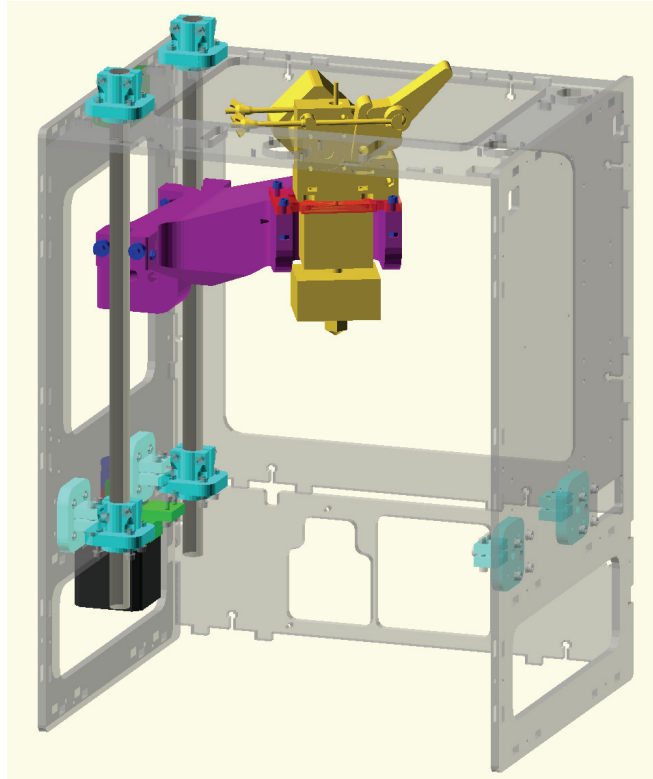


MiZ: MiseryBot Z-Rider



MiZ is a complete Z-Stage replacement for the MakerBot Cupcake. Almost all the parts can be printed on your MakerBot. It will work with many extruders: MK5, MK6, MiseryPusher (shown: <http://www.thingiverse.com/thing:7129>) as well as any other extruder that is designed to attach to the standard MBI MK5 style extruder base plate.

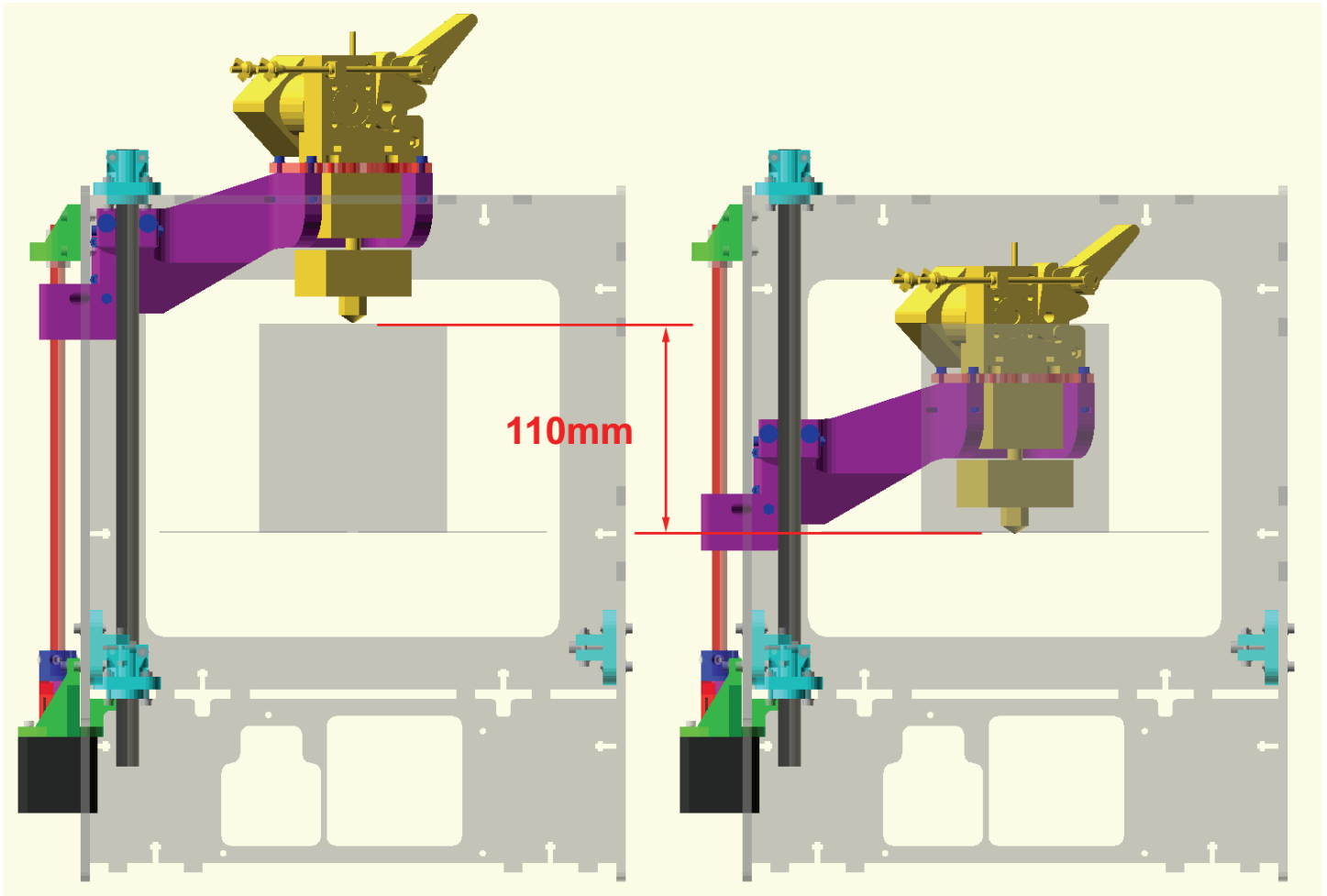
2011/04/21: This is **0v0** which lives at:

<http://www.thingiverse.com/thing:7954>

Please check there to see if a new version is out before building.

Build Volume

When MiZ is combined with a Low Rider (<http://www.thingiverse.com/thing:4213>) you should get about 110 mm vertical travel, without heavy modifications to the MakerBot CupCake:



If you have not made a lowrider yet, you should probably do that mod first.

Heritage

This design owes a lot of inspiration to these two things:

Z-Rider by twotimes <http://www.thingiverse.com/thing:4740>

Type A Z-Rider. v3.2 by TheRuttmeister <http://www.thingiverse.com/thing:5586>

This design strives to be simple, robust, and to make as few modifications to the original MakerBot Cupcake as possible.

Shopping for Vitamins

The design will re-use one of the threaded M8 Z-stage lift rods and 3 of the M8 nuts from your CupCake (roll the rods on a glass table top to find the straightest one). It will re-use one of the Z-stage bearings (8mm ID, 22mm OD, 7mm thick). It can re-use the Z-stage stepper (although higher speed and lower operating temperatures may be achieved with alternate steppers).

Here is the list of parts you will need in addition to the printed or re-used parts. The links are just suggestions.

