

# **Mostly Printed 120 Technical Camera (MP120TC) Assembly Instructions**



**By Kent Williams  
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# Introduction

In Summer 2021 I decided to build a Goodman Axis technical camera, having found it online. I began printing the files provided and quickly noticed that the camera's design had flaws, some of which would completely prevent the camera from being usable. Due to these issues, I determined that the amount of time involved in modifying the design was not worth the effort and that I would start my own design from scratch.

I was inspired by the Mostly Printed CNC (MPCNC), where as many parts as possible are 3D printed, augmented by off-the-shelf hardware and parts where needed. I decided that I would follow this design philosophy and make a Mostly Printed 120 Technical Camera (MP120TC).

## Format

The default format, which is also the recommended format, is 6x7cm on 120 film, although 6x9 is possible. This was selected over 4x5 inches for several reasons. First, 120 film is much more convenient to work with. 120 film is also considerably less expensive to purchase and easier to find labs to process. If you process the film yourself, 120 film is considerably easier to work with. Once developed, 120 film is also easier to get scans from when working in an analog/digital hybrid workflow. The cost overall is at least  $\frac{1}{4}$  that of 4x5 film and image quality is comparable at most common print sizes. Files for 6x9-capable film backs are included if you want to use them, but 6x7 is recommended.

## Film Backs

This camera is compatible with Graflok 23 style film backs, primarily Graflex RH10 and Mamiya RB-67 backs. The sliders that secure the backs will catch the darkslide release on Mamiya Pro-S and Pro-SD backs, so any RB 6x7 film back should work. 6x9 backs can be used provided you use the rear frame, repositionable plate, and ground glass holder parts designed for 6x9. Other Graflok 23 backs such as Horseman and Linhof should work, but they have not been tested.

## Lenses

Any lens over 75mm in focal length in a #00, #0, or #1 shutter that covers 6x7cm can be used. The most common lenses are those designed for 4x5 inch large format cameras in a #0 shutter. The lens you choose will dictate how long of a rail, how long of a lead screw, and how long of a bellows you need. If you wish to use lenses shorter than 90mm, you will need a bag bellows. Additionally, a recessed lensboard (not designed yet) would be advisable for lenses shorter than 90mm.

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# Before You Begin

First, order the 2X M8 x 20mm hollow hex-head bolts!

These bolts will most likely have to come from China, so order them before you do anything. Alternatively, if you have access to metal machining equipment you can have M4 clearance holes bored through commonly available M8x20mm hex head bolts.

## Do you wish to have the L-standards with their knobs on the left or the right?

The default configuration is to have the L-standards on the left when behind the camera. This is dictated by the direction the Graflok/Mamiya RB backs' film advance levers are oriented. You can choose to put them on the right if you wish. If you do, you will need to mirror a few parts when you print them:

1. Rear frame
2. Repositionable Graflok back

Additionally, you can mount the focusing system on the left or the right side of the rail. The default configuration is to have the focusing system on the right side. If you wish to have the focusing system on the left side of the rail, you will need to mirror the following parts:

1. Front carriage
2. Front carriage focusing mount

## Do you want to build your own bellows or order one?

You may choose to build a bellows yourself if you wish. Some guidance will be included if you want to undertake this task. If you have not built a bellows before, it is strongly recommended that you order one. Building a bellows is not a trivial task. Once you factor in time and all the materials you'll need, ordering one is only a few dollars more and offers the advantage that it will almost certainly be usable.

If you wish to order one, the best place to order from is Custom Bellows in the UK (<http://www.custombellows.co.uk/>). **If you are ordering one from them, ORDER IT NOW!**

The specifications are below:

**Outer dimensions:** 100x100mm Front, 100x100mm rear

**Inner dimensions:** 80x80mm Front, 80x80mm rear

**Length/# of pleats:** this is determined by the lens you choose. For a 150mm lens a bellows with 14 pleats seems to work well and allows for good close-focusing extension. If you want to use a bag bellows for wide angle lenses, you can do so - consult Custom Bellows UK for options.

## Focusing Screen / Ground Glass

This camera can accept plain ground glass or a bright screen. Plain ground glass will work OK, but it will be a little dim and gritty. In addition, plain ground glass will suffer from light falloff away from the center of the glass.

