A 3D Printed Key for Straight Key Night

Everything old is new again when using a cutting-edge technology to make a tried-and-true tool.

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I have been following the progress of 3D printing technology for the better part of a decade, and after watching printers geared toward the Maker and DIY crowd become more affordable, I was thrilled when my amazing wife bought me one for my birthday. I had been thinking for quite some time about how I could apply 3D printing to Amateur Radio. Between custom antenna insulators, project enclosures, radio mounts, replacement knobs, and a huge variety of other items I could print, a straight key seemed like the most obvious choice for the first item to tackle.

Designing a straight key turned out to be a much more interesting and daunting task than I had first envisioned. In the past, I have written software, constructed trivial circuits following a schematic, and played with a variety of physical computing platforms like the Arduino. But modeling what would ultimately be a physical object was all new territory. Lucky for me, the 3D printing world is full of mature tools and guidelines for accomplishing such a task.

The Coolest New Tool

First, let me describe what a 3D printer is and how it works. My particular printer (XYZPrinting Da Vinci 1.0, $399, Amazon), can print an object roughly 8 × 8 × 8 inches in size. It uses a technique called fused deposition modeling, or FDM, a very simple additive printing process that has been around since the 1980s. A strand of plastic is fed into an extruder that heats up to roughly 212º C. I used ABS plastic, the same plastic that's used for just about every piece of consumer electronics in your household. There are many other kinds of plastics to choose from, ranging from some made from recycled milk containers to plastic composites combined with wood or copper that can be sanded or even buffed to a shine. The plastic is fed through the extruder by a small gear driven by a stepper motor — one of many in the printer. The melted plastic is extruded through a very small hole onto a glass bed that is heated to

90º C. The heated bed prevents the plastic from cooling too quickly and possibly shrinking, ultimately warping and ruining your print. The plastic hardens almost immediately and the first layer of the print is formed. The extruder moves on the X and Y axes, and the heated glass bed moves on the Z axis. As each layer is extruded, the Z axis moves down, anywhere between 100 – 400 microns (in the case of my printer), which you adjust in the software by specifying the resolution of the print. It then proceeds to print additional layers, as shown in Figure 1, until the entire object has been printed. The only prerequisite for a given layer is that it has something to print on top of. Many printers can handle an overhang of roughly 45 degrees. Anything more re-

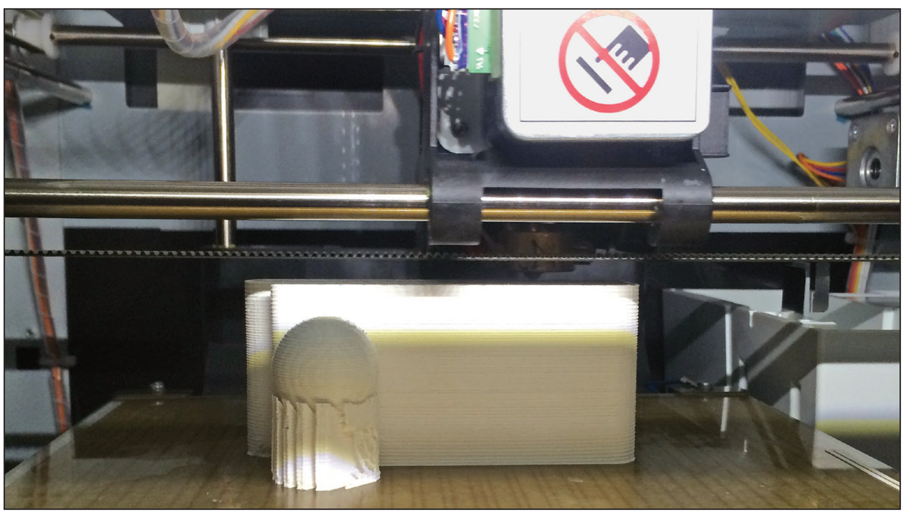

Figure 1 — 3D print in progress.

quires supports, a scaffolding-like structure that is added to the print automatically and can be easily removed afterward.

