Building a CNC Router
to Cut Styrene Parts for R2D2

Media Conversions

Outline

- Introduction & My Background

- What is a CNC Router & What Can You Do With One

- Build vs Buy and Something In Between

- Accessories – Making Life Easier

- Designing R2 parts How & Why

- Incorporating 3D Printed Parts

- References

Introduction & My Background

- Grew up in a Machine Shop/Home Shop

- Engineer by training, EE & CS degrees

- Spent first 1/2 of my career doing Engineering Projects (fun!)

- Spent second 1/2 of my career in management (not nearly as much fun!)

- Retired 1999 and again in 2003

May 2008 Servo

What is a CNC Router ?

- CNC = Computer Numerical Control

- Computer Aided Design (CAD) Software creates drawings [Geomagic Design, Formerly Alibre Design]

- Computer Aided Manufacturing (CAM) converts drawings to machine instructions (G-code) [Vectric – Cut 2D]

- CNC machine runs software to drive stepper motors following G-code instructions to cut parts [LinuxCNC]

- But – Why bother with CNC?

  - Poor Coordination & Accidents

  - Chance to build a better mousetrap

  - Features difficult to get using other methods

Dec. 2008 Nuts & Volts

PERSONAL ROBOTICS

UNDERSTANDING, DESIGNING & CONSTRUCTING ROBOTS & ROBOTIC SYSTEMS

BY VERN GRANER

THE PROBOTIX FIREBALL V90 CNC ROUTER
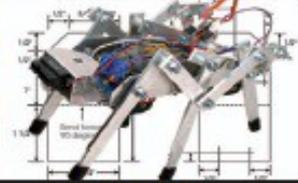
■ FIGURE 1. The PROBOTIX FireBall V90 CNC router.
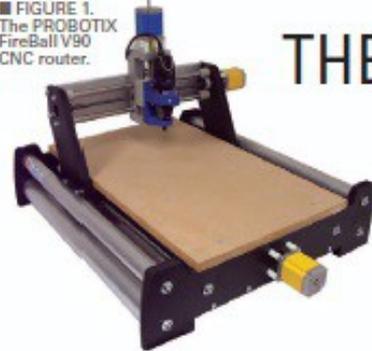
IN THIS MONTH'S ISSUE, WE CONSTRUCT THE PROBOTIX FireBall V90 CNC router from a kit and then put it through its paces.

TEA. EARL GREY. HOT.

Jean Luc Picard of *Star Trek* fame had high tech replication gadgets at his disposal. In his Utopian sci-fi future, these devices would be so common that they were used for such mundane tasks as making a cup of tea in the captain's quarters. Although we have a long way to go before we can expect any item we ask for to pop into existence from a wall-mounted gadget, some intrepid folks are diligently working in that direction, starting with automating the creation of parts.

When building things both robotic and mundane, I've found myself sanding, cutting, shaping, bending, and otherwise changing the physical shape of some item used in

I SEE, CNC!

CNC or Computer Numeric Control is an acronym that refers to a tool that can cut or shape by using computer generated instructions (see the sidebar for a bit of history). Most CNC machines have a number of axes and a tool of some sort that can be guided by a computer to very precisely remove material. Originally created in the 1940s for the automation of large-scale manufacturing (Figure 2), CNC has become more capable over the years and has made its way down to small desk top fabrication systems. Though some small-project CNC systems are available to the hobbyist, most are in the multi-thousand dollar range so they

many of these tools on a typical hobby workbench.

BRINGING DOWN THE PRICE

I was having lunch with long-time Robot Group member and good friend Paul Atkinson at Poke-Jo's BBQ restaurant here in Austin, TX where we were munching BBQ and talking tech while the electric train circled the dining room (see The TrainSaver, Nuts & Volts, July '06). Paul mentioned that he had recently read about a new CNC machine from PROBOTIX that seemed to have finally managed to break the $1,000

Becoming A Machinist

- Unpacked Sherline Desktop Mill bought in 1999, not assembled until 2008. Installed FlashCut CNC package.

- Early Days, Used Autocad LT98 for drawing & CamBam for CAM. FlashCut package is a dedicated CNC controller.

- "Easier to teach a machinist how to program than to teach a programmer to be a machinist."

- Helpful References
    - Machine Shop Trade Secrets by James Harvey
    - Metalworking Sink or Swim: Tips and Tricks for Machinists, Welders and Fabricators by Tom Lipton

- Make some Manual cuts. Try simple CNC cuts. Test in soft materials (Machinable Wax, MDF)

Sherline Mill

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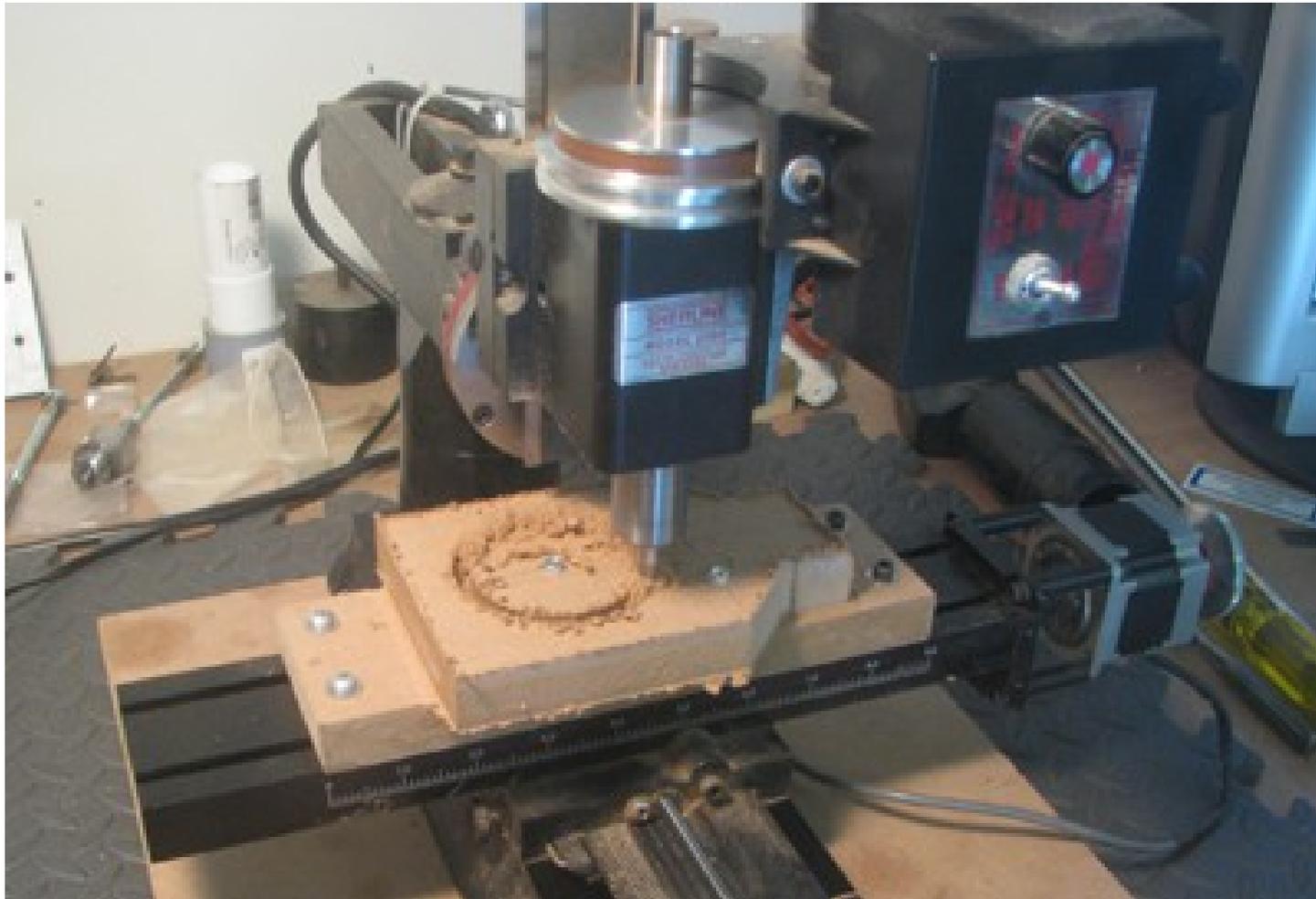
Search for a CNC Machine
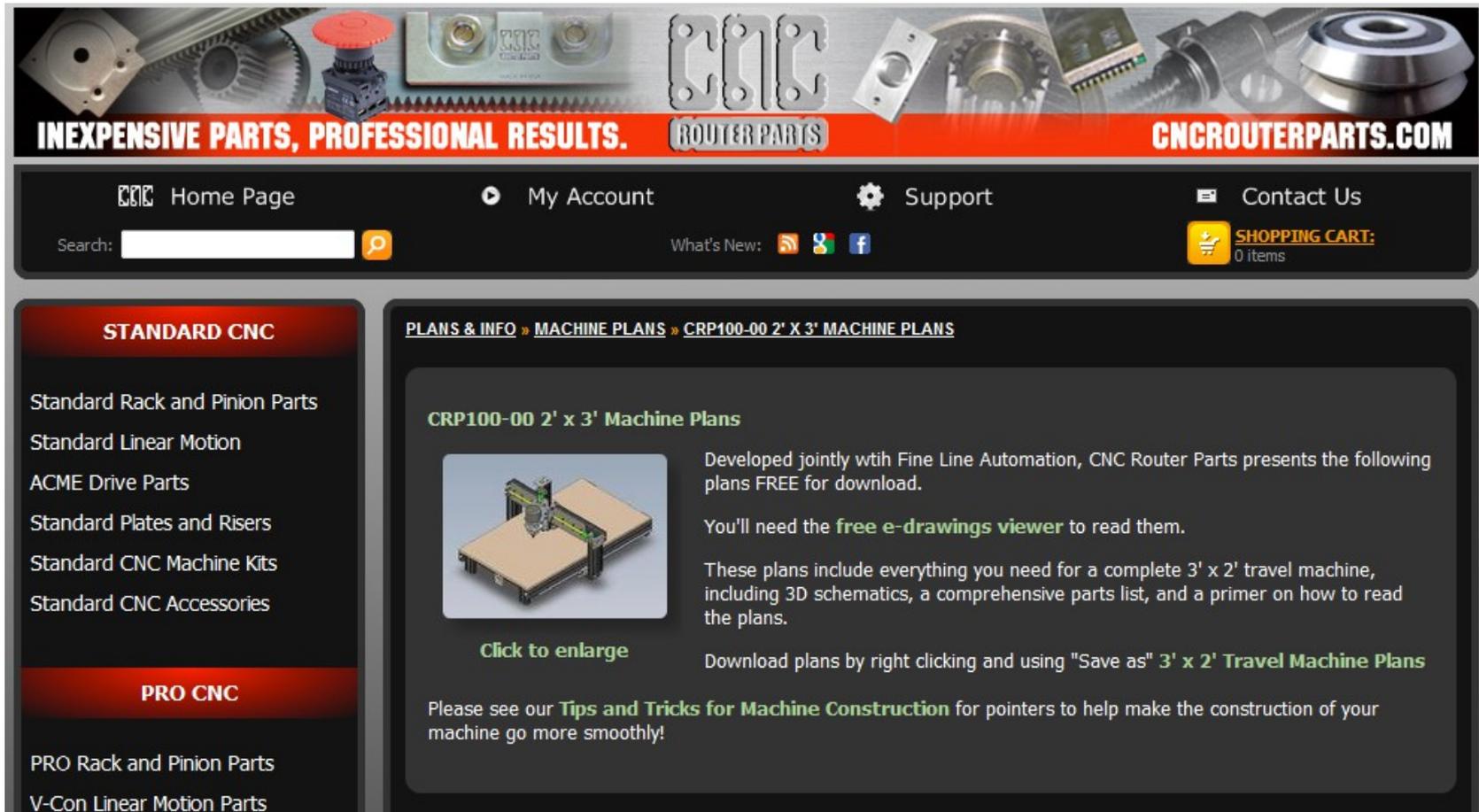
CNC Router Parts website Features Design examples
Using 80/20 Aluminum Extrusions and CRS Plates for rails.

