

MOJO.cc proudly presents:

Build Your Own Rack Cabinet

Or, how to rack 'em and stack 'em for a third the price...

By Tom H. - Team Florida Mojo

NOTE: Due to TREMENDOUS bandwidth usage thanks to this article's sudden fame on sites like Overclockers.com and Slashdot (to the tune of 17 THOUSAND hits in 18 hours!), you may experience problems loading images. If you do, please load the individual images manually.

We've also removed the dark background from this page for the large number of users of browsers that don't display the table backgrounds, etc. this site uses. (The site's designed for 4th-generation or newer Windows-platform browsers, but has been getting a LOT of traffic from Linux/*NIX users whose browsers don't render the page the same way.)

Rackmounting equipment is so far the best means we've come up with as a species for packing a lot of processing power in little floorspace - 40 or more computers in a single storage space that uses 4.5 square feet of floor space and stands 8 feet tall. Rackmount cabinets are, on the other hand, appallingly expensive, often costing well over a thousand dollars US. And they're so heavy that you can pretty much be guaranteed another couple hundred dollars' worth of shipping charges will be tacked on if you buy one.

But if you're a home user with a lot of equipment, run a small office, a budding musician with a lot of rackmount toys, a home theater enthusiast wanting more functional and adjustable mounting space for your gear, or any of a number of other possibilities, rackmounting your gear may be the only game in town. But the expense, ouch the expense!

In this article we'll do something that so far we're not aware anyone has done yet - discuss building a small 18-unit (18 units of height x 1.75" of height per unit = 31.5" of mounting space) rack cabinet for as little as \$50. If you're in need of a light- to medium-duty rack cabinet for lightweight gear such as musical effects and recording gear, home theater equipment, and so on, you'll be able to accomplish rackmounting for cheap. If you need EIA-standard-compliant storage for heavy equipment such as servers, UPSs, telecom gear, and so on, then you'll end up spending \$200 or so (assuming you know how to weld and have the equipment to do so - if not, figure more \$ to hire

someone to do this work) on the 18-unit steel-framed cabinet we'll discuss in detail.

We will discuss the basic ideas and a how-to on building a light- or medium-duty wood-framed 18U rack cabinet for less than 200 lbs. of equipment, and then we'll jump into building a VERY heavy-duty 18U cabinet that can safely handle 600 lbs. Of gear. If you need more or less height, you'll naturally need to scale the height accordingly, but 18 units is about the most comfortable height for home, small-office, or studio use.

Rackmount 101

First, the basics on racks and rackmount gear...

Rackmount equipment sizes are standardized, thankfully, so you'll most likely have and/or see equipment that designed for a "19-inch rack." This means that the faceplates or front panels on the equipment are 19 inches wide. The minimum height for any piece of equipment is called a "unit," (abbreviated as an uppercase 'U') and each unit is a multiple of 1.75" of vertical space. So a 3U device is 3 units x 1.75 per unit = 5.25" tall.

The standard also calls for the body of rackmount equipment to be 17 inches wide and can be however deep, although anything deeper than 28 inches is unusual for a 19" rack. Most rackmount computers that are 4 units tall are about 22 inches deep, for example.

Rackmount equipment is attached to a pair of rails, each of which has a series of holes drilled into it in a regular pattern, which is 1/2"-5/8"-5/8" and repeated for the entire height of the rail. The mounting holes for rackmount equipment require that the rails be aligned vertically to within 1/16", and must be as close to 18 1/4" apart center-to-center as you can get, although tolerance will vary with the mounting holes on the equipment's faceplate. As long as the horizontal distance is within 1/16" all is generally well.

Some rails use captive nuts, which are nuts with retaining clips that clip onto the rack rail over or into holes provided for this purpose, while other rails simply have drilled and tapped holes that can accept screws directly. Most US-made rack equipment is secured with 10-32 screws, although 10-24, 12-24, and M6 screws are also used. The screws have to be able to hold at least 30 lbs. per screw though, due to the next item for discussion:

Rackmount equipment weighing less than about 50 lbs. has to be designed so that the entire weight can be supported by the equipment's faceplate, and heavier gear generally requires a set of rails in the back of the cabinet to hold up the back end. (Sometimes the heavy stuff includes a set of rear rack brackets that attach to the side of the item in

question, and other times a rackmount shelf is provided for this purpose.) Thanks to this requirement, rackmount equipment tends to have very thick faceplates and very stiff side panels to handle the weight. Rackmount equipment also usually will have a pair of handles on the front to make installation and removal easier.