Preparing a Model

Before you can do any printing, you must obtain a model and process it using the printer software. STL (stereolithography) is the most widely adopted file format for 3D printers. STL files contain the surface geometry for your three-dimensional object. Most 3D CAD applications will export your model straight to an STL file, which can be imported into the printer's software. At this point you can scale the object, orient it, and move it around the print bed to a desired print location (or position multiple objects to be printed at once).

The final step in getting your object to the printer is the export process, also known as "slicing." The software will analyze the 3D object, determine the best path for the extruder print head, and generate a file containing the code that provides the path for the print head to generate your object. You will also decide on additional configuration options at this point (as seen in Figure 2): layer height, support structures (if you need them), what speed the printer should use, and how much fill density you would like your model to have. For less dense models, your printer will print a honeycomb structure to provide strength in enclosed areas, or if you need more strength, you can have it print up to 100% solid. These configurations will vary from print to print based on your needs. After the software has sliced the object, you will get a rough estimate of how long the print will take, how much plastic filament will be used, and what the support structures will look like.

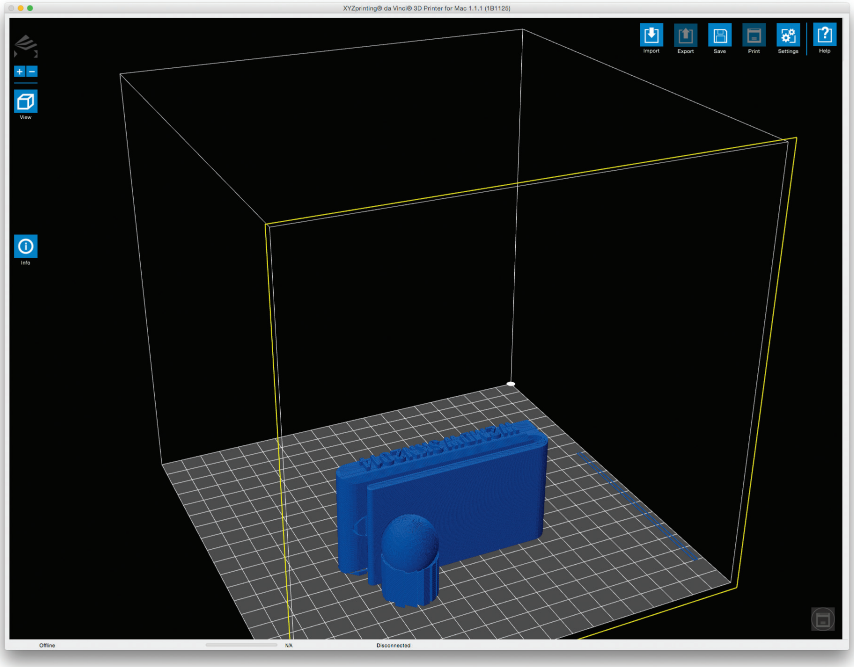

Figure 2 — The sliced model with supports added, ready to be sent to the printer.

At this point the model is ready to go! Plug the printer in via its USB cable, click "print," and the model is sent to the printer, where it begins the printing process. Once it begins, you can disconnect the USB cable — the printer stores the 3D model in its internal memory.

3D models can be obtained through a variety of sources. You can model your own or explore a site like Thingiverse (**www.thingiverse.com/**), a community for sharing 3D models. I was happily surprised to find many Amateur Radio-related items on Thingiverse, including a basic iambic

