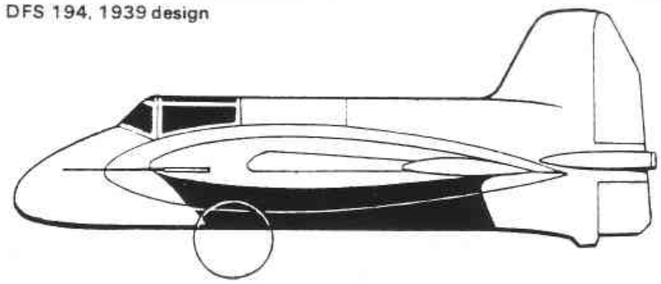
No. 135 SEPTEMBER 1997

T.W.I.T.T. NEWSLETTER

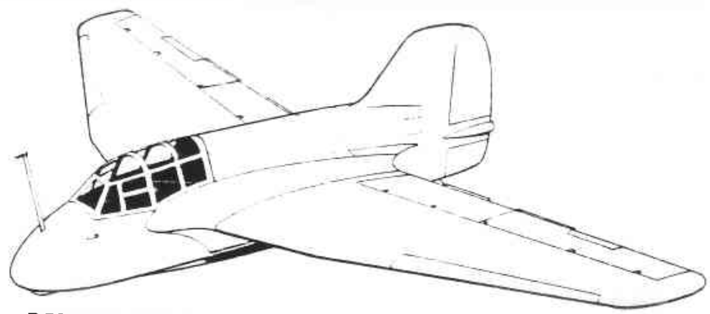
DFS 194, 1939 design



DFS 194 (Projekt X) - The DFS rocket aircraft had its origins in two separate research programs which finally converged when the RLM initiated the highly secret Projekt X in 1937. This combined Doctor Alexander Lippisch's tailless aircraft experiments and Doctor Hellmuth Walter's rocket motor work to produce the direct predecessor of the war's most startling combat aircraft, the Me 163 Komet.

When preliminary design work started on the DFS 194, it was intended to have a piston engine. But when Projekt X and Lippisch's team came under the Messerschmitt umbrella in January 1939, work started on converting it to rocket power. The DFS 194 was completed in early 1939. The DFS 194 airframe was first test flown as a glider in early 1940 and made its first rocket powered flight in August 1940 at Peenemunde-West. It eventually achieved a level flight speed of 324 mph.

Source: David Master's German Jet Genesis, contributed by Kevin Renshaw.



DFS 194 in flight during 1940

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., **9709** means this is your last issue unless renewed.

Next TWITT meeting: Saturday, September 20, 1997, beginning at 1330 hrs at hanger A-4, Gillespie Field, El Cajon, CA (first hanger row on Joe Crosson Drive - East side of Gillespie).

SEPTEMBER 20, 1997 PROGRAM

We have a very special program this month. **Al Bowers**, from the Dryden Flight Research Center, will repeat his presentation given at the recent Flying Wing Symposium on July 17, 1997. Al became interested in flying wings while working on span loader aircraft studies, and has collected information on Horten, Lippisch and Northrop types of aircraft. His presentation covers a historical and engineering appraisal of these aircraft. It was extremely well received at both the Symposium and the SHA Western Workshop over the Labor Day weekend. He will also be glad to take questions from the audience and seems to enjoy responding to the particularly difficult ones.

Al is a senior aerodynamicist for NASA at the Dryden Center. He belongs to a number of organizations like USHGA, SSA, and AIAA.. He is a skier, does some sailing, likes photography, bicycling and, tinkering on cars and motorcycles. He's worked SR-71s, high alpha thrust vectoring, authored a grad level textbook, and now he's working on a towed space launch vehicle concept. He is a constant contributor to the Nurflugel mailing list and has a wealth of knowledge on a number of subjects related to aerodynamics (this may be partly due to the excellent source for historical data at Dryden).

Time permitting after you all have picked Al's brain, we will have a group presentation by **Bruce Carmichael and Bob Chase (and perhaps Al)** covering their impressions on the Flying Wing Symposium. Some of this you have seen in last month's newsletter, but this is your chance to ask them specific questions, especially since Bob had a chance to talk with Karl Nickel for almost an hour on flying wing stability.

We anticipate our hospitality Chairpersons will be on had with something cool and wet for refreshments, since it will probably still be a little warm in the hanger.

