No. 286 APRIL 2010

T.W.I.T.T. NEWSLETTER

From back to front, the Roswell, Assassin and Titan foam based models. These look like easy and quick builds and probably allow for some innovation by the builder.
Source: http://www.rcgroups.com/forums/showthread.php?t=1121604

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., **1004** means this is your last issue unless renewed.

Next TWITT meeting: Saturday, May 15, 2010, beginning at 1:30 pm at hanger A-4, Gillespie Field, El Cajon, CA (first hanger row on Joe Crosson Drive - Southeast side of Gillespie).

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

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

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

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PRESIDENT'S CORNER

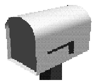
My thanks to Phil Barnes for providing a recap of his ESA Western Workshop presentation that starts on page 5. I also must apologize to those TWITT members that are also ESA members since you are seeing this twice due to the article being included in the most recent issue of *Sailplane Builder*. However, that is the synergy of editing two aviation-oriented newsletters where material can often cross over.

I was going to use some material from the Nurflugel discussion group but they have been very silent over the past several weeks. I can't believe that everything about flying wings has been covered by that group to the point there is no further discussion.

On pages 9-10 I have included a copy of an article sent to us by Steve Torpey of Bakersfield. There is no indication of what publication it came from but I thought you might enjoy it. It might be a little hard to read in this format but I needed to keep the resolution under control in order to minimize the impact it would have on the overall file size of the newsletter. If it gets too big it becomes hard to e-mail to the printer and makes for longer downloads when accessing it through the web site.

I will make my usual sales pitch for material to put in the newsletter. I would really like to have things that are personal to your project, but will take other reference materials related to flying wings that you haven't seen in past issues. It is getting harder to come up with stuff each month and with Nurflugel on the down swing, it has become more critical. Please contribute.

Andy



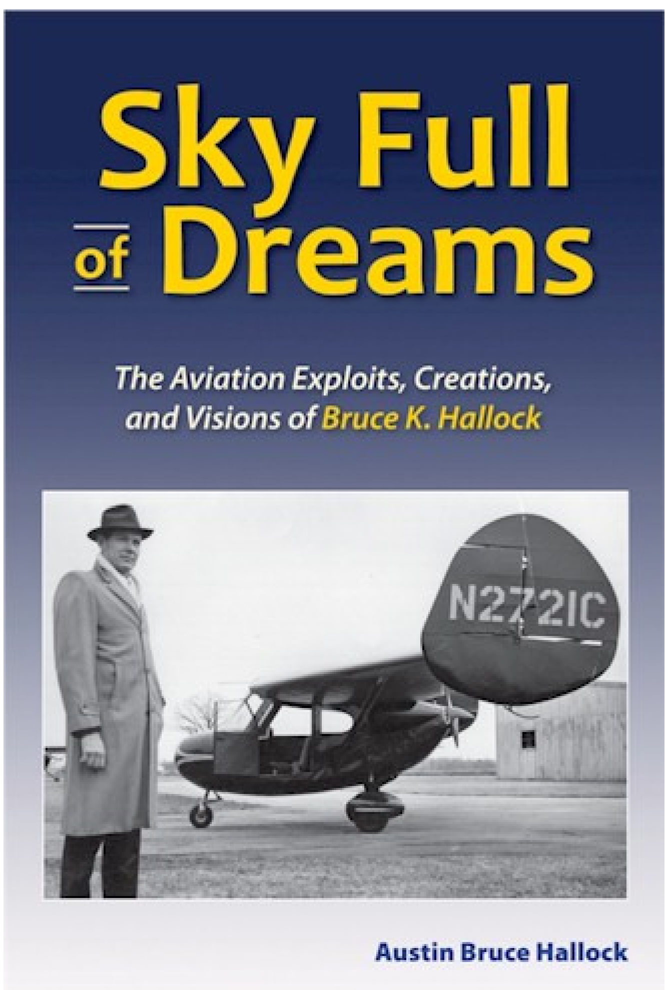
LETTERS TO THE EDITOR

March 7, 2009

I have just published a book about my father's aviation career titled Sky Full of Dreams. He designed and built several tailless airplanes, which are pictured and described in detail in the book. Information about the book can be found at ElevonBooks.com. The book is now on sale at Amazon.com.

Austin Bruce Hallock
Corvallis, OR

(ed. – If you would like to see more about this new book go to the ElevonBooks.com site then use the link to Amazon to buy a copy. I have also put a link to it on the home page of our web site and if you are viewing this in electronic format click on the cover page to be connected.)



March 19, 2010

Here is another, higher quality video clip of Evert Klienhans gull model in S. Africa. Beautiful model. (Paul McKenzie - you can see in his message that he is OK with posting on RCGroups.) I know he added more twist (washout) to the wing from what mine has. I'm going to have to quiz Evert on what other changes he made. If there is enough interest, I may even have to write another construction article!!

http://www.youtube.com/watch?v=srxLGIdx5_M

Hoey
<bobh@antelecom.net>

(ed. – This is a good video of an RC gull flying in great conditions. Evert commented in this letter to Bob, "I like the last bit where the cameraman keeps filming as the seagull flies around him!")

March 15, 2010

Enclosed is an old plan of the "Zoing". If you think Pete Loftus would be interested in it and the above two-decade-old Airbus conceptual drawing from *Flight International*, forward them to him. The Zoing would be the easiest built and could be varied in the number of aft mounted ducted fans, vertical fins, strake and outer wing panels.

You have also covered the McDonnell Douglas-Boeing Blended Wing Body designs well in the *TWITT Newsletter*. From all of these new and old designs, many variations could be tried.

Larry Nicholson
Calcutta, OH

(ed. – By the time I got this it seemed like the best way to pass it along to Pete would be through the newsletter so everyone else could share in the information and decide if perhaps a Zoing is for them. You can find the plans on the next page.

Larry also included a copy of the December 1949 Air Trails Pictorial showing a very sleek Burnelli conceptual design. It appears to have counter rotating propellers. I have included it on the page following the Zoing plans.

Thanks Larry.)

