F-104G Starfighter

By Michael Hammer

The real F-104 Starfighter

The Lockheed F-104 Starfighter is an American single-engine, supersonic air superiority fighter which was extensively deployed as a fighter-bomber during the Cold War. Created as a day fighter by Lockheed as one of the "Century Series" of fighter aircraft for the United States Air Force (USAF), it was developed into an all-weather multirole aircraft in the early 1960s and produced by several other nations, seeing widespread service outside the United States.

Specifications:
Length: 16.66 m (54 ft 8 in)
Wingspan: 6.63 m (21 ft 9 in)
Height: 4.11 m (13 ft 6 in)
Wing area: 18.22 m² (196.1 ft²)
Max. takeoff weight: 11166 kg (29027 lb)

The F-104G Starfighter semi scale model

The 3D printed F-104G Starfighter is designed to look and fly like the full size Starfighter. The lines and proportions of the model match the real jet with its long, elegant fuselage and short thin wings.

The optimized edf duct ensures great performance without the use of cheater holes or non scale sized air intakes. Designed to be powered by a 50mm XFly Galaxy electric ducted fan, the model has great performance and flight times from 4-6 minutes. The model is designed to be printed from LW-PLA. Some parts need to be printed from regular PLA.

The model requires no carbon tubes or similar reinforcements. Just print the parts and glue them together with cyano glue. The Starfighter model is designed to be powered by a 3S or 4S XFly Galaxy 50mm EDF and a 3S2200mAh or 4S1800mAh quality battery.Other performance EDFs like FMS will also fit. Three 3.7g servos are needed to control the model.You can upgrade the servos to more expensive ones like KST X06.

The model features a large hatch for easy access to the battery and radio equipment. The hatch has a spring loaded locking mechanism for ease of use. A seperate hatch underneath the rear fuselage gives access to the EDF unit.

Control throw gauges are included with the model for easy adjustment of the correct amount of movement of both ailerons and elevator. Special jigs are included to help building a straight and true model. A CG craddle is included to make it easy to balance the model correctly at the Center of Gravity.

The F-104G Starfighter is designed with a catapult hook for bungee assisted launching. It is highly recommended to use a catapult or bungee launcher with 6-7 kg pulling force for a safe launch of the model.You can find instructions on how to build an inexpensive Bungee Launcher here: Bungee Launcher Youtube video

All parts are designed to be easily aligned and glued with cyano glue.

Model specifications:

Wingspan: 504mm
Length: 1214mm

LW-PLA 3S version: Ready to fly weight (3S2200mAh): 749g
(699g without Wingtanks and ventral fin)

LW-PLA 4S version: Ready to fly weight (4S2200mAh): 769g
(719g without Wingtanks and ventral fin)

3D Printer Requirements

Recommended Prusa MK3S or equivalent.
Nozzle: 0,4mm
Filament: Light weight PLA (foaming PLA) like PolyLight 1.0
Slicing software: PrusaSlicer

Print settings

All parts are designed to be printed with 0,4mm nozzle, 0,25mm layer height

Before you start slicing the stl-files yourself, I highly recommend printing a couple of the supplied G-Code files first to see if they will print OK on your printer. For many the supplied G-Code files will do the job just fine.

If you prefer to slice the files yourself you should use the latest version of PrusaSlicer and load the supplied 3mf files into it. The 3mf files contain all the optimal slicing info for the parts. You can then choose your printer and press slice. Or you can modify the settings to suit your needs.

If you wish to slice the parts with a slicer of your own choice, it is still recommended to start by checking the slicer settings for the specific part in PrusaSlice. It will give you a very precise overview of how the part was designed to be printed. It just takes the guesswork out of trying to find the optimal way to print the part.

You can also preview the G-code files with PrusaSlicer G-code Viewer to get an idea of how the parts should look when printed correctly. Launch PrusaSlicer G-code Viewer from the file menu of PrusaSlicer or run the prusa-gcodeviewer.exe

If using a slicer which can not handle multiple processes, just print the part with bottom layers and no top layers. A hot knife or Dremel can be used to remove any unwanted part when the print is finished.

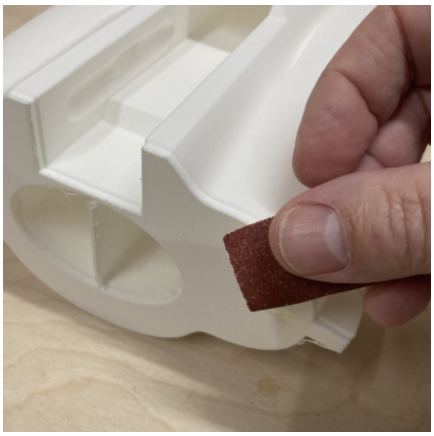
Bill of Materials

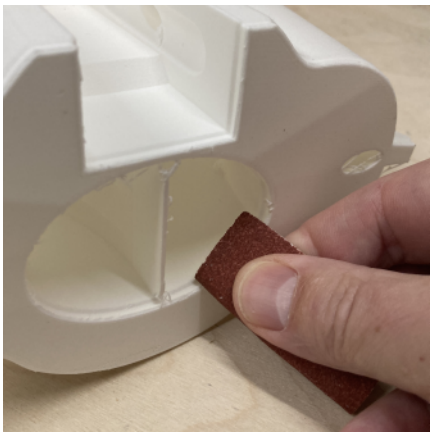
1mm pianowire
Spring from ball point pen
Cyano hinge sheet (or use strong plastic from blister pakaging. Remember to sand with coarse sandpaper)
Cyano glue and accelerator spray, medium or thin
3 x inexpensive 3.7g servoes or more expensive servoes like X06N and X08N from KST or HV06N and DS06 from CHA servo.
EDF: XFly Galaxy 3S or 4S edition available from www.turbines-rc.com (Europe) or www.bananahobby.com (North America) Otherdealers can be found here: www.xfly-model.com/wheretobuy
Other quality EDFs like FMS can also be used to power the Starfighter
Receiver: 4-6 ch
ESC: 40A
Battery: 3S2200mAh 25C or higher for 3S EDF or 4S1800mAh 25C or higher for 4S EDF (Max battery cross section size: 26x35mm)

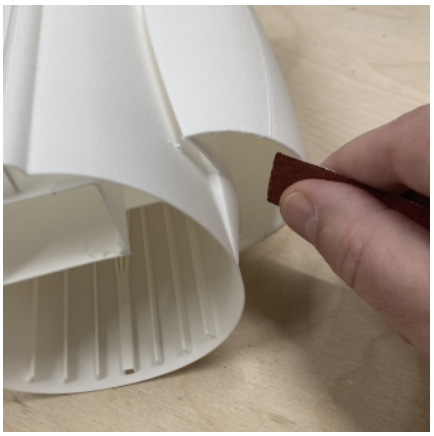
Important:

All printed parts should be cleaned up using a sharp knife or sandpaper. It is especially important to prepare the fuselage sections well so they will slide easily into the neighboring part. Use a piece of sandpaper to bevel the edges of the parts.

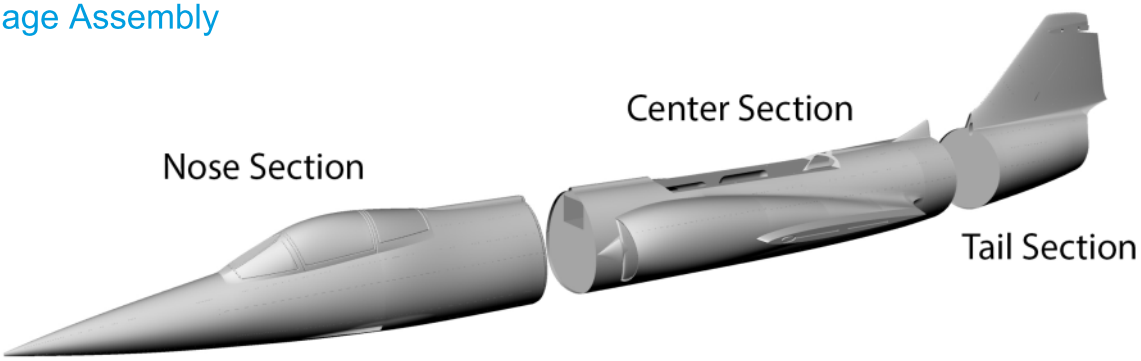
Follow the steps outlined in this User Guide. It will help you through the build process and ensure that the finished F-104 Starfighter model will fly well and give you lots of enjoyable flight time.







