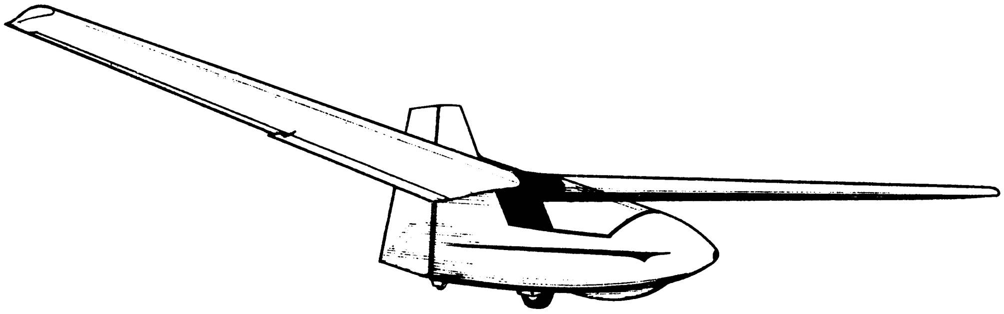


On the ’Wing... #157

Larry Haig’s *Minibat*

The chance to build a reasonably sized 1/2 scale sailplane does not present itself very often. In this case, the model wing span would be just 12.5 feet. That’s right, the wing panels turn out to be less than six feet long!

The Minibat was Larry Haig’s response to what he saw as fundamental problems within general aviation in the late ’70’s. His goals during the design process included safety and performance at the lowest price, achieved through use of modern materials and recent revisions to FAA regulations; quick building time, approximately 40 to 80 hours; small size and an ability to serve as an inexpensive teaching platform; a modular design which could be expanded to a larger span and better performance without major modifications. Unfortunately, the Minibat did not fulfill safety requirements, and kit production was terminated. Approximately 55 kits were sold.

Planform and controls

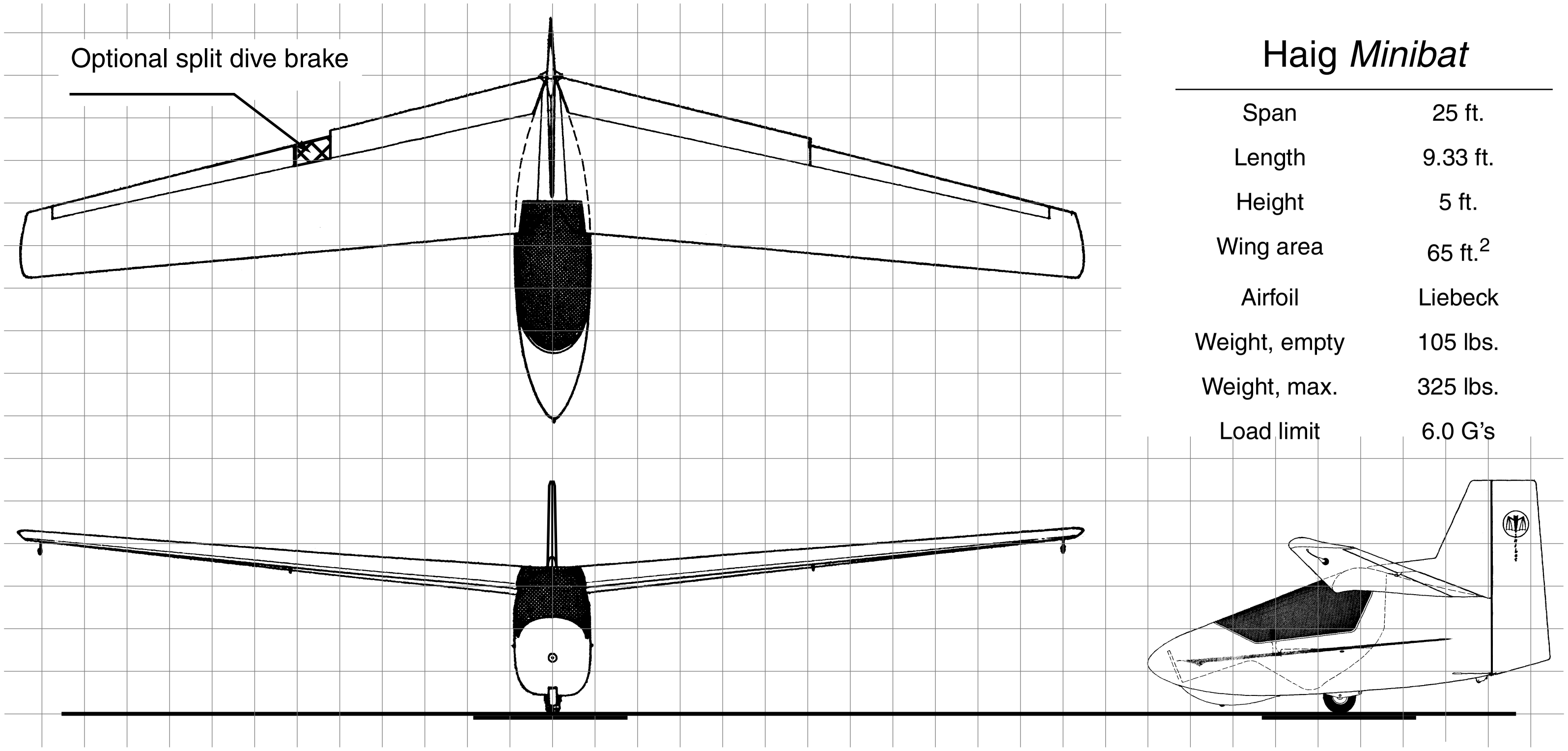
The Minibat is also somewhat unique from a planform standpoint in that the wings are swept forward more severely than is usually seen in tailless aircraft. Jim Marske’s Pioneer II and Monarch, for example, have much less forward sweep of the quarter chord line.

