WingFocus

Gemot V2

Assembly Manual

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Abstract

The Gemot V2.0 is a remote controlled flying wing. The main chassis is CNC milled from an EPS foam block which is supplied to the customer. This chassis then has the RC control gear inserted and then is laminated with standard 80gsm copy paper and glue to finalise the superstructure.

The purpose of the Gemot flying wing is purely for entertainment. It is intended to fly in light and unstable wind conditions with the ability to handle up to about 25kts air speed. This manual presents the steps taken to build the Gemot flying wing from the CNC milled chassis. We hope you enjoy building and flying the Gemot V2 as much as we do.

Acknowledgments

Thank you to Roger, Dana, Josh, Miki, Shervin, Andrew, Nathan, Craig and Clayton.

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TERMINOLOGY AND ACRONYMS

AFHDS	=	Automatic Frequency Hopping Digital Signal
Chord	=	Straight line length between the leading edge and the trailing edge.
COG	=	Centre of Gravity
COL	=	Centre of Lift
Control horn	=	Appendage connecting the ailerons or flaps to the control arm.
Control surface	=	The elevons, flaps, spoilers and ailerons are all control surfaces. Any surface you can control to modify the flow over the surface.
EPS	=	Expanded Poly-Styrene
I/O	=	Input / Output
Linkage stopper	=	Rotating connection fitting allowing a solid adjustable connection between the control arm and the control horn.
PVA	=	PolyVinyl Acetate – generally known as woodworking glue.
RX	=	Receiver
Span (spanwise)	=	A line across the wing from wingtip to wingtip.
TX	=	Transmitter

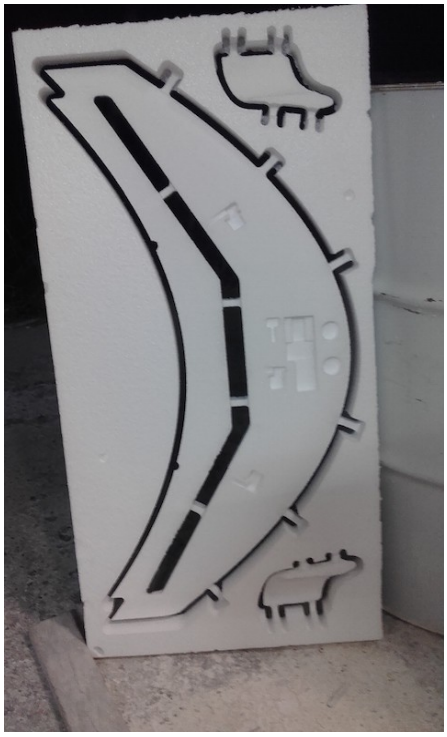
1. CAUTION !!!

EPS foam melts easily. Test all glues, pens and markers on the excess scrap foam before using it on the model. Polyester resins (fibre glass resin), thinners, petrol (gasoline), thinners based markers, contact adhesive (like Sellys Kwik grip – also known as shoe glue) and many others melt EPS foam. TEST TEST TEST before using these on the actual model. Damage of this sort is NOT covered by warranty.

2. IN THE KIT

The wing is milled from a 1000 * 500 * 50mm piece of EPS foam. The main chassis, port and starboard winglets are included.

Figure 1: A newly milled Gemot V2.



3. BUILDING

The following is our suggested procedure for building the aircraft using the EPS chassis.

3.1 EQUIPMENT

1. 180 grit sandpaper
2. Hacksaw blade
3. Sharp blade or knife
4. Glue
    4.1. Multihesive from prep-productions.com which is a styrene acrylate. Available from some hardware stores.
    4.2. 5 minute araldite epoxy. A 2 part glue available from most hardware stores.
5. Duct tape or packing tape about 40mm wide.
6. Hex head screw driver – Size ??? to fit linkage stoppers.
7. Q-cell or micro-balloons.
8. Liquid thread lock – Loctite is the major brand in Australia. Get the lowest strength as the high strength versions are almost impossible to undo. For the nut on the linkage stoppers.
9. Torx external T6 or Hex key for the Linkage stoppers.