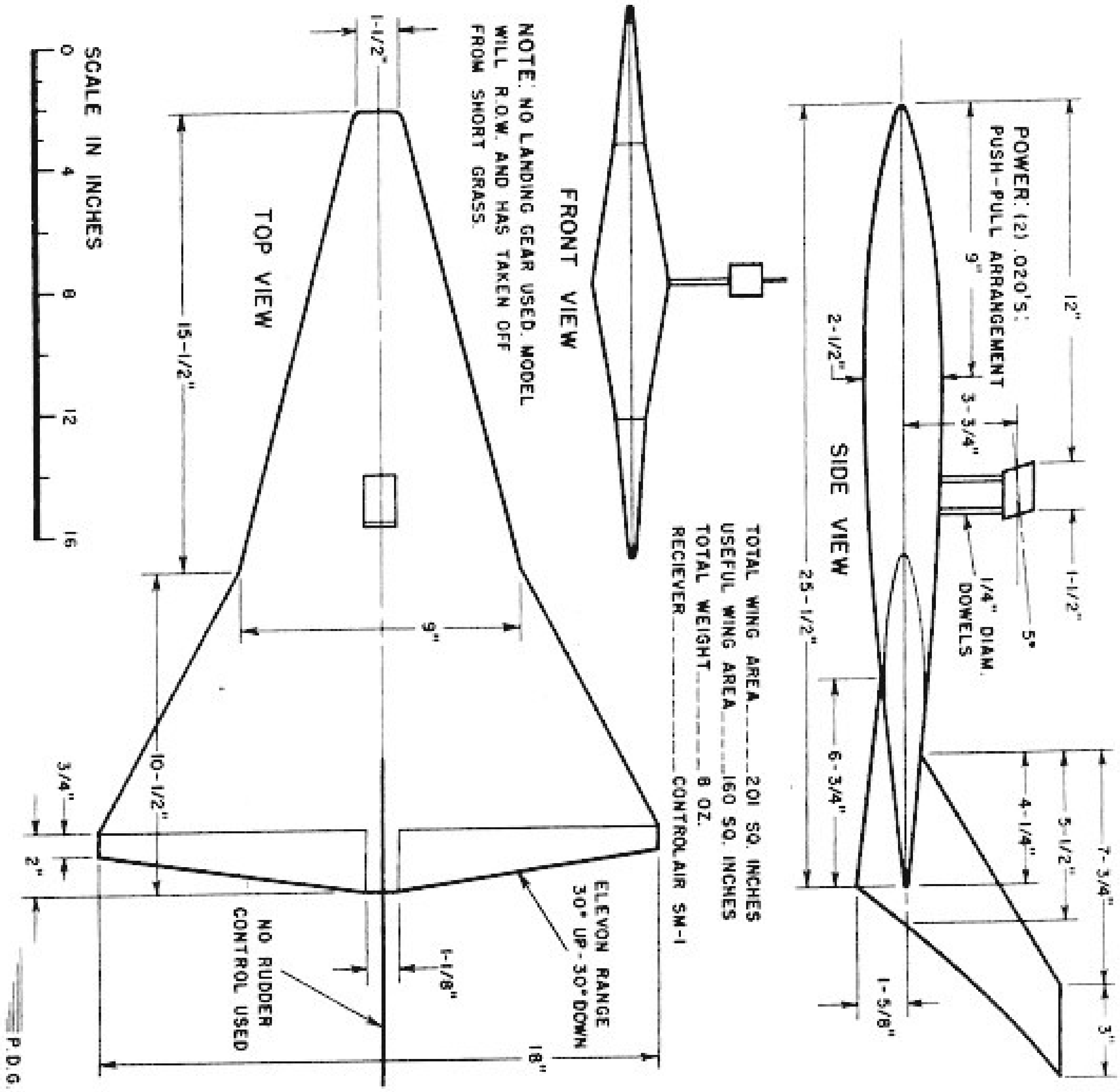
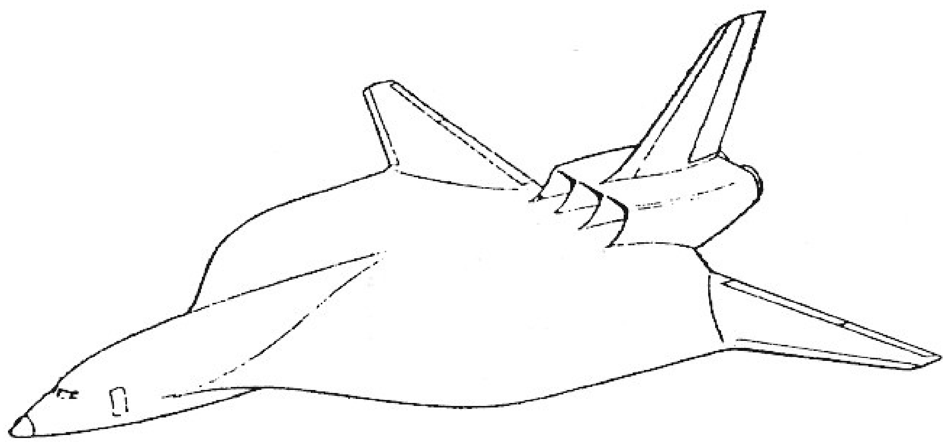
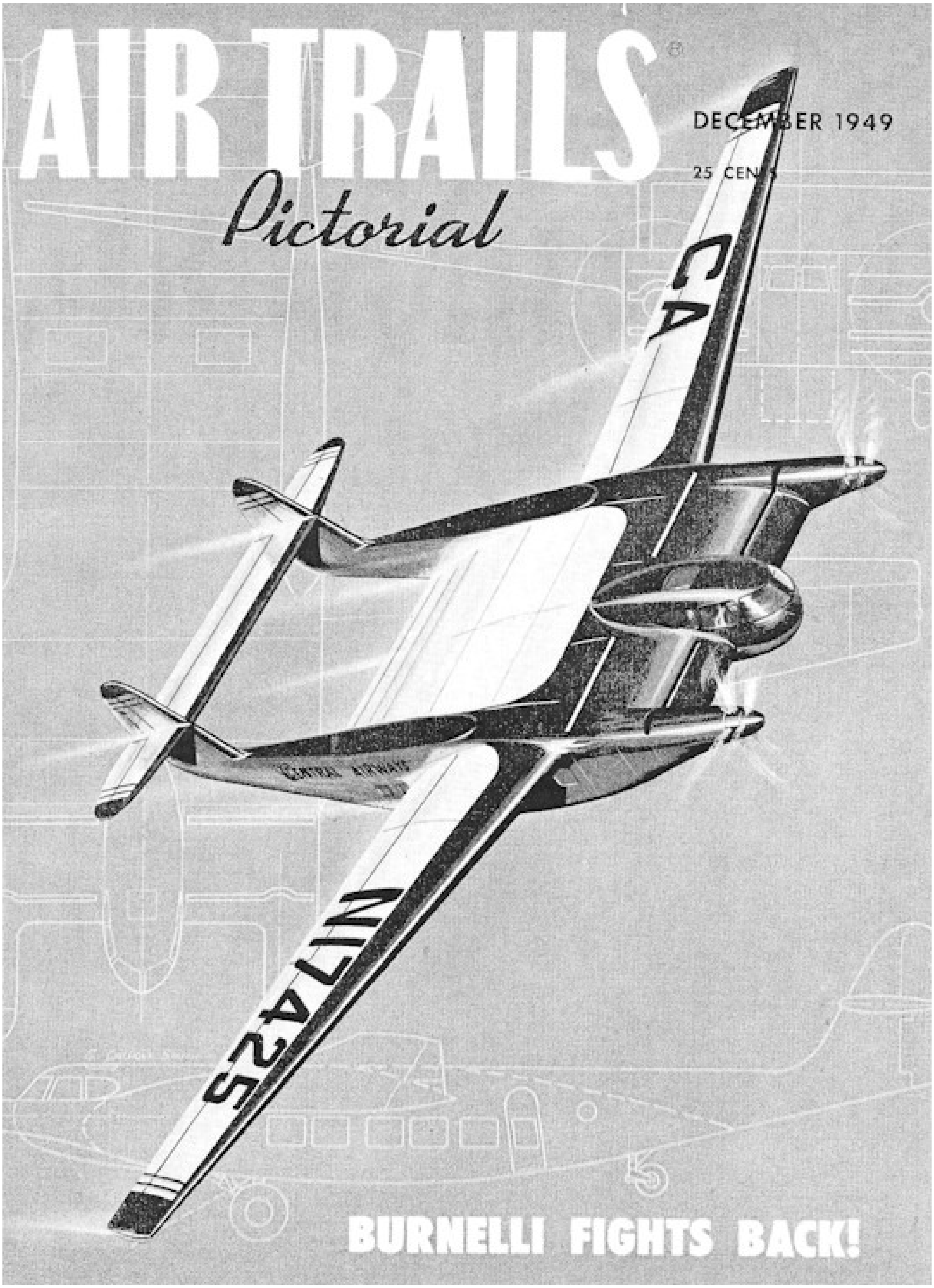