Controls are conventional, despite the tailless planform and forward sweep. Central elevators, outboard ailerons, and rudder encompass all of the control surfaces of the original design. For landing, the ailerons can be raised into a spoileron position, while the elevator deflects downward to act as a flap. As of an information bulletin dated April 1981, the outboard ten inches of the elevator could be turned into split panel dive brakes. This modification is noted in the included 3-view in the top view, right wing.

Construction

Minibat construction was unique for the time period. Most of the 18 major parts consist of a PVC core with fiberglass on both sides and formed in a female mold. A few dozen hardware parts are sufficient to complete the aircraft. Despite the extent of molding and preformed parts, the FAA determined that the aircraft is 64.5% fabricated by the builder.

The wing consists of molded upper and lower shells of E-glass and foam, a spar using unidirectional S-glass for the caps, and molded shear webs of glass and foam. The shells are held



Haig *Minibat*

Span	25 ft.
Length	9.33 ft.
Height	5 ft.
Wing area	65 $ft.^2$
Airfoil	Liebeck
Weight, empty	105 lbs.
Weight, max.	325 lbs.
Load limit	6.0 G's

together at the leading edge by J-joint, and at the trailing edge by the molded rear spar. The elevators and ailerons are made from molded glass upper and lower surfaces over glass and foam ribs. The wing halves attach internally at the centerline with pins. Additional wing panels of about four foot length became available to increase the wing span and decrease the wing loading. These extensions substantially improved gliding performance.

The fuselage is built in the same way as the wings, except there is no spar cap. The outer skin carries the bending loads and the inner skin carries the torsional loads. Reinforcement is provided in the area of the landing gear, tail skid, etc. Besides a J-joint on the outside, the fuselage is tied together on the inside by the seat, armrests and keel.

The fin and rudder are constructed like the ailerons and elevators — glass skins are placed over foam ribs.

