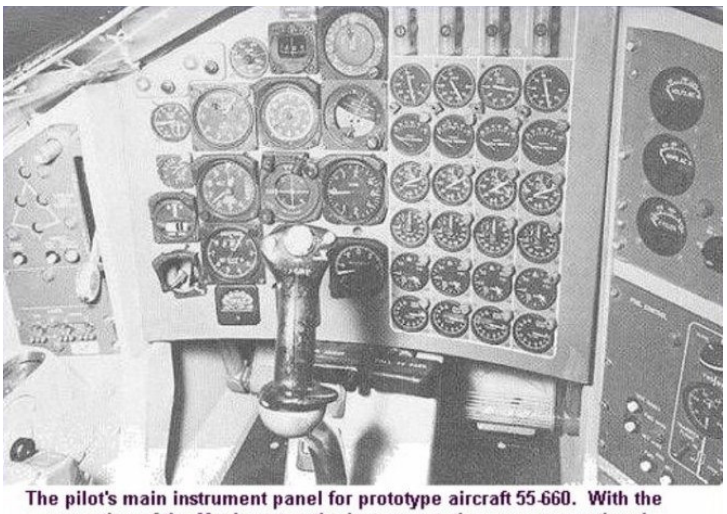
He went through a typical supersonic profile to demonstrate how the aircraft performed with this aerodynamic effect. The other thing a little different is the engine intake spikes that keep the shock wave out of the engines versus those in an SR-71 that actually uses the shockwave for power enhancement. The B-58 also had an automatic system for moving the CG fore and aft which was necessary to offset the changes in aerodynamic pressures as the aircraft went through the sound barrier. The CG was further forward in the subsonic phase and then moved to the aft limit upon going supersonic.

The throttles would be pushed forward to maximum military thrust and then eased into minimum afterburner to wait for all four to light off. Then they are advanced to the maximum burner position and then over the last notch to the overspeed setting. This brought the engines up to 103.5% which could only be done under certain low temperature settings. He was asked what the fuel flow was like at this speed and his answer was whoosh!! (ed. – Sounds like the Lockheed Jetstar when it was being pushed to its maximum cruise Mach number. You could actually see the fuel gages moving.) The B-58 could only hold these settings while burning out of the main fuel tanks since they were the only ones with high enough capacity pumps to handle the fuel delivery rates.


Pulling into the contact position to air refuel with a KC-135 tanker aircraft

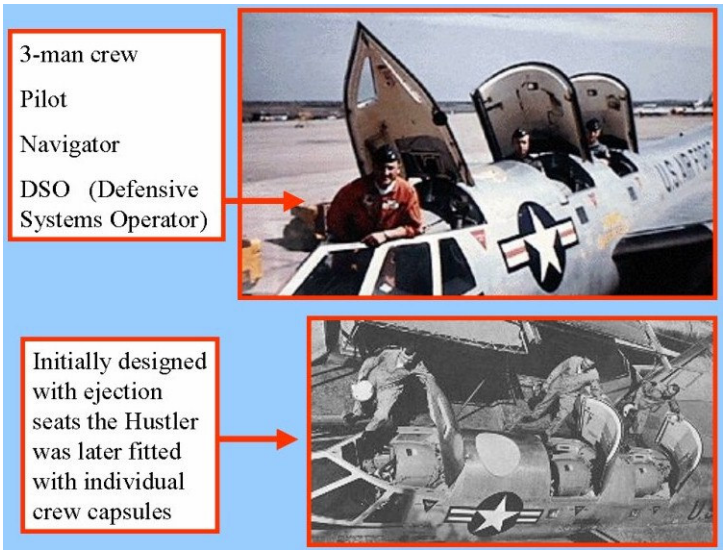

A TB-58 taxiing for takeoff. Note the extra windows. The TB-58 has no navigator. He is replaced by an Instructor Pilot who sits behind and offset from the Pilot. No capsules are on the TB, only the original ejection seats.