THIS IS A MUST PROGRAM FOR EVERYONE WHO CAN POSSIBLY MAKE IT.

MINUTES OF THE JULY 19, 1997 MEETING

Part II

(ed. - As noted at the end of last months Part I of the minutes, we will be covering Marc dePiolenc's presentation on ducted fans which was the second part of the day's program. This was a dry run to work out any bugs and develop a good program for presentation to other aviation groups, such as EAA chapters, and went a little long. I will hit the main points he covered to give you the meat of the subject. This is an interesting area, and offers some applications within the flying wing community.)

Marc began by giving us some background on why he and his partners wrote their book on ducted fans. George Wright, one of the partners in the project they call MassFlow, was also present to help Marc with some parts of the program.

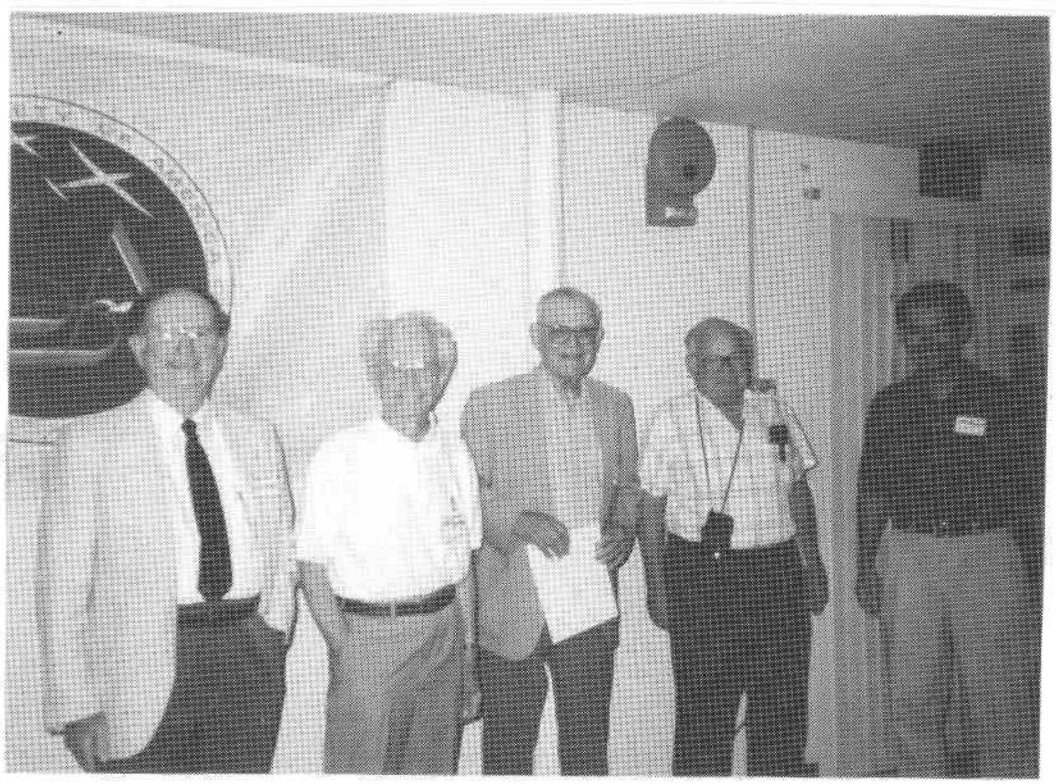
The ducted fan project was an outgrowth of their interest in developing lighter than air blimps that could be easily deflated and shipped from point to point rather than doing a ferry flight. The transportation package required things be compact while the blimp required a power source that could put out a high amount of thrust at low speeds to overcome the high drag of the ship.

George then got interested in the portion of the aviation market that wanted to have a scale version of a jet aircraft they could fly around for fun without the high cost of a jet engine and the fuel requirements. The plans they finally settled on as the best airframe for a ducted fan propulsion system was the Saunders Jet Hawk II. It already had a ducted fan system, however, it wasn't producing the results desired to provide the necessary performance for such a plane. The project became one of redesigning the ducted fan to use the existing airframe and then produce retrofit plans for the people who already had the original plans (there were 150 sets of plans sold).