8 pieces of "623" sealed bearings (3mm ID, 10mm OD, 4mm thick)

<http://www.vxb.com/page/bearings/PROD/3mm/kit845>

(\$19.95 for a set of 10)

2 pieces of 13" long 12mm linear guide rods

<http://www.vxb.com/page/bearings/PROD/12mmLinearMotionSystems/kit1002>

(\$4.95 each, need 2)

a bunch of M3 flat washers:

<http://www.grainger.com/Grainger/Flat-Washer-6FA27?Pid=search>

(\$2.13 for a box of 100)

and a bunch of M3 nuts:

<http://www.grainger.com/Grainger/Hex-Nut-6CA14?Pid=search>

(\$5.48 for a box of 100)

You will also need several different lengths of "Socket Head Cap Screw, Standard Head Style, Alloy Steel, Black Oxide Finish, Hex Socket, Thread Size M3 x 0.50mm, Drive Size 2.50mm, Thread Type Metric"

xx pieces of M3 x 12

xx pieces of M3 x 16 (you probably have plenty from disassembly)

xx pieces of M3 x 20

xx pieces of M3 x 25

xx pieces of M3 x 30

Your local Ace Hardware probably has a good assortment of these.

Glue:

If you are printing in Black ABS, get some Oatey #30889 black ABS cement -- the kind used for black ABS drain pipe:

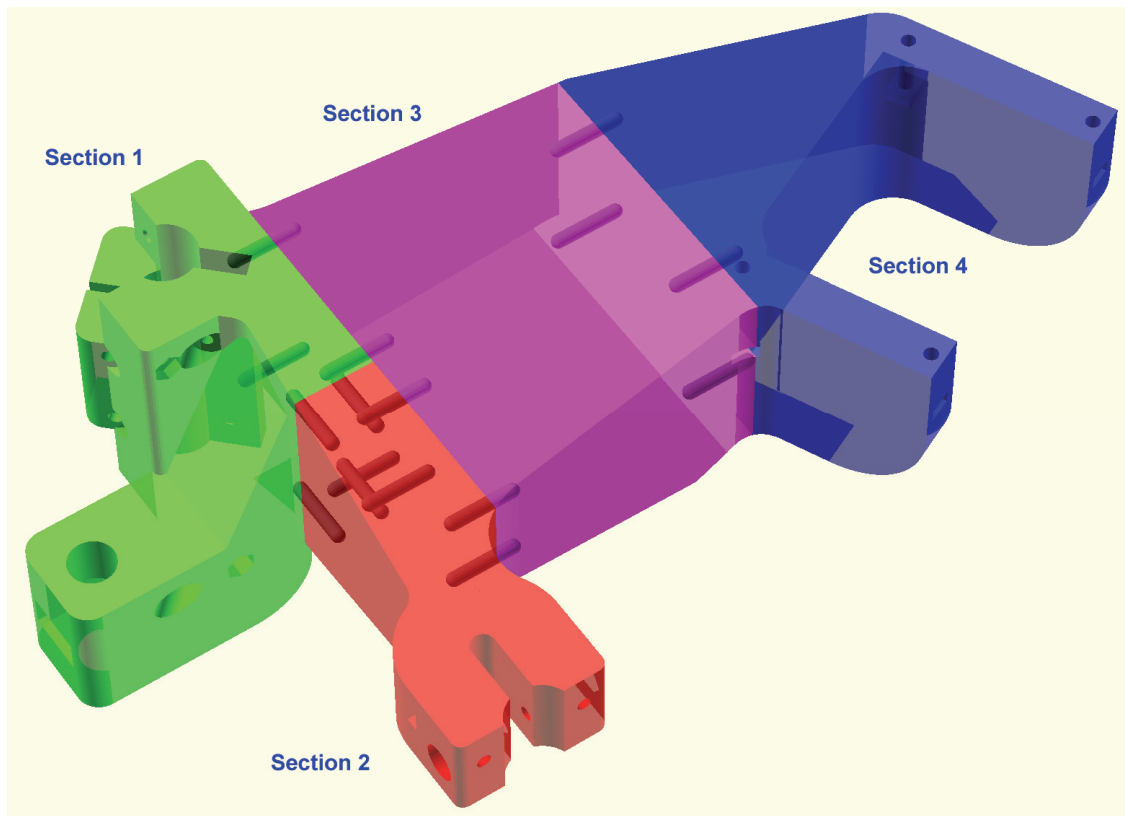
http://www.homedepot.com/h_d1/N-5yc1v/R-100345366/h_d2/ProductDisplay?langId=-1&storeId=10051&catalogId=10053

If you are using any other color of ABS, get some Oatey #30821 All Purpose Cement -- this is also good for ABS but is clear.

http://www.homedepot.com/Plumbing-Plumbing-Accessories/Oatey/h_d1/N-5yc1vZbql8Z12z/R-100116580/h_d2/ProductDisplay?langId=-1&storeId=10051&catalogId=10053

Printed Parts Introduction

The main arm is too large to build in one shot on a Makerbot. For this reason, it is broken out into four sections, each of which can be built on a makerbot. The sections are glued together after printing. There are 3mm blind alignment holes that make the gluing easier and more accurate. This image shows how the arm is constructed. As a note this image is generated from importing the build STL files back into OpenSCAD.



For building on the MakerBot, MiZ is divided up onto 8 build plates.

Plate 1:

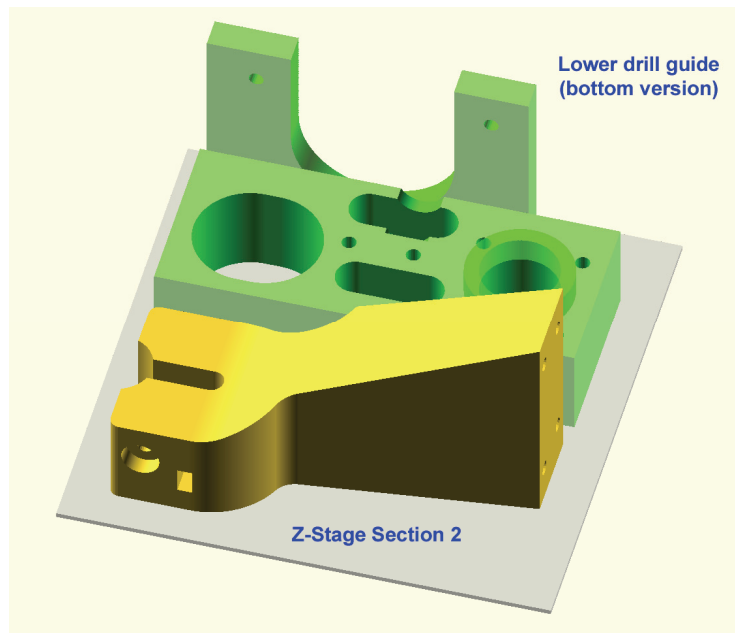


Plate 2:

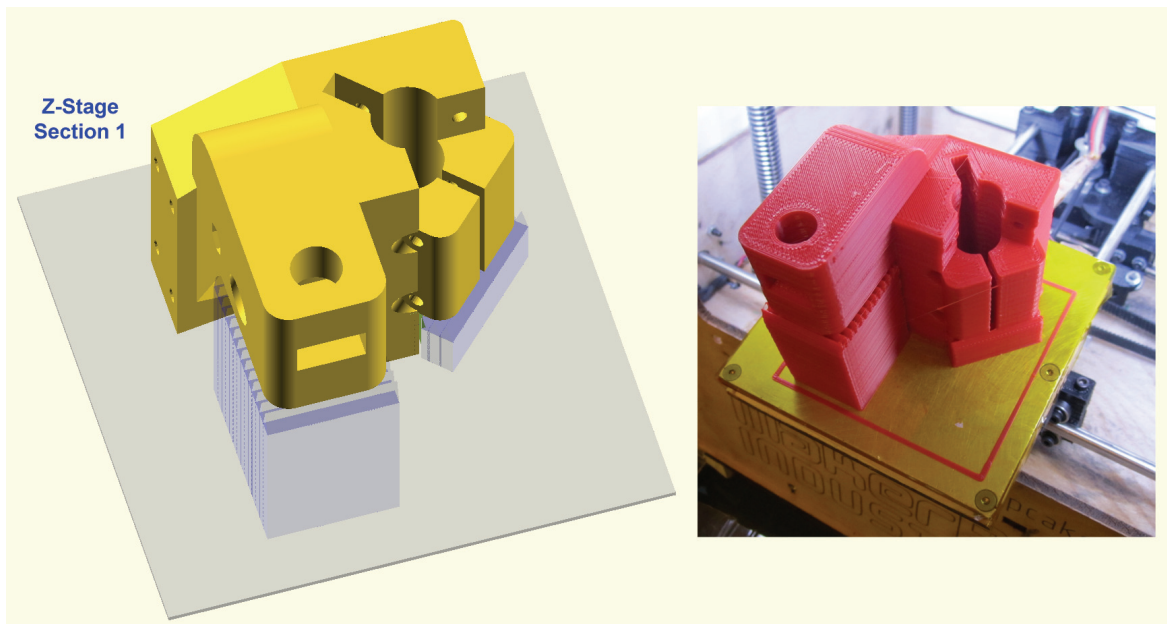


Plate 3:

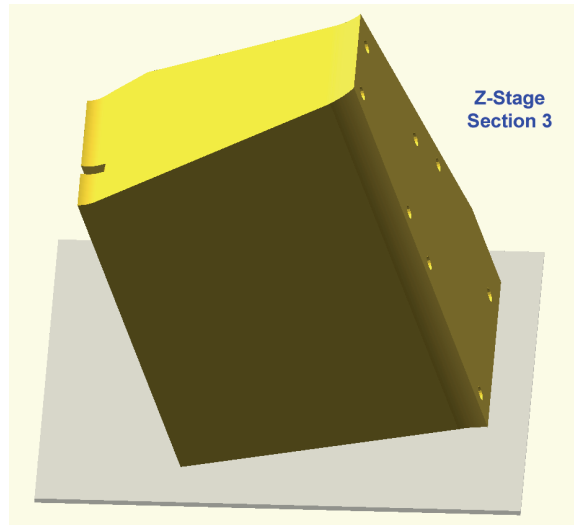


Plate 4:

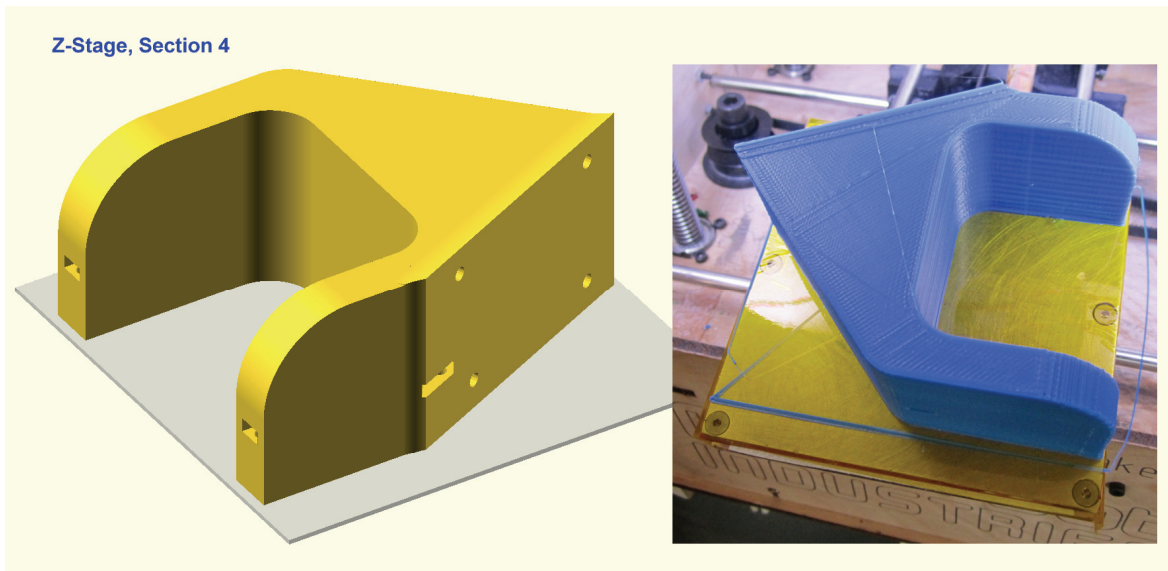


Plate 5:

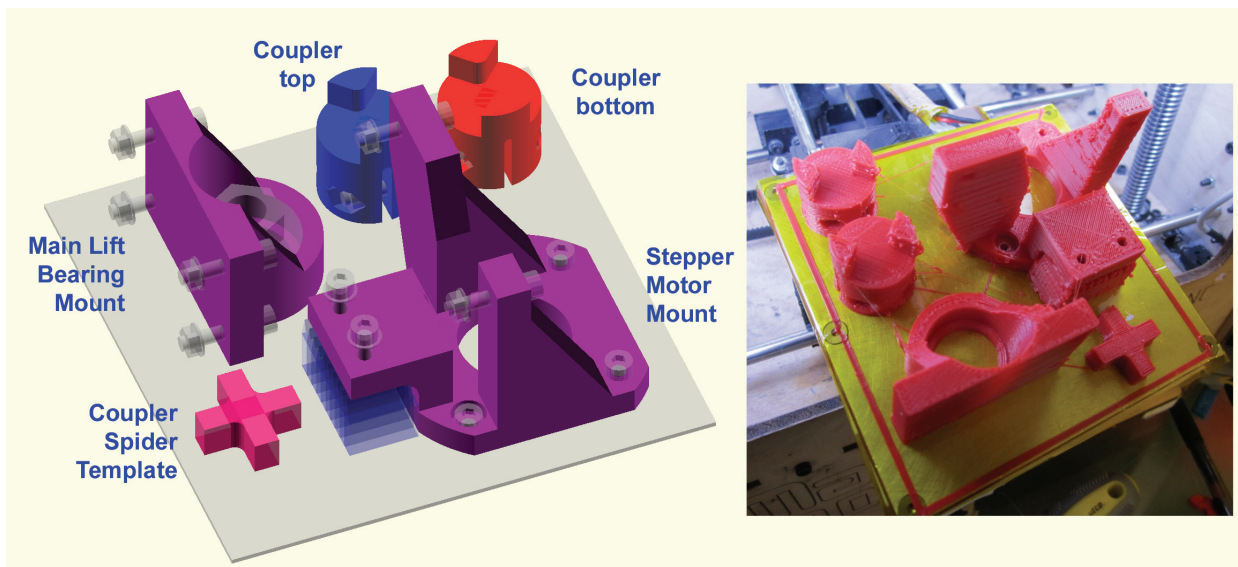


Plate 6:

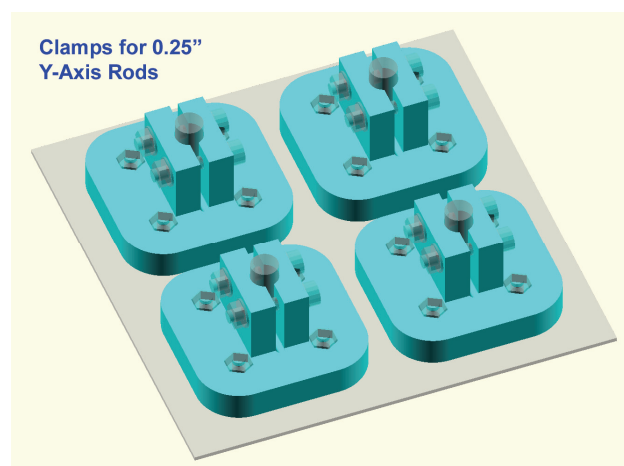
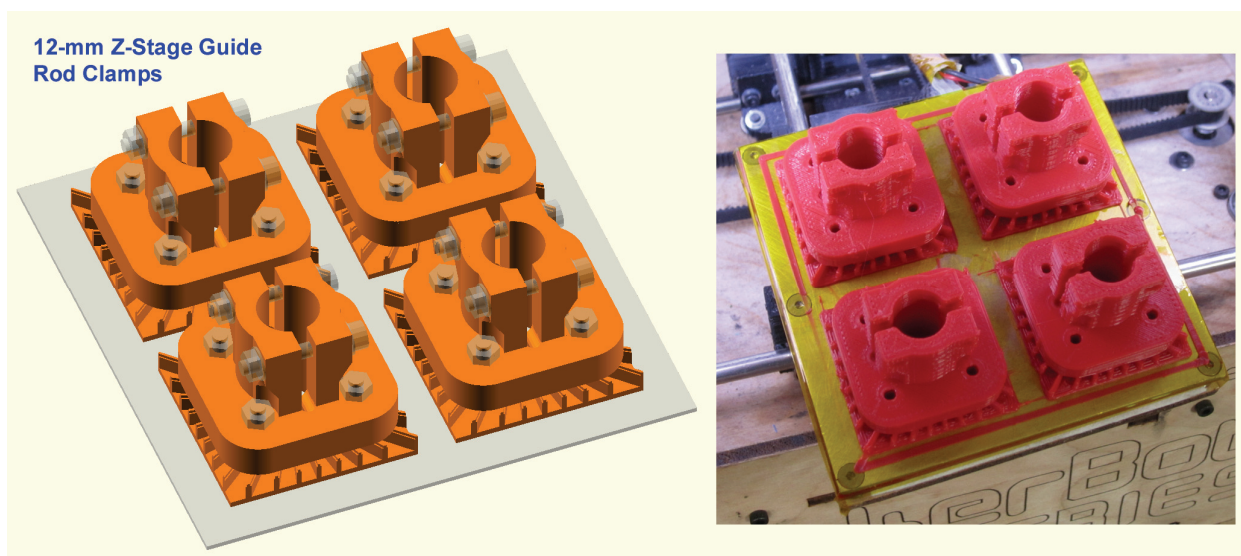
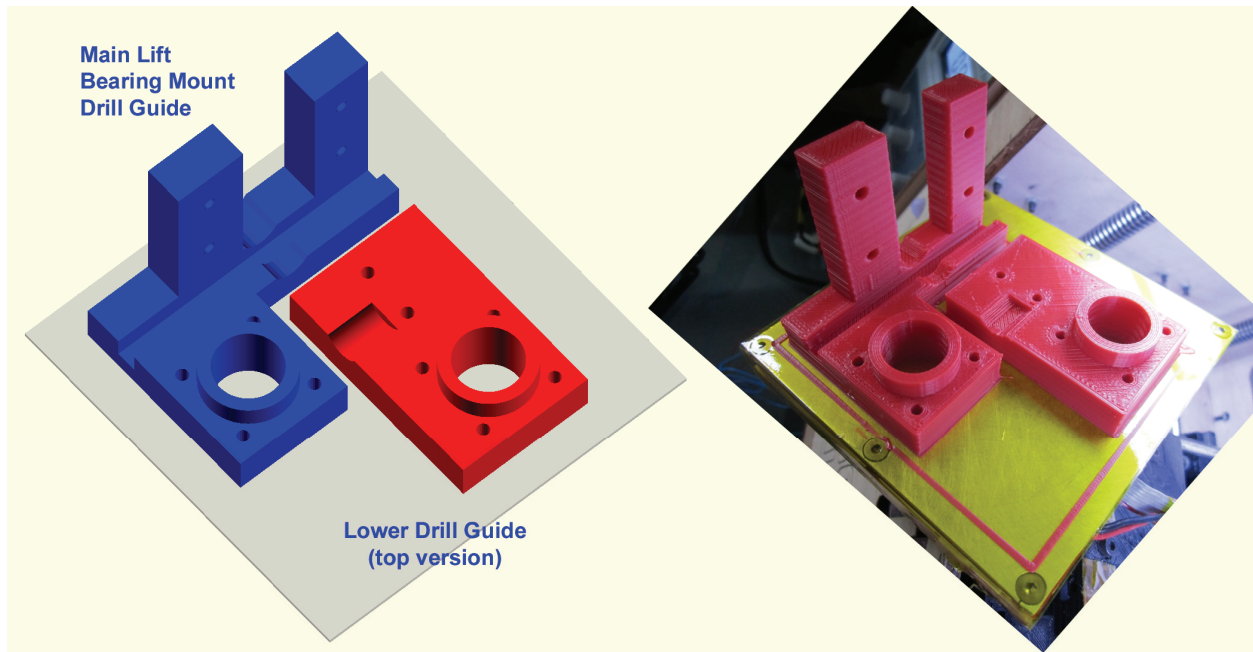


Plate 7:





Construction

// Clean Up Parts

First, print all the parts out. The plates with clamping parts (1,2,5,6 & 7) should probably be printed with a solid profile for strength. Printing in one color is fine. (I was trying to use up a bunch of the odd colors I had around, giving the nice "Technicolor yawn" appearance of the photos).

Hint: Give yourself a break on the drill bits and get one of these: <http://www.harborfreight.com/115-piece-titanium-nitride-coated-m2-high-speed-steel-drill-bit-set-1611.html> Be sure to use the 20% off coupon from the Sunday Paper.

Once the parts are all cleaned up, use a 3mm drill (#31 = 0.120" = 3.048 mm) open up all the small holes. I usually just put the bit in vice grips and do it by hand. It is too easy to go over depth with a power drill.