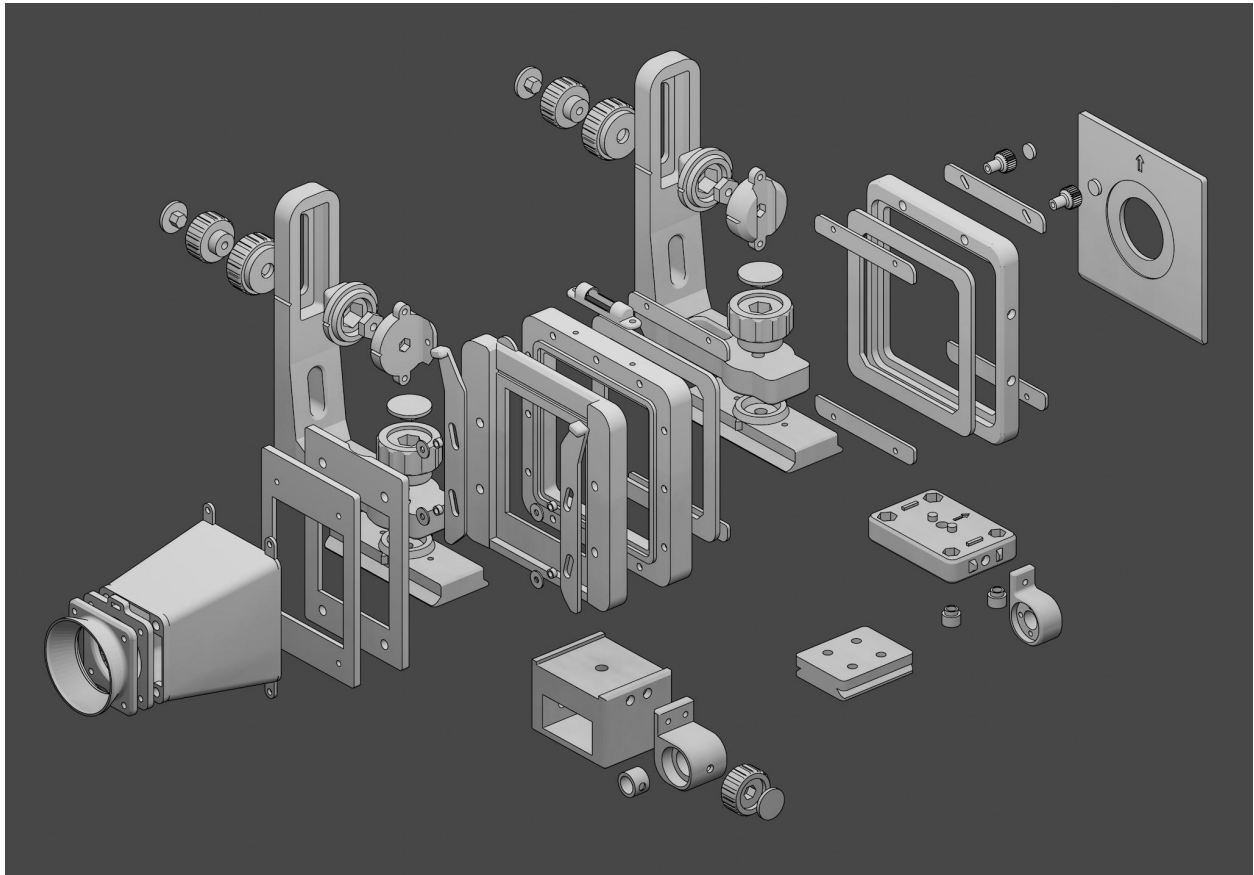
A bright screen will be more pleasant to use if you have the budget to buy one. For bright screens I recommend the Rick Oleson bright screens (<https://rickoleson-brightscreen.com/>). Other screens are available from many sources, but Rick Oleson's are the best balance of price and quality.

### Ground Glass Specifications

Camera/Film Back Format	Ground Glass Size
6x7 (default configuration)	68 x 78mm x 1.5mm
6x9 (optional configuration)	68 x 88mm x 1.5mm

**6x9 Note:** if you are doing 6x9, Rick Oleson sells these, but only in pure matte - no engraved lines or focusing aids. This is because they are cutting the screen down from a 4x5 inch screen.

# Exploded View of 3D Printed Parts



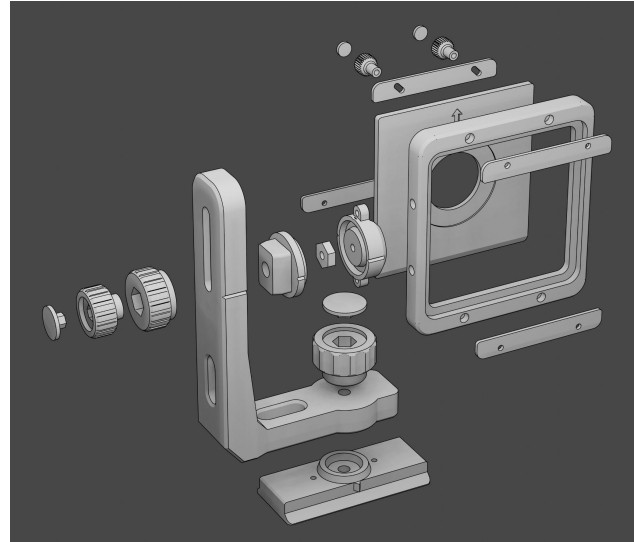
Above you will see an exploded view of all of the 3D printed parts that comprise the MP120TC. Effort was made to minimize use of supports, and heat-set threaded inserts are used on most threaded screws for durability and strength. A standard FDM type 3D printer can be used to print all of these parts. PLA+ material is sufficient, but if you have the ability to print in stronger materials, it is recommended. With PLA you may occasionally need to replace parts as they wear.