CNC Router Parts 2x3 Design

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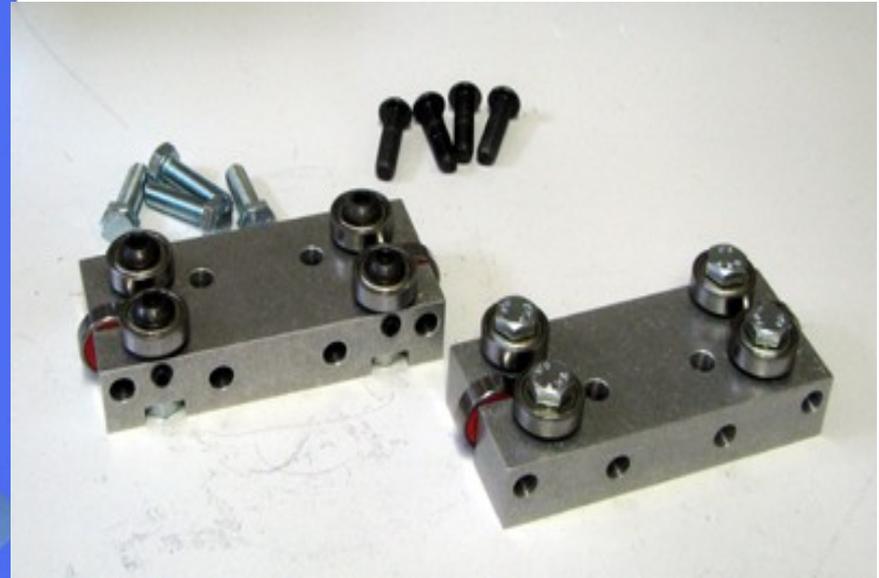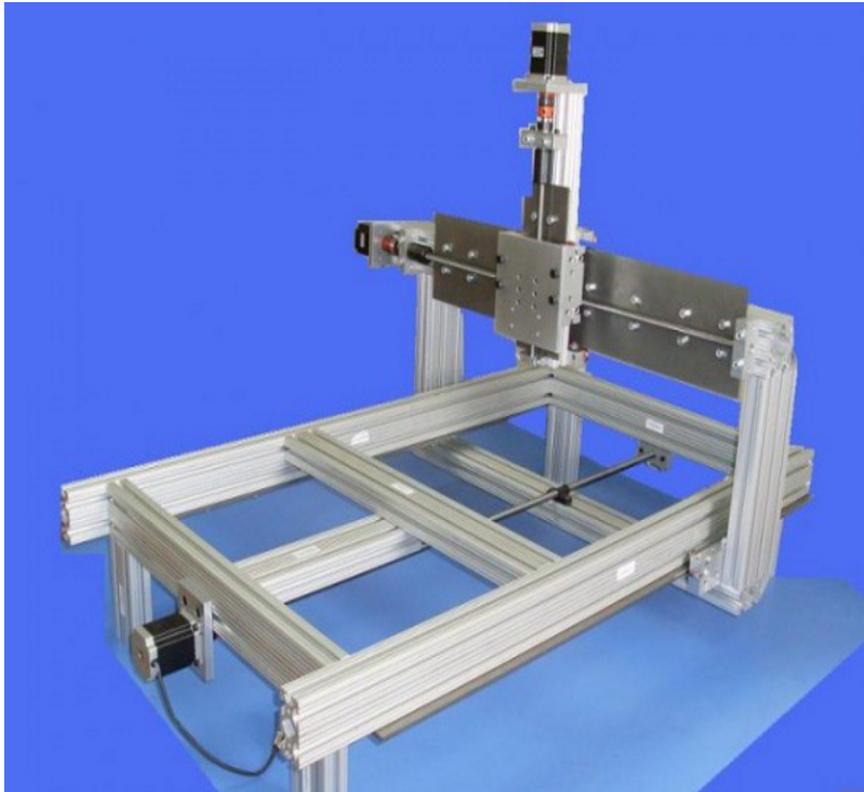
Building a CNC Router

- Carriages purchased from CNC Router Parts. 80/20 sourced from eBay. Hardware items from McMaster. Raw metals from Speedy Metals. [Alternative – kits available from FineLine Automation. $1399 w/o electronics]

- Used Sherline to fabricate bearing blocks, Nema motor mounts & Z axis mounting plate. Cut 80/20 to length using a cutoff saw with a carbide blade. [Recommend using Misumi pre cut 80/20 equivalent extrusions – cheaper & more accurate]

- Drilled Holes in cross members & Tapped holes in ends of 80/20 extrusions. Used tap chucked in hand drill to tap holes.

Cutting 80/20

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Drilling 80/20

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Tapping 80/20
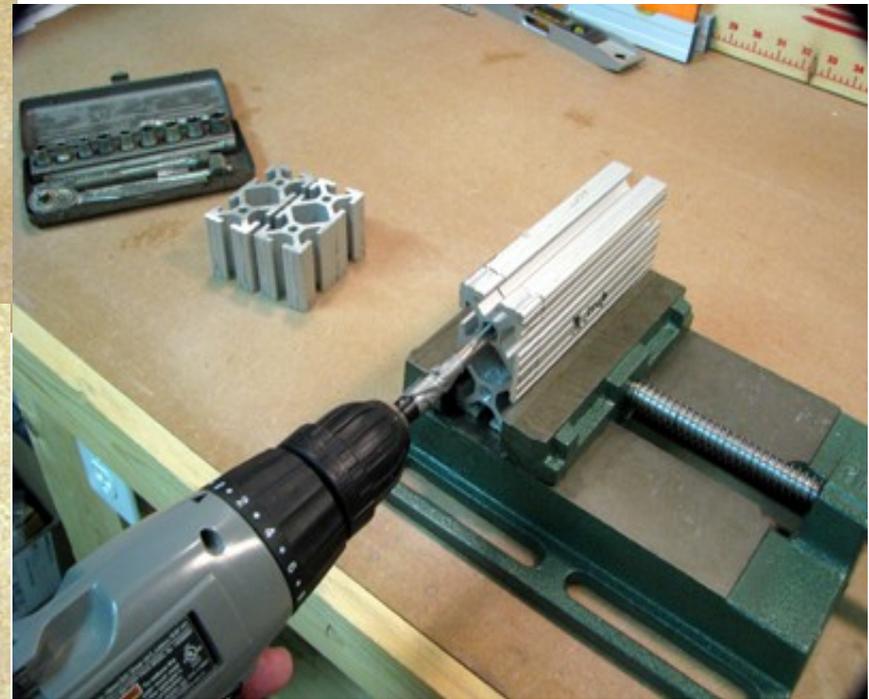
Assembling the Base

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Tinkering with the Design

Offset 2x2
used to support
gantry cross
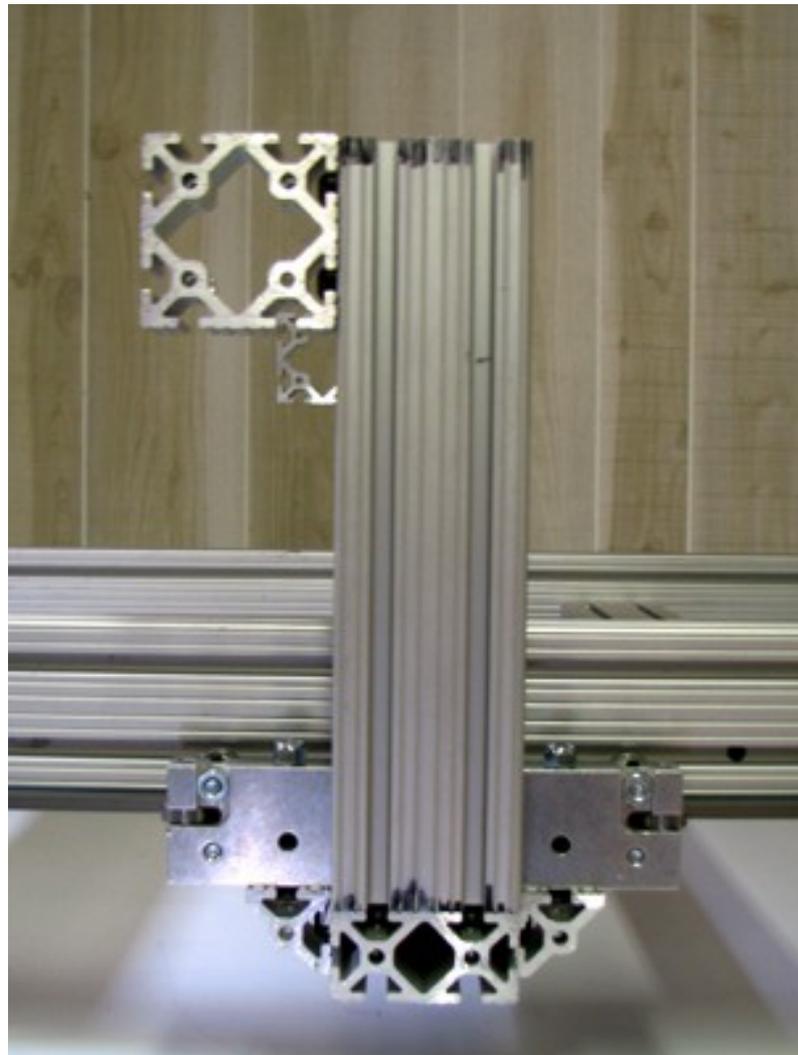
1x2 used for
Gantry riser
Instead of 1x3