Fuselage Assembly



The Starfighter should be built in three separate section: nose section, center section and tail section.

The nose section is assembled of Fuselage-01, Fuselage-02 and Fuselage-03

The center section is assembled of Fuselage-04, Fuselage-05, Fuselage-06, Fuselage-07, Wing-Left-01, Wing-Left-02, Wing_Right-01, Wing-Right-02

The tail section is assembled of Fuselage-08 and Fuselage_09

The fuselage parts are best glued together by applying medium thickness cyano glue to the outside seam. It is not necessary to glue the edf thrust tube. Assemble the parts and push them together. Wipe off excess glue with a cloth and spray with accelerator.

Nose section

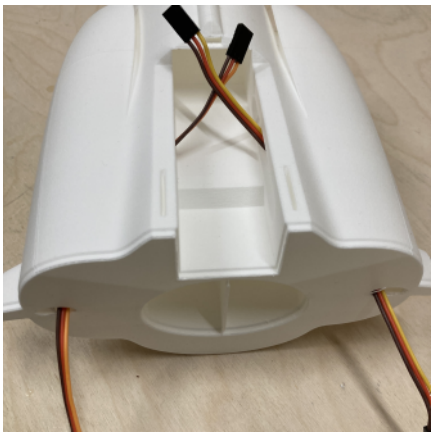
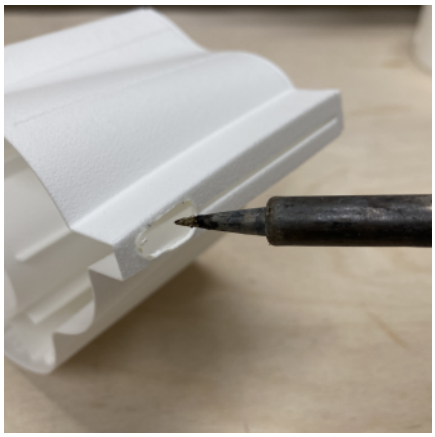
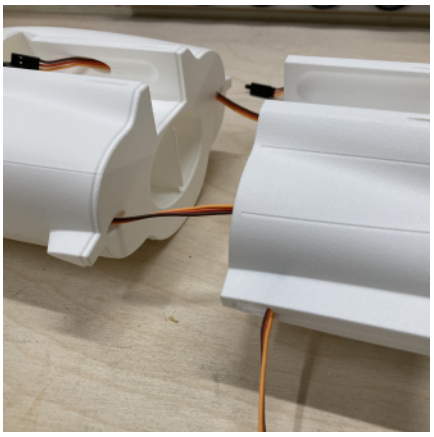
The assembly of the nose section is pretty straight forward. Align the fuselage parts with each other and add thin cyano glue to the seams. Or you can add medium cyano to one part, assemble the parts and align them before spraying with accelerator. Start with Fuselage_01 and Fuselage_02. Make sure the mark in Fuselage_01 is pointing upwards. Glue them together and then repeat with Fuselage_03. With the nose section done, put it aside.

Center section

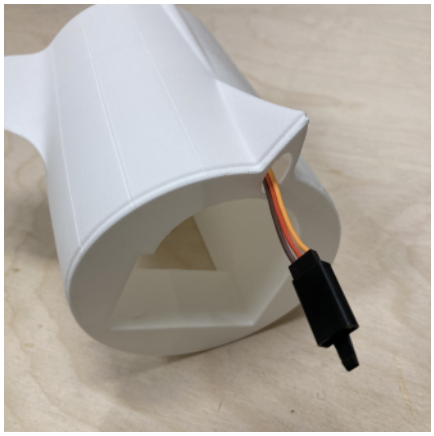
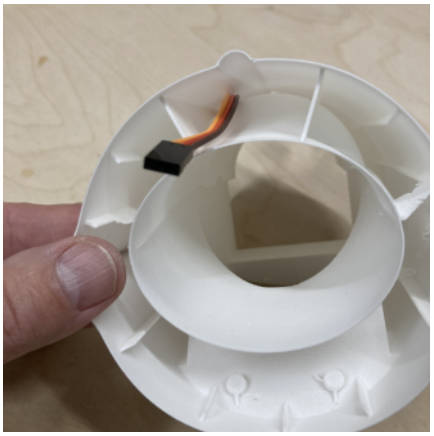
The center section is assembled from four fuselage parts and four wing parts. The fuselage parts should be assembled first, then the wings and finally the whole center section is joined together with the help of jig parts 0-4.
This will ensure that the wings are correctly aligned with the fuselage and have the correct amount of anhedral.

Fuselage Center Section assembly

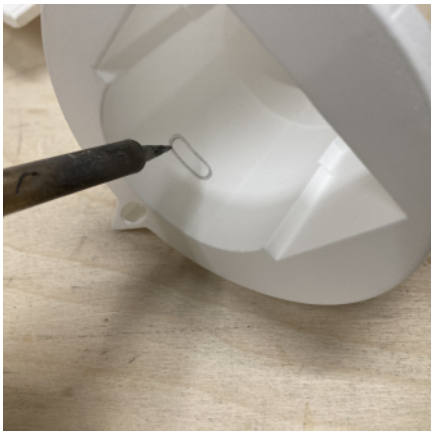
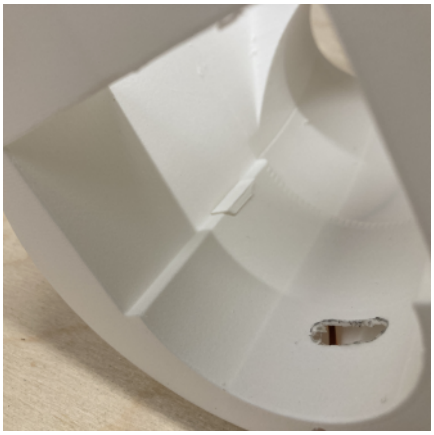
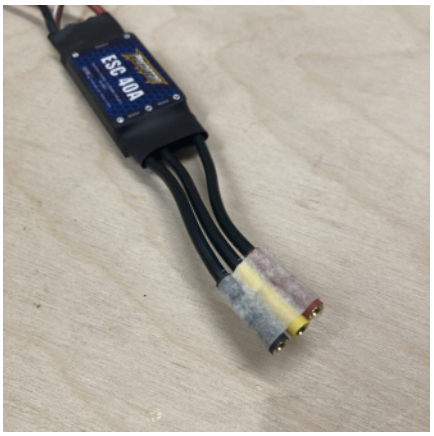
Start with Fuselage_04 and route a servo extension cable through the channel. Cut the two holes for the aileron servo wires in Fuselage_05 at the markings. Use a soldering iron, hot knife or just a sharp knife. Testfit Fuselage_04 and Fuselage_05 while making sure the servo cables are routed through both fuselage parts and exit at the wing root. Glue the two fuselage parts together. Glue Fuselage_06 to Fuselage_05.

Now it is time to prepare Fuselage_07 for the 50 EDF unit. Start by routing a servo extension wire through the part as shown in the photos.

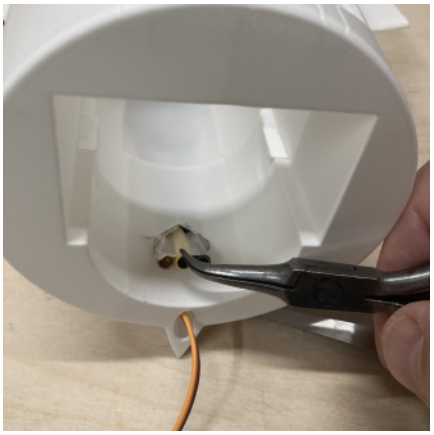




Cut a hole for the ESC wires at the marking. Use a hot knife, a soldering iron or a sharp knife. Glue the two EDF_Screw_Mount in place at the EDF rails. Tape the three wires from the ESC together as shown.