There is no specific order of assembly. Individual 3D printed parts are assembled into larger part assemblies that you can build in the order of your choosing.

# Assemble Front L-Frame and Lens Frame

3D printed parts:

- 1X Frame QR Slider
- 1X Front L arm
- 1X Front lens frame\*
- 1X Lens board\*
- 1X Lens board sliding plate
- 3X Bellows locking plates
- 2X M3 thumbscrews
- 2X M3 thumbscrew caps
- 1X Front tilt block
- 1X Rise/Fall block
- 1X Rise/Fall knob
- 1X Tilt knob
- 1X Tilt knob cap
- 1X M8 plug
- 1X Swing knob
- 1X Swing knob cap



\* **Note:** Several users requested that the front be modified to allow use of a Linhof Technika IV/V lens board. STL Files have been included for a Linhof lens board and an alternate Front lens frame that can accept the Linhof boards. You can decide which you wish to print.

**Important:** if you decide to use the Linhof front frame and you're mounting the L arms on the right side, you will need to flip the Front lens frame for printing since it is not symmetrical. The default frame is symmetrical and doesn't need to be flipped.

Hardware:

- 1X M8 x 20mm hollow bolt (M4 hole)
- 1X M8 nut
- 1X M4 x 45mm hex head bolt
- 1X M4 nut
- 1X ¼-20 x 1.5 inch hex head bolt
- 1X ¼-20 nut
- 10X M3 brass heat-set threaded inserts
- 2X M3 x 4mm screws
- 8X M3 x 6mm screws
- 2X M3 x 16mm screws
- 2X M3 nuts
- 2X 4mm diameter, 5mm long spring ball detents with POM ball (**optional**)
- Thin Superglue

## Steps

1. Install the M3 brass heat-set inserts into the front lens frame, ensuring that all are flush with the surface around them. **Note:** several holes for inserts are close to edges and you may see some deformation of the plastic when inserts are installed where the lens board and bellows are attached. If you see deformations, carefully remove them with a sharp chisel. The amount to remove is quite small, so be careful and proceed slowly to avoid slipping and damaging the front.
2. Insert the M8 hollow bolt into the rise/fall block
3. Insert the M8 plug into the remaining space in the rise/fall block and glue it, making certain that the plug is pushed in flush
4. Insert the M4 nut into the hex shaped recess on the front tilt block
5. Attach the front tilt block onto the front lens frame using two M3 screws
6. Insert the M8 nut into the rise/fall knob
7. Insert the M4 x 45mm bolt into the tilt knob
8. Insert the tilt knob cap, gluing if necessary
9. Insert the rise/fall block into the inset on the front L arm with the M8 bolt toward the outside
10. Tighten the rise/fall knob onto the protruding M8 bolt
11. Insert the tilt knob with the bolt through the center of the M8 hollow bolt and through the tilt block into the M4 nut and tighten it
12. Screw one M3 nut onto each M3 x 16mm screw, tightening it fully against the head of the screw
13. Insert each M3 x 16mm screw assembly into a thumbscrew, making certain it is in as far as possible
14. Install the thumbscrew caps onto each thumbscrew, gluing them in place
15. Install the bellows locking plate onto the bottom front of the front lens frame using M3 screws
16. Install the lens board sliding plate onto the top front of the front lens frame using the two thumbscrews
17. Insert the 1/4-20 nut into the bottom of the frame QR slider
18. Install one M3 x 4mm screw into each remaining hole on the bottom of the QR slider
19. If you are using spring ball detents, insert them into the frame QR slider
20. Insert the 1/4-20 bolt into the swing knob
21. Install the swing knob cap
22. Insert the swing knob and bolt through the frame QR slider and tighten



# Assemble Front Carriage

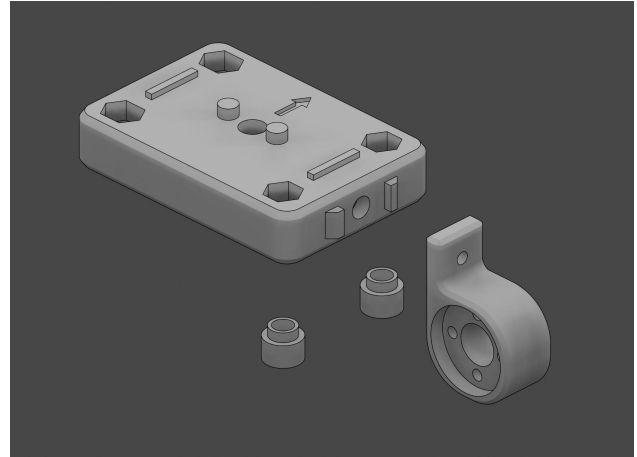
3D printed parts:

- 1X Front carriage\*
- 2X Front carriage wheel spacers
- 1X Front carriage focusing mount\*

\* mirror this part if you are flipping the configuration of the camera to have the focusing system on the left side

Hardware:

- 4X M5 x 30mm shallow head screws
- 4X M5 nylon lock nuts
- 4X Delrin Mini V wheel assemblies (including bearings)
- 2X 6mm Eccentric spacers
- 1X M3 heat-set brass threaded insert
- 1X Brass lead screw nut
- 1X Arca quick release plate with mounting screw
- 5X M3x8mm screws
- 1X M3 washer



## Steps

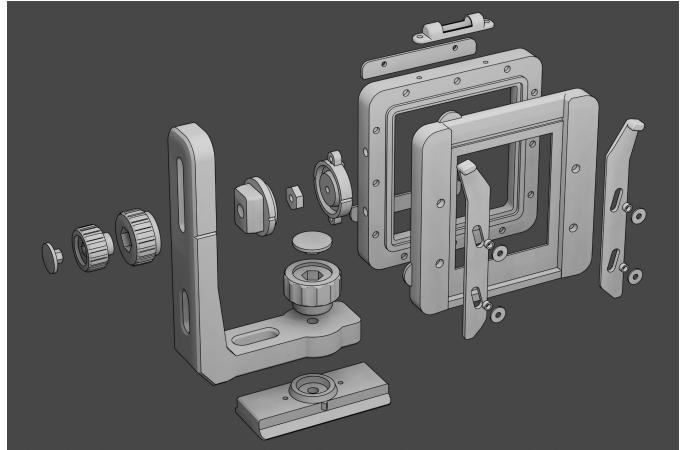
1. 3D print parts and remove supports
2. Install brass threaded insert into the side hole on the front carriage, ensuring that it is flush with the plastic surface
3. Install M5 nylon lock nuts into the hex-shaped slots on the top of the front carriage
4. Install the two 3D printed spacers into the holes on the bottom of the front carriage nearest the focusing mount
5. Install the two 6mm eccentric spacers into the two remaining holes on the bottom of the front carriage
6. Fasten all 4 Delrin mini wheel assemblies onto the bottom of all four spacers using the M5 shallow head screws. Make sure you use any provided washers and that the screws do not protrude above the top surface of the carriage.
7. Tighten the M5 shallow head screws down until the bearings become stiff, then back them off just until the bearings become smooth, in  $\frac{1}{8}$  turn increments.
8. Install the brass lead screw nut into the front focusing mount. Use 4 M3 screws directly into the plastic to secure the nut. Take care to not strip the plastic when tightening the screws.
9. Install the front focusing mount into place on the side of the front carriage using a M3 screw and washer. Ensure the brass lead screw nut is downward, around the same level as the mini wheels.
10. Attach the Arca quick release plate onto the top of the front carriage, ensuring that the locking knob faces the same direction as the arrow on the top of the front carriage.

11. Slide the carriage onto the front of the 2040 extrusion and adjust the eccentric spacers with an 8mm open end wrench until there is just barely a small amount of tension. You will want to periodically adjust this, as it will likely loosen slightly with use and wear.

# Assemble Rear L-Frame and Graflok Back

3D printed parts:

- 1X Frame QR Slider
- 1X Rear L arm
- 1X Rear frame\*
- 1X Repositionable back\*
- 2X Graflok sliders, 1 printed as in the STL file, the other mirrored
- 4X Graflok slider spacers
- 4X Graflok slider washers
- 2X Bellows locking plates
- 1X Bubble level holder
- 1X Rear tilt block
- 1X Rise/Fall block
- 1X Rise/Fall knob
- 1X Tilt knob
- 1X Tilt knob cap
- 1X M8 plug
- 1X Swing knob
- 1X Swing knob cap



\* mirror this part if you are flipping the configuration of the camera to have the L arms on the right side. If you are using 6x9 film backs, you must use the 6x9 parts instead of the standard ones.

Hardware:

- 1X M8 x 20mm hollow bolt (M4 hole)
- 1X M8 nut
- 1X M4 x 45mm hex head bolt
- 1X M4 nut
- 1X ¼-20 x 1.5 inch hex head bolt
- 1X ¼-20 nut
- 11X M3 brass heat-set threaded inserts
- 8X M3 x 6mm screws
- 2X M3 x 4mm screws
- 4X M3 metal washers
- 2X 4mm diameter, 5mm long spring ball detents with POM ball **(optional)**
- 1X 8mm x 35m vial bubble level
- 24X 4mm x 2mm neodymium disc magnets
- Thin Superglue

