‘Jester’ Manual (version v1.3)

1. Tools

Scalpel with new blade

Steel straight edge

Metric ruler

Cutting mat

Building board – plasterboard is good (a 1220x600x12 mm sheet cut lengthwise in half makes a good size board. Coating the cut edges with PVA glue stops them shedding dust).

Model making pins (with large T-shaped head)

Small steel set square

Sharp large and small pointed scissors

Tweezers

Fine copper wire side cutters

Side cutters for piano wire

Needle nose pliers

Dremel type rotary tool with fine cutting disc (for cutting carbon fibre (CF) rods).

Facemask

Soldering iron

Good light

2. Materials and parts

Sheet of 2 mm Pichler Super Board (polypropylene foam); used to be sold by Graupner as Vector board.

For a lighter build the wings could probably be made of 1mm Super Board but I have not tried this yet.

Carbon fibre:

500 mm of 3x0.5 mm flat strip

1000 mm of 0.8 mm rod

500 mm of 1 mm rod

330 mm of 2 mm rod

Glues

Uhu-Por

Use Uhu-Por to stick carbon fibre (CF) to foam, and foam to itself.

The Super-noz from Micro Aces makes applying a fine bead of glue much easier https://microaces.myshopify.com/collections/building-tools/products/super-noz

Apply glue to one part and bring the parts together straight away.

Checking that the joint has not opened up until glue has dried. If it has, push together again.

Thin CA (also known as cyano or superglue)

No Nonsense Superglue from Screwfix is thin CA and is low cost (CA has a short shelf life so it is handy to have a local supply).

Place the parts together and apply the glue. It will wick into the join.

Either use a micro nozzle for CA or apply a drop to a pin and use this to place the CA on the joint.

You can use a paper towel to mop up any surplus.

Breath on the CA to speed up hardening or spray with cyano activator.

5 minute epoxy

Isopropanol (isopropyl alcohol, also known as IPA) for degreasing carbon fibre rod and piano wire. Meths should work too but I have not tried it.

Masking tape

Non-stick clear film (such as poly pockets)

Fine sandpaper (about 200 grit)

Cocktail stick to mix epoxy

1.25cm 3M Blenderm surgical tape

3M VHB strong double sided adhesive tape

Kevlar thread (https://www.troutcatchers.co.uk/kevlar-thread-c2x17503553)

0.6 mm heat shrink tubing http://www.micronradiocontrol.co.uk/wire.html

0.5 mm piano wire https://www.ebay.co.uk/itm/165108292820 ; a 300 mm length will leave plenty to spare.

Small piece of 2 mm thick balsa (medium density)

3D printed parts (see below)

All in one receiver (RX) with 2 linear servos (such as https://microaces.myshopify.com/collections/all-in-one-receivers/products/all-in-one-aio-5ch-micro-receiver)

20x8.5 mm brushed motor and 65 mm push-on prop https://bmks.co.uk/products/bmk-high-power-coreless-motor-8-5mm-x-20mm and https://bmks.co.uk/products/gemfan-65mm-props-with-1mm-hole

Connector for motor lead, 2 Pin 1.27 mm Pitch Polarised Connector http://www.micronradiocontrol.co.uk/conn_p127mm.html includes heat shrink.

1S lipo about 150 to 175 mAh with a UM type connector (1.25mm pin spacing) suits the leads on all-in-one RXs. The model would also carry the weight of a 250 mAh 1S lipo with a PH2.0 connector.

3. General

View and download build photos at:

https://www.dropbox.com/scl/fo/z7sb19jwrtnzv517qw92i/h?rlkey=axhmlz6q52nd1odhmsej30e58&dl=0

Drawings

Drawings download:

https://www.dropbox.com/scl/fo/hnu91j83653dwyowrwy15/h?rlkey=yys02wv2kcoxaxgskxl3r7ove&dl=0

These drawings can be opened with Adobe Acrobat Reader.

When printing these .pri files click on File > Print > Custom Scale and set it to 97.087%. Then measure the length of the 200mm dimension line on the drawings to see if the dimensions are correct.