Marc began doing the research through the various pieces of literature on the subject (which sounded like it was not a lot). He finally came to the conclusion that a ducted fan was just that, a FAN. It is not a compressor or other type of turbine machinery, and it does not produce a pressure ratio. With this revelation, you throw out all the literature and pick up an industrial fan design manual and everything starts coming together.

They thought about writing a AIAA paper and then got to thinking they would be better off producing something the average homebuilder could use to produce a power system for their own designs. The market for ducted fans looked like they needed to be powered by conventional piston or rotary engines and another segment would be to have these in a pylon mounted application which could also be retrofitted to some other existing types.

The book they wrote was part of the result from this research and the desire to get this information out to the designers and builders. They found this was necessary since some of the professional ducted fan designers apparently were making errors in their systems that Marc and George felt needed to be corrected in order to have a well performing ducted fan unit.



ABOVE: (Although this doesn't have anything to do with ducted fans, it was a place to put the picture) From the left: Bruce Carmichael, Rudy Opitz, Paul Schweizer, Al Backstrom and Al Bowers in attendance at the NSM Flying Wing Symposium at Harris Hill on July 17, 1997.

In the low speed range the purpose of the duct is to produce mass flow through the system which, all other things being equal, will result in increased thrust. This gives you some speed range restrictions, and if very high speeds are desired the duct and fan geometry become much more complicated. What they are looking at are applications where thrust per unit of horse power needs to be maximized at low speeds, such as, a sea plane that needs this during the beginning of the takeoff run from water. Another application would be some types of ground effect vehicles since the power system would be smaller but give the necessary thrust, and air boats since they have almost constant contact with the water.

Marc made a point that the typical jet turbo fan engine works just the opposite of what they are trying to design and promote. These are for high speed applications and the ducts are designed to slow down air to limit tip mach number on the large fans. And it is here that some low speed designers have been making their errors by using some of the same high speed duct philosophies in these smaller systems.

He went on to explain that what is trying to be accomplished is a change in the momentum of the air passing through the propulsion system to produce thrust. This is done by adding a fixed increment of speed to a constant flow of air. Adding this increment could require large amounts of power depending on how you design the duct and fan to produce the change in mass flow. One thing he did find during his analysis was that it takes more power to produce the same thrust at higher speeds due to the speed of the airplane being added into the equation.

Marc presented some of the math it takes to produce a good duct and fan. The first was the equation of continuity which comes from the principle of the conservation of mass where the amount of air entering the system has to equal the amount leaving the system. The other equation is Burnuell's energy equation which says that unless you are doing work on the air, by either taking energy out of it or putting it in, the sum of the dynamic and static pressures will be a constant. So in a ducted fan you have one constant at the front of the fan and higher one down stream of the fan. The question was asked about the difference between static and dynamic pressure. Static pressure is what we feel being exerted on our bodies by just standing still, while dynamic is the pressure the air would exert as a result of its motion if you suddenly stopped it.

The idea is to try and get the lowest possible value of "Delta p" (velocity change from one side of the fan to the other), and typically this should be less than a 10% rise at the rear of the fan. Due to this low value you can then treat the density of the air as a constant, again simplifying the calculations. The propulsion really does become a FAN and not a compressor. With density being a constant it means the axial velocity component cannot be changed by the fan. This gives you a constant volume flow through the duct, assuming it is a cylinder without any changes in shape to mechanically change airspeed. The swirl of the air can and will change yielding a step change in static pressure at that point, which is one of the things you should be looking for. This represents the increment of energy that has been added to the flow. Marc commented that the amount of swirl affect had less than a 2hp loss, therefore, eliminated the need for stators in the ducting.

He then moved on to duct losses where there is a lot of wetted area. When talking about a long thrust augmenting duct (induces more airflow) you have an accelerating flow but you also have a negative pressure gradient. This is the ideal condition for boundary layer development, which if duct construction were smooth enough would result in laminar flow clear up to the fan blade. What happens after the fan depends on the speed it is optimized for. In a typical application for 200 mph using 150 hp you have a pressure profile that is very favorable throughout the duct except right at the fan. He went on to compare this to a typical turbo fan to show the differences and why a low speed ducted fan works like it does.