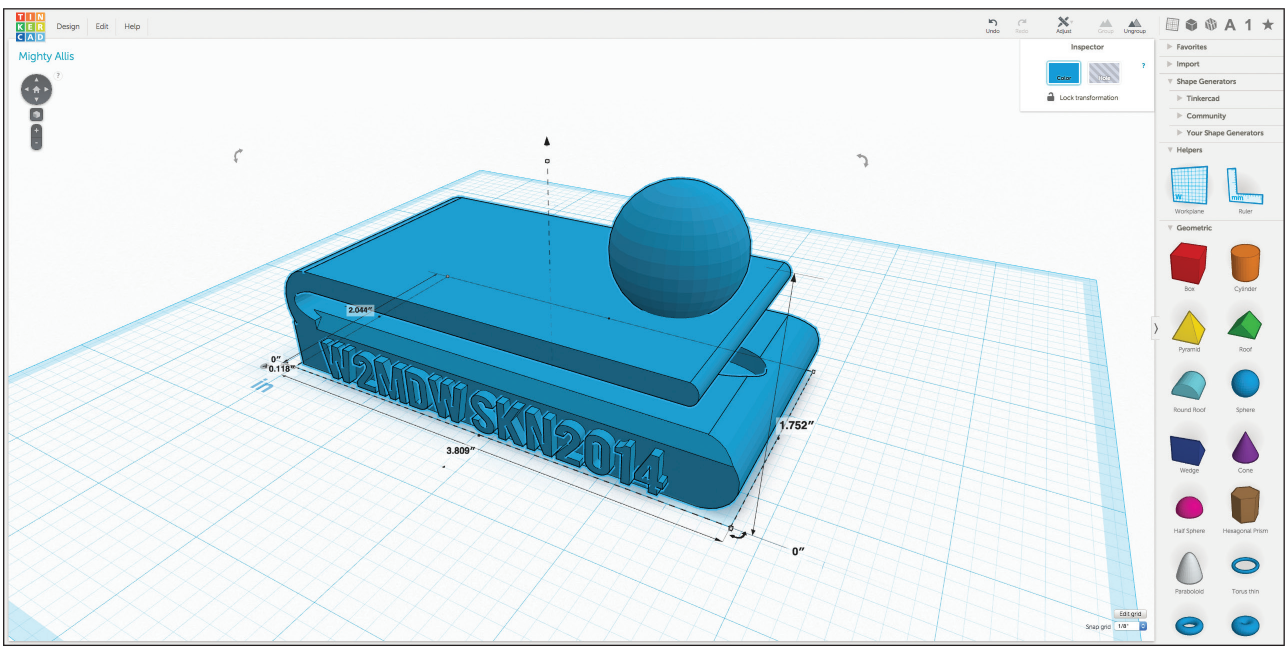

Figure 3 — Preparing the model in Tinkercad.

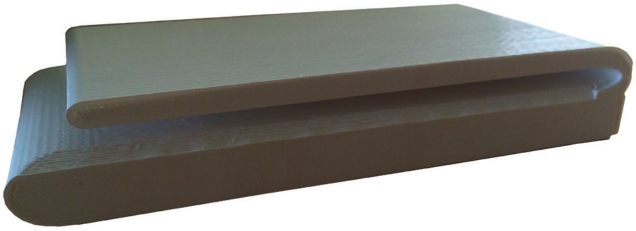

Figure 4 — Prototype print to test how the ABS plastic would spring back.

Figure 6 — The newly printed key, cooled down and fresh off the printer.

