FS 32-A NEW GLIDER PROJECT WITH RETRACTABLE EXTERNAL AIRFOIL FLAP

by Frieder Schuon

Akaflieg Stuttgart

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Summary

The FS 32 of the Akaflieg Stuttgart is a glider project to test a new wing section, which can be used in two configurations:

A) Hinged flap: The performance is equal to that of the flap wing sections of modern 15-meter class ships.

B) External airfoil flap: The flap is lowered below the main wing, which closes the trailing edge from 50 percent of the chord. An elastic membrane gives a smooth rounding. The maximum lift coefficient is about 2.3 at a profile drag coefficient of about 0.02.

The extended flap configuration is made for thermaling only. For wide thermals and high speed flight, the flap will be retracted. The name of the wing section is FX 81 k 144; it was designed in the laminar wind tunnel of the University of Stuttgart by Mr. Althaus assisted by a member of the Akaflieg. The FS 32 will be a glider of the 15-meter class. The flaps, which extend over the whole wing span, will serve as aileron, hinged flap or external airfoil, depending on the configuration. The t-tail gets also a new wing section of 12 percent thickness. The vertical tail uses glassfiber prepregs. The fuselage will be made in the molds of Schempp-Hirth's Ventus B. Carbon and aramid-fibres will reduce the weight.

General

The evolution in sailplane design has reached now such a high standard, that improving the performance has become much more difficult than it was some years ago. The possibility of variable wing geometric seems very promising. On the one hand, there is the telescopic wing, on the other the increase of wing area with a fowler-flap. The first option was realized with our FS 29. It is possible to increase the wingspan in flight from 13.6 meters up to 19 meters. The other was constructed for example, by the Akaflieg Braunscheig, the famous SB 11. Looking back, we can now say that the Braunschweig design has more advantages than the FS 29, above all in handling, if flown in (European) contests.

On the other hand, the area-increasing flap has one disadvantage. The maneuverability in thermals is not too good, for the following reason: At slow speed and with a larger wing area, the rudder area is smaller relative to the wing, and the aircraft is not so agile as when flying with flap retracted.

Some years ago we had the opportunity to design a wing section, which does not enlarge the wing area, if the flap is extended. This took place in the laminar wind tunnel of the University of Stuttgart, and was made possible by the help of Mr. Althaus and Prof. Wortmann. In the slow-flight configuration, the wing section has an external airfoil flap, which gives lift coefficients up to 2.3 at a profile drag coefficient of 0.021. With retracted flap, the wing section is adequate to other wing sections of modern 15-meter class gliders. To move the external airfoil flap out, it extends over the whole wing span, the flap is lowered about 6-10 mm below the main wing. The upper surface is tilted down behind 50 percent of chord to close the trailing edge (See Figure 1). To make this part movable and still smooth, the so called "membrane" is included in the upper surface.