Airfoil

Perhaps the most problematic component of the Minibat is the airfoil. A Liebeck section (maximum camber at 20% chord, camber = 5.5%, thickness = 14.5%) was used in an effort to achieve a high coefficient of lift. The Liebeck airfoil was one of the first computer-designed sections, and the code at that time was not reliable. It was predicted that the section would achieve a maximum coefficient of lift of at least 1.4 while not having the excessive drag of other high lift sections. Evaluating the Liebeck section with modern computer codes, the Liebeck section does not live up to its expectations.

- The upper surface does not behave well at Reynolds numbers below three million. A good sailplane section should be good down to Re = 500K or lower, depending on the local wing chord. The Minibat mean chord is 30 inches, and the Reynolds number in slow flight is around one million. The wing tips just cannot produce enough lift, and the reaction of the pilot is to feed in more up elevator. Up elevator produces a large down force, counteracting the lift generated by the wing. Jim Marske predicted that the maximum coefficient of lift of about 0.8 under these conditions, just 60% of the predicted value.

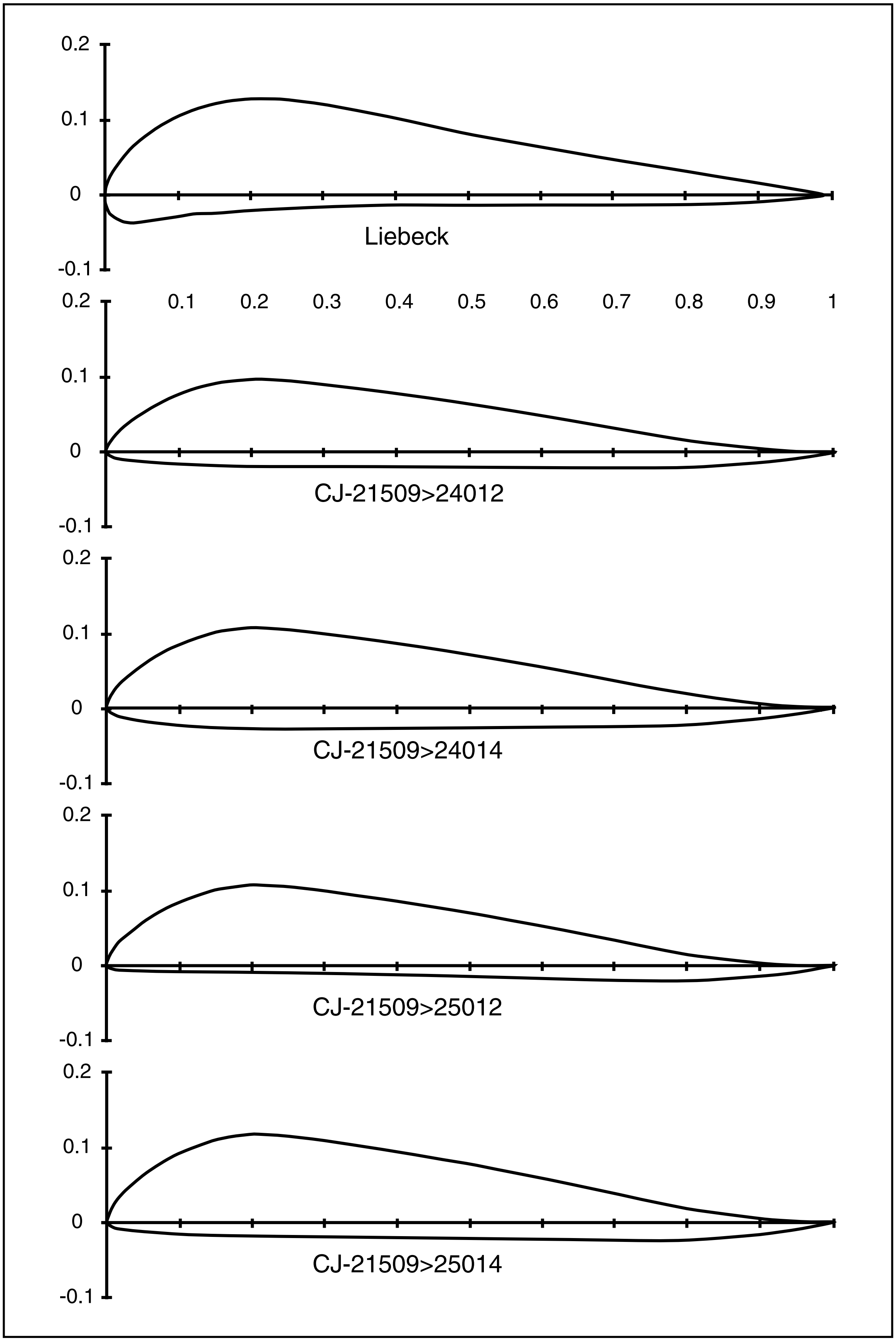
- The bulbous protrusion on the lower surface near the leading edge causes a large amount of drag at high speed. As the angle of attack decreases, this area acts as a lower surface spoiler. Poor upper surface boundary layer control at low speeds and this lower leading edge protrusion which causes exceptional drag at high speed severely limit the speed range of this section.

