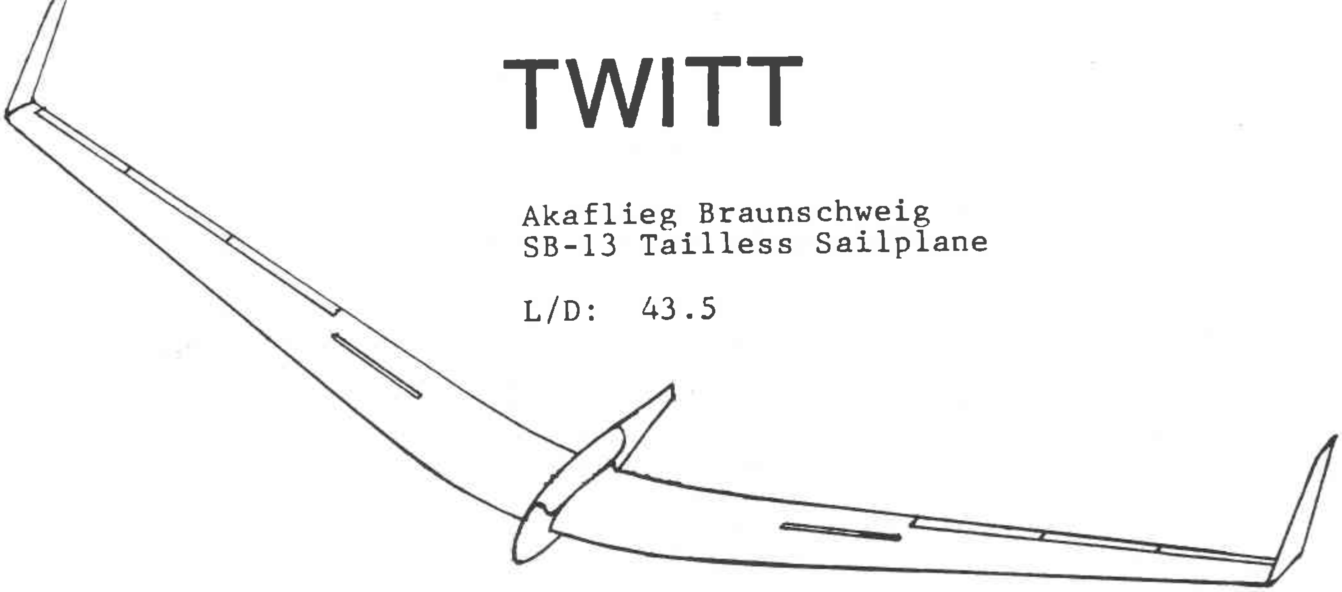
TWITT



Akaflieg Braunschweig
SB-13 Tailless Sailplane

L/D: 43.5

NEWSLETTER No. 10, April 1987

F. Marc de Piolenc, Editor

TWITT
(The Wing Is The Thing)
PO Box 20430
El Cajon, CA 92021

NEXT MEETING: Saturday,
18 April 1987, 1330 hrs,
Hangar A-4, Gillespie Fld.

Telephone: (619) 224-1497 before 10 AM or after 10 PM

MINUTES OF 21 MARCH 1987 MEETING

TWITT's tenth (!) monthly meeting convened at hangar B-4, Gillespie Field, El Cajon, California at 1:30 PM (NOT 1:00 as announced by your slightly befuddled Editor). Phillip Burgers spoke first on methods of reducing induced drag. He first reviewed the basic mechanism of induced drag in a finite-span wing--the shedding of the bound, lifting vortex at the tips in the form of the familiar trailing "tip vortex." He then discussed various schemes that have been proposed to eliminate the tip vortex and its associated expenditure of energy, pointing out the misconception involved. Phillip divided practical induced-drag reduction methods into two categories:

(1) those which move the tip vortex core outward, increasing the effective span of the wing, and

(2) those which recover some of the energy in the vortex.

