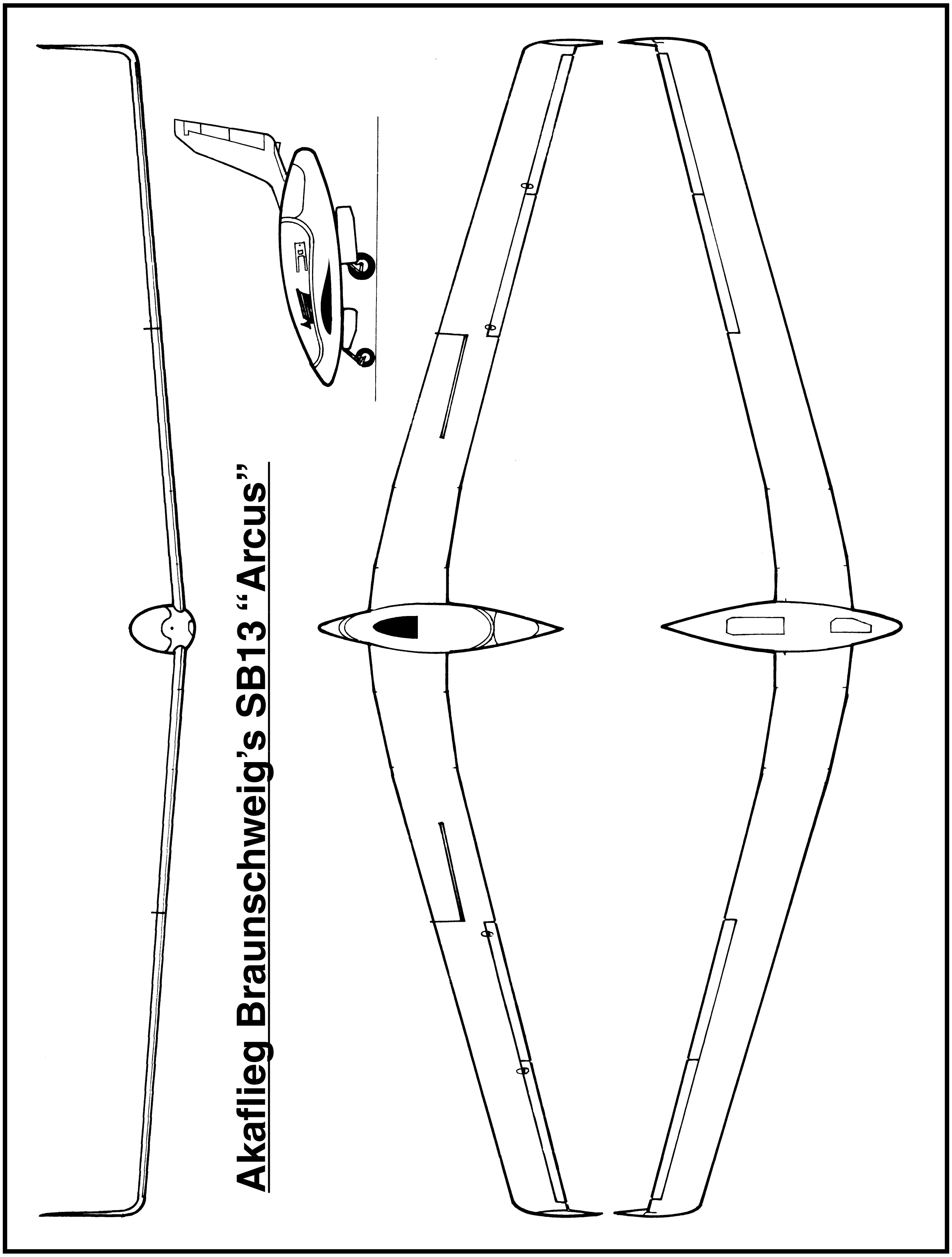
Akaflieg Braunschweig's SB13 "Arcus" an update

In one of our first columns (*RCSD*, Vol. 5 No. 9, September 1988) we described the then new SB13. This full sized swept wing tailless sailplane, product of the Technical University of Braunschweig, Akaflieg Braunschweig, had flown just six months prior, and specific information about its construction and performance had not yet appeared. Interest in the SB13 has not declined over the intervening years, and there are at least a few modelers, ourselves included, who have expressed an interest in building a replica.