The transition to supersonic had to be monitored with the Mach indicator light since that was the only time you knew you had gone supersonic. There was only a small amount of flutter as far as being able to feel the transition.

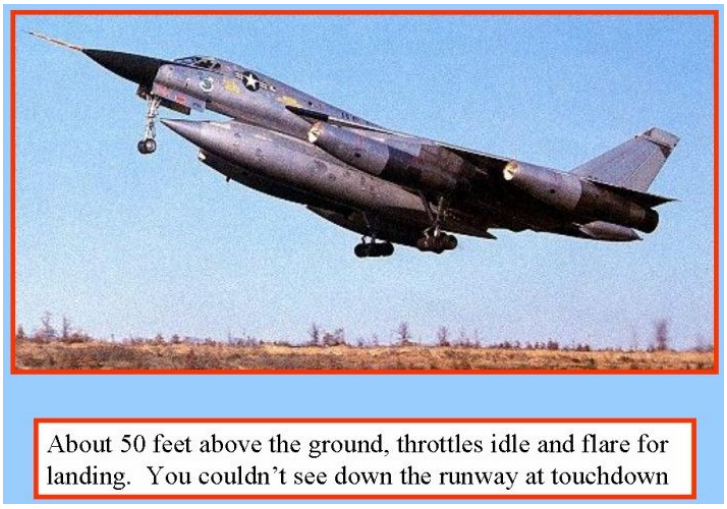

The pilot's main instrument panel for prototype aircraft 55-660. With the exception of the Mach meter, the instrumentation was conventional for a multi-engine aircraft.

The elevons had control movement limitations throughout the speed range. At .9 Mach the movement of the elevons was restricted quite a bit to prevent over stressing the airframe at that speed. Once supersonic the amount of movement was automatically increased due to the position of the

shock wave over the surfaces. Then at about 1.5 Mach it started closing back down again.



As the aircraft approached 600 MPH indicated at 30,000' the pilot would come back on the stick and start a climb that would maintain the speed. This resulted in a climb rate of 4-5,000 FPM while the Mach number continued to build until approaching 50,000'. About 3-4,000' below the level off maneuver would start to prevent an overshoot. This was also the point where the aircraft was approaching Mach 2 and the pilot started throttling back to mid afterburner range. The autopilot and auto throttles would then be engaged and the cruise phase started.



Bob Chase asked if the B-58 landing attitude was about the same as the F-102 and F-106 he observed when he was stationed at Travis AFB, CA. Darrell commented that the initial training for the B-58 was in an F-102 due to the similarities in aircraft configuration with the delta wing and elevons. It was also a cheaper way to find out if the pilot could handle the aircraft.

The B-58 was flown down final by angle of attack that was high enough where the pilot couldn't really see the runway so side references had to be used to touchdown.

"Moose" Fordham - Instructor Darrell Schmidt - New B-58 Pilot

Air refueling with the B-58 was relatively easy since the receptacle was in the nose right in front of the pilot. The roll and pitch dampers, and triple redundant yaw damper made the aircraft very stable for holding the refueling position behind the tanker.

The aircraft was manned by a crew of three: pilot, navigator and, defensive systems operator. There was no copilot so the DSO ran the checklists for the pilot and handled the fuel tanks during refueling. The DSO and navigator sat in small compartments behind the pilot with only small side windows and some had periodic troubles with claustrophobia.

The tail had a gattling gun for defensive purposes. It was interesting in that the muzzle velocity was about Mach 2, which was the same speed as the aircraft. So for an observer on the ground it would appear the bullets had stopped and the plane was flying away from them at Mach 2. But any enemy approaching the bullets would be hit at Mach 2 and destroyed.

At this point we had a VCR ready to go so Darrell put in his tape, which he had already narrated. The information on this tape is basically available on Darrell's B-58 Hustler website under the Annex Section. That was the source of the pictures included in the newsletter.