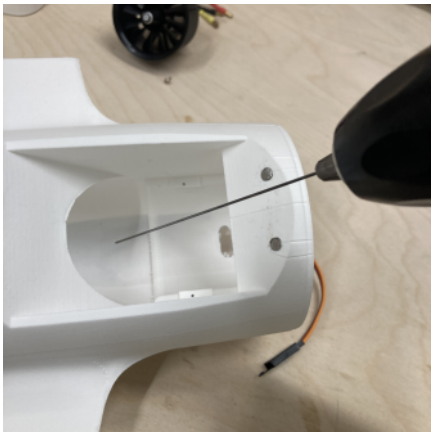




It may be necessary to cut the opening with a pair of scissors as shown. Push the ESC and its wires into Fuselage_07 until the wires reach the opening. Use a Needle nose pliers or similar to pull the three wires out as shown in the photo.





Trial fit the EDF. The XFly Galaxy EDF has flanges for mounting. Mark the position of the flange holes with a felt pen. Remove the EDF and drill pilot holes for two servo screws. You can make a drill by cutting a length of 1mm piano wire and mount it in a power drill. Remove the tape from the ESC wires and connect them to the EDF. Test that the EDF is blowing air in the correct direction.

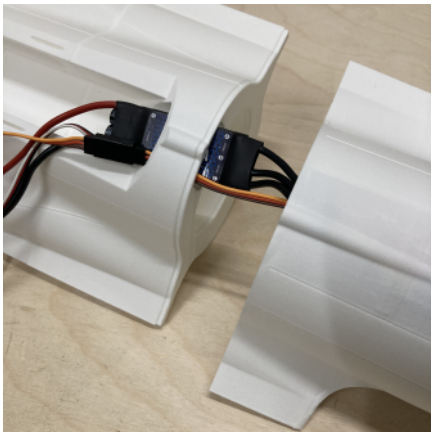
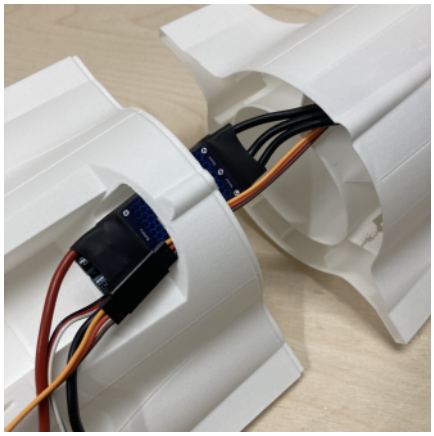
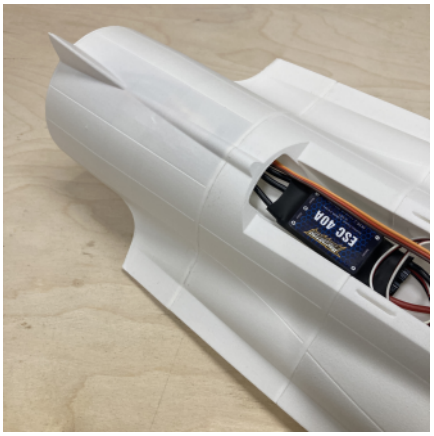



Glue EDF_Exhaust_Duct_01 and EDF_Exhaust_Duct_02_85_FSA together while making sure that the two marks line up with each other. Use a hot knife, a soldering iron or a sharp knife to cut three openings at the markings. Test that the exhaust duct will fit over the EDF.



Place the EDF in its correct position and fix it with two servo screws. Make sure the wires from the EDF enters the hole in a nice way by pulling the ESC out of Fuselage_07 until the wires are taut. Also make sure that the exhaust duct can be fitted on the EDF.

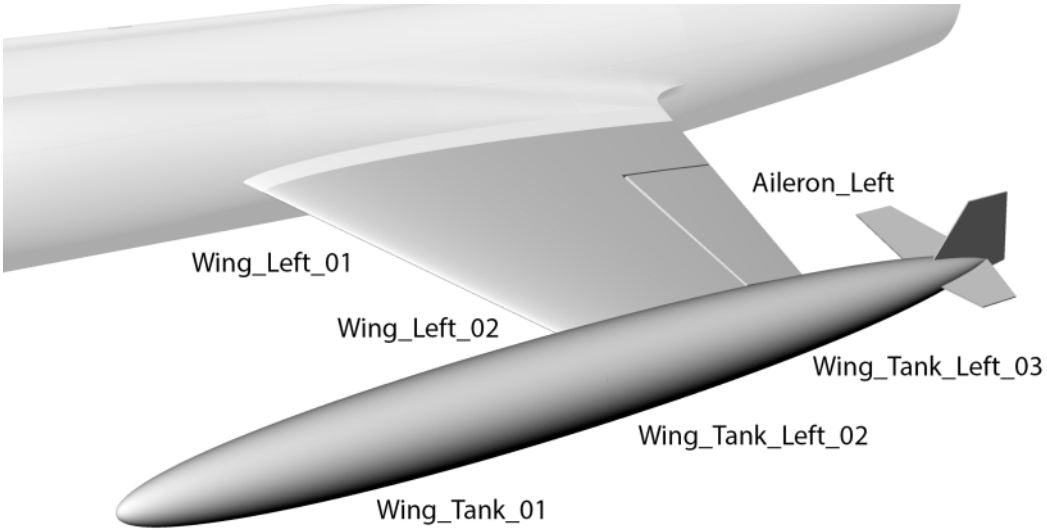

Pull the ESC through the hole in Fuselage_06 and glue Fuselage_07 to Fuselage_06 as shown in the photos.

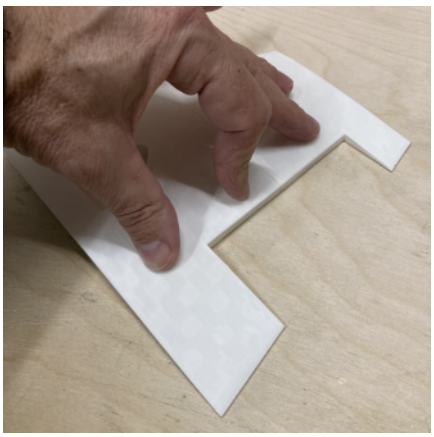
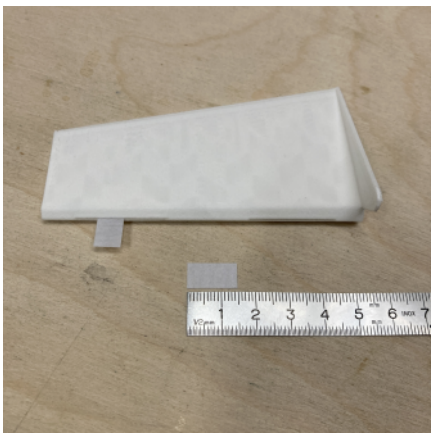
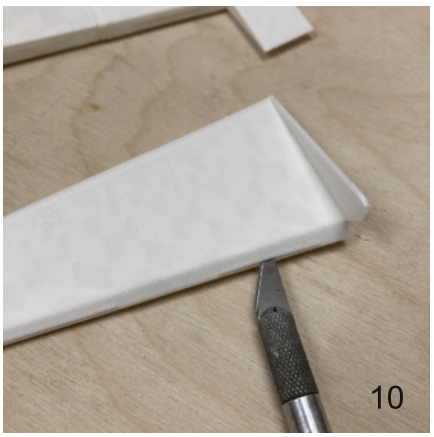
If you choose to use a FMS EDF or similar without mounting flanges, you can mount the EDF with doublesided tape or a few blobs of hotglue. Just make sure that the EDF exhaust duct will slip over the EDF unit once mounted.