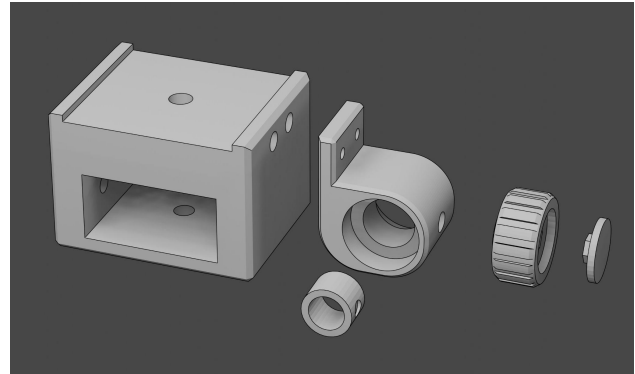
## Steps

1. Install the M3 brass heat-set inserts into the rear frame and repositionable frame, ensuring that all are flush with the surface around them
2. Install the magnets into the rear frame. For each magnet:
  - a. Prior to installation put a small drop of super glue in the hole into which the magnet will be installed
  - b. Ensure that the magnet's polarity is correct
  - c. Press the magnet fully into the hole, making certain it is flush with the surface around it
3. Install the magnets into the repositionable back. For each magnet:
  - a. Prior to installation put a small drop of super glue in the hole into which the magnet will be installed
  - b. Ensure that the magnet's polarity is correct and that it attracts to those installed on the rear frame
  - c. Press the magnet fully into the hole, making certain it is flush with the surface around it
4. Insert the M8 hollow bolt into the rise/fall block
5. Insert the M8 plug into the remaining space in the rise/fall block and glue it, making certain that the plug is pushed in flush
6. Insert the M4 nut into the hex shaped recess on the rear tilt block
7. Attach the rear tilt block onto the rear frame using three M3 screws (two on the side, one on the front)
8. Insert the M8 nut into the rise/fall knob
9. Insert the M4 x 45mm bolt into the tilt knob
10. Insert the tilt knob cap, gluing if necessary
11. Insert the rise/fall block into the inset on the front L arm with the M8 bolt toward the outside
12. Tighten the rise/fall knob onto the protruding M8 bolt
13. Insert the tilt knob with the bolt through the center of the M8 hollow bolt and through the tilt block into the M4 nut and tighten it
14. Insert the ¼-20 nut into the bottom of the frame QR slider
15. Install one M3 x 4mm screw into each remaining hole on the bottom of the QR slider
16. If you are using spring ball detents, insert them into the frame QR slider
17. Insert the ¼-20 bolt into the swing knob
18. Install the swing knob cap
19. Insert the swing knob and bolt through the frame QR slider and tighten
20. Install the 8mmx35mm vial bubble level into the bubble level holder
21. Install the bubble level holder onto the top of the rear frame with M3x6mm screws
22. Make 4 M3-6mm screws into low-profile screws. Using a drill, insert the threaded end of each M3-6mm screw into the chuck and tighten just enough to keep it in place. Run the drill and grind the head down on a piece of sandpaper until the head thickness is no more than 1.1mm. 0.9mm to 1.0mm is best.
23. Insert the Graflok spacers into each slot on the Graflok sliders, one spacer per slot

24. Install one standard metal M3 washer and then one Graflok slider washer onto each of 4 M3x6mm screws
25. Install the Graflok sliders using the M3x6mm/washers
26. Adjust the tension of the M3 screws so the sliders move sufficiently easily
27. You may need to sand down the edges that mate with your back slightly, on the edge that was in contact with your printer's build plate. Some backs don't seem to need this, but others do. Test-fit your back to be sure.

## Assemble Rear Rail and Focusing Mount

This assembly has one optional part: the lead screw sleeve. You may choose to use a 3D printed sleeve (STL file included) or a piece of 9mm OD stainless steel tubing. The steel is more durable and operates more smoothly than the 3D printed sleeve, but the 3D printed sleeve tends to lock more firmly.



### 3D printed parts:

- 1X Rear rail mount
- 1X Rear focusing mount
- 1X Lead screw sleeve (if you are NOT using stainless steel tubing)
- 1X Steel tube lead screw sleeve (if you ARE using stainless steel tubing)
- 1X Focus lock knob
- 1X Focus lock knob cap

### Hardware:

- 1X M4 x 16mm hex head bolt
- 1X M4 nut
- 2X M3 heat-set brass threaded insert
- 2X M3 x 8mm screws
- 2X M5 x 10mm screws
- 1X M5 Double Tee nut
- 1X Arca quick release plate with mounting screw
- 1X 8mm lead screw
- 1X Jog knob
- 1X Lock collar
- 2X 608 style ball bearings
- 1X piece of 9mm ID stainless steel tubing, 0.4mm wall thickness, cut to 10mm