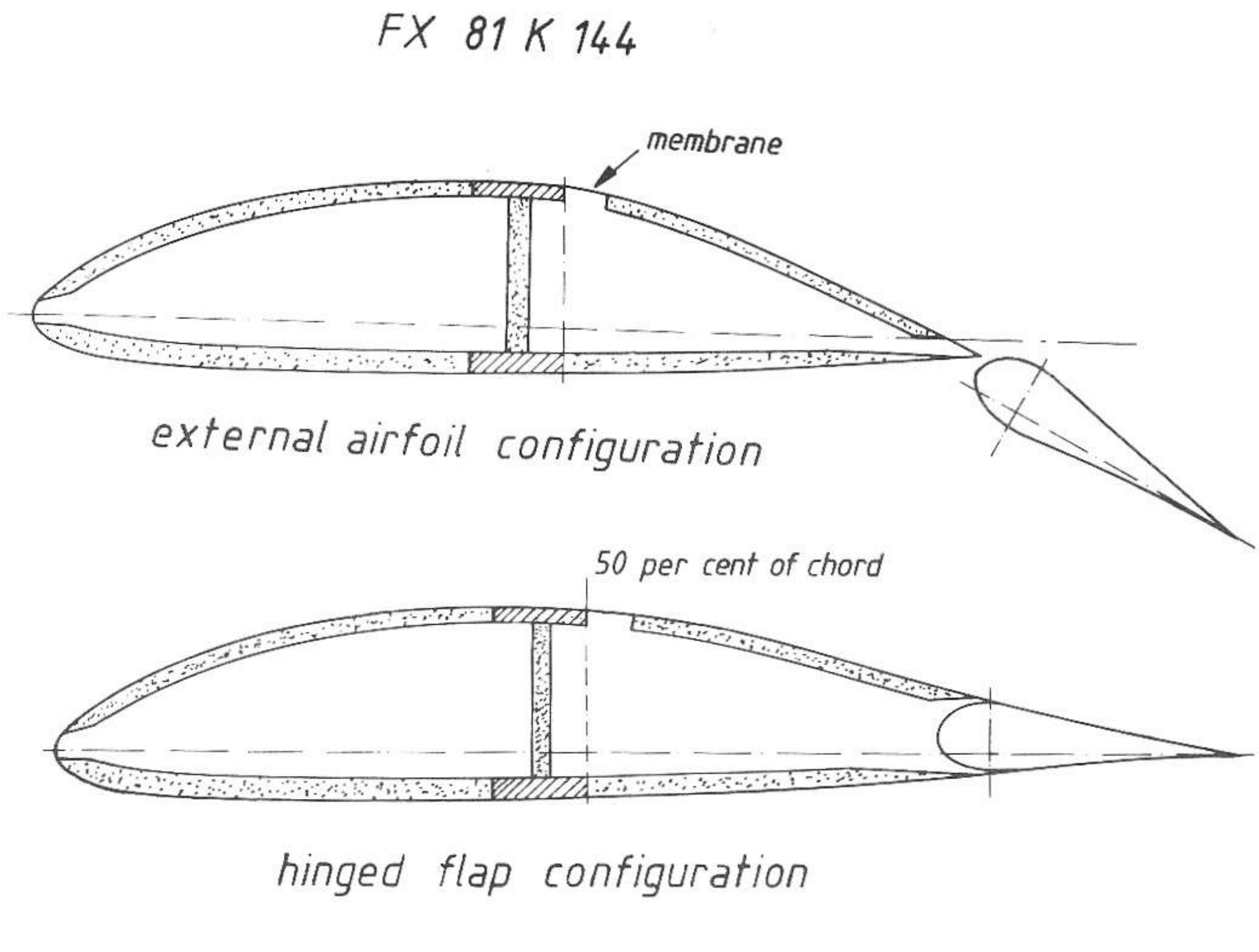

FIGURE 1. Airfoil section and configuration.