Following the video there was some questions and answers about the tactics employed by the B-58 to deliver ordinance on the designated targets. There

were also a few more war stories of unusual events in the life of a B-58 pilot. One of the final questions was whether or not Darrell had the same number of landings as takeoffs, to which he replied yes indicating he never had to punch out of the aircraft using the escape pod system.

We all thanked Darrell for coming down and giving us a good look at the B-58 Hustler supersonic tailless bomber.

LETTERS TO THE EDITOR

May 9, 2005

Link With TWITT:

Our club in Kamloops, BC recently set up a web site and have tried to include links to other clubs, manufacturers and wholesalers in order to provide hobbyists with a complete library of information. If you would like to look at our web site the address is

<http://www.skyrangersmodelflyers.com/

We would like to link with your club but our mandate is to obtain the permission of those we link with and ask where possible, for a reciprocal link.

Please let us know by return e-mail at your earliest convenience, if we can add your site to our links.

Sincerely,

Luella Cousins
Asst. Webmaster
<billcousins@telus.net>

(ed. – Probably by the time you read this I still haven't had the time to get this link added to the website, but I have let them know they can add a link to the TWITT site.

This is an R/C modelers club so we have a lot of members who will like browsing about their site.)

May 9, 2005

Andy:

Can you change my mailing address for TWITT and SHA/ESA to: 5707 Jamboree Court, Austin, TX 78731. I will send new email address when I have one.

Al Backstrom
<albackstrom@cebridge.net>

(ed. – As of the time we published this newsletter, Al hadn't gotten back to me with a new e-mail address so this one should still be good for a while longer.)

May 16, 2005

Control Surface Sizing Question

For starters I think you have a wonderful website that is a great source of information. I am searching for technical information or rules of thumb that help size the area of the control surfaces for longitudinal S&C. Could you recommend an equation or information source that can provide me with this sort of data? Typically, for conventional aircraft the Vbar method suffices to get a start at a tail area. Is there a similar method adopted for flying wings?

Thanks and best regards,

Zarir Pastakia
<zppilot@hotmail.com>

(ed. – I didn't have a good answer for Zarir, so if someone could please contribute one via e-mail to him and include us as a CC: so I can share it next month.)

May 17, 2005

Hi Andy:

I haven't been a member of TWITT very long so I don't know if you've talked to Klaus Savier before. I just heard of him last week. He has an engineering company up in Santa Paula, CA. He has been racing a Vari Eze in sport class. I haven't found anything revealing about it on the web but some of the web pages that mention it say it's highly modified. What got my attention was that he had a Mitchell U-2, kit #333, N number N32KS. There is practically no information about his U-2 on the web. This is all I know: First flight was in "84

Some modifications to the TE of the outboard wing, landing gear and fuselage

The plane was damaged when a nylon landing gear hub disintegrated upon landing.

This could be something interesting to fill a few pages in the newsletter. Here's the URL of the company's contact page:

http://www.lightspeedengineering.com/Company/TheTeam/LSE_Team.htm

Norman Masters
<nmasters@acsol.net>

(ed. – A long time and many issues ago, we had Klaus at one of our meetings and he discussed his extensive modifications to the Vari Eze and how he did in-flight air flow analyses using oil and carbon black, if I recall correctly. I have seen pictures of the U-2, but don't know anymore than what Norm related, so if anyone has information they could share, please send it along.

If anyone knows Klaus well enough to ask him, could you try and see if he would come down and do a program on the U-2 and its modifications. Thanks.)