Fig. 2. Zoing, a missilelike delta by Bill Poythress was RC'ed by two .02's in tandem.




AIR TRAILS
Pictorial
DECEMBER 1949
25 CENTS
CA
CENTRAL AIRWAYS
NI7425
BURNELLI FIGHTS BACK!

Low-Speed Airfoil Design and Analysis
- Aided by the Power of the Cubic Spline

J. Philip Barnes, March 2010

INTRODUCTION

In this article, we highlight some of the new methods for low-speed airfoil design and analysis first presented by the author at the 2009 ESA Western Workshop. Our motivation is to offer more simplified, and yet more powerful, methods to define and synthesize low-speed airfoil geometry and to calculate pressure and viscous forces and moments (this article limited to inviscid flow).

We'll leverage the power of the cubic spline, together with a new formulation, to first define an airfoil with just one "spline knot" on each upper and lower surface. Then adding a few more points, we can obtain a compact, smooth, and accurate model of any airfoil. In calculating surface pressures with the well-known vortex-panel method, we'll introduce new and fundamental methods which "slay the dragon of discontinuity" when it becomes necessary to compute the panel-self-induced normal and tangential velocities. Finally the new methods, once reasonably validated with test data, are applied toward the design of an efficient, high-lift laminar airfoil.

1.0 AIRFOIL GEOMETRY DEFINITION

Traditionally, airfoil geometry has been defined by a lengthy tabulation of coordinates, (z/c) versus (x/c). Typically, 70 or so points are necessary to mitigate both the differences in interpolation methods and the risk of oscillations in computed velocity near the leading edge. An efficient and ultimately more accurate alternative is to characterize the geometry with a handful of well-placed points, then interpolating between points with a spline. Choices then become the type of spline and the type of coordinates. Herein we apply a *cubic spline* together with the *Glauert Coordinate*, the latter representing the polar angle (□) taken clockwise from the lower trailing edge. This approach enjoys "automatic" anchor points at the leading and trailing edges, enabling airfoil construction with as little as one "spline knot" on each upper/lower surface (Figure 1.0-1). For any number of knots, this approach ensures continuous curvature throughout, including the leading edge where such continuity is particularly important. EQ [1.0-1] relates the horizontal coordinate ($X \equiv x/c$) and Glauert coordinate, the latter used for cubic-spline interpolation of the vertical coordinate ($Z \equiv z/c$) as shown in Figure 1.0-2.

$$X \equiv x/c = (1/2)\,(1 + \cos □) \qquad [1.0\text{-}1]$$

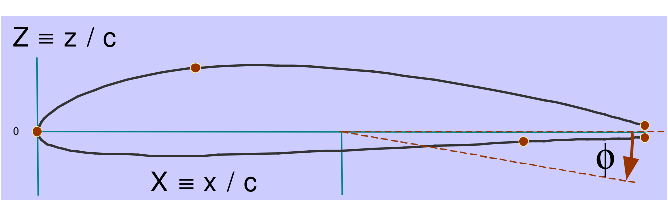


Figure 1.0-1 "One-point-per-surface" Airfoil

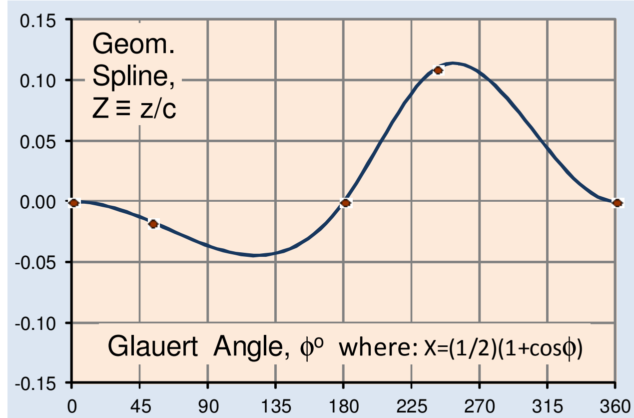


Figure 1.0-2 Spline-based Geometry Characterization

2.0 CUBIC SPLINE REVIEW AND RENEW

The cubic spline numerical method joins a series of "knots," each having coordinates (X,Y), with a series of third-order polynomials, while preserving continuity of the zeroth, first, and second derivatives at each *internal* knot. Although with this method the third derivative is in general not continuous, indeed exhibiting a "zig-zag" shape, we postulate that airfoil geometry characterized with a cubic spline will be in effect smooth, not only to the eye, but also to the air flowing over it.

3.0 PANEL-METHOD OVERVIEW

Our linear-vortex-panel method follows the general approach of Katz and Plotkin (3), but with a different approach to calculate panel-to-panel and self-induced velocities, accommodation of panel curvature, and mixed (normal versus tangential) boundary conditions.