For the coupler, if you use the MakerBot supplied stepper with the 4.75mm shaft, use a 4.75mm drill (#13 = 0.185 = 4.699mm) to open size the motor side. If you use a standard 5mm shaft stepper, then use a 5mm drill (#9 = 0.196 = 4.978mm).

For the threaded screw end, of the coupler you can use an 8mm drill ('O' = 0.316" = 8.026mm).

For reference, the coupler is available on thingiverse separately: <http://www.thingiverse.com/thing:7678>

Or, if you are feeling adventurous, this coupler should work too: <http://www.thingiverse.com/thing:7831>

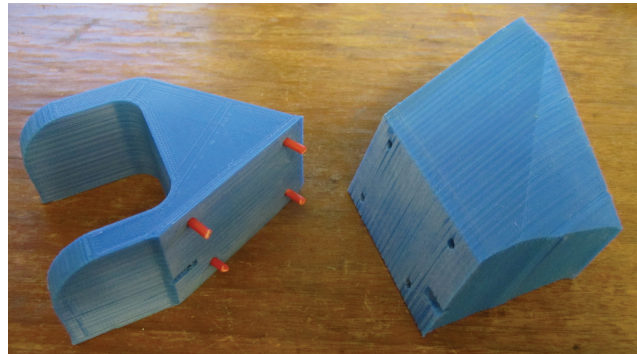
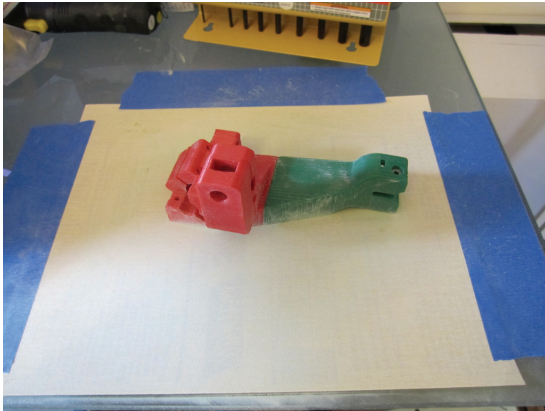
For the 0.25" (6.35mm) X stage clamps, you can just use a 1/4" drill (even your dad has that drill in his set).

For the 12mm clamps, I used a 31/64" (12.3mm) in the clamping area, and a 15/32" (11.9mm) all the way through. This makes the 12mm rod a nice tight fit in the clamps, even before you tighten the bolts. It will take a little force by hand to push the rods through.

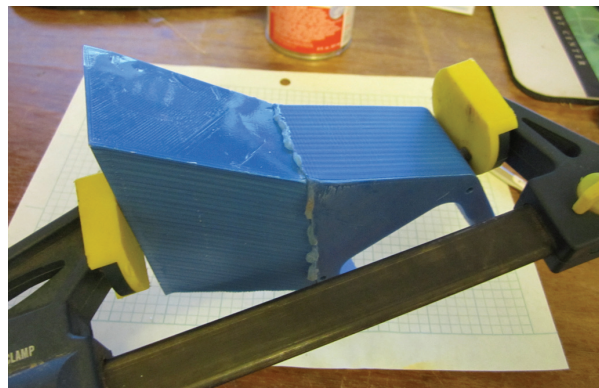
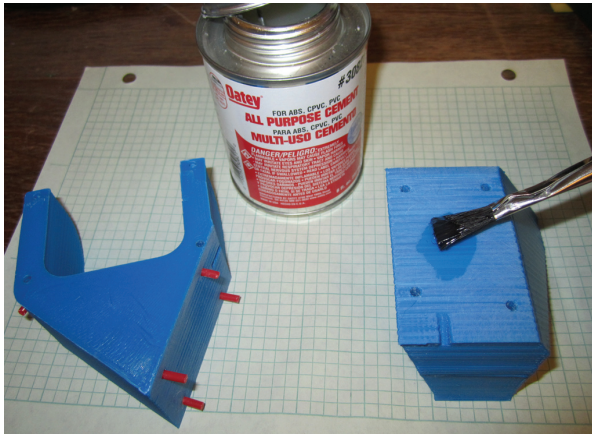
For the round portions of the 12mm clamps and the drill guides that go through the large (22mm) holes on the MakerBot Cupcake plywood frame, you may/will need to use an X-acto knife to trim those slightly to fit. That portion is meant for alignment, so be careful to not remove too much. It should be a snug fit.

// Glue the four parts of the Z stage together

Before gluing the sides of the parts that will be bonded should be flat sanded. To flat sand, tape a piece of 120 to 220 grit sand paper to a flat glass table top. The rub the part lightly on the flat paper, making sure that it stays flat and does not tip. The ABS glue is pretty forgiving, so it just has to be decently flat, not every imperfection needs to be gone.

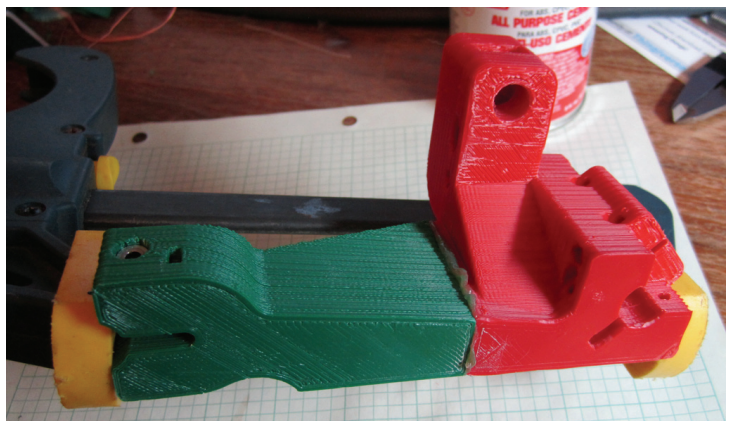
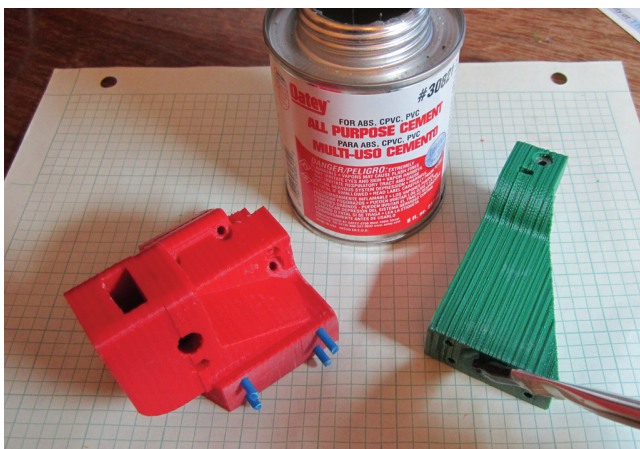


Insert short (1/2 inch or 13mm) sections of filament into the alignment holes. Test fit the parts. Use a disposable "flux brush" to apply the glue, then give it the clamps:



I let the glue cure overnight.

Repeat for sections 1 and 2:



Then repeat the whole thing again to glue the union of sections 1 & 2 with the union of sections 3 & 4. Clamp that up and let it cure. Clean up the joints, etc.