- Because of the upper surface behavior at low Reynolds numbers, the ailerons on the Minibat do not start operating until the aircraft has nearly reached flying speed.

- The Liebeck section is not so stable as had been originally thought. In fact, some amount of up elevator trim is required for stable flight. This is not a problem in the Minibat, as the elevator is large, but it is something to keep in mind.

Since the Liebeck section performs so poorly on full size aircraft, its performance on a model, even at half size, can be easily predicted to be abysmal. We’ve looked through our collection of airfoils and found what we believe to be a suitable replacement.

Dave Jones was a prolific designer of airfoils for use on plank planforms. Rather than use sophisticated airfoil design programs, Dave utilized relatively simple mathematical formulae to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define camber lines and surface contours. His technique was much like the old NACA 4-digit and 5-digit methodologies and the resulting airfoils are turbulent flow sections. This is exactly what is needed for modeling purposes.

One of Dave's last sections was his CJ-21509 (maximum camber at 20% chord, camber = 1.5%, thickness = 9%). Note that the maximum camber point of the CJ-21509 exactly matches the maximum camber point of the Liebeck airfoil. By increasing the camber of the CJ-21509 to 5%, that parameter can be made roughly the same as the Liebeck. We remain somewhat leery of increasing the thickness to 14%. For this reason we've plotted other modifications of the CJ-21509 with variations of camber (4% and 5%) and thickness (12% and 14%).

We very much recommend that the builder construct a primitive all foam wing and ballast it to match the anticipated wing loading of the completed scale model. A free flight prototype would be fine. This is the only way to determine if the chosen airfoil will actually work well at the scale model Reynolds number.

Idiosyncrasies

During ROG takeoff, whether by winch or aerotow, there are pronounced pitching moments which require compensation. When level on the ground, the CG is below the wing and directly over the main wheel. While standing still, nose down and ready for takeoff, the CG is in front of the wheel. This is because the CG is well above the axle. The elevator and wing reflex are producing no down force at the rear. As the takeoff roll begins and the air speed increases, the forces generated by the elevator and airfoil reflex increase with the square of the speed. The aircraft starts to rotate once these aerodynamic forces are great enough, and the CG moves back in relation to the wheel. As the CG moves over and past the wheel axle, the aircraft is pitched up by both aerodynamic and mass forces. The greater the upward rotation angle, the more the aircraft will want to rear back even further.

It is therefore possible to lift off the ground at a speed less than the minimal flying speed. The wing is fully stalled under this condition, the aircraft is not controllable, and a crash is nearly always inevitable. Two fatal Minibat accidents can most probably be attributed to this behavior. Jim Marske reports, "As I understand it, both accidents occurred during the takeoff run and the gliders cartwheeled down the runway. One wing struck the ground causing a groundloop."

