

Stechmücke

An Ultra Micro Super Floater

By Gordon Johnson



The Stechmücke is a classic indoor slow flyer that takes full advantage of recent advancements in radio, battery cells, and gearboxes to achieve a weight well below one ounce and slow yet nimble flying characteristics.

When the Dynamics Unlimited RFFS-100 integrated micro radio system came out I immediately knew I wanted one. But, what to put it in? The Skeeter plans that come with the radio system are nice, but I wanted to try something slower. After a bit of research I decided to try my hand at a mostly carbon fiber indoor floater. If you have ever wanted a very light indoor slow flyer, all the pieces are now readily available to allow you to break the one-ounce barrier with the Stechmücke. This plane has its roots in the Kolibri/Stubenfliege designs. Since Kolibri is German for Hummingbird, my friend Klaus suggested I call this much lighter plane Stechmücke, which is German for Mosquito. That name fits as throughout its design and construction I emphasized weight minimization.

The key to any ultra slow flying indoor plane is low wing loading. This can be achieved either with a large wing area, or by making it as light as possible. I chose to focus on making it as light as possible. Since the biggest weight in most planes is the battery pack, I am currently using one of the only very recently available 135mAh LiP (Lithium-ion Polymer) batteries from Skyborn Electronics. Only one cell is needed because of the higher voltage of Lithium cells. This cell weighs 4.1 grams with wires and JST plug compared to a 120x3 NiMH pack's 11.8 grams. I am using a Mabuchi M20-HV (high-volt) motor from Toytronics, which generates plenty of thrust for a plane this light. I plan to switch soon to a pager motor and gearbox from the Swiss firm Didel. Before you worry that this plane will be successful with only the lightest components, let me assure you that it will fly slowly and very well with heavier components. I have flown this plane with a 120x3 NiMH battery pack and heavier prop, gears and wheels and it was still a superb performer. Other readily available motors are also adequate. The M20-LV (low-volt) motor from the E-Charger toy plane is also acceptable and is roughly equivalent to the M20 motor that comes in the KP-00 propulsion set, which is also an acceptable choice. The M20-LV motor will generate more thrust, but flight times will be somewhat shorter as it has a much higher amp draw. I'm using a Westech carbon fiber 6.3"x4.7" (160x120mm) prop from Dave Lewis. But, I've also flown the plane with the much less expensive and slightly heavier GWS 6x5.0 prop. In short, this plane is suitable for a wide variety of components and is perfect for testing different micro propulsion systems.

SPECIFICATIONS

Model: Stechmücke

Type: indoor floater

Designer: Gordon Johnson

Wingspan: 19 in.

Wing area: 123 sq. in.

Weight: 23.4g (0.83 oz.)

Wing loading: 0.97 oz./sq. ft.

Radio req'd: DU RFFS-100

Radio used: DU RFFS-100

Motor: Mabuchi M20-HV (Toytronics)
geared 6:1

Battery: 135mAh Lithium-ion Polymer or 3-cell, 120mAh NiMH

Prop: 6.3x4.7 CF or equivalent

Flying speed: 4 to 5 mph

Duration: 10 to 15 min. depending on battery used

Comments: The Stechmücke is a very light indoor slow-flying plane that just floats around in the air. It uses readily available components. And, fabricating electronic components is not required to achieve a plane well below the one ounce barrier. It can easily fly in a space one-third the size of a basketball court. The Stechmücke is capable of very tight circles, figure eights, and touch and goes all in a very small space.



Shown on the left is the old standard, a 3-cell 120mAh NiMH battery pack which weighs 11.8g. On the Right is a new 135mAh LiP battery, which weighs 4.1g. I label each of my battery packs and keep a log to monitor each pack's charging history.

Here is a rundown on the various pieces I used. The Didel gearbox can be ordered either with brass bearings or sized to accept 2mm id ball bearings. I'm using 6:1 gearing from a 10t Kenway pinion gear and a 60t Didel spur gear. I've also used Didel's standard 5:1 gearbox with good results. I used the ball bearing version of their gearbox and got the bearings from Dave Lewis along with the CF tube, rods, and RA Microlite covering I needed. The Microlite covering is the lightest colored covering I have found, and substantially lighter than the Reynolds Wrap sometimes used. You will need one each of 2.2mm CF tube, 1mm CF rod, and 0.8mm CF rod. For the tail I used 5 pound density 1/32-inch and 1/16-inch contest-grade balsa from Superior Balsa. I purchased copper tubing to cut out the holes in the tail at my local hobby shop. For wrapping the joints I used Kevlar thread from Wild RC, but you can also use thin unwaxed dental floss.