If you have a front and rear set of rack rails, more options become possible, such as the use of rack slides to allow equipment to be pulled out like a drawer. Also, there are pullout shelves and storage drawers, keyboard drawers (these require narrow keyboards, obviously), even rackmount monitors.

Building a Light-Duty Open Rack Cabinet

Now that the basics have been covered, let's discuss the basic idea behind building a light-duty 18U rack cabinet for about \$50 in materials. This design would be suitable for home-theater, professional audio, and in some cases light-duty computing/networking applications where only a front rail set is required, and the total weight of equipment to be mounted is less than 150 lbs. The resulting cabinet is 33" tall, 20 5/8" wide, and 24" deep.

What you'll need for this design:

- ?? Two pieces of 5/8" thick plywood (DO NOT use particle board or OSB) cut to 24" wide x 31.75" long - these will form the sides;
- ?? Two pieces of 5/8" thick plywood cut to 24" wide 20 5/8" long - these will become the top and bottom;
- ?? Four pieces of 1" steel 90-degree angle stock, each 21" long
- ?? One box of 100 each (you'll only use about half, but buying them in this quantity is generally cheaper than buying them in sets of 50) of the following: 8-32 flat-head machine screws 1 1/4" long, #8 washers, #8 split lockwashers, and 8-32 nuts;
- ?? Eight each of the following: 1/4-20 x 1 1/8" flathead machine screw, 1/4-20 nut, 1/4" external-tooth lockwasher;
- ?? Sixteen 1/4" flat washers;
- ?? Two 18U rack rails from [MilesTek](http://www.milestek.com/) [http://www.milestek.com/], their part # [50-70226](http://www.milestek.com/OrderItem.asp?PartNumber=50-70226)
[http://www.milestek.com/OrderItem.asp?PartNumber=50-70226];
- ?? A drill with two drill bits: 3/16" and 5/16";
- ?? A tube of construction adhesive (and a caulk gun if using that style of tube);
- ?? Measuring tape;
- ?? Two or more (Preferably at least four) clamps capable of opening at least 2";

And now, to build it:

First, use the construction adhesive to glue one piece of steel angle to the each end of the side panels along the 24" long edges, and make sure both steel angles are on the same side the plywood (presumably the worst-looking one, as whichever side the angles are glued to will be the inside of the cabinet.) Be sure to align one end of each angle with the edge of the panel, and also ensure that both angles on one panel align with the same side, so that there's a 3" gap between the angle's other end and the edge of the panel. These gaps allow clearance for the rack rails, and the edge with this gap will be the front of the cabinet.

Clamp the angles in place and let the adhesive set. Repeat this to make the two side panels.

Then, starting 1" in from the angle's end that aligns with the panel, drill a hole every 4 inches through angle and wood with a 3/16" drill bit, centering it in the flat part of the angle. Repeat for the other angle, and then repeat for the other side panel.

Slide an 8-32 screw into each hole from the outside (the wood side) and slip a flat washer, lockwasher, and nut onto the angle side. Tighten them all evenly and with enough pressure to pull the heads of the screws flush with the surface of the wood. Again, repeat for the other angles on both panels. This finishes the side panels.

The top and bottom panels are then attached to the sides. The sides rest on the bottom, and the top rests on the sides. Since a 3" gap was left for clearance of the rack rails, make sure that the gaps on both sides are pointed in the same direction or you'll be unable to mount one of the rails. (Flip the side over to change which way the gaps point.)

Use more construction adhesive to glue the wood panels to each other where they butt together, as well as to glue the angles to the top and bottom. Again, clamp and let the adhesive set.

As was done for the sides, drill holes every 4", starting 3" from the corner where the angles align with the back edges of the top and side, and 1 1/8" in from the outside edge. Use the same means to attach the top and bottom to the angles as was used to mount the angles to the sides.