In category (1), Phil highlighted the solution that consists of giving a wing very high sweep at the tips. This induces a local outward flow at the tips on the top surface of the wing. Since the tip vortex rolls up above the wing, this local flow has the effect of shoving the vortex core outboard. Category (2) is represented by the well-known (or at least well-noticed) Whitcomb winglet, which (if properly designed) will derive some thrust from the tip vortex, reducing the induced drag of the wing as a whole. Fortunato ("Tuto") Figueroa pointed out that end bodies and endplates can improve the performance of a wing, and Phil replied that they did this by displacing the vortex core outward, putting them in category (1). Phil continued with a discussion of lift distribution, beginning with Prandtl's "ideal" elliptical spanwise distribution of lift, which produces constant downwash over the entire wing and gives the absolute minimum achievable induced drag for a given wingspan and weight. But while the elliptical distribution is fine in straight and level flight, it causes problems in maneuvering. When the lift distribution is changed, e.g. by deflecting ailerons, the drag of the down-going wing increases more than that of the up-going wing, producing yaw opposite to roll. This adverse yaw is an inconvenience to conventional airplane pilots, but it can make an all-wing or tailless airplane uncontrollable. Something other than the elliptical lift distribution is needed. Horten's solution is the bell-shaped lift distribution, which has a horizontal tangent at the tips. With ailerons near the wingtips, this distribution gives positive (favorable) or neutral yaw with roll. There is a price, of course; the effective span of the wing decreases, or to put it a different way the induced drag is higher for a given span than with an elliptical distribution. [Horten's bell-shaped curve is empirical, refined by experiment. Phil has received from Prof. Karl Nickel, a former collaborator of Horten, a paper giving a mathematical analysis of the "constrained optimization" problem of achieving minimum induced drag with specified lift, rolling moment and yawing moment coefficients. You will see more on this in the future.--Ed.] Somebody brought up the various schemes for recovering tip-vortex energy either by placing the propeller at the tip and using it to "de-whirl" the rotating flow, or by putting a wind-turbine at the tip. It seems that at least one aircraft accessory company tested a tip-turbine as a source of auxilliary power. Somebody else [your Editor was not doing a very good job of taking names] mentioned a Rohr project of the early postwar period which had a propeller equipped with an overrunning clutch that allowed it to windmill when the engine was idle or shut down. The windmilling prop drove a blower exhausting into a plenum which in turn fed wing-tip yaw thrusters. The machine, which never flew, was designed by Burt Rains.

Bob Fronius then introduced the students from Morse High to introduce themselves. Bob then introduced their instructor, Steve Adams. Before yielding the floor to Steve, however, he appealed to the assembled company to donate old engine and air-frame manuals to John Karlovich, who has several (?) restoration projects going.

Steve Adams then took the floor. He teaches Aviation Technology at Morse High School, 6509 Skyline Drive, San Diego, an aviation "magnet school." His students learn sheet-metal work, practice such academic skills as trigonometry in laying out parts, and eventually go on to learn such specialized skills as MIG welding. In their third year they also get some composites experience. Some engine work is also included in the curriculum. Steve's teaching vehicle is a Thorp T-18 project. An earlier VP-1 project has been sold and is in service. The program has placed students with aerospace companies in the San Diego area.

At Steve Adams' request, Don Cummins, one of Steve's students and a participant in February's TWITT meeting, reviewed his plans to test a fiber-composite wing segment with partial upper-surface blowing in the San Diego State University wind tunnel [see last month's newsletter for details]. Don will also enter the project in competition in the Greater San Diego Science and Engineering Fair. Your Editor was frankly impressed with this group; you'll have to look elsewhere to find slack-jawed, bored teenagers. These students obviously have a vocation and a purpose...and what a blessed relief that is from the California Airhead prototype! Mr. Adams' obvious pride in them and in him-self is well justified.

There followed a talk by our featured speaker, Walt Mooney, on the subject of the Rohr Two-175, an advanced (to put it very mildly) two-seat light airplane designed, built, tested and then scrapped by Rohr Industries in the early Seventies. There was so much fascinating info in the talk that it didn't make sense to bury it all in these Minutes. You'll find a brief article on it elsewhere in this issue. Walt's exposition of the design and development was complemented by Don Westergren's expert discussion of the flight test results from the unique viewpoint of the program's sole test pilot. Your Editor, a straitjacket-qualified Delta wing maniac, spent the entire time furiously writing notes and frequently interrupted the proceedings with exclamations of delight. The presentation--and the meeting--ended but the questions did not.

