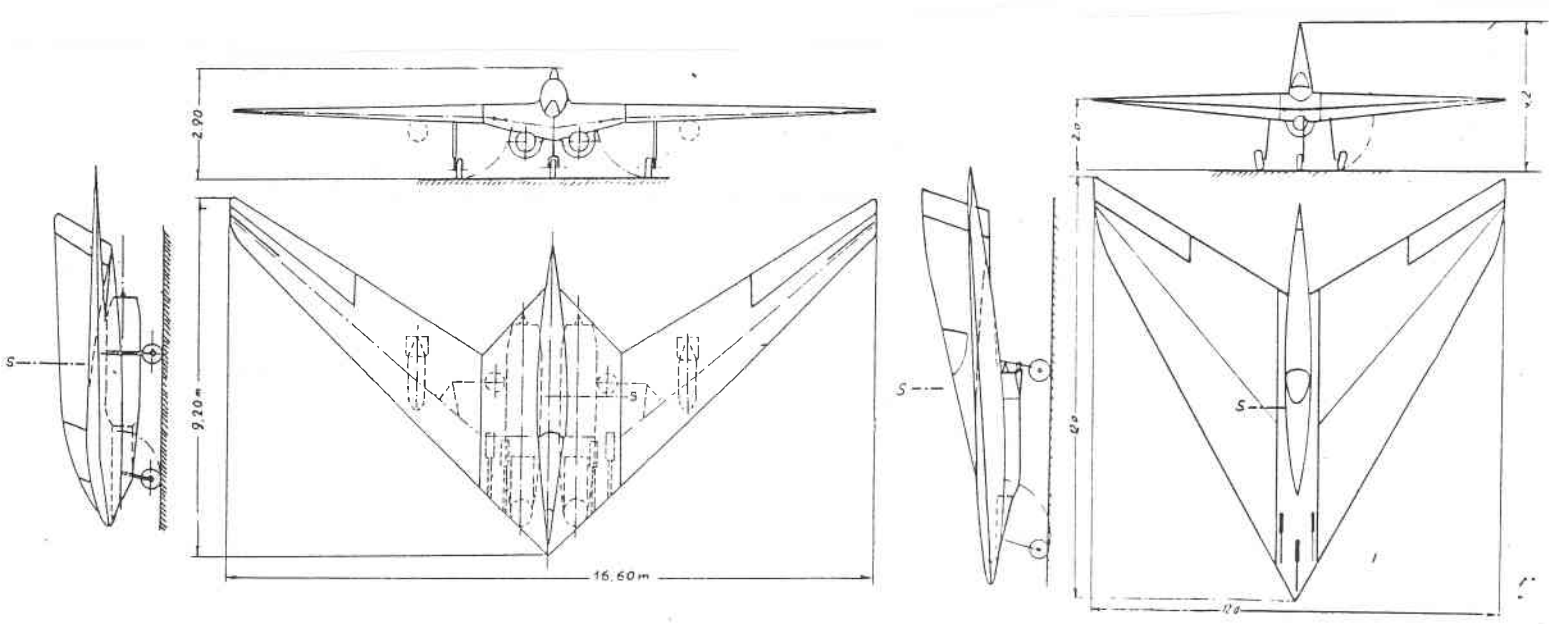
No. 99 SEPTEMBER 1994

T.W.I.T.T. NEWSLETTER

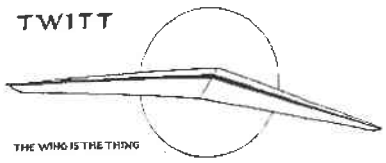


LEFT: Ho IXB. RIGHT: Ho XIIIB. Caption: "Even here there were numerous variations and it's not certain that al were true Horten designs." Source: Lippisch P13a & Experimental DM-1, by Hans-Peter Dabrowski, Schiffer Military History, Atglen, PA, 1993, p. 45. (Book donated to TWITT Library by Chris Tuffli.)

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

The number to the right of your name indicates the last issue of your current subscription, e.g., **9409** means this is your last issue unless renewed.

Next TWITT meeting: Saturday, September 17, 1994, beginning at 1330 hrs at hanger A-4, Gillespie Field, El Cajon, CA (first hanger row on Joe Crosson Drive - East 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, east side of Gillespie).

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PRESIDENT'S CORNER

I won't go into details here, but if you didn't get to the SHA Workshop at Tehachapi over Labor Day weekend, you missed one of the best ever. There were more flying wing type aircraft than every before, and lots of flying. From what I saw the technical sessions were all good and well attended, despite the favorable flying conditions.

It is time for another "send me your cards and letters" plea. There has been a noticeable drop in the incoming mail letting us know what you are doing out there, or what it is you want to see in future newsletters. If you have found some material that might be of interest to other members, send it in and we will see what it takes to republish it (copyrights and all that stuff). The newsletter is all about sharing information, so get out your pencils, pens, typewriters or computers and send in your contribution.

I would like to remind those of you with computers that I use an MS-DOS version of WordPerfect 5.1. However, if you have a MAC version of 5.1, or some other word processing software, simply save the article as an ASCII file (.TXT or similar) and send it along. I should be able to convert it, but just in case also send a printed copy so I can adjust for the differences in puntuation marks, etc.

This issue has a lot of AIAA abstracts in it that might be of interest to some of you. There is also an order form for AIAA material that you may want to make photocopies of it in the event you decide to place one or more orders at a later date. It will also provide you with their 800 number so you can call for price information before deciding on that purchase.