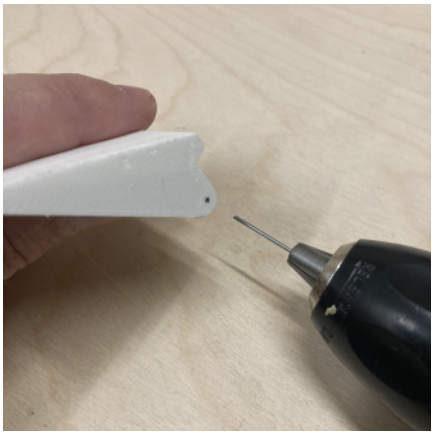


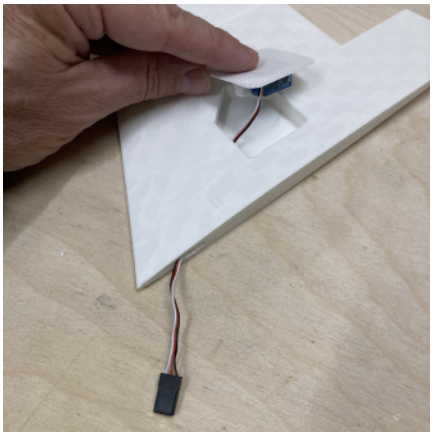
Wing assembly



Start by gluing Wing_Left_01 and Wing_Left_02 together while pressing the parts down onto a flat surface. Cut 8x15mm hinges from cyano hinge sheet. Alternatively you can cut hinges from blister packaging. Just make sure to sand the surface matt with semi coarse sanding paper. Use an exacto knife to open the hinge pockets of both the aileron and wing.

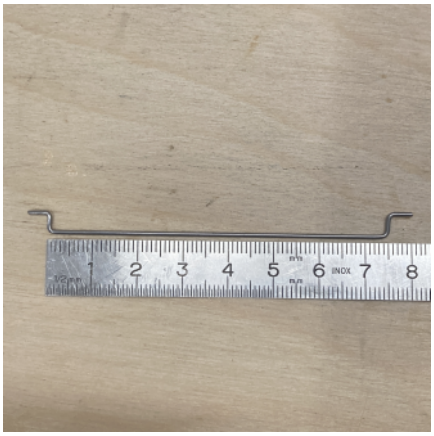
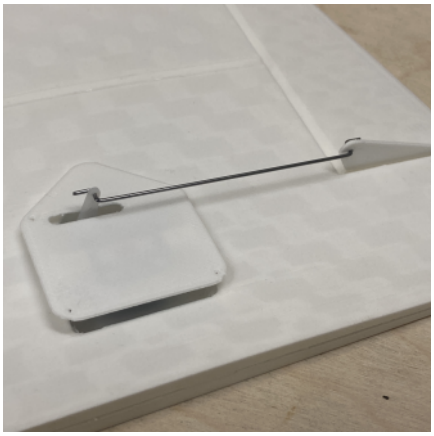
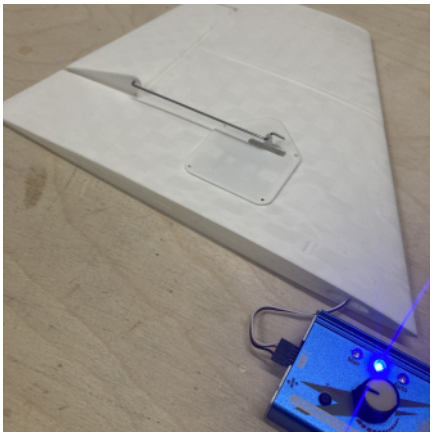








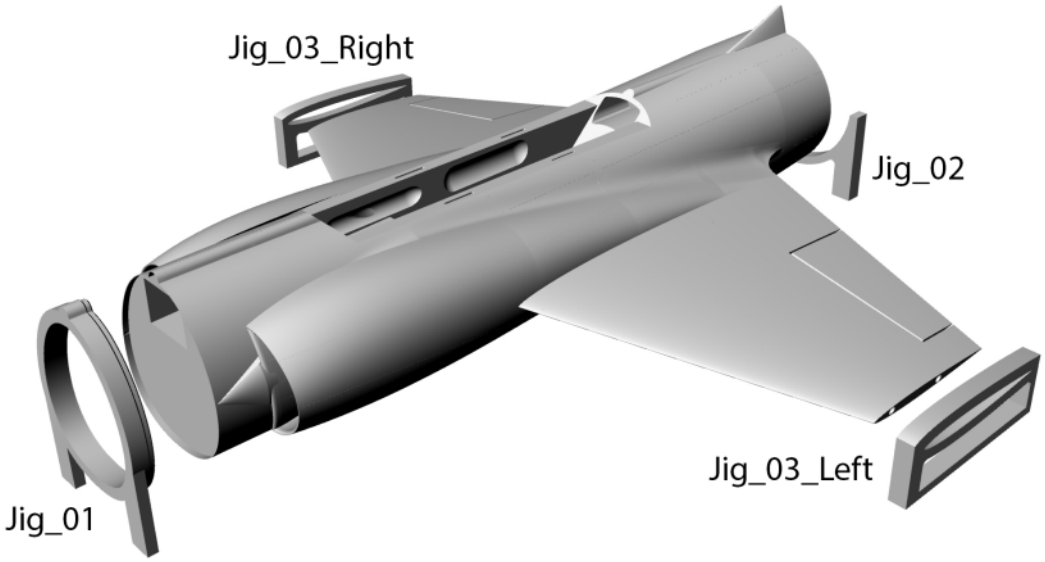
Insert the hinges and mount the aileron. When satisfied with the fit put a drop of thin cyano onto the hinges right at the hinge line. Wipe excess cyano of with a toothpick or similar. Be careful not to get cyano between the aileron and the trailing edge. The aileron should move freely up and down.

Use 1mm piano wire for the servo/aileron pushrod. You can choose your favorite method of connecting the servo/pushrod/aileron. Personally on this size models I prefer to make a z-bend at both ends of the pushrod. Make two z-bends 75mm apart measured on the inside of the bends as shown in the photo. Insert the pushrod into the aileron control horn. Insert the other end into the servo control arm. Insert the servo and mount into the wing. With both the aileron and servo in neutral position mark the position of the servo mount. Test the movement of the aileron with a servo tester. Glue the servo mount to the wing with cyano. You can always pry the mount off again with a sharp knife. Or you can use 4 small screws.

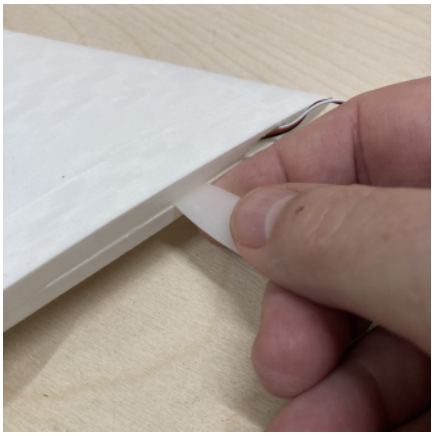




Center Section Assembly

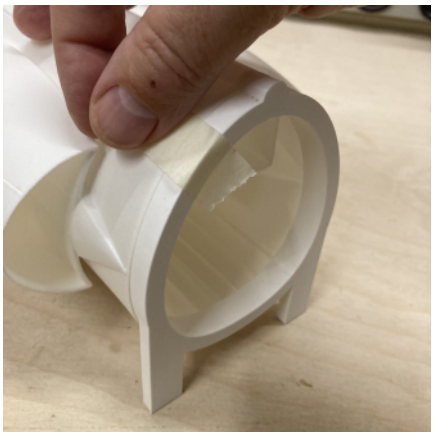
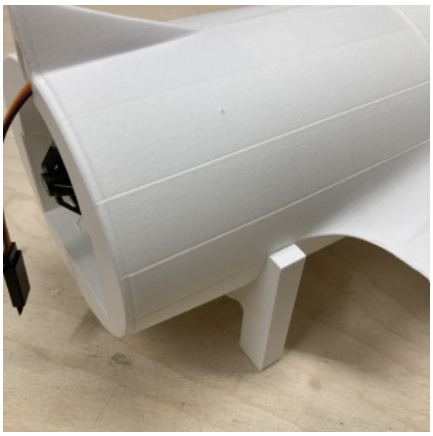
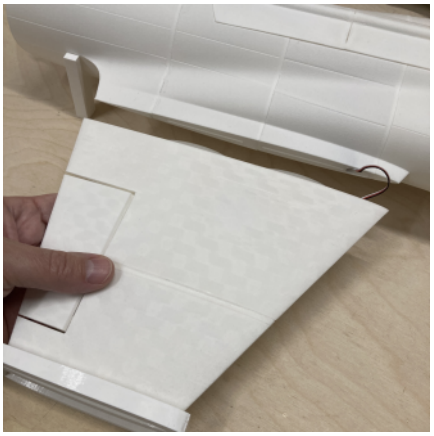
4 Jigs are supplied to help you assemble the center section into a straight and true Starfighter Center Section with its characteristic anhedral.



