Build a “Tradigital” Lofty Sheldon Shelter

Intro:

tra-dig-i-tal
/traˈdi juh tl/

adjective

1. **Pertaining to fabrication methods that combine traditional and digital tools and workflows**

Shelter 2.0 is an Open Design, Open Source project that focuses on the construction of all sorts of structures for those in need. It is based on the use of digital design tools, digital fabrication tools, and digital file sharing, and promotes both specific designs and techniques for DIY fabrication and assembly

One of the designs we’ve developed is “Sheldon”, an 8’x8’ round-roofed structure. We’ve done much of the work for you so that you don’t need CAD or other digital design tools to build one, but we do share the CAD source files if you want to dig in. But what do you do if you don’t have access to a ShopBot or other CNC tool to fabricate the parts?

We’ve written a bit about one possible solution in a Medium.com post called There’s more than just 0’s and 1’s, but the Reader’s Digest version is that you (or someone with access) would use a digital cutting tool like a ShopBot to create very accurate templates. These templates would then be used on site with traditional analog hand power tools to create the final parts for the building. Tools that are easily available like routers, jigsaws, and circular saws. We call this process Digitally Augmented Construction or “Tradigital”

When does it work well?

- When there’s a limited number of unique parts in a design, but several copies of each are needed. This minimizes the number of templates needed

- When the parts require mostly 2d outline cutting, although some 2.5d features like pockets are certainly possible.

- When there is an excess of available labor. The process can branch and grow as extra labor becomes available, but it needs people to work. Fortunately the skills needed are easily taught and, when learned, can be used on traditional jobsites.

- When security and electrical infrastructure are problematic. All the tools needed for Tradigital construction can be powered by a small generator or even a solar panel array, and can be locked in a secure location onsite or taken off-site at the end of the day.

- When the design was initially created to be somewhat “material agnostic”, allowing the use of a wide range of similar materials.

When wouldn’t you use it?

- It’s loud and dusty. Hearing, eye, and dust protection are important and certainly help, but it’s still loud and dusty!

- When you need high precision or can’t have a couple of screw holes on your parts. If you’re making artificial heart valves, this technique is definitely not for you!

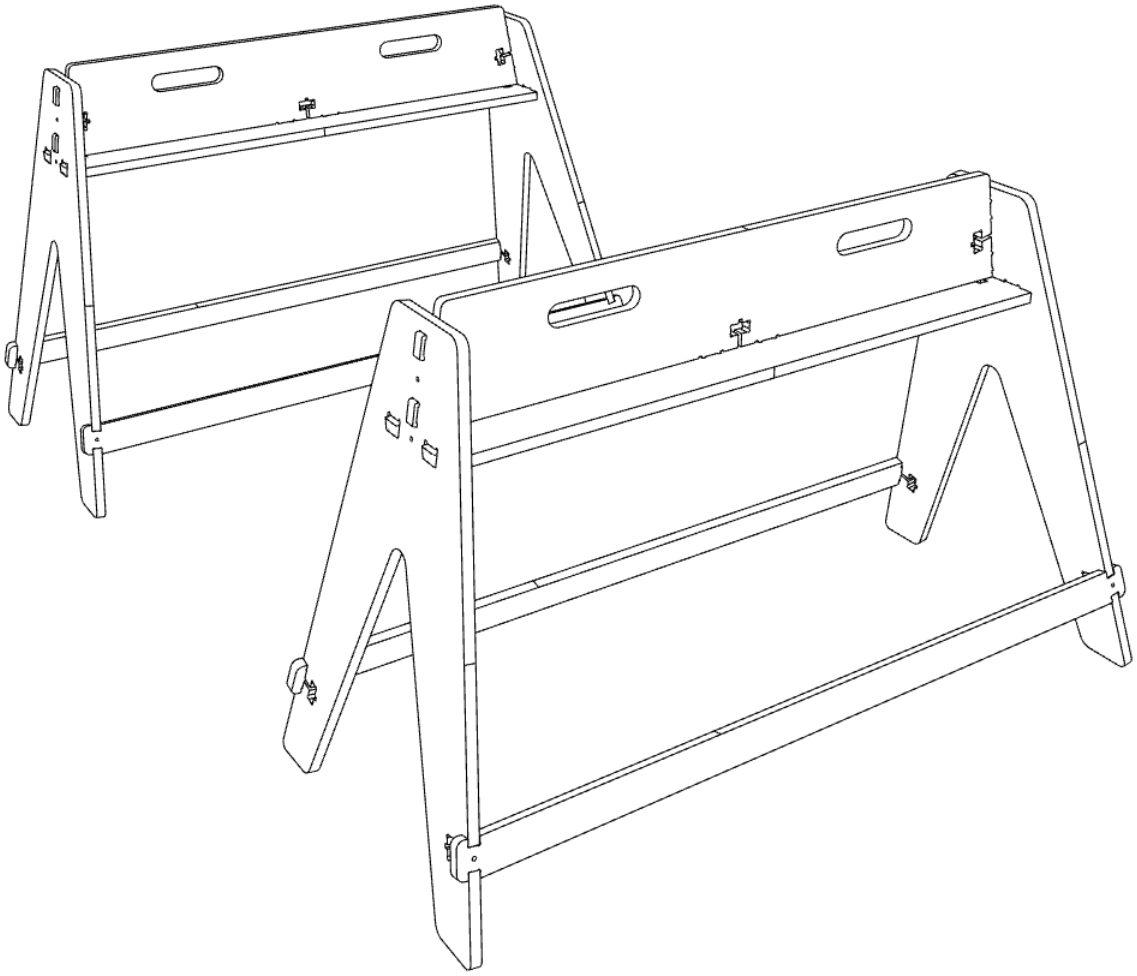
- If you already have a ShopBot or other cnc machine that you can use. That’s the easiest, fastest, and most accurate way to build a Sheldon Shelter, or just about anything really!

Setting up your workspace:

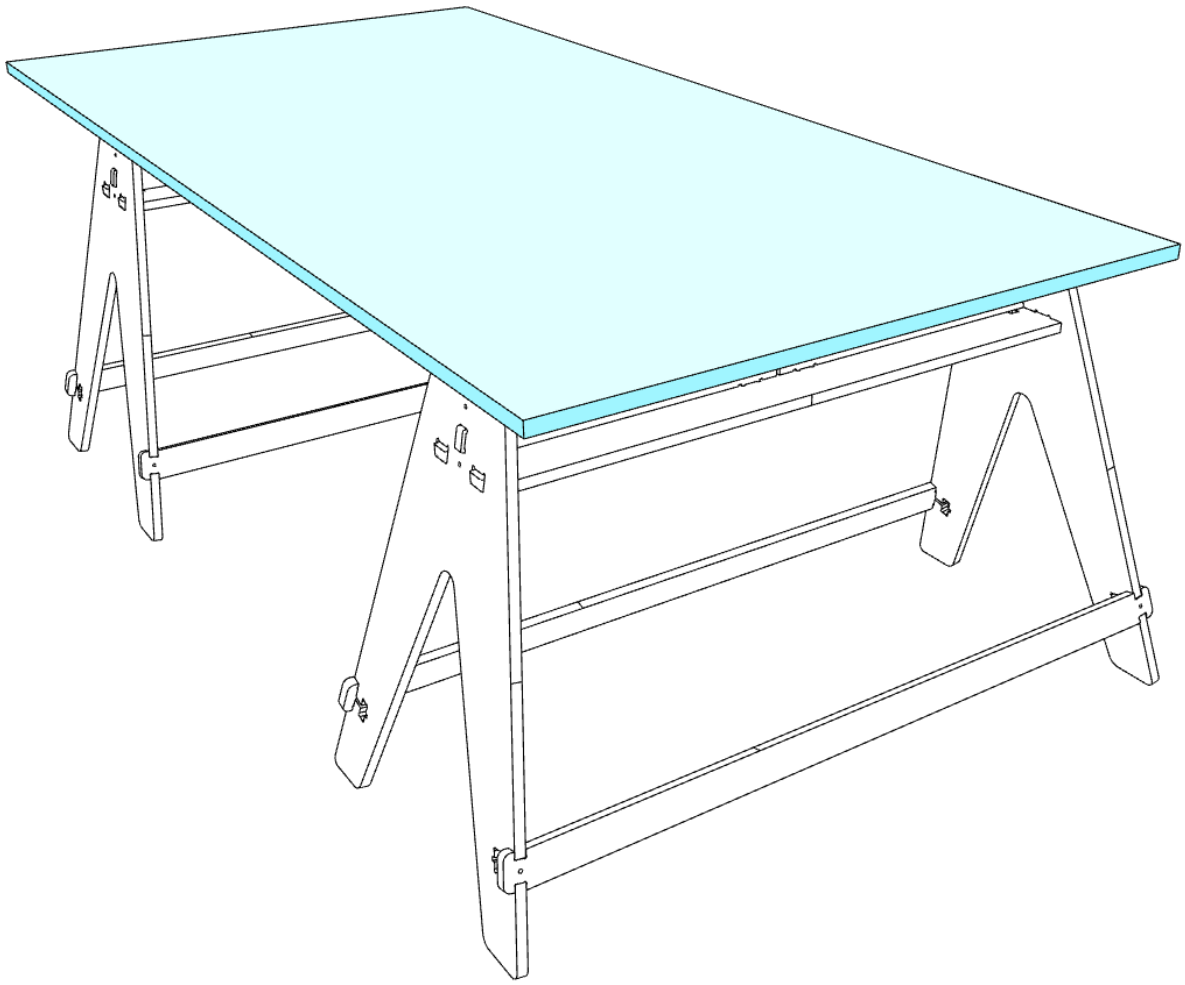
We’ll begin by assuming that you already have a set of Sheldon tradigital templates and are planning on heading to the build site. What tools and materials can’t you live without, and what ones are nice but not necessary?

