# Open Source CNC

My experience with LinuxCNC & GRBL

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# Home Airport - Richland 93C

# Are you a builder?

- I’m not an expert, I'm an enthusiast with a lot of experience.
- Every project I’m talking about here or with a raspberry pi - you can buy something off the self that does the same thing - but I'm a builder, I have this crazy need to build things and I learn so much in the process that I would never want to do it the other way -  to just buy a cnc setup.

# Zenith 750 STOL - 750WW

# Open Source - Why now?

Maturity Ease of use -  has come a long way

Even 10 years ago installing stuff was a nightmare, dependencies. LinuxCNC wizards

Accessibility just like open source OS

Open source is everywhere, try out a dozen different OS and programs

Cost  Most of it is FREE $$

If you make something cool, share it - give back

# What is Open Source?

FOSS - Free and Open Source Software

**Operating systems** - Linux and Android

For operating systems, think of **Linux** as the engine and **Distributions** as the type of car. Every car has an engine but different cars do different things - a truck vs a van vs a sports car. If you have an old laptop or desktop, try Zorin or Linux Mint or elementary OS or Debian. These offerings have come along way in the last 5 years.

# What is Open Source?

## Software

FreeCad - if you know basic solidworks, similar

Inkscape - Drawing

LibreCAD - 2D

LinuxCNC - controller software

GRBL - microcontroller based

# Overview

- Software
- Hardware
- Workflow
- and a little controversy?

# Software

CAD - Computer Aided Design
What you use to design a part.
***This may stop a lot of people right here but I will show you a super sweet shortcut for some simple tasks.
**FreeCAD**, Solidworks, Fusion360

# Software

**CAM**
Translates part design into a tool path. I use SheetCAM which is not Open Source but it is not that expensive and well worth it.

**MasterCAM, SheetCAM**, Aspire, Photo V Carve

# Software

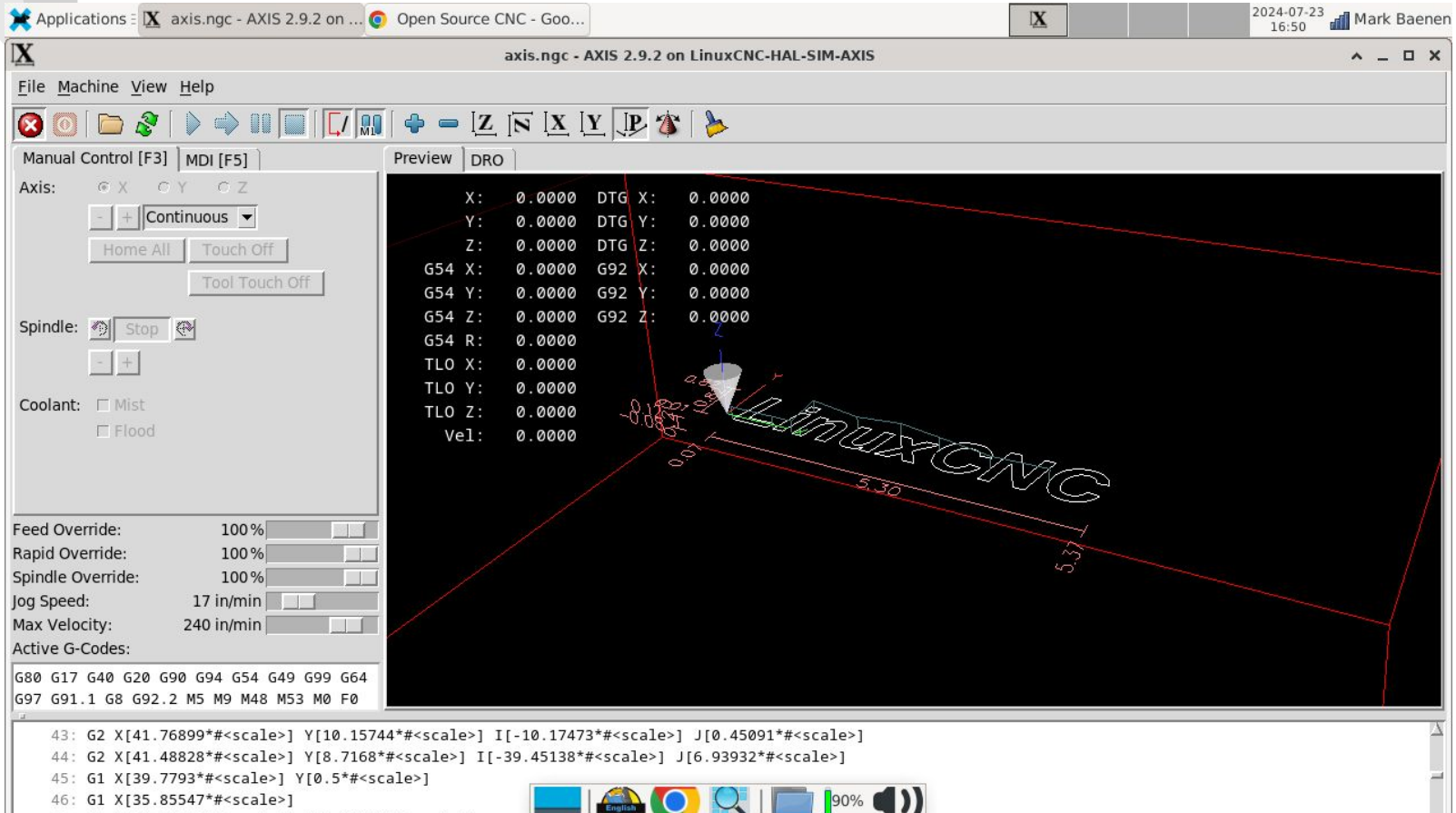
**Tool Driver**

Takes the tool path (Gcode) and drives the tool

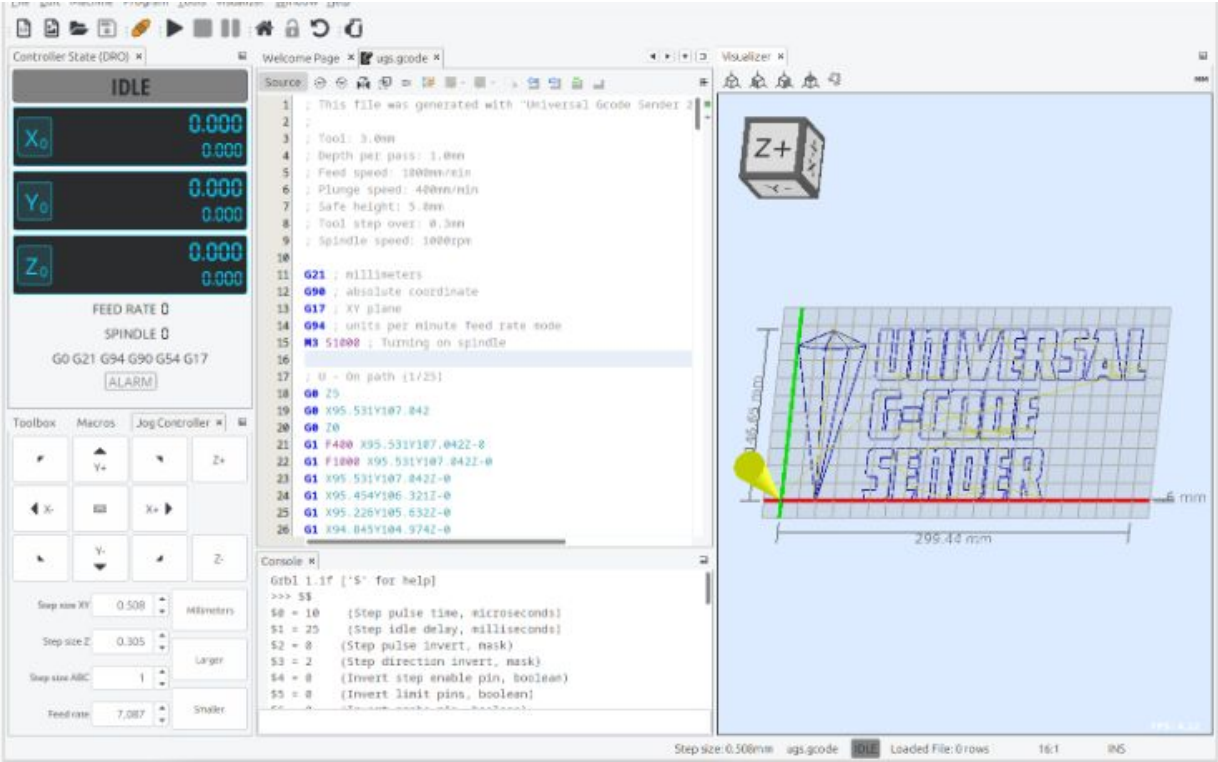
**LinuxCNC**, Mach3, Mach4

LinuxCNC comes as it's own full package - the OS and controller program all in one plus a secret weapon.

# Software- LinuxCNC



# Software - Universal G-Code Sender



# Software

Is there an all-in-one program?

No

# Hardware

**Table design**

I'm advocating and using the gantry design because it can be made from **cheaper materials** and is **easily expanded** and the **drive system** can be made in several different ways.

# Hardware

The gantry has two trucks or skates that roll along the top rails of the table.