Our objective is to solve for the distribution of pressure coefficient (c_p) and velocity along the airfoil surface in inviscid, low-speed flow. Although such modeling is "inviscid," indeed viscosity itself is essential for the development of lift by giving rise to the boundary layer and by enforcing the well-known *Kutta Condition* at the trailing edge. The boundary layer is herein modeled as an infinitely-thin continuous vortex surface with local vortex density (□), the latter positive when rotating clockwise for "left-to-right" flow. Airfoil geometry and vortex density are non-dimensionalized, respectively, to the chord (c) and flight velocity (v_o). The non-dimensional distance ($S \equiv s/c$) is integrated beginning at the lower trailing edge, including the effects of local curvature, as unit normal vectors (**n**) are computed. Applying boundary conditions, with self-induced velocities where applicable, we solve for the non-dimensional vortex strength ($G \equiv □/v_o$) at (n_v) vortex cores.

3.1 SPLINE-BASED VECTOR INTEGRATION

In Figure 3.1-1, the incremental sub vortex ($□_k$ □s) induces a velocity [$v_{ik} = □_k □s / (2□r_{ik})$] at node (i), the latter having unit normal and tangential vectors ($\mathbf{n}_i$) and ($\mathbf{t}_i$), respectively. In general, we apply the boundary condition whereby the velocity normal to the surface at node (i) is zero, and where such normal velocity is the vector sum
thereof induced by the free stream and the vortex surface. With the aid of a cubic spline, vectors, and new methods

herein for self-induced velocities, we integrate over the vortex surface for the non-dimensional normal velocity (□$_i$) at each node (i). To avoid numerical difficulties near the trailing edge, we apply the *tangential* counterpart of this boundary condition at two or more panels near the trailing edge.

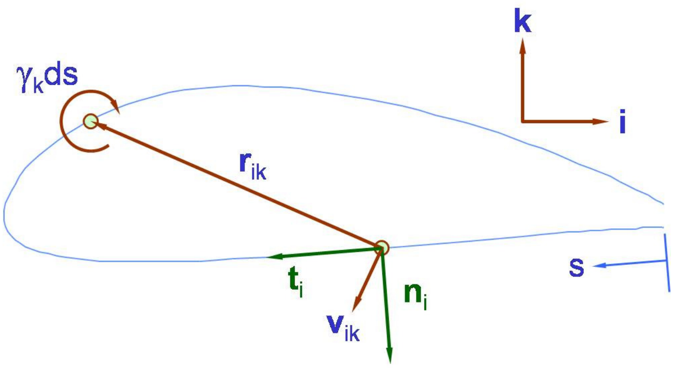


Figure 3.1-1 Induced Velocity Vector Integrand Constituents

3.2 PANEL-SELF-INDUCED NORMAL VELOCITY

At the center of panel (a-b) in Figure 3.2-1, we now compute the panel-self-induced normal velocity. The simplest study treats the panel as flat, but it can be shown that a fixed radius of curvature will have no effect. First, we characterize the local non-dimensional vortex density (G=□/v_o) as parabolic with non-dimensional distance (S) from the panel center. G(S) is then distilled to three isolated components representing the average, first derivative, and second derivative. By inspection, the effects of the average cancel. Also, paying careful attention to sign, we discover that the effects of the 2nd-derivative also cancel, whereby we need concern ourselves only with the 1st derivative (dG/dS), given by [$(G_b-G_a)/(S_b- S_a)$].

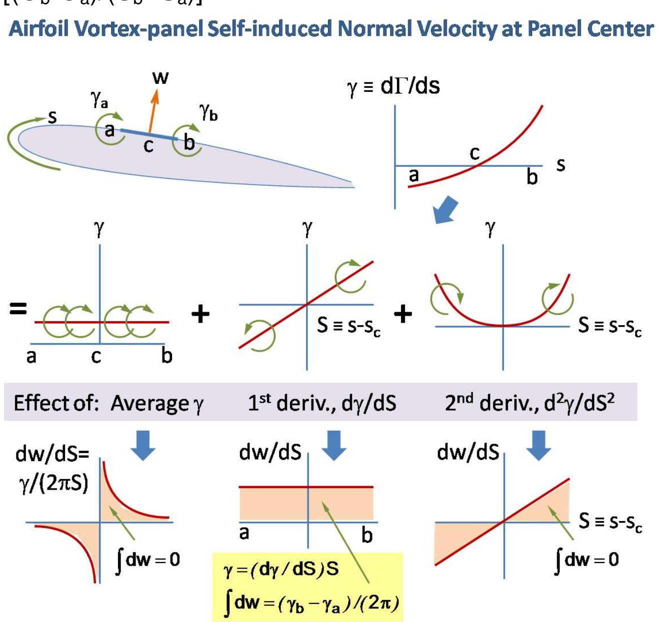


Figure 3.2-1 Self-induced Normal Velocity Study

3.3 SELF-INDUCED TANGENTIAL VELOCITY

When integrating induced *normal* velocity, we find that the strong mutual influence of upper and lower panels adjacent to the trailing edge leads to relatively large integrands together with mid-panel sign changes. These phenomena locally de-stabilize the solution for vortex strength. An alternative boundary condition, based on the *tangential* induced velocity, essentially resolves this problem. As before, however, we encounter the need to compute panel-self-induced velocity when integrating effects of the vortex surface.

Assuming the vortex panel is flat, a first look suggests that the panel-self-induced tangential velocity is either zero or perhaps undefined. However, taking into consideration the finite thickness of the boundary layer, while recognizing that the local velocity of interest resides just outside the boundary layer, we find that the self-induced tangential velocity is not zero. Figure 3.3-1 derives the self-induced tangential velocity increment (dv_t) which, integrated in the limit as the b'layer thins, yields the self-induced tangential velocity of EQ 3.3-1.

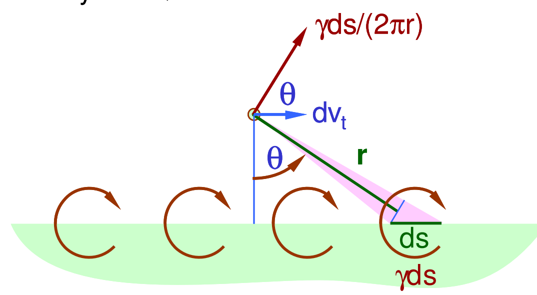


Figure 3.3-1 Panel Self-induced Tangential Velocity Study

$$\Delta\tau \equiv \frac{\Delta}{\quad} = \frac{\quad}{\quad}\int^{\pi/} \frac{\gamma}{\pi} cos\theta$$