Akaflieg Braunschweig is one of nine institutions in Germany known as Akademische Fliegergruppe (academic flying group), or simply Akaflieg. The history of these groups can be traced back to the years immediately following World War I and the Versailles Treaty. As powered aircraft were forbidden under the Versailles Treaty, but the desire to design, build and fly aircraft remained, the newly founded Akafliegs concentrated on sailplane development. Because of a similar but wider ban on all aircraft development following WWII, it was not until 1951 that these groups could again be active. Since then, however, they have been both active and productive. Table 1 lists just a few of the accomplishments of the Akafliegs. Akaflieg Braunschweig is probably one of the more prolific groups, having designed, constructed and flown several advanced sailplanes, yet it has only about 25 students enrolled at any one time.

The primary goal of the Akafliegs is to synthesize academics, developments in aerodynamics, and new materials to design and build better sailplanes, but a few powered sailplanes and lightplanes have also been produced. Organization centers on the Idaflieg, the Syndicate of German Academic Flying Groups. Guidance, major funding, a number of technical facilities, and much equipment come directly from the DFVLR, the German Aerospace Research Institute. Materials, tools, access to private technical facilities, and additional funding come from the aerospace industry. Students, when not building prototypes, are involved in other activities, as eligibility for flying the group's sailplanes is dependent upon accumulated work hours.

Akaflieg Braunschweig's 1982 decision to build the tailless SB13 was based upon three arguments. First, it was felt recent standard class sailplane performance improvements were due primarily to use of laminar flow airfoils and development of better fuselage aerodynamics. Future performance


Akaflieg Braunschweig's SB13 "Arcus"

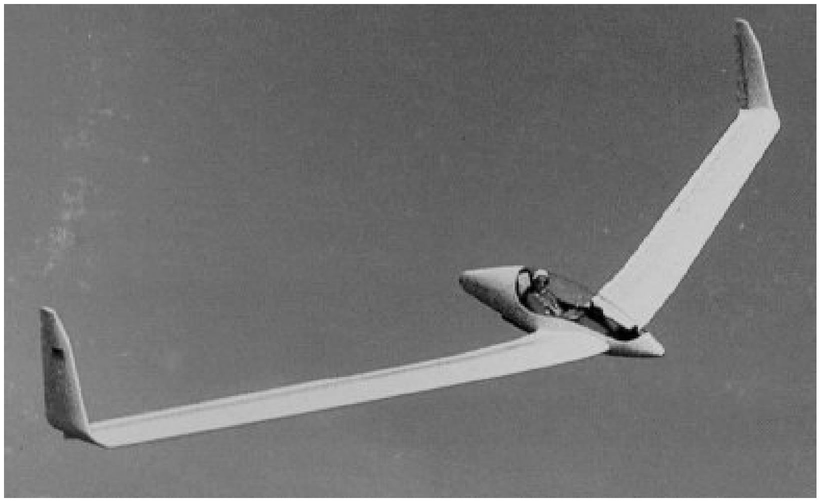
Sailplane	Distinctive Characteristics
fs-24 Phönix	• first sailplane constructed entirely of fiber reinforced plastics
SB10 Schirokko	• first use of carbon fiber in a sailplane • four world records in 1979 • best two place sailplane for over 10 years
fs-29 Teleskop-Flügel	• first and only telescopic wing sailplane
SB11 Antares	• equipped with Wortmann flaps • made entirely of carbon fiber • piloted by Helmut von Reichmann, it won the world championship in 1978, just weeks after its first flight
SB12	• first sailplane with active boundary layer control
Mu28	• fully aerobatic • automatic trailing edge flap • maximum airspeed 250 mph
SB13 Arcus	• first tailless sailplane to be constructed with modern composite technologies • first use of carbon fiber control rods in an aircraft • development of a process for molding a monolithic curved spar
Akaflieg designations: fs = Stuttgart, SB = Braunschweig, Mu = Munchen	