Most of you have now read where the U.S. Congress has passed General Aviation Revitalization Act of 1993 with an 18 statue of repose. This will mean a resurgence in the production of general aviation aircraft, and perhaps bring some new models onto the market. Keep an eye on your favorite aviation magazines for more on this in the coming months.

That is all I have for this month. Hope your summer flying was fun.

Andy

SEPTEMBER 1994 PROGRAM

This should be a very special program since we will have **Barnaby Wainfan** as the main speaker. He will be telling us about his new design, the **FMX-4** *(see below)*, and if everything has gone right on the way back from Oshkosh, he should have the aircraft at the meeting for everyone to inspect.

The FMX-4 was built by the team of Barnaby (a Northrop aerodynamics engineer), his wife Lynne (Hughes control systems and dynamics engineer), and Rick Dean (retired Hughes Helicopter and McDonnell Aircraft design engineer). Dave Morss made the initial ground effects flight tests and Chino Airport in the Spring of 1993, and Peter Lert made the first test flight on April 22, 1993. Peter is the one now trying to get it back from Oshkosh.

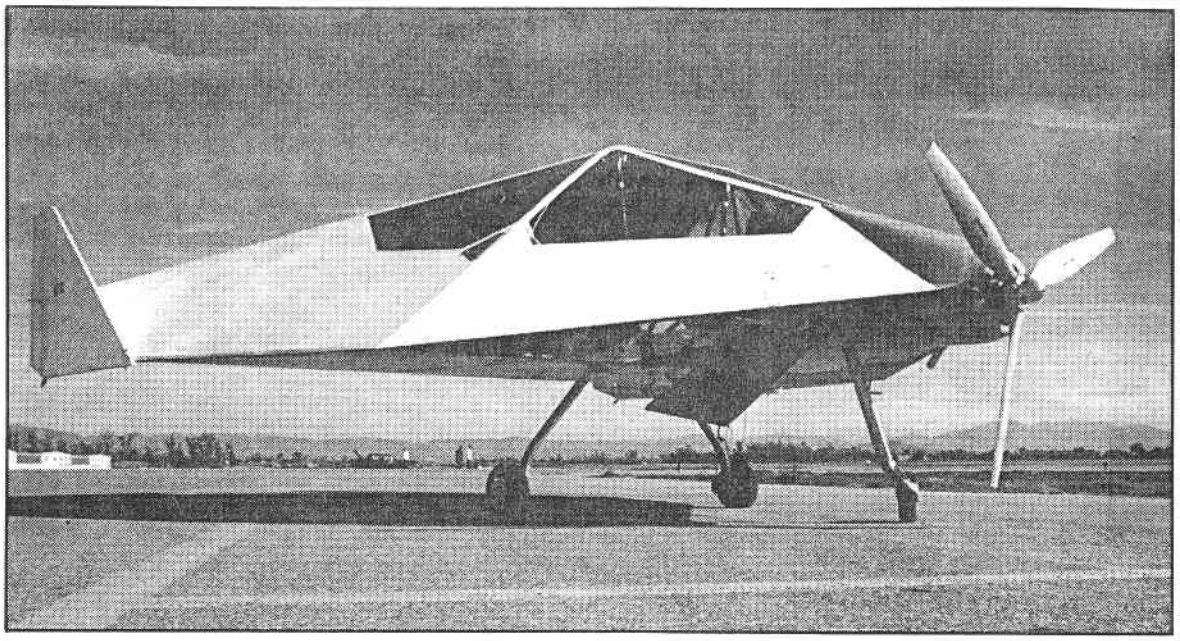
rudder travel exceeds 30 degrees and both rudder pedals can be pushed forward at the same time.

Barnaby is considering the possibility of eventually marketing kits of his design, but not before he has had a chance to refine the aircraft a bit more.

It looks like we will also have some forward swept wing RC models at this meeting courtesy of Paul Stahlhuth. They look fascinating from the photos accompanying his letter, and he says they fly very well. If your looking for new building ideas this will be for you.

This is a program you definitely do not want to miss. It is flying wing design in action, which is what it is all about.

SO BE THERE ! ! !



The structure is 6061-T6 aluminum tube covered with 1.5 ounce Stitts dacron. Control surfaces consist of rudders on the fins that only move out-board to 30 degrees and two elevons and a central pitch trim flap at the rear of the body.

It is powered by a 49.5 hp Rotax 503 engine, has a span of 15' and length of 19.5' (or 214 square feet of thing area). Empty weight is 370 lbs with a gross weight of more than 600 lbs. The wing loading is about three pounds per square foot, so it is a bit wind sensitive (crosswinds are a no no).

It took Barnaby and this team two and half years to build the FMX-4 and another year to work up the systems.

It cruises at about 80 mph and has a climb rate of 700 fpm, with a takeoff roll of about 600', while landing speed is in the 45-50 mph range.

Wheel braking is controlled by the rudder pedals. The brakes are activated when the

LETTERS TO THE EDITOR

7/29/94

TWITT

I read with interest your comments about my bibliography. I am pleased to make it available, without charge, to other flying wing enthusiasts. However, I would like to replace that rough draft with a more finished version that I have enclosed.

The minutes of the Lilienthal Society meeting held April 14, 1943, may be available as a series of articles. I will attempt to locate a domestic source and send you a copy. However, I was told that in this article,

Reimar and Walter did little more than recap their work over the previous ten years.