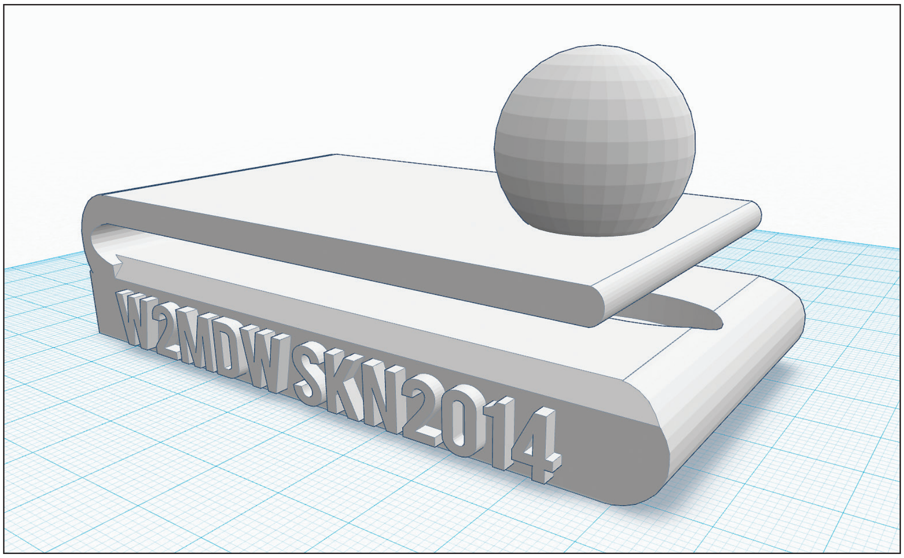

Figure 5 — Final rendering of the model, ready to be exported for printing.

paddle. However, I wanted my key to be something of my own design, and with Straight Key Night right around the corner, I needed to figure out how to model it.

Designing the Key

After a quick search, I found myself exploring Tinkercad (**https://tinkercad.com/**), an in-browser 3D modeling tool that helps you turn an idea into a CAD model for a 3D printer (see Figure 3). After a quick tutorial, I was ready to go. My first test was a simple U-shaped structure. The modeling process is very straightforward, combining basic geometric shapes into the desired shape of your object, while subtracting areas that you either do not need, or that are not part of your design. I started with two rectangles joined by a half-circle to act as my hinge. It was nothing fancy and hardly resembled a straight key, but I needed a test print to determine if the plastic would give me enough spring. An hour later, I was holding the first prototype in my hand, and sure enough, the ABS plastic had enough spring in it (see Figure 4). I could press down on the open end and, upon release, it would spring back to its original shape. Straight Key Night was just 2 days away, so it was time to work on the next prototype.

First, I rounded off the corners a bit on the key's base, which gave it a nice look and feel. I knew I wasn't going to produce something like I would see from Pietro Begali, I2RTF, but I could certainly do better than a bunch of rectangles put together. Next, I needed the hinge that would support the arm. To do this, I dragged a cylinder into my design space and aligned it to the end of the base. I created a second cylinder that had a smaller diameter, and used that to cut a hole in the middle of the first cylinder. Lastly, I cut the first cylinder in half, resulting in a nice rounded curve of a pivot point for my key. To that I attached a thin rectangle to act as the key's arm that would be pressed down on, and to top it off, a sphere to act as a knob, positioned near the front of the key on the arm. I then grouped all of these shapes together, which formed a solid and single shape. I added a few features I thought would be nice, like a hole from the back of the key into the center, which would allow me to easily route wire into the key. I also added a few recessed holes that I could use for placing contact points, or even a spring if needed. To top things off, I added my call sign, followed by "SKN 2014," to the side of the key (see Figure 5). I exported my newly designed key to an STL file and sent it straight to my printer. (The STL files for both prototype keys can be found on the *QST* in Depth web page.[1])

The Finished Object

It took roughly 3 hours to print the key, using less than $2 worth of plastic. When it was finished, I could hold in my hands an object that did not exist hours prior, shown in Figure 6. This was rapid prototyping at its finest, and that is when I truly realized the power and the important role 3D printing will play in the future as the technology matures. How soon will it be before I can call the manufacturer for an appliance in my kitchen, and they send me a 3D file that I can print at home to use in repairs?

Making it Work

The key still needed to be wired up. I planned on using some small nuts in the recessed holes for contacts, but I modeled those holes too small, so I had to raid my junk box for plan B, as Straight Key Night was a day away and I didn't have time to revise the design and print another key. I discovered two flat metal pieces for constructing picture frames, soldered the stripped ends of a mono audio cable to them, and hot glued them in place, one on the top and one on the bottom (see Figure 7). I plugged the key into my radio, made sure VOX was off so I wouldn't key up the rig, gave the key a press, and I had a sidetone! I released the key and heard silence — success! The key was ready for Straight Key Night.