PROGRAM OF 18 APRIL 1987 MEETING

Next month your friendly Editor, Marc de Piolenc, will give a talk based on Karl Nickel's paper, "Minimal Drag for Wings with Prescribed Lift, Roll Moment and Yaw Moment, or How to Fight Adverse Yaw." Dr. Nickel is a mathematician, a former collaborator of Dr. Reimar Horten...and now a TWITT. His published work on aerodynamic problems of flying wing design goes back at least to 1948 (see e.g. Nurfluegel). Your Editor's qualifications to discuss this subject are more modest: he is a full-time student of Mechanical Engineering at UC San Diego, with minors in Mathematics and Linguistics. It would be much better if we could get Dr. Nickel over here to discuss his work, and perhaps one day we may. The topic of the paper is of enormous interest to TWITT, because Dr. Nickel has taken Prandtl's famous work of optimizing the lift distribution of a planar wing two steps further. The only constraint imposed by Prandtl was a non-zero lift coefficient, which yielded the well-known (and widely misunderstood) elliptical spanwise lift distribution. Unfortunately for us TWITTs, tailless airplanes must be able to generate rolling moments without adverse yaw, and one of Nickel's results is a proof that this is impossible to achieve with an elliptical basic lift distribution. Designers have learned this the hard way over the years, and pioneer tailless airplane builders have, usually by trial and error, found lift distributions that would mitigate adverse yaw. Here comes Nickel bombshell number two: ANY non-elliptical lift distribution, when combined with a suitably chosen additional lift distribution due to aileron deflection, can be made to yield a wing without adverse yaw; the trick is to find the curve that gives the lowest induced drag, keeping in mind that ANY flat wing with a non-elliptical spanwise lift distribution will be inferior in this respect to a wing with Prandtl's magic ellipse. It is this problem in "constrained optimization" that Dr. Nickel tackles in his paper. Because the paper is addressed to an audience of mathematicians, it skips some steps which engineers might like to see. Your Editor will try to fill in those gaps on April 18th.

Marc de Piolenc, Ed Lockhart and Phil Burgers will discuss a series of aerodynamics lectures given at San Diego State on 2 April, including a talk by R.T. Jones on a supersonic skewed flying wing.

ADDITIONS TO THE LIBRARY

Schweiger, Sensburg and Berns: "Aeroelastic Problems and Structural Design of a Tailless CFC Sailplane." [from Stu Cochran]

Nickel, Karl L.E.: "Minimal Drag for Wings with Prescribed Lift, Roll Moment and Yaw Moment." Applications of Mathematics in Technology, Proceedings of the German-Italian Symposium March 26-30, 1984, Rome, pp 7-50. Stuttgart: Teubner, 1984. [from Dr. Nickel]

A Synopsis (by Ed Lockhart) of:
"AEROELASTIC PROBLEMS AND STRUCTURAL DESIGN OF A TAILLESS CFC*
SAILPLANE" by J. Schweigert, O. Sensburg and H.J. Berns

This synopsis of the above noted eleven-page paper describes some of the problems and solutions for the 15 meter SB-13 swept-back tailless sailplane.

Most remarkable (and encouraging) is its max L/D of 43.5 to 1 and minimum sink of 0.53 m/s. The 15 meter span wing has an aspect ratio of 19.4, area 11.6 square meters, dihedral 4 degrees, twist -1.5 degrees; airfoils are HQ 34 N/14.83 inboard and HQ 36N/15-12 outboard.

Substantial winglets, full chord at the root, are swept back, apparently at the same angle as the wing. Though sweepback is not given, a protractor indicates 12 1/2 degrees. Height is 1.25 meters, which would give a wingspan of 17 1/2 m. were they laid flat to increase the span. As a characteristic of winglets is to increase effective span, it's no surprise that 15 meter sailplane designers find them attractive.

A major change in design was from a straight Vee sweep to a planform with a parabolic center-section. Horten and others have proven this to yield aerodynamic gains, but the primary reason for choosing this planform for the SB-13 was to reduce the wing root bending moment. Flutter problems had arrived early, and this alleviated them.

A one-third scale radio controlled model was invaluable in helping to find and fix the aeroelastic/flutter headaches inherent in developing sweptback tailless configurations.

A quite similar contemporary design called "Ricochet" was being developed at Cranfield in England. This effort was eventually abandoned due to aeroelastic and flutter problems nearly identical to those of the SB-13. Ricochet failed, and SB-13 finally succeeded, because the ability to rework and tailor carbon-graphite or other composites to counter aeroelastic bending far exceeds the practical limitations imposed by Ricochet's 6061-T6 aluminum structure.