2x2 cut up
To make
Angle braces

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Installing the Y Axis
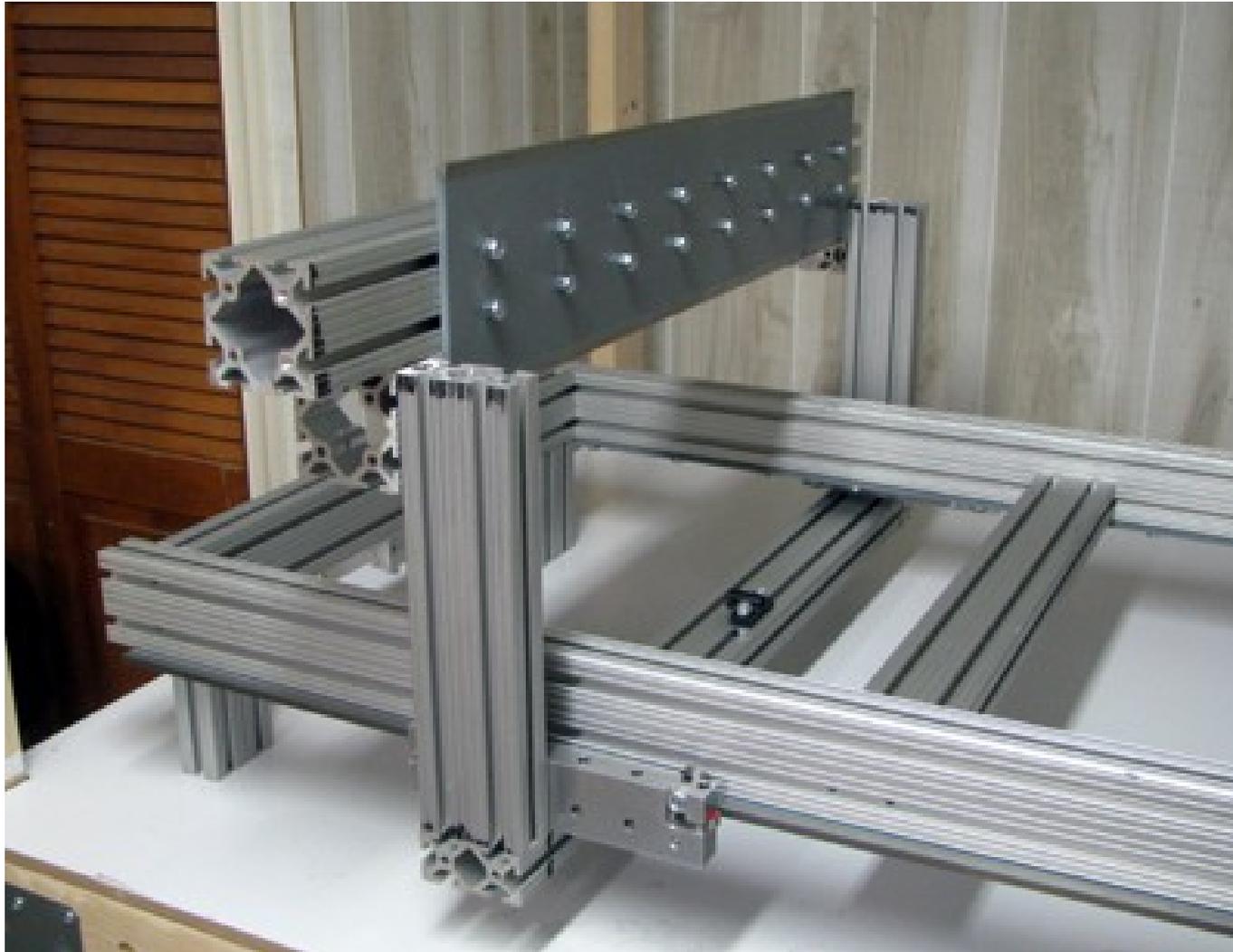
Z Axis mounted on Y Rails

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My CNC Router

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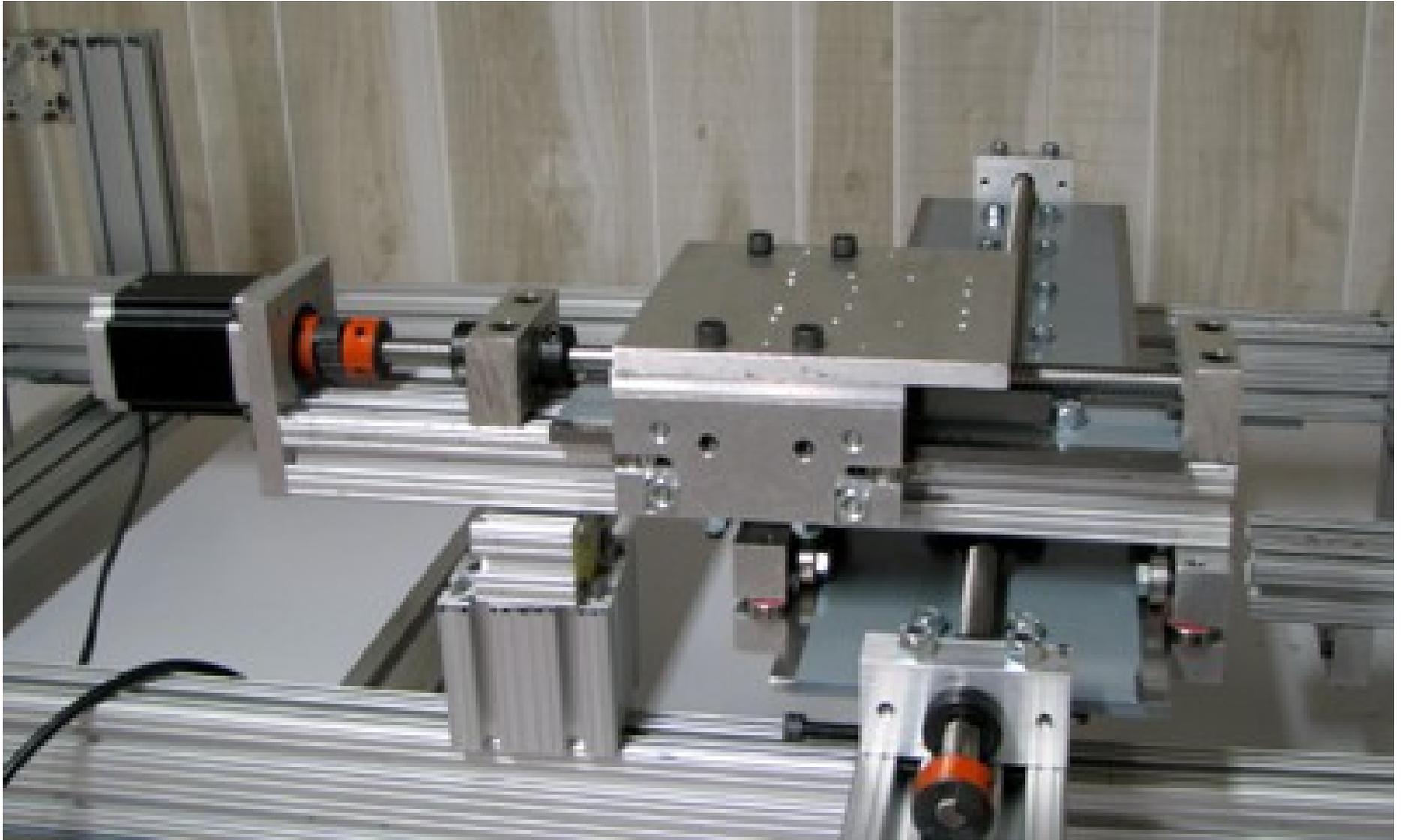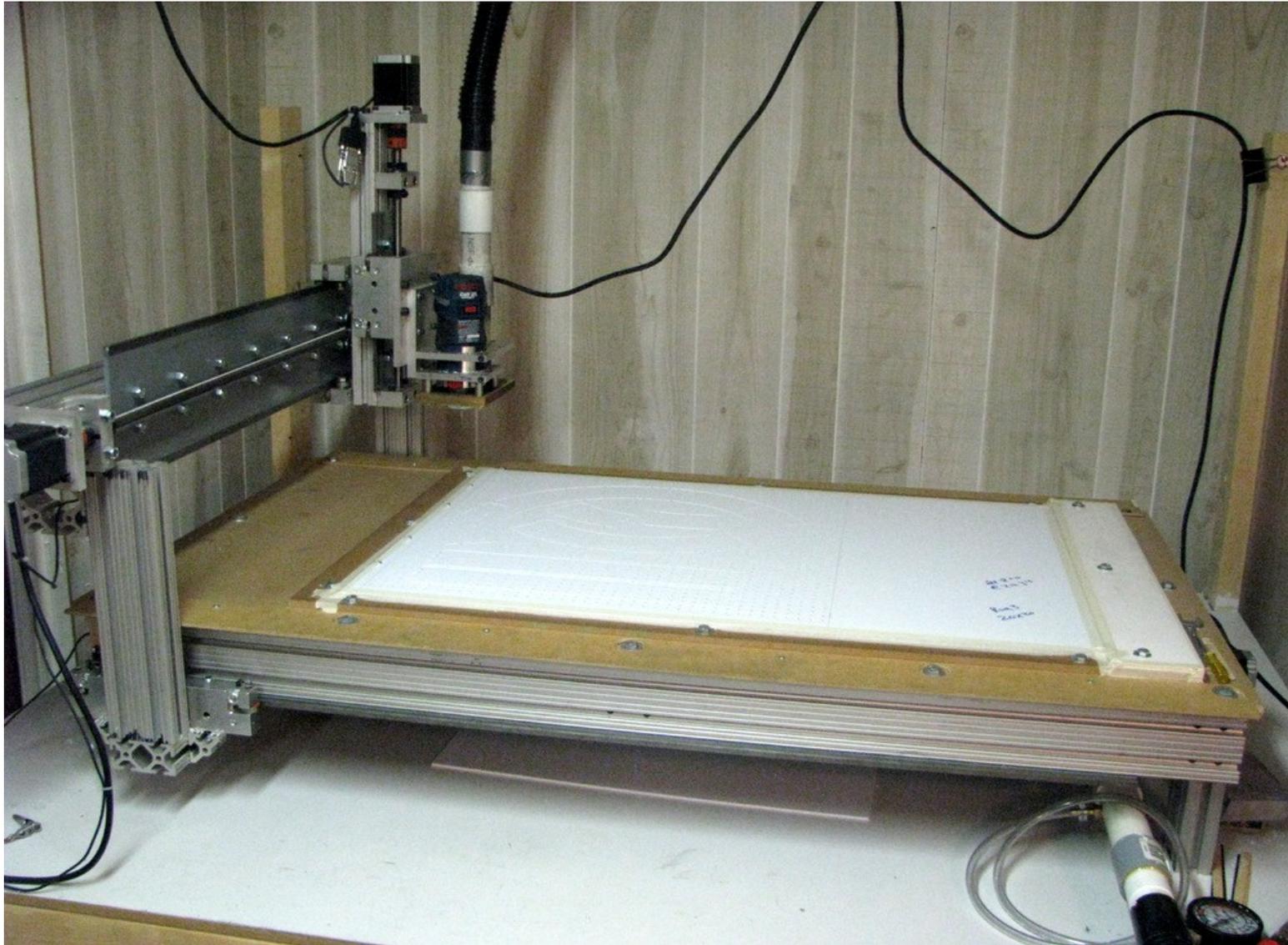
Accessories/Necessities

- Table, Chassis for Drive Electronics & PSU, keyboard, monitor, mouse & CPU

- Dust Collection – 2 parts

  - Router 'downdraft' blows swarf all over. Need to deflect the downdraft so it does not do that.