Check for square by taking diagonal measurements across the open inside of the rack - if both measurements are within 1/16" of each other, you're square, otherwise carefully flex the cabinet slightly to force it into square.

Finally, it's time to mount the rack rails. Hold each rack rail flat against the side panel and centered on the panel vertically, keeping the shorter side that has the rack holes on it flush with the front edge of the side panel, and mark the second and fourth holes in from each end. Remove the rails and drill through the wood at each marked location with the 5/16" drill bit.

Slide all four 1/4-20 screws into one side panel and slip one flat washer onto each. Then slip the rail onto the screws and apply a flat washer, lockwasher, and nut to each. Gradually tighten each in sequence until the heads are pulled flush with the side panel's surface. Then repeat for the other side.

Double-check your handiwork, and if all looks well you can start mounting your gear into the new cabinet. Or, finish its exterior however you feel fit and *then* start to fill it. If you plan to cover the exterior AND the screw heads (which is NOT a good idea), you might want to apply some form of thread-locking compound on all the hardware used to secure the rack panels and rails, to prevent them working loose later.

If you want to include a door, you'll need to either alter the design to suit the addition of a door, with the most notable change being the need to increase the depth by 3" and recess the rails at least 3" in from the front edge of the side panels. And then there's the door itself. Since the door can be anything - a cut-down interior door, a simple piece of plywood, even smoked acrylic (my personal favorite), the details of the door are left to the builder to work out based on the chosen material and application.

Building a Medium-Duty Open Rack Cabinet

A medium-duty cabinet, suited for basic computing/networking use for more heavy equipment can be built using the same plywood structure, but adding steel tubing vertically, spaced 1" in from each rack rail and corner to add rigidity. This design is good up to about 250 lbs. if properly constructed.

The tubing would need to be spaced out from the panels enough to rest flush against the angles used to connect the panels together. This can be accomplished with flat washers. Additional tubing running diagonally from the top front to the bottom rear may be required to shore the

cabinet up from racking due to the weight of equipment mounted into it.

If your rackmount gear will weigh more than about 200 lbs., you might want to consider the heavy-duty version, below.

Building a Heavy-Duty Steel-Frame Open Rack Cabinet

And now, the granddaddy of homebrew rack cabinets, the steel-frame heavy-duty EIA-compliant cabinet. This design is suited to loads up to about 600 lbs. (assuming a height of 18U) and requires welding (stick or MIG) skills and equipment as well as some means to cut steel plate and tubing. However, for heavy equipment such as rackmount UPSs and multiple servers, this is the only way to go.

Since this design was actually built by the author (*Ed Note: Seemed like a good excuse to teach myself how to weld!*), this is the only design that will be included here with photographs.

First, a few caveats:

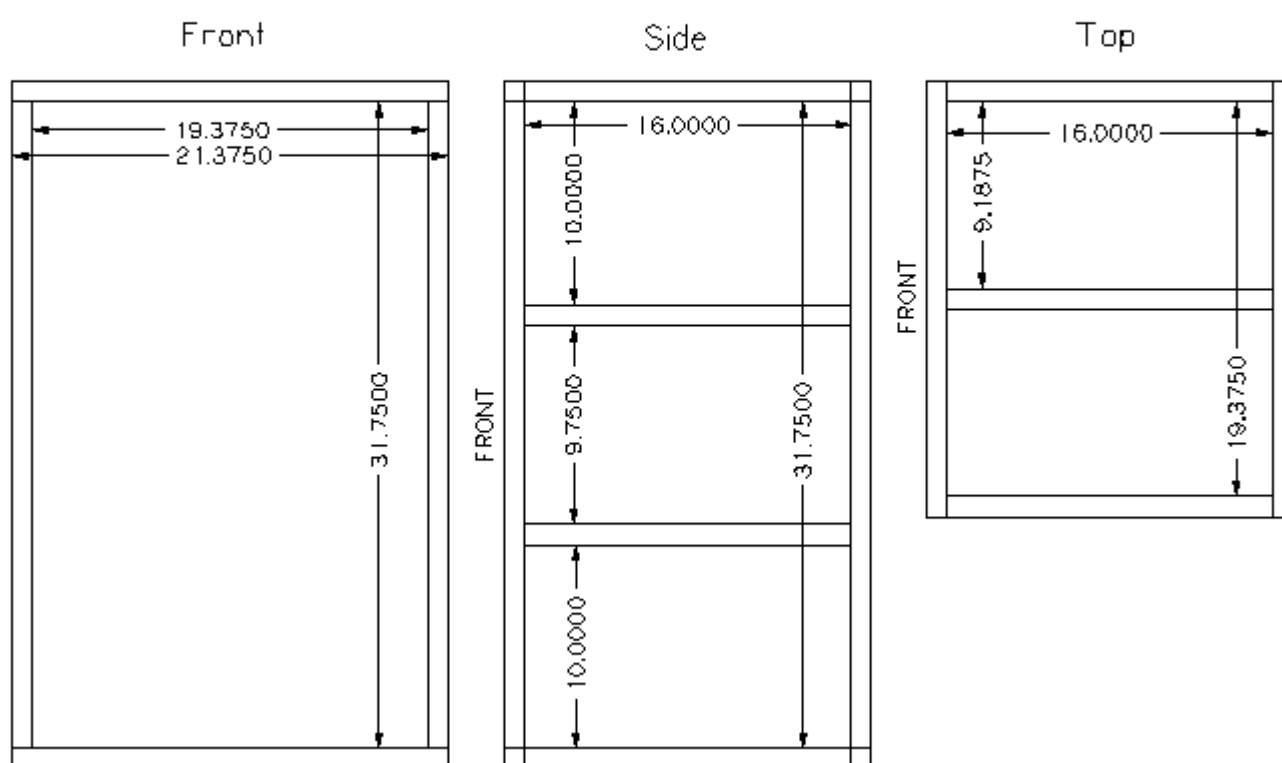
1. This project requires welding. If you lack the equipment and/or skills to do this safely, you may want to hire someone to perform this process.
2. This project involves cutting steel. Usually, fiber-reinforced cutoff wheels or a bandsaw are used to perform this, and such tools are EXTREMELY dangerous. If it can cut steel, it can certainly go through bone. And then there's the eye hazards from flying metal particles. If you perform the steel cutting operation yourself it's advised that you not get a MRI or any other form of medical magnetic imaging procedures performed for a minimum of six (6) months, as a MRI can literally pull an iron filing *through* the body and this is NOT a good thing to have happen. (MRI technicians will usually refuse to give perform MRIs on any person employed as a metalworker for precisely this reason.) Again, this might be a good thing to pay to have done.
3. Welds generally get ground smooth - see above re: cutting for the hazards typical to grinding a welded bead.
4. Since there's welding and cutting involved, expect a lot of flesh-hostile things to be a concern, such as cutting yourself on a jagged metal edge or burning yourself on a fresh weld. For instance, a bit of glowing metal at about 1,800 deg. F is NOT a good thing to have land on your hand. Consult the manuals for

your welding and cutting equipment for safety precautions appropriate to that equipment.