Thank you for the VHS tape. Very good, particularly the Northrop story and, of course, the HoIV footage - excellent!

Sincerely,

Russell E. Lee
Curator
Aeronautics Department
Smithsonian Institution
Washington, DC 20560

(ed. - I am assuming from your letter that you would not mind providing anyone who wrote to you a copy of the bibliography, so I included your mailing address. If this is not what you meant, please let me know and I will make the material available at cost to those who are interested.

I am sure that there are some members out there that would love to read the articles you mentioned even if they were a recap of previous experiences. There are a lot of people out there hungry for any information coming directly from Reimar Horten.

I'm glad you enjoyed the video. It has been one of your most popular items, along with the audio tapes of Don Mitchell's two presentations.

Thank you for your efforts in providing bits of information from you sources at the Smithsonian. I am sure I speak for all the members who will probably take advantage of it in the future.)

6/27/94

TWITT:

I apologize for the mix up in my membership dues submission. The enclosed check should bring me current - thanks.

I will miss the July meeting because I will be in Tehachapi that week at an elderhostel program covering aviation and the space program at Edwards, plus studies of full size gliding and soaring - and hopefully a flight in a sailplane.

I expect to attend the September meeting and will bring along my forward swept wing (FSW) RC sailplanes.

The black model ("MANX") is my first FSW RC design, 66" span, 40 oz., and is a delight to fly - stable but slow rolls on rudders only. I'm using differential rudder throw; larger angle on rudder on inside of turn.

The small white version was a disaster; tends to spiral dive on the slightest rudder commands. I think I gave it too much vertical surface area.

The yellow FSW sailplane (LAMBDA - the Greek letter representing an inverted vee tail) is also a pleasure to fly. It has a 40" span, 17 oz., mixed rudder and elevator controls only. Again, very stable, but maneuverable.

Both of the successful designs turn very sharply without tip stalling. Increasing "UP" trim in level flight results in a relatively flat, controllable "mushing."

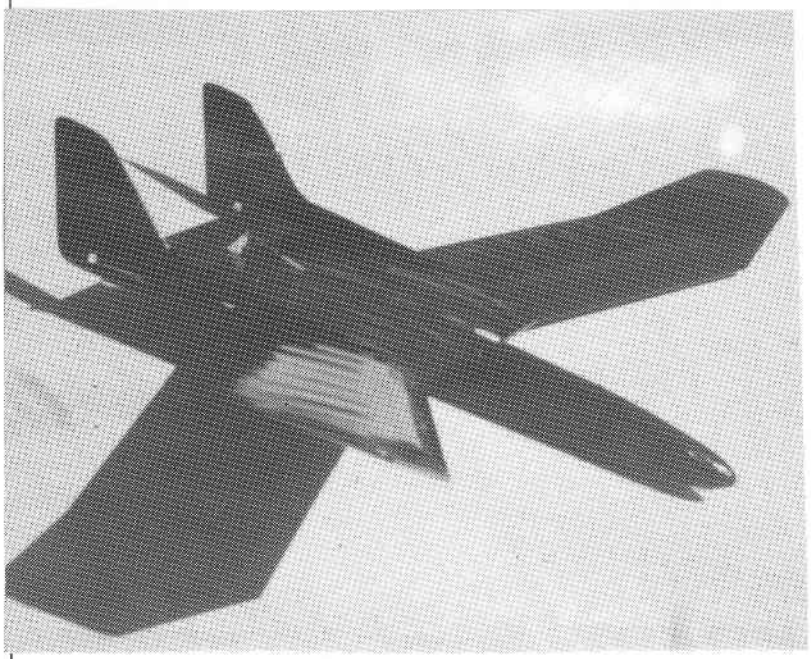
I'm building a 75" span, lighter, and reduced airfoil thickness version of the MANX.

Hope I'll see you in September.

Paul Stahlhuth

(ed. - Thanks for the letter and accompanying pictures. I have published the best ones to try and wet everyone's appetite and come see them at the meeting.

I know there are other modelers out there with projects similar to yours. I hope this will spur some of them to submit a letter describing their aircraft, its flying qualities, and if possible include some pictures. What do you say guys??)



THE "MANX"

8/1/94

TWITT:

The April '94 issue arrived here while I was in deep trouble because of a virus caused illness; the darned bug has been eventually defeated and I am in full swing again.

I can, therefore, translate and summarize the two articles on the Horten designed PUL 10 tailless, which appeared in the September and December 1993 issues of the Italian magazine VOLARE SPORT (Sport Flying).

The basic statistics of the PUL 10 are as follows:

Type:	Tailless Powered Plane
Seats:	Two Abreast
Engine:	Rotax 582, 64 hp
Wing Span:	10 m
Wing Area:	15.45 sq. m
Length:	3.95 m
Width of Central Section:	2.45 m
Height:	1.45 m
Empty Weight:	245 Kg
Max Take Off Weight:	450 Kg
Wing Loading:	29.12 Kb/sq. m
Fuel Tank Capacity:	90 liters
Cruise Speed:	155 Km/h
Max Speed:	200 Km/h plus
Stall Speed:	60 Km/h

The retractable landing gear has a front castering wheel and two main wheels; it is operated electrically, with a manual actuation system for emergencies. The front leg can be locked into two positions; the higher one sets the plane at 9° attitude for takeoff and landing. The lower position is for boarding the plane and for taxiing.