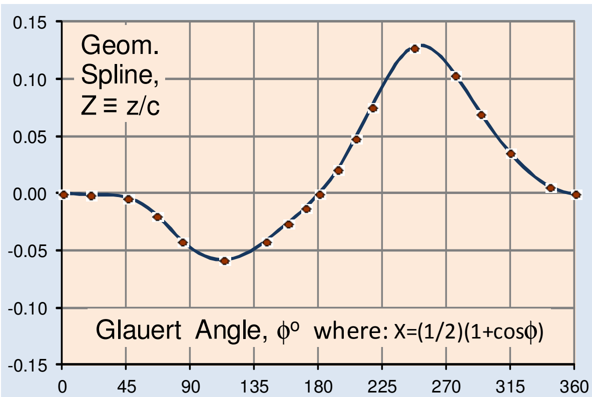
$$= \frac{\quad}{\quad}\int^{\pi/} \frac{\gamma}{\pi}\frac{\theta}{\quad} = \frac{\quad}{\quad}\frac{\gamma}{\pi}\int^{\pi/} \theta$$

$$= \frac{\gamma}{\quad} = \qquad -$$

A similar analysis to that carried out for the normal velocity reveals for tangential velocity that the effects of (G'=dG/dS) cancel, whereas the effects of both the average and 2nd-derivative remain. However, we will assume herein that the effects of the 2nd-derivative on panel self-induced tangential velocity near the trailing edge can reasonably be neglected. To end this section, we note that a reasonable solution can be obtained applying the tangential boundary condition throughout, but at some expense in "numerical stiffness."

3.4 METHOD VALIDATION

The method obtains a good match with test data as shown for three airfoils in Figures 3.4-1 though 3.4-3, the first three sub-figures representing the geometry spline, vortex density, and pressure coefficient of the FX66 airfoil. Recall that the magnitude |G| is the ratio of local-to-flight velocity. For example, we see that the maximum upper-surface velocity is 60% greater than flight velocity. Looking more closely, we observe the stagnation point (G=0) to reside on the lower surface at about 0.5% of chord aft of the leading edge At the trailing edge, the airflow slows down to 85% of flight velocity. With further inspection, we notice upper-surface laminar-to-turbulent transition at 48% chord (62% lower surface). By plotting either (G) or ($1-c_p$) versus (X), the upper surface naturally resides on top, without the need for scale inversion.