May 18, 2005

Dear Phil,

Re: Albatross

I agree with all of your comments in the May 2005 TWITT Newsletter regarding no-wind albatross soaring methods, but would like to add a couple of things. Being an old glider pilot, I try to put myself in the "cockpit" of an albatross, flying over a moderate sea, below the wave crest. If I look for, and head toward, the water that has just bottomed out, and is moving upward relative to the horizon, I should be able to benefit from the energy in the upward-moving air immediately above the surface. If the energy gained is less than that required to maintain flight, and there is no wind, I guess I had better land and wait for either some wind, or a higher sea state. If the energy gained is equal to the aerodynamic energy lost (L/d = 27), then I can just maintain speed and altitude, as you have suggested. If the energy gained from the vertical velocity of the wave is MORE than that lost due to aerodynamics (over 2 fps in your example) I have two choices; I can continue to maintain my altitude and allow my speed to increase, or I can hold airspeed and zoom to a higher altitude. In a fairly heavy sea, it would seem that the albatross could "terrain-follow" using this technique while gaining speed, then zoom, bleeding off the energy to change direction.

You have characterized this as classical "wave lift" (which usually implies a wind gradient with altitude). I suggest that it is more like simple ridge soaring but with a vertical undulating ridge whose motion is observable, if not completely predictable. This may be the reason that the birds always hold their heads parallel with the horizon. They are observing sea motion strictly relative to the horizon.

I certainly agree that we should encourage others to join in the study of the albatross. I recently saw a TV show that mentioned fitting some albatross with GPS units so they could monitor the migration patterns. It would seem that a miniature video camera (similar to those used on "Tillie the Eagle" for the Discovery video) could help confirm some of these theories.

Bob Hoey
<bobh@antelecom.net>

(ed. – Thanks go to Bob for adding to Phil's excellent presentation on the dynamic soaring done by the albatross.)

June 1, 2005

Dear Andy,

Could you put a request in the June SB for anyone wishing to make a presentation at the Western ESA Workshop Labor Day weekend to contact Bruce Carmichael at 34795 Camino Capistrrano, Capistrano Beach, CA 92624. Phone 949 496 5191 e-mail brucehcarmichael@aol.com.

I have four volunteers so far including two great ones on bird flight, one on a new theory of dynamic soaring, and one on simplified performance estimation.

Cheers,

Bruce
<Brucehcarmichael@aol.com>

(ed. – Although Bruce sent this to me as editor of Sailplane Builder for SHA/ESA, I thought it would be a good idea to also publish it here. If you know of someone who would make a good presenter at the SHA/ESA Western Workshop, please contact Bruce. If you know someone who could do a good construction demonstration, like building ribs, spars, etc., he would also like to hear from you since the workshop is also supposed to a hands-on experience where possible.)

June 1, 2005

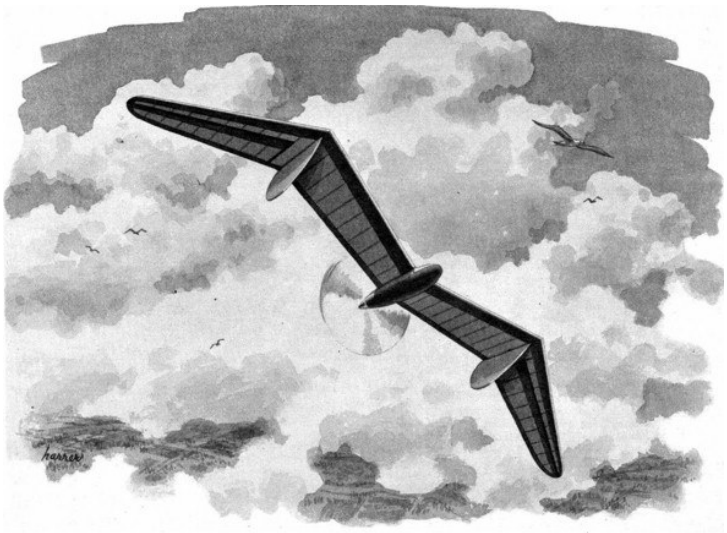
TWITT:

A friend in Australia stumbled across this website. It's a reprint of an article on tailless models written by Henry Cole in the April 1943 issue of Air Trails. Thought you might be interested. Times haven't changed much, have they!

http://www.theplanpage.com/Months/2504/tailless.htm

Bob Hoey

(ed. – I have included one of the pictures from the article. Don't forget, this was 1943.)