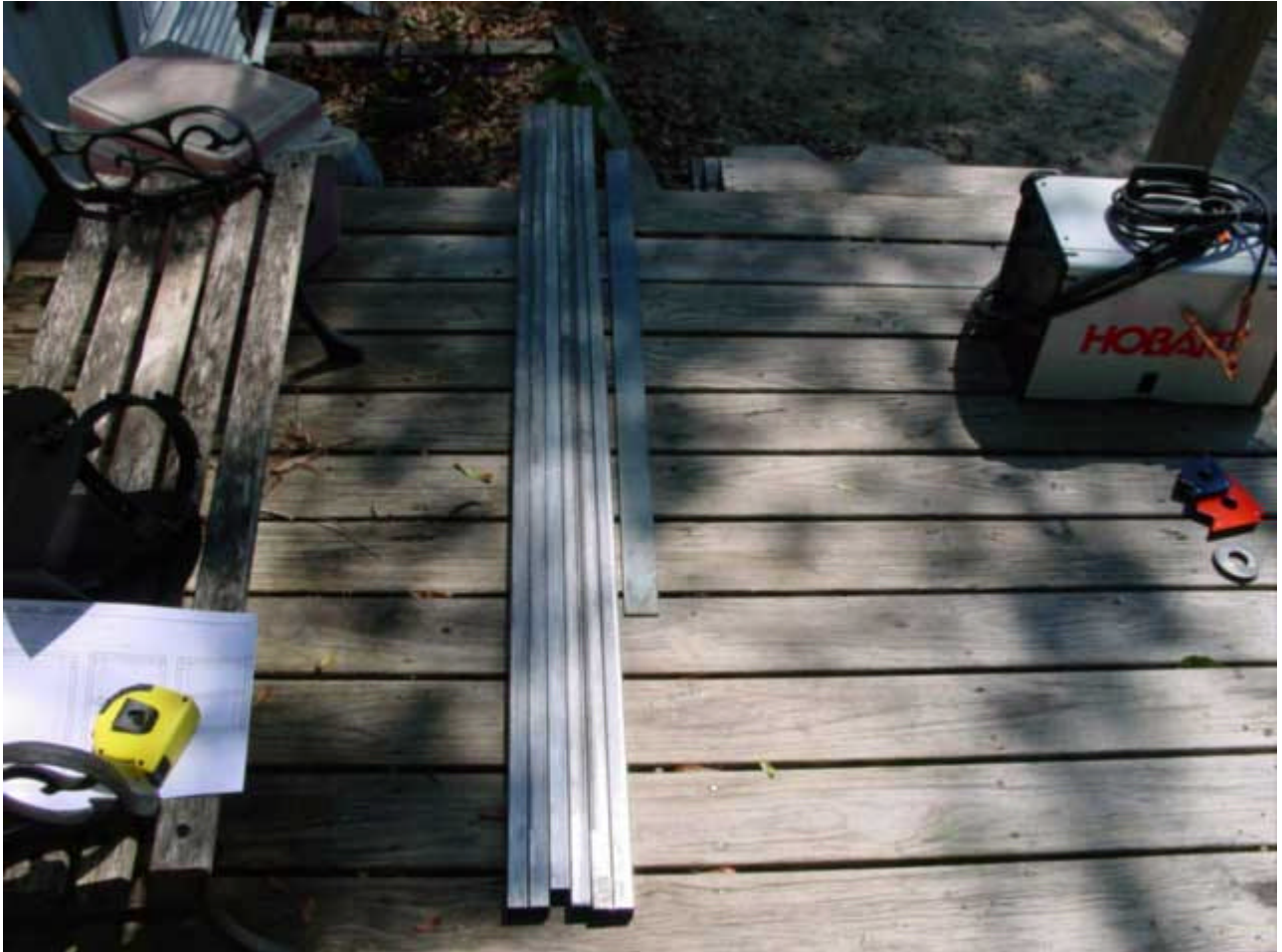
18U Rack Cabinet

Square-Tube Steel Frame Layout

(All materials: 1" x 1" x .062" wall steel tubing.)



The design is simple, a basic ladder frame construction that's deliberately designed to be slightly larger than the rack space within, in order to allow room to adjust the vertical alignment, horizontal mounting-center spacing, and front-to-back alignment. Since rack rails are generally 1/2" longer than the number of units of mounting space they permit, an extra 1/8" was added to the inside height of the frame to allow some room to adjust the rails' heights. The front-to-back rail spacing was set at 18" in this design, as only two components destined for its use in the prototype cabinet are deeper than 18", and 18" is really the safe minimum depth for the rear rail set for most rack shelves, drawers, etc.



The material chosen was 0.62" wall, 1" x 1" square steel tubing. This tubing is widely available at home-improvement stores and usually costs about \$7 for a 6-foot length. For this project, six pieces of 6-foot tubing are required. As an option, a flat metal bar can be used to create corner reinforcements that double as mounting points for casters.



The tools used for the project are shown above. At left, a Hobart Handler MIG welder to perform the union of metal pieces, and a couple welding magnets to ensure angles are maintained and tubing held in place when the welding is performed. At right, a 10" miter saw with a metal-cutting blade. NOTE THE GUARD IS STILL ON THE SAW - if you use a miter saw and you removed the guard, *put the guard back on, fool!* The metal cutting blade is a compressed-abrasive type, and are also widely available at home-improvement stores. These must be used with caution though, as too much speed or pressure in the wrong direction may cause one to explode violently, and the little bits can do a number on anything nearby. (Thus the admonition to reinstall any missing guards.) They also throw sparks and dust during use, so cut outside or in a very well ventilated area only.