## Steps

1. Install the two M3 heat-set threaded inserts into the rear rail mount
2. Insert the two M5 screws into the rear rail mount's side holes
3. Insert the double tee nut into the opening in the rear rail mount
4. Thread the two M5 screws into the double tee nut holes, leaving them loose
5. Fasten the rear focusing mount to the rear rail mount using the two M3 screws
6. Insert the M4 hex head bolt into the focus lock knob
7. Insert the focus lock knob cap into the focus lock knob, gluing if desired
8. Insert the M4 nut into the recess on the interior of the rear focusing mount
9. Insert one 608 bearing into one of the recesses on the rear focusing mount
10. Fasten the jog knob onto the end of your 8mm lead screw
11. Insert the 8mm lead screw into the center of the installed 608 bearing in the rear focusing mount
12. If you are using a piece of 9mm OD stainless steel tubing:
  - a. Insert the 10mm long 9mm OD steel tube into the steel tube lead screw sleeve
  - b. Slide the steel tube lead screw sleeve and steel tubing onto the lead screw and then into the rear focusing mount, making sure the small indent on the lead screw sleeve faces the screw hole for the focus lock screw
13. If you are using the solid plastic lead screw sleeve:
  - a. Slide the solid plastic lead screw sleeve onto the lead screw and then into the rear focusing mount, making sure the small indent on the lead screw sleeve faces the screw hole for the focus lock screw
14. Thread the focus lock knob into the captive M4 nut, ensuring the screw engages with the indent on the lead screw sleeve
15. Insert the remaining 608 bearing into the second inset
16. Slide the lock collar onto the lead screw
17. Ensure the jog knob and lock collar are tight against the 608 bearings and tighten the grub screws on the lock collar
18. Mount the Arca quick release plate to the top of the rear rail mount, with the tightening knob facing the rear of the camera, using the bottom hole for the Allen wrench to tighten the 1/4-20 mounting bolt
19. Slide the rear rail mount onto the end of your 20x40mm aluminum extrusion, ensuring the double tee nut slides into the slot
20. Tighten the M5 screws to firmly attach the rear rail mount to the rail

## Attach Tripod Mount to Rail

### 3D Printed Parts:

- Rail tripod mount

### Hardware:

- 2X Double Tee Nuts
- 4X M5 x 10mm screws

### Steps

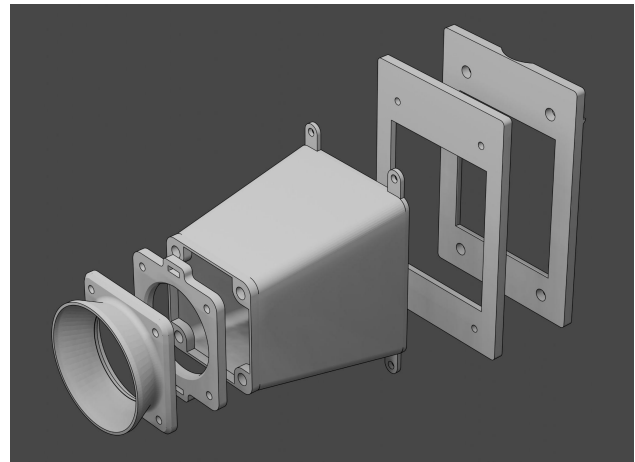
1. Insert all 4 screws through the holes on the bottom of the rail tripod mount
2. Loosely attach the double tee nuts
3. Slide the double tee nuts into the channels on the bottom of the 20x40 aluminum extrusion
4. Tighten the M5 screws

## Attach Standards to Rail

1. Slide the front focusing carriage assembly onto the 20x40 aluminum extrusion rail
2. Engage the lead screw into the lead screw nut in the front focus carriage assembly
3. Move the front focus carriage assembly a reasonable distance from the rear
4. Loosen both Arca quick release plate knobs fully
5. Insert the Front L Arm assembly into the front focus carriage's Arca quick release plate, aligning the arrow on the QR slider to the zero mark on the Arca quick release plate
6. Insert the Rear L Arm assembly into the rear rail mount's Arca quick release plate, aligning the arrow on the QR slider to the zero mark on the Arca quick release plate

## Assemble Ground Glass Holder

In addition to the option to use a bright screen instead of plain ground glass, you may choose to build a magnifying focusing hood that attaches to the ground glass holder. The idea of the magnifying focusing hood is to make it possible to use the camera without a darkcloth and focusing loupe.



### 3D Printed Parts:

- Ground glass frame - front\*
- Ground glass frame - rear\*
- Magnifying hood eye cup (optional)
- Magnifying hood lower lens holder (optional)
- Magnifying hood tunnel (optional)

\* if you are using a 6x9 film back, you must use the 6x9 version of these parts

### Hardware:

- 4X M3 brass heat-set threaded inserts for the ground glass holder
- 4X M3 brass heat-set threaded inserts for the magnifying hood (if using the hood)
- 4X M3 x 8mm screws (if using the magnifying hood)

- 4X M3 x 6mm screws (if not using the magnifying hood)
- 4X M3 x 10mm screws (if using the magnifying hood)
- 1X plano-convex lens, 100mm focal length, 50mm diameter, Eisco brand
- 1X ground glass (either plain ground glass or Oleson bright screen)

#### Steps

1. Install all four M3 heat-set inserts into the front ground glass frame
2. Clean the ground glass
3. Install the glass into the rear ground glass frame, ground side facing the front ground glass frame
4. If using the magnifying hood:
  - a. Install the M3 heat-set inserts into the magnifying hood tunnel's upper surface
  - b. Fasten the hood tunnel and the rear ground glass frame onto the front ground glass frame using the M3 x 8mm screws
  - c. Clean the plano-convex lens
  - d. Place the lens into the lower lens holder, curved side toward the ground glass
  - e. Fasten the eye cup and lower lens holder with lens onto the focusing hood's outer surface using M3 x 10mm screws
5. If NOT using the magnifying hood:
  - a. Fasten the rear ground glass frame onto the front ground glass frame using the M3 x 6mm screws.