Posted on the Nurflugel bulletin board.

May 25, 2005

News on the PUL-10!

I know I've been rather quiet on the list for some time - work and life have made it difficult to do much more than lurk on this list. But, when I do contribute, it's a doozie.

I've been contacted by Bernhard Mattlener - one of the guys behind the PUL-10! They're working on a new model, the H 3000, which has front-and-back seating instead of side-by-side seating like the PUL-10, and other improvements based on what they've learned in testing the PUL-10.

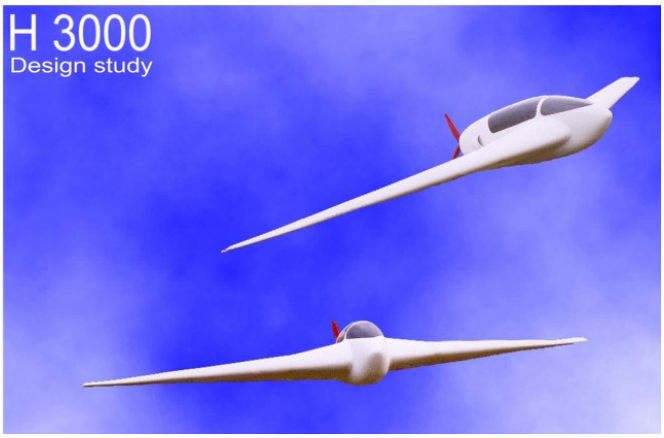
They're constructing a 5-meter model for flight testing, and trying to get funds for full-scale construction. Bill Gates, where are you when we need you?

There's a picture on the web site - http://www.nurflugel.com/Nurflugel/Horten_Nurflugels/H_3000/h_3000.html

In addition, Bernhard is joining the mailing list, so I expect to have more frequent updates on progress (I want to see pictures of that model!). Since he has a day job, the aircraft project, and a personal life (how does he manage all that?), don't expect him to be a frequently contributing member.

Hope this makes people happy - I get a lot of requests about the PUL-10, and it's nice to get some good news.

Douglas Bullard



(ed. – Here is the lone shot from Doug's website. I was under the impression this concept had been under consideration for some time in lieu of the side-by-side arrangement of the flying prototype of the PUL-10)

June 2, 2005

Karlo Godel and Frank Zaic

Tom Wilk just posted this on a C/L stunt forum:

"I was sent this from Hannans Hangar

We received a phone call from Carmen Zaic this afternoon, saying that Frank had passed away yesterday. We think he was about 92. Certainly he was a living legend...

This closely following a call from Otto Kuhni, that Carlo Godel had died."

I loved reading Frank Zaic's yearbooks and enjoyed his theorizing and explanations of model airplane dynamics and trim. He was a true model aviation pioneer and recorded its history as no other ever has. His kits and designs were classics.

I know we will all miss Carlo's participation here. So unexpected...

Sad day.

Serge Krauss
<skrauss@ameritech.net>

I last saw Carlo 6 weeks ago we chatted for a couple of hours and exchanged some books. He had had some trouble with congestive heart failure earlier in the year but seemed to have it under control. In addition to model airplanes Carlo was involved with astronomy, rocketry, paleontology, painting and old cars. Carlo Axl Godel was only 62. Here is his site: http://www.acsol.net/~regiaero/

Norman Masters
<nmasters@acsol.net>

(ed. – This should remind everyone of Carlo who introduced us to the Etrich wing. He was a constant contributor to the Nurflugel bulletin board as you will recall from past TWITT newsletters where he commented on a number of subjects. Norm also posted the following about Carlo.)