Last December the PUL 10 had been flown by the Italian test pilot Jack Zanazzo; his impressions can be summarized as follows:

> The direction during takeoff is easily controlled by means of the elevons; the landing gear retracts easily, without any effect on the flight attitude.
>
> As logically expected, the climb rate is not extraordinary, but the overall performance is quite satisfactory once the plane is in level flight.
>
> The dynamic longitudinal stability shows a very small porpoising, probably due to trim conditions which can be corrected. With the stick pulled all the way back the speed is reduced to 70 Km/h; the design stalling speed of 60 Km/h is difficult to reach.
>
> Turns are easily made with the elevons, although there is a minor lag in response due to some *inverse aileron effect*. The yaw stability is quite acceptable, with almost unnoticeable oscillations around the zero position. [Gale' - If I remember exactly, this is one of the excuses taken by the U.S. military authorities for rejecting the Northrop flying wing bomber.]

Summarizing, Jack Zanazzo believes that the PUL 10 is the most comfortable two control plane he has ever flown (there is not rudder pedal). More details can be obtained from NURFLUGEL GERMANY, Hauptstrasse 38, Hirshberg, Germany, tel. & fax: 0049-64397559.

I am also sending the sketch of another tailless: the RAMPHORINCUS, which is being built by the Italian amateur builder Cesare Frau in Sardinia.

I am also enclosing two IRCs, since dollar banknotes are not easily found over here (banks don't trade banknotes smaller than $10). Please send me issue 89, November 1993. Thanks!

I wish I lived in California: I would not miss one of the TWITT meetings.

Regards,

Ferdinando Gale'
Via Marconi 10
28042 BAVENO [NO]
Italy

(ed. - Thanks for the material on the PUL 10. Maybe someone over here will get interested enough in it to contact Germany and order a set of plans.

I have reduced the size of your enclosed sketch to fit it in the newsletter. It looks like it might be easy to build and would make a good, low cost sport plane for a flying wing enthusiast.

Thanks for pointing out the difficulty in getting banknotes overseas. Any type of financial instrument that is payable in U.S. dollars is acceptable for purchasing items or paying your annual membership. We just can't accept any foreign currency type checks or money orders since we do not have any way to get them converted into U.S. currency. There are banks that handle it, but the transaction fees are so high (and vary from bank to bank) that it would make foreign membership dues higher than they already are.

If you ever plan a trip to the U.S. and will be on the west coast, make sure to plan it around a TWITT Saturday, if at all possible. We would be very pleased to see you and exchange information first hand.)

8/6/94

TWITT:

Enclosed is an ad for something that we have been waiting for, namely the publication of Karl Nickel's book Tailless Aircraft in Theory and Practice. The American Institute of Aeronautics and Astronautics (AIAA) will be publishing the book in September. This is the translation (done by Captain Eric Brown, RN) of the book Schwanslose Flugeuge that was previously available only in German. The price is a little steep ($79.95) but they do have a discount for AIAA members ($59.95) (so find a friend who is a member and get them to order it for you!).

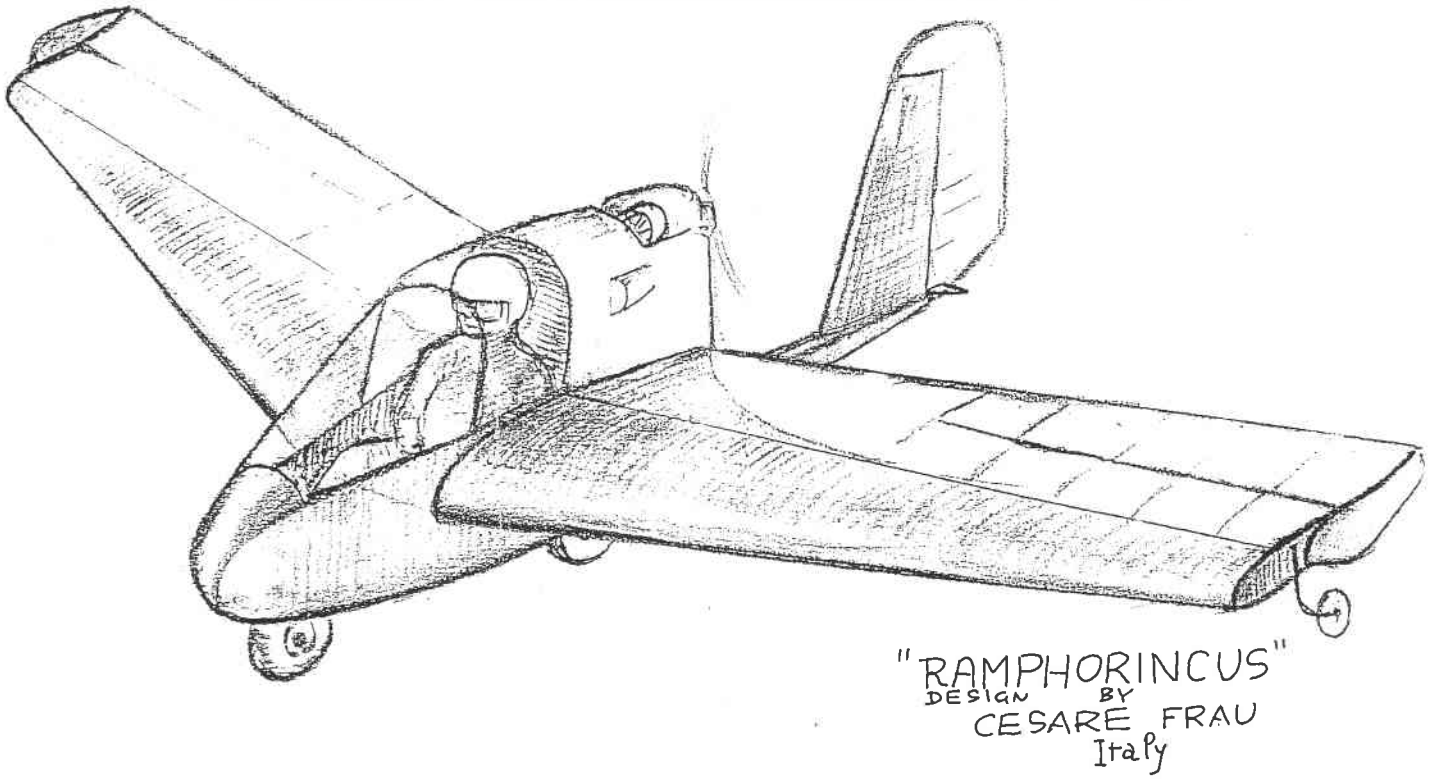
I'll let you reproduce the address and as much of the order form as you think necessary.