The first part of the process is to cut the stock tubing into pieces. For this project, we need 4 pieces that are 31 3/4" long, 4 pieces that are 21 3/8" long, and 10 pieces that are 16" long. If done correctly you can get all these lengths out of six 6-foot tubing sticks and have enough scrap left over to practice your welding and/or set the welder up for the material. Since the tubing walls are 0.062" thick, most MIG welders would work effectively at their lowest or second-lowest power setting and still get adequate metal penetration. Be careful about the power setting or you'll burn holes through the tubing.



Once the cut work is done, two of the 31 3/4" lengths and two of the 21 3/8" lengths are welded to form a rectangle. This is repeated to form the second. These will be the front and back openings and rack rail support struts for the rack cabinet's frame. Welding magnets make this process easy, by holding the tubing in place and keeping the angle 90 degrees.

Once the two rectangular sections are welded and the welds have been checked and allowed to cool, the sections are each checked to ensure that they aren't warped or bent into a slight "taco" shape (which is where diagonally opposite corners lift toward each other), which can happen with welding if a joint slips a bit during welding. Slight cases of warping can be corrected with a little brute force to bend the section flat, but more extreme examples might require cutting out and redoing the welds in one or more corners. Taking the time to do this job right the first time pays dividends.



Next, risers are welded at the corners of one of the sections. Again, welding magnets make this easier. When that's finished, the other section is placed onto the risers, indexed properly into place with magnets, and welded to form a basic enclosure.



The next step is to weld in the remaining 16" pieces that will serve as supports to reinforce the frame. One per side is centered into the top and bottom, and two into each side. These help distribute weight from the rack rails and help prevent the tubing buckling under extreme loads.

When the welding is completed and checked, the joints are ground smooth.



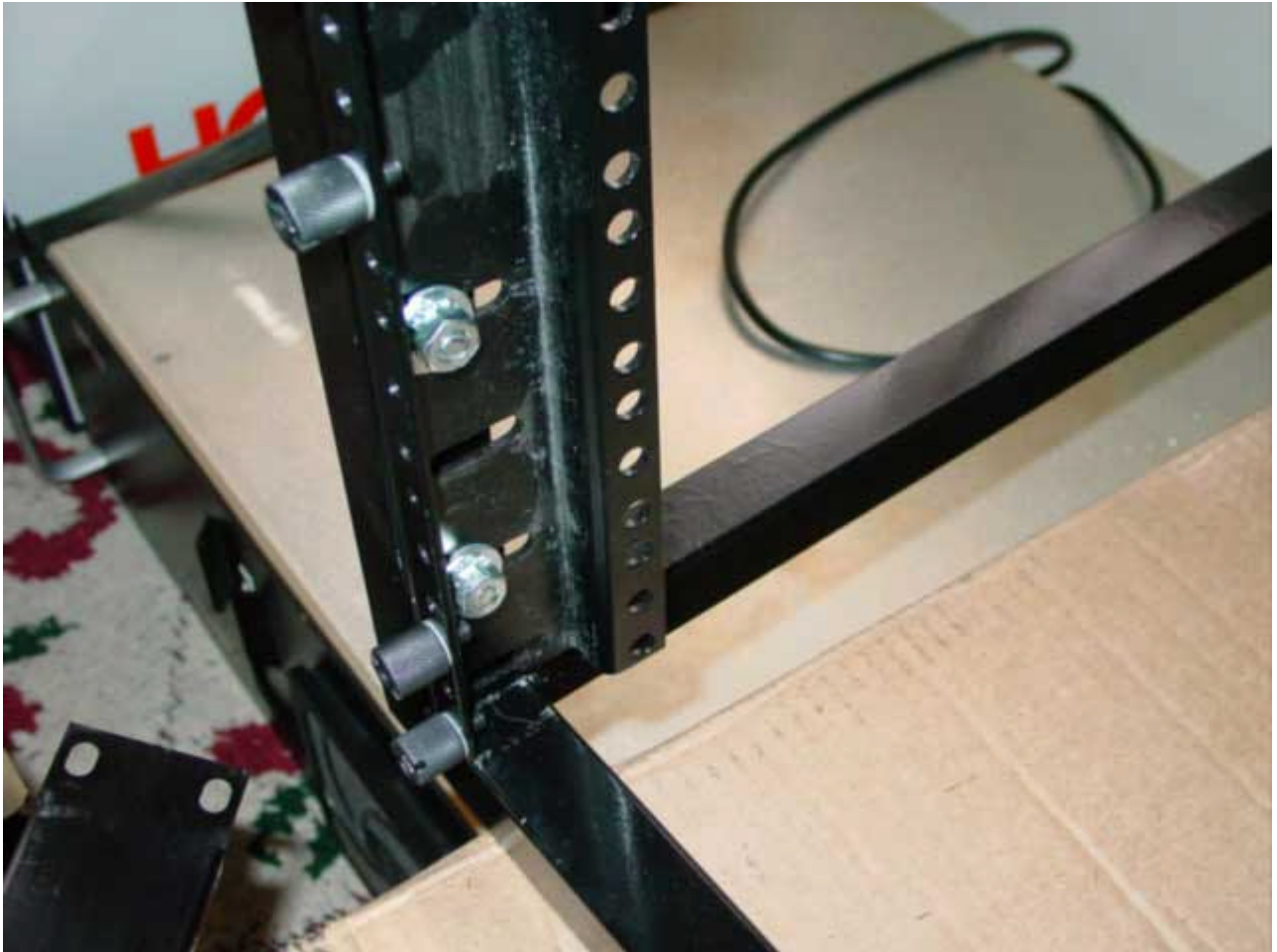
The next steps are to clean the frame thoroughly, and then to paint the frame completely with primer and then a good quality paint. This isn't intended to be cosmetic so much as to prevent corrosion - exposed steel will eventually rust.