  - Vacuum pickup close to cutting bit to suck up the swarf.

- Vacuum table to hold parts down while being cut

- Rotary Axis for machining cylinders

- X & Y zero location switches & Z touch plate for homing.

- Stepper motor, Router Power Cable & Vacuum Hose management

- Emergency Stop Switch [Ideally should turn off router]

- Router modified for PID Speed Controler allows reduced cutting speeds [std 16,000 to 35,000 rpm – really want 5,000] & quieter

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Dust Collection & Vac Hold Down

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Dust Collection

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Dust Collection

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Vacuum Hold Down

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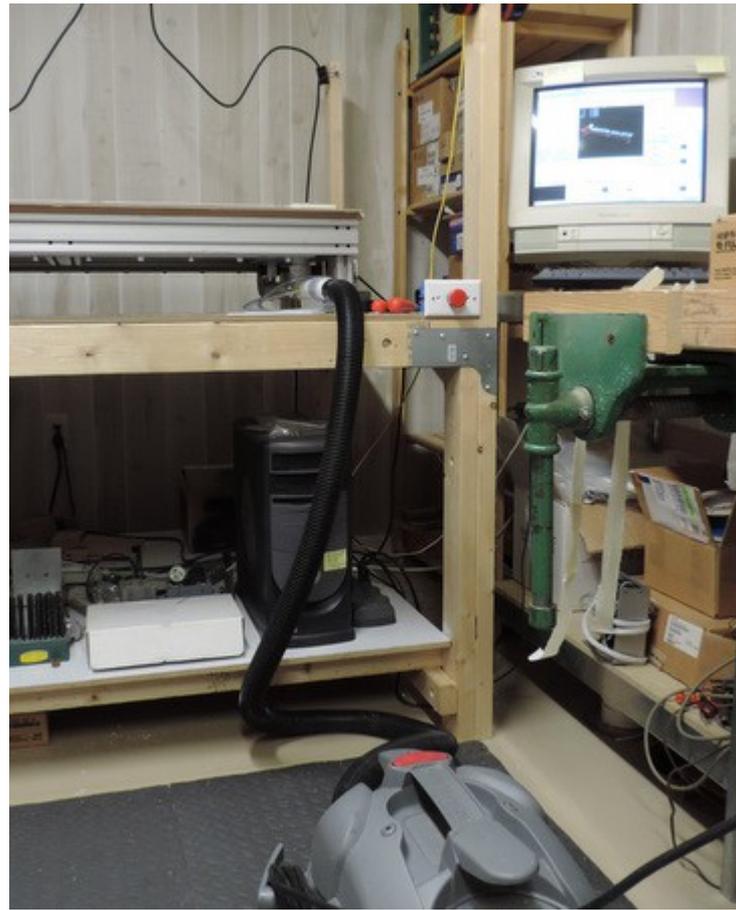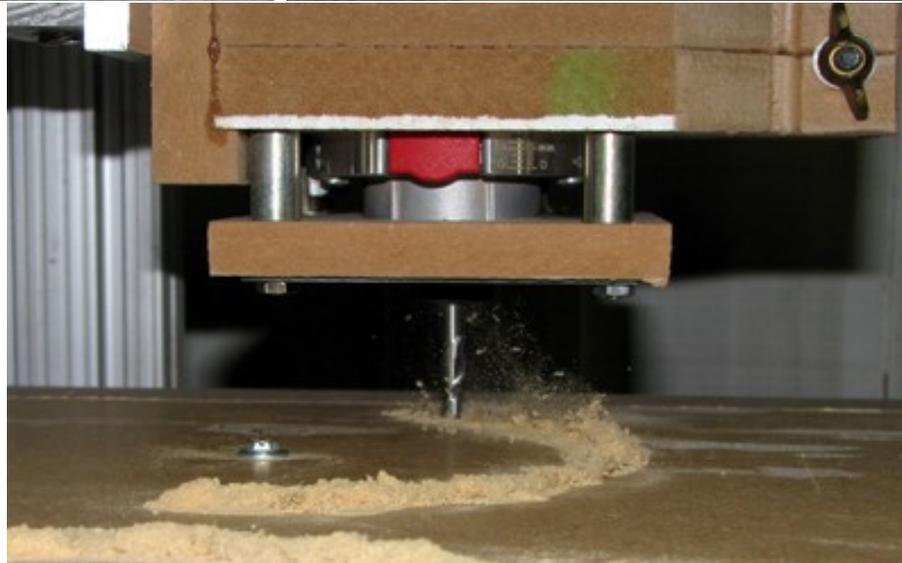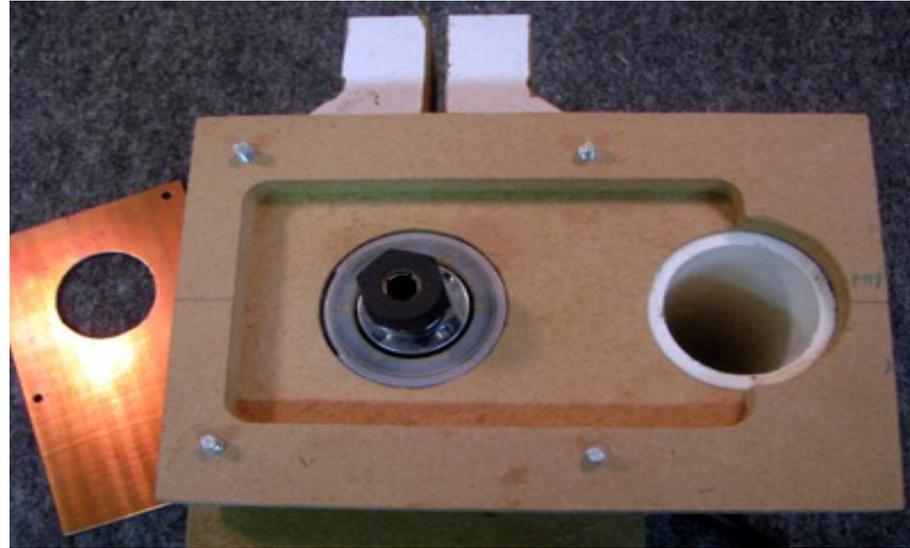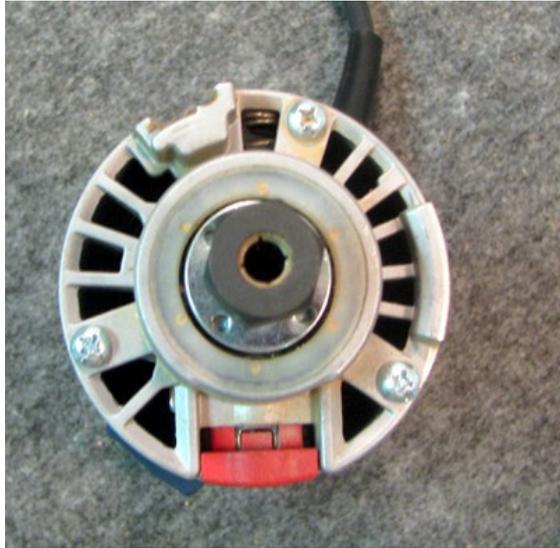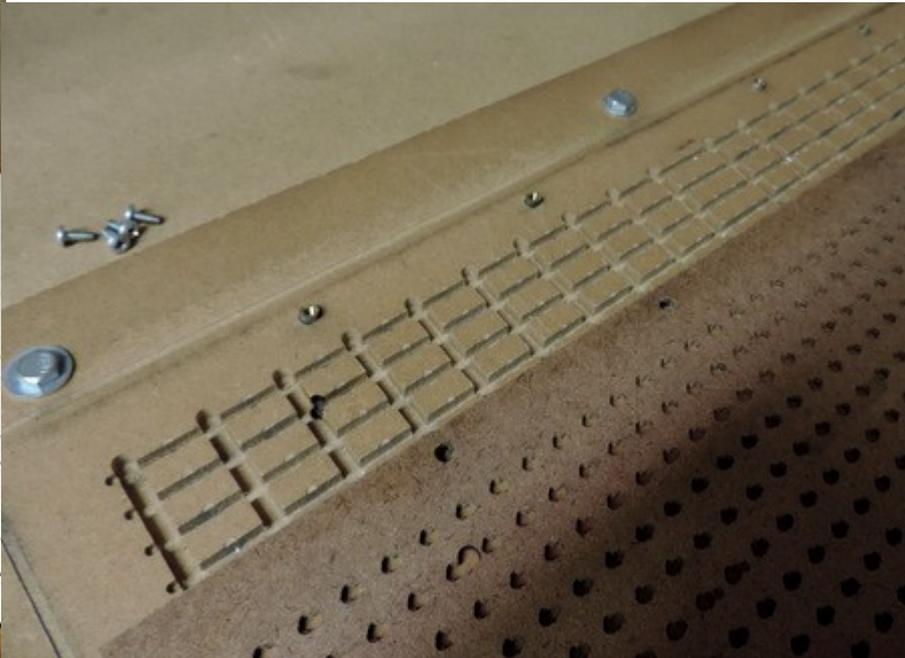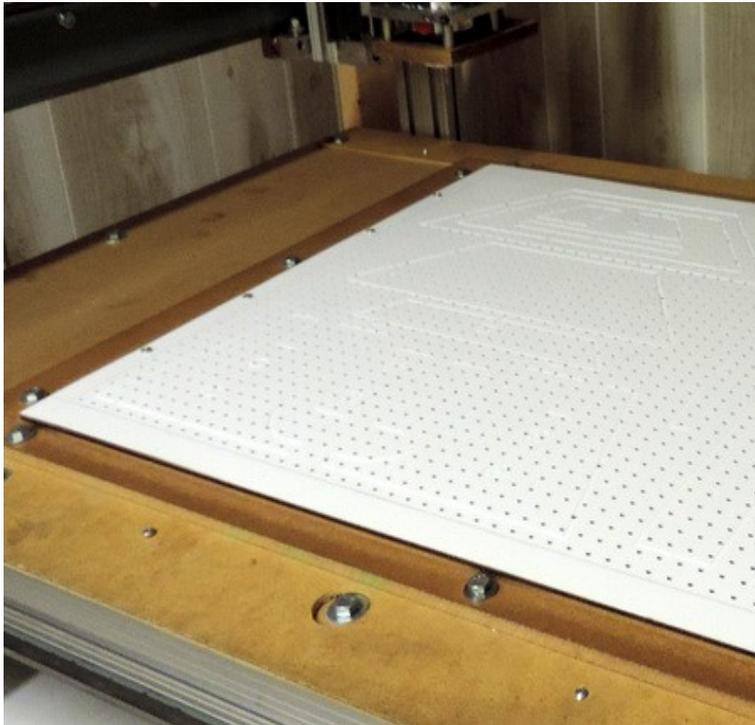
Vacuum Hold Down