After retiring from the Los Angeles department of public works in 1998 Carlo and his wife Blanche moved to Grand Junction Colorado, Blanche's hometown. I contacted him some time after that when I noticed that our e-mail addresses were in the same domain. Over those few years that I knew him we had several lively conversations in his study/drafting studio/astronomy equipment storage room and exchanged books and drawings. I considered him a friend but we weren't particularly close.

The Godels have two sons, one of them is already handling the disposition of is father's belongings and the other may be out here to help with that later. Carlo died in mid May but because he had asked that there not be a funeral and nobody thought to put an obituary in the local newspaper the news of his passing has gotten around slowly. Cards and letters can be addressed to:

Blanche in care of Ron Campbell
225 S. 13th Street
Grand Junction, Colorado 81501.

June 3, 2005

"...but they who wait upon the Lord shall renew their strength;
they shall mount up on wings like eagles;
they shall run and not be weary;
they shall walk and not faint."
-Isaiah 40:31

May you fly faster through the heavens than you did in your dreams.

Godspeed Carlo...

Al Bowers

AVAILABLE PLANS & REFERENCE MATERIAL

Coming Soon: <u>Tailless Aircraft Bibliography</u>
Edition 1-g

Edition 1-f, which is sold out, contained over 5600 annotated tailless aircraft and related listings: reports, papers, books, articles, patents, etc. of 1867 - present, listed chronologically and supported by introductory material, 3 Appendices, and other helpful information. Historical overview. Information on
sources, location and acquisition of material. Alphabetical listing of 370 creators of tailless and related aircraft, including dates and configurations. More. Only a limited number printed. Not cross referenced: 342 pages. It was spiral bound in plain black vinyl. By far the largest ever of its kind - a unique source of hardcore information.

But don't despair, Edition 1-g is in the works and will be bigger and better than ever. It will also include a very extensive listing of the relevant U.S. patents, which may be the most comprehensive one ever put together. A publication date has not been set yet, so check back here once in a while.

Prices: To Be Announced

Serge Krauss, Jr. skrauss@earthlink.net
3114 Edgehill Road
Cleveland Hts., OH 44118 (216) 321-5743

<u>Personal Aircraft Drag Reduction,</u> by Bruce Carmichael.

Soft cover, 81/2 by 11, 220 page, 195 illustrations, 230 references. Laminar flow history, detailed data and, drag minimization methods. Unique data on laminar bodies, wings, tails. Practical problems and solutions and, drag calculations for 100HP 300mph aircraft. 3d printing. $25 post paid.

Bruce Carmichael brucecar1@juno.com

34795 Camino Capistrano
Capistrano Beach, CA 92624 (949) 496-5191

VIDEOS AND AUDIO TAPES

VHS tape containing First Flights "Flying Wings," Discovery Channel's The Wing Will Fly, and ME-163, SWIFT flight footage, Paragliding, and other miscellaneous items (approximately 3½+ hours of material).

Cost: $8.00 postage paid
Add: $2.00 for foreign postage

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

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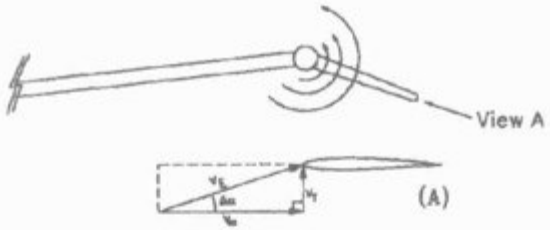

Fig. 4. Vortex/Empennage flow field (Port wing view looking aft)

$\left(1-\frac{\partial\varepsilon}{\partial\alpha}\right) > 1.0$ instead of the usual 0.7 to 0.8 for a conventional aircraft. This directly increases the stability and control contribution of the empennage. For the same empennage effectiveness the surface can now be downsized, reducing the drag contribution of the surface.

In order to model the tip vortex/surface interaction it is necessary to first model the spanwise loading of the main wing to obtain the circulation distribution to establish the strength of the tip vortex and to then model the tip vortex to define the flow field at the empennage.

