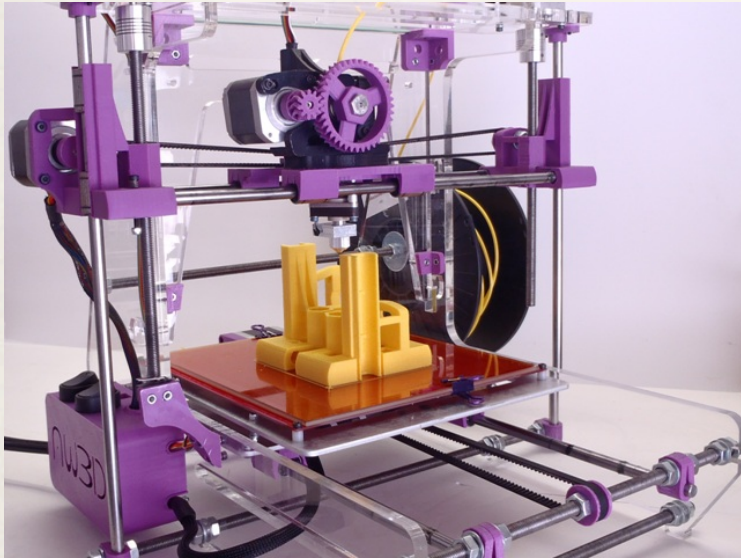

10/28/2015

What is CNC?