Vacuum Hold Down

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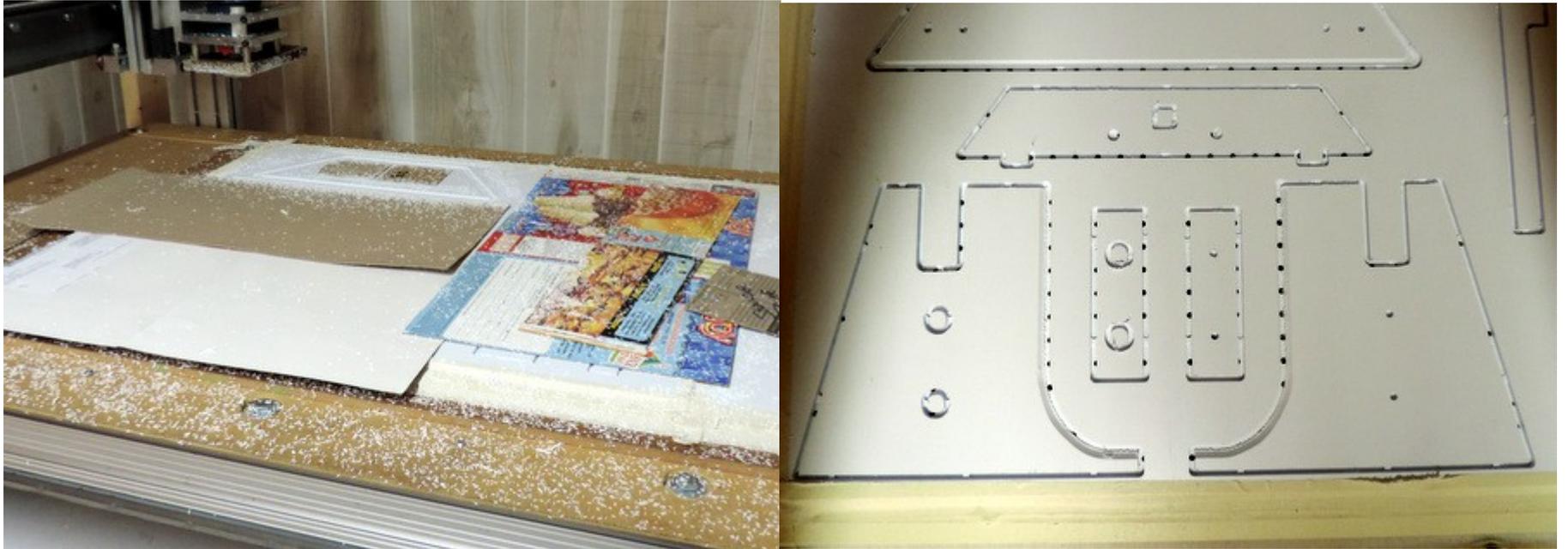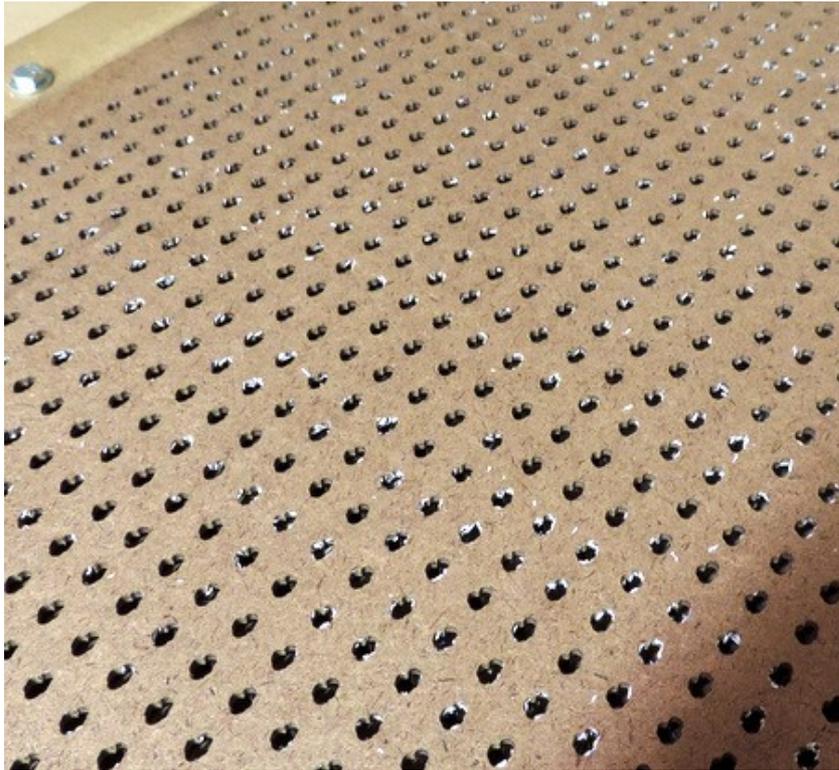
Adding 4th (Rotary) Axis

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What are my CNC Routers Cutting Abilities & Limits

- Typically 2D or 2.5D designs because the angle of the cutting head is fixed.

- Angle cuts restricted to 30,45,60 degrees by available cutters. Requires manual cutter change.

- Undercutting an edge would be difficult. Turning a part over to machine both sides also difficult.

- My machine bed is 24 in. x 36 in. Vacuum hold down 20 in. x 30 in. for sheet parts.

- Backlash limits accuracy to +/- .005 in. X and Y (couplers) and bed leveling limits Z to +/- .01 in.

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R2 Parts Done Differently

- Chance to build a better mouse trap

- Egg Crate designs add strength in the same way that an I-Beam is stronger than a flat piece of plastic

- Tab-in-Slot facilitates easy assembly by simplifying part registration.

- Sometimes I'm even smart enough to make it difficult/impossible to assemble wrong. But not always!

- CNC enables blind holes/slots

- Incorporate metal fasteners into Styrene Design.

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Examples of CNC Features

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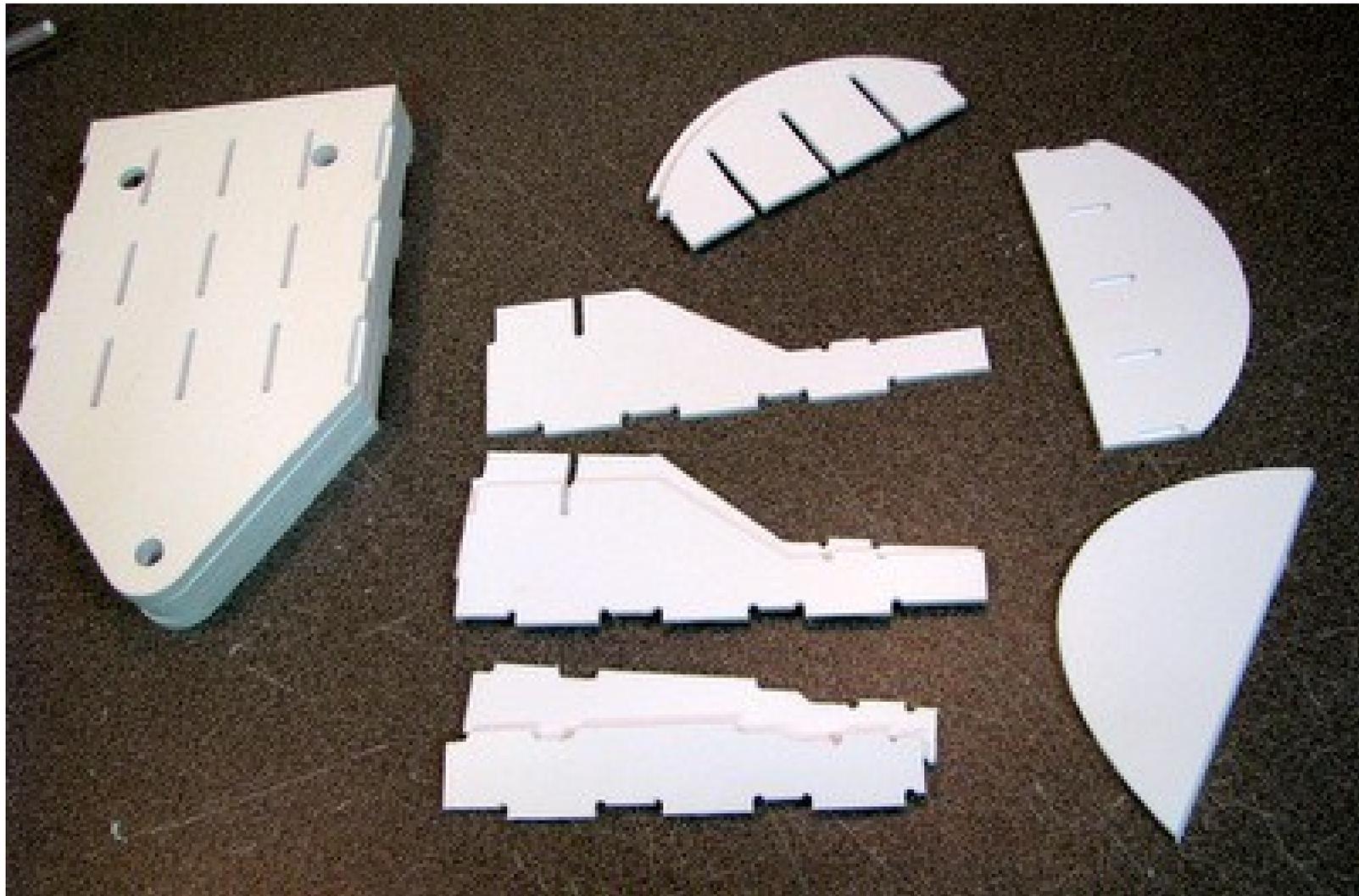
Metal Fasteners