A pair of sawhorses help get the work up to a good height for working, saving a lot of strain on your back.

There are a lot of designs for sawhorses available online, but if you want to get some practice with Tradigital techniques we’ve made the files for the ones that we use that are cut from ¾” plywood. If you’re clever with how you lay out your pieces you can get 3 sawhorses out of 2 sheets of plywood

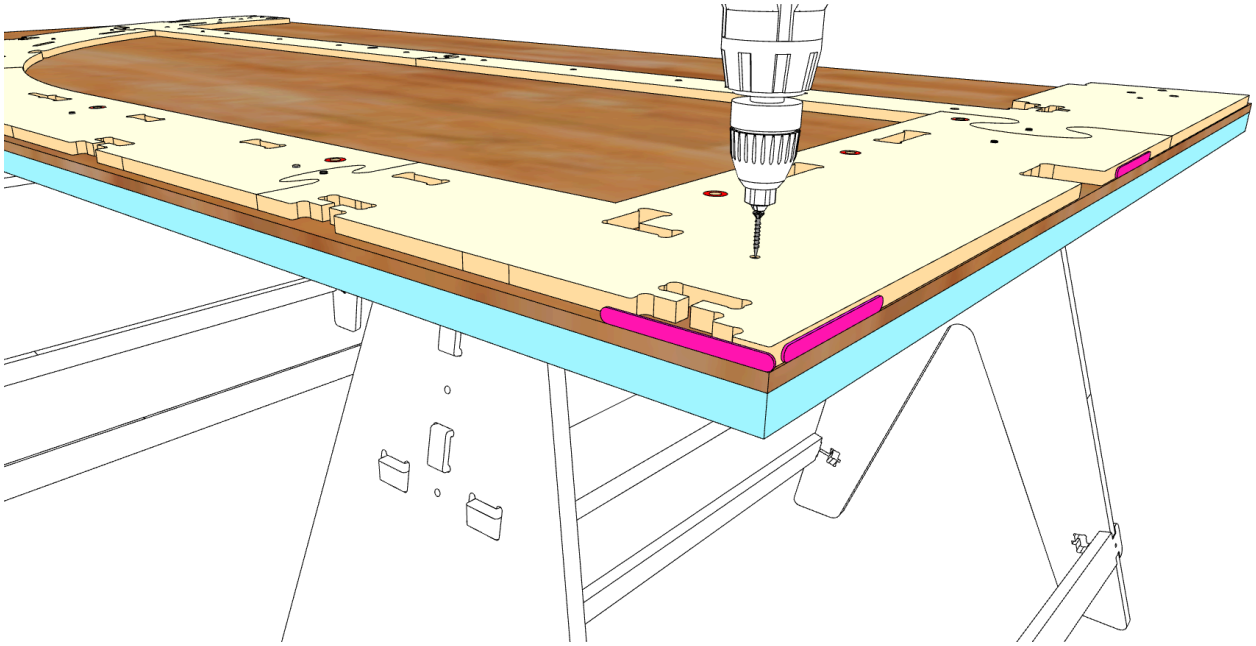


Since you'll be cutting all the way through your material, it helps a lot to have a sheet of some sacrificial material to keep from cutting into your sawhorses or table surface and to help support the parts as they are cut out. A sheet of rigid foam insulation is what we prefer, but just about any 4x8 sheet will do. The softer and cheaper, the better!



On top of this foam “spoilboard” you’ll place the material you’ll be cutting your Sheldon out of..the sheets of coroplast, ½” plywood, and ¾” Advantech or plywood

Before you start cutting you'll need to screw the templates down to the material you'll be cutting. You could certainly do it with a hand screwdriver, but a cordless drill or driver would make the job much easier. You'll also need a couple dozen drywall screws that are long enough to screw the templates to your material. 1 ¼"" screws are available just about everywhere and are a good length. but you can go longer if that's what you have on hand..



Routers:

To cut out the parts you'll need a router, and preferably one with a plunge base. We suppose you could use one with a traditional fixed base and adjust for depth each time you want to cut, but a plunge router will make your life a lot easier and plunge bases are available as accessories for just about any router.

We use a DeWALT DW618 (above) for all the cutting with the ¼” bit, and a DeWALT DWP611 (below) trim router for drilling with the ⅛” bit, but if necessary the Dewalt 611 can work for everything by using multiple shallow passes. The brand and size of tools is up to you, but as with all tools in most cases more power is better.

Using templates:

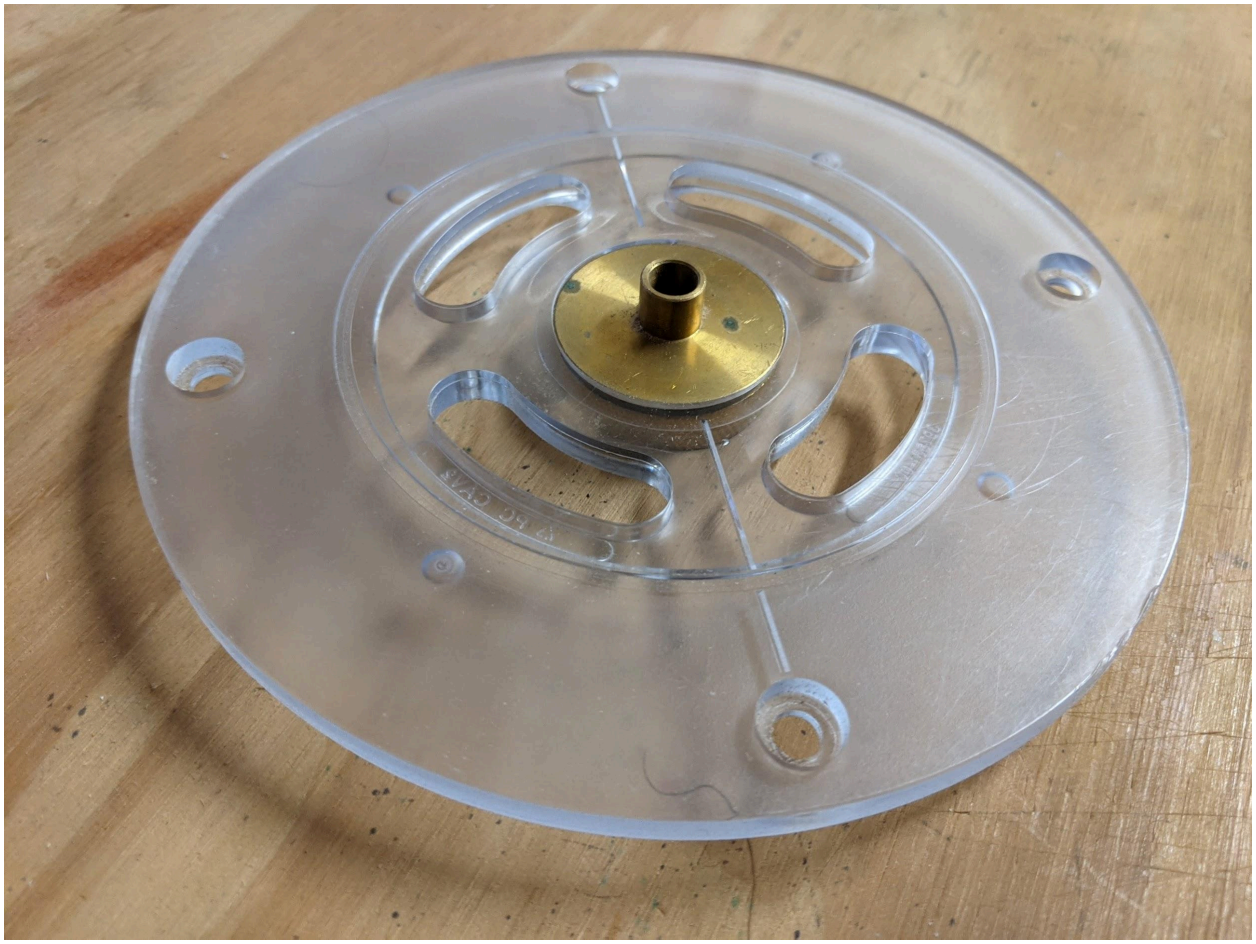
To accurately copy any template with a router you'll need a way to "trace" the templates to create accurate copies. There are two common ways to do that with a router..using a piloted bit or template collars.

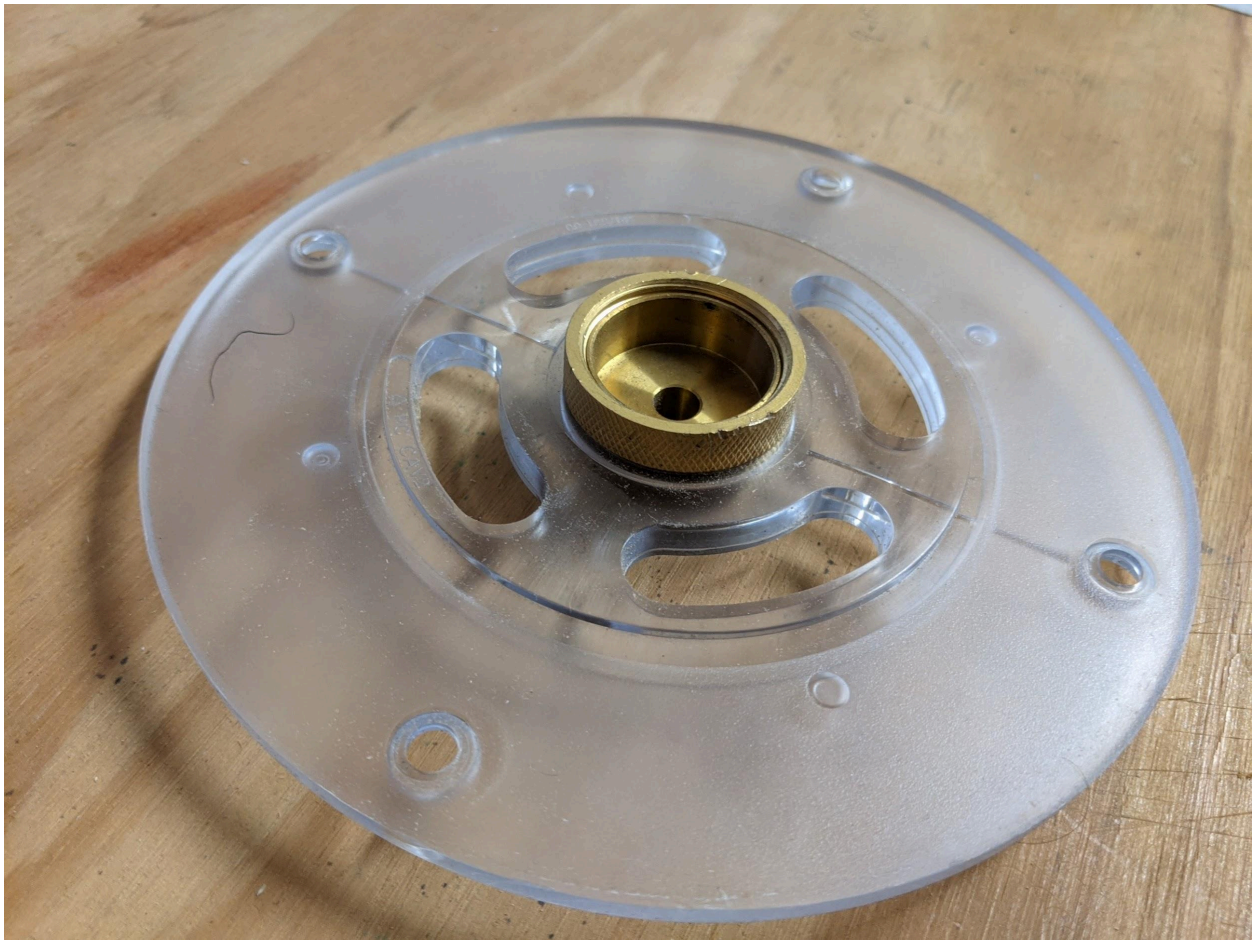
Piloted bits use a ball bearing or smoothed machined section to act as a template follower. They are available with the bearing above the cutting surface or below, and in many cases are a great option. For our application though they have a couple of downsides. The bottom bearing version doesn't plunge at all, and the top bearing version requires constant template contact as the cutting depth changes so are much fussier to work with. They are also only available in larger diameters. For these reasons the Lofty Sheldon templates use a "Template Collar" and standard bits, rather than piloted bits

Working with template collars:

A template collar is a two-part insert that attaches to the baseplate of your router and keeps the cut a consistent distance from the templates. You'll be using ¼" bits to do the cutout steps, and the outside diameter of the collar is ⅜" which leaves a 1/16" offset all the way around. To compensate for that offset the Lofty Sheldon templates have already been cut smaller by 1/16" to compensate for that offset. When drilling the pilot holes with the ⅛" bit, the template collar helps to keeps the bit centered in the hole.

There are several styles of template collars, but if you use the kind we prefer, the part of the template with the collar is inserted into a recess in the router base-plate and the ring is screwed onto it.





It’s critical to get the ring REALLY tight so that it doesn’t vibrate loose. A big pair of pliers on the rings will usually get it tight enough, but a dot of temporary thread locker like blue Locktite will make it secure but permanent. If you use thread locker you may have to replace the router’s baseplate if you need to replace the collar, but it’s a ***REAL*** hassle if the collar comes loose while you’re cutting!

Once the collar is securely in the baseplate you need to make sure that the bit is centered in the collar. The mounting screws that attach the base plate to the router have a little “slop” built in to allow for adjustment and you can get pretty close by installing a ¼” bit or round rod and just eyeballing it, but of course they make a special cone-shaped gizmo for just that job. Nice but not necessary!

Safety

Working with power tools is a noisy, dusty job and if you are careless there are multiple ways you can get hurt. Using protective equipment like safety glasses, dust masks, and hearing protection is essential, but just as important is always being aware of what you and those around you are doing. In reality the most dangerous thing you'll do all day is driving to the job site, but always keep safety in the back of your mind. If something SEEMS dangerous, it probably is!