Regards,

Kevin Renshaw

(ed. - I have included the book announcement on the next page and a reduced size order form on the last page for members to use as they desire.

If we have any TWITT members who are also members of AIAA who would like to help us in



ordering a copy, we will send you a check for a copy for the TWITT library. Please give us a call.

Captain Eric Brown, Royal Navy, is a well known test pilot and aviation author, so this translation should be very good.)

8/10/94

TWITT:

This just quick. My left eye is now A-Okay - need new glasses though.

I haven't forgotten my reply to P.B.'s; its just not a priority - will do so soon.

Meanwhile these interesting references. Papers and microfiche available from AIAA Technical Information Service, 555 W. 57th St., New York, NY 10019 (these abstracts are public domain and could be reprinted in TWITT newsletter).

I had a spare copy of Torviks' paper , but I've the sneaky suspicion that I already sent it to you not too long ago. (It's an excellent piece of work!)

My time runs out.

Karl Sanders

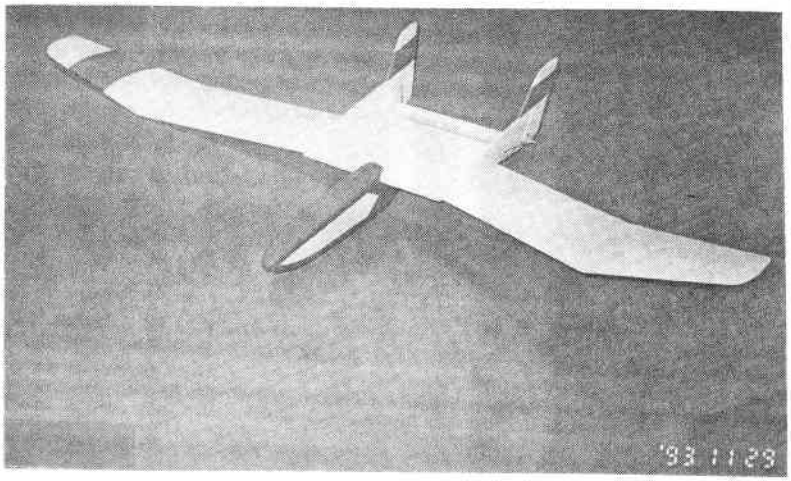
8/13/94

TWITT:

A few days ago I went "into" my NAC(S)A files an dug out Donlan's 1944 stability and

control report on tailless airplanes. Last time I did it was in 1982 when working on my Eagle project.

Donlan's report documents NACA's knowledge and state-of-the-art at that time. Because the subject is still loaded to this day I'm sending you a compressed copy of it and urge all interested TWITTs to read it attentively! Suggest also to reprint the framed text on the first and last pages in an upcoming newsletter (incidentally I don't know if there was ever a "final" report written by NACA; more recent NASA paper were concerned with structural loads and weights aspects of very large spanloaders - a stillborn species in my personal opinion - but more about that soon). All the characteristics so aptly and informatively discussed by Donlan are still with us today. His conclusions and recommendations should still be the guidelines with which to begin a new tailless or flying wing design.



ABOVE: The "MINI MANX" by Paul Stahlhuth.

The last 50 years - apart from less dramatic aerodynamic improvements - saw of course the more dramatic impact of "electronoptics"© with which (only) to mask any uncouth handling qualities (of *any* airplane). Questions: 1) Is an "ics" affordable ($); 2) Is an "ics" reliable (¿); and, 3) Is an "ics" advisable? (what if...)

Very unjustly, Donlan's report was, on occasions, vilified and accursed by several tailless and flying wing proponents I have come to know on my way. After reviewing the report again in that light, I'm astonished about this NIH xenophobia. Ironically, some of Donlan's recommendations were not taken seriously in the years that followed - and with predictable results. Also interesting is how few, if any, of the practical design aspects discussed were mentioned, or at least referenced or quoted in to recently published books. But that's the way we are...

Interested readers may get better copies of Report 796 and also of A.R. Weyl's articles (abstracts enclosed). Write and include check; cost $1 per original page including postage and handling.