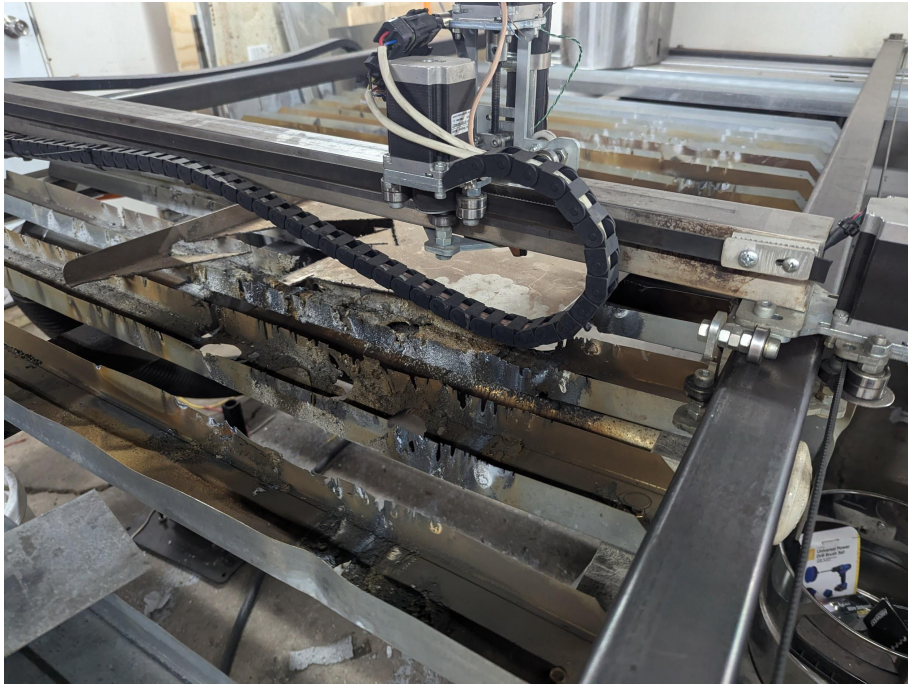
It usually is the x-axis

A beam connects the two trucks

A single truck rolls along the beam and holds the tool

It is usually the y-axis

The tool is on the z-axis slide



# Hardware

Gantry - “Crib” style construction

2 Y axis members are the most critical

They can be clamped and drilled together for most accuracy.

Do not want taper in the two x-axis members

# Hardware

The bottom X-axis rail supports the bed

- Plywood, MDF, wasteboard
- Slats or metal studs

# Hardware

The gantry is THREE AXES but requires 4 motor controllers

Sometimes called XYZA

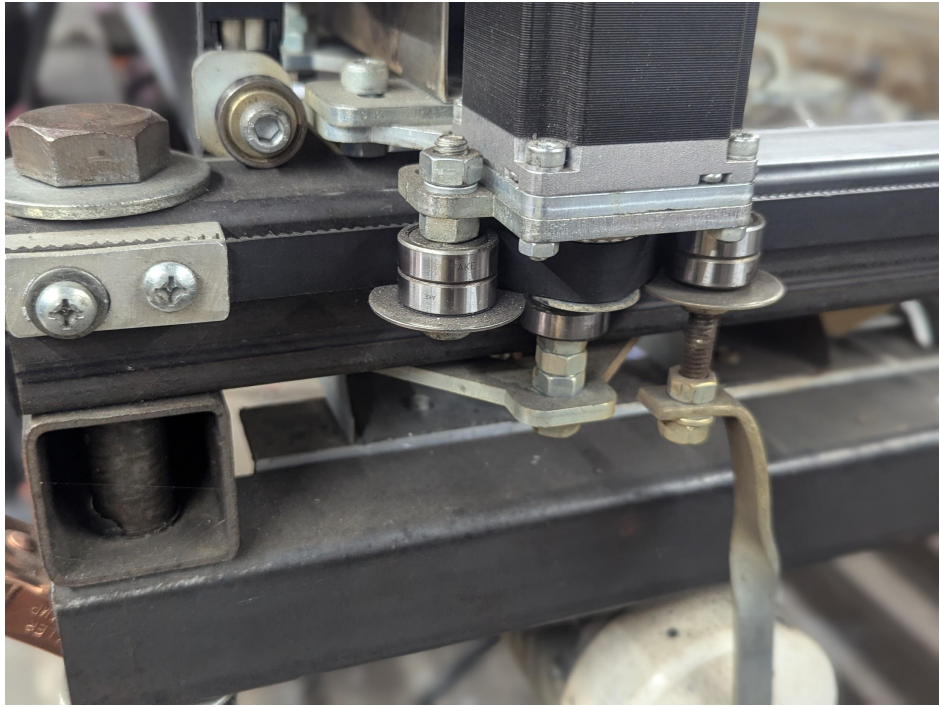
Or XXYZ

The A axis gets duplicated or “slaved” to the X

# Hardware

Different drive options:

- Timing belt and gear
- Rack and pinion
- Lead screw
- Ball screw



# Hardware

- **Rack and pinion**
  High torque, easy to use w/ **reduction gear**
- **Lead screw**
  Better accuracy, high torque
- **Ball screw**
  Best accuracy, more expensive