The primary point of the paper was to prove that flutter could not be cured using conventional materials. The advent of high-modulus carbon fibers provides a Young's modulus 50% higher than that of high-tensile fibers usually used in composite structures.

* Carbon-Fiber Composite

THE ROHR TWO-175 (1974)
by F. Marc de Piolenc

In 1974, Rohr Chairman Burt Raynes resolved to move Rohr into the light airplane market. Challenging the marketing base of the Wichita Giants would be an extraordinary step in itself. In order to succeed, Rohr had to offer a product so undeniably superior to its competition that prospective buyers and dealers could not resist it. Raynes summoned Walt Mooney and told him to come up with a quantum leap in light aircraft technology. It must have better performance; greater safety, accessibility and comfort; greater economy and lower production cost than any competitor. It must also, in Mr. Raynes' own words, "drive Cessna nuts." Walt was given an adequate budget and promised the services of any Rohr employee he needed. Within budget and on time, Mooney et al. built three airframes (two flying prototypes and a static test article) and two scale models (1/10 and 1/2) for water landing/takeoff feasibility tests (!). By the time the project ended (for reasons having nothing to do with the merits of the airplane), one prototype had accumulated 23 hours in the air.

Walt took full advantage of Burt Raynes' license to grab the best people Rohr had to offer. The key players on the project team were:

Walt Mooney	Designer and Project Manager
Bill Chana	Engineer and Project Administrator
Mike Voydisch	Propeller and Duct Design
Don Westergren	Test Pilot
Bob Fronius	Shop Foreman

At first glance, the Rohr Two-175 looks like an exercise in novelty for its own sake. It is a low wing Delta of stressed skin, fiber-reinforced plastic (FRP) construction, propelled by a buried pusher engine driving a shrouded propeller. Its nosewheel fairing doubles as a "rhino rudder." Both the wing and the vertical tail fold for transport and storage. Seating is side by side; access to the cockpit is through huge polycarbonate (!!) panels that open in gullwing fashion. The single stick is mounted centrally, accessible to both pilot and co-pilot. The landing gear is fixed and rigid...no springs. Oh yes: the vertical tail is attached to the top of the propeller shroud. It is very hard to find a single conventional feature in the aircraft.

In context, the bizarre features listed above seem not only sensible but ingenious. Take the Delta wing: the whole machine was intended to fit a standard FHA single-car garage, which dictated a 20' span. Keeping the wing loading and structural loads within reason led to a deep root chord and sharp taper, and voila! A Delta with folding outer panels. The vertical tail alternatives were a fuselage-mounted tail which would have to be huge to compensate for its shorter moment arm, or a small-area, high AR tail mounted on the prop shroud. The second choice reduced wetted area, so that's what Two-175 got...with a hinge so it would fit that low-ceilinged FHA automobile hangar. But why composite construction? Surely that was a big technical risk in 1974. The point of that choice of manufacturing technique was to reduce the parts count and the number of manufacturing operations, which it did. The combination of adhesive bonding and molding major subassemblies in one piece kept parts count down to a miniscule fraction of that of a two-seat metal airplane, even counting each ply of laminate as a separate piece. Wing cores for the prototype were cut by the hot wire method familiar to builders of modern FRP homebuilt airplanes, but a faster and more elegant method had been worked out for production. The wing, which was the airplane's primary structure, would be built in clamshell molds. First, foam "sugar" would be placed in the mold. Live steam would then be injected to expand the polystyrene beads to the mold contour. The mold would be opened, the core temporarily withdrawn, and "B" stage fiberglass prepreg would be laid up on the inside surfaces of the mold. The core would then be reinserted and the mold would be closed, compressing the core slightly and ensuring even pressure on the laminate. Heat would then be applied in the usual manner to cure the assembly. The use of prepreg would avoid the weight gain problem of a wet layup and would prevent the laminate from becoming resin-starved. The process as a whole is simple, repeatable and cheap. Polycarbonate is both stronger and harder than Plexiglass, both very desirable features considering the huge "glass" area in the cockpit, but the conventional wisdom said it couldn't be molded. Bob Fronius and his team worked out a way and molded three sets. The landing gear needed only to be long enough for the 'plane to rotate without dragging its tail; prop clearance was not a problem. So why not have a fixed, unsprung gear, with the mains faired directly into the bottom wing surface and the fin-like nosegear fairing attached to the steerable nosewheel strut? Conventional wisdom said it wouldn't work. Of course it did.