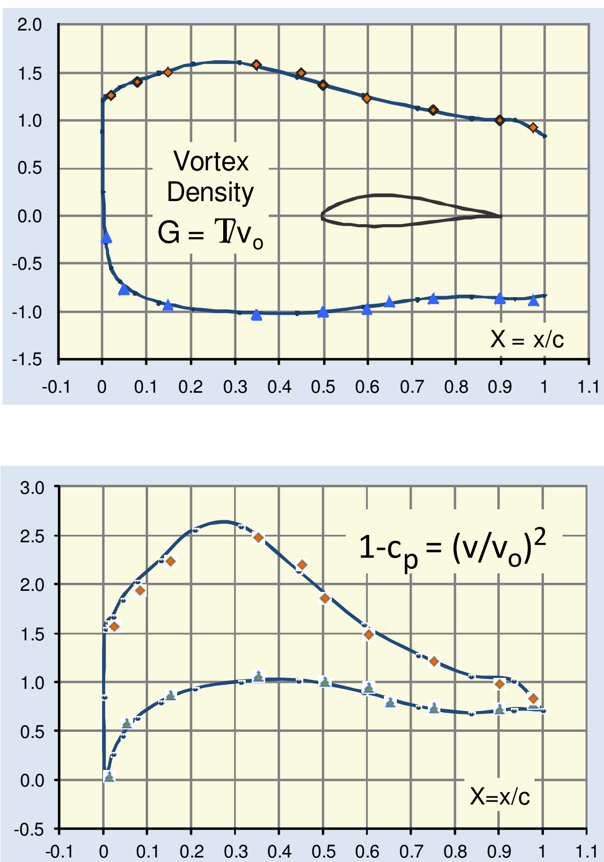


Figure 3.4-1 Method Validation, FX66 Airfoil, □=4°

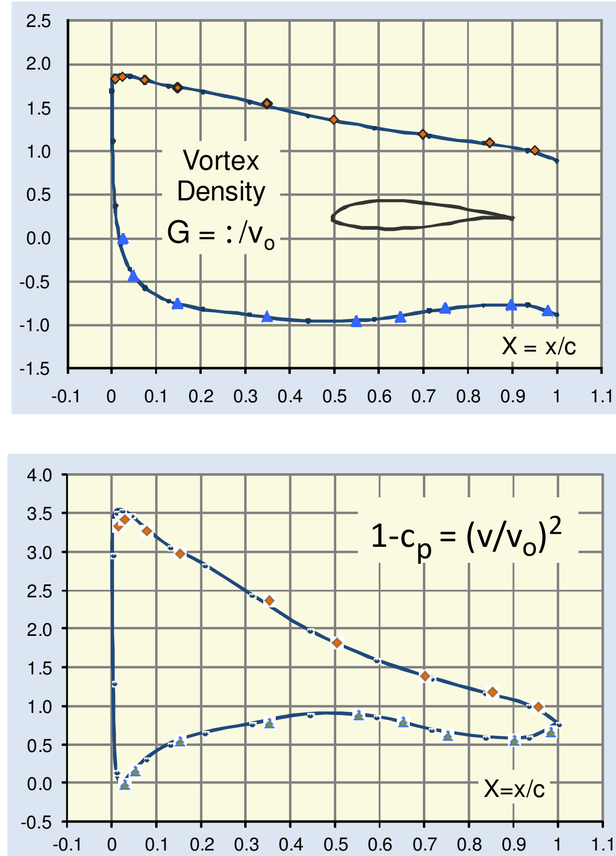


Figure 3.4-2 Method Validation, NLF(1)-0416 Airfoil, □=8°

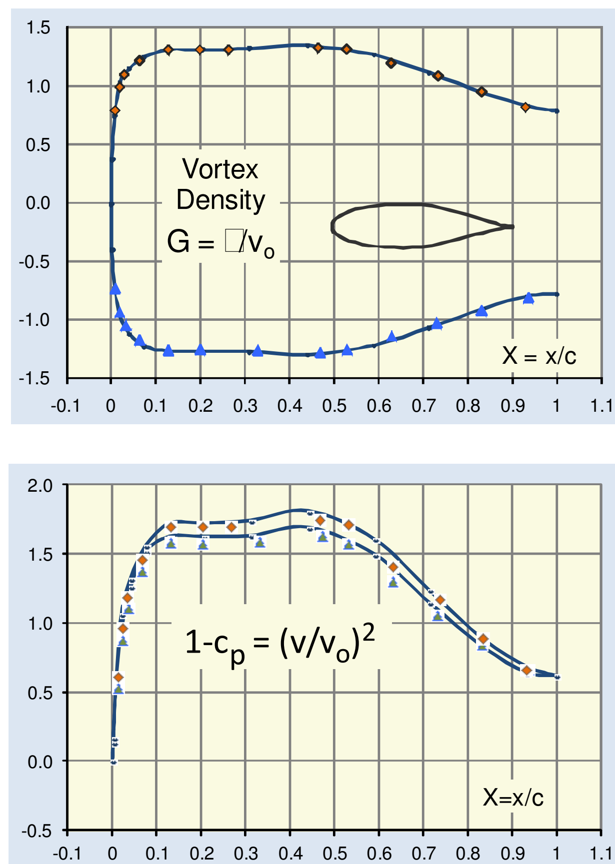
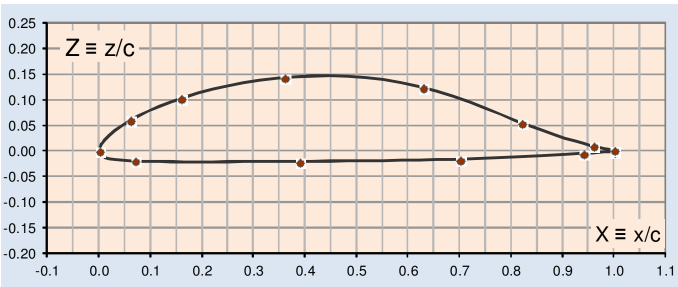
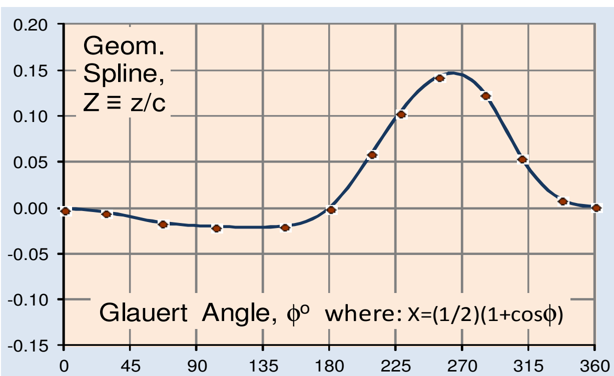


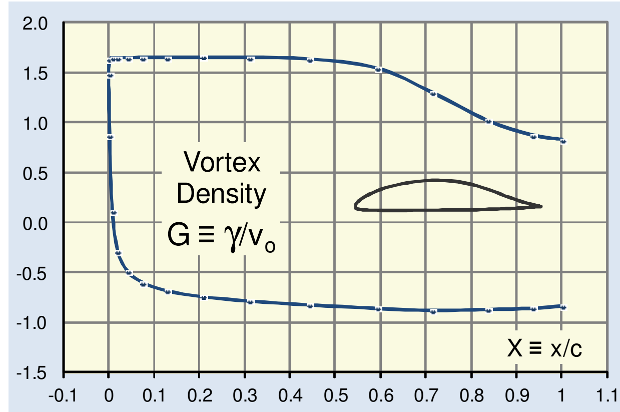
Figure 3.4-3 Method Validation, NACA 45-125 Airfoil, □=0°

4.0 METHOD APPLICATION

Finally, we apply the foregoing methods to obtain the PCS-001 laminar airfoil of Figure 4.1. This airfoil, defined by 13 spline knots, incorporates the well-known "laminar rooftop" feature for high lift and low drag. Selected knots on the upper forward surface were manually adjusted to obtain the desired "plateau" represented by constant pressure and constant velocity. Not yet knowing its stall characteristics, further analysis and testing are needed to assess its suitability for safe flight.







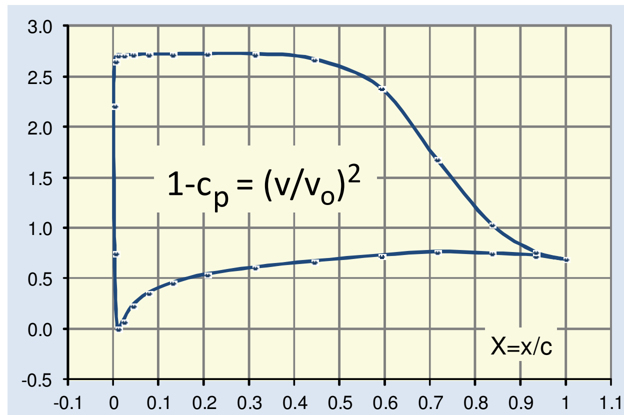
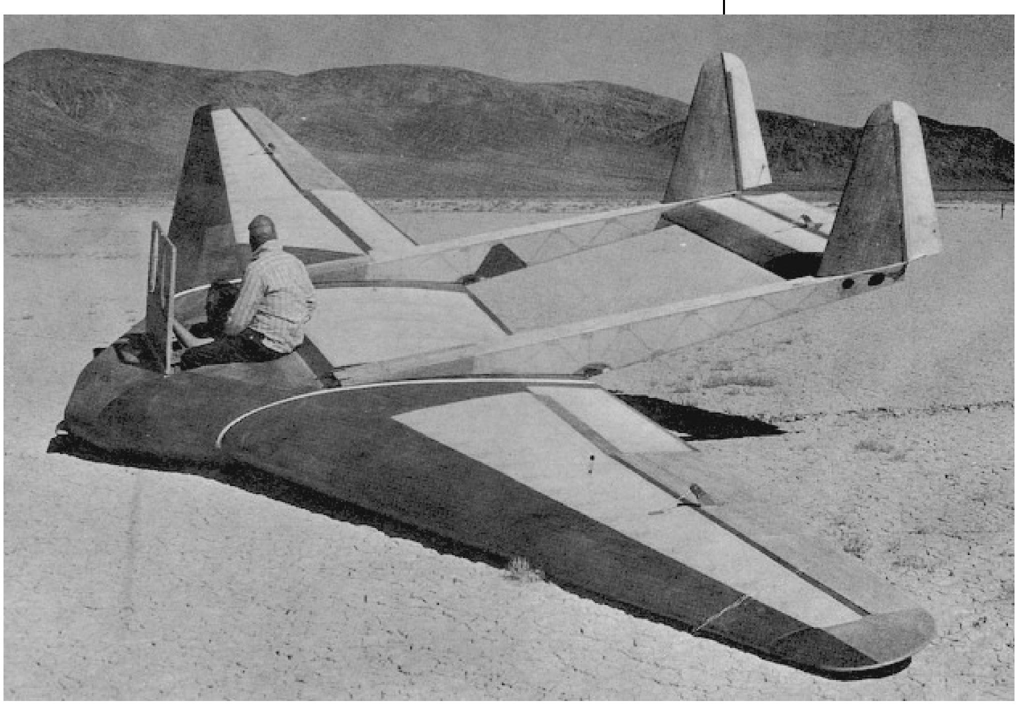