In designing the propulsion system, you first start with the duct and then design the fan based on what the duct needs. You do have to start with a guess of what you think the rotor efficiency is, and Marc used 80% as a point for his initial calculations. You then need to correct for swirl horsepower (power used in spinning the air versus pushing it out the back - no propulsive affect) by calculating engine torque to come up with corrected horsepower which is what is available to produce the pressure rise in the duct. You compute the mass flow which is the speed of the air passing through the fan (axial flow velocity). You also need to compute the static pressure at the front of the fan.

The tip speed needs to be kept to about .7 mach or less and if your calculations yield a higher speed, the diameter and or airfoil section should be changed. You calculate the exit velocity you require to get the necessary Delta p which will give you the exit area according to the continuity equation.

Marc then went into the inlet design problems that may be dictated by the airframe design you are considering. These may be flush, semi-flush and scoop. Jet engine designers usually stay away from the flush and semi-flush due to working with decelerating air. However, for a ducted fan which is working with accelerating air, there doesn't seem to be any real penalty from the duct inlet style. This gives you more freedom of design. Inlet lip camber also needs to be considered, and he drew a picture on the black board to show the lip should be fairly rounded to allow for a smoother flow of air in the static mode. Air has a tendency of being sucked in from behind the lip so it needs to have a smooth transition form to prevent separation of this air as it turns the corner entering the duct.

Now he turned to the duct profile and that he had found any fair curve will do. Although the duct shape may change along its length, these changes should be kept smooth, with these reasonable curves to prevent separation of flow. The longer the duct, the more change in cross-section you can probably get away with and not have separation or vortex shedding. Short ducts will probably need to be pretty straight forward with minimal changes in cross-section - no drastic change from a round inlet to a slot type of exit point.

It was now time to look at designing the fan blades, which many start with instead of the duct. He went into a discussion of the free vortex concept of swirl velocity and how this can be controlled to minimize the swirl horsepower losses (this comes from the industrial fan applications which are generally low speed). Rear duct shape will also have an impact on the swirl affect and velocity and could result in more horsepower loss. Sometimes this can't be avoided based on the aircraft's design constraints, especially when getting into scale versions. Somewhere in all this the subject of blade twist distribution was passed over, but is necessary in the blade design.

Choosing an airfoil section for the fan was the next area covered and is somewhat of a different consideration than when designing wings. The Army

N-6 and the old Clark-Y have been popular airfoils for ducted fan blades. In fact, design of a fan blade is easier than doing an open propeller blade. Laminar flow is not necessarily an answer due to the flow field the blade encounters in inducing a pressure increase. The older airfoils have flat bottoms which makes them easier to manufacture and to set the blade pitch. The longitudinal shape of the blade is also not as critical, with some being a rectangular shaper like a low aspect ratio wing. You do have to allow for the cascade ratio of the blades, but it too is not as critical due to the low pressure ratios being encountered. The number of blades is more a factor of the lift coefficients, or its loss, as you exceed the optimum number of blades.

Marc went into more about performing what I would consider a complex series of calculations on how to establish the blade angle throughout the length of the blade. This involved laying out concentric circles from the hub that gave an equal area of flow through the blade versus doing it by equal radius segments. This appears to be a lot of work, but he indicated it gives much more accurate blade settings and optimizes the mass flow through the fan.

The next segment of the presentation covered the most common types of errors made in designing a ducted fan. One of these is trying to use jet turbine technology when building a ducted fan, since one is the high pressure transfer of air and the other is low speed, looking more at mass flow rather than speed. Another error is using too sharp a leading edge on the shroud (inlet lip) since this automatically eliminates the gains from static thrust augmentation. The next error he covered was making drastic changes in the direction of air flow moving through the duct. The changes need to be smooth to avoid vortex separation. One error mentioned was that of trying to scale up a model ducted fan into a man carrying aircraft. There are scaling rules that apply to ducted fans, but when you get down too small problems can arise, such as, the differences in the horsepower to weight and thrust ratios. Model engines put out a lot of power for their weight and may not be typical of what a piston engine could deliver to a full size fan.

Unrealistic performance goals is another one of the errors facing the designer. This is related to the difference between internal combustion engines and gas turbines. The IC engine produces a fixed amount of horsepower that stays constant throughout the performance envelope (or perhaps degrades with altitude, etc.). The turbine on the over hand produces constant thrust due to the dynamic airflow relieving pressure on the compressor and allowing for more thrust to be produced. Marc went on to explain more about this phenomenon and the difficulties it produces if you try to build a ducted fan for high speed flight.