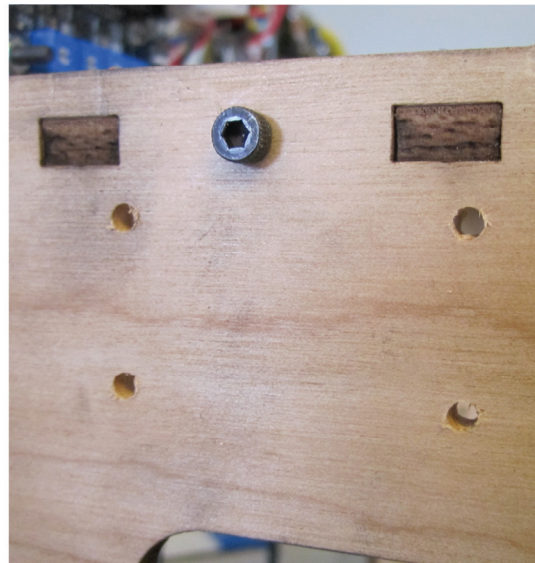
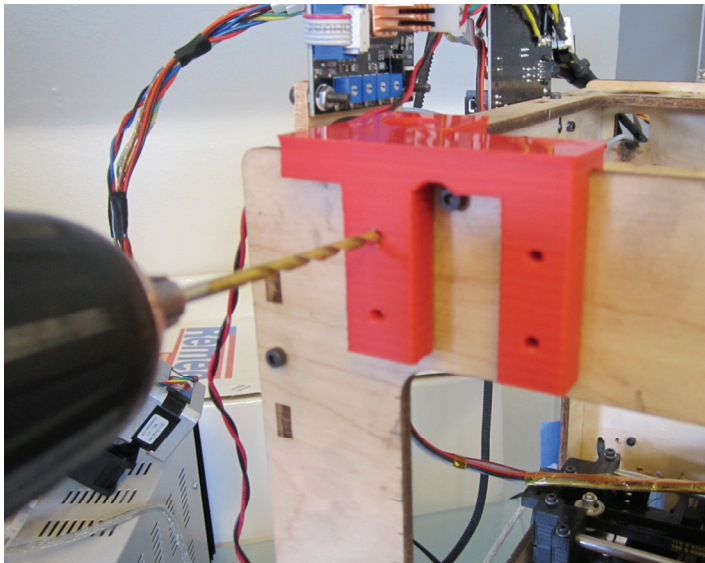
// Disassemble the old Z-stage

While the glued parts are curing, remove the old plexiglas Z-stage, four threaded Z lift rods, bearings, bearing caps, stepper, pulleys, belts, etc. from your MakerBot CupCake.

If you are expert with your hands, a flashlight and tweezers, and also perhaps having slight masochistic tendencies, you can assemble this without further disassembly of the CupCake. If you want this to go easy and quick, with no pliers stuck in the wall after being thrown in a fit of utter frustration, then take the bottom plywood of the bot off.

// Drill mounting holes for the stepper and bearing brackets..

Easiest first. Get the Main Lift Bearing Mount Drill Guide, and position it as shown. Make sure the large round boss goes through the big hole in the top wood of the CupCake (this is the bit that may need trimming). The guide should fit snugly against the top plywood and the side plywood. All level and straight. Double-check against the photos, hold your breath and use a 3mm drill to make the holes:



Next get the "Lower Drill Guide, Bottom Version". Push it into place from underneath, making sure its alignment portion goes into the large hole in the bottom plywood:

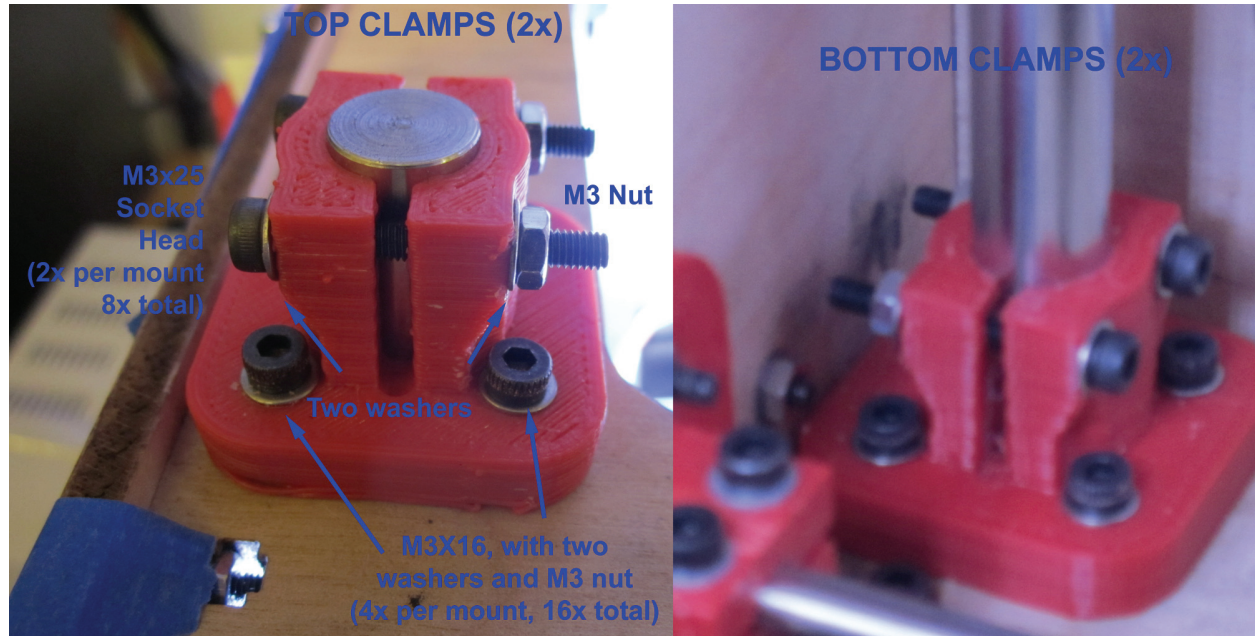


From the side, drill through the two holes visible in the photo above. Push some M3x16 through these to make sure the drill guide does not move. From the bottom drill the other two holes. (If you are masochistic, and did not take off the bottom plywood, you can use the "Lower Drill Guide, Top Version) with a manually twisted drill. Don't do that. It is stupid and will make your fingers hurt.)

// Mount 12mm guide rod clamps (but not the rods yet)

Loosely install eight M3x25 clamping bolts in the four 12mm guide rod clamps, Use two washers and a nut on each (see photo below).