I only had time for a few contacts: KN4ZQ on 80 meters was the first contact with my

[1]**www.arrl.org/qst-in-depth**

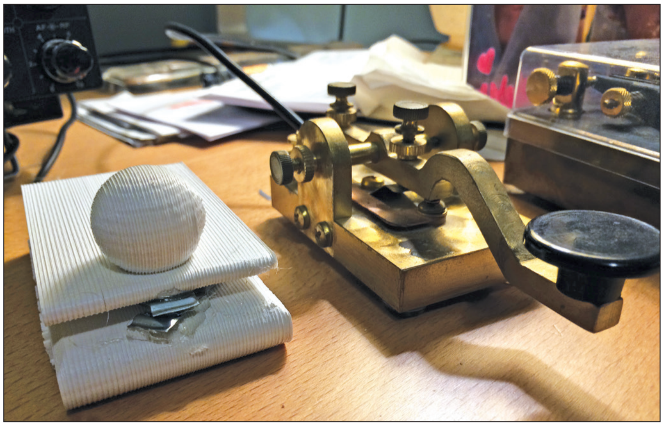

Figure 7 — Size comparison with a Vizkey Camelback. You can see the improvised metal contacts at the front of the key.

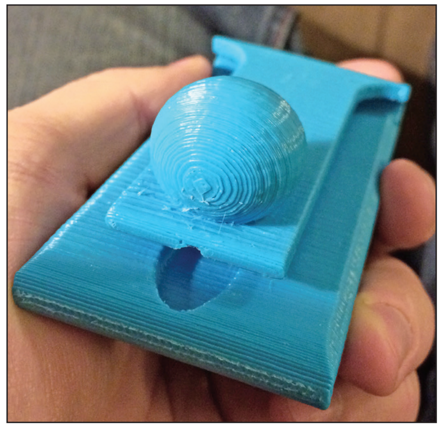

Figure 8 — Revision 2 of the key, leaner and less plastic needed to print.

3D printed key on New Year's Eve, followed by AA5D on New Year's Day on 10 meters. It was quite the thrill to use a key I designed from scratch and to hear it on the air. It was certainly one of my more proud moments in my Amateur Radio career. And I thank the two operators who worked me, who had to deal with my nerves and shaky sending!

With the pressure of Straight Key Night behind me, I was able to iterate on my design. I trimmed down the key's arm so it wasn't as wide as the base, which made the key more lean and also used less plastic (see Figure 8). And as I continue to use and analyze the key, I continue to find areas of improvement that are simply a click away. With the cost of each print ranging from $1 – $2, it is not a very costly endeavor to print and test a new design.

You Can Do It Too

This is just the beginning. Almost everywhere I look, I begin to think of how I could apply 3D printing. As the technology becomes less expensive and more widely adopted, I truly believe we are going to see a very positive and radical change in manufacturing, and I cannot wait to see what else other hams produce with their 3D printers.

Anyone can download and print their version of my key; it can be found on Thingiverse at **www.thingiverse.com/thing:656835**. You can also make changes to the model and make your own customizations. You can see the key in action on YouTube at **https://www.youtube.com/watch?v=vfhFqiTnQdQ**.

Matthew got licensed in 2011 after reading an article about Amateur Radio in *MAKE* Magazine. His fascination with CW began after observing Stan Levandowski, WB2LQF, working DX on an Elecraft K1 before a meeting of the QSY Society, a local radio club. Matt works for a Boston-area startup as a software developer. When he's not printing new tools and equipment for his shack, he's spending time with his wife Lindsey, and his 2-year-old twins, Bennett and Madeline, who both keep him very busy! Engage with Matthew on Twitter, **@W2MDW**, or via e-mail at **w2mdw.arrl.net**.

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