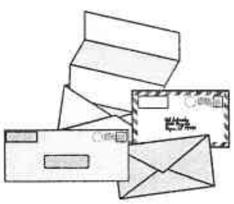
He talked a little bit about the basic plans for the Jet Hawk retrofit. It would include moving the engine forward and, putting the fuel in the wings. The construction would be straight forward using a steel tube fuselage and conventional materials for the skins. The only composites would be in the areas requiring a fairing.

ABOVE: (This still doesn't have anything to do with ducted fans, but we didn't have any diagrams or pictures from the presentation for this section) From the left: Bruce Carmichael, unknown, Paul MacCready, and William Foshag (TWITT's contact with the National Archives).

Marc went through several examples of how ducted fans have been used in the past, some were reasonably successful, and some were poor performers. George Wright also gave us some insight into the types of aircraft that have considered using ducted fans in the past and what he has seen that has worked in the low speed realm.

There was several minutes of general discussion between Marc, George and the group on adaptations of ducted fans and some of the inherent problems when they are used incorrectly. One final point that George made was in the selection of the right kind of engine to power the fan. He was especially concerned about what happens in the failure mode when you become a glider with a lot of wetted area drag from the interior of the duct and the drag of the static blades. There are several engines becoming available that may help minimize this problem, such as rotaries and those designed to run for short periods of time without cooling fluids.

After a few more questions, Marc wrapped up his presentation and Andy adjourned the meeting. Afterwards they talked a little bit about the talk and where some cuts could be made that would make it more appropriate for the average EAA type of group.



LETTERS TO THE EDITOR

May 3, 1997

Dear TWITT:

Yeah, I'm back!

Am hot on Kasper BKB-1 design. Has TWITT published anything? Anyone know of whereabouts of BKB-1 or other Kasper designs? (Hard Wing)

Fred L. Maier
60 W. Balcom Street
Buffalo NY 14209

(ed. - Glad to have you back. Information on Kasper wings has been hard to come by. We know that people associated with the Nurflugel mailing list are trying to track down as much as they can on the BKB-1 and other designs, so there may be more on this in the month's to come. If you have e-mail capability you might want to consider joining the mailing list (its free) and see if you can get them inspired to speed to the research process up.)

July 28, 1997

Dear TWITT:

Please sign me up for another year.

I'm including a copy of the only ducted fan info I've seen, as it come from an old <u>Sport Aviation</u> ("Ducted Fan Propulsion", by Paul E. Best). How about August 1965 (pp. 17-18)! You might pass this on to Marc.

It would seem to me that "high" speed auto engines would be a natural for ducted fan use.

Thanks for a good newsletter and also for making Alex's program on composites available.

Randy Laatsch

(ed. - With all the research the Marc and his partner's did I imagine they came across this article, but I will pass it along just in case. I have included the one figure from the article that was reproducible, since it showed at least one of the things Marc said had been wrong with previous versions of ducted fans, i.e., stators in front or aft of the fan. It also shows very simple set of blades, which Marc commented were okay as long as the airfoil and twist were done properly.

I hope that the information on ducted fans is going to be of some value to those out there building tailless aircraft, since it may provide another option for designing in a cleaner propulsion unit than an external propeller. Only time will tell.)

7/14/97

Dear TWITT:

Sign me up for another year of TWITT. It's nice to know there are others out there involved with flying wings. I now have over 280 hours of flying time on my A-10 Mitchell Wing.

By the time you read this I will be at the Flying Wing Symposium at Harris Hill, New York with my A-10.

Also this past winter, Mike Waters, Dave Simmonds and myself got a Jim Marske Monarch F Model kit. Mike spent the last five months building the kit with Dave and myself as helpers. We did three auto tows with it last weekend. It flies very well. With a little tweaking, it will fly super. We will also have the Monarch at Harris Hill for the SHA Eastern Workshop.

See ya,

Woody Jones
Arlington, VA

(ed. - By the time everyone reads this they will have heard more about the Flying Wing Symposium from the August newsletter.

It sounds like you and your friends are "really into" flying wings, what with your A-10 and the Monarch both in the air. If I don't get some of your A-10 pictures in this issue, I will use them as filler next month. If you have any of the Monarch in the building stages and in-flight, please send them along.