With best regards as always,

Karl Sanders
Aeronautical Engineering Consultant
26514 Via Marquette
Lomita, CA 90717
(310) 539-9516

(ed. - Again, we would like to thank Karl for this endless contributions. I have reproduced the various abstracts he included in this latest batch of material so everyone will have a chance to determine if there is anything of interest.

I am presuming when you say write, it is to you so that you can provide the pages in their original size. For those of you who feel you need this document based on the following information Karl asked to be printed, there are 16 original pages so the cost would be $16 including postage and handling.

The paper contains many graphs and illustrations, and I am sure from just perusing it that it very technical. For those of you who are serious "garage" engineers, it might be well worth the expense when it comes to designing and building your next flying wing.)

ABSTRACTS OF PAPERS AVAILABLE FROM AIAA

REPORT No. 796

"An Interim Report on the Stability and Control of Tailless Airplanes", compiled by Charles J. Donlan, Langley Stability Research Division.

Summary

Problems relating to the stability and control of tailless airplanes are discussed in consideration of contemporary experience and practice. In the present state of the design of tailless airplanes, it appears that:

(1) Sweepback affords a method of supplying tail length for directional and longitudinal stability and control and allows the utilization of a high-lift flap but introduces undesirable tip stalling tendencies that must be overcome before the advantages of sweepback can be realized.

(2) The damping in pitching appears to have little effect on the longitudinal behavior of the airplane provided the static margin is never permitted to become negative.

(3) The directional stability must be great as for conventional airplanes if the same requirements regarding satisfactory stability and control characteristics are to be adhered to.

(4) The influence of the lateral resistance and the damping in yawing on the flying qualities is somewhat obscure; however, it is believed that these parameters will be of secondary importance if adequate directional stability is supplied.

(5) On account of the difficulties encountered in obtaining adequate stability and control with tailless airplanes, it appears that a thorough reevaluation of the relative performance to be expected from tailless and conventional designs should be made before proceeding further with stability and control studies.

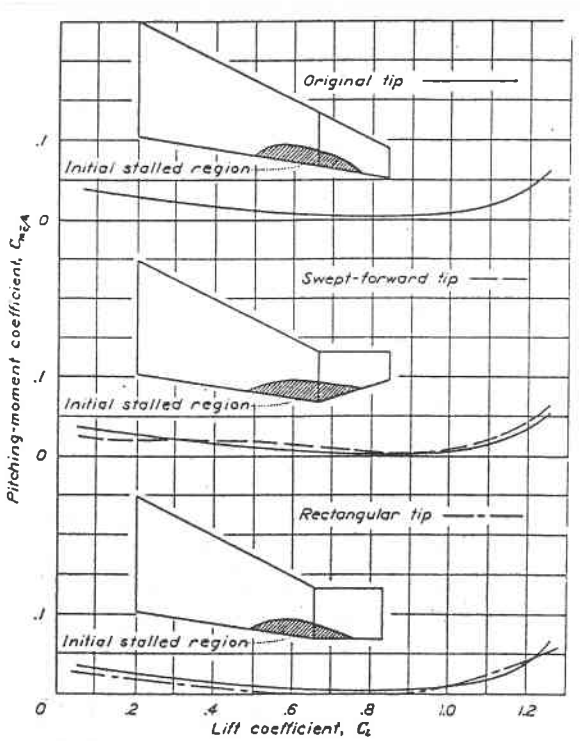


FIGURE 5.—Effect of change in tip shape on the pitching-moment characteristics of a swept-back wing.

Sample of figure from Report No. 796

General Considerations of Tailless and Conventional Airplanes

In recent years opinion has been divided as regards the relative adaptability of tailless and conventional airplanes for both fighter and bomber airplanes as evidenced by the variety of designs that have appeared. Some observations concerning the relative merits of tailless and conventional designs are offered here from consideration of stability and control problems that have been discussed.

Small airplanes - On account of the thin wing sections required for high speed, the volume enclosed by the wings of a small airplane is not large enough to carry all the load; consequently, it is necessary on small airplanes of either the tailless or conventional type to incorporate a fuselage or some other load-carrying element. It appears also that a vertical tail is necessary for directional stability. The difference between a small tailless airplane and a small conventional airplane, therefore, is essentially due to the suppression of a horizontal tail as a means of obtaining longitudinal stability and control. If the conventional airplane were permitted a reduction in maximum lift comparable with that tolerated on tailless airplanes, the tail size could be reduced considerably. With the small horizontal tail then allowable, the conventional airplane might have a performance comparable with that usually claimed for tailless airplanes without the restrictions attached to the longitudinal control.

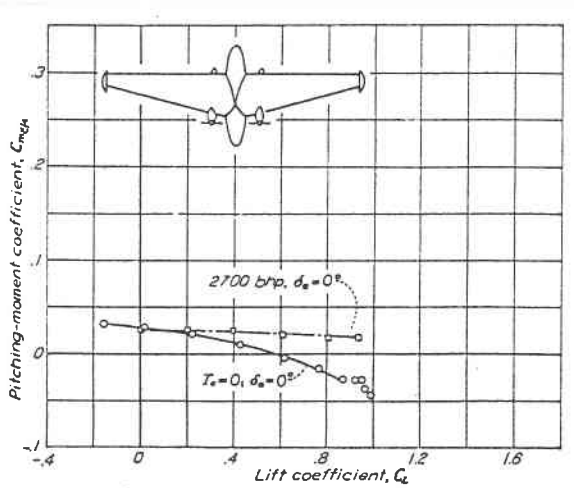


FIGURE 8.—Effect of power on the longitudinal stability of a tractor-type tailless airplane. $\frac{i}{c} = 0$.