To correct any inaccuracy, adjust the custom scale value proportionally. For example, if the length of the dimension line were 201mm the new custom scale would be:

200/201 x 97.087 = 96.604

It is a good idea to read the whole manual and look at the photos before you start. Then, before each section, have a refresh.

Lashings to join rods together

Black Kevlar thread is the strongest and has least stretch. Polyester thread may work just as well.

Protect plan with poly pocket material or thin polythene bag.

Place CF rods together over the drawing.

Tack CF rods together with drop of CA.

When glue is hard, make a clove hitch https://www.netknots.com/rope_knots/clove-hitch around one rod.

Lash with 4 square turns and round turn on 1 rod. Like a square lashing but omit the 'frapping turns'. See https://www.netknots.com/rope_knots/square-lashing

Position over plan to check squareness of parts.

Apply CA to secure lashing.

There are some photos this.

Foam parts

This is best done by cutting through the drawing and the foam. Cutting out around the paper drawing, tracing around this template and cutting to this line gives a less accurate result.

With the wing, cut the drawing along one edge of the wing and position the drawing at the edge of the foam (see photos 3a2 and 3).

Position drawing of part on the foam sheet and secure with masking tape.

Cut out foam by working from the right side of the sheet if you are right-handed (see photo 3a4).

There is a wing root template to help with cutting the foam at a bevel at the wing root so the joint between the wings is neater.

For a slower flying model the cord of the wing could be increased but I have not tried this yet.

CF parts

Mark the cuts with masking tape for all the cuts before starting to cut a rod (see photo 3b1). Allow 1 mm for each cut and marked the tape to show on which side of tape to cut.

It is easier to cut the 0.8 mm rod with copper wire side cutters rather than a Dremel cutting disc.

Cutting schedule:

Wing spars 3 x 0.5 mm flat strip, 2 pieces 245 mm long

Fin spar 1 mm rod, 94 mm long

Elevator rod 1 mm rod, 176 mm long

Stabilizer spars 1 mm rod, 2 pieces 75 mm long

Fuselage boom 2 mm rod, 330 mm long (20 mm longer than drawings – to be cut down when CG checked)

Undercarriage 0.8 mm rod, 4 pieces 84 mm long

Pushrods 0.8 mm rod, 2 pieces 250 mm long

Clean/degrease all CF parts with IPA.

3D printed parts

STL file download:
https://www.dropbox.com/scl/fo/rpxh5pv40zbwvl0jxgdtu/h?dl=0&rlkey=gga5d8rvejorllv3seq8563vt

PETG filament worked well but PLA should be strong enough.

If you are an IVCMAC member and don't have access to a 3D printer, let me know and I will print these parts for you.

The holes in these parts are based on the size of my CF rods. The actual size was slightly smaller than the nominal size.

4. Wing

Making each wing

Pin through the plan in 3 places to mark the edge of CF spar on the lower foam sheet (see photo 4a1). Remove plan.

Push 3 pins vertical through foam into building board (see photo 4a2). Use small set square to get vertical.

Use a diagonal pin to act as a stop end to give a 6.5 mm projection of the spar beyond end of wing.

Glue spar to foam (see photo 4a3) checking spar is upright.

Scrape off surplus glue.

Repeatedly press spar down onto foam until dry.

Dry fit pins at an angle to allow top and bottom sheets to align along their leading edge (LE). Place a pin at end to assist with alignment.

Support trailing edge (TE) of upper sheet on some books at an angle.

Glue top sheet to bottom sheet with bead of glue on the LE (see photo 4a4).

Every couple of minutes run finger along LE until glue is dry.

Allow glue to dry well.

Apply a bead of glue on top of spar and rear edge of lower panel.

Hold down edges with books (see photo 4a5).

When dry, glue wing tip together.

Joining the wings

Use a block under one wing to get dihedral correct. Use the dihedral template to adjust angle (see photo 4a8).

Dry fit and plan how to hold everything in place before mixing epoxy. One spar is in front of the other; try which one in front gives the best alignment of the two wings.

Use a small crocodile clip to hold the spars together.

Check that wings are not warped and they are both aligned correctly so there is no twist between the wings.