The router will make a high-pitched sound when cutting so invest in good hearing protector. The foam rubber plugs are cheap and probably OK for people working in the general area, but the headphone-style ones work much better if you're the person cutting. They are available at all the big-box store like Home Depot or Lowes, and also from Amazon starting around $10

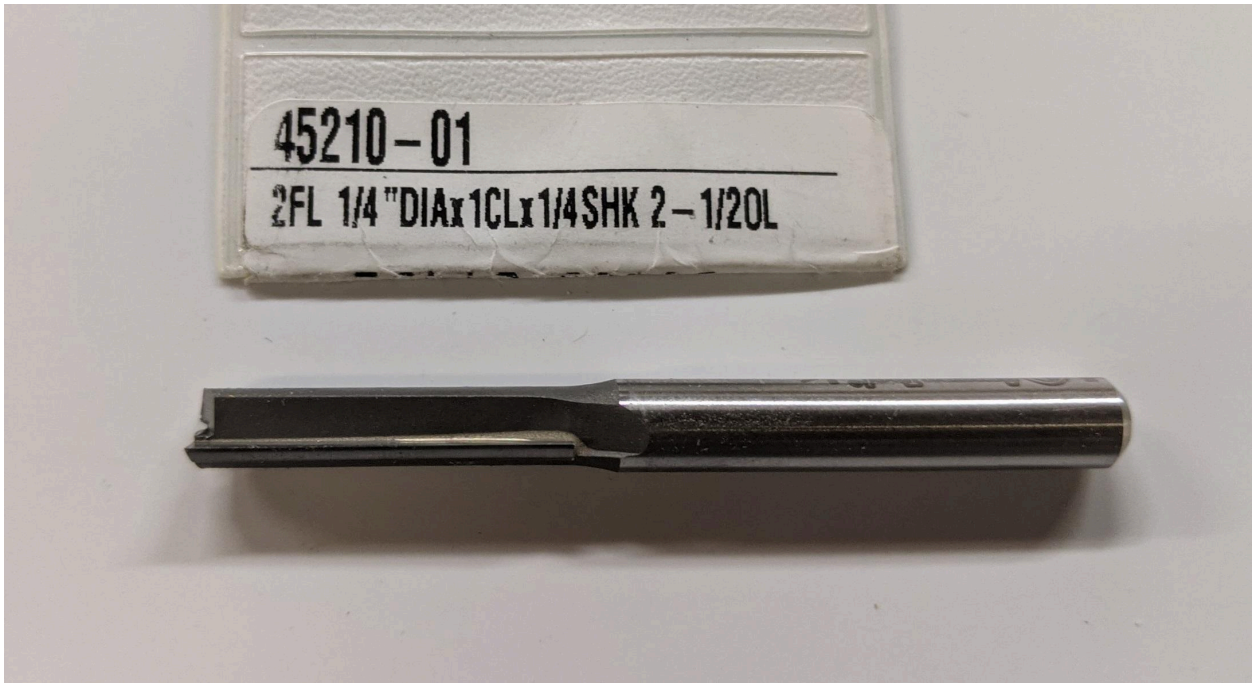
You won't be generating very fine dust like you would if you were sanding so dust masks should work fine, but again it's your health so better is..well..better. I prefer the ones with two bands

rather than one..they are a little more expensive but seal to your face better. And if you write your name on yours when you start, it might last the whole job!

Bits

There are lots of different types of router bits to choose from for cutting out your parts. An upspiral bit cuts a little cleaner and helps to remove the chips, but make sure that you get the collet that holds it in the router REALLY tight...the screw-like spiral tends to want to pull it down and out of the collet.

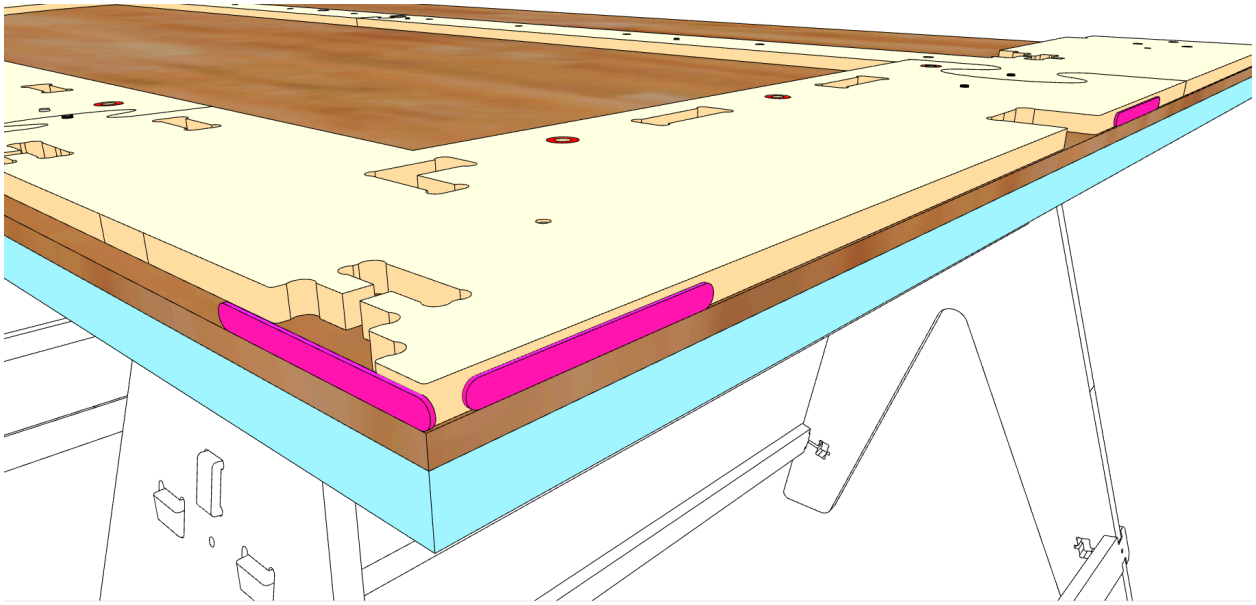
Solid carbide bits stay sharp for a bit longer, but carbide is somewhat brittle and can break more easily than steel bits with carbide inserts. We've been using Amana Tool - 45210-01 bits and have been happy with the way they cut and hold up.



You'll also need ⅛" bits to drill the pilot holes for screws. A plunge router works great for this and we usually use our second smaller plunge router with this ⅛" bit to drill these holes. This avoids the problems that come from drilling through a pilot hole in a template with a drill bit...the pilot hole slowly gets bigger every time you drill. Since there's no side load..you'll be drilling instead of cutting...these Yonico 31413-SC bits work well with enough cut length to drill through the ¾" material

Working with Tradigital Templates:

It’s important to place the template on the material to allow for the 1/16” offset created by the diameter of the collar. You could measure that with a ruler or a scrap of thin material, but a popsicle stick is a tiny bit bigger than 1/16” and works really well: We’ve included some in the template kit that have been dyed red to make them easy to find, but if you need more just buy your crew some popsicles!



For some features like pockets and large holes where the sawdust can't easily be ejected by the bit, the sawdust will tend to pack in the corners and block the template collarand you'll need to stop occasionally to remove any dust that's accumulated. A ShopVac works great but you can also use an air compressor to blow the chips out. If you don't have either of these you can clean it out with your finger (after stopping and removing the router of course!).

If you've got access to a table saw some tasks are a bit easier. For example if you can cut seven 3" wide strips off of a sheet of your ½" material and then center the Purlins templates in these rough-cut blanks, so that you will mostly be just cutting the the only semi-critical parts...the notches where they inset into the ribs and endwalls. Pre-cutting into strips like this is certainly not necessary, but if you have a saw and the skills it makes life easier by eliminating some of the dust and noise. The same with the splice plates that join the inside and outside wall panels to their extensions...since they don't have any important machined features, they can be cut to width and length using table or circular hand saws if you prefer.