# Hardware

Table exhaust or dust / chip collection

Downdraft, updraft & water table for **Plasma**

Vacuum system for **Router** or **Laser**

Mist cooling for **Mill** / **Lathe**

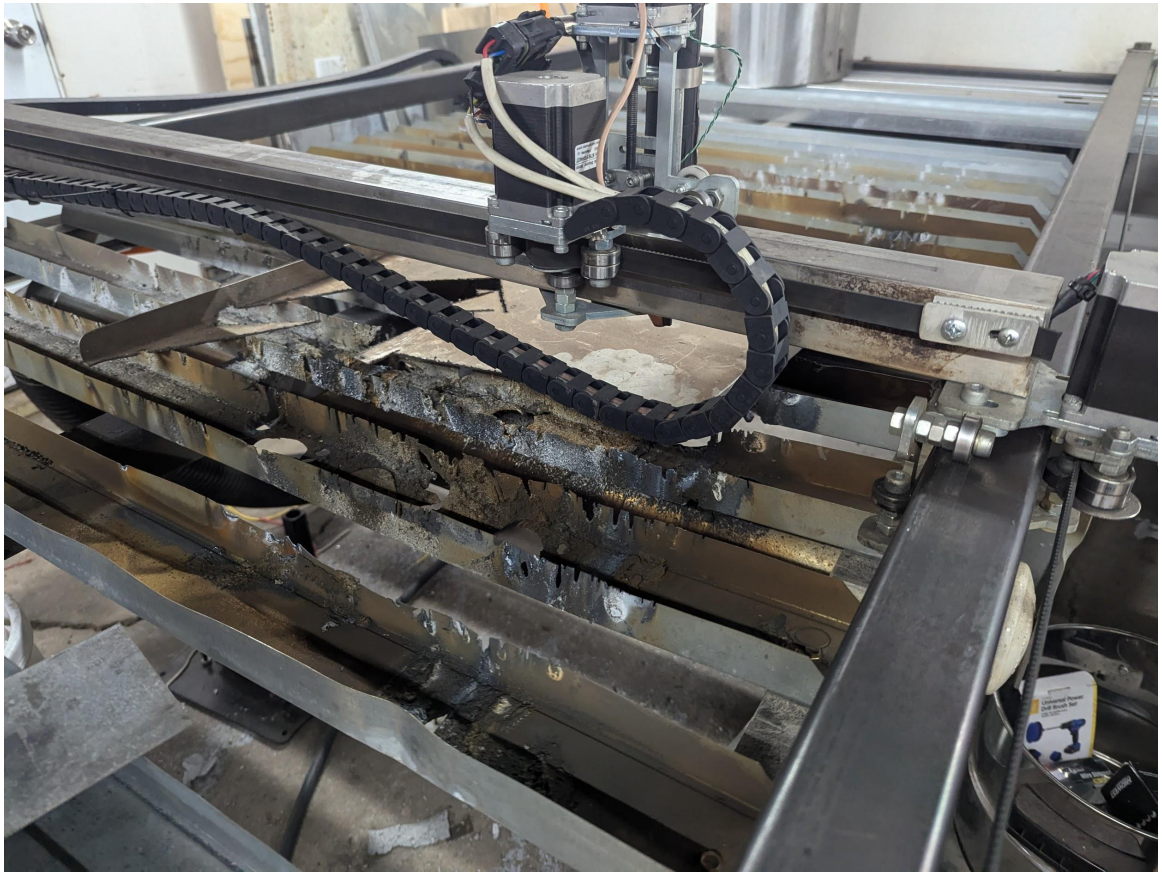
# Hardware

Downdraft

- Slotted tube below slats
- Connected to dust collector vented outside

Water Table

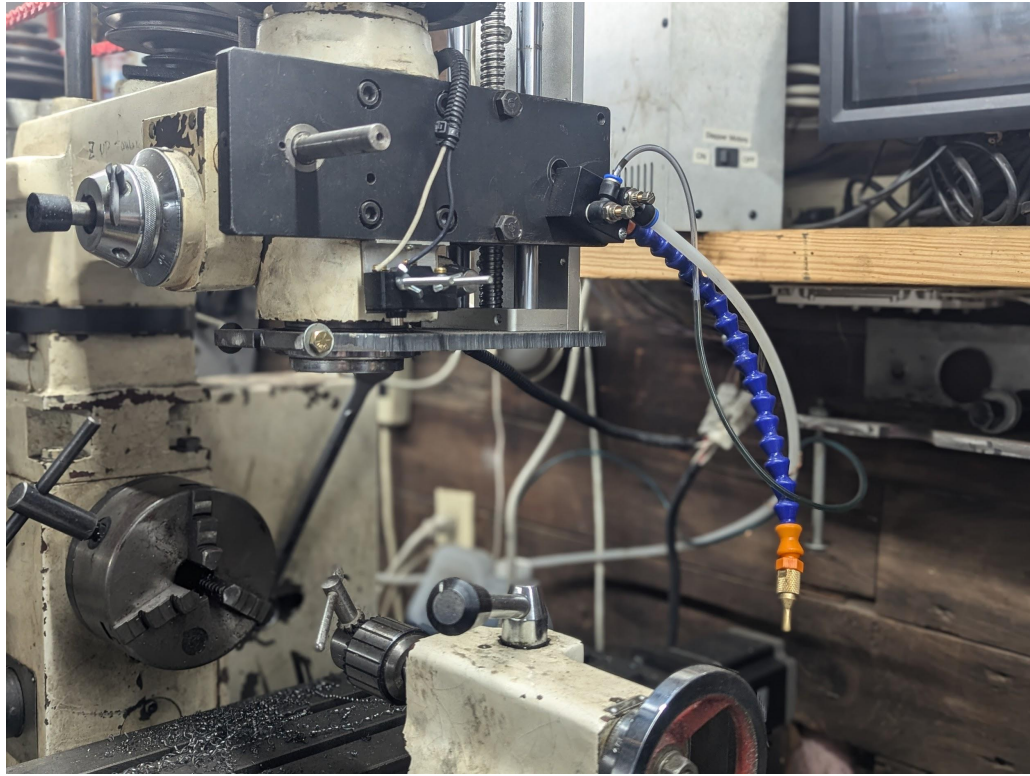
- Messy but **COOL**



# Hardware

Mist Coolant

- Controlled from G-Code
- Mill / Lathe /Router



# Hardware

Gantry Trucks

github.com

markbaenen/Open-Source-CNC

2x2-Gantry-All.dxf

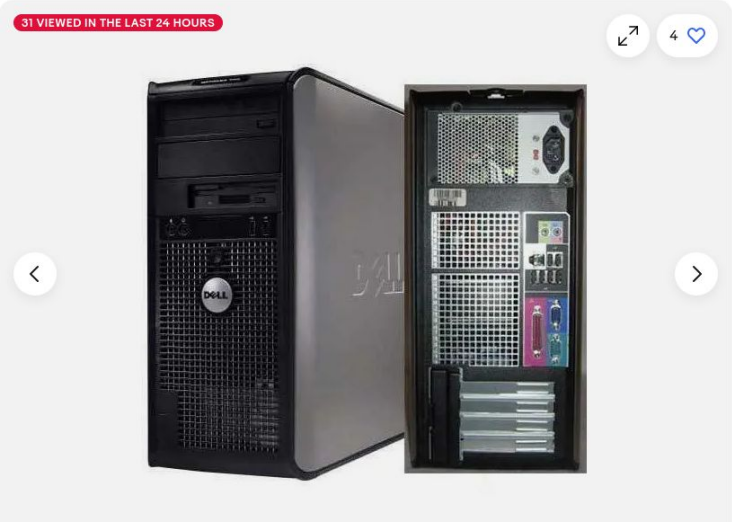
# Hardware

| CPU | Interface | Connector | Motor Controller | Motor Driver |
|---|---|---|---|---|
| Old 32 bit PC (LinuxCNC) | Parallel Port | Parallel Cable | Generic TB6560 | GenericTB6560 |
| Newer PC (LinuxCNC) | Add in Parallel Card (see Forum for compatibility) | Parallel Cable | Gecko G540 | Gecko G540 |
| Newer PC (LinuxCNC) | Mesa 5i25 | Parallel Cable (Plug-N-Go kit mesanet.com) | Mesa 7i78 | Separate Motor drivers |
| RaspberyPi (LinuxCNC) | Ethernet | Ethernet Cable | Mesa 7i76 | Separate |
| RaspberryPi (LinuxCNC) | SPI | Direct Connection | Mesa 7c80 | Separate |
| Old Laptop UGS (Universal Gcode Sender) | USB | USB Cable | Arduino Uno + CNC Shield (GRBL) | Separate |

# HARDWARE

## Old PC?

- Parallel port (pink)
- 32 - bit
- Windows XP vintage




**Windows XP PR**
**PC - RS232 Seri**

To create your account, Google will share your name, email address, and profile picture with eBay. See eBay's privacy policy and terms of service.

TickTock Deals (45759)
94.5% positive · Seller's other items · Contact seller

**US $99.99/ea**

No Interest if paid in full in 6 mo on $99+ with PayPal Credit*

Condition: **Used**

*"Brands Include Dell HP Compaq and Lenovo. Choose either Full Size Tower or SFF."*

Size: **Select**

Quantity: 1 More than 10 available · 2 sold

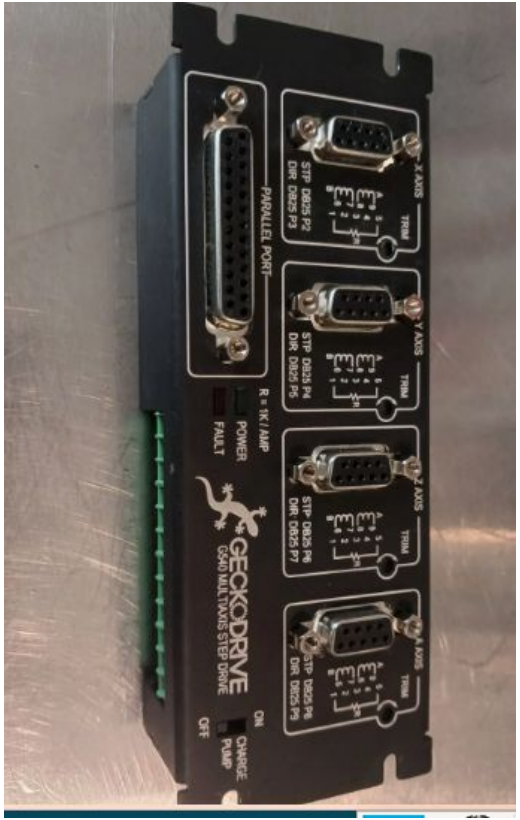
Bulk savings:

| Buy 1 | Buy 2 | Buy 3 | 4 or more for |
|---|---|---|---|
| $99.99/ea | $97.99/ea | $95.99/ea | $93.99/ea |

# Hardware

TB6560

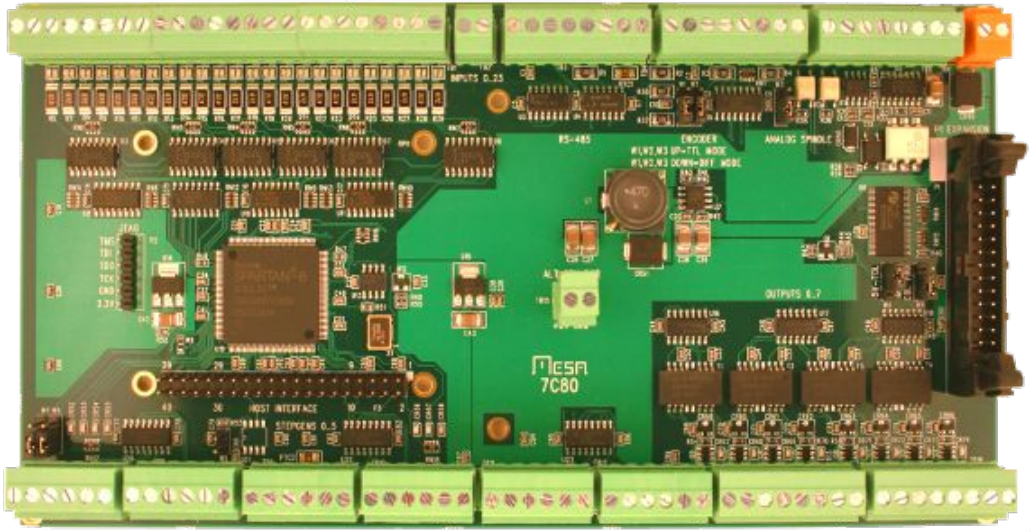
Gecko G540



# Hardware

**Mesa 7c80**

- RPi 4
- Direct connect by SPI
- Many connections = 6 motors + 24 IO
- RPi 4 = $35



# Hardware

Separate Driver?

# Hardware

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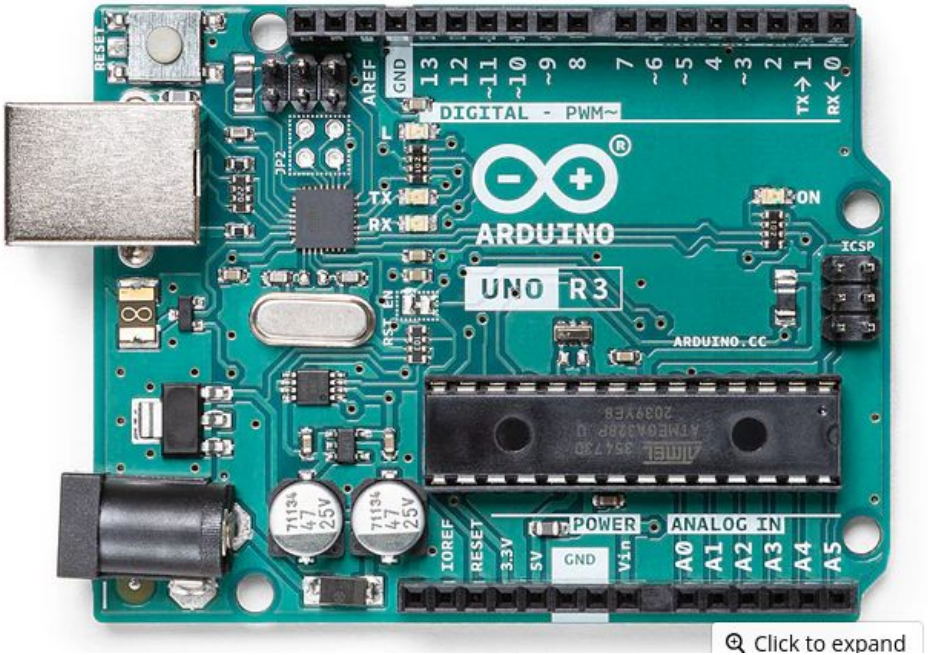
# Hardware

## Arduino Uno +

## Shield

- Microcontroller - load a small program, it executes.
- Shield is for easier wiring, it plugs on top
- Uno =$27



# Hardware

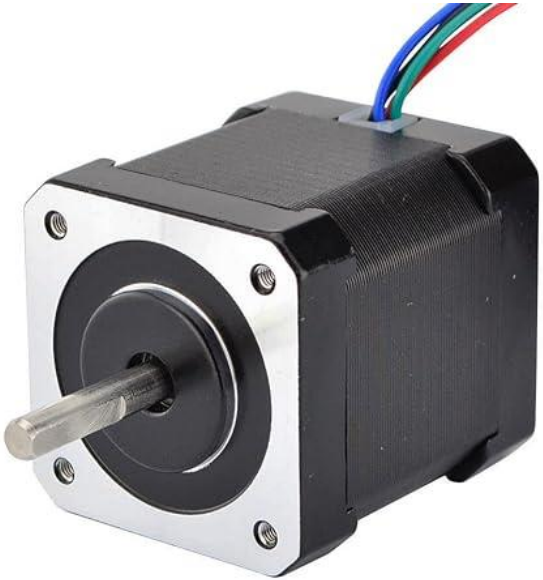
- Arduino Uno micro controller uses GRBL to control the motor drivers.
- GRBL is an acronym - G-Code Reference Block Library
- Communicates with the control program over USB (not Real Time)

grbl

# Hardware

**Stepper Motors**

- Typical NEMA sizes - 17, 23, 34, 42
- Size is distance between bolt holes
- Has no direct indication of strength
- Hybrid stepper motors??? - closed loop feedback