Start with the left wing. Glue two Wing Joiners into the wingroot. You can use a wing joiner to clean out the stringing in the slots as shown in the photo. Press Jig_03_Left onto the wingtip. Repeat the process with the right wing.

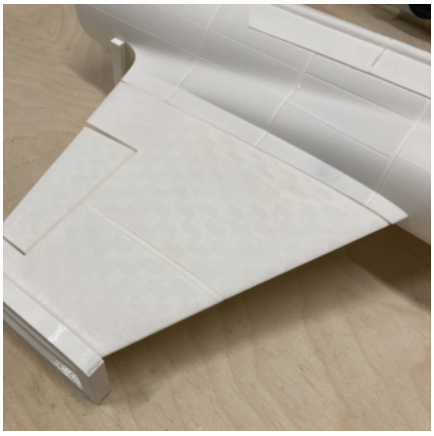


Mount the Jig_01 onto Fuselage_04 and fix with painters tape. Place Jig_02 underneath fuselage_07. Connect the aileron servo wires to the servo wire extensions cables.

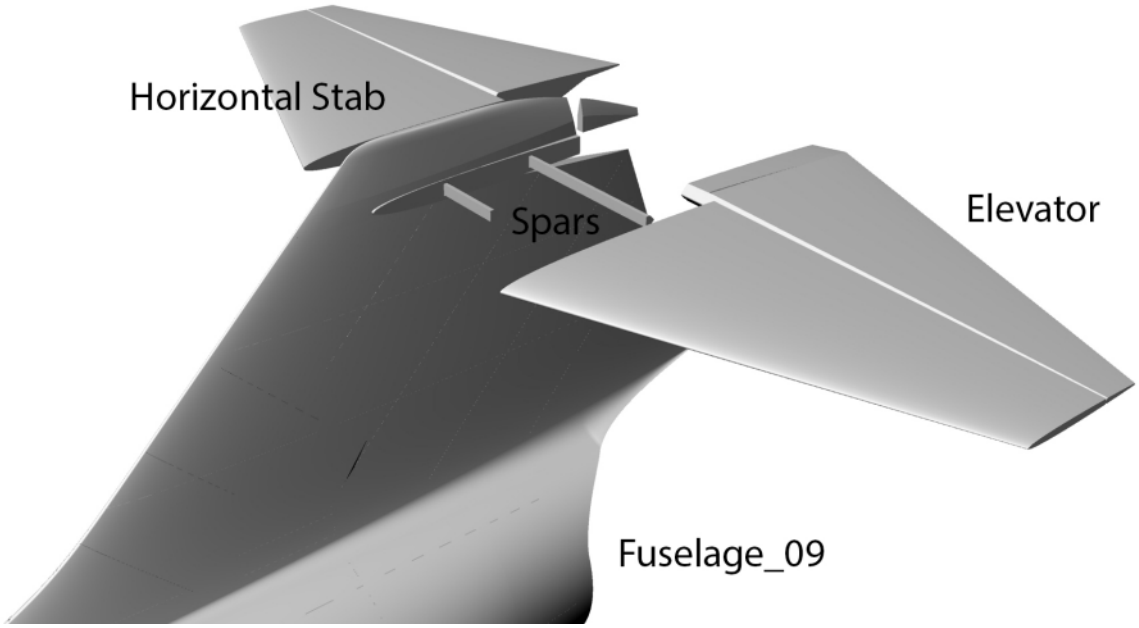
Feed the wires into the fuselage while mounting the wings and make sure the wing joiners are inserted correctly. Place the center section and the jigs on a flat surface. Check that the wings are seated correctly and the base surface of the jigs are touching the flat surface as shown in the photos.

Pull one of the wings away from the fuselage and add medium cyano to the surface of the wing root and wing joiners. Reposition the wing at the fuselage and again check that the wings are seated correctly and the base surface of the jigs are touching the flat surface. When satisfied with the fit of all parts, spray with accelerator spray. Wait for the glue to set completely and then repeat the process with the other wing.



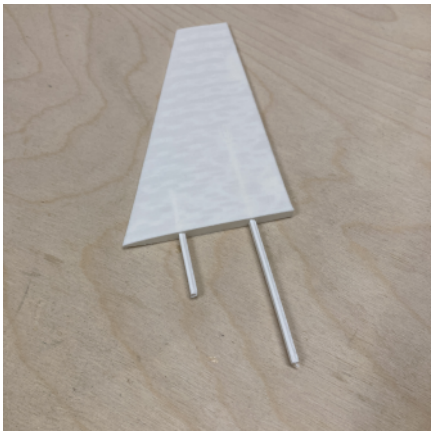
Remove the jigs. The center section is now finished and can be joined with the front section.

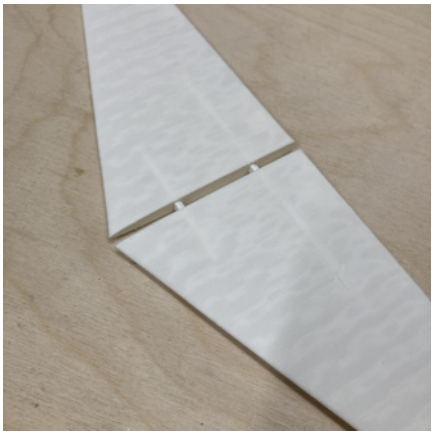
Horizontal Stabilizer Assembly

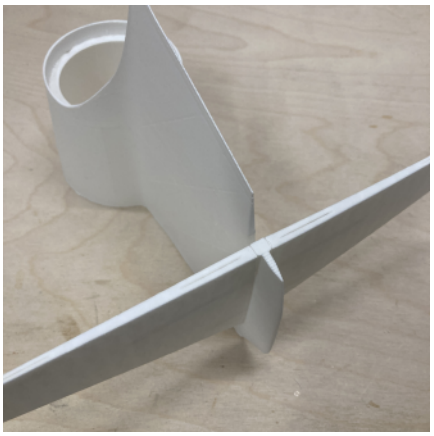


Remove stringing from the spar holes in the horizontal stabilizers. Use a small screw driver or similar to clean the holes. Push the Horizontal_Stab_Front_Spar and Horizontal_Stab_Front_Rear into the holes. Push the two stabilizers together. They should be able to be pushed almost completely together. If not, then try to clean the holes some more. If the stabilizers still can't be pushed together, you can cut the spars to make them shorter.

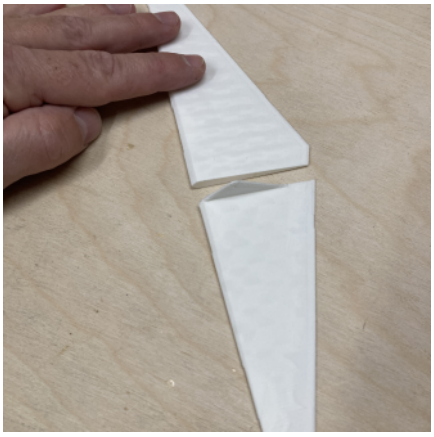
Pull the stabilizers away from each other and assemble them with Fuselage_09. Make sure the stabilizers are perpendicular to the vertical stabilizer. Glue both stabilizers to Fuselage_09.