Sample of figure from Report No. 796

Large airplanes - For large airplanes having spans of 150 to 500 feet, the volume of the wing alone may be sufficient to enclose bulk or weight of an appreciable magnitude even with the thin wing sections required for high speed. There is little reason to suspect that conventional airplanes of equal span will have any less wing space available for cargo purposes than tailless airplanes. It appears, therefor, that the suppression of the fuselage as a load-carrying element is primarily a matter of airplane size rather than of type.

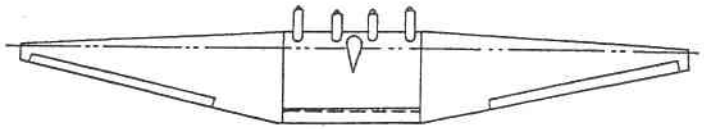
In spite of the suppression of the fuselage, however, a vertical tail may be necessary on any large airplane, particularly on bombers, if optimum directional stability and control are to be obtained. Some method must also be provided for obtaining longitudinal control. Whether the longitudinal control is obtained by elevons or by a horizontal tail located on a tail boom would seem to have a secondary influence on the ultimate performance to be expected. On the basis of the present knowledge of the stability and control characteristics of tailless airplanes, it appears desirable to make a comprehensive study of the comparative performance to be expected from tailless and conventional airplanes before proceeding further with stability and control studies.

"On The Maximum Range of Flying Wings", by Peter J. Torvik, Professor of Aerospace Engineering and Engineering Mechanics, Department of Aeronautics and Astronautics, Air Force Institute of Technology, Wright Patterson AFB, OH 45433, AIAA-92-4223.

The classical equations for determining the maximum range of aircraft with propeller and jet propulsion systems are reviewed, along with previous work conducted to determine the optimal division of aircraft volume between fuselage and wing components. That the jet powered flying wing configuration produces optimal range only for limited geometries is confirmed. The optimal range of aircraft employing high bypass jet engines is explored, and found to lead to a broader range of design parameters for which the flying wing design produces maximum range than is the case when a pure jet system is used.

(ed. - Karl sent along a good copy of this paper so we can provide it to you for $1, including postage and handling.)

Vertical tails tested on a tailless-airplane model



Plan view of tailless-airplane model

Tail	A Two wing-tip tails toed-out 5°	B Two wing-tip tails toed-in 5°
Area (percent S)	5	10
Aspect ratio	4	0.5
C_{n_β}	0.00010	0.00012

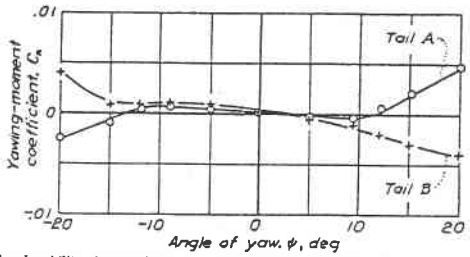


FIGURE 15.—Directional stability characteristics of a tailless airplane equipped with toed-in and toed-out tip fins.

Sample of figure from Report No. 796

AIAA Paper 93-3615

"Effect of Geometry, Static Stability, and Mass Distribution on the Tumbling Characteristics of Generic Flying-Wing Models." C.M. Fremaux, D.M Vairo (Lockheed Research Center, Hampton, VA).

Results from an investigation to determine the low-speed tumbling characteristics of twelve generic flying-wing models are summarized. There is a concern that airplanes with flying-wing planforms could inadvertently enter an out-of-control tumbling motion under certain conditions. The objectives of this investigation were to: 1) Identify the geometric and mass-related parameters that cause flying wings to be capable of sustained tumbling; 2) Analyze some of the driving mechanisms that cause tumbling; and 3) Determine the feasibility of using computer simulations to predict the tumbling characteristics of flying wings. Free-tumble and free-to-pitch tests were conducted with dynamically-scaled generic flying wing models. The use of computer simulations as a predictive tool for tumbling was explored. Results indicated that center-of-gravity location, mass distribution, and geometric aspect ratio strongly affected the tumbling characteristics of the models tested and that positive static stability did not necessarily preclude tumbling. The magnitude of dynamic effects were found to be of the same order as static effects for the models undergoing autorotation-in-pitch. The simulations indicated that the dynamic terms in the equations of motion used to predict tumbling must be obtained using experimental methods that account for the large amplitude/high pitch-rate environment that characterizes tumbling.

AIAA Paper 93-3668

"A New Flying Qualities Criterion for Flying Wings." Wulf Mönnich (DLR. Inst. für Flugmechanik, Braunschweig, Germany) and Lothar Dolldorff (FFA Flugzeugwerke Altenrhein AG, Switzerland).

The paper deals with the flying qualities problems of the flying wing sailplane SB-13 in a turbulent atmosphere. By comparison with a conventional sailplane both in time and frequency domain the reason for this behavior is found. A new flying qualities criterion for flying wings is proposed.