Use small pieces of masking tape to mark which faces on the spars are to be glued. Note where glue should be applied so it can be mostly confined to the joint area on both faces.

Sand the joining faces of the CF to give a better bond and clean with IPA.

Mix 5 minute epoxy with a cocktail stick on a piece of paper. It only requires the smallest of blobs of the same size of resin and hardener (see photo 4a6).

Apply glue sparingly to the area of both spars which will touch. Apply Uhu-Por to the edge of the top of one of the wing skins. No glue on the bottom skins (they will be cut back slightly later to allow the fuselage rod to be recessed into the wing).

Bring together and secure with clip and masking tape as required (see photo 4a7).

After the epoxy has gone off, but is still rubbery, carefully cut away the excess glue particularly in the V between the two spars on the underside which will fit against the fuselage boom.

Round the LE of the wings with clean sandpaper to give a slight round. A face mask is advised as the dust is an irritant.

Tape LE of wing with 1.25 cm Blenderm tape (see photo 4a9 – shows the tape lightly stuck but not yet smoothed down over and under the wing). If you get folds where the LE curves at the tips, snip these with fine scissors and press cut edges down.

5. Elevator

Slide elevator horn and arm over the elevator rod. Tape and pin down to plan covered in poly pocket (see photo 5a2). The elevator horn is on the starboard side.

Check horn is vertical.

Apply thin CA to joints with a pin. Soak up any excess with a paper towel.

Leave for about an hour to harden.

Uhu-Por the elevators to the spar, horn and elevator arm (see photos 5b1 and 2). The top of the rod should be level with the top of the elevators.

Cut small recesses in the stabilizer to accommodate the projections on the horn and arm (see photo 5b3).

Position elevators against stabilizer and tape the joints on the top with Blenderm to form a hinge. Avoid pushing the elevators tight against the stabilizer, just gently touching it. This should provide enough room for the elevator to pivot to the down position as the rod (pivot point) is at the top of the elevator.

6. Fin spar

Place poly pocket over side view.

Get fuselage boom and fin spar square on their side taped over plan and follow lash procedure (see photos 6a1 and 2).

7. Stabilizer

Fit the stabilizer mounting spars to fuselage boom following the lash procedure:

The aft spar should be just clear of the lashing securing the fin spar.

Have fin spar hanging off building board vertically and stabilizer spars on the bench over the plan (see photos 7a2, 3 and 4).

When lashing complete, cut hole (2 mm wide x 1 mm) 1mm to starboard of midpoint of stabilizer to accommodate the fin spar (see photo 7b1).

Have stabilizer/elevator assembly inverted (horn down) at edge of building board with long part of the fin spar poking down through the hole in the stabilizer (see photo 7b2).

Support end of fuselage boom so stabilizer spars lie flat on the stabilizer.

Glue stabilizer to spars with Uhu Por.

8. Fin

The fin aligns with the starboard side of the fin spar (see drawing).

Glue top section of fin to the stabilizer and fin spar (see photo 8a1).

Check that fin is parallel with centreline of boom.

Cut the corner off the bottom section of fin to fit over the lashing (see photo 8a2).

When the top section has dried, glue the bottom section to the boom and fin spar. Check alignment with top section and fuselage boom.

9. Rudder

Cut a single slit for the horn as drawing. A set square can be used to get the cut at right angles to the surface of the rudder.

To form the hinge, stick 1.25 cm Blenderm tape to the top and bottom sections of the fin on the fin spar side of the fin.

Attach rudder to the tape with the rudder turned away from the tape hinge (towards the rudder horn) (see photo 9a1).

10. Undercarriage (u/c)

Lay two 0.8 mm CF rods into recesses in 3D printed skid using 3D printed packers (small square pieces) under other ends of rods. Apply CA with a pin to the joints. Repeat for the second leg.

Assemble both legs over covered front view drawing. Use strips of masking tape and pins to hold in place. The main aim is to get the legs at 90° and the cross over 4 mm from the ends of the CF rods (see photos 10a1 and 2).

Tack all joints with CA. Leave to harden.