# Hardware

If you build a Plasma Table, I HIGHLY RECOMMEND

A GOOD Torch

THC (Torch Height Control)

# Workflow

**FreeCAD**
->DXF, SVG (drawing file)
-> **SheetCAM**
-> TAP, NGC (Gcode)
-> **LinuxCNC**

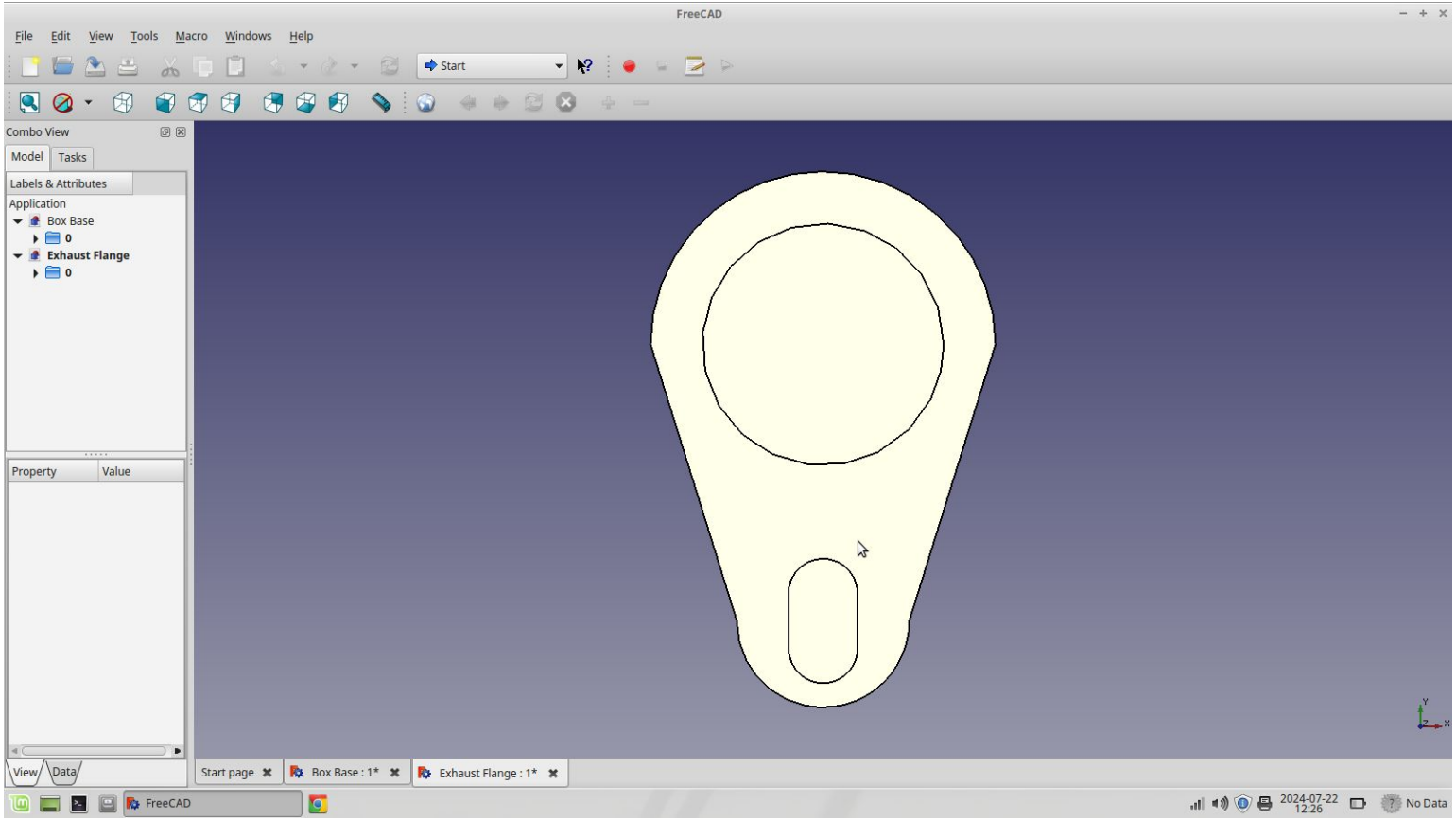
# Workflow

Most CAM software have a specific Post-Processor for your specific hardware

- Different hardware can have different specific functions
- The Post-Processor tailors the design to your hardware.