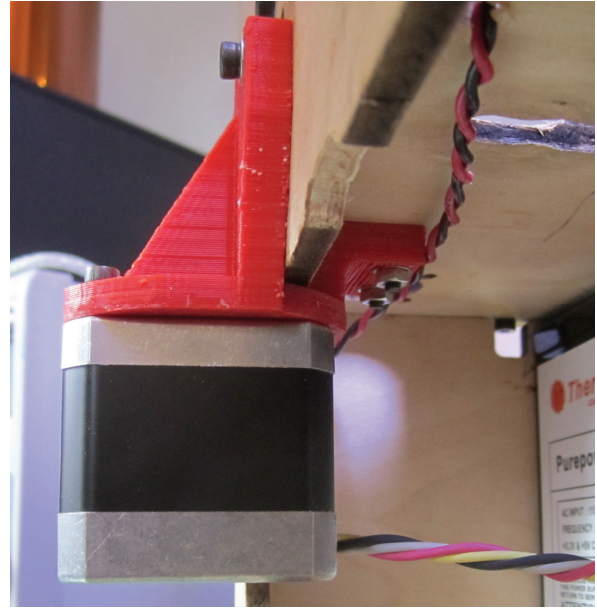
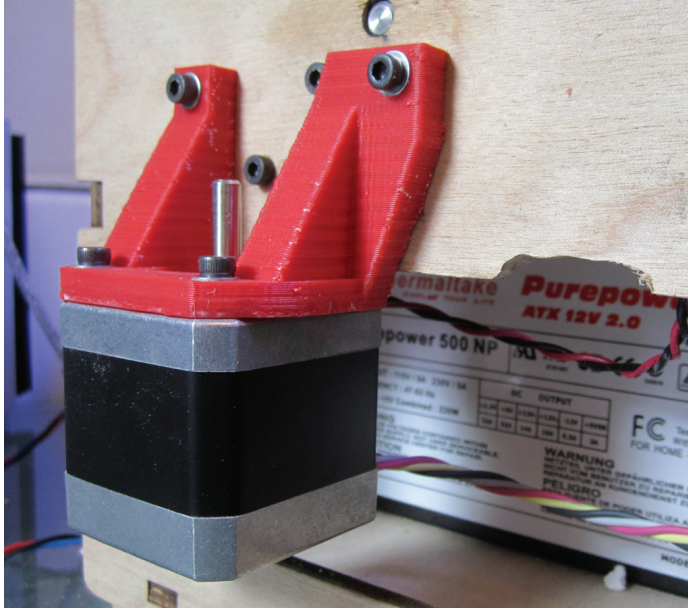
Next off, install the four 12mm clamps to the plywood, using a total of sixteen M3x16 bolts, 32 washers and 16 nuts to mount them to the wood. Sorry, I forgot to take the photo, so you will have to imagine that the 12mm guide rods have not been installed yet.



// Assemble the Stepper Motor Mount

Fasten the stepper motor to the mount. The alignment ring of the motor should fit snugly into the hole of the mount. You may need to trim that slightly. The heads of the screws in back need to be recessed. I ended up grinding those screws down a bit because the ones I had available were bottoming out. Use washers on the front screws. Washers are good.

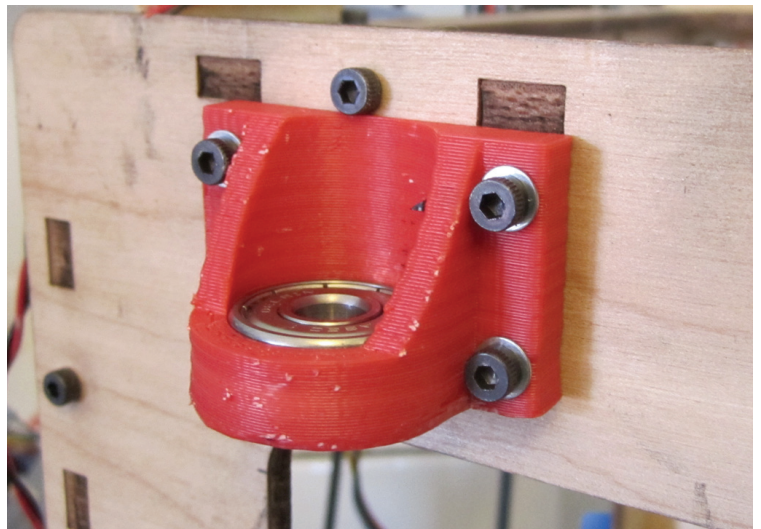
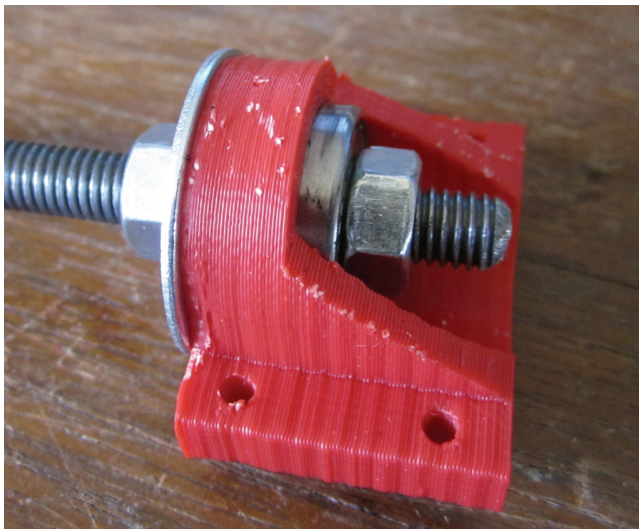
Use 3 pieces of M3x16 bolts, 2 nuts and 6 washers to install the stepper motor plus mount assembly to the CupCake. Leave the upper outside bolt out for now, that bolt needs to go through the X-Stage clamp later:



If you are using the Z-Stage motor that came with your CupCake, It should fit in OK. I am using a bit better motor that is taller, and I had to notch the plywood some to get it in there, which is visible in the left photo above.

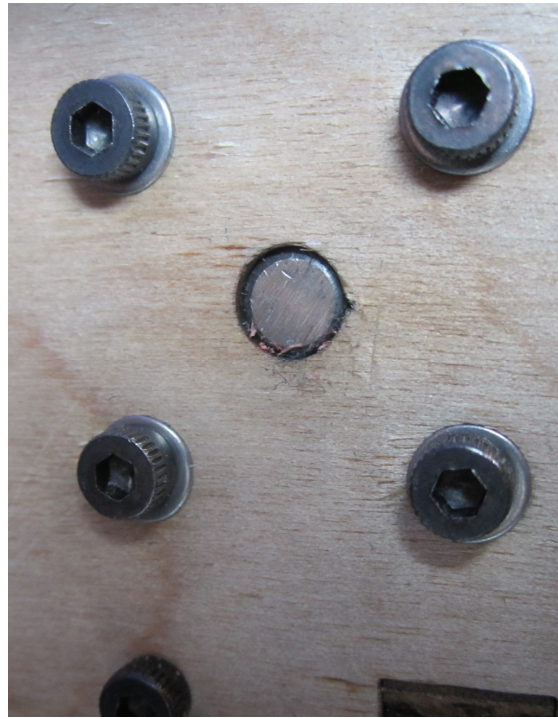
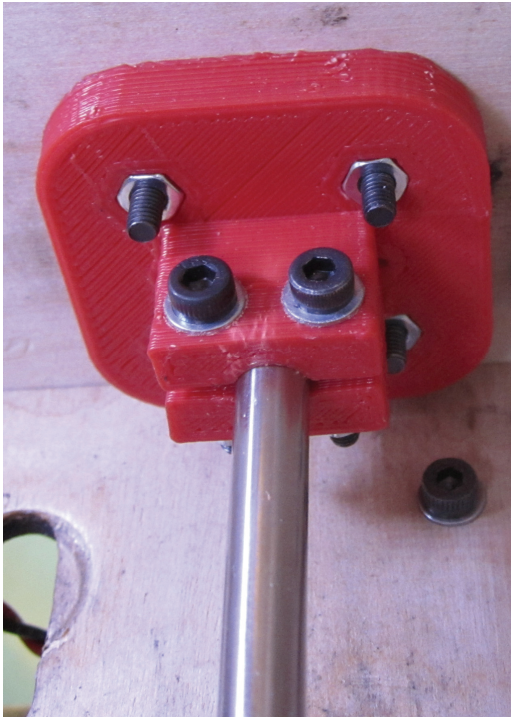
// Assemble the Bearing Mount

Use a fender washer, the 8mm all-thread and two 8mm nuts to press the bearing into the bearing mount. It should not be loose, but also not so tight that you split the plastic part. The attach the bearing mount to the bot with 4 pieces of M3 x 16, 4 nuts and 8 washers. Did I mention I like washers?