Table 1

improvements using tailed planforms were therefore predicted to be relatively small. Second, building a tailless sailplane would be scientifically interesting, as a competitive tailless sailplane had not been built for three decades. Third, it was felt the tailless planform, due to its smaller number of parts, would be more rapidly built than a conventional design.

The third argument turned out to be completely fallacious, as many of the difficulties which would eventuate had never been addressed before, and solutions to these aerodynamic and structural design problems could not be directly derived from experience with conventional tailed designs.

Sweep back was chosen so the elevator had sufficient leverage, and the wing tip chord was kept relatively large to improve the lift distribution. This large chord allowed sufficient section depth to support vertical fins at the wing



ends. The fins were then designed to cover the entire wing tip, providing sufficient area with reasonable height, and acting as winglets to reduce induced drag. A dihedral angle of four degrees was chosen to provide ground clearance for the wing tips during landing.

The laminar flow airfoil sections for the SB13 had to be designed for good stalling characteristics, high lift, minimal pitching moment, and a resistance to air flow disruption resulting from debris on the leading edge. Modern laminar flow airfoils, fairly easily designed utilizing modern computer software, seemed to be tending toward all of these characteristics, and so designing the new airfoils did not present any major difficulties. The HQ 34N/14.83 was chosen for the wing root, and the HQ 36K/15.12 was chosen for the outboard portions of the wing where the ailerons and elevators are situated. Both of these sections are shown in Figure 1. The HQ 36K/15.12 features a down turned trailing edge. This relieves the otherwise incessant download on the control system caused by the airfoil's reflexed camber line. Once the HQ 34N/14.83 and HQ 36K/15.12 were shown to be equivalent to other modern laminar flow airfoils in all

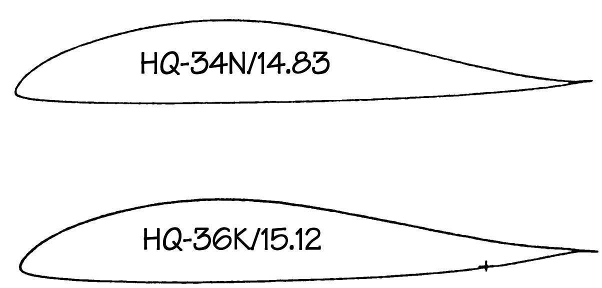


Figure 1

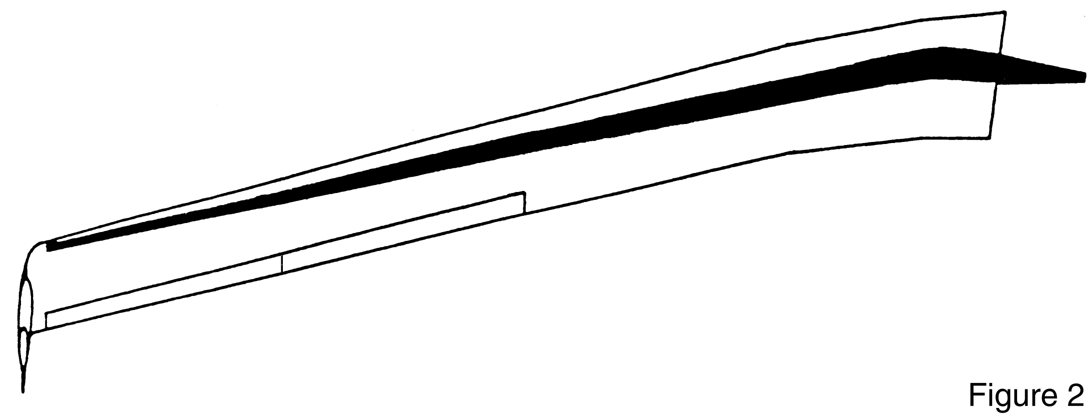


Figure 2

performance dimensions, Akaflieg Braunschweig felt it was possible to build a tailless sailplane with better performance than any existing standard class glider. (A condensed version of the rules for the standard class is provided at the end of this column.)