Since the choice of components and materials is the key to a very light indoor plane, I've included a breakdown of weights of various components and at different stages of construction. This allows you to compare, say, substituting a GWS 6x5.0 prop with rubber push-on adapter that weighs 2.1g for the Westech CF prop and see that it would add 0.8g to the weight. Likewise, substituting a 3-cell 120mAh NiMH pack for the 135mAh LiP cell would add 7.7g to the weight.

Stechmücke Weight Breakdown (grams)

CF fuselage & wing (uncovered = 2.6g)	3.8
Elevator: no actuator (uncovered = 1.0g)	1.5
Rudder: no actuator	0.7
Didel gearbox/M20/JST wire & plug (M20=3.8g)	4.7
Westech CF prop	1.3
135mAh LiP battery with JST plug	4.1
DU RFFS-100 radio system & actuators	3.9
Wheels & landing gear (wheels = 0.3g)	0.5
Wires for motor & battery & JST plug & antenna	1.1
Receiver/battery/tail skid balsa	0.5
Glue and misc.	1.3
Total weight (grams)	<u>23.4</u>

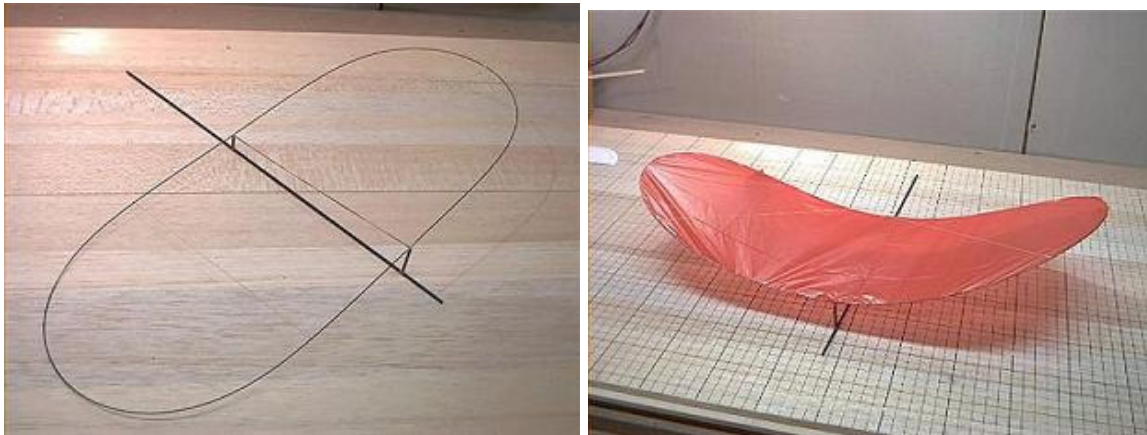
Building The Wing & Fuselage

First a note on building light with carbon fiber rods and tubes. CA is heavy, and the natural tendency is to wrap too many turns of kevlar thread or unwaxed dental floss around the joint, and then apply too much CA. It doesn't take much of either. I first tack the joint together with a spot of medium CA applied with a tooth pick or length of piano wire. Then I wrap the joint with two to three wraps of thread in each direction. I apply thin CA to this wrapped joint, and immediately wipe it with a paper towel to remove excess CA. These joints have proven to be extremely durable. As a final touch I color the joints with a black Sharpie marker so they match the carbon fiber. The CF construction of this plane does not allow for taking it apart for transportation as some CF designs do. This is mostly for weight considerations and the fact that the tail does not lend itself to easy removal. As a side effect, the CF construction is simplified.

The basic idea for the wing is to take a length of 1mm CF rod 46 inches long and bend it around and attach it to itself. I reamed out a length of aluminum tubing 1/2 inch long till the CF rod slid

into it from both ends, and then wicked thin CA inside. Alternately, you could simply overlap the two ends, bind with thread, and CA the joint.