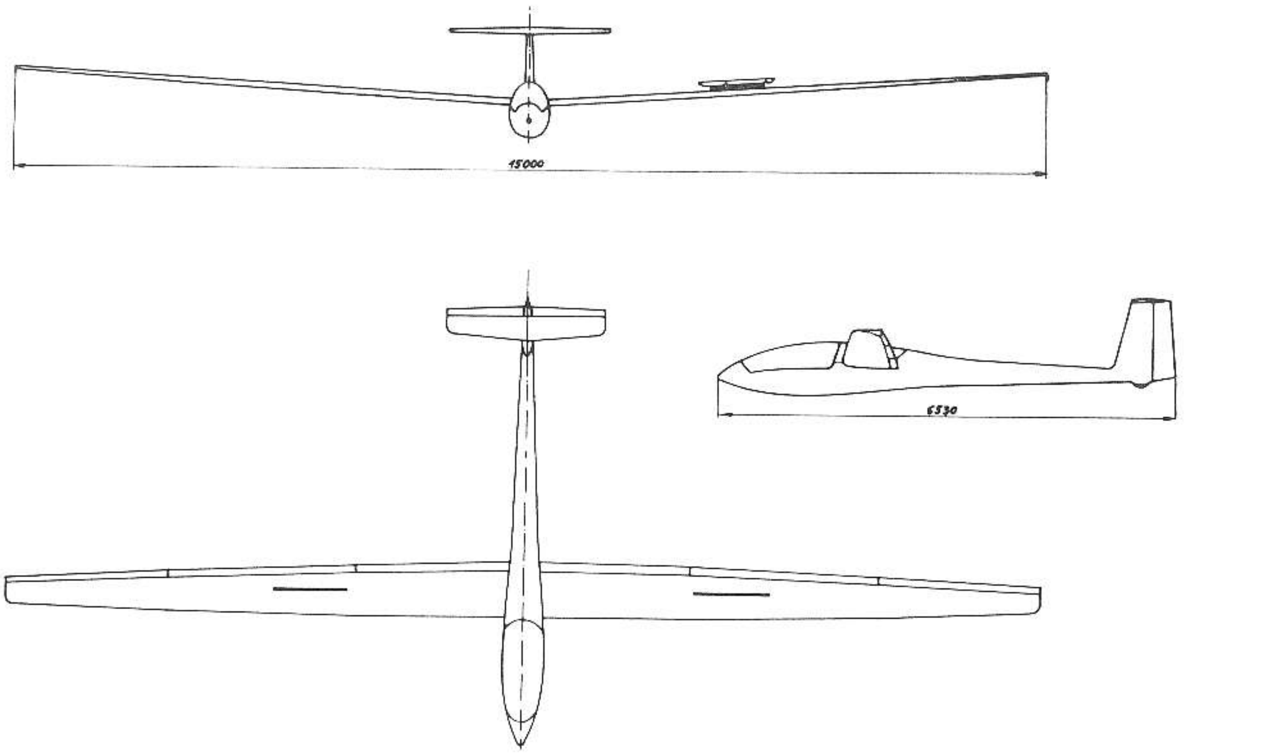

FIGURE 2. General arrangement.

The glider

To limit the expense in man-hours, it was decided to design a glider in the 15-meter class, an unlimited class apart from the span limitation. After optimizing the profile, we began to design the whole airplane. To avoid too high a wingloading, we designed quite conservatively a wing area of 9.94 square meters. It was considered a good compromise, resulting in an aspect ratio of 22.6. A "tri-tropezoidal" geometry minimizes the induced drag (See Figure 2).

The wing

Sadly, the new section has disadvantages, which concern the mechanics and the static. The elastic part of the upper surface allows a small torsion-chamber only. To make the wing nevertheless torsionally stiff, it is necessary to use a lot of carbon fibre. But, to reduce the danger of buckling of the thin membrane, it must be built in a special way. Our decision was to take diagonally directed glass fibres for the membrane and high modulus carbon fibres in the spars. The carbon fibres have an E-modulus of 200000 Mpa. (Fibrevolume is 53 percent). The combination of the stiff wing and the yield membrane induces only a minimum of stress in the membrane. By the way the stiffness of the spar favors also the mechanism of flap setting.

Unfortunately, the mechanism is not easy. Seven supports keep the flaps in position and 23 lid carriers bring the surface behind the membrane up and down. Large Schempp-Hirth type of airbrakes are used to confer excellent landing handling.

The fuselage

Thanks to the help of Schempp-Hirth, the fuselage will be made in the molds of the Ventus B, so that it will have the same shape.

Unlike that of the Ventus, our fuselage will be built with carbon fibre behind the wing. In the cockpit area it is planned to use a carbon-aramid hybrid construction, as in the FS 31 or a construction made from glass fibres, to improve the possibilities of repair.

It is not possible to use only carbon fibre, because this tends to splinter in the case of a crash, which behavior has to be avoided for the security of the pilot.

To secure good maintenance of the control mechanism from and to the wing, we plan to make the fairing behind the canopy removable. The fuselage strength is calculated by means of a finite element program to optimize the weight of the structure. Last but not least, we use aramid fibres as much as possible for the inner parts of the fuselage.

The tail

The T-tail also gets a specially designed wing section. With the help of Mr. Althaus and the airfoil design computer program of Prof. Eppler, we could develop a symmetrical section with a thickness of 12 percent. We hope to improve the glider performance by this T-tail by about 1.5 percent at speeds above 100 km/h, compared to a normal airfoil.

To maintain the stabilizer in the optimum range, there will be a trimmer connected with the lever that operates the external airfoil flap. The vertical tail is designed to build with glass-prepregs. That is to say factory preimpregnated fibres. It will be the first time that prepregs are used in glider manufacturing.

Not to need an autoclav, normally used to cure prepregs, we tested a low temperature, low pressure prepregsystem by Ciba-Giegy. The conditions to cure is now: More than 80 °C and vacuum of about 0.85 bar. Due to the low energy loss, we intend to use heating molds.

The calculated performance

Our calculations show that this glider will be able to fly more slowly than 60 km/h. On account of this, it can thermal in the best zones of the lift. Leaving the lift, the FS 32 cruises with L/D up to 43. Five flap setting positions and one external airfoil position allow the pilot to have the right choices of configuration for the conditions.

To fit the glider to any weather, the wings are able to carry up to 190 liters of water ballast. We intend not to exceed an empty weight of about 260 kg. The range of wingloading is therefore from 340 N/m^2 to 500 N/m^2.

The calculated performance figures are as follows:

Extended flap out:	L/D maximum 28 at 67 km/h
	Min. sink rate 0.67 m/s at 65 km/h
Extended flap in:	L/D maximum 43 at 105 km/h
	Min. sink rate 0.6 m/s at 85 km/h

We hope to bring this interesting project to reality in the next two or three years.