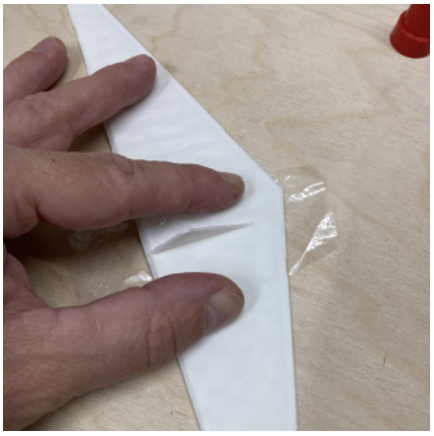




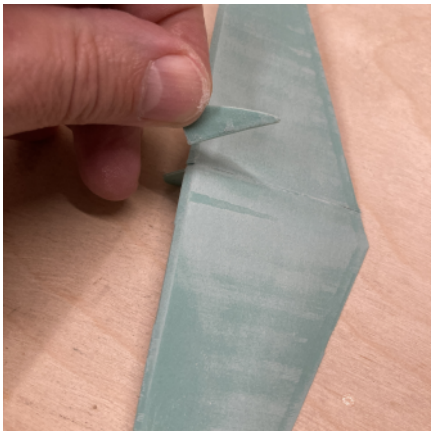
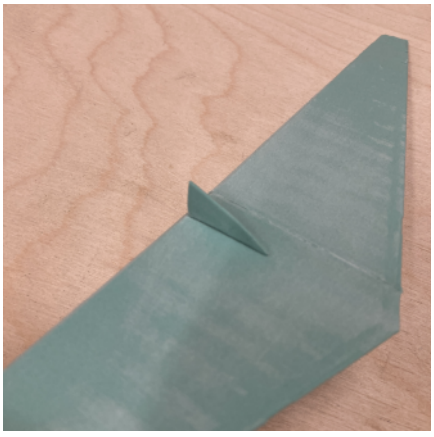
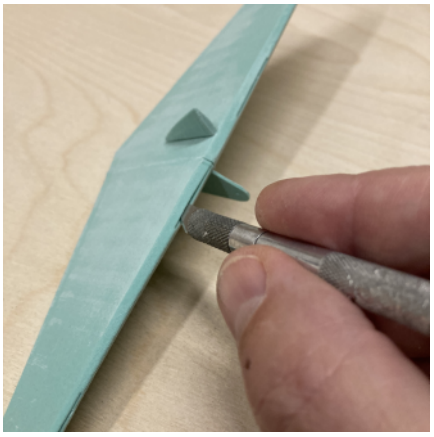


Put Elevator_Right and Elevator_Left on a flat surface. Put some plastic film underneath to avoid glueing the stabilizers to the surface. Add cyano glue and press the stabilizers together.

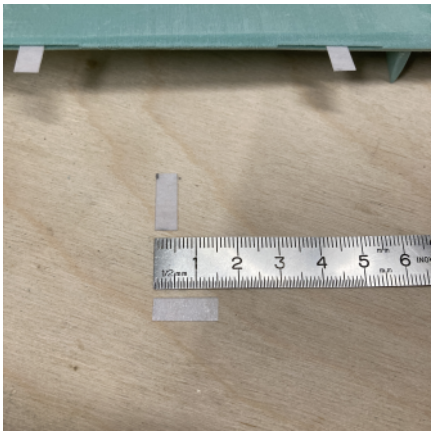




Glue the Vertical_Fin_Extension onto the elevator. There is a mark on the elevator indicating the correct location of the Vertical_Fin_Extension. Use an exacto knife to open the hinge pockets of both the elevator and the horizontal stabilizer.

Cut four 6x15mm hinges from cyano hinge sheet. Glue the hinges into the hinge pockets of the horizontal stabilizer. Do not mount the elevator yet. Make a elevator pushrod from 1mm piano wire with a length of 135mm and with z-bends like shown in the photo below. Wrap a standard 3.7g servo with painters tape.

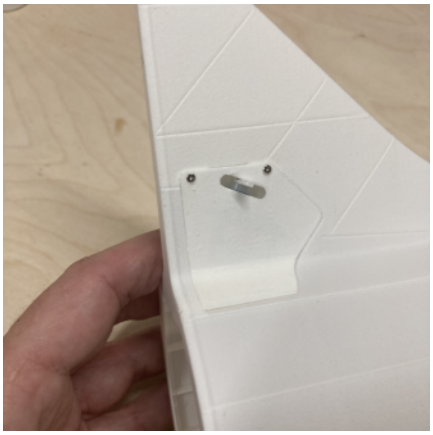
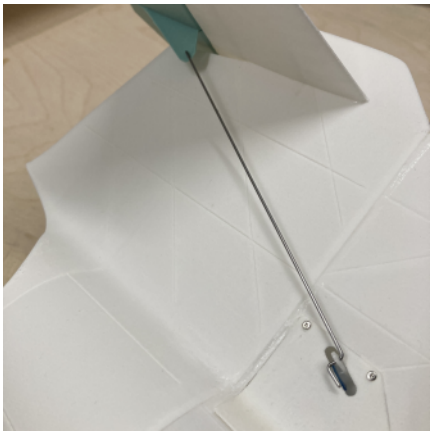


Feed the servo wire through the channel in Fuselage_08. Line up the servo with the two marks and glue the servo into the servo pocket as shown in the photos.

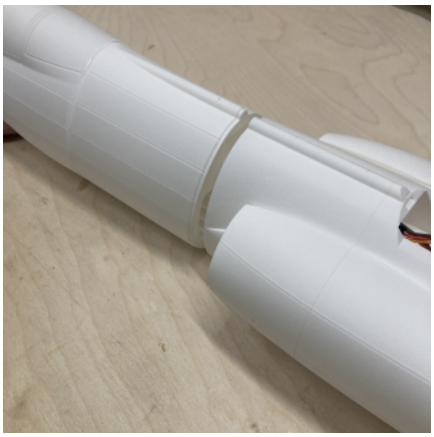
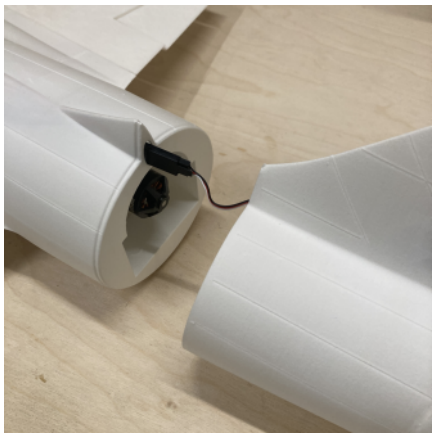
Mount the Elevator_Servo_Hatch with two servo screws or a few drops of cyano glue.

Glue Fuselage_08 to Fuselage_09.

Mount the elevator pushrod to the elevator servo arm and then to the elevator control horn. Mount the elevator and make sure all four hinges are engaged into the hinge pockets. Make sure the elevator servo is in its neutral position. Check that the elevator is also in its neutral position. If not, adjust the trim setting of your radio. If it is not possible to get the elevator into neutral position, you should make a new pushrod that compensates for this. Use a servo tester to test the elevator movement. The starfighter do not need a lot of elevator movement but it should be able to move 10mm freely up and down. When happy with the elevator movement, the elevator hinges can be glued.

The three sections can now be joined. Glue the nose section to the center section. Connect the elevator servo wire to the servo wire extension from the center section. Pull the elevator servo wire into the center section and glue the tail section to the center section.

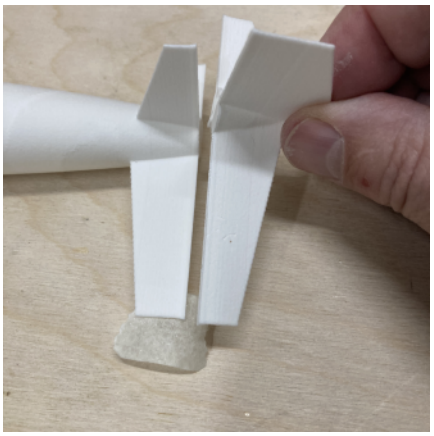

Wing Tanks assembly

The real Starfighter often flew with wing tanks which gave it a very distinctive look. The model can be flown both with and without wing tanks. The tanks are held in place by magnets and will fall off the model in case of a rough landing.