Thank you for you renewal, and we are glad you are enjoying the newsletter.)

6/24/97

Dear TWITT:

I have just received your address from the book publisher B² Streamlines which specializes in aeromodels and tailless aircraft models. Apparently your group specializes in tailless planes and all-wing planes (nurflugel in German language) and is publishing a monthly newsletter. Please, could you explain to me how it could be possible to receive regularly your newsletter (by subscription, or ??).

I am myself a Mechanical Engineer from the University of Louvain- Belgium and, since a long time, I am interested in flying wings and would like to increase my knowledge in this type of airplane, its history and its theory.

I am especially interested in the Horten and Northrop concepts of flying wings and I would like to make contacts with old engineers of these two companies, clubs of fanatics of flying wings, museum and places where I can find help in order to be able to have access to some archives concerning flying wings. Maybe you could help me for this purpose and give me some advice and addresses in this view.

I thank you in advance for your help, and remain,

Yours faithfully,

Eric du Trieu de Terdonck
Rue Grison, 19
B-7387 Angre
Belgium
Tel +32/65/75.00.80
Office Fax +32/65/31.14.74

(ed. - Bob has sent along an information package to Eric, but we haven't heard back from him yet.

Perhaps some of our European members might be able to contact him with information on museums and other research points in the Benelux area and Germany, especially for Horten data. The Northrop stuff we will have to work out another way.)

8/14/97

Dear TWITT:

Please find enclosed my years subscription.

Perhaps you would be interested in my latest RC slope glider. It has been flying since the first of July. It is a home brew design with one central fin. Specifications are:

Span	48"
Root Chord	12"
Tip Chord	6.5"
Sweepback	7°
Weight	28 oz
Wing Loading	8 oz/sq ft
Airfoil	EH2-10, no twist or dihedral
Control	Elevons

It seems to fly well in wings from about 5-10 mph to 25-30 mph so far and the top speed seems to be about 50-60 mph. It has no tendency to tip stall or spin and, as I am flying over the ocean I haven't tryed snap rolls yet.

So thanks for all the work that goes into the newsletter. I find it very encouraging to a somewhat esoteric hobby.

Sincerely,

Allan Morse

(ed. - Thanks for your renewal. We are pleased more of you are renewing each year. We are now back up to about 150 members from all over the world.

If you have any pictures of you "home brew" glider, please send us a couple so we can share them with the other members. We have a lot of them who are into building RC slope soarers and a new project may be just what they are looking for.)

BRIGHT STAR'S MILLENNIUM

At the recent SHA Western Workshop, the Bright Star Gliders company brought out their latest hangglider and set it up for all to see. It is a lighter version of the famous SWIFT they introduced several years back that is now manufactured in Belgium.

They had a one page handout which explained some of the characteristics of the Millennium and visual inspection of the glider (although in prototype configuration) showed it to be well constructed. The material below came from their handout. (TWITT does not endorse this aircraft, but is simply providing the information for use by its members.)

What do you say about a glider that gets 20:1 L/D and 130 fpm sink rate, effortless handling with aerodynamic controls, safer and more comfortable supine pilot position, 5 minute set-up unfolding from its compact zippered bag - 85 lbs weight with harness - that's easier to launch and land than a performance flex-wing and all for only $8,500 msrp? *(ed. - I heard this price may be somewhat low.)*

How about, "I want one!"

After two years of design development and testing, the new Millennium from Bright Star Gliders is being released. While the SWIFT remains the highest performing, foot-launched glider currently available, the Millennium fills a slightly different role. We agreed at Bright Star that a sister ship was needed that combined the excellent performance and safety features of the SWIFT with more affordability, and portability in a user friendly package for the sport pilot.