Lash and secure with CA (see photo 10a3).

Mark on fuselage boom with masking tape where aft end of u/c is positioned (237 mm from aft end of fuselage boom).

Support under stabilizer spar and place u/c in position under fuselage boom (see photo 10b1). Ensure that the stabilizer is horizontal.

Tack glue with CA.

Lash to boom (see photo 10b2).

11. Fixing wing to boom

Trim bottom skin to fit around boom. Cut less than 1 mm off each wing's lower skin.

Place a small strip of masking tape on the fuselage boom to mark the position for TE of the wing (171 mm from the aft end of the boom).

Place a sheet of white paper under the model to make it easier to see the black thread when doing the lashing. A bright work lamp is also useful.

To start with it may help to support the wings on small boxes or books so they are roughly level.

This time do not tack the CF parts together.

Square lash spar to boom with 4 turns.

It helps to place a finger under the wing against the tread turns to hold the tension in the lashings. A helper could be useful.

Holding the fuselage in a vertical position, lock the thread to the wing spar only (do not get glue on the boom yet) with a very small drop of CA.

Support the wings so the wing tips are the same height off the bench (see photo 11a1). Check the TE is at the masking tape on the boom.

Apply a small drop of CA to each side of the spar where the lashing goes around the boom (see photo 11a2).

Allow to completely harden before checking that the lashing is completely soaked in CA.

Apply Uhu-Por to the edges of the lower wing skin to glue them to the boom.

When the glue has dried, tape over top and bottom circular access holes.

12. Lipo mount

With model inverted (support under wing on small box), fit balsa lipo mount onto u/c.

Check mount is level and place a drop of CA where each leg touches the balsa mount (see photo 12a1).

Bind between legs under balsa with two turns of thread and fix with CA (see photo 12a2).

13. RX mount

Cut out RX mount with the grain of the balsa across the model to give support from the boom.

Sand 45° bevel on the 2 lower outer edges (see photo 13a).

The double-sided mounting tape is used to secure the RX to the plate. With the Micro Aces RX it works well to have 4mm wide strips of 3M VHB tape at the two sides (away from the larger components on the PCB).

On the upper surface, coat the balsa with CA to prime the wood where the tape mounting strips will go.

Glue the balsa mount to the leading edge of the wing and the top of the fuselage boom with Uhu-Por.

Check that the mount is centred and level.

With the Micro Aces RX the motor socket and lipo lead face forwards.

Fit RX to the mount (see photos 13a1 and 2) with 3M VHB tape.

14. Linkages

General

Degrease the 0.8 mm CF rod and 0.5 mm piano wire with IPA.

The Micro Aces' RX has 3 different size holes. Use the middle one which is 0.5 mm.

Bind RX to TX and check servos are centred.

Making piano wire linkages for pushrod ends:

Small strips of masking tape are good for marking each cut/bend position against a ruler.

Needle nose pliers are good for making the bends as they allow the wire to be bent past 90° to allow for it springing back.

While making the bends, look at the link in the plane of the bends to ensure that all the bends are made in plane. Small misalignments can be corrected after each bend is made.

See drawing which give the profiles and dimensions of the links.

Degrease the links with IPA after cutting.

Servo end

Tape wire link to a set square so the short leg is vertical (see photo 14d2).

Lay down on poly pocket sheet.

Lay the CF pushrod beside it so that when it is fitted to the servo the CF rod will be above the piano wire part (the clearances around the linear servos are small). NB the pushrods lie on the motor side of each servo.

Weigh down the CF rod. Overlap between the CF rod and wire part to be 8 mm. Tack together with CA and allow to harden.

Whipping to secure:

Tie a clove hitch around the CF rod next to the piano wire. Wind thread around the wire/CF with each turn lying neatly next to the previous turn. Continue until the whipping is 6 mm long. Holding tight and apply CA to both sides of whipping. Wick off surplus with paper towel and, when hardened, trim ends of thread (see photo 14a2).

Tail end

Bend piano wire link for horn as drawing (see photo 14d1).

Slide 3D printed pushrod guide onto pushrod and clip onto boom. Connect pushrod to servo and tape in position.