Lofty Sheldon Materials:

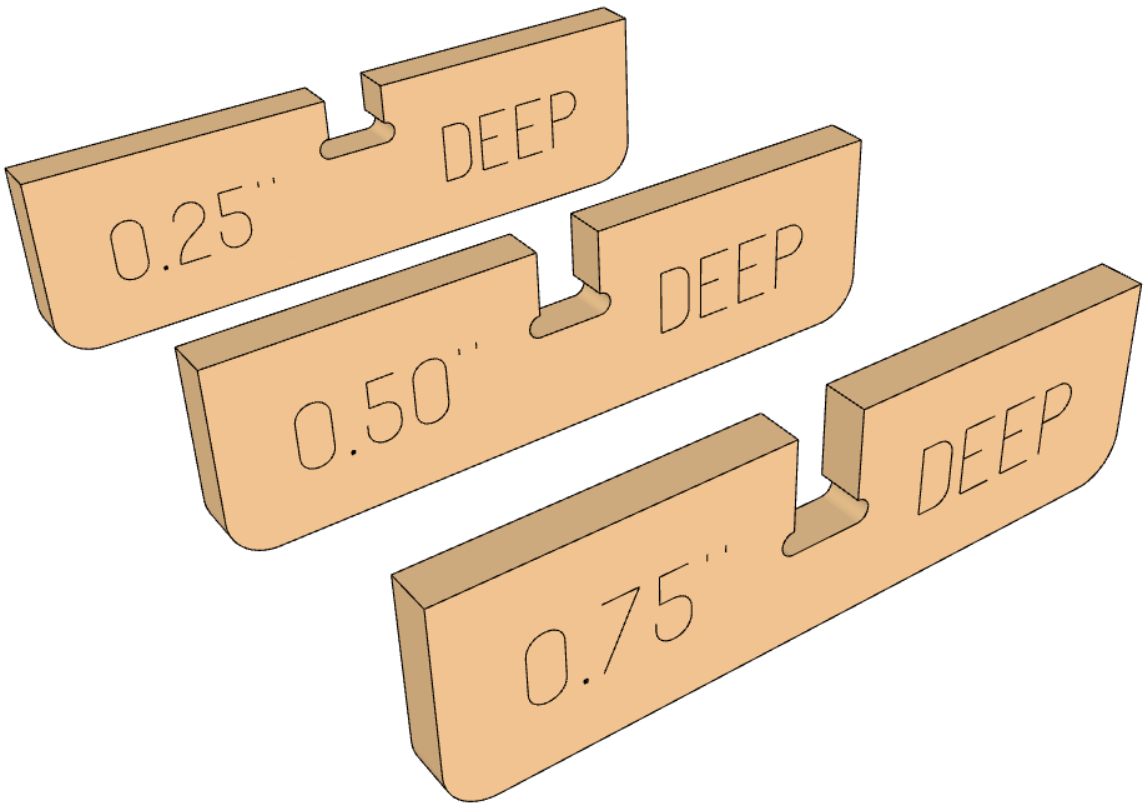
You'll need the material you'll be building your "Lofty Sheldon" from. If you're REALLY efficient you'll need 15 sheets of ½", 3 sheets of ¾" and 3 sheets of 3/16" coroplast or other flexible ceiling material.That's the amount of sheets we use when we're production cutting them, but it will be a bit of a puzzle to get all the parts to fit. My guess is that it will take another sheet or so. The good news is that you might be able to use recycled materials for some of the smaller parts like the rib sections, and even full sheets that have been used to protect windows and are no longer needed.

We use a plywood called Selex for the ½” parts of Shelters we cut, and a sub-flooring material called Advantech for the ¾” floors and sleepers, but you can use whatever is available and makes sense to you. In a lot of ways you have more options because you can use sheets that are “Potato chips”...too warped to efficiently cut with a CNC machine but fine for this

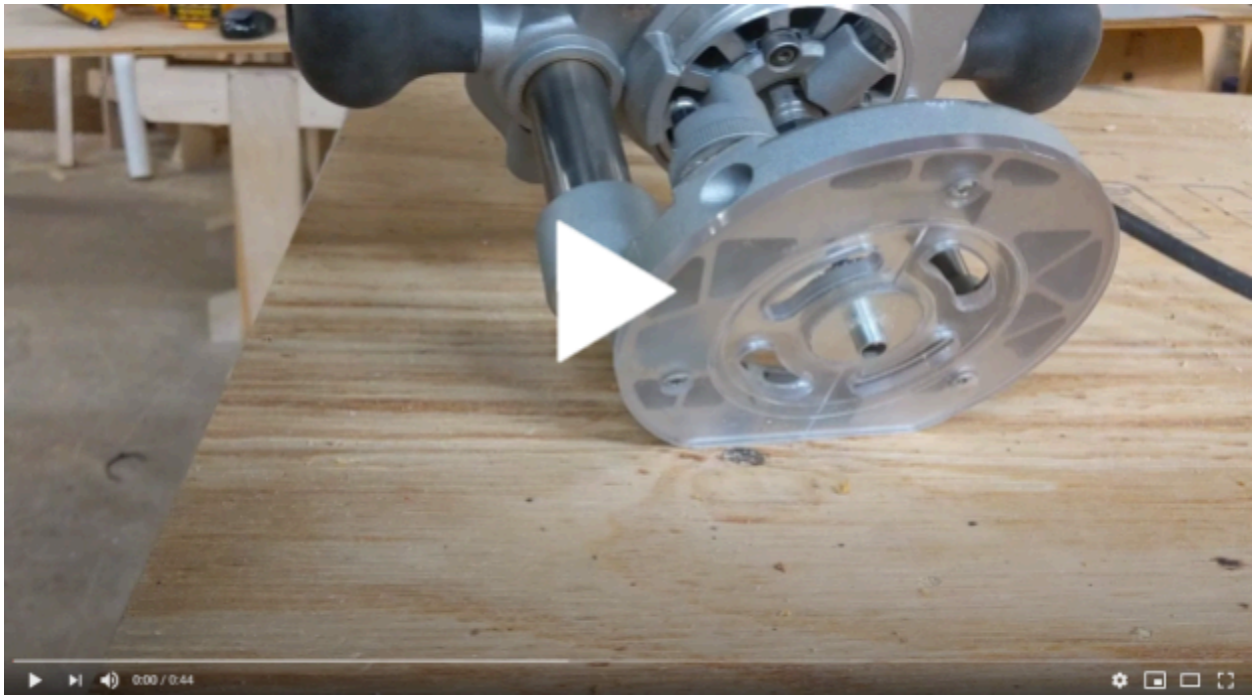
Setting the router depth stops:

When we cut Shelters in our shop with our ShopBot we cut pretty aggressively with a ¼” bt. We cut the ½” ply in one full pass and the ¾” in 2 passes. You probably could do the same but it would be a battle and you would probably break a lot of bits..you just can’t hold a router with your hands as rigidly as a CNC machine can.

We recommend that you cut everything in ¼” deep passes...two passes for ½” thick material and three passes for the ¾” floors and sleepers. We’ve included some depth jigs that you can use to easily set the router depth