Deltas need high static thrust for takeoff, when their high induced drag puts them at a disadvantage vis-a-vis conventional planes. Getting the necessary thrust with reasonable horsepower and prop diameter called for a shrouded prop turning at 4400 rpm, faster than any conventional reciprocating airplane engine's output. Fate intervened: Lycoming had two special high speed engines which had been built for a contract that didn't quite pan out...Lyc let Rohr have them cheap. These gave 150 horsepower at 4400 rpm. They had special cam profiles, but were otherwise conventional. That stroke of luck left the problem of cooling a buried aircooled engine for long periods at zero forward speed. A generously-sized dorsal scoop and an exhaust-driven ejector nozzle did the trick. In typical 108 degree F weather at the test site, the engine never overheated. The cooling system was in fact a bit too effective, and the inlet area would likely have been reduced or louvered if the program had continued. A short extension shaft drove a four bladed propeller. Mike Voydisch's prop, shroud and six-bladed stator gave a 1280 fpm climb with one man on board. Stator and blade profiles and pitch distributions are critical. The wing and fuselage underbody formed a "chassis" which was the major structure of the airplane; the rest (except for the duct and tail) was a fairing. Plugs for non-structural panels were carved out of body clay, Detroit style. Even the engine mount, though otherwise conventional, attached to the structural "pan" instead of the firewall bulkhead. Fatigue tests on the FRP structure showed that a structure that could resist a specified static load had an indefinite life under alternating loads. NASA spent a lot of money some years later to find out the same thing.

A few details of wing design: the outboard leading-edge droop/extension (Walt Mooney calls it a "dog tooth") was added to correct a pitch-up tendency at high angles of attack. The airfoil section is a symmetrical french curve special laid out by Walt according to exacting scientific criteria: if it looks right, use it. There is no spar, and the structural joint between the center-section and the outboard panel is made up of two FRP piano hinges adhesive-bonded to the stressed skin of the wing. The FRP hinges were developed for the Two-175 because of questions about the reliability of adhesive bonds to metal. Torsional loads were transmitted by trunconic bosses molded into the root of the outboard panel near the leading and trailing edges; these fit neatly into recesses in the center-section. Folding the wing was a matter of removing the lower hinge pin.

Don Westergren, the project's test pilot, noted that despite the machine's unorthodox layout it had a very normal feel. He got used to the machine quickly and felt comfortable with it, despite the fact that the wing was completely outside his field of vision, requiring the use of the instrument panel as an attitude reference. Only in landing did the Delta's special character demand special technique: approaches must be flown at constant attitude and the machine allowed to flare itself in ground effect; hauling back on the stick C-150 style would have "buried" the tail. Don had a chance to test engine-out performance somewhat earlier than intended when a driveshaft coupling failed shortly after takeoff. Don 180'd and put the 'plane down on the runway without damage. The pivot point of the nosewheel fairing/rudder had to be moved forward early on. Otherwise the tests were uneventful and there was little down-time for modifications.

Early in the program somebody realized that the plane was capable of floating on its sealed, foam-filled wing. Tests with scale models showed that the airplane could take-off and land on water with the help of hydro-skis. This opened up the possibility of snow landings as well. With retractable skis, the Two-175 would certainly have had the cleanest seaplane configuration ever seen.

So what happened? Rohr got into financial trouble with other projects and the Two was a victim of the ensuing corporate belt-tightening. Reusable equipment was salvaged from the airframes and they were destroyed, as was every speck of technical documentation. The plane lives on only in Walt's collection of color slides, a few 3-views and memory.

FROM ONE TWITT TO ANOTHER

[The title is Bob Fronius' idea!--Ed]

DON SEIVENO

How he can twitt.

FIRSTLY, twitting is useless; that's why (a) we do it, and (b) it's fun.

Since I have specialized in doing what most of my colleagues insist is nonproductive and even nonengineering for over two decades, my qualifications to twitt are self-evident [HUMPH!--Edt.