Spanwise Loading Calculation

Since a combination of wing sweep and boom length is used to generate the required moment arm for stability and control, the wing theory used to model the configuration must include sweep effects. In 1942, J. Weissinger[4] developed a theory to predict spanwise lift distributions of swept wings. Instead of a straight vortex line located at the quarter cord of an unswept wing (Prandtl's lifting line)[5], Weissinger's method allowed the vortex line to be swept with a single discontinuity at the midspan location (Fig. 5). The method enforced the surface velocity tangency condition at the 0.75c point for each section of the wing. This lifting-line method became known as Weissinger's L-Method.

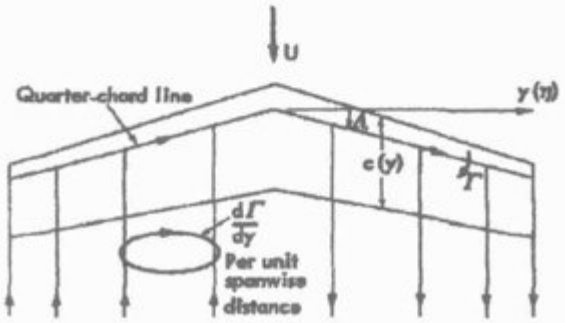

Fig. 5. Swept geometry for Weissinger's L-Method[6]

Although this method is not as detailed as current panel methods, it is fast, very efficient and is completely adequate for the preliminary design and analysis of swept-wing configurations. The method allows one to obtain spanwise loading, C_L 's, and bound circulation distributions quickly and easily. Other effects such as flaps, fuselage, booms, etc. can be easily incorporated into the model.

Tip Vortex Modeling

The tip vortex circulation is modeled as the total circulation, G_w, of the wing concentrated at that location. This follows the classical theory of Prandtl.[5] Thus, for the complete wing, a pair of counter-rotating vortices, each with a circulation equal to the bound circulation of the wing, emanate one from each tip (Fig. 6).

The total circulation of the wing can be determined from the method described in the previous section. The manner in which the tip vortex rollup is formed for this circulation can be found using Betz's[8] original theories modeling vortex behavior, which were based on idealized kinematic fluid relationships, neglected viscous effects and assumed an infinitesimal core region. Others such as Rossow[9], McCormick[10], and Grow[10] have proposed extensions or enhancements to Betz's original work. These methods do not lend themselves readily to preliminary design configuration evaluations.

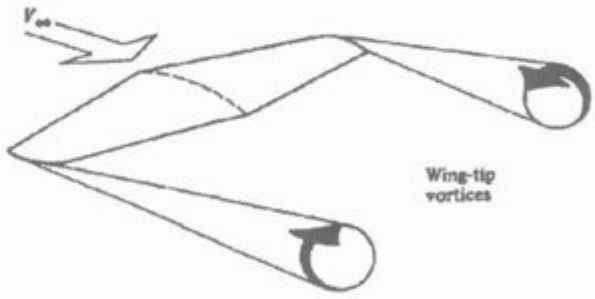

Fig. 6. Counter-rotating wing tip vortices[7]

These theories only predict fully developed vortices, where the structure and motion of the vortex itself has reached a steady state. Hoerner[11] indicates that vortical flows can be presumed to be fully developed only after the vortex has traveled approximately 4.5 wing spans downstream. For the configurations under consideration, the leading edge of the empennage begins immediately behind the trailing edge of the main wing. Thus, modeling the vortex as fully developed, such as the Betz's model, cannot accurately describe the

flow field in the region of the empennage. Rossow[9] states that an exact evaluation of just the starting points for vortex rollup would require a calculation of the complete time history of the change of the vortex sheet into final vortices. This is not practical for a preliminary design analysis.