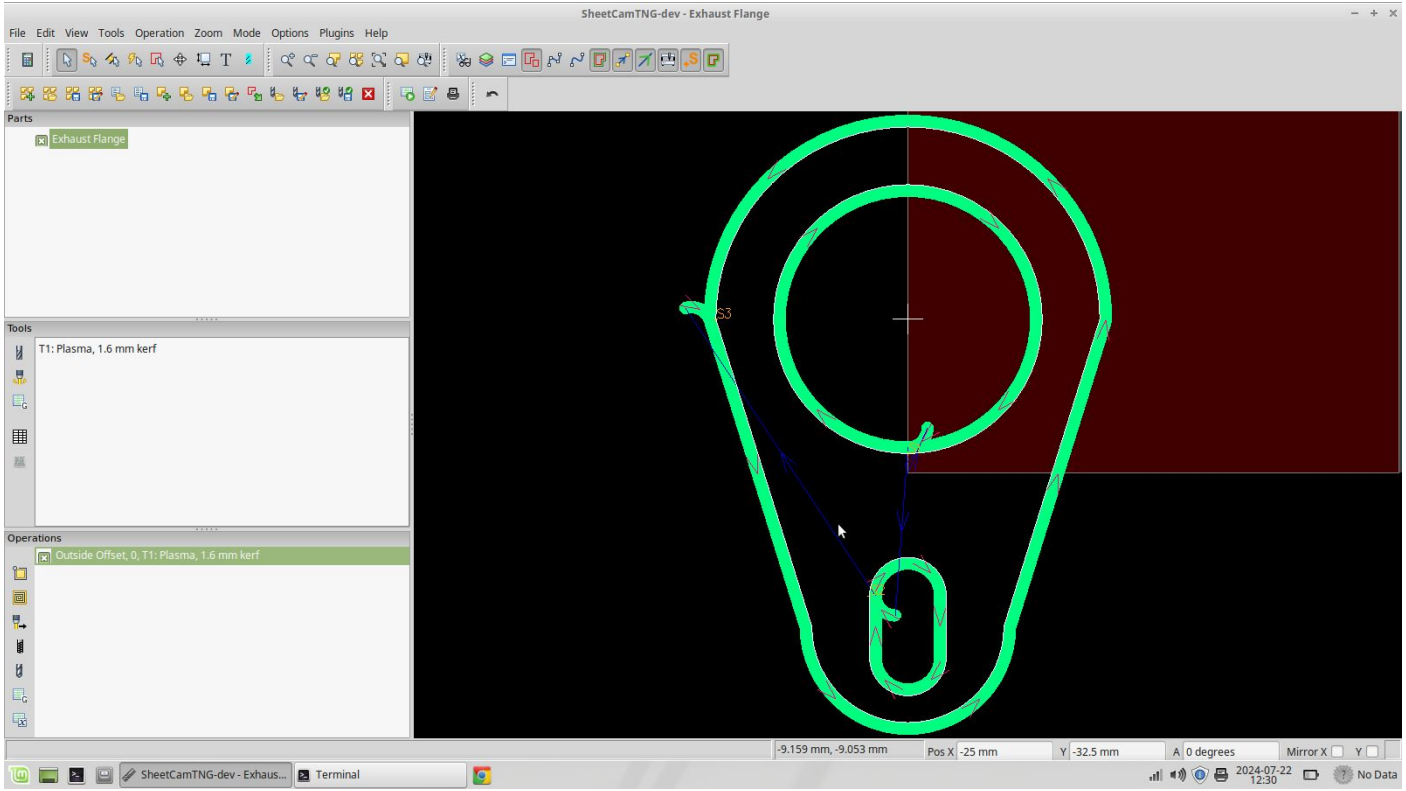
# Workflow

Exhaust flange designed in FreeCAD



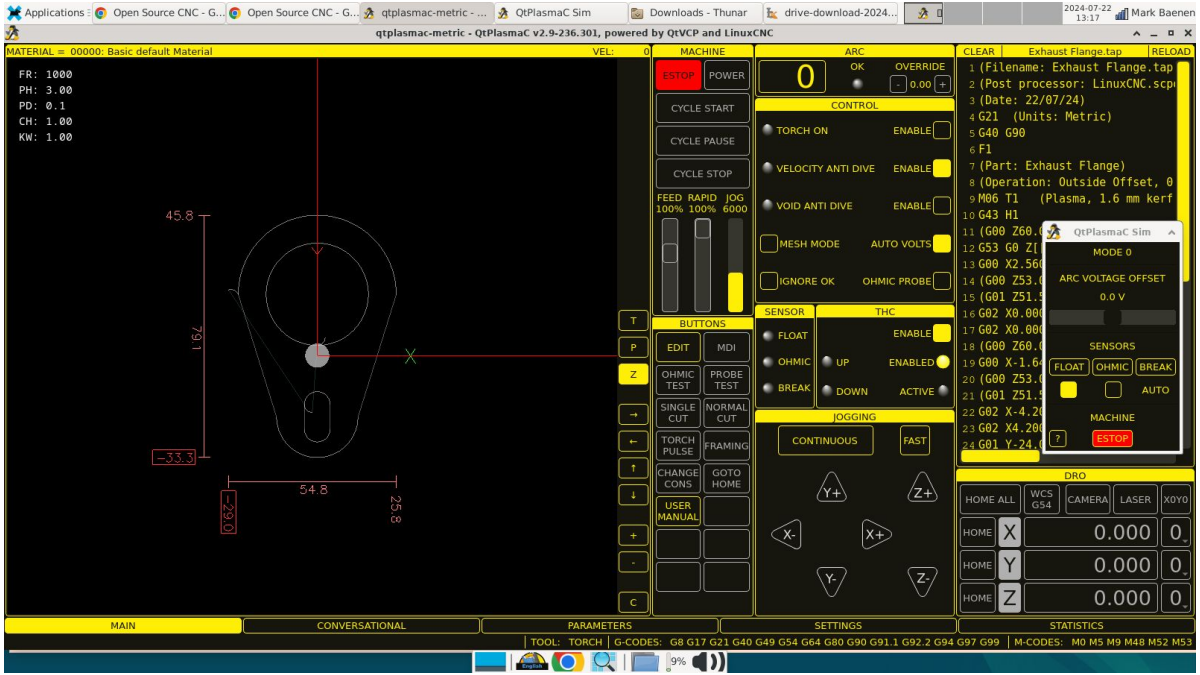
# Workflow

Exhaust flange in SheetCAM



# Workflow

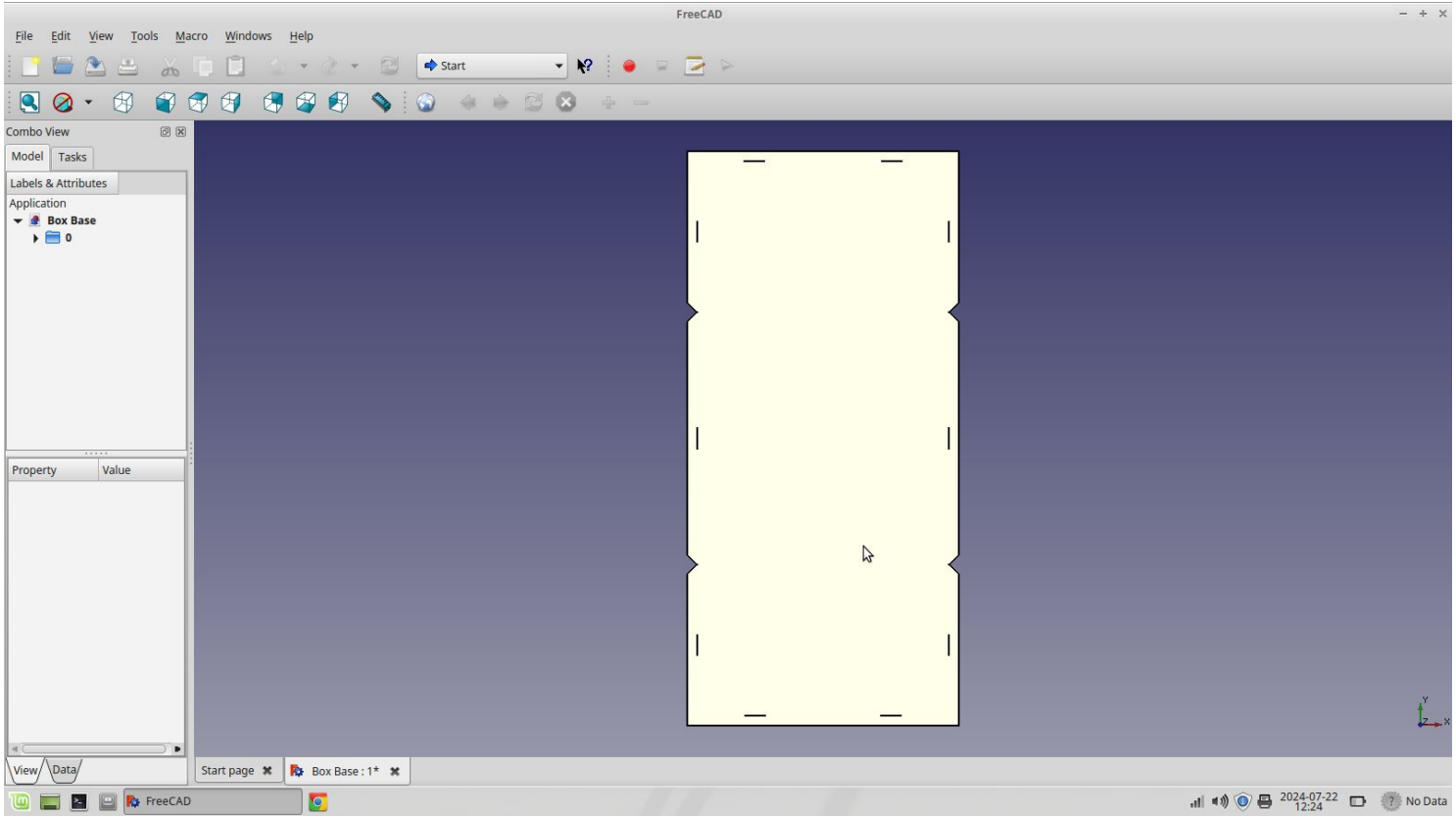
Exhaust flange in LinuxCNC



# Workflow

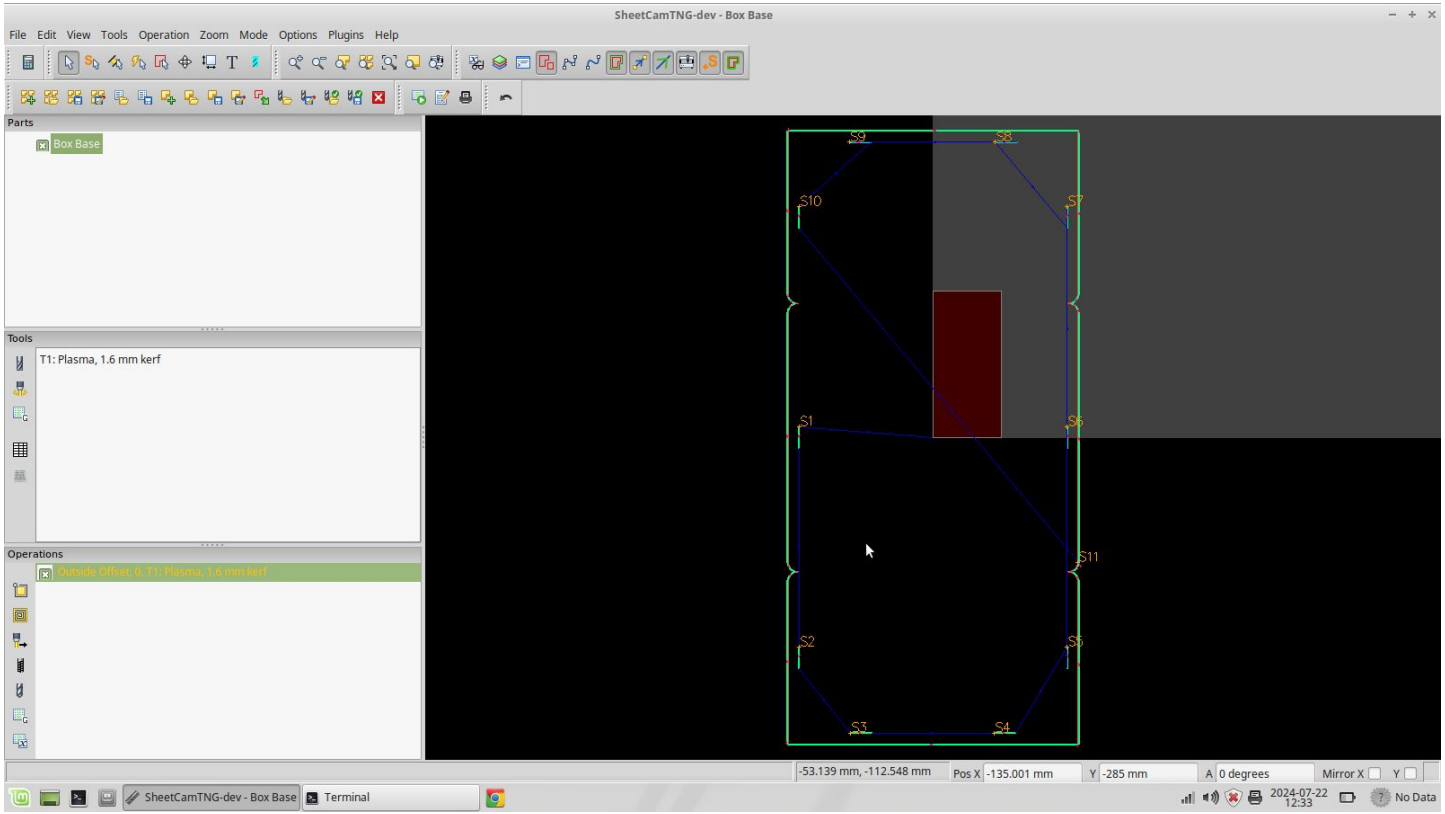
Control Box

designed in FreeCAD



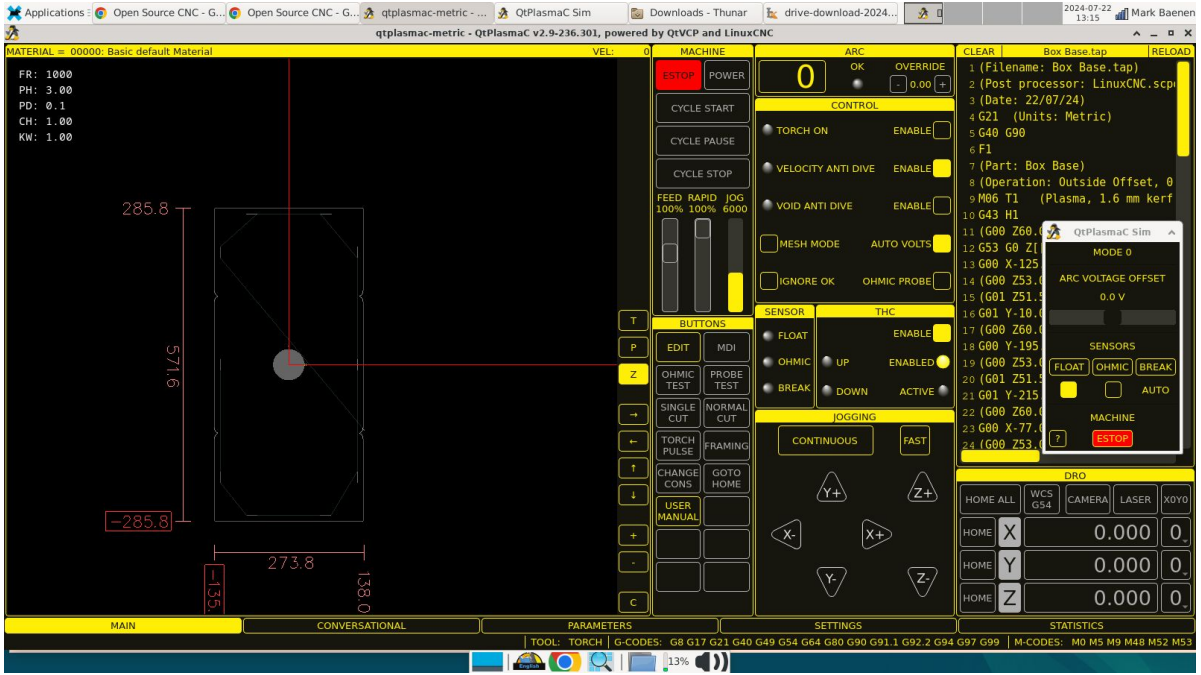
# Workflow

Control Box In SheetCAM



# Workflow

Control Box in LinuxCNC



# Workflow

Super Sweet shortcut In LinuxCNC - Plasma

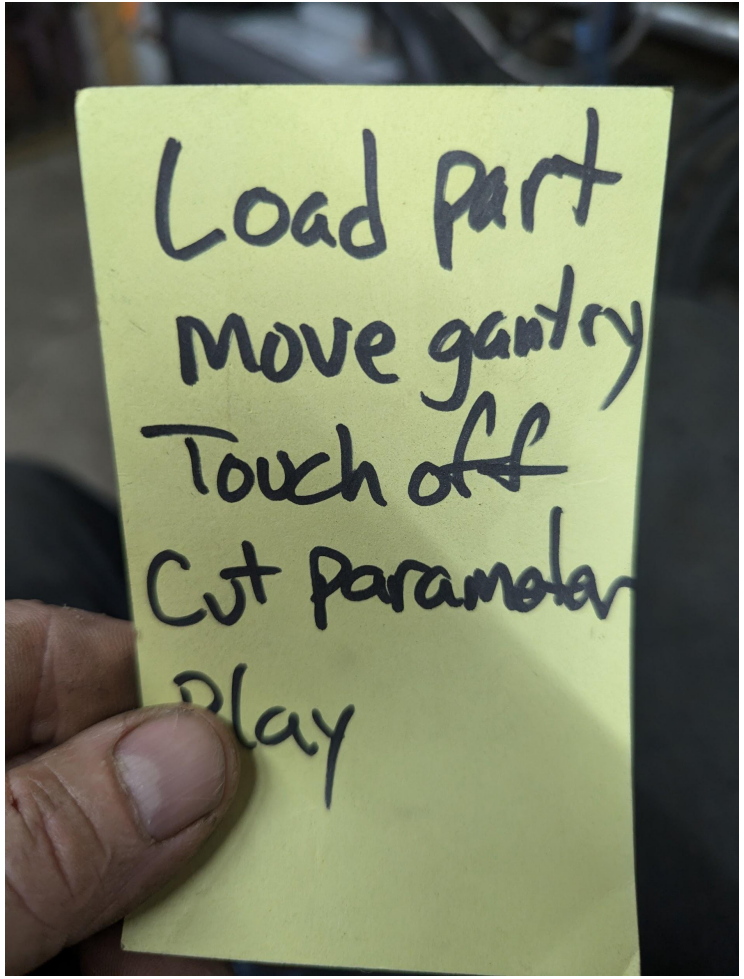
**Conversational**

- Built in
- Basic Shapes to Complicated
- CAD is the step that slows down most people
- If I wanted to cut out a 10 x 30 cm rectangle out of .065 steel, I need to design it in CAD?
- NO! **Conversational**!

# Workflow

Demo
Conversational

My Cheat Sheet



# Workflow

Say I want to make a firewall fuel pass through. I have a ⅜ NPT stainless nipple and I want to cut out a flange to weld to it. Draw inner circle - add, draw bolt circle - add, draw outer circle - add. Pass to QTPlasma. Move gantry. Touch off. Select our material.  Press play.

# Workflow

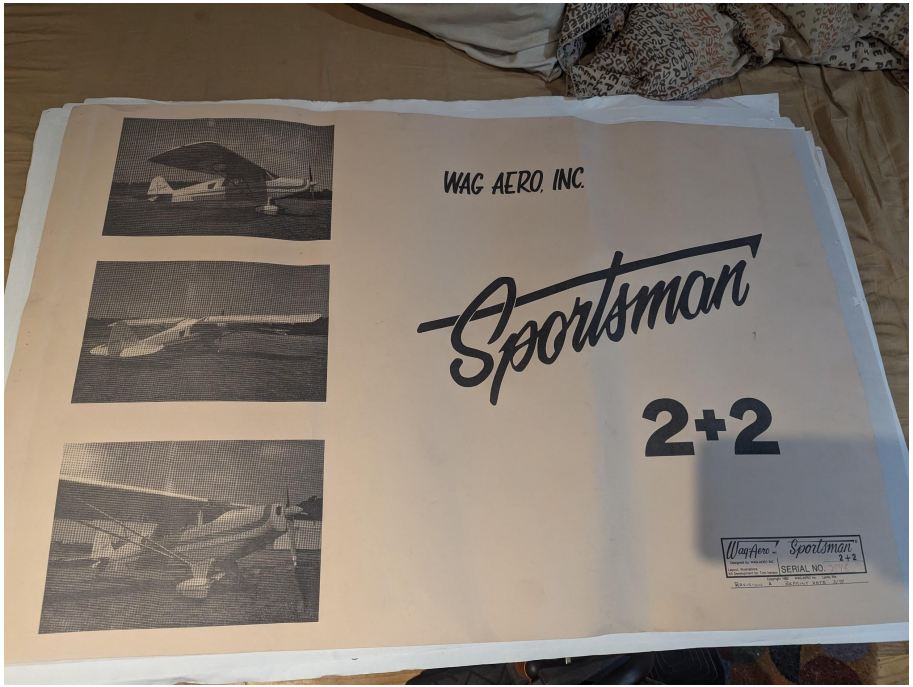
Instead of multiple steps in multiple programs, Conversational is all inside of LinuxCNC making some tasks very easy.

Just about every project:

You always start off with “So I need a piece .....”