SECONDLY, during high school years I developed a highly successful rubber-powered canard family. With no adjustments whatsoever, they all flew their predestined paths: vertically up under power and vertically down when pooped out. A field volume of ten feet square by one hundred fifty feet high was always sufficient. These same models, with tail clipped and TE tweaked flew nicely, but less spectacularly, horizontally. But none would come back. I have mulled over this dilemma for many decades and have found the only solution to be to throw the little beasties like a boomerang. Maybe a TWITT can suggest a solution less dynamic and more aero.

THIRDLY, my English Stab and See textbook insists that wings without sweep don't fly alone, but even my aerodynamics professor knew that any old wing does fine if it's upside down and properly ballasted. So clearly I outknow a proper schoolbook on the subject. Maybe I can contribute to twitt: one small fire, for heat during a cold meeting.

FOURTHLY, once upon a time I thought I was an aerodynamicist, but perhaps an unstable one. When put on DC-8's and DC-9's I popped out into air cushion vehicles and found Bruce Carmichael, who taught me about talless sailplanes--vertically tailless. When I corrected, I popped all the way to hypersonic ice cream cones and escaped only by declaring to a non-listening world that I really was a specialist in magnetohydrodynamic generation of electricity. If you need advice on using a magnetohydrodynamic channel with Mach one, six atmospheres pressure and five thousand F as a wind tunnel, perhaps I can help. The Reynolds number should be favorable if you develop a racey twitt. [!!!--Ed.]

FOURTHLY, oh...that's the last one! If your filing system has no appropriate heading you may deposit in Firth of Fourthly.
P.S. Don't tell Ed.

[not signed]

Bob Peck, of Peck Polymers fame, makes model kits including a flying scale model of the Goodyear Pony Blimp of the 30's. He writes:"Always liked flying wings--build models--could help with test models." Thanks, Bob; we know you can.

Keith Sterner of Bath, Pennsylvania writes:

I can offer the TWITT organization my talents as a professional draftsman. I'm also an accomplished model designer and builder. I have 26 years of experience in this area. Enclosed are two of my published designs [for] which I also did the drawings. I would be very willing to put my talents to work for the TWITT's organization as a draftsman to aid in the documentation of your designs and/or as a modeler to prototype an R/C version of your (hopefully "our" as a TWITT member) designs for a proof of concept. [Mr. Sterner enclosed two articles from Model Airplane News: one, from Jan 82, shows a very clean scale model Quickie; the other, Jan 84, shows a scale Woodhopper ultralight, also very believable.]

Here's a familiar last name...

Dear Marc,

Bob Fronius is my brother and he has sent me your Newsletter. Thanks to him he has kept my interest up on my project: a self launched man powered wing. So far I haven't anything to contribute except $15 membership. The TWITT Newsletter helps a lot in my thinking. I have built a model that appears to work, needs more development. Is it possible to get more reading material?

Joe Fronius
Sun City West, AZ

HAIL!

On behalf of TWITT, welcome to all our new subscribers. Please keep us posted on your projects. Those of your who live far away and need technical information should call Marc de Piolenc at (619) 272-1725. He will provide reprints from the collection at nominal cost. Try to be as specific as possible about what you need. Or write and include a stamped envelope for our reply. And always remember: the wing is the thing.

CONTRIBUTORS TO THIS ISSUE

STU COCHRAN, President of EAA Chapter 14, contributed two copies of the paper, "Aeroelastic Problems..." about the SB-13.

ED LOCKHART, TWITT at large, summarized it.

MARC DE PIOLENC, TWITT Secretary, provided the article on the Rohr Two-175, summarizing WALT MOONEY's presentation of 21 March.

NASA OPENS STUDY TO SOLVE PROBLEMS WITH 'FLYING WING'
[This article appeared in Defense Daily for April 15, 1987; many thanks to Karl Sanders for bringing it to our attention.]

