3D Printing on the Baden, Vogt & DeSmet
A Clinic for Model Railroaders

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Well, the Gateway-X Virtual Convention of the NMRA for 2020 is now over, and I'm looking for something new to do. 3D printing is where I am headed. I don't yet know how I am going to organize this section, or when it will be really ready for sharing, but I already have learned some things.

I started out in early May, 2020, and visited YouTube where I saw some encouraging ideas. My first attempt was to make room dividers for the "Randomizing LEDs" project for the "Amazing Arduino Animations" clinic described above. I used free "TinkerCAD" software and the "makeXYZ" service bureau to print the design, and eventually it worked.

The project was really simple, just a bunch of extruded rectangles for floors, ceilings and walls, and it took me three tries to get something that worked. The makeXYZ service bureau folks were very helpful in understanding what I was trying to do and explaining where I was going wrong. I did learn that in order to have walls and ceilings that indeed are bonded together, the top and bottoms of the walls must be extended through their corresponding floors and ceilings, not just to them, but through them. They also need to be thicker than the 1.0mm I first used (2mm worked, but I want to try 1.5mm in the future). The thing that I didn't like with the service bureau was that it took about 2 weeks to fabricate and deliver my design, and in many cases their printer network would decline to fabricate my design at the quoted price. Also, be aware that service bureaus charge based on the amount of resin used to create the design, and how fast you want it done.

I had hoped that the St Louis County Library would have a 3D printer that I could try, without using a Service Bureau or buying one myself, but they had none. The St Charles Library's web site indicated that the did have one, but that was only occasionally, when aficionados taught an evening clinic, and these were not particularly oriented to model railroading. St Louis City and University City libraries each had one, but they were not that conveniently located to me in Florissant, and at the time the libraries were closed due to COVID-19. So if I wanted to cut my turn-around time, I was going to have to buy my own 3D printer.

I first purchased a Monoprice "Cadet" 3D Printer from Amazon for about $250 because it seemed really simple, and I was attracted to their claim that the bed was self-leveling (that feature never worked for me). But the first one was Dead On Arrival. Monoprice Customer Support's Chat Line said, "Send it back to Amazon for replacement", which I did. The replacement worked for about a week before failing, and again, Monoprice

said to send it back; I was extremely disappointed with their technicians, as they made recommendations that someone with a background in Computer Science, as I have, would know to be inappropriate.

My next attempt was to purchase an "Ender 3 Pro" from Amazon, again for about $250. It arrived on a Thursday evening, and on Friday morning, before ever unboxing the unit, MicroCenter sent out an email offering them for $199. So, I returned the unit to Amazon and bought one from MicroCenter (I subsequently learned that the "Ender 3 Pro" is scheduled for replacement with a "Version 2" model containing some upgrades, but they are not yet shipping, just announcing, and since the aftermarket for upgrade parts is extremely rich, I decided to go for the "better deal" now).

The Ender 3 Pro unit comes "semi-assembled", but I had it together in about an hour. The instructions were illustrated only with no textual instructions (think “IKEA”), but they worked (watching an "unboxing" video on YouTube would have made the task a bit easier, but it wasn't really that difficult). I leveled the bed manually, which was easily done. I tried their test print, a "Fortune Cat", and it worked.

Creating your own 3D models of anything more difficult than building interiors is difficult, but fortunately there are literally millions of designs for free on web sites such as http://www.thingiverse.com and http://sketchup.3Dwarehouse.com and several others. I wanted some motorcycles, so I did a web search, found some and downloaded them in ".STL" format ("STereo Lithography"). TinkerCAD was a feature that allows one to import 3D models and scale them, so I imported a Harley model file. A motorcycle is about 8 feet long, or about one inch in HO scale, and is full of fine details, such as spokes and handle bars, but I gave it a try. It ended up as a pile of mush, and filament back-flowed around the "hot end" of the printer, necessitating a full clean-out of the nozzle (Nozzles are cheap, so buy them by the dozens). The moral of this story is "Not all free images will print well when scaled down to HO".

If the nozzle gets gummed up, it is better to replace it rather than trying to clean it. To remove it, remove the two screws holding the fan, and drape the fan housing over the X-axis rail. Heat the hot end to about 200 and extract the filament. Hold the hot end gently with pliers and unscrew the nozzle with a M6 socket. Clean any filament residue from the hot end. Remove the clip from the Bowden tube and remove it. Take an old Bowden tube and force it through the hot end, essentially removing any internal gunk. Reattach a new nozzle but back it off 3/4 of a turn. Reattach the Bowden tube and then crank the nozzle all the way in. Load filament and you are ready to go.

If you follow the 3D printing groups on Facebook, they are adamant about “calibrating your E-steps”, which at fir confused me. Simply, this just means that we need to make sure that when we command the extruder motor to eject 100mm of filament, we want to make sure that it indeed does eject that amount. To do the calibration, we raise the Z-axis to about 150mm, and heat the hot end. Once hot, we snip off any resin, instruct the extruder to eject 100mm, and once the extruder motor stops rotating we snip off the filament again. We measure the filament, and if it is not exactly 100mm in length the

ratio of its actual length to 100mm is the factor by which we must “calibrate the E-steps” in the Slicer. For model railroad applications, this may not be critical, but it is easy enough to do, so I recommend it; Failure to do so will result in prints that are too thin or too thick.