3.2 OPTIONAL EQUIPMENT

1. Z-bend pliers Link - https://hobbyking.com/en_us/z-bend-pliers-heavy-duty-90-degree-up-to-1-16.html
2. Dremel
3. Fibreglass roller

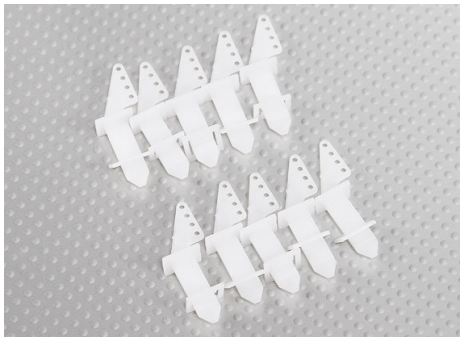
3.3 PARTS NEEDED

1. Linkage stoppers * 3 - We like to use brass linkage stoppers for 2mm pushrods (10pcs). Part # SKU 450001025-0. Link - https://hobbyking.com/en_us/brass-linkage-stopper-for-2mm-pushrods-10pcs.html

Figure 2: Brass linkage stopper 2mm

2. Control horns * 3 – We use HobbyKing.com control horns.
   Pin Horns L41xW12xH9.5 (Suit Bixler 2)(10sets) – Part # 310000061 – Link https://hobbyking.com/en_us/pin-horns-l41xw12xh9-5-suit-bixler-2-10sets.html

Figure 3: Control horn – 31000006 I



3. Almost any hobby servo will do. We use the Corona DS939MG as it is strong and noisy. A noisy servo is excellent for finding a plane when it has crashed in thick bushland. Without it, we would have lost far more planes than we have. The holes in the chassis are also milled specifically for these servos, but using our glue system and chassis modification method you'll be able to fit whatever you like.
4. Digital Metal Gear Servo 2.7kg / 0.13sec / 12.5g – Part # DS939MG - Link - https://hobbyking.com/en_us/corona-939mg-digital-metal-gear-servo-2-7kg-0-13sec-12-5g.html

Figure 4: Corona DS939MG servo

5. Receiver. Which ever you like as long as it has at least 3 channels and your remote can mix aileron and elevator functions with 2 servos. We use the

receiver below to go with the Turnigy i10 AFHDS 10 Channel radio control unit.

6. Turnigy TGY-iA6B V2 Receiver 6CH 2.4G AFHDS 2A Telemetry Receiver w/SBUS – Part # 9114000062-0. Link - https://hobbyking.com/en_us/turnigy-ia6b-v2-receiver-6ch-2-4g-afhds-2a-telemetry-receiver-w-sbus.html

Figure 5: Receiver - Turnigy iA6B

7. Servo extension wires.
   Port = Xmm long
   Starboard = Xmm long
   Wire = Copper 0.33 mm^2 = 22AWG
   Dupont connectors either side male to female. Buy them pre-made from HobbyKing, ebay or at an electronics shop.
   https://hobbyking.com/en_us/twisted-15cm-servo-lead-extention-jr-with-hook-22awg-5pcs-bag.html

3.3.1 CUTTING THE FOAM

Of course you can just snap the wing parts out of the foam support packaging, but the way we prefer is to use a hack saw blade to saw the tabs back. A knife cuts EPS easily, but the EPS tries move back onto the trailing edge of the knife blade. A hacksaw blade makes its own path by removing some foam with each movement, allowing it to keep cutting easily. Once cut from the support packaging, cut the tabs down to short

stumps. Then use the sharp knife to slice away the remainder. Using this method the foam needs little sanding at the tab points as the surface is close to the intended design.

3.3.2 SANDING THE WING

180 grit sandpaper is all you need to sand the wing smooth. It sands very easily. The milling bit leaves ridges all over the plane. The lowest part of the ridges is the finished surface level as the mill does not cut deeper than the designed shape. We like to sand the winglets first leaving them moderately rough near the glue point. This is done so that there is enough material at the glue point to sand it perfectly inline with the main chassis. The main chassis should flow smoothly into the wingtips.

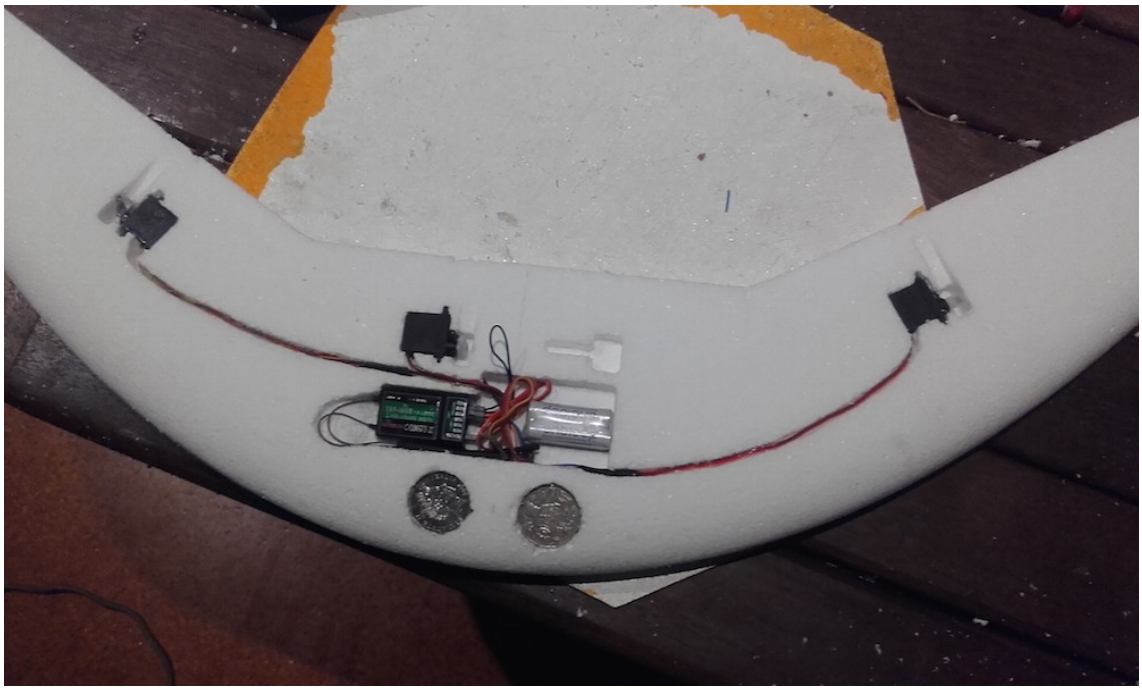
3.3.2.1 GLUING THE WINGLETS ON

The winglets can be glued on with 5 minute araldite. Araldite is a type of epoxy resin. The real strength of the plane is in the paper laminate and therefore the winglets do not need much glue. In fact the preference is to put just a little bit of glue in the middle of the foil being glued. This allows you to sand the winglet shape into the main chassis shape. If the glue squeezes out right to the edges and dries, then sanding the two shapes together is far more difficult as the glue is harder than the EPS. When sanding the EPS will be removed far more rapidly than the araldite epoxy glue and there will be a bump at the glue point.

The smoother the shape is, the more contact your laminate will have and the less glue you'll require.

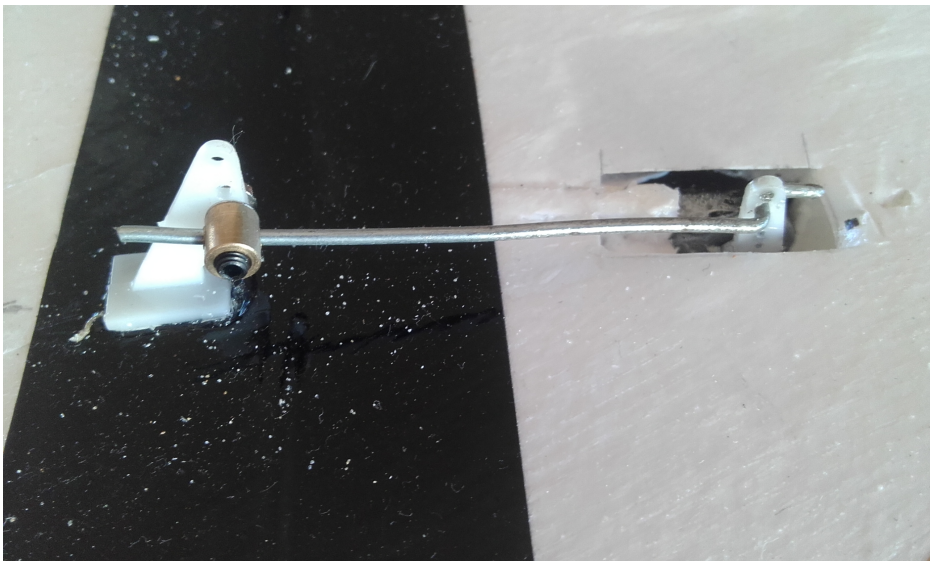
3.4 INSERTING THE CONTROL GEAR

Figure 6: Control gear inserted before laminating.



We prefer to insert most of the control gear before laminating the wing, however there is nothing stopping you from doing so afterwards. The paper laminate is easy to cut with a sharp knife for modifications.

Figure 7: Control mechanism including servo, servo horn, control arm, linkage stopper and control horn.



3.4.1 WIRING

In this version of Gemot we have not milled pathways for the wiring as we understand that many people will not be using the same brand of control gear. We use a Dremel to mill out the wire pathways, but two equally effective (maybe not as neat) ways are:

1. Cut the cable paths is with a knife or

2. Heat a nail held in a vice grip and melt the wire paths.

3.4.2 BATTERY

The battery compartment is made to take a 4 * AAA cell battery pack. We like to use the Eneloop brand of battery. The battery compartment can take a flat 4 cell battery pack or a square 4 cell battery pack. You can make your own battery pack, but the pre-made ones often have a microchip which has a third wire going to the receiver which gives battery voltage telemetry back to your remote. Quality batteries are more reliably bought from your local hobby shop.

*Figure 8: Battery – 4 * AAA Flat arrangement with voltage telemetry wire.*

*Figure 9: Battery - 4 * AAA box arrangement with voltage telemetry wire.*

3.4.3 RECEIVER (RX)

The receiver compartment is made to take a Turnigy iA6B or an iA10B. There is enough space for the Dupont connectors and a persons fingers to operate on the RX I/O. The laminate and a piece of tape will hold the RX in place so gluing is not necessary.

3.4.4 COL AND BALLAST

The convention is to talk about the COG, but we prefer to talk about the COL (Centre Of Lift). The COL lies at 130mm from the leading edge or 35mm from the flap hinge point. The edge of a rule can be used spanwise at this point. Balanace the plane on the edge of the rule and the plane should not pitch fore or aft with any preference on this balance point.

We have found that 6 * $AUD0.50 coins in the front ballast chambers balance the plane quite well. An Australian 50 cent coin weighs 15.55grams.
Therefore 6 * 15.55g = 93.3g

Any ballast weighing about 93 grams will work. It will vary a bit depending on how much glue and paper is used. The intention is to get the COG of the overall plane directly over the COL.. The COL is a force pushing upwards. The COG is a force pushing towards the centre of the earth (mostly). When flying parallel to the ground with all elevons and flaps in neutral alignment, the COG should be directly above the COL and the forces equal.

3.4.5 SERVOS

The servo mechanisms have the hinge point for the control arm at 12mm. The control horns are to be mounted with the control arm hinge point 12mm above the control surface hinge. This gives a 1:1 ratio of servo angle to control surface angle. The control surfaces can move to x° and the DS939-MG servos have a 40° angle either side of centre.

The servos are glued in using a bog created from Q-cell (micro-balloons) and Multihesive.

1. Drill a 2mm hole in the servo horn at the 12mm radius hole. If you can match the hole diametre to the control arm diametre so it's a snug fit, there will be less play in your control surfaces later.
2. Cover the servo horn in surfboard wax or plasticine to protect it from the glue.
3. Pour a small quantity of Q-cell in a mixing container and slowly add the Multihesive glue until the bog has the consistency of whipped cream.
4. Add the bog on 4 sides of the servo. We want total connection to the foam on all 4 sides.
5. Let it dry.

The 2 elevon servos will also need cable extenders.

3.4.5.1 CONTROL ARMS

To create the control arm use ~1.8 - 2mm fencing wire which is available from most hardware stores (2mm is preferable if you can get it to match the servo horn hole). We use Z-bender pliers to create the z bend on the servo side. Alternately a pair of long nosed pliers will do the job. It's just more time consuming.

The other side remains straight and goes into the linkage stopper. Cut it a bit longer than you need and then cut it back to the desired length.

Linkage stoppers can bind up easily and take a bit of practise to get right. The best method we've found for installing them is as follows:

1. Put a washer on the linkage stopper.
2. Put the linkage stopper through the control horn.

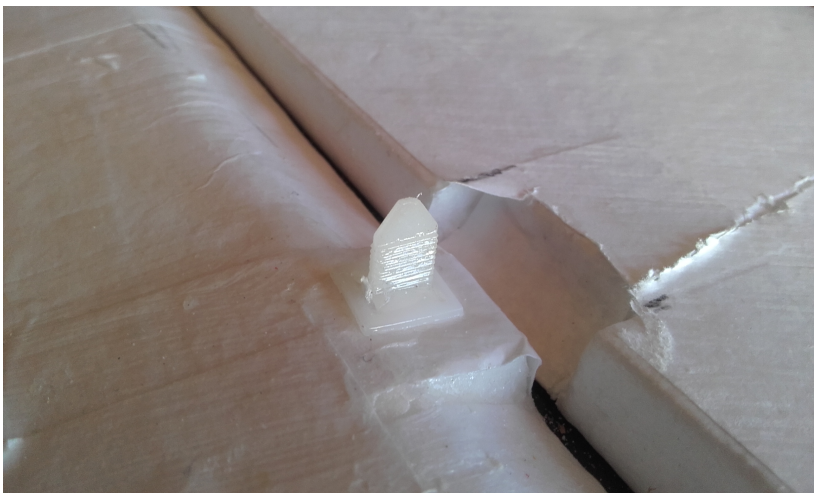
3. Put another washer on the other side.
4. Tighten the nut on all the way which will make it too tight. The linkage stopper must rotate depending on the relative angle of the control arm.
5. Put some thread lock on the screw thread protruding past the nut.
6. Undo the nut a bit into the thread lock just enough to make the linkage stopper rotate freely in the control horn.
7. Insert worm screw with the torx or hex key with the control arm.

3.4.5.2 CONTROL HORNS

Insert the control horn by:

1. Using a a blade about the width of the horn leg, slice through the wing at the horn reinforcement point.
2. Put a small amount of Multihesive or araldite under the foot of the top part of the horn and push it through.
3. Put another small bit of adhesive on the horn locking tab and click it into place on the underside of the control surface.

Figure 10: Underside of control surface at the horn reinforcement point and horn locking tab.



4. LAMINATING

Most of the strength is in the glued paper laminate. It is incredibly strong for it's weight. The foam as a whole does add some compressive strength to the surface, but it is more just to keep the paper in place. When laminating, keep in mind that creating a shape resembling a cylinder will greatly increase the stiffness of the wing or control surface. Thus wrapping all way around the back of control surfaces and hinge points helps greatly.

Paper is very easy to repair and tape sticks to it well. See chapter 6 on repairs

4.1 THE PLANE

1. Place a sheet of A4 80gsm copy paper on the wing where you want to laminate it. If possible make all paper edges and cuts run in line with the air flow direction.
2. Cut slits in the paper to make it go around corners.
3. Mix approximately 1part water to 10 parts Multihesive.
4. Using a paintbrush paint the plane surface just a bit bigger than the sheet of paper you're about to apply.
5. Paint the paper.
6. Put the paper on the surface of the plane smoothing it out with your finger at first. If possible start from the centre of the paper and work your way outwards.
7. Use a fibre glass roller to roll the paper into the plane before the glue dries.

8. On fine edges where the paper lifts, use straight glue to join the paper to the surface.
9. If you want a glossy finish paint another coat of 1:10 ratio water : Multihesive on the wing. Most tapes will stick more readily to a glossy surface.

4.2 THE CONTROL SURFACES

The control surfaces could be laminated as one piece and then cut into the flaps and elevons, or individually. The underside surface of the square lug for the control horn is parallel to the top surface. This allows the attachment points of the control horn to naturally sit flush with the paper. This means that you do not have to crush the surface when fitting the control horn as the real strength is I the paper laminate. You may put an extra wrap of paper around the control surface to make it stronger.

5. CHASSIS MODIFICATION METHOD

When installing the servo wires, switch wires, or antenna wires, wire pathways will need to be custom made. Best to test your method on the scrap foam before the real wing.

Use one of the 3 following methods:

1. Cut a slot with a sharp knife and push the wires into them.
2. Use a Dremel to hand mill the slots.
3. Take a nail and hold it with a pair of vice grips.
    a) Heat the nail on a gas stove or with a flame of some sort.
    b) Drag the nail through the foam to melt in the hole or slot you need.

6. REPAIRS

6.1 MAGIC BOG

Multihesive creates a great filler bog / glue when mixed with Q-cell (microballoons). The Q-cell is available from most fibreglass supply shops as it is used heavily in fibreglass operations. PVA does not seem to mix properly with Q-cell.

To make the filler bog:

Pour a small quantity of Q-cell in a mixing container and slowly add the Multihesive glue until the bog has the consistency of whipped cream.

It is an air setting glue so if it is applied thickly it will take longer.

6.2 FIXING A LEADING EDGE

When you have a crash (This is a 'when' and not an 'if') and the dent is inwards, fill it with the filler bog and sand it back. If the paper is too crinkled then cut the paper away and fill the hole and sand as above.

6.3 SNAPPED WING

When onsite and you snap a wing, the brake is usually quite clean. Just tape the wing back together and fly again.

For a better repair, use a little araldite to hold the two halves in place, wrap with a new paper laminate (using the laminating procedure) with about 4-5cm either side of the break and you're good to go again.

Planes often get faster with each repair as people tend to finish surfaces more accurately every time.

7. INCREASING PERFORMANCE

Drag points from the leading edge back to the thickest point of the foil make more of a

difference than drag points after the thickest part of the foil. Sand and fill out all

bumps, corners and dags around the leading edge. Another tip is to paint the leading edge with house paint. Ceiling white is high in pigment and is easy to sand. 600 grit paper sanded in the direction of flow makes a noticeable difference. In the case of Gemot we are looking at keeping lamination over the wing to lower the minimum flying speed and give it more control in turbulent air near the ground. Gemots foil is not a high speed foil. It is a low speed foil which handles a wide angle of attack and generates high lift at low speeds. WingFocus has plans to make a faster version once the this version is refined some more.

8. SPECIFICATIONS

Flaps – Chassis shape max down angle 58.4°

Elevons - Chassis shape max down angle 55°

9. THE FINISHED WING

Figure 11: Gemot V2 - Ready to fly.

10. External appendix

11. References