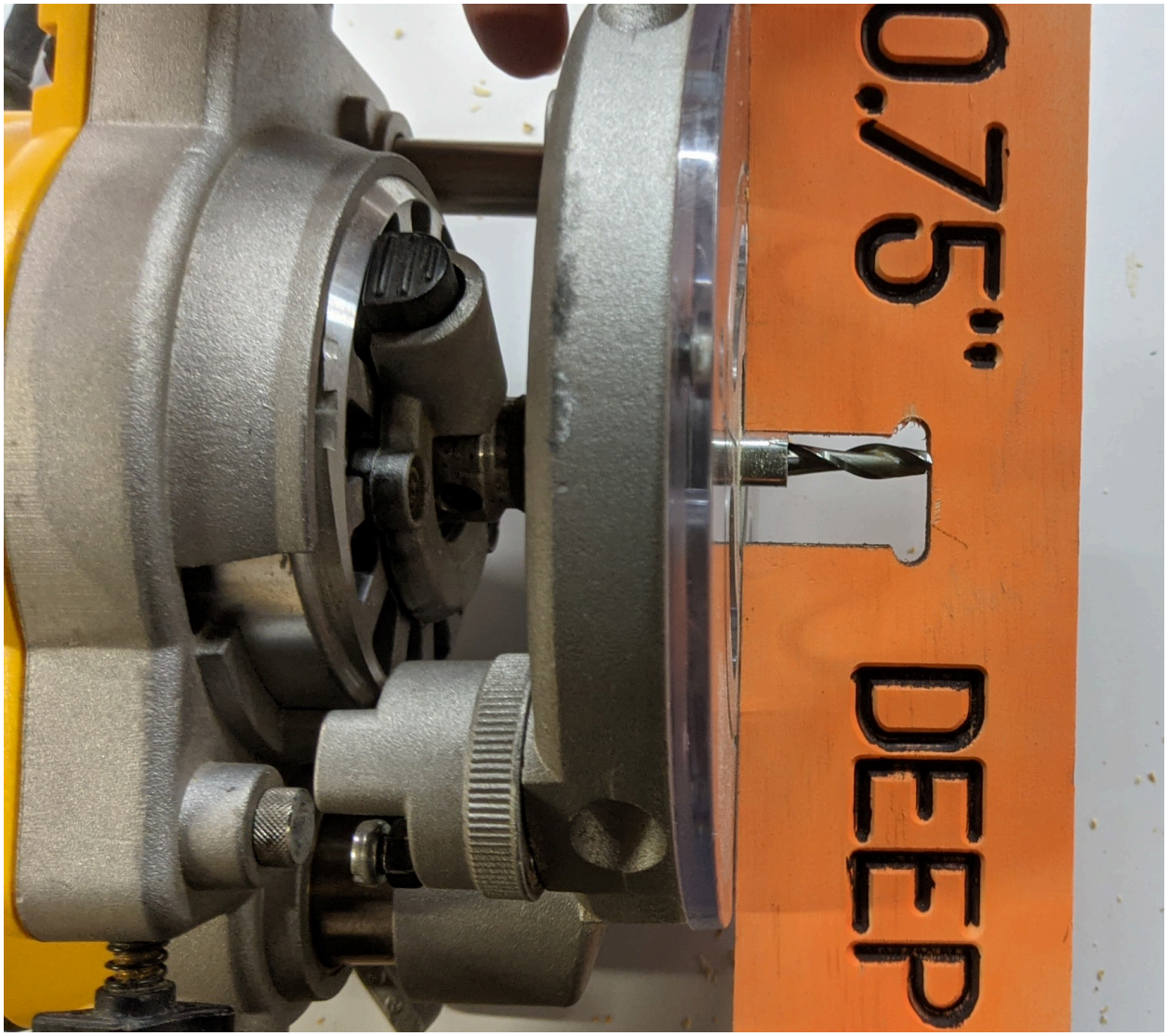


The next step is kind of fiddly, but isn't hard and needs to be done.



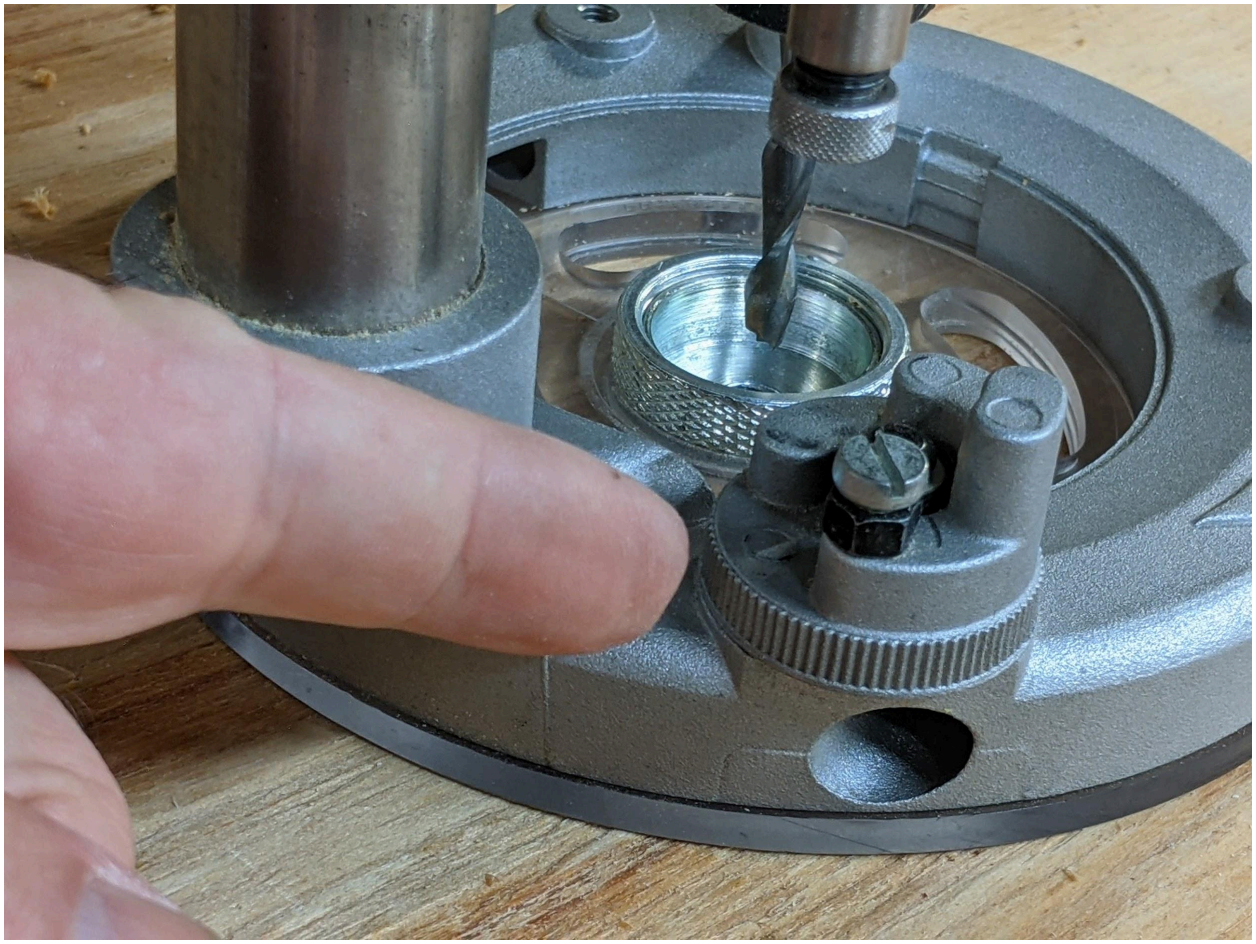
Here's the Readers Digest version of the steps.

Using the 0.75" template, plunge the router until the bit touches the template. We use the 0.75" template to set the depth stops because tt's better to have it go a little too far than not far enough and ¾" is the deepest you'll need to cut.