Now we come to some recommendations for YouTube videos which got me back up and running. There is a YouTuber whose moniker is "Tomb of 3D Horrors" and I liked him a lot. He has a video on cleaning out on the Ender 3 at https://www.youtube.com/watch?v=dIkjR2Ytx-g. I started by heating the hot end to 210 degrees C. I followed the instructions, including flushing filament from the hot end, turning the nozzle all the way in, and then backing it out 3/4 of a turn before fully inserting the Bowden Tube and filament, then tightening the whole thing up. It worked!

I have had differing levels of success with different brands of PLA filament. The stuff purple sold by ERYONE, HZST3D and SHENGTIAN (some gold and some purple) have been good, but some reels from GizmoDorks were brittle, poorly wound and tended to break during printing. Metallic filament from MIKA3D were in the middle; they looked great and did not break, but the winding was poor, which necessitated pulling enough from the reel to complete the job prior to starting, or to visit the printer hourly to make sure there was some slack in the reel along the way.

A YouTuber, "Just Vlad", is a fountain of knowledge of Ender 3 Pro upgrades, and I purchased several, including replacement connectors surrounding the ends of the Bowden Tube, a "Capricorn" Bowden Tube (BTW, the Bowden Tube length of an Ender 3 Pro is 1/3 of a meter), "TL Smoothers" (diodes that eliminate back-EMF when the steppers change direction, a bracket for the top end of the "Z Screw", and a metal extruder assembly to replace the plastic one. Be advised, the one I purchased from AMAZON, (ASIN:B089YN54Z8) used a different connector for the Bowden tube at the cold end, and did not document that there was a difference, and I lost a week of productivity while I figured out what was changed (the new unit used a small black "press-in" plastic fitting instead of the screwed in metal fitting which originally came with the unit).

The bed leveling springs under the build plate which came with the Ender 3 Pro are weak, and more than once they failed to hold the build plate in place, when one of the handles in the back actually rotated enough to fall off during a print. I removed all of the handles and replaced the springs with aftermarket ones. The spring in the back left, the one where the build plate wires come in, is confusing. Its spring goes between the build plate and the wiring harness, not between the wiring harness and the handle. When installing the new springs, you will need to raise the Z-axis limit switch a bit because the new springs are taller, and this is a simple matter of loosening two screws and raising the limit switch. Of course, after changing the springs, I needed to re-level the bed.

The drive gear above the extruder motor does wear and needs to be changed periodically. To do so, heat the hot end and remove the filament. Rotate the motor

shaft to gain access to the set screws on the gear. You may be able to get by with just raising or lowering the gear a bit to expose unworn parts of the gear, then retightening the set screws. But if the entire gear is worn, it will need to be replaced, and they are available from Amazon at a reasonable price.

If you decide to get rid of the magnetic build plate and replace it with glass, the glass plates are available from Amazon. The glass plate can be held in place with self-printed clips whose STL files are available from Thingiverse; they may also be held in place with Frog Tape.

"Just Vlad" also has several videos where he prints useful parts for the Ender 3 Pro, and I intend to print some of them myself, including a back plate for the display, clips for the cable from the CPU to the display, a shim for the Z axis motor to eliminate stiffness in the Z-axis threaded rod, a tool drawer, a filament advancement knob, and several others; I like this guy.

Now about a piece of software called a “slicer”. While projects are designed in CAD systems such as “SketchUP”, “Fusion 360” or “TinkerCAD”, once the project is created, it needs to be converted into instructions for movement of an extruder for a specific 3D printer, and this process is called “slicing the model”. My Ender 3D came with slicing software based on “Cura” version 1.2.3, a reliable but hopelessly obsolete version. I looked online and discovered the current free version was 4.6.2, so I downloaded it, while keeping the older version for backup.

I am starting on a new 3D printing project, printing decorative Herald Plaques for my Railroad. I want these to be in two colors, purple for the background and gold for the lettering and trim. I decided to draw an oval about 140mm by 80mm, 2mm thick, for the background or “field”. I created another oval on top of the first, of the same height and width, but 3mm deep and only 2mm wide, in gold, for trim above and around the oval. Now I needed to include the name of the railroad, in Windows “Algerian” type, inside the oval trim and above the field. But how could I get TinkerCAD to import words in Algerian Type?

Enter a web site called http://www.ANYCONV.COM, an internet application that converts files from one format to another. Among the files it can convert are PDF files into STL files for CAD applications. It also turns out that PowerPoint can save a screen into a PDF file. So, I designed the text for my logo, complete with type in the Algerian type face, and then did a “File”, “Save As’ and saved the type into a PDF file format. I then visited http://www.anyconv.com and converted the PDF file into a STL file and downloaded it from the web into the Download folder of my PC. From there I opened TinkerCAD and imported the STL file into the drawing; it did require some change in size (it had to be enlarged by 10,000 times), and once imported, its height had to be reduced from 20mm to 1.75mm, but fortunately TinkerCAD does this quite easily.