# Building a Bellows (if you didn't order one)

As mentioned above, building a bellows is a difficult task. You can build one if you choose, but it is strongly recommended to consider ordering one from Custom Bellows, UK instead. However, some builders want to be able to say that they built the bellows too. For those that want to build a bellows, the methods I currently use are described below.

The bellows described below are suitable for a 125mm to 150mm lens. For shorter focal lengths you will need to remove some ribs and for longer lenses you will probably want to add some.

For light-tightness, it is best to use the blackout nylon on both the interior and exterior. Unfortunately, that means a black bellows. You may choose to substitute another material for the exterior for colors, but when doing so, ensure that the exterior fabric has a water-resistant coating and that the combination of BK5 and the exterior fabric are light-tight.

As for glue, the easiest glue to use is DAP Weldwood or similar. 3M Super 90 can be used if you prefer a spray glue, but it can be very messy.

While you do not need to, it is highly recommended that you hot-cut the fabric, especially with ripstop nylons. You will be masking along cut edges, and if they are not hot-cut, they will fray. Hot cutting can be done with a simple conical tip on a low-wattage soldering iron, with a piece of glass behind. Use a metal ruler that has a cork pad on it to keep your lines straight.

For the bellows shown below, the interior and exterior fabric pieces are 380mm x 340mm each.

## **Materials You Will Need:**

Thorlabs BK5 blackout nylon

Exterior fabric - I recommend at least 1.9 ounce polyurethane coated fabric.

Contact cement

Clear packing tape

Masking tape (19mm / 3/4")

Matte black spray paint (preferably flexible)

Paper to protect your work surface

## **Ribs/Stiffeners:**

You have the option to either 3D print the ribs or if you have access to a printer of sufficient size, print them onto Bristol board and cut them out with a hobby knife.

## 3D Printed Ribs

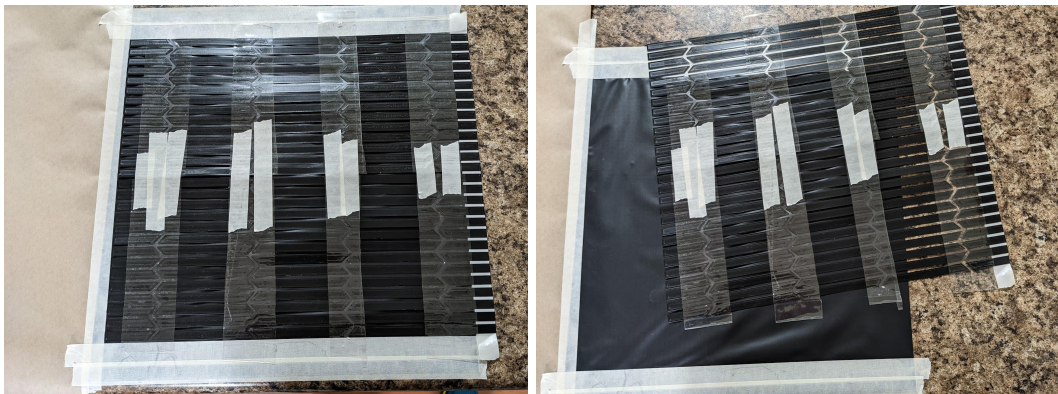
If you choose the 3D printed route, you will be printing "tiles" of ribs.

- 4X - Bellows\_Ribs\_Sides\_Bottom
- 2X - Bellows\_Ribs\_Tops

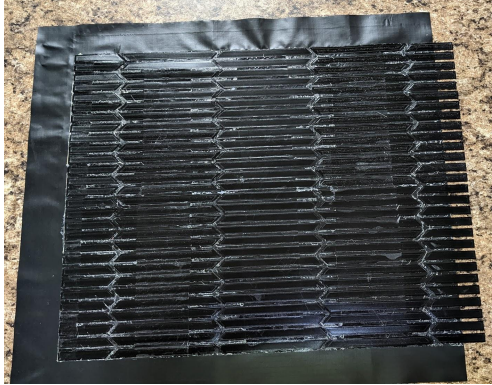
When you print these tiles, as soon as a tile of ribs is complete, apply strips of tape along the ribs before removing them from the build plate. The tape will preserve the spacing. Ensure you use enough strips of tape to keep everything aligned. You don't need to cover the entire area of the ribs, but you do want to make sure they stay aligned.