# Controversy?

This is the next project that I want to build. a Wag Aero Sportsman 2+2. I have super useful and accurate tools to build things.



# Controversy?

All I need now are plans of the things I want to build. It would be super easy if I could buy **digital plans** of something that I want to make. Again, that is the biggest barrier for most people - the CAD part.

# Controversy?

I have asked several companies (Thatcher and Hummel) if they would sell digital plans. They will happily sell you paper plans but they act like you're asking for an organ donation if you want digital plans.

# Controversy?

You Say - “But digital plans are so easy to copy.”

- My local printer will do large format scans to PDFs for $50 - a complete set of plans.
- A scanned set of plans is NOT a CAD model - a CAD model has all the possibilities.

Does anyone know of a real aircraft that has been built & registered from a copied set of plans?

# Controversy?

So what do I do?

I hired a Freelancer, freelancer.com to convert my plans to CAD.

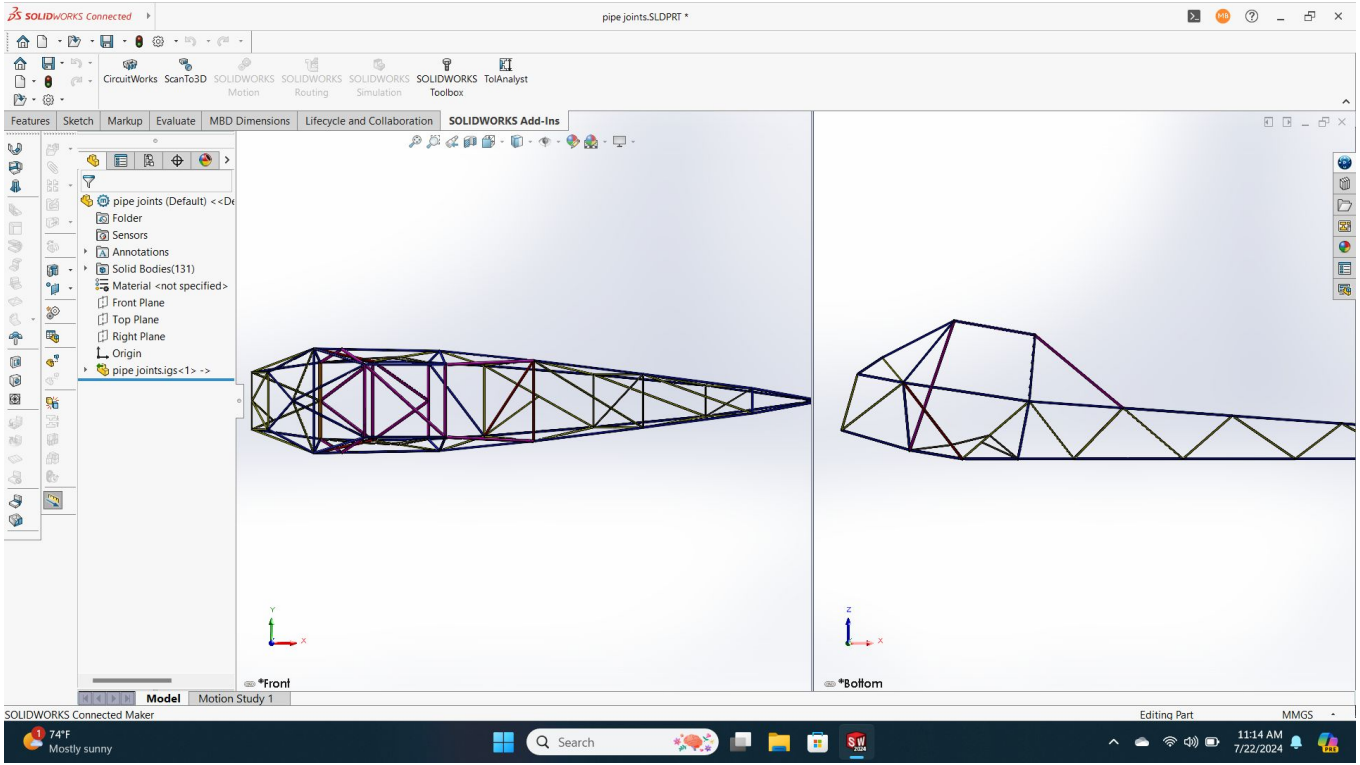
Very easy to find someone with tube frame and manufacturing experience in SolidWorks

# Controversy?

My point -

- Why are we stuck in the 20th century?
- How can digital plans be copy protected?
- Why can’t the owner make more $ off me by selling digital plans?
- Is there really a copying “problem”?

# Next(ish) Project - Rotary Plasma Tube Notcher



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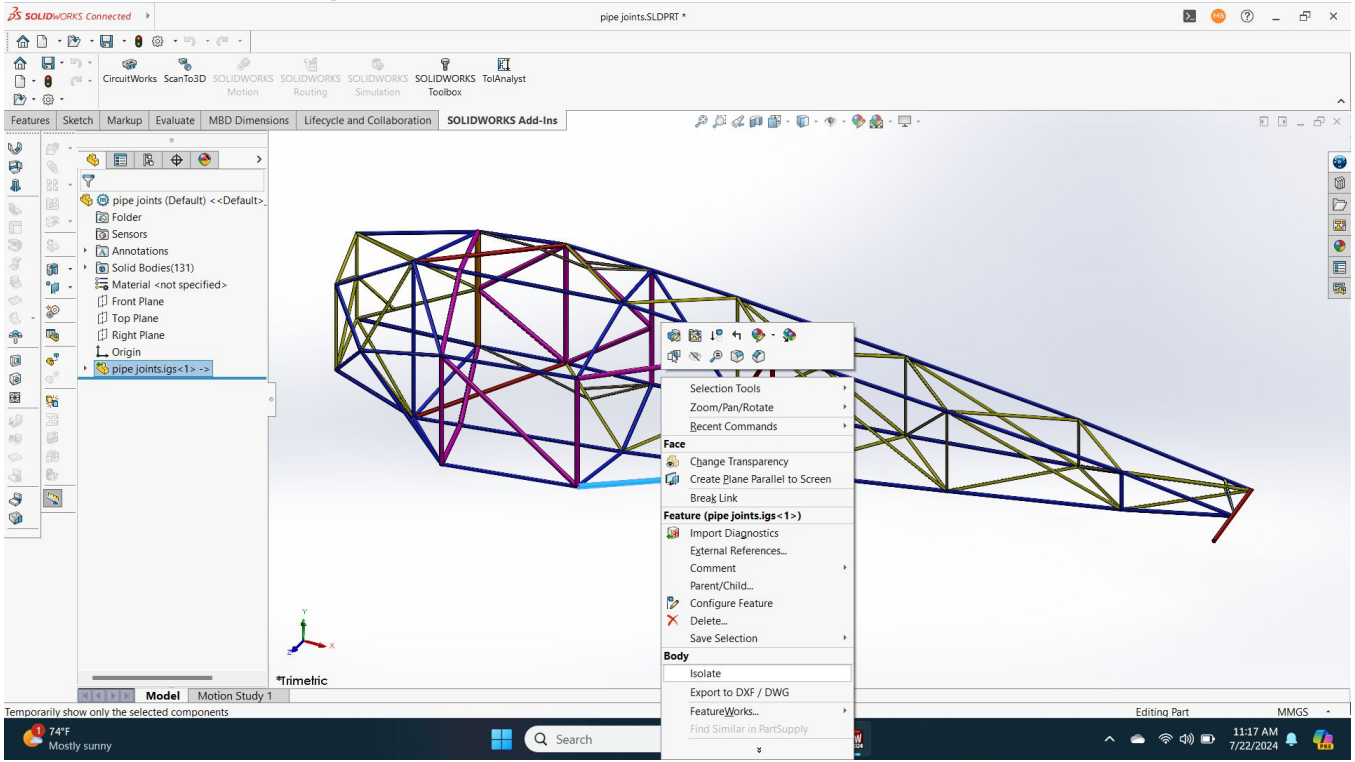

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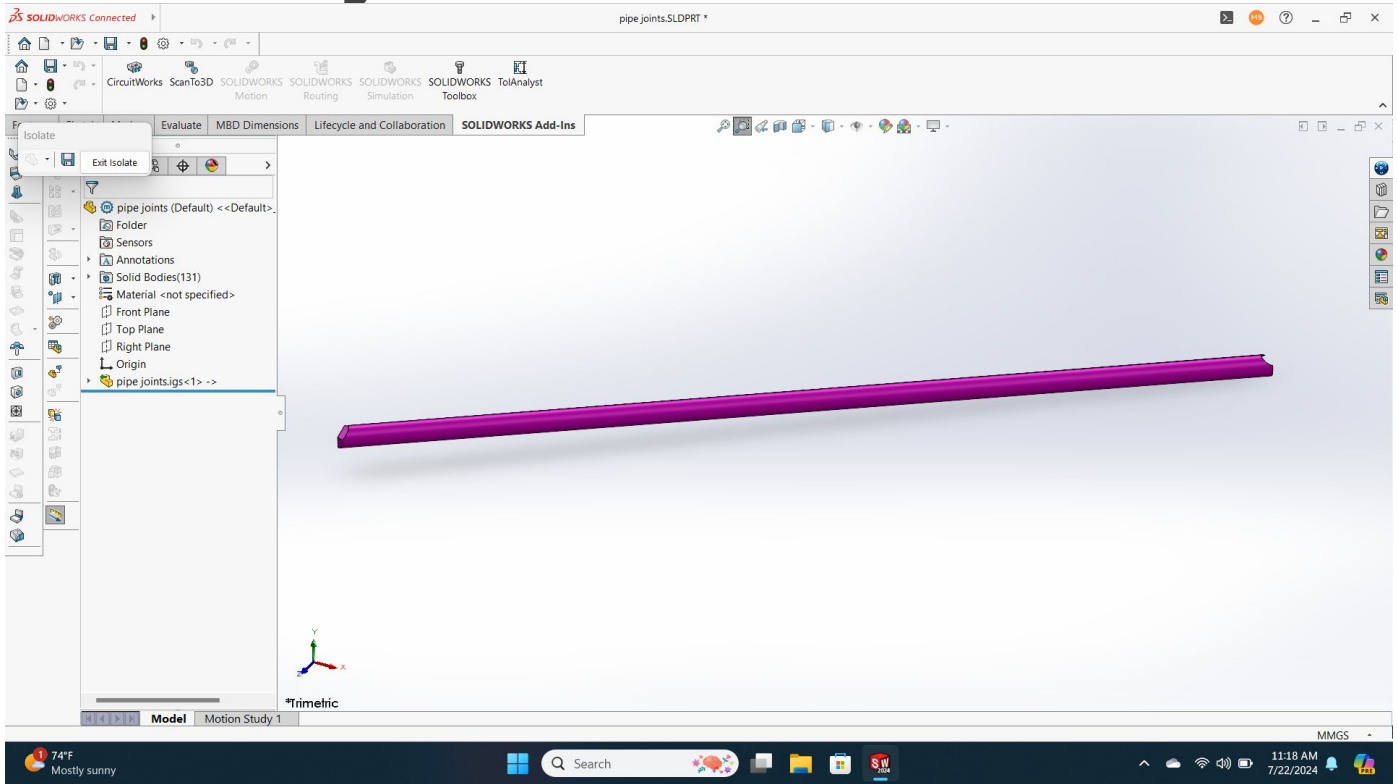

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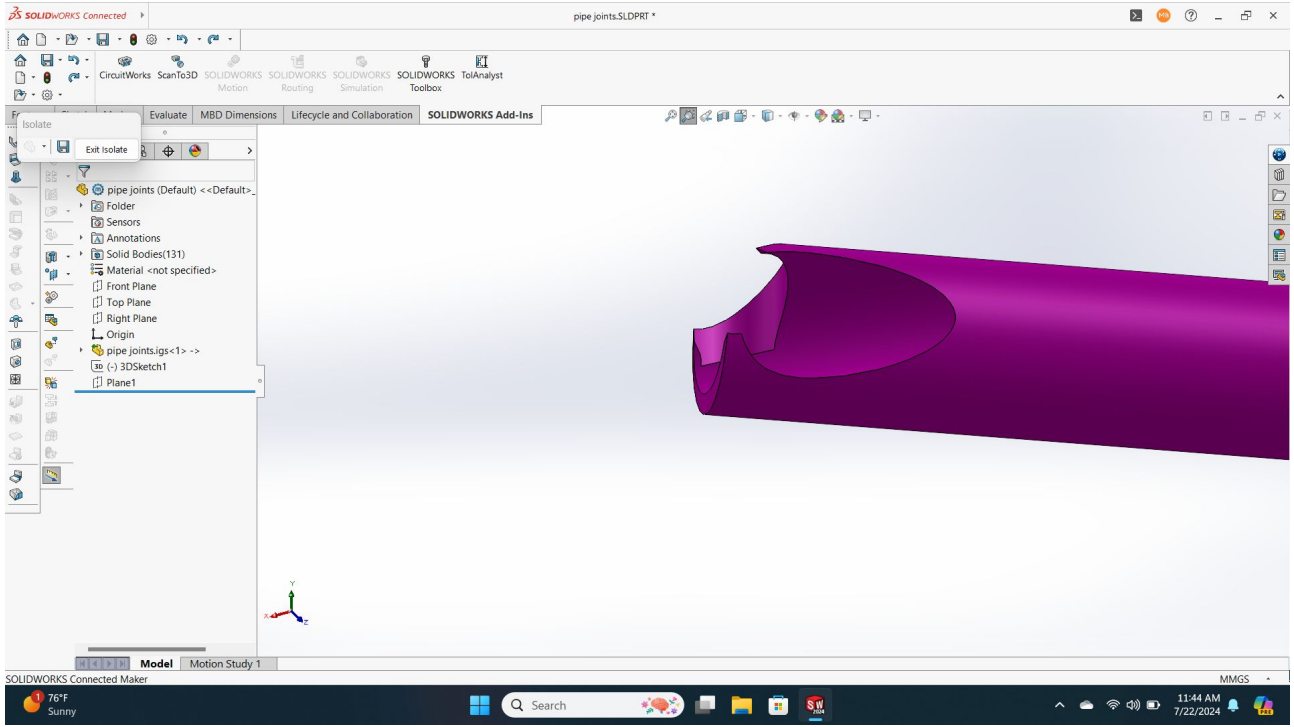


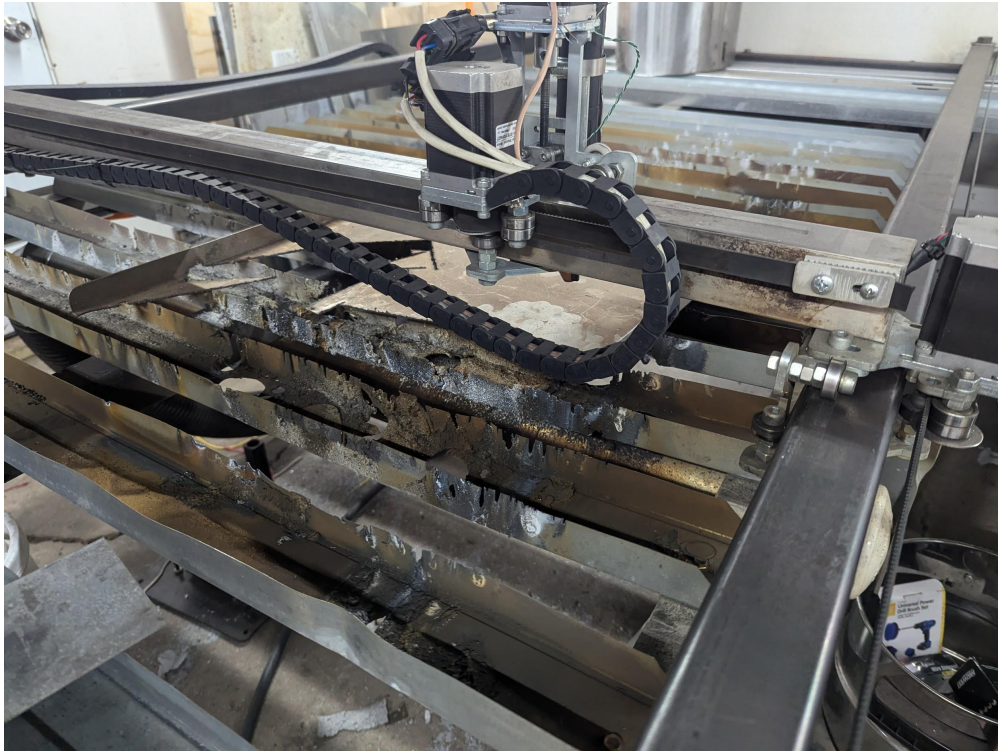
# Next(ish) Project - Rotary Plasma Tube Notcher

## Each tube - in SolidWorks

- Extrude a cut down the length of the tube
- Use Sheetmetal to unroll and flatten each tube.
- Save each “flat” as a DXF
- Feed into CAM program

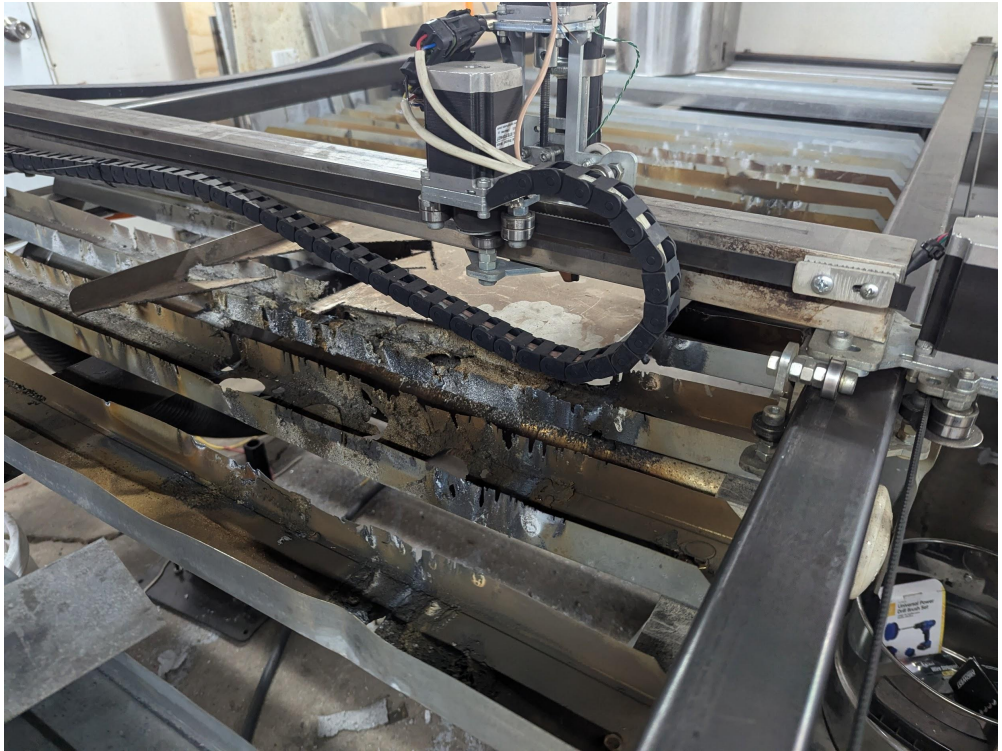
# Next(ish) Project - Rotary Plasma Tube Notcher

Using my same plasma table, add a rotary axis at the end of table.



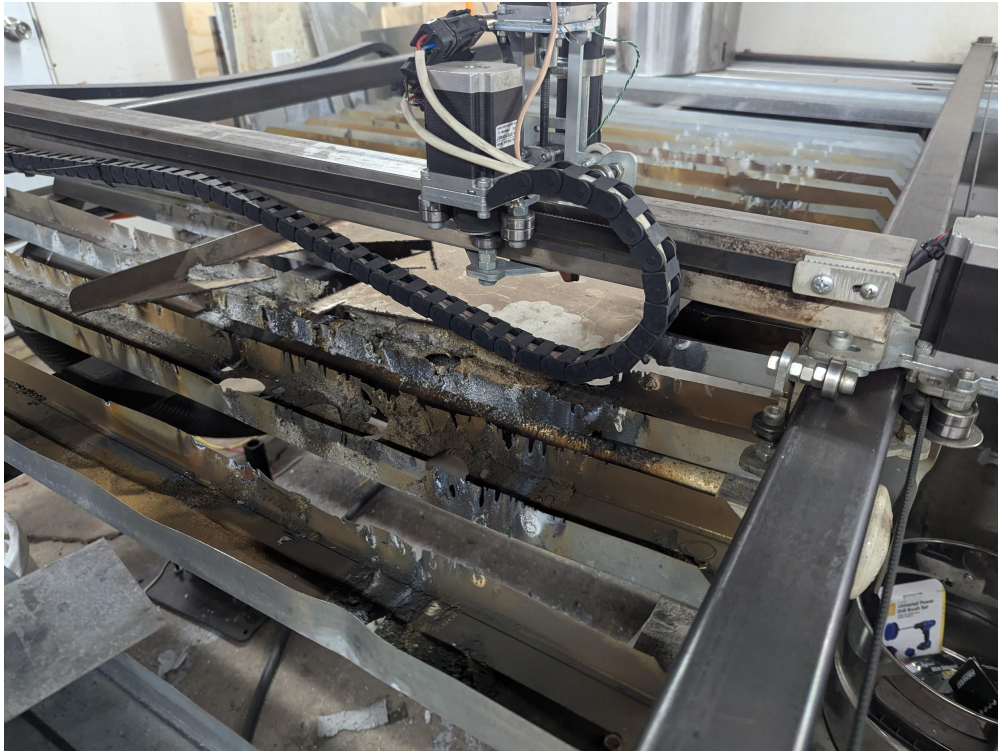
# Next(ish) Project - Rotary Plasma Tube Notcher

Create a profile in LinuxCNC that uses the X & Rotary Axes



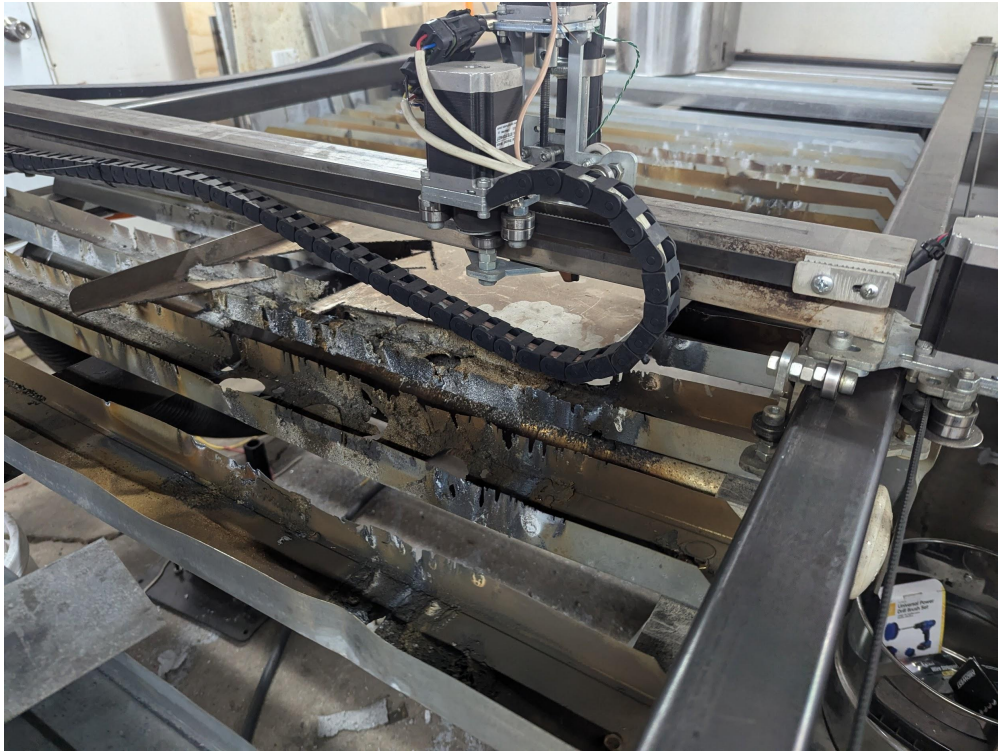
# Next(ish) Project - Rotary Plasma Tube Notcher

You would need a separate profile for each tube diameter.



# Next(ish) Project - Rotary Plasma Tube Notcher

Dual Use Table!



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