Glue 5x3 magnets into the holes in the wingtips. Make sure to orient all magnets with south or north facing outwards.

Glue Wing_Tank_Left_02 and Wing_Tank_Left_03 together. Use painters tape to line up the stabilizers to each other. Then glue Wing_Tank_01 to Wing_Tank_Left_02.

Glue 5x3 magnet into the holes in Wing_Tank_01. Make sure to orient the magnets in such a way that they attract to the magnets in the wing tips.

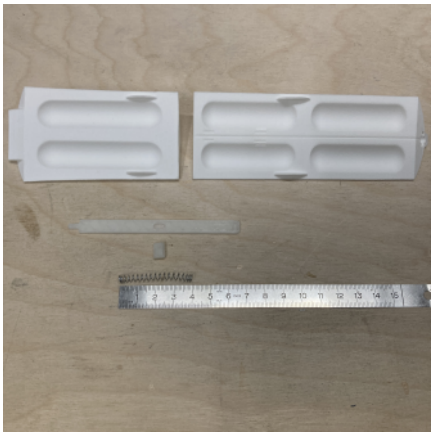
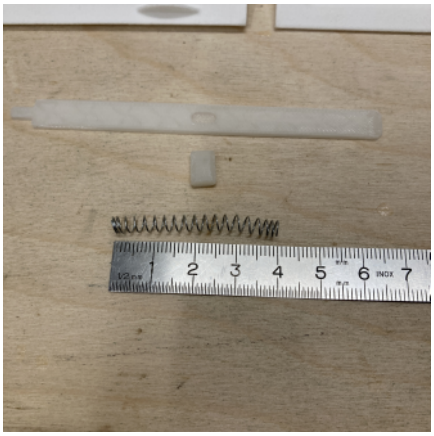
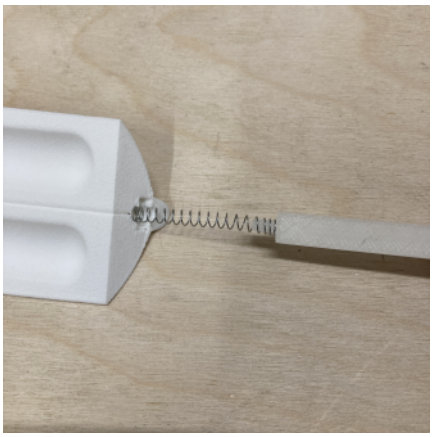




The wings have a line that indicate where the wing tanks should sit when mounted. The line should be right next to the wing tank.



Hatch Assembly

You will need a spring from a ball point pen or similar. Stretch the spring to make it 40mm long when in a relaxed state. The latch, Canopy_Lock_01 has a recess that Canopy_Lock_02 fits into. Make sure the side with the recess is pointing upwards. Make sure the spring can be pushed onto the pointed end of the latch as shown in the photo.

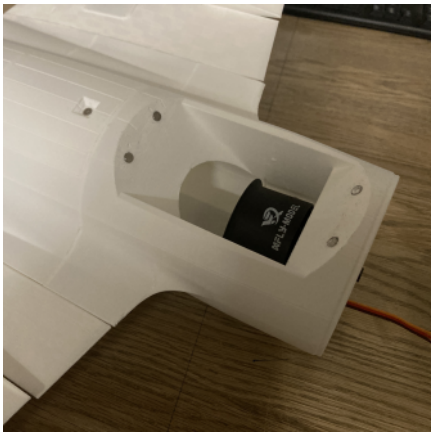




Insert the latch and spring into the slot in Hatch_01. Press the latch all the way in and test the action of the latch. Pull the latch out again and add glue into the recess on the latch. Use medium cyano and be careful not to get glue between the hatch and the latch. Push Canopy_Lock_02 through the slot in the hatch and into the recess. Spray with accelerator. You should now be able to operate the latch mechanism by moving Canopy_Lock_02 back and forth.

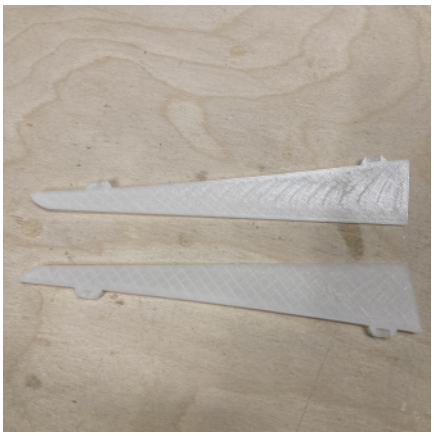
Place Hatch_01 and Hatch_02 onto the center section. Place a bit of plastic film underneath the seam between the two parts in order to avoid gluing the hatch onto the fuselage. Glue the two hatch parts.

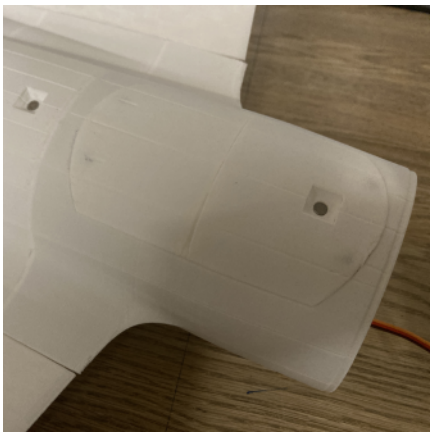


The EDF hatch is held in place by magnets. But it can also be glued in place with small blops of cyano glue and pried open with the blade of a knife in case you need to access the EDF.
Glue EDF_Hatch_01 and EDF_Hatch_02 together while positioned on the fuselage. Glue four magnets to the EDF opening and four to the hatch. Make sure the magnets attract each other.
Glue a magnet into the recess of the EDF hatch as shown in the photo below.



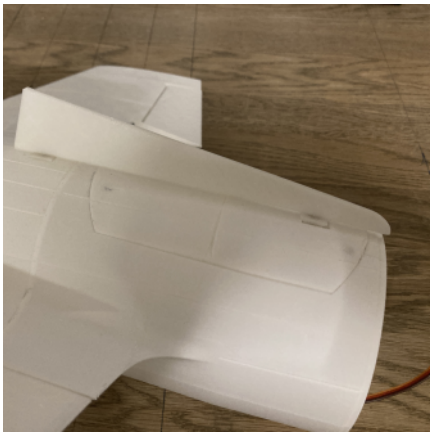
Glue Ventral_Fin_Left and Ventral_Fin_Right together. Glue a magnet into the recess of Fuselage_08



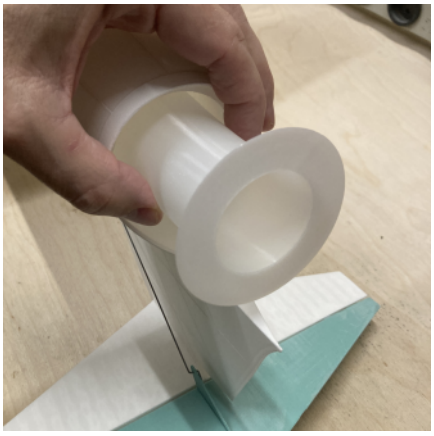


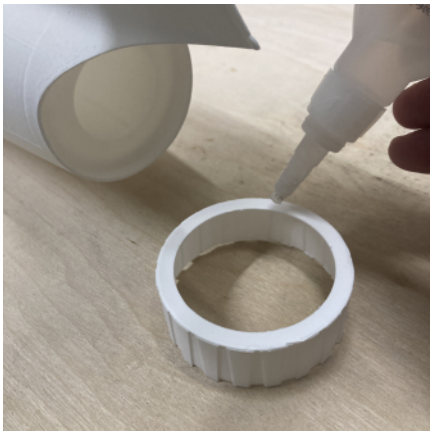
Protect the fuselage with thin plastic film and place two magnets on top of the two magnet in the recesses. Add medium thick cyano glue to the magnet holes of the ventral fin and place it on the fuselage. Make sure the ventral fin is pointing straight down when model is in flying straight.