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Conversions
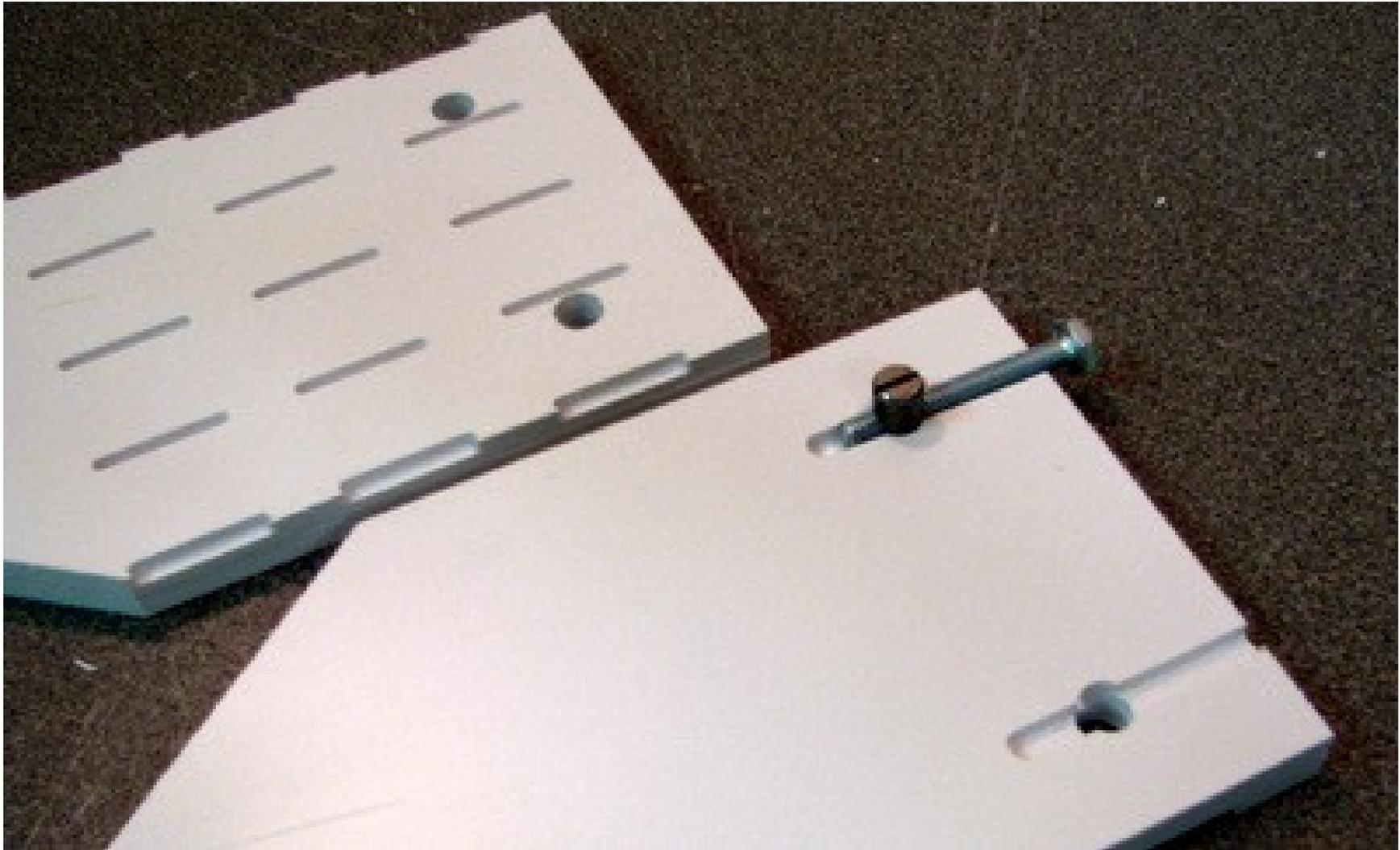
Part Registration

Blind Features

FUBAR Talk

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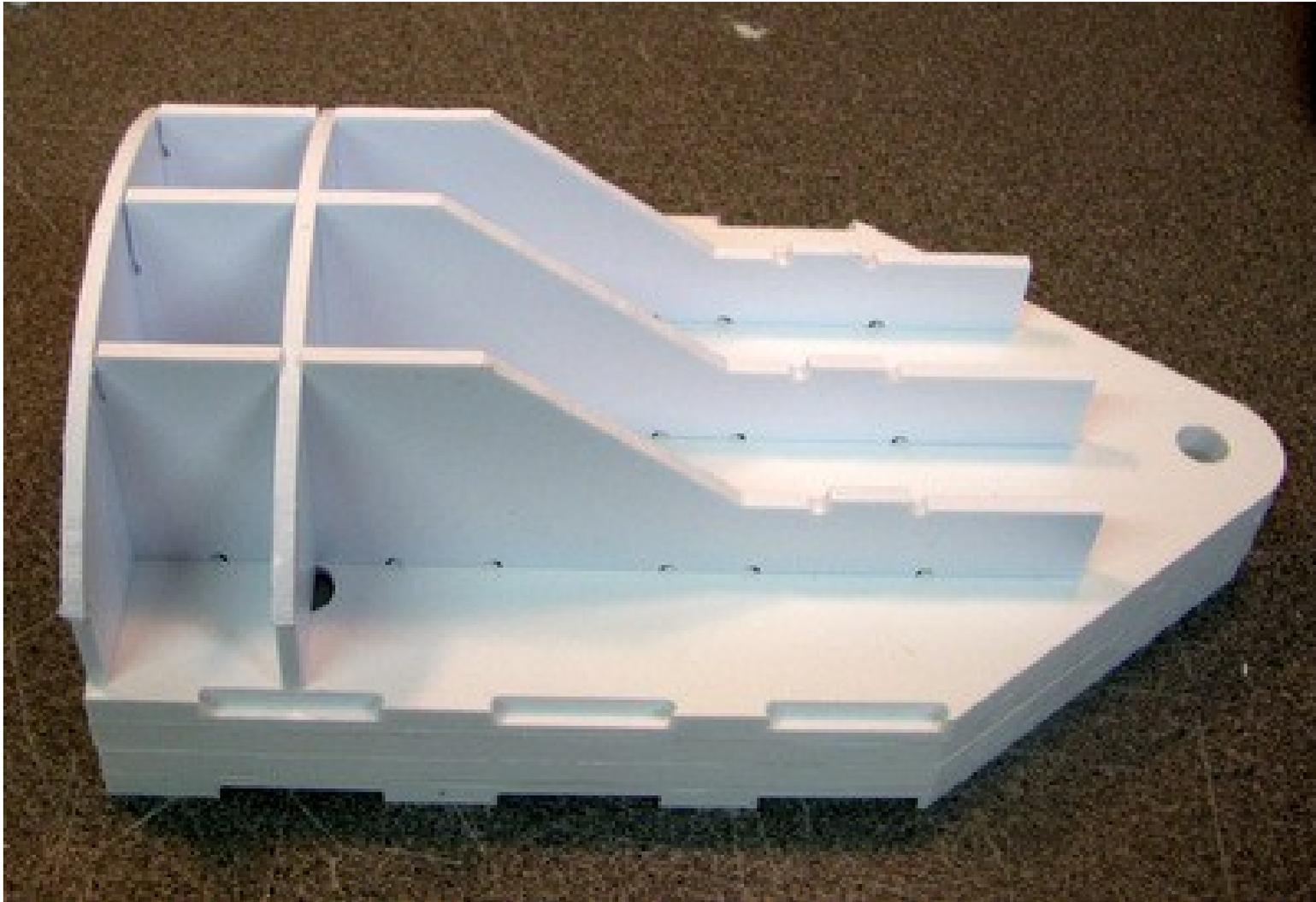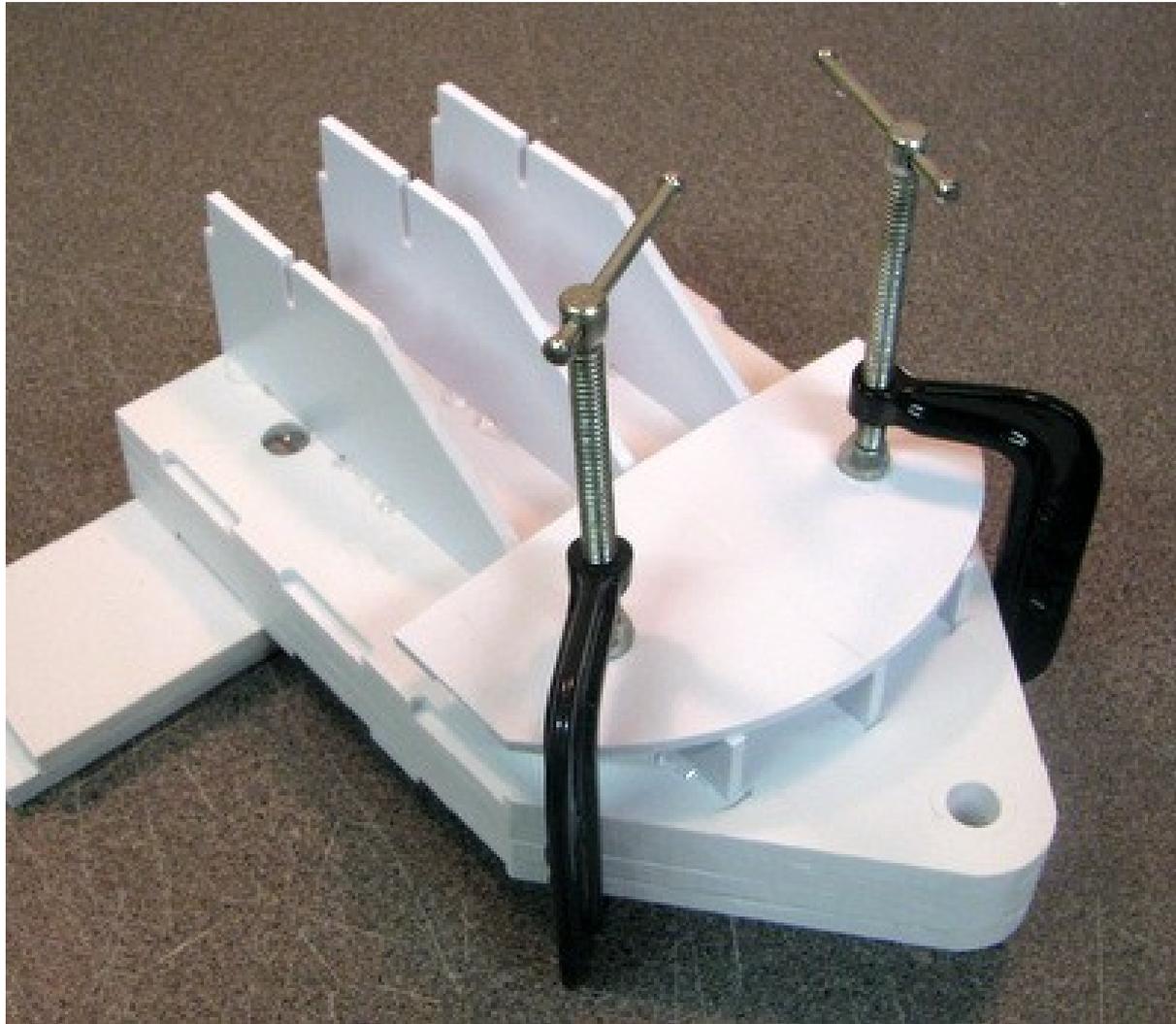
Part Strength