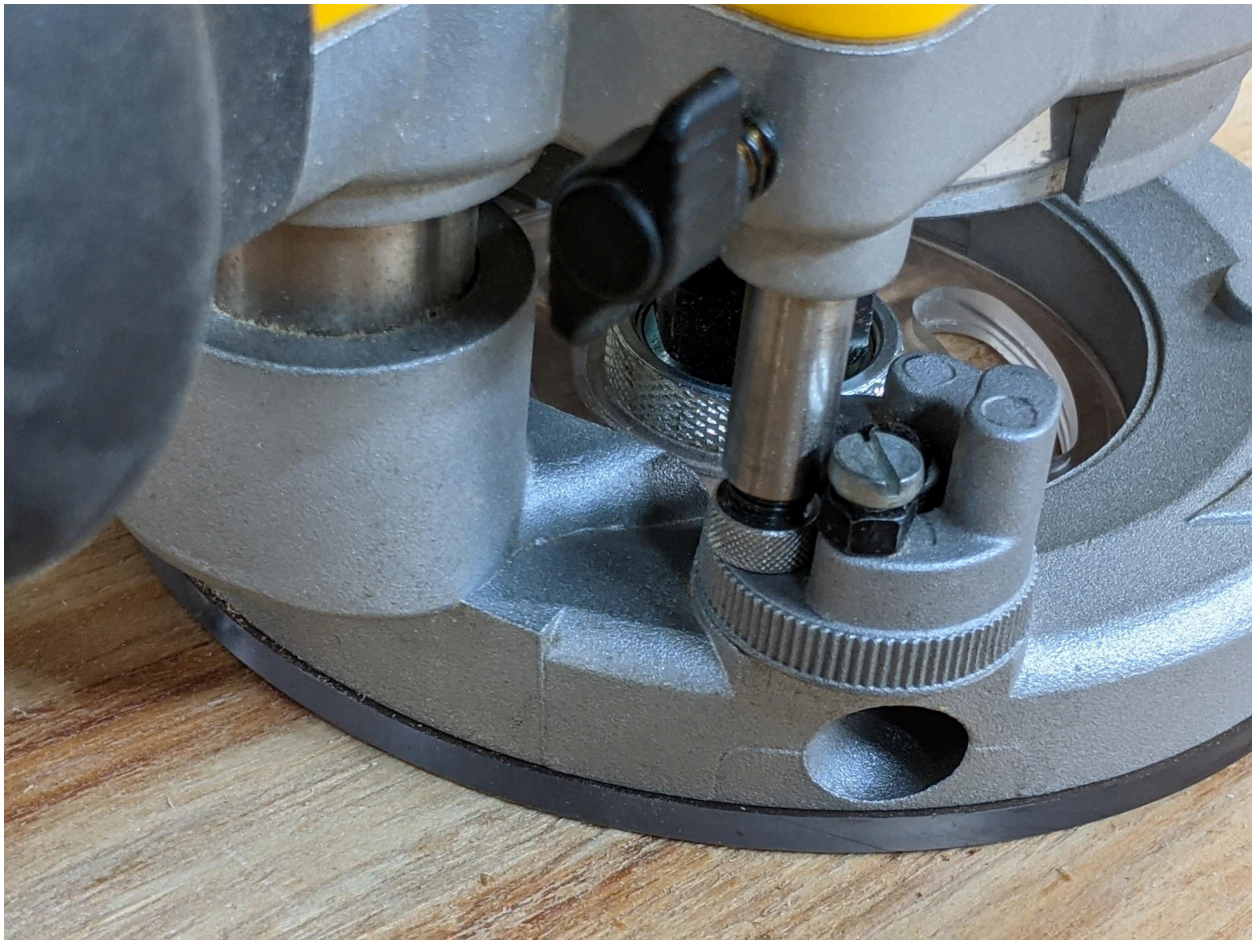


Lock the router at that depth using its looking lever and double-check the depth with the template. If it’s not right keep messing with it until it is!

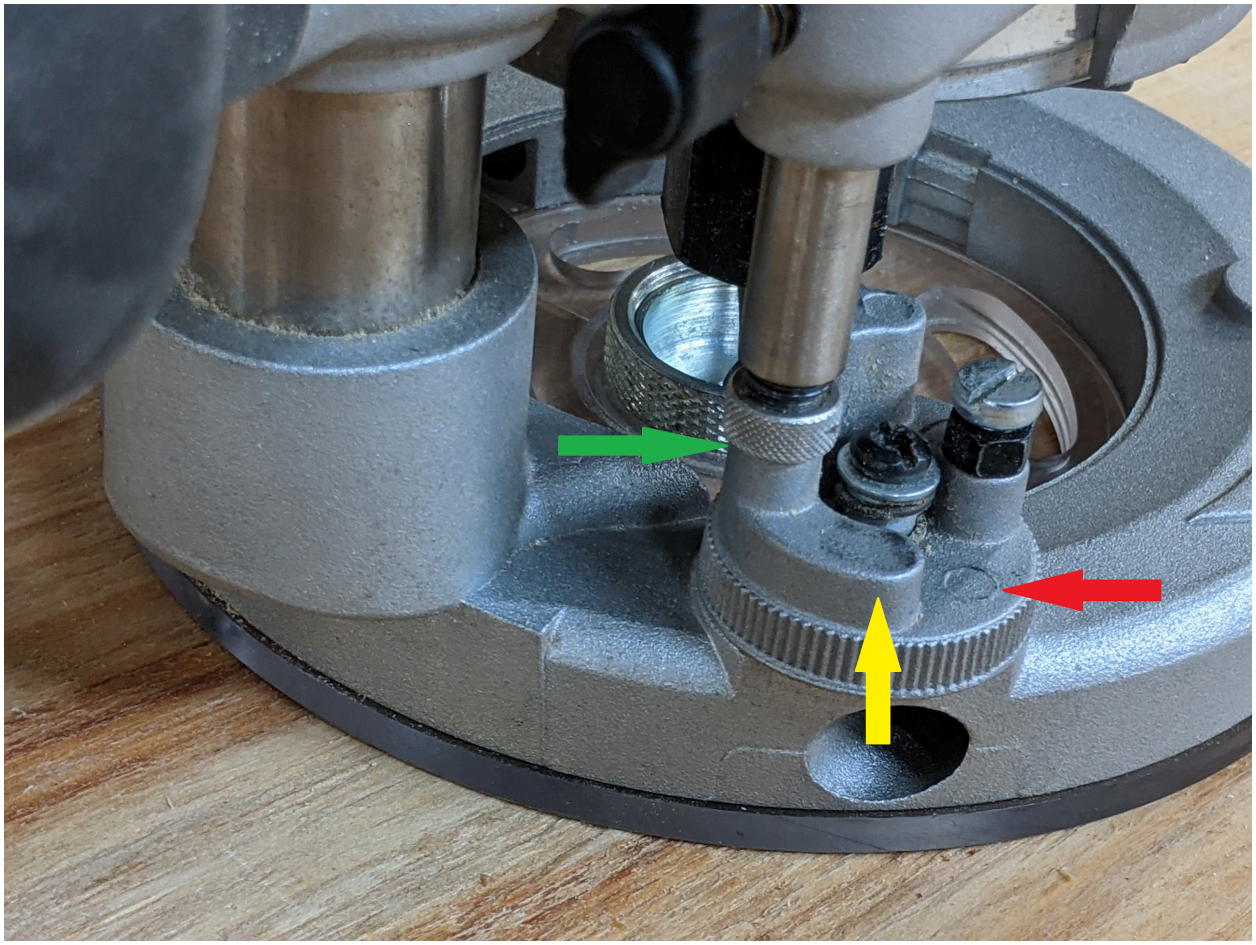
With the router still locked at that depth, rotate the stepped depth stop until the shortest step is directly below the adjusting rod



Loosen the locking nut on the adjusting rod and extend it until the end of the rod is firmly on the depth stop. Tighten the locking nut so that it’s good and tight...you don’t want anything to slip!



You’re done with the setup so you can now release the locking lever so that the bit retracts. With the Depth stop set that way, the bit will cut ¾” deep (Red setting below) when it is plunged until the adjusting rod hits the stop. If you rotate the stop to the next tallest position the bit will cut ½” deep (Yellow setting) and at the next tallest it will cut ¼” deep (Green setting).



If you’re a bit of a gadget nerd and like digital dohickeys, there’s a really neat digital depth gauge that we use in the shop and like a lot, the Wixey depth gauge. Not only is it good for setting the depth of router bits, but is also superb for table saw blades. They are available at woodworking stores and from Amazon for less than $30

Download Files:

The files to cut a set of Tradigital Sheldon templates can be downloaded from DropBox at: https://www.dropbox.com/s/zun8csbhe23b611/Traditional%20Sheldon%20templates.zip They are in the VCarve Pro v10.122 format, the most up to date version when they were created. Making them available as dxf and earlier VCarve formats is in the works, but may take a little while.

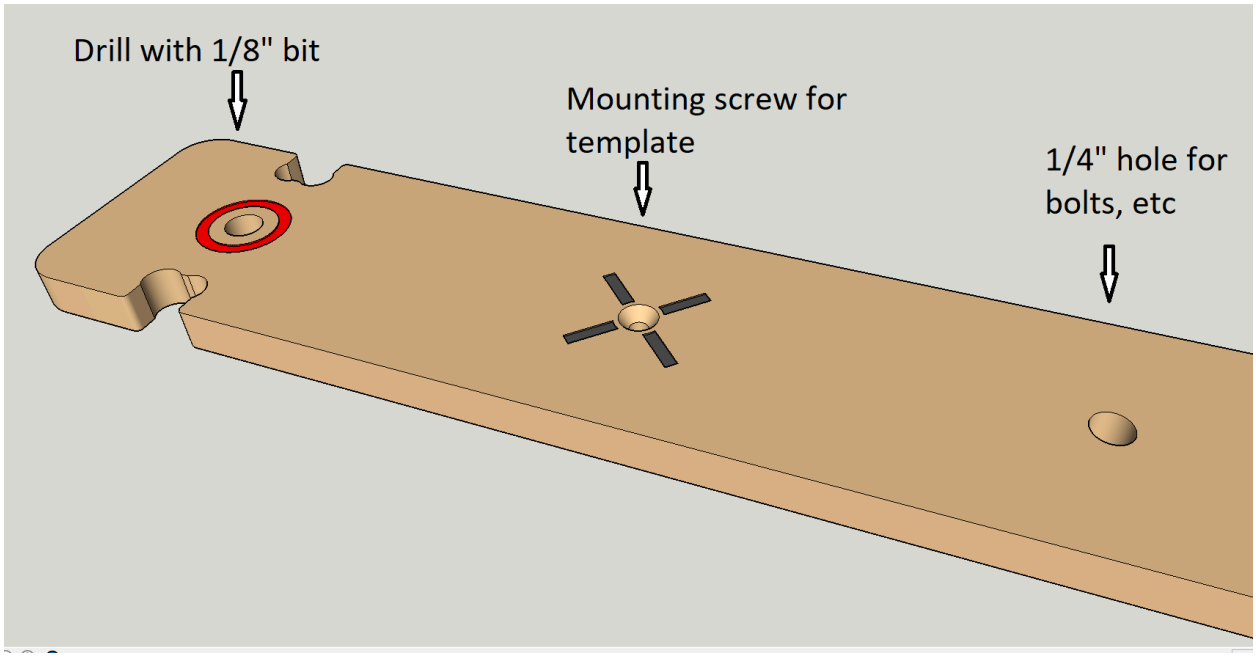
The only thing not included are templates for the PVC roof panels. Our thinking is that if you're using this system you'll probably want to use a commodity roofing material like a tarp or corrugated metal, but are certainly open to suggestions if you disagree.

The files are sorted by the material that they will eventually be used to fabricate, but to cut out a set of templates we suggest cutting them from ½" plywood or similar material.

We've painted colored dots on the templates to indicate what material they should be used to cut out. We've arbitrarily painted the ones we use the following colors, but only because those are the color paints that we had on hand. You can just as easily use paint dots or marks from colored sharpies to differentiate them. Whatever you decide just make sure it's obvious to anyone that might be using them, so that material isn't wasted

- Red/Pink for ½"
- Green for ¾"
- Orange for 3/16" ceiling material

Template markings:



The rule of thumb is that if a hole has a ***red circle*** around it to drill with the ⅛" bit..it's a pilot hole for a screw. If it has a ***black X*** across it it's for holddown screws to attach the templates to the material. Feel free to reposition the holddown screws to anywhere that makes sense to you,

but just be sure that you countersink the head of the screw below the template's surface if it is within 3" of a cut edge. You don't want the router base to hit the screw's head.
If it's just a ***circle with no markings***, drill it with the same ¼" setup that you're cutting the parts out with.

Types of parts and quantities:

Each template has the type of part that it is used for written on the template. Here are the quantities you'll need of each, with notes to describe special cases:

Type of part	**Quantity**
½" plywood	
Rib bottom...joint	3
Rib upright...stud	6
Rib top...rafter	3
Outside wall	2
Outside wall extension	2
Inside wall	2
Inside wall extension	2
Purlins	7
Wall splice plates (***see note #1***)	24
Loft platform	1
Wall zipper (inside) (***see note #1***)	1
Wall zipper (outside)	2
Endwall top	2
Solid back endwall (***see note #2***)	2
Endwall top splice	2
Front endwall with door opening (***see note #2***)	2
Loft beam	1

Rib bolted splices	12
Endwall fillers	4

¾” Advantech or plywood

Edge floor panel	2
Center floor panel	1
Floor splice	2
Sleeper (***see note #3***	6

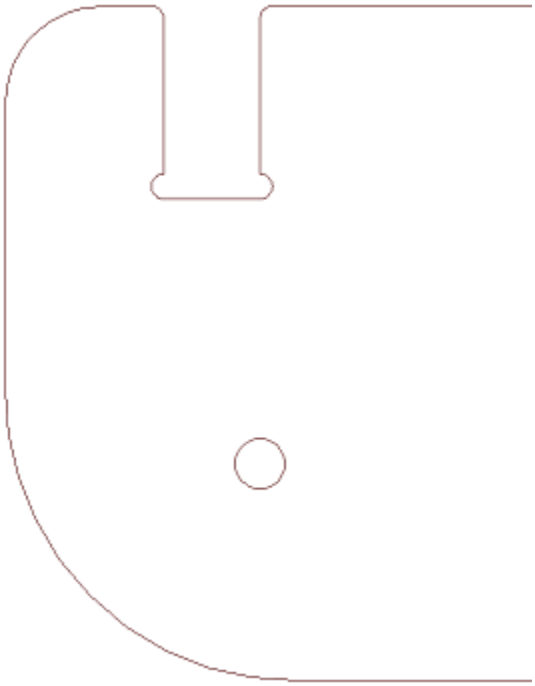
3/16” ceiling material (Coroplast)

Ceiling panel (***see note #4***)	3
Ceiling splice plates	8

Note #1 - For some inexplicable reason we call vertical strips that help hold panels together “zippers” but call horizontal ones “splice plates”? It’s a part of our quirky charm I guess, but they serve the same purpose

Note #2 - Almost all plywood has a good side and a bad side, and for most of the parts you’ll cut we suggest you have the good side facing up..it’s easier to see what you’re doing if there aren’t knots or other defects to distract you. The endwall panels however are mirrored from left to right, so we suggest cutting one of each pair of panels with the good side up, and the second with the good side down. It certainly won’t fall down if you don’t, but the endwalls will look better if you do.

Note #3 - The sleepers have a ½” hole near each end that can be used with a rope sling to drag the Shelter around a bit. They should be cut just like any cutout...plunge the bit and then follow around the inside of the hole.



Note #4 - You'll need 3 of the ceiling panels, but only 2 of them will have a rectangular hole cut in them. This hole is for the loft beam to pass through the ceiling and be bolted to the ribs.

Layout and material optimizing:

You can lay out the parts any way that works for you and the material you have on hand. The small parts especially can be cut from odd corners of sheets, and even scrap pieces from other projects.

Our cnc layouts are pretty optimized and can be used as guides to help with layout. You can get them at bit.ly/Lofty_Sheldon_template_layouts

Cutting Hatchets:

The keystone-shaped hatchets are the one part you can't sensibly cut "tradigitally" with templates, and unfortunately you'll need a lot of them...250+. Luckily there are a couple of options for fabricating them: cutting with a CNC machine or using a tablesaw or chopsaw:

If you have access to a smaller CNC machine like a ShopBot Desktop or Max that will cut a bucket full of them for you, life will be good. It won't take them too long, they'll get the warm fuzzy feeling that comes from helping others, and we've even supplied the files to make it easy for them

If not you can cut them with a table or circular saw and a chopsaw. The hatchets are 1" wide and 2.06" long with 3.5 degree angled cuts on each end, so start by ripping some of your scrap plywood into 1" wide strips with a table saw or with a circular saw and a fence. You'll need 60+ feet of strips but can use random lengths to use up some of your scrap.

- Set the crosscut angle of your chopsaw to 3.5 degrees and clamp a stop block onto the fence so that the long side of the hatchet will be 2.06" long.

Trim one end of one of your 1” wide strips, flip it over, and cut the other end. Continue flipping and cutting until you have at least 250 hatchets. You’ll have to check the first couple of them and adjust the fence to make sure they are the right length, but after that it’s a simple process of cutting and flipping.

SAFETY NOTE: *These kinds of repetitive jobs can be dangerous when you get “In the zone”, so please be aware at all times of where the blade is in relation to your body parts!*