Degrease wire link and CF pushrod near tail with IPA.

Tape balsa stick under stabilizer/elevator (or on the side of the fin/rudder) to keep both in line.

Fit wire link into the outer hole of the horn:

On the elevator the wire passes from the outside towards the rudder.

On the rudder the wire passes from the stabilizer side upwards.

Pack (pieces of balsa are good) under link and pushrod so they align and are side by side (see photos 14b2 and 3).

If necessary, cut CF pushrod with fine wire side cutters so it overlaps wire by 8 mm.

Put a small piece of poly pocket under link and CF. Align CF rod and wire link so they are tight together (see photos 14b4 and 14d3).

Tack with CA using a pin to apply. Mop up surplus CA.

When hard, carefully disconnect pushrod at both ends and slide backwards clear of model.

Whip wire link to CF pushrod as before (see photo 14c1).

Fitting pushrods

Refit pushrods and temporarily secure with masking tape so they are fully pressed into horn and servo arm (see photo 14c2).

Securing link in horn and servo with 0.6 mm heat shrink tube:

Either cut tube full length of projecting wire and carefully touch with soldering iron to shrink to wire. Be careful not to melt plastic or foam parts. It could be helpful to protect the foam with a piece of paper folded in half (see photo 14d4).

OR, cut 2 mm piece of heat shrink and secure with a small amount of Uhu-Por on the wire and at end of tube.

With the glue method you can reposition the tube if it gets nudged out of position. See photo 14d5 which shows the glue method on the upper servo in the photo and the heat method on the lower.

Position the pushrod guides at the centre of the pushrod and apply CA where they touch each other and the fuselage boom (see photos 14e2 and 3).

15. Motor

Solder the plug to the motor wire (see photos 15a1, 2 and 3). To do this cut wires with say 20 mm slack. Strip ends back 4 mm, slide pieces of heat shrink tubing over the wires up next to motor, tin wires and connector pins, tape down to wooden board, and solder. Slide down heat shrink and shrink by bring soldering iron close or use a hot air gun.

A brushed motor with red/blue wires should be used together with a prop which turns anticlockwise (when viewed from the cockpit); this is the direction the brushes are made for and gives a longer life. Motors with black/white wires should be used with a clockwise rotating prop. See https://micronwings.com/brushed-motor-guide/

The 3D printed motor mount has 1° downthrust and 1° left thrust to suit an anticlockwise turning prop. One end of the part was on the printer bed and is flatter and more filled in. Slide this end onto the fuselage boom. The other way round will give 1° upthrust.

When pushing the prop onto the motor shaft, support below the end cap (where the wires come out) otherwise there is a risk that the end cap will be pushed off. It is not possible to refit the cap without damaging the brushes.

Slide the motor into the 3D mount on the fuselage boom. The motor should be roughly in the centre of the mount.

Clamp the motor in the mount as follows (see photo 15b1). Bind thread twice around the mount and, while holding tension on the thread, put a small drop of CA where the tread goes over the top of the mount. Wipe off excess CA and blow on it to speed hardening. Continue to wind thread around the mount to give a total of about 7 turns and add a small drop of CA to secure all the turns at the top only. This will allow the threads to be easily cut off to remove the motor if required.

16. Preparing for first flight

The CG should be between 26 and 31mm from the LE.

Check CG and slide motor mount if necessary.

Cut boom to final length. You can have about 5mm of rod protruding from the front of the mount which allows some scope to adjust the CG.

Check that the rudder and elevator move in the right direction and are centred (adjust the bend in the links at the tail to centre if required).

Check the prop is giving forward thrust. Reverse the plug in the RX if it goes the wrong way.

If possible, either adjust the trim on the throttle or use a throttle curve so that the motor starts to turn with the smallest amount of stick movement. This makes flying slowly easier as the throttle can be taken to the bottom and moved up a little for slow flight.

The motor is powerful for the size of the model and only needs a very small of throttle to cruise after take-off.

After flying and adjusting the CG position the motor mount could be tack glued to boom with Uhu-Por but if it is a tight fit it could be left for future CG experiments.

Happy flights!