FUBAR Talk

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Battery Box 3D Model

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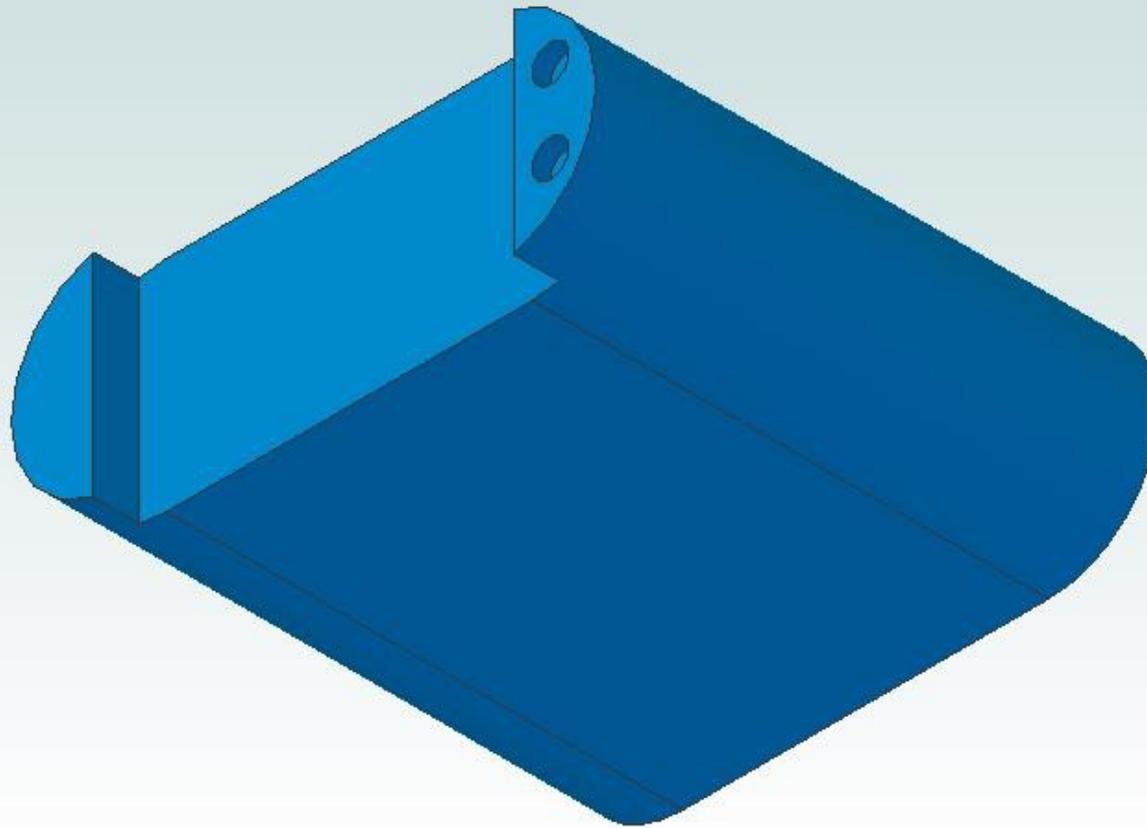
Battery Box Part Projection

Media Conversions
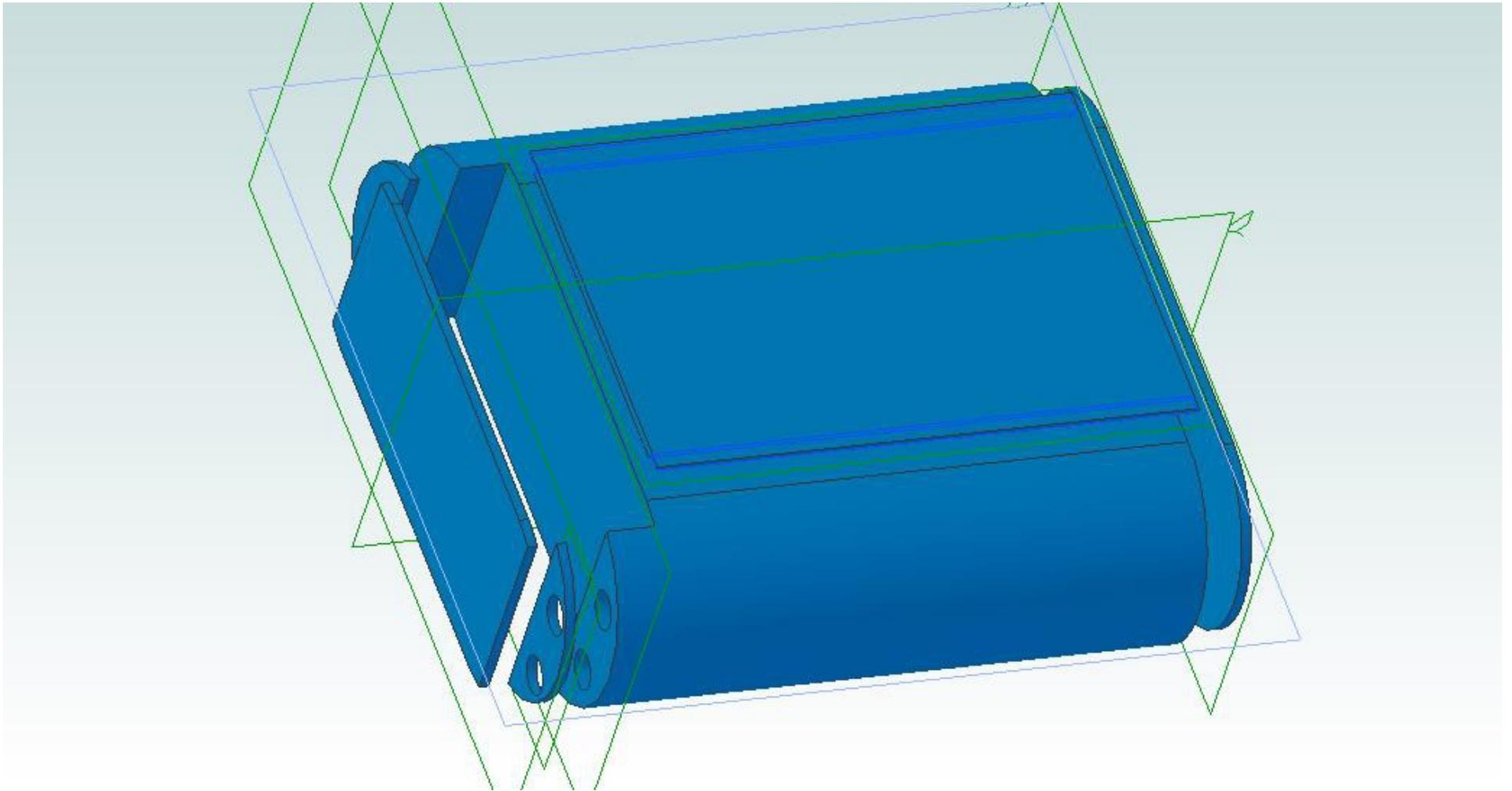
# Battery Box Assembly

New Battery Box Design
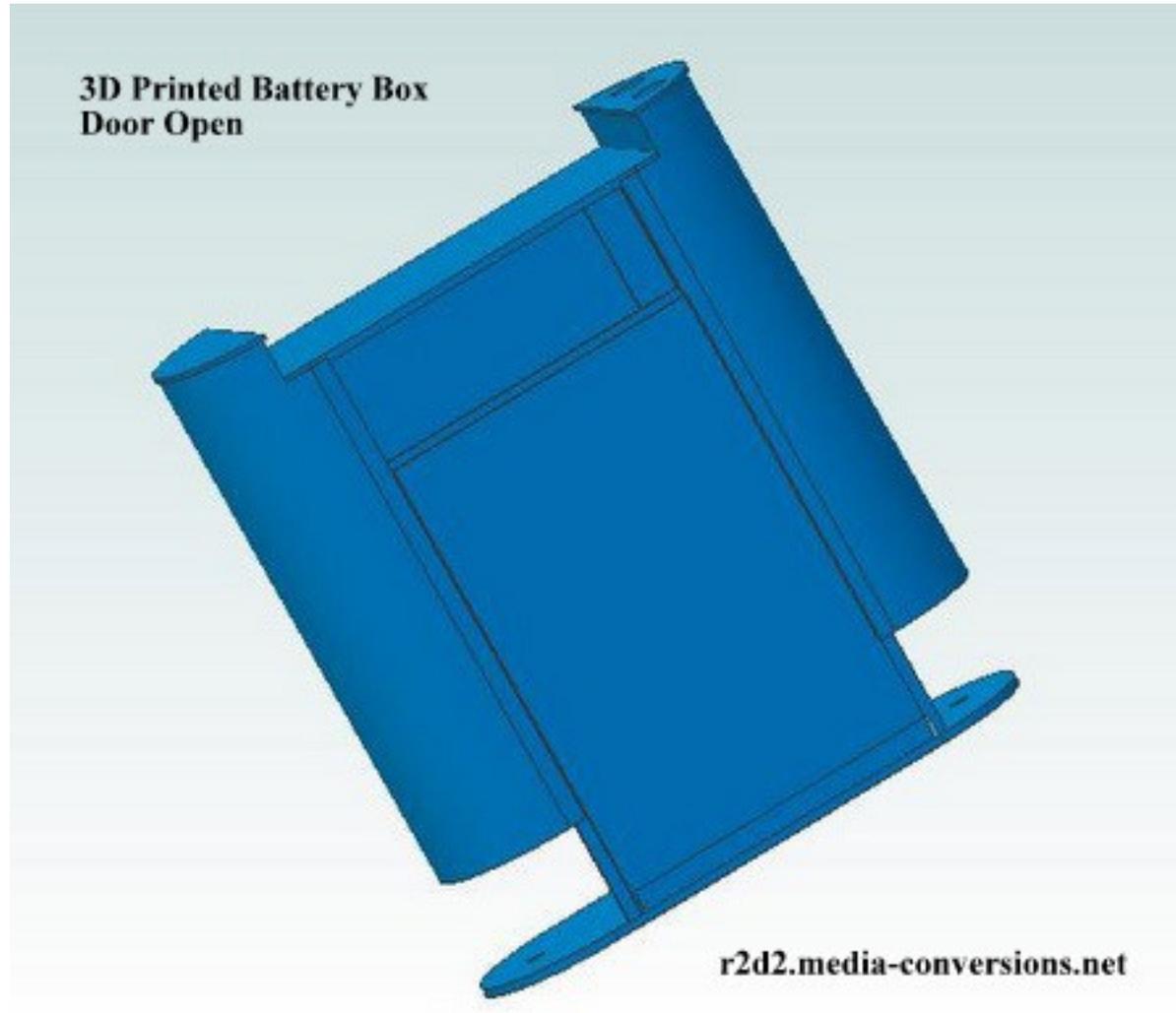

3D printed parts enable track for Sliding Door

Battery Box with 3D Printed Parts

Separate piece (not shown) used to hold Barrel Nut for attaching door

3D Part Evolution – Part 1

Curved End (original design)