The only alternative is to utilize experimental data to establish the vortical structures associated with the initial rollup process. Experimental wake data for a constant cord wing with the NACA 0012 airfoil section, swept aft 30°, can be found in Ref. 12. These wake data provide the velocity field, as measured using three-component hot-wire surveys, at three stations (0.05c, 1.05c, 2.025c) downstream of the trailing edge of the wing. These data sets provide a complete picture of the vortex flow field in the region immediately aft of the trailing edge of the wing.

By scaling the data using the classical vortex model, the velocity field normal to the empennage can now be determined.[13] It should be noted that only a portion of the empennage surface is immersed in the core and near vortex field which possess the high tangential velocities. However, the vortex entrains flow far past the wing tip through viscous action. To extend the influence of the vortex to the tip of the empennage, the classical model of the tangential velocity of a vortex varying inversely with the radius[5] was utilized. The velocity can be written as

$$V_T = K\frac{1}{r}, \quad \text{where} \quad r > r_{\substack{near \\ vortex}}$$

where K is a constant matched to the data to determine the transverse velocity at the last empirical point defined by $r_{\substack{near \\ vortex}}$. This allows the prediction of the complete upwash field experienced by the empennage through an interpolation of normalized sets of wake data. This vortex velocity field is superimposed onto the freestream velocity and represents a local change in the angle of attack or

$$\Delta\alpha = V_T / V_\infty \qquad (5)$$

This can be readily incorporated into the Weissinger's L-Method as applied to the empennage surface.

The dynamic pressure ratio at the empennage is then calculated by

$$\eta_E = \int_0^1 \frac{1}{\left\{\cos\left[\tan^{-1}\left(V_T/V_\infty\right)\right]\right\}^2} d\eta \qquad (6)$$

where η, the span station, should not be confused with η_E. The integrated upwash ($-\varepsilon$) and the dynamic pressure ratio of the empennage for the configuration is established. Fig. 7 shows the dynamic pressure distribution along the empennage of the configuration in question for different values of G_w. Note that the high tangential velocities (near vortex field), and therefore high dynamic pressures, are concentrated at the inboard portion of the empennage.

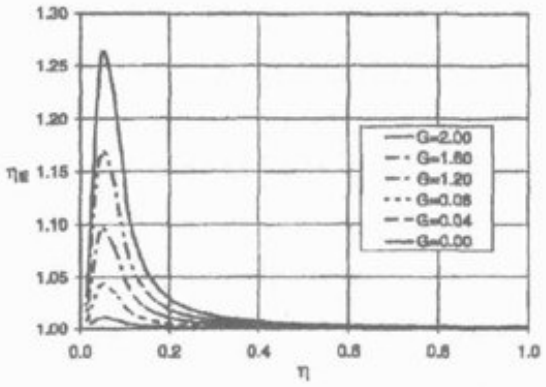

Fig. 7. Dynamic pressure ratio at empennage.

Surface Effectiveness

The effectiveness of the empennage can be characterized by an increase in the dynamic pressure ratio and by the surface being immersed in an upwash field. Fig. 8 shows the value of the empennage dynamic pressure ratio, η_E, as a function of the non-dimensional wing circulation. Notice that η_E is not significantly more than unity until G_w is on the order of 0.1. This corresponds to either the aircraft at an extremely high angle of attack (17°) or a large amount of flap deflection (δ_f>30°). Thus, for a majority of the mission time, η_E remains close to unity.

Incorporation into Performance and Stability and Control

During the evaluation of the configuration it was observed that a linear shift occurred in α_{L0} of the empennage from one value of the non-dimensional circulation of the wing, G_w, to the next. This result is due to the fact that Weissinger's L-Method is a linear theory. Thus, a new effectiveness parameter is introduced to account for this vortex/empennage interaction in the expression for the lift coefficient of the empennage, C_{L_E}, by writing the lift coefficient of the empennage as

$$C_{L_E} = C_{L_\alpha}\alpha + C_{L_{\delta_e}}\delta_e + C_{L_{G_w}}G_w \qquad (7)$$