A 1/3 scale model of the initial design was built and flown, but two problems immediately arose. The model would enter a spin when stalled, then spin in the opposite direction when recovery was attempted, and severe flutter was in evidence even at low speed. While the airfoil chosen for the model was responsible for the stall-spin characteristics, the flutter problem was not so easily identified. It was only after computer modeling by Messerschmitt-Bölkow-Blohm that the sources of the problems were identified and specific changes to the spar structure could be recommended. That structural change involved reducing the sweep angle of the main spar at the wing root. The graceful curve of the inner portion of the SB13 wing was a direct result of integrating the redesigned spar with the chosen airfoils and the overall wing sweep needed for stability.

This was the first time construction of a spar of this type was to be attempted, and Akaflieg Braunschweig was forced to invent a method of creating a one piece complex curved structure of laminated unidirectional rovings and bidirectional fabrics. Inadvertent mishandling which could damage the materials had to be avoided and the entire spar had to be fabricated in less than five hours to assure proper matrix formation. Following fabrication of a portion of one spar as a preliminary exercise, both full length monolithic spars were molded successfully. An overhead view of the SB13's spar system is depicted in Figure 2.

Testing of the completed wing structure included loading it to 13g (7.5g expected load with a safety factor of 1.725). The wing was eventually loaded to 16.5g without failure. Testing concluded, construction of the remaining portions of the primary structure was rapidly completed. The control system, however, which is quite intricate, took longer to construct and install than expected. Carbon fiber rods were used in this application, another first for the aviation industry.

The resulting aircraft was then tested for resonance frequencies to determine the speed at which flutter would occur. Data and computer modeling showed flutter occurring above 270 km/h (168 mph), a speed which is significantly higher than the SB13's 210 km/h (131 mph) maximum.

The first flight of the SB13 took place on 18 March 1988. Aerotow was employed, with a nose attachment point. Launched from a height of 3000 feet, it became the first tailless sailplane to be built with modern advanced composite technologies.

Flight testing showed only one major problem. Flight performance improved as the CG was moved back, but at extreme rearward position the SB13 would easily enter a spin – spins were sometimes induced by turbulence alone. Tuft studies carried out under conditions of higher stability showed cross span flow at the leading edge which precipitated stalling of the outer wing. Flow fences were installed on each wing at the leading edge and in line with the aileron root. This entirely solved the abrupt stall problem and dramatically improved the flying characteristics in all regimes. At last report, there were five pilots rated for the SB13.

The glide ratio of the SB13 is reported to be at least 42:1, with one source reporting 43.5:1. This is an excellent value for a standard class sailplane. Table 2 provides the glide ratio and maximum speed for a number of well known standard class sailplanes. Although its maximum speed is lower than

The SB13, with the SB10 in the background.