Next, drill two holes, the diameter of small finish nails, in a board 7 inches apart and insert two small finish nails. Loop kevlar thread around the nails and tie a knot. Slip the nails out of the board and remove the Kevlar loop. Repeat twice more for a total of three loops. Drill a third hole 15.75 inches from the first, and make a ½ inch loop at one end and knot it. Spot CA the knot. Run the thread to the other nail, make a ½ inch loop, knot it, and spot CA it so the thread is tight between the nails but terminates in a loop at each end. Repeat once more for a total of two. These are the threads that will pull dihedral into the wing.



Left: The basic carbon fiber construction is completed and the wing is ready for covering.

Right: RA Microlite covering has been applied, and the Kevlar threads installed to pull the dihedral into the wing.

Squish the CF hoop into an oval and slide one of the three loops on to the middle with your joint at what will become the trailing edge. Slide the other two loops on and position them 4.25 inches out from the middle. See the dotted lines on the plan. After checking that the wing is symmetric, spot CA each loop at the LE and TE.

Cut four pieces of 0.8mm CF rod 3/16 long. Position them 7.75 inches out from the center of the wing (see plan) flat to the building board covered with wax paper and tack them with CA. Take the wing off the building board and wrap the joints with two turns each way of Kevlar thread and adhere with CA. These are the hooks for the dihedral threads.

Cut lengths of 2.2mm CF tube 1.1 and 0.6 inches long for the wing pylons. Lay them all flat on wax paper on your building board, pin them in place as shown in the plan on the remaining length of CF tube. Note, do not cut the fuselage CF tube to the length shown on the plan. Leave it long at the nose and the last step will be to shorten it as required to position the motor where the model will balance. (In the pictures you will notice that I ended up lengthening the fuselage when I switched to the light LiP battery in order to make the plane balance.) Tack the shorter tube 6-inches from the tail end of the fuselage tube. Measure the chord on your wing and position the front wing pylon exactly this distance from the rear pylon. Tack glue the joints with CA. When dry, remove from the board and wrap and CA joints. Pin the fuselage on the board with the wing pylons perpendicular to the building surface. Tack glue the wing on top of the

pylons, with the joint at the trailing edge. Cut a length of 0.8mm CF rod to go between the LE and TE edge of the wing where it attaches to the pylons. Tack, and CA and wrap a ½ inch length of 0.8mm CF rod to the rod between the LE and TE 2.3 inches back from the LE. This is the CG and you can hold the plane between your thumb and index finger to balance the plane and check its CG. Make sure the wing is perpendicular to the pylons before proceeding. Wrap and glue LE and TE joints.

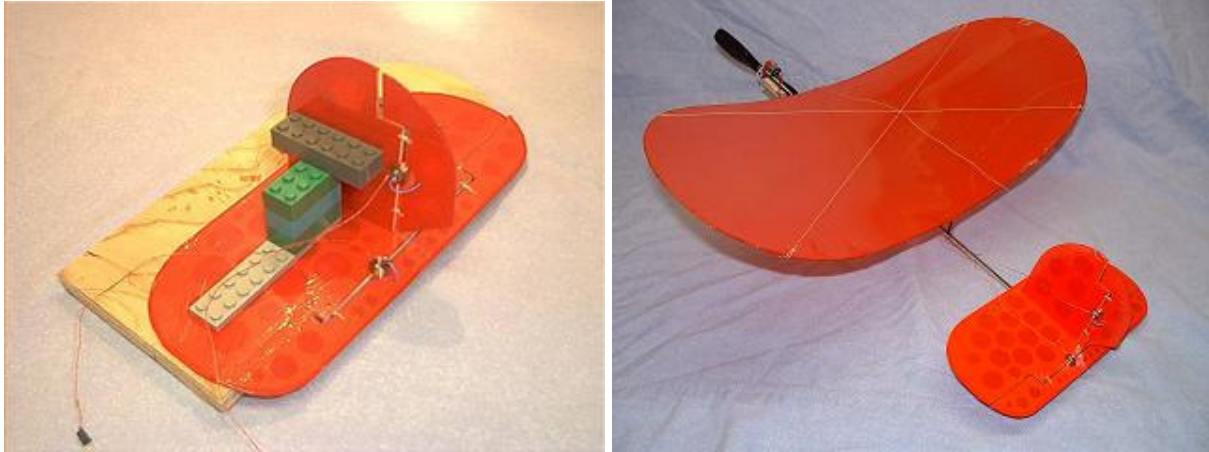
Cut out a rectangle of RA Microlite about ¼ to ½ inch larger than the wing and tape it shiny side down to your building board or workbench so it is flat and wrinkle free. Apply Avery glue stick to the top, bottom, and outside edges of the wing — not to the CF rod between the LE and TE in the middle of the wing. Lay the wing down with the fuselage up on the RA Microlite. Remove tape from the covering and lift the wing and covering off the board. Using your fingers smooth the covering onto the glue on the CF rod, moving around the outside till the covering is firmly attached and wraps around the rod. Leave to dry for 24 hours. Take a new hobby knife and carefully trim the excess covering off as close as possible to the CF rod.