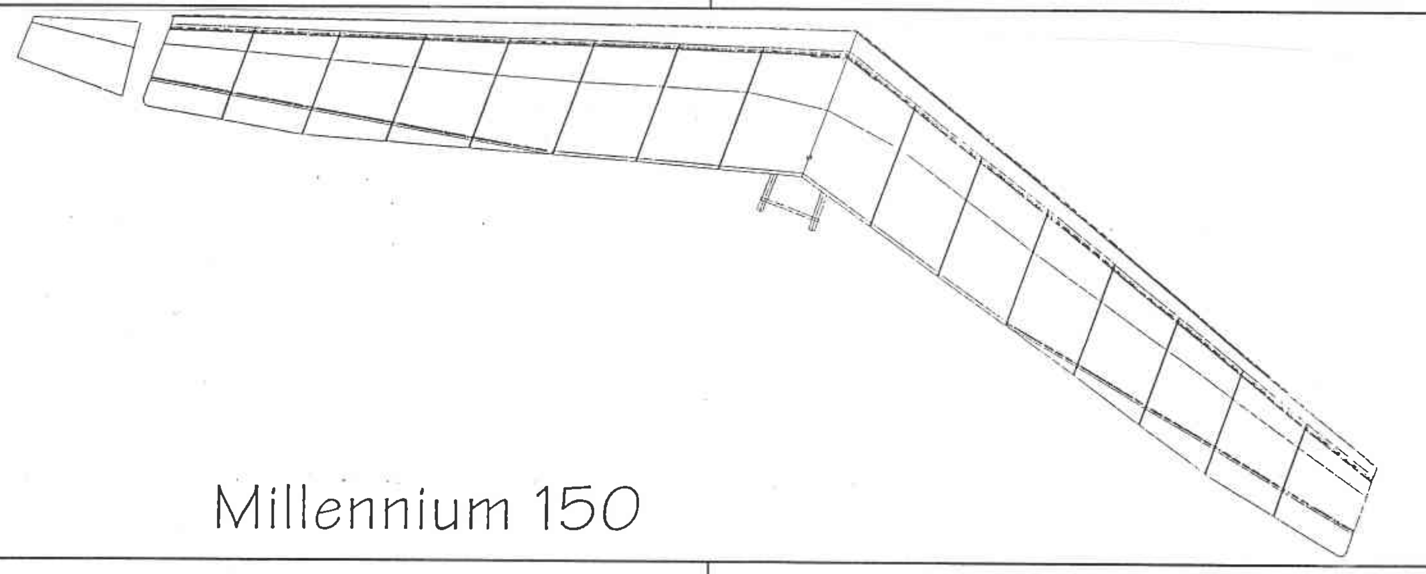
The Millennium is Bright Star's answer to the question: what design will dominate the future of hang gliding? The Millennium features a carbon/Kevlar™ D-tube leading edge spar, with a unique folding rib system that allows all controls to remain rigged. No more stuffing battens. The elevon controls are operated with a side mounted control stick with the SWIFT (and the F-16 fighter). The Millennium is flown in a reclined seated position like a sailplane for increased pilot safety and added comfort. The glider folds into a bag that looks a bit like a pregnant flex-wing.

Bright Star Gliders has over 10 years of experience designing and building aerodynamically controlled hang gliders to the satisfaction of customers worldwide. We invite you to join us and be a part of the next revolution in hang gliders, the Bright Star Millennium.

Specifications

Span	37.5' (11.43m)
Area	150 ft² (13.9m²)
Aspect Ratio	9.37:1
Weight	~85 lbs (38.6 kg)

Options: Tow release (for either aero or ground), pilot fairing (for maximum performance), power unit (ultralight motorglider)


Millennium 150

Membership Dues: (payable in U.S. currency)

United States	$21 /yr
Canada	$26 /yr
So/Cntrl Amer.	$36 /yr
Europe	$41 /yr
Pacific Rim	$46 /yr
U.S. Students	$15 /yr

(includes 12 issues of SAILPLANE BUILDER)

Make checks payable to: Sailplane Homebuilders Association, & mail to Secretary-Treasurer, 21100 Angel Street, Tehachapi, CA 93561.

ULTRALIGHT SOARING NEWS

The United State Ultralight Soaring Association's newsletter is now available. Their purpose is to foster a heightened consciousness about ultralight soaring, to encourage an exchange of knowledge and information making possible the growth of this sector of soaring, and to serve members in their common ultralight soaring needs.

Donations are being accepted to cover the cost of sending the newsletter: suggested amount is $15 for one year (may be later credited towards first year's membership dues), or you can send $25 for your "Founding Membership".