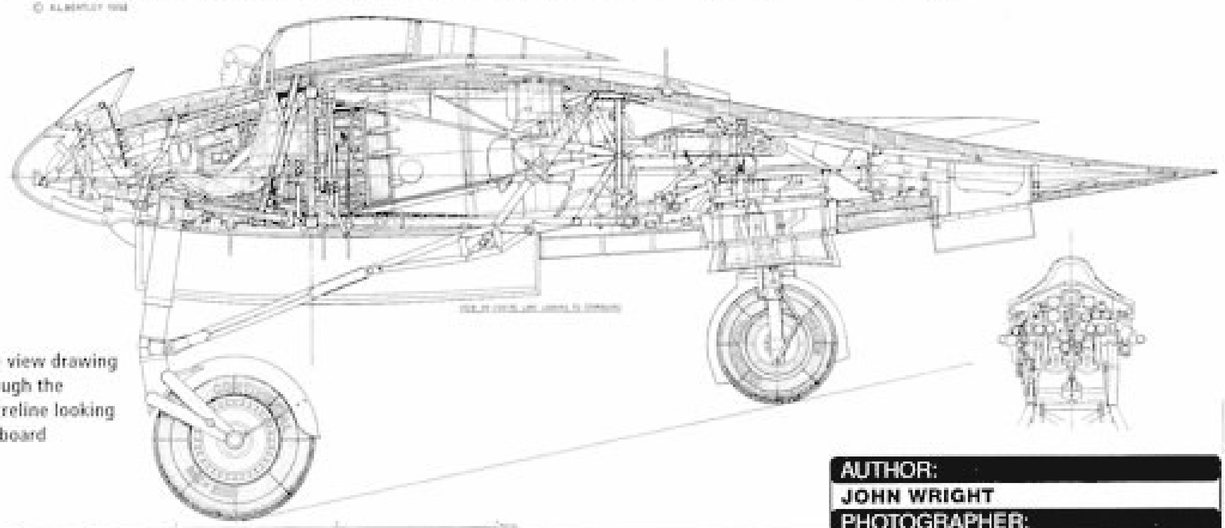
Figure 4.1 PCS-001 Laminar Airfoil, □=6.9 °



This is a scale, flying version of a Hawley Bowlus concept design for a troop glider for the Army Air Corps. Compare this to the Burnelli design on page 4. The article in Aeroplane Monthly, May 1990, indicated the Air Corps contacted the Burnelli company to grant a license to Bowlus' company so the project could proceed. However, the article doesn't mention if Bowlus had actually been influenced by Burnelli in coming up with design.

HORTEN Ho229 INTRODUCTION

The Editor introduces the famous Horten Ho229 with two building articles to follow



Side view drawing through the centreline looking starboard

AUTHOR:
JOHN WRIGHT
PHOTOGRAPHER:
HISTORICAL ARCHIVE AND DRAWINGS COURTESY ARTHUR BENTLEY

In the course of the next few issues we plan to feature the construction of two different size Horten model aircraft.

The first one is to a scale of 1:8 and is powered by EDF, and has a wingspan of 82". It is available as a kit both in all wood or as a deluxe short kit with a glass fibre centre section. This was designed by Gary Hethcoat in the USA with the help of noted draughtsman Arthur Bentley, and the plane is being constructed by Paul Sforza. The original model constructed by Gary has flown successfully and video of it flying is available.

The second plane is 1:5 scale to the CNC design of Ralf Bendel and Heiner Skroblin, and I saw Heiner's version flying at Porz in 2007. This is not available as a kit but as a special favour I obtained a set of CNC cut ribs, outline plans and the main materials required, plus a large number of photos that were taken during construction. This plane was originally designed for two 120 mm EDF Deis fan units. The plane being constructed is for two MW44 gold engines which produce similar thrust and are a similar weight to the fans. The plane has a wingspan of 3.36 m.

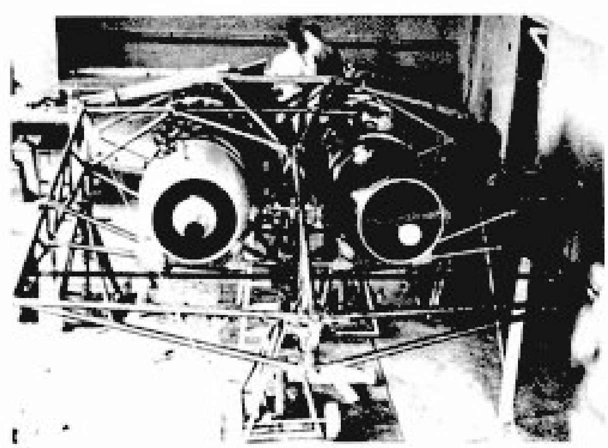
From a modelling perspective this is one of the ultimate design challenges. Two large Horten Ho229s have been built and flown successfully. The Dutch Horten of Erik van den Hoogen I hear is no longer flying and the only other large Horten that I know of is the one that John Greenfield built some time ago. We have no guarantee that these aircraft will fly so it should make the first flights an exciting event.

Historical Perspective

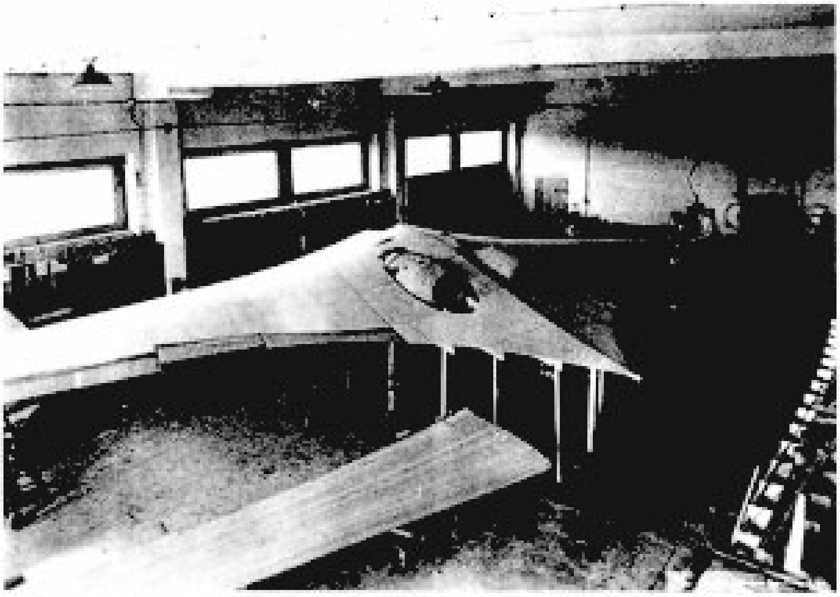
On 18 February 1945 Erwin Ziller took off in the twin engine Ho229 for its 3rd fateful flight. This flight was the culmination of the work of the Horten Brothers, Reimar and Walter. During this flight the speed was measured at 795 kph using a theodolite. The plane flew for some 45 minutes and soon after one engine flamed out. Despite Erwin's efforts he was unable to restart the engine and crashed due to lack of airspeed as the undercarriage was lowered. He was killed and the plane written off.