Year of First Flight	Builder and Nomenclature	Glide Ratio @ mph	Max. Speed, mph	Min. Sink ft/sec @ mph
(1988)	Akaflieg Braunschweig SB13	43 @ ??	131	1.74 @ ??
(1979)	Akaflieg Aachen FVA-20	35 @ 56	155	1.97 @ 42
(1978)	Grob G-104 Speed Astir II	41 @ 74	168	1.97 @ 47
(1977)	Bölkow Phoebus B3	39 @ 58	124	2.00 @ 51
(1977)	Glaser-Dirks DG-200	42 @ 68	168	1.80 @ 45
(1977)	Schleicher ASW 20	42 @ 60	168	1.97 @ 45
(1976)	ISF Mistral-C	37 @ 58	155	2.17 @ 43
(1976)	Schempp-Hirth Mini-Nimbus HS-7	42 @ 62	155	1.87 @ 50
(1975)	Schleicher ASW 19	38 @ 65	152	2.13 @ 45
(1974)	Grob G-102 Astir CS	38 @ 65	155	1.97 @ 47
(1974)	Glaser-Dirks DG-100	39 @ 65	161	1.94. @ 46
(1969)	Schempp-Hirth Standard Cirrus (Cirrus 75)	36 @ 53	137	1.87 @ 44
(1968)	Schleicher ASW 15B	36 @ 55	137	2.00 @ 48
(1967)	Glasflügel H 301 Libelle	39 @ 59	155	1.80 @ 46
(1938)	DFS Meise	25 @ 42	136	2.20 @ 37

Table 2

most modern standard class ships, its thermaling ability is said to be significantly better than that of conventional tailed sailplanes. Minimum sink is reported to be an extremely low 0.5 m/sec, and stands in contrast to rates of about 0.6 m/sec for tailed ships of its class.

Since a 1/3 scale model of the SB13 has already been constructed using relatively conventional construction techniques, modelers should not be easily dissuaded from constructing a large scale replica of their own. A 4-view of the SB13, based on information and drawings found in various issues of the *TWITT Newsletter* and in *Silent Flight*, is provided in Figure 3; dimensions and other data are listed in Table 3.

Dimension	Magnitude
span	15 meters, 49.2 ft.
wing area	11.6 m^2, 124.8 ft^2
aspect ratio	19.4:1
wing twist, total	-1.5 degrees
dihedral	4 degrees
winglet height	1.25 meters, 4.1 ft.
fuselage length	3.02 meters, 9.91 ft.
empty weight	300 kg, 660 lbs.
control surfaces	aileron and elevator, with mixing, and differential rudders
maximum speed	210 km/h, 131 mph
landing gear	2 wheel tandem, retractable
best glide ratio	43.5 to 1
parachute recovery system	vacuum bagged, ballistic extraction, 20 Kg (44 lbs.), 1.35 ft^3

Table 3

Use of the new EH airfoils is recommended, as these sections have a near zero pitching moment and good lift and stall characteristics. The thickness of the EH 3/12 compares favorably with that of the sections used on the full size SB13 and affords the height needed for a stiff, torsionally rigid spar along with plenty of room for servos and control linkages entirely within the wing structure. Wing construction will pose some challenges, but no insurmountable difficulties. The curve of the wings is really the result of connecting three straight sections, sort of a highly modified Scheumann planform. A torsionally rigid spar reinforced with carbon fiber is a necessity, but otherwise a wing structure using normal "foam core and fiberglass skin" construction methods should work well.

Control hookup should, of course, match the original, with interconnected ailerons and elevators, differential rudder function, and spoilers. (The SB13 control system will be examined in detail in a future column.) Set aside an additional channel for retracting and extending the landing gear.

The SB13 is a truly beautiful machine which very much deserves to be accurately modeled. We'd appreciate hearing from *RCSD* readers who tackle this scale project.

SOURCES:

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Back issues and subscriptions are available from are available from the Sales and Circulation Department, Argus Specialist Publications, Argus House, Boundary Way, Hemel Hempstead, Hefts. HP2 7ST England.

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BASIC RULES FOR STANDARD CLASS SAILPLANES

1. 15 meter span maximum. Devices for increasing lift, i.e. flaps, are prohibited.

2. Air brakes are mandatory, but they cannot increase lift or improve performance.

3. The landing gear may be either fixed or retractable. The main wheel must be at least 300 mm in diameter and have a width of at least 100 mm.

4. Jettisonable water ballast is permissible.

A Fauvel AV 221/222 at a meet in England. Photo by Eric Marsden.