Now it's time to put the dihedral and airfoil in the wing. Loop one of the dihedral threads from the LE hook to the TE hook on one wing tip. Bow the wing by putting that wing tip down on your workbench, and then attach the other dihedral thread to one of the hooks on the other tip, then through the installed dihedral thread, and back to the other hook on the upper wing tip. Once this is done, pin the fuselage down on your building board, and prop the wing up. You can twist the wing till it is not warped. Keep sighting down the fuselage till it is right. Then, apply a spot of CA where the two dihedral threads cross. Finally, shrink the covering with a sealing iron. Be careful to not let the iron touch the CF rod forming the wing. Even a quick touch can result in melting the rod. It will kink from the pressure and you will have to start over or fix the wing.

Elevator & Rudder

I designed the shapes of the rudder and elevator to echo the rounded shape of the wing. I made the rudder from 5 lb density 1/32-inch balsa and the elevator from the same density 1/16-inch balsa. If you don't have any contest grade balsa, use 1/32-inch for the elevator. I like planes with tail feathers that match the wing. So, I covered mine with RA Microlite. If you don't mind bare balsa wood, leave the tail uncovered and skip the lightening holes. I bored the holes with a sharpened brass tube from my local hobby shop before cutting the elevator and rudder out from the sheet to avoid breaking them. Then, I cut out the shapes, including the hinge line. Dynamics Unlimited (DU) recommends a 1/16-inch gap between the control surfaces. I stripped a short length of 1/16-inch balsa and positioned it between the main part and the control surface for both the rudder and elevator, and used a short piece of Scotch tape to temporarily keep it in place. I covered the side without the tape with RA Microlite, then turned it over, removed the tape, and covered that side. I used a 3/32-inch diameter sharpened brass tube to bore the holes for the actuator, centering it exactly in the middle of the balsa spacer. Next, I carefully cut through the covering to separate the control surface, removing the temporary balsa spacer strip. Finally, I trimmed an extra 1/16-inch around the hole in the control surface to allow it to clear the actuator coil.

Installing the DU supplied rubber band hinges can be tricky. The single biggest problem people have is getting too much CA on the rubber band hinges so they don't flex easily. This causes the control surface deflection to be much less than the 45-degrees or so that is normal. If you don't get the deflection you need, chances are you need to remove the rubber hinges and start again. Don't use very much CA as this may wick out to the center of the rubber hinge and harden it, and then it won't deflect as far. Apply CA with a toothpick, and only near the ends of the rubber bands. You can also drop a bit of accelerator on the CA to keep it from wicking where you don't want it to go. I recommend attaching the elevator and rudder actuator leads to the RFFS-100 and testing the control surface deflection before gluing them to each other or the fuselage. It is much easier to remove the rubber band hinge and try again if the final assembly has not been done yet.



Left: Actuators have been installed and tested for full deflection. Using a technique previously written up in RC Microflight, I used my sons' Lego blocks to insure perfectly positioned tail and elevator.