AIAA Paper 92-4604

"Integrated Aerodynamics and Control System Design for Tailless Aircraft." Stephen J. Morris (Stanford Univ., CA)

This paper presents a numerical method for simultaneously designing an aircraft and its feedback control system to minimize drag with a fixed level of handling qualities. The method used a nonlinear optimization to reconfigure the aircraft and choose control gains that minimize a composite performance index consisting of trimmed drag and a handling qualities measure, both evaluated at several flight conditions. Using this technique, tailless aircraft are synthesized for minimum drag with acceptable handling qualities. Some

cases include a feedback control system so that the impact of active control on reduced trimmed drag can be assessed. The method shows how low drag can be achieved in unaugmented designs by careful choice of wing sweep, taper, and twist. Designs with stability augmentation show a 13% reduction in drag over the best designs without augmentation.

The following abstracts are from the series titled "Stalling Phenomena and the Tailless Aeroplane", by A.R. Weyl, The Aeroplane, (Volumes, Numbers and pages as indicated for each article).

{The author, after a period as Permanent Assistant to the Professor of Aeronautical Engineering at the Technical University, Berlin, worked in the German Defense Ministry as well as editing an aeronautical journal, until his arrest by the Nazis in 1933. He escaped to England and began a new career as test pilot, manager of a small aircraft firm and engineering consultant. He died in 1959.}

I - Vol. 72, No. 1872, April 25, 1947, pp. 427-429, figs.

A statement of the physical phenomena accompanying stall. High incidence stall and incipient stall are described and the development of the spanwise spreading of the flow separation is discussed with reference to self-contained wing systems.

II - Vol. 72, Nos. 1874, May 9, 1947, pp. 478, 479, diagrs.

Simultaneous stalling all along the span is, for a tailless airplane, neither desirable nor practically achievable. This implies that the maximum lift coefficient of the tailless airplane will remain below the optimum value that can be realized for a conventional design with equal aspect ratio and equal airfoil section. It means also that the tailless airplane will not have a wing system of minimum induced drag, although, in practice, the difference may become negligibly small. In all probability, this inherent aerodynamic deficiency would be more than balanced by other advantages of tailless airplanes.

III - Vol. 72, No. 1879, June 13, 1947, pp. 624, 627, 628, illus.

The nature of a stall and the mechanics of incipient stall as a factor of the wing plan form indicate that aerodynamically the flying-plank type would seem superior to all tailless systems that rely on effective sweep. An elliptic lift-grading over the span, i.e., minimum induced drag, can be achieved for lift coefficients of practical flight. Structurally, taper would allow the bending moment to be kept low and the torsional load on the wing structure to be reduced possibly to a minimum.

IV - Vol. 72, No. 1881, June 27, 1947, pp. 685-687, illus.

Stability of the aircraft under stalling conditions exists when the aerodynamic center of gravity shifts forward, thus producing a tail-heavy trim. In the case of sweptback wing systems, the premature stall that occurs at the wing tips increases in severity with increase in the angle of effective sweepback. The lift curves of such a wing system have two peaks, and with increasing sweepback the curve becomes more gradual at the stall and free from abrupt discontinuities.

V - Vol. 73, No. 1883, July 11, 1947, pp. 47-49.

The chief factors that determine the characteristics of the pitching-moment curve at stall are the sweepback and the aspect ratio of the wing. While in the case of moderate sweepback the introduction of wing twist and an increase in section camber toward the tip will tend to prevent premature tip stall, the use of suction slots for this purpose seems preferable.

VI - Vol. 73, No. 1886, August 1, 1947, pp. 133-135, illus, diagrs.

After a résumé of their development, leading-edge flaps are evaluated and compared with automatic wing-tip slots. Control of the boundary layer by suction as a remedy for tip stall is examined from an appraisal of data on existing designs. A combination of suction and discharge may be the most effective remedy.

VII - Vol. 73, No. 1888, August 15, 1947, pp. 190-192, illus. 85 references.

An historical summary of the development of swept-forward and the low-aspect-ratio wing. The performance of these types in stall is estimated to show their applicability to tailless aircraft. The list of references contains some allusion to compressibility stall in addition to tailless airplane problems.

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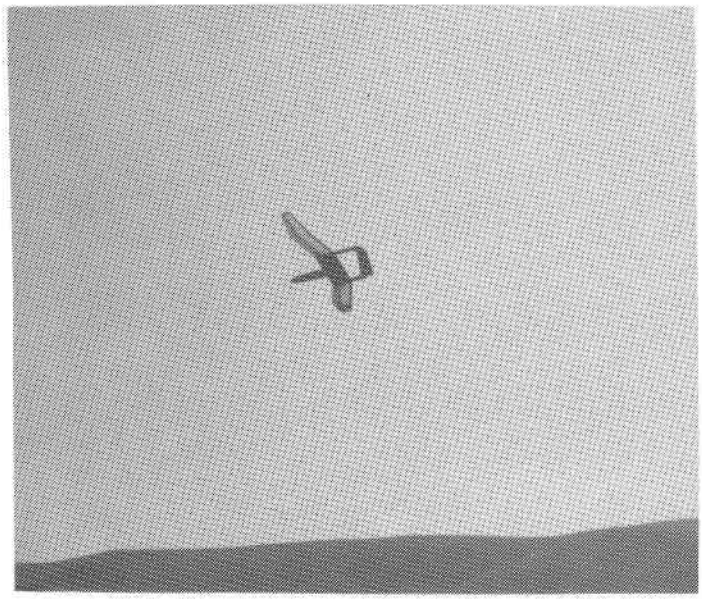

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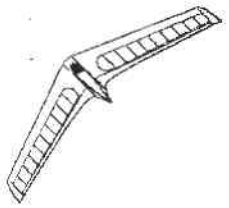

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