r2d2.media-conversions.net
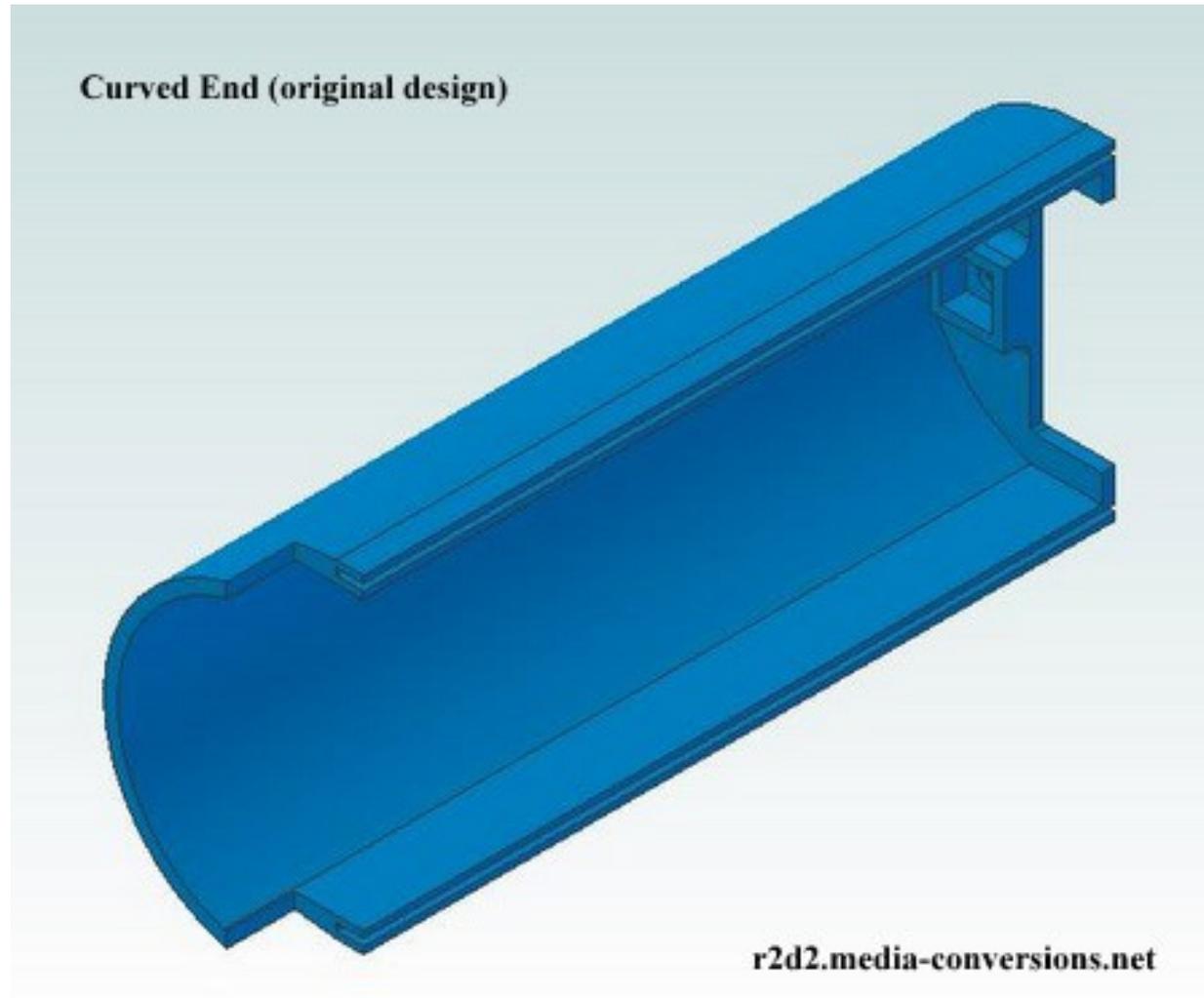
Converting to Square Nut enabled one piece design printed Nut Trap

3D Part Evolution – Part 2

Curved End with Closed Top

r2d2.media-conversions.net
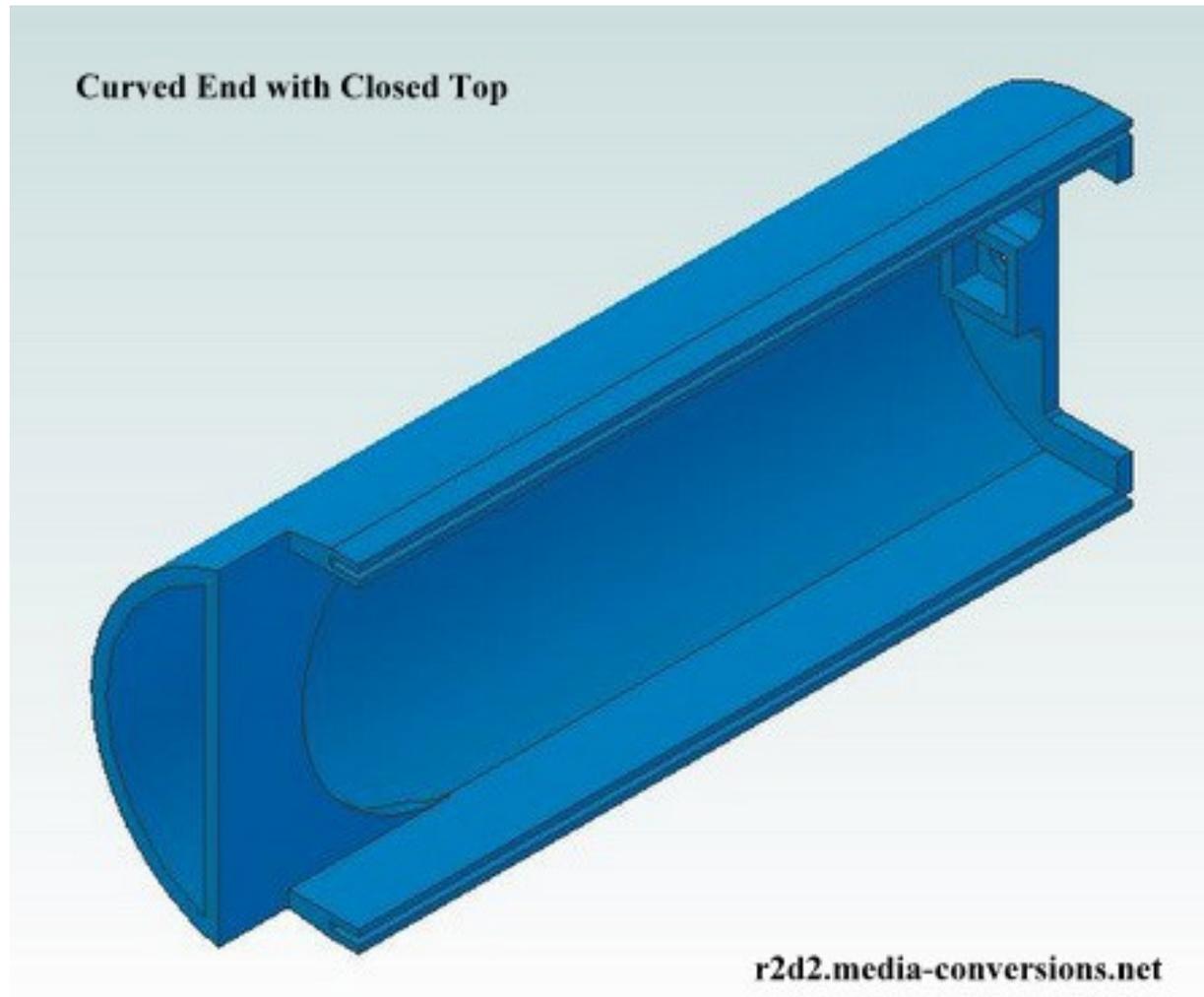
By closing top there is one less part & no hand fitting required

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Foot on the Half Shell

Andrew Radovich takes a different approach to 3D Printing

References

- Media Conversions Web Sites
  - CNC machine info:
    http://www.cnc.media-conversions.net/index.html
  - R2D2 construction:
    http://www.r2d2.media-conversions.net/index.html
  - R2D2 CNC Cut Styrene Parts:
    http://www.r2d2-cnc.media-conversions.net/index.html
  - R2D2 3D Printed Parts
    http://www.r2-3d.media-conversions.net/index.html
- Nuts & Volts - http://www.nutsvolts.com/
- Servo - http://www.servomagazine.com/
- Sherline - http://sherline.com/#menu
- Probotix - https://probotix.com/ also https://groups.yahoo.com/neo/groups/Fireballcnc/info
- CNC Zone Forum - http://www.cnczone.com/forums/
- CNC Router Parts - http://www.cncrouterparts.com
- Fine Line Automation Router Kits - http://www.finelineautomation.com/
- 80/20 - http://8020.net/ also Misumi - http://us.misumi-ec.com/vona2/mech/M1500000000/
- Geomagic Design (Formerly Alibre Design) software - http://www.alibre.com/
- Vectric Cut 2D software - http://www.vectric.com
- LinuxCNC software – http://www.linuxcnc.org/
- This Presentation located at:http://www.cnc.media-conversions.net/FUBAR.cnc.pdf