// Re-Install the X-Stage Rods, using the new clamps

Use a bunch of M3 x 16 bolts, nuts and washers to re-install the X-stage rods. You need a longer bolt in the position that is shared with the stepper motor mount. Actually the conflict with that X end cap is what made me decide to make the X clamps that could be mounted inside the bot:

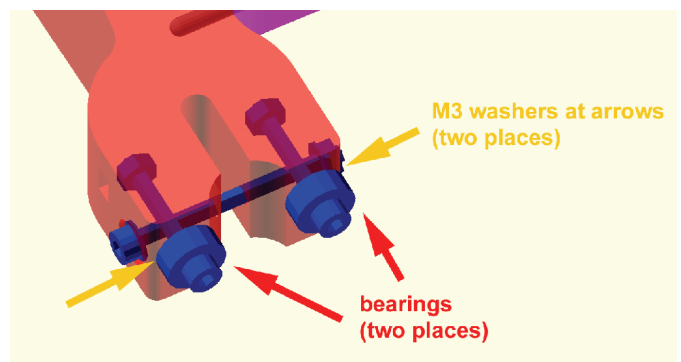
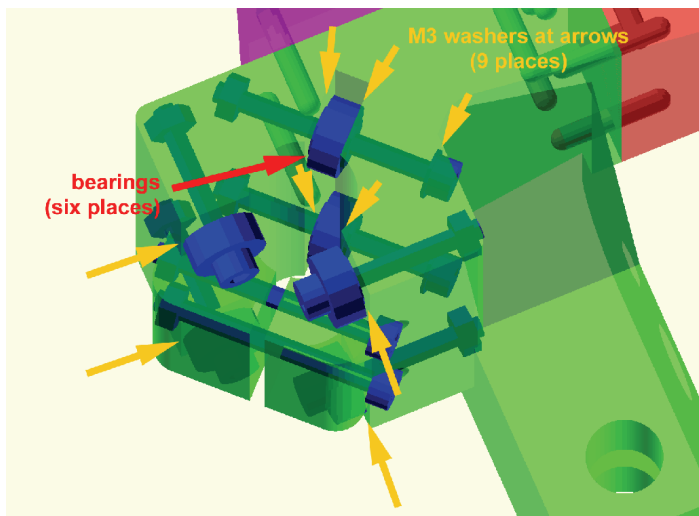


// Assemble the hardware to the Z-Stage

Hopefully the glue on the z stage is cured by now.

Push M3 nuts into the 6 captive slots where the bolts will go through them. Make sure the square hole is clean and deep enough. If the print is right, pushing the nut to the bottom of the slot will line it up nicely with the intersecting hole.

Install the bearings and adjustment bolts in the Z-Stage:



The important things to keep in mind are to always have a washer between the bearing and the plastic. The plastic is rough enough and soft enough that otherwise the hub of the bearing could sink into the abs that A washer is not needed between the head of the screw and the bearing. Contrary to your painful experience to date, the two bearings that slide into the slot with the washer on either side and the long bolt going through it are not *impossible* to assemble. They are

only *extremely difficult* to assemble. You do want the two washers and the bearing to be sandwiched in there kind of tight though, so the inner race of the bearing does not spin on the bolt. It could happen!

Test fit the 12mm rods in the bearing sets. You want a little pre-tension on the bearings so there is no slop, but you do not want so much force that the bearings will wear out. When the rod is pressed through the bearings, it should roll up and down easily and without any slop, but not rotate.

// Install the Z stage in the bot

Install the front guide rod. Press it through the 12mm mounts. Leave a small amount showing on the top. The remainder will extend into the empty power supply area. The clamps on the front rod can be tightened now:



Press the rear guide rod part way through the top 12mm clamp. Position the two front anti-rotation bearings of the Z-Stage around the front 12mm guide rod. Lift the Z-Stage up onto the rear 12mm guide rod. Holding the Z-Stage up, press the rear guide rod down through the lower 12mm clamp.

Check that the stage moves freely up and down, and that there is no slop. Cool, huh?

// Install the spider coupler and threaded Z lift rod

Make the rubber spider for the coupler as detailed here:

<http://www.thingiverse.com/thing:7678>

Alternatively, you can use this thing:

<http://www.thingiverse.com/thing:7831>

Fit the smaller end of the coupler to the stepper motor shaft.

Do a test fit with the threaded rod coming down through the bearing, through the Z-stage lift arm and into the larger end of the coupler. Move the Z-Stage to make sure the threaded rod is well centered and aligned. I had to shave the hole in the Z-Stage lift arm a bit. Seems like that would not be necessary with the drill alignment guides--who knows what happened there.

Once the test fit looks good, slide a M8 nut into the lift arm. It should not be tight. Tight means friction. Friction leads slow stepper speeds. Slow stepper speeds lead to anger. Anger leads to the dark side.

Bring the rod down through the bearing, with an M8 nut above the bearing and one below the bearing (the third nut is loose in the Z-Stage lift arm).

Connect the stepper up to the driver board and use Rep-G to give it a whirl. With my setup (this stepper motor:

<http://search.digikey.com/scripts/DkSearch/dksus.dll?keywords=403-1037-ND> from DigiKey, and using a 35v supply) I can get 550mm/minute:

<http://www.youtube.com/watch?v=K-9MwgUz1v0>

// Final Assembly and Calibration

Tighten the any bolts that have not been tightened yet.

Mount your extruder on the Z-Stage. Hook up all the wires.

Find your bot's XML file (mine is at . . . \Replicator G 0024\replicatorg-0024\machines\miserybot.xml) and modify the Z axis like this:

```
<!-- 1.25 mm per rotation 200 steps per rotation -->
<!-- 1600 1/8 steps per rotation 1600 steps/1.25 mm
<!-- 1280 steps/mm -->
<!-- fiik, moves 20mm, so use 1280/2 = 640 -->
<axis id="z" length="109.7" maxfeedrate="550" stepspermm="640" endstops="max"/>
```

That setup is for 1/8 step Gen4 electronics. For Gen 3 electronics it should be 1/8 of the value. You might need to use a lower maxfeedrate for standard steppers at 12v.

Have fun. Please like this thing and post I made one pictures back to thingiverse when you build it.