## Steps

1. Print and trim ribs on Bristol board or 3D print the ribs (see note above). If you 3D print, these must be as thin as you can get them while still using two layers of plastic. Two 0.12mm layers seems to be a good balance between durability and light-blocking. Use black filament to print them
2. Align the tiles very carefully. You will form two rows of tiles: 1 side/bottom tile + 1 tops tile + 1 more side/bottom tile on each row. It must be square, consistently spaced, and the ends of the ribs must align to get a nice looking bellows. Use packing tape to ensure that the tiles do not shift relative to each other. Make sure the tape is all on the same face of the rib tiles.
3. Hot-cut the two pieces of fabric. They should be the same size, 380mm x 340mm.
4. On the non-taped side of the ribs, run a piece of 19mm /  $\frac{3}{4}$ " masking tape down one edge.
5. Start with your interior fabric. Make sure the polyurethane coated side of the fabric is facing upward. Lay the ribs, packing tape side up, on the fabric, and align the 340mm long edge with the edge of the masking tape you applied in step 4. Mask the fabric so that only the area the ribs cover will be exposed.



6. Apply glue to the exposed fabric (be careful that you don't get glue on the un-masked side)
7. Apply glue to the ribs, on the side with the single edge masked (not the packing tape side)
8. Allow the glue to dry as specified in the glue's instructions and carefully apply the ribs to the fabric. Press down firmly, but only on the ribs, not spaces between them.
9. Carefully remove the packing tape and the masking tape on the ribs and fabric.



10. Run a piece of 19mm /  $\frac{3}{4}$ " masking tape down the flap of fabric next to the glued edge of the ribs. Apply additional masking tape to cover the rest of the fabric to the edge of the fabric.
11. Measure the distance from the edge of the masking tape by the ribs to the opposite end of the fabric (not the end of the ribs).
12. Mask off one end of the exterior fabric. Use the measurement you obtained from step 11 to do so and mask along the 340mm length edge. You will need to use multiple pieces of tape to cover the area. Ensure you are masking the interior face of the exterior fabric (not the side you will see when it's done).



Note: this photo shows an additional strip of masking tape along the other end of the exterior fabric's interior face. This strip of masking is not necessary.

13. With the ribs/fabric assembly face up (ribs up), run a strip of masking tape down the exposed ribs right at the edge of the fabric.
14. Apply glue to the rib area on the ribs/fabric assembly, making sure you do not go past the masking tape. Also, only apply glue just a little bit above and below the area the ribs occupy.
15. Remove the masking tape on the ribs/fabric assembly.
16. Apply glue to the exterior fabric's interior face. Make certain you do not get glue on the exterior surface! Also, leave yourself a small border of un-glued area along the top and bottom, making sure you apply glue to all areas a rib will contact.
17. Remove the masking tape.
18. Allow the glue to dry the recommended amount of time.

19. CAREFULLY apply the exterior fabric to the ribs/fabric assembly. Align the non-masked edge with the edge of the glued-down ribs (not the exposed ends). You will want someone to help you with this. You only get one attempt and the glued fabric will tend to want to stick to itself.
20. You now have a sandwich of two layers of fabric with the ribs between. On the edge of the ribs where the ribs are completely glued down (with a flap of exposed fabric), mask off the fabric at the edge of the ribs, leaving the flap of fabric exposed.
21. On the opposite end where there are exposed unglued ribs, fold back the excess fabric, but do not crease it. Hold the flap back with some pieces of tape. Apply some tape to the surface of the ribs.
22. Flip the assembly over. Determine where the edge of the fabric from the opposite end of the ribs will appear, probably about 35mm from the edge of the exposed ribs. Mask that edge so the 35mm is exposed.
23. Apply glue to the exposed ribs up to the masking at the 35mm tape. Remove the masking and allow the glue to dry.
24. Flip the assembly over and glue the masked flap of fabric right up to the edge of the ribs. Remove the masking.
25. Clamp a 3" wide piece of wood that is at least 500mm long securely to a counter or table.
26. Adhere some masking tape to a 3" wide piece of wood with the sticky side up. You can use superglue or some thin wraps of tape to keep it from coming free.
27. Apply the non-rib end of fabric to the masking tape with the glue facing up.
28. Carefully curve the fabric around and very, very carefully align the ends of the ribs up with their matching ribs. Press down firmly.
29. Determine where the last flap of fabric will fall on the exterior of the bellows and mask it off.
30. Apply glue to the ribs up to the masking. Apply glue to the fabric flap, making sure it stays out of contact with the ribs.
31. When the glue has dried, carefully roll the last fabric flap down and press firmly.
32. Carefully fold the bellows. You will need to work your way around slowly in a spiral.

## Mounting Bellows to the Bellows Frames

1. Trim the fabric of the bellows right up to the edge of the outermost ribs.
2. Apply contact cement to the surfaces of the bellows frames that will contact the bellows.
3. Apply contact cement to the bellows' last ribs' surfaces on both ends.
4. Allow the glue to dry.
5. Carefully attach the bellows to the frames and press very firmly.
6. Insert the bellows frames into their locations in the camera and secure them using bellows locking plates and M3 screws.

# Preparations to Interior Surfaces

As a final step, you should ensure that all exposed interior surfaces of plastic are painted matte black to reduce reflections. You may also wish to paint the surfaces of your bellows frames that face towards the lens and towards the film black as well. The interior surface of the lens board must be painted matte black.