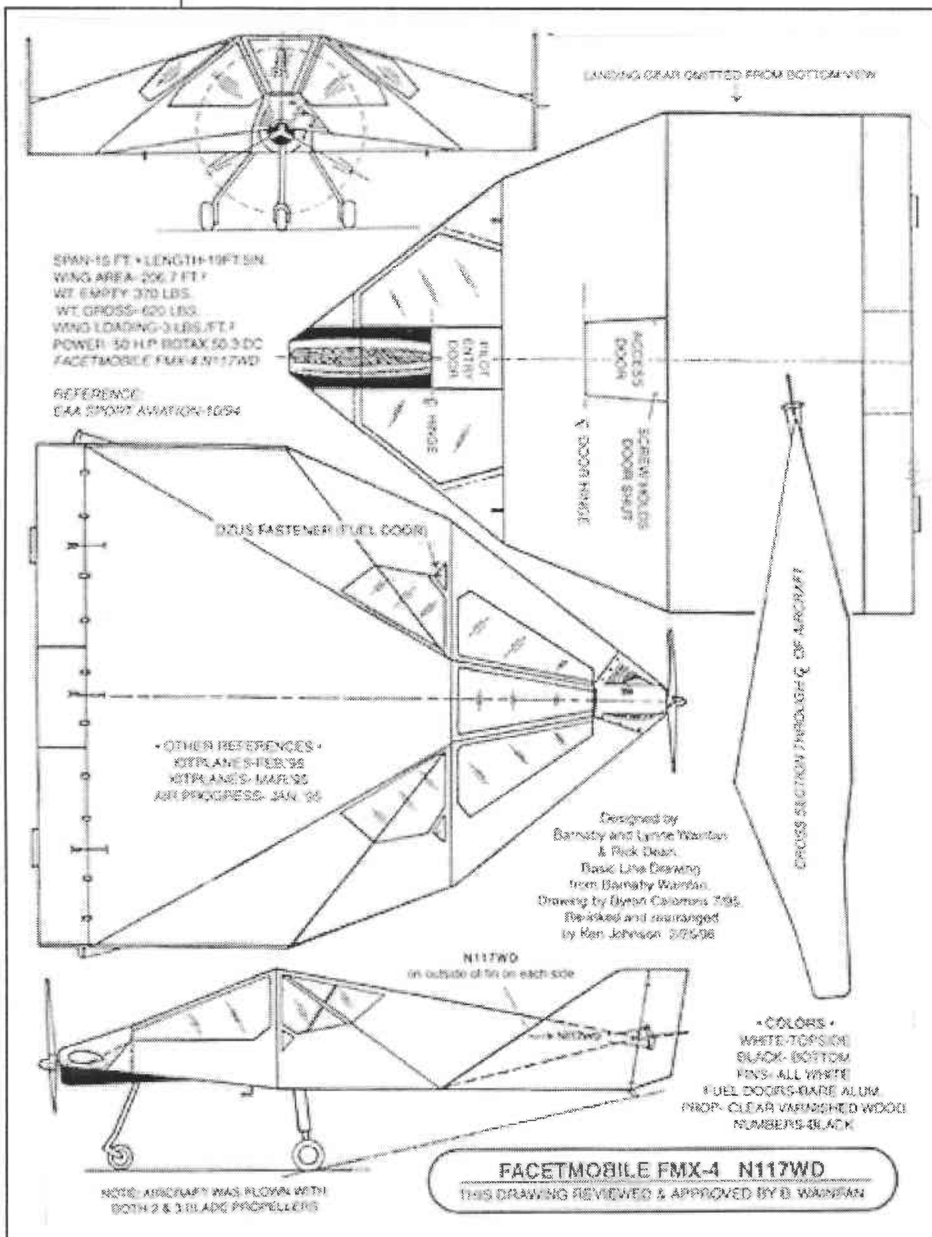
Please make checks payable to:

Chuck Rhodes
130 Los Padres Drive
Camp Pendleton, CA 92054
(619) 385-4068

THE AUSTRALIAN HOMEBUILT SAILPLANE ASSOCIATION

This is the newsletter for the homebuilders group in Australia. It is 8-11 pages and appears to be published the first month of each quarter. It contains sections on mail, shop talk, technicalities, and tips and hints. For more information about subscription, contact:

James Garay
3 Magnolia Avenue
Kings Park, Victoria, 3021
Australia



RIGHT: Barnaby Wainfan's FacetMobile as shown on the Doug Bullard's web site.