It was a significant moment in aviation, as there had only been a handful of jets that had flown at all, and most were by comparison rather crude aerodynamically. The Ho229 was amazingly advanced for its day, as it was stable enough by virtue of the way the wing was shaped. It had no tail or fin and the fuselage was simply a thickened wing section. The aircraft's statistics tell it all. The power to weight ratio was only 0.26. Its landing speed was 130 kph and the projected maximum speed was 840 kph. Unbeknown to the Horten brothers at the time the airframe was also a very low radar cross section, due partly to the shape and partly the type of plywood that was used in the construction.

In many ways it is one of the most elegant aerodynamically of any jet plane ever made. The design worked out over many trials with a series of gliders had resulted in a design where the lift from the wing provided a lift that varied along the span and gave the now famous 'bell shaped' distribution. The wing uses the way the vortex is produced at the tip to make the design stable in yaw without the fin. This was a stunning achievement and it was only with the use of high power computers that the B-2 stealth bomber design without a fin was to fly again, some 45 years



The 'Birdcage' tubular construction of the centre section



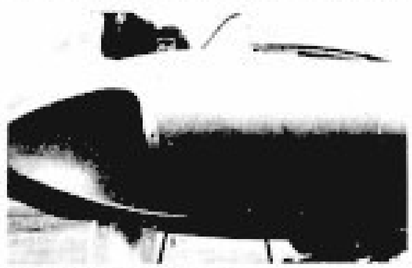
Assembly of the V2 version in the garage where the plane is nearly completed but not painted. Note the outer elevon and 2 inner flaps

later. The aerodynamics is a complex issue and not without some debate. We hope to look in detail at it in a future issue.

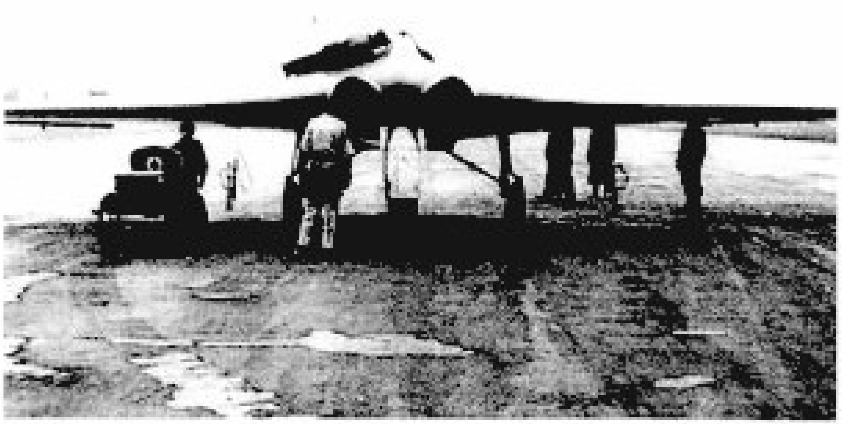
Production of the prototype V2 was in a three-car garage and there was only a handful of dedicated staff. The Horten brothers did benefit however from high-level patronage, which went against them after the war ended. Karl Nickel carried out most of the calculation for the aircraft.

After the war the various aircraft were gathered up as part of operation 'Paperclip' and the nearly completed V3 was transported back to the USA. It is still in existence but in a sorry state of repair. It is a shame that such an important aircraft has not been fully restored, as many of the factory working drawings still survive. Initially there were hopes that it might be completed and test flown but these came to nothing. There were deficiencies in safety matters and it would have been a very brave pilot to have flown it in the original configuration and with the original unreliable engines.

The drag rudders extended (with the wings held in a vertical position in the storage cradle)



Erwin Ziller at the controls



We have been very fortunate to obtain the drawings and gain the approval of Arthur Bentley to use his drawing and photos for this article. Arthur is a world-renowned aircraft draughtsman and has made the Ho229 something of a lifetimes work to understand and fully document. He has visited the original in the USA several times and started his drawings back in 1967. They culminated in the excellent book 'Horten Ho 229 Spirit of Thuringia' Written by Adrei Shepelev and Huib Ottens published by Ian Allan Publishing. ISBN 1-903223-66-0. It is 'the' reference book for anyone interested in the Ho229. Arthur does a series of his superb drawings and will supply them for a modest price. http://www.albentley-drawings.com/main.htm

The central tub of the plane is made of a complex tubular space frame and the skin is attached at specific places. This is a highly complex and difficult structure to detail and to draw. The tub has anchorage points that the wings are hung from. The wings are largely of wood with many layers of ply strengthening pickup points. The fuel tanks are located inside the wing panels.

The wing control surfaces are elevons on the outer sections that are Friese type with an action that provides part of the lower surface that protrudes into the air stream and 'digs in' to the airflow under the wing surface to provide more action for the turn. The manufacturer Gotha, was not that happy with them and intended to have normal ailerons on their P60 flying wing design. The wing can mask the action of the ailerons when the plane is in a steep climb and it may be necessary to lower the nose to make a turn.

The drag rudders on the originals were fashioned like a typical speed brake for a glider with a 'pop-up' section with holes drilled in it to give drag. This further aids turning the aircraft and also by deploying all simultaneously increases drag to slow the plane down for landing.

There are two sets of flaps that lower further on the inner surface than on the outer one. By raising the elevons and lowering the flaps it is possible to have 'crow' braking to lower landing speed. On the original there was a speed brake on the underside of the centre section that popped down a glider type airbrake with a series of holes in it.

On the original the fuel tanks were in the outer section wing. On a model there is ample room to site fuel in the centre section. During the articles we will endeavour to highlight the differences between the approaches taken in building these 2 aircraft and avoid too much duplication.

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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.

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VHS tape of July 15, 2000 presentation by Stefanie Brochocki on the design history of the BKB-1 (<u>B</u>rochocki,<u>K</u>asper,<u>B</u>odek) as related by her father Stefan. The second part of this program was conducted by Henry Jex on the design and flights of the radio controlled Quetzalcoatlus northropi (pterodactyl) used in the Smithsonian IMAX film. This was an Aerovironment project led by Dr. Paul MacCready.
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An Overview of Composite Design Properties, by Alex Kozloff, as presented at the TWITT Meeting 3/19/94. Includes pamphlet of charts and graphs on composite characteristics, and audio cassette tape of Alex's presentation explaining the material.
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