With the frame finished, the rack rails can be mounted. Since the design leaves the rack slightly larger than required, the rails can be centered into the frame vertically by using something to gap the bottom of each rail up from the bottom tubing. A cheap but workable tool for this is an ordinary coin of roughly 1/16" thickness, such as a penny. Simply place a penny on the bottom tubing and stand the rail vertically onto it.



With a rail held in place, its mounting holes can be marked. These should be centered on the tubing for greatest strength, and may result in the rail's rackmounting surface extending out from the front of the tubing. It's a good idea to use the second and fourth mounting holes from each end of the rail if there are enough holes. That way you won't drill close enough to the corners to risk disturbing a weld or unnecessarily weakening the structure of the frame. 5/16" holes are then drilled completely through the tubing to allow the use of 1/4-20 bolts to mount the rails. If you're using 1/4-20 carriage bolts, a rotary tool with an engraving bit can be used to square up the outside holes in order to provide something for the square portion of the carriage bolt's head something to grip.



Each rail is mounted with four 1/4-20 bolts, flat washers, lock washers, and nuts. An additional flat washer is placed between the rack rail and the frame itself in order to make sure the space between the rails is proper to produce the required horizontal mounting-hole spacing of 18 1/4". The rack rails are then checked to ensure they're level vertically as well as the right distance horizontally, and then hardware is tightened down to complete the installation.

The rear rail set is installed the same way.



If all goes well, faceplate filler panels, shelves, etc. should drop right in without interference or alignment problems.



At this point, the rack cabinet frame is complete enough to use as-is, or you can attach side panels to the frame using whatever hardware you need. One nice-looking (if a bit pricey) suggestion is to drill and tap holes and use cap screws to attach the side panels, and use tinted acrylic for the side panels themselves.



The prototype shown in this article was stuffed with gear without the addition of any side panels, as the author's need for the setup was a bit too immediate to allow for the wait time needed to get large enough acrylic panels. Despite not having side panels, the cabinet looks pretty slick (especially for a home-build setup!)

Now you've got all the know-how you need to build your own rack cabinet, and make it look however you want, without having to spend a fortune to get it. If only the rackmount gear was less expensive...

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