I started the actual printing of the Herald by opening TinkerCAD, selecting the field (the base) only, and exporting a STL file. I opened the slicer and generated the Gcode, then printed the Gcode using purple filament..

With the field still on the build base, I again opened TinkerCAD, selected the trim ring and text for the logo, and exported just these items to a STL file. I opened the slicer, generated the Gcode and change the printer filament to gold. But if I then printed the Gcode without further modification, the nozzle would not print on top of the field, but would plow straight through it like a drunken farmer laying a trail of golden seeds. We need some way to elevate the extruder with some "offset" before printing, and that is where the "M206 Z-1.98" statement comes in to play.

The "M206 Z-1.98" statement specifies that all subsequent instructions involving the Z axis are to be raised by 1.98mm (yeah, the fact that we use a negative number to raise the print head seems backwards, but that's the way it works). Since the thickness of the field is actually a bit less than 2.00mm, this offset is enough to prevent plowing, but not so much as we get reduced adhesion. But how do we make such a change? By editing the Gcode in Microsoft Word.

While just about every user of a Windows-based personal computer uses MS Word to create documents, few know that it can also be used as a general, unformatted text editor, just the thing we need to edit the Gcode. Just open the Gcode file (you probably want to enter a "mask" of "*.Gcode" in the filename field, otherwise you won't see the file you want, because MS Word is looking only for files with a ".doc" file type.

Once the file is open, scroll down about 28 lines, until you see a line like

```
G92 E0; Reset Extruder
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Note that there are two of these lines at the beginning of the file, and we want to place our cursor following the second of these, the one after "Draw the second line". Following the word "Extruder", hit the "Enter" key from the keyboard to start a new line, then type "M206 Z-1.98" and save the file. MS Word will challenge us that we might really want to change the file type into a standard Word document, but we want to keep it in clear text, so we click on the "YES" button indicating we really know what we are doing.

```
G92 E0 ; Reset Extruder
G28 ; Home all axes
G1 Z2.0 F3000; Move Z Axis up little
G1 X0.1 Y20 Z0.3 F5000.0 ; Move to start position
G1 X0.1 Y200.0 Z0.3 F1500.0 E15 ; Draw the first line
G1 X0.4 Y200.0 Z0.3 F5000.0 ; Move to side a little
G1 X0.4 Y20 Z0.3 F1500.0 E30 ; Draw the second line
G92 E0 ; Reset Extruder
M206 Z-1.98;
```

But before printing, we need to learn a bit about Build Plate Adhesion alternatives. Getting an object to stick to the build plate of the printer (aka: "the bed") can be problematic, especially if the object does not have a large, flat back surface. So, by

default, Cura places a “skirt” around or a “raft” under most objects, which is generally OK, but not when we want to print directly on top of a pre-existing object, like our Herald “field”, so we need to turn the adhesion technique to “None”. To control this property, click on the “Quality Setting” in the upper right, just below the “Marketplace” button. A list of various setting groups will appear; click on the left arrow in the “Build Plate Adhesion” row. A popup will appear listing various adhesion types, and select “None”, then start the print. The end result will be a beautiful Herald for your railroad.

My first Herald was 140mm wide and 80mm tall, but quickly I wanted something larger, so in TinkerCAD I rotated the logo 45 degrees so that it extended from corner to corner, and then enlarged the X and Y dimensions concurrently to make it as large as my printer could accommodate, which is close to 220mm in each direction. I then printed the field in purple and the trim in gold, as seen at the start of this project. Pretty neat! Alternatively, I could have done the same enlargement directly in Cura. But be careful just how you enlarge the image; I once grabbed a corner handle, held down the shift key to enlarge proportionally, and then moved my mouse to enlarge. What I didn’t notice was that I enlarged the image in all 3 dimensions, including the height. After enlarging, it was taller than the 2mm I intended, and when I set the offset to my recommended “M206 Z-1.98”, the nozzle plowed through the field, rendering the print a complete disaster. So if you enlarge by dragging your mouse in all 3 dimensions, make sure and go back and reduce the height of the field appropriately.

When doing a big oval for the Baden, Vogt & DeSmet, the field prints in about 6.5 hours.

I generally don’t use images from 3DCADBrowser.com, because a subscription is required and is quite expensive. I generally don’t use images from DOWNLOADFREE3D.COM because they required specific download software, and I don’t trust these sights to download executables to my PC.

I do like TurboSquid and Free3D models. They do require me to be registered at their site, and not all their models are free, but they do have some good stuff, and their rates are reasonable.

Models from 3DWAREHOUSE.SKETCHUP.COM are iffy. They supply .SKP files which can be opened in the free SketchUP 2017 software, and then saved as STL files, but often the files are defective and will not print successfully; Buyer Beware.

More to come in the following weeks.

PS: Luke Hatfield is mentioned as a YouTuber who is respected for Ender 3 Pros, but I have yet to review his videos.