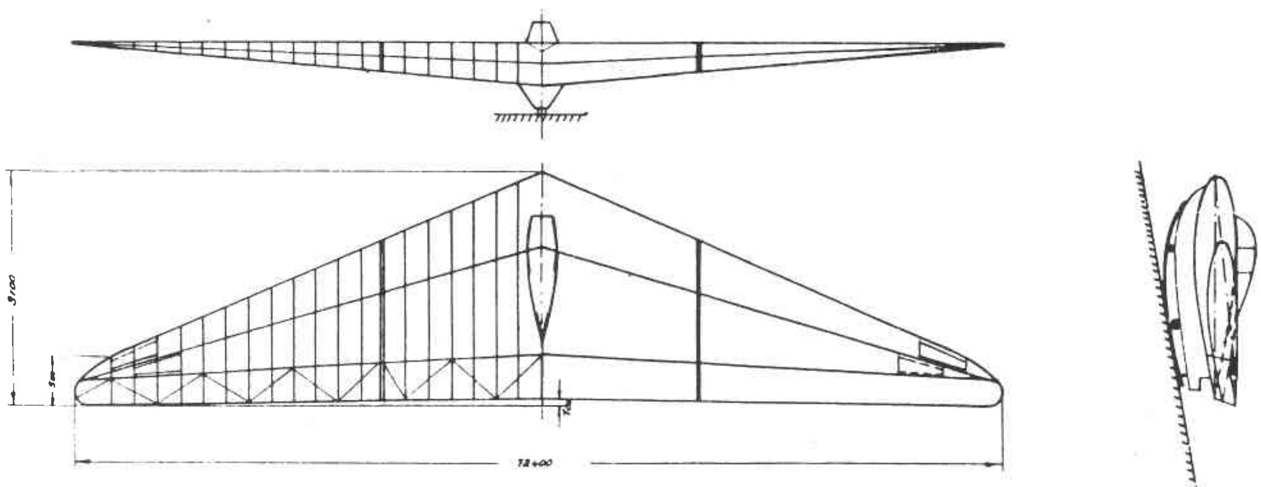
A study designed to identify and recommend solutions to problems with "flying wing" tailless aircraft will be conducted by Systems Technology Inc. (Hawthorne, Calif.) under a cost-plus-fixed-fee contract from NASA's Langley Research Center, awarded on the basis of an unsolicited proposal.

Under the four- to six-month "tailless aircraft performance with relaxed static stability study," STI will identify critical technology advances for successful functional and dynamic systems integrated needed to convert the "possible" improvements to eventual reality, the center said.

The issues in various disciplines, including aerodynamics, stability and control, flying qualities, power plant control and installation and digital flight controls, will be connected and evaluated in an "interdisciplinary manner, which will emphasize the overall impact of given technology issues on total design performance and viability."

Langley said that STI will "highlight, identify and delineate basic problems of flying wing aircraft that require further study and new developments; will suggest future research programs to address these problems, and will propose 'potential' remedies to these problems."
(The highly secret Air Force Advanced Technology Bomber (ATB) is reported to be a flying wing, which would make it the only existing aircraft of that design.)

[Karl Sanders notes that Mr. I.L. Ashkenas, President of STI, was Chief Aerodynamicist on the Northrop Flying Wing bombers in the 40's. STI's address is 13766 S. Hawthorne Boulevard. Their 'phone number is (213) 679-2281.]



RECENT ADDITIONS TO THE TWITT LIBRARY

Sears, William R.: Recollection of the Northrop Flying Wing Program (Manuscript courtesy of the author)

Carmichael, Bruce: Laminar Lightplanes, Parts I and II (Sport Aviation, August and September 1976)

Carmichael, Bruce: Underwater Vehicle Drag Reduction through Choice of Shape (AIAA Second Propulsion Joint Specialist Conference, Colorado Springs, June 13-17, 1966; AIAA Paper 66-657)

Galbraith, R. A. McD.: The Aerodynamic Characteristics of a GU 25-5(11)8 Aerofoil for Low Reynolds Numbers (Experiments in Fluids 3, 252-256, (1985))

Lippisch, A.: Ueber die Entwicklung der schwanzlosen Flugzeuge [The Development of Tailless Aircraft] (Abstract, from the Jahrbuch der deutschen Akademie der Luftfahrtforschung, 1942-43)

Kickert, Reiner (AKAFLIEG Braunschweig): Das Segelflugzeug-Bergungssystem and der SB-13 [The sailplane escape system on the SB-13] (IDAFLIEG Winter Conference 1987)

Norbert, Doris: Minimaler induzierter Widerstand eines Tragflueg-els unter Nebenbedingungen [Minimum induced drag of a wing with additional contraints] (Doctoral Dissertation, Inst. fuer Angewandte Mathematik, Universitaet Freiburg i. Br. West Germany) Contributed by Dr. Karl L.E. Nickel.

TWITT also wishes to thank Harold Pio for the loan of:
Marske, Jim: Experiment in Flying Wing Sailplanes