Right: Final assembly is complete. Note the dihedral threads. The antenna is rubber-coated antenna wire from Cloud 9 RC, cut to the length recommended by DU, and is simply run from the receiver over the front of the wing and through a hole drilled in the top of the rudder.

To install the actuators, I followed the instructions that came with the DU RFFS-100 system. Use Ambroid glue to attach the coils to the rudder and elevator so you can remove them at a later date without damage by applying some acetone. I used a spot of CA between the magnets so they didn't misalign themselves when I was wrapping the wire around them. After getting the wire bent in approximately the correct shape, I drilled a small hole in the control surface and poked the wire through and then bent to the correct shape before applying a small drop of CA.

I made my own wheels from two sheets of 1/32-inch contest grade balsa laminated cross-grain and then sanded round on my Dremel. Make a light ply circle with a hole drilled in the middle and glue a CF rod in the hole. I slide the balsa blanks on the CF rod, then a corresponding drilled light ply circle, and then chuck it all snugly in the Dremel. A sanding block with the Dremel at low speed quickly sands the wheels round. Remove and glue an aluminum axle in each wheel. Tires can be drawn on with a Sharpie marker. My wheels weigh 0.3 grams for the pair. I have not found any plastic wheels this light. The landing gear is 1/32-inch piano wire bent and CA'd and wrapped on one end of a pair of 0.8mm CF rods. These are arranged in an inverted V on the fuselage immediately in front of the LE wing pylon, tacked in place, and then wrapped and CA'd. The plane is so light, that this landing gear is more than strong enough.

Motor, Battery, and Receiver Installation

The receiver and battery are mounted on two-layer 1/32-inch balsa sandwiches with the grain oriented 90-degrees between layers. The actuator leads supplied from DU are not long enough to reach the position shown on the plan for the receiver. There are two solutions: (1) lengthen the actuator leads, or (2) glue the receiver mount near the TE instead of the LE. If you choose method #2, and are using a 120x3 NiMH battery, you will have to position the battery mount in front of the LE as required to balance the plane. Or, if you are using a LiP battery, leave the fuselage longer than shown and move the motor and LiP mount further forward as required to balance the plane. I chose to lengthen the actuator leads. This is not as difficult as it sounds, but requires some AWG #40 wire from DU or some other source. Simply cut the wire before the

plugs at the ends, apply electronics soldering flux, and hold the end of the wire and the new extension wire together and bring to a hot soldering iron that already has solder on the tip. Then, paint the joint with regular modeler's enamel paint to insulate it. You will then need to solder the wire for the plugs on the lengthened leads and apply new heat shrink tubing.



The Stechmücke is completed. Note the LiP battery mounted underneath and directly behind the motor with magnets. This picture also shows the airfoil that is created by shrinking the covering after the dihedral is pulled in with the threads on the top. The Kevlar thread loops between the LE and TE are left in place in case the covering comes loose, but could be cut off if desired.

The receiver is simply stuck on to its balsa mount with a strip of 3M double-sided foam tape. I attached the LiP battery with four 1/16x1/32-inch neodymium magnets from Forcefield. Velcro would also work, especially if you use NiMH or NiCd packs. I glued the motor/gearbox to a piece of scrap balsa sanded to give a 2-degree downthrust, which was then CA'd to the fuselage tube. This makes it easy to remove for trying alternate motors.

Flying

Be prepared for a lot of comments about how slowly this plane flies when you take it to an indoor fun fly event. The Stechmücke takes off in a short distance with only partial throttle. It can do slow tight circles or figure eights in a compact space right in front of you. It can also fly around the entire facility at either a slow or fast speed. It is stable enough to bring down to within inches of the floor and fly the length of the hall. Touch and goes are a lot of fun. If the landing is a bit too hard it simply bounces since it is so light. In short it is a very relaxing and fun flyer. With a LiP battery it is capable of flying in excess of 15 minutes, but I really don't know what it is capable of yet. With 120x3 NiMH cells it can easily fly for 10 to 12 minutes.

Since the Stechmücke will attract so much attention, it's probably a good idea to know how to pronounce it. It sounds something like Stesh-moo-k', which kind of rhymes with the sound cows

make for the moo part of it. I hope you have fun experimenting with motors, gearing, and props, or just relaxing and flying it.