It is imperative that the nose be kept down until flying speed is reached. Once at flying speed and in the air, the location of the CG is below the wing, so the aircraft is self-stabilizing in this regard.

The canopy seal must be carefully watched. Air leaks in this area severely degrade performance.

Full size flight experiences

Two flight experiences, while rather harrowing, point out both positive and negative aspects of the Minibat design. The first episode, as told by Jim Marske, appeared on the nurflugel e-mail list while we were researching this column:

> "To clear up some mystery concerning the Minibat at Elmira, New York back in the '80's. We had a meeting of the U.S. Sailplane Homebuilders group. Al Backstrom, Larry Haig and myself gave presentations on flying wings. Just as I completed my presentation on the Monarch and Pioneer 2, I was told that Larry

> was about to auto tow his Minibat down the Harris Hill runway. If you are not familiar with this airstrip, it is about 1,800 feet long with a considerable dropoff at each end. The Minibat, even though it was small and light, it had a small wing also which resulted in a fairly high wing loading. So takeoff speed was quite high and required a lengthy run just to get the glider into the air.
>
> "Just before my presentation Larry told me that one of his elevator bellcrank brackets had come off. He decided to anchor the bracket with a pair of vise grips (a cam lock pliers). Well during the bouncy takeoff the vise grip pliers let go and the young pilot was left without any elevator control. The Minibat proceeded to climb very steeply to about 200 feet (65m) where the pilot released. The nose high glider stalled and dropped vertically for the ground. The pilot, being a hang glider pilot as well, shifted his weight as far back as he could to effect a recovery - which fortunately worked. The Minibat rounded out just short of the ground and skimmed the runway. The pilot threw his weight forward to keep the glider on the ground and stopped just before he slid off the edge of the steep hill. Only the grace of God and his hang gliding experience saved him.
>
> "An amusing ending to the story... One fellow was expounding on how dangerous flying wings were as unstable and uncontrollable. I interrupted and asked him just what would he have done if he were in a tailed glider and the elevator control did not respond. I added that if he had been flying anything other than a flying wing under those circumstances he surely would have been killed. The short coupling of a flying wing and the rather narrow c.g. range made for a responsive to weight shift pitch control."

Mat Redsell's experience was nearly fatal as well. For some reason the CG was misplaced during preflight and was too far forward, and this lead to a rather severe dive upon release from the tow line. Elevator deflection was not sufficient to correct the situation, so Mat tried shifting back in the seat, much like Larry Haig had done at Elmira, but to no avail. In desperation, he folded his knees closer to his body. This moved the CG far enough aft that the aircraft was controllable in pitch, but the rudder was free to deflect on its own and it simply followed the oncoming airflow.

In contrast to a swept back wing, a forward swept wing is directionally unstable. As soon as he removed his feet from the pedals, the Minibat started yawing. The resulting side slip drastically reduced the glide ratio, and stretching the glide to achieve a landing site was next to impossible. When he put his feet back on the pedals to reduce the side slip, the Minibat went into a dive. With a landing site in view, Mat set up an approach. At that point, the Minibat went into a side slip and the canopy blew open. Mat somehow managed to get the canopy closed and make a "successful" landing.

Conclusion

Despite the relatively poor, unpredictable performance and safety concerns of the full size Minibat, it should make a very good scale model. In a model, the CG will not move, control surfaces will maintain direct connections to driving servos, and human life is not at stake. No matter the airfoil chosen or the scale of the model, keeping the weight down will be the primary factor influencing performance. Lower weight equates to lower flying speed and more rapid response to control inputs. Additionally, a model at half scale is reasonably sized and would be easy to detail.

Readers wanting coordinate tables for the airfoils mentioned in this month's column need only send a request to us at either our post office box or e-mail address. Suggestions for other viable airfoils are especially wanted.

We would appreciate hearing from anyone contemplating construction of a scale rendition of this aircraft. As usual, we can be reached at P.O. Box 975, Olalla WA 98359-0975, or by e-mail at <bsquared@appleisp.net>.

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