Push the EDF exhaust duct into the fuselage. Make sure the duct is pushed over the EDF as shown in the photo below. Use tape or a few blobs of hot glue to fix the exhaust duct in place. Glue the Ehaust_Ring to the duct. If you plan to paint your Starfighter you should paint the model and exhaust seperately before gluing.

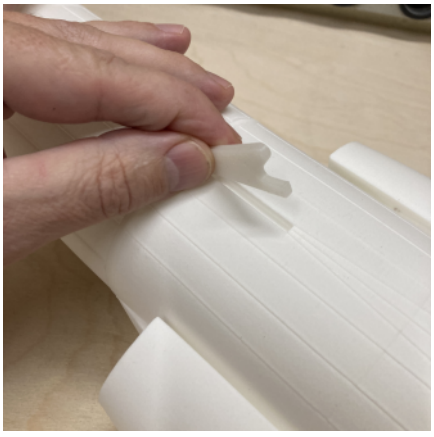
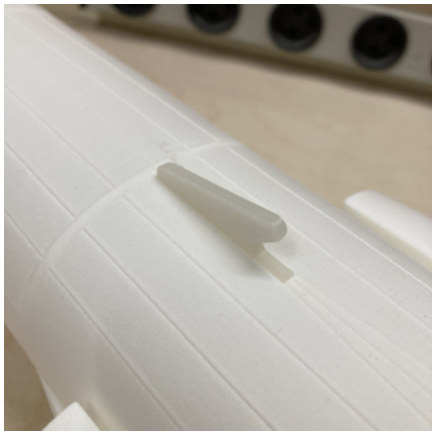


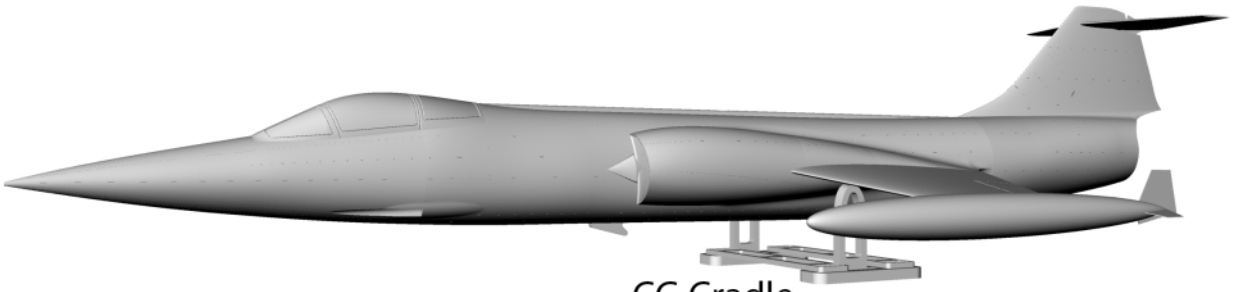
Fuselage_04 has room for the battery. The position of the battery should be determined by the balancing the model at the location of the CG. (See page 21) When the correct position of the battery has been established the battery should be secured with blocks of foam in front of it and behind if neccesary. A battery stop is supplied to avoid the battery sliding backwards during a bungee launch. Mark the location of the battery stop and glue it in place.



The Starfighter is designed to be launched with a catapult/Bungee launcher. Glue the bungee hook into the recess in Fuselage_04

Balancing the model

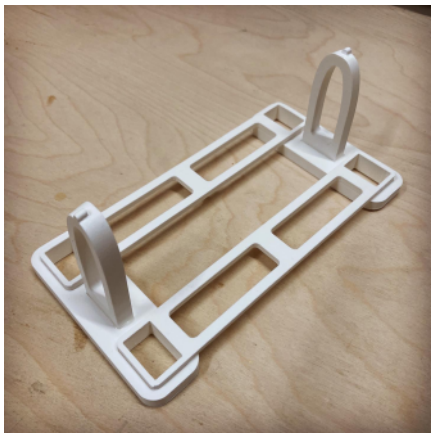


Before first flight make sure the model balances at the Center of Gravity, CG which is indicated underneath the wings by two recesses.

To help you balance the model, a balancing craddle is supplied with the Starfighter files.

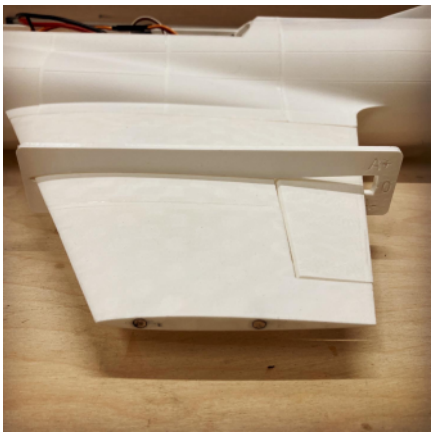
Push CG_Cradle_Left into CG_Cradle_Base and make sure CG_Cradle_Left is perpendicular to CG_Cradle_Base. Repeat the process for the right side. Use the two CG_Cradle_Spacer to assemble the CG-Craddle as shown in the photo below.

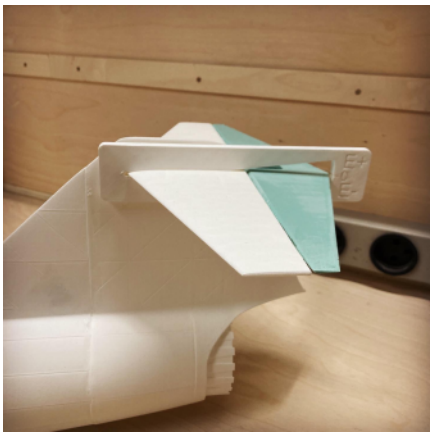
Place the ready to fly model on the CG-Craddle while making sure the contact points of the craddle are placed into the recesses in the wings. Move the battery and receiver forward/backward until the model balances nicely on the CG-Craddle.



Control Throw Adjustment

Use the control gauges to adjust the aileron and elevator control throws. Push the control throw gauges in as far as they will go as shown in the photos below. The gauges have marks to indicate the neutral point of the control surfaces. Use your radio to program the control surfaces to move only in the space restricted by the control throw gauges.





First flight

Always remember: It is the airflow across the wings that creates lift. So keep the airspeed up at all times.

The F-104G Starfighter model flies much like a real jetfighter. Speed should be kept up at all times and flying is all about energy management. Energy will bleed quickly if for example very tight turns are performed resulting in slow speed and in worst cases, a stall. If the Starfighter model is flown in a scale like manner with gentle maneuvers and enough speed, the model will fly "Like on Rails" with no bad habits at all. Make sure your place of flying has plenty of open space as the Starfighter will cover a lot of distance in a short period of time.

It is highly recommended to use a catapult/bungee system to launch the F-104G Starfighter model. A catapult/bungee system will launch the model in a predictable way with plenty of airspeed at a nice angle. And it will do it again and again. Check out this Youtube video about building a simple yet very reliable catapult system.

The F-104G Starfighter should be launched with a pull of 6-7 kg and at a 5-10 degree upward angle. Add full power to the EDF just after the launch. Keep the wings level and fly straight until speed builds up. Do not begin a climb out straight after the launch. Get airflow across the wings before any maneuvering.

It is not recommended to hand launch the Starfighter model.

Landings should be performed on a grass strip with short cut grass. Bring the model in low over the end of the grass strip but with enough speed to avoid any stall situation. At very low height over the grass keep dialing in elevator until the model settles on the grass at almost stall speed.

Extras

If you want to hang your Starfighter model on the wall, the supplied Wall Hook fits the bungee hook. Drill the holes with a 1mm drill bit and insert a piece of 1mm piano wire.
Decals for the Starfighter can be printed on waterslide decal paper. Use both clear and white paper for best result.

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I wish you many successful flights with the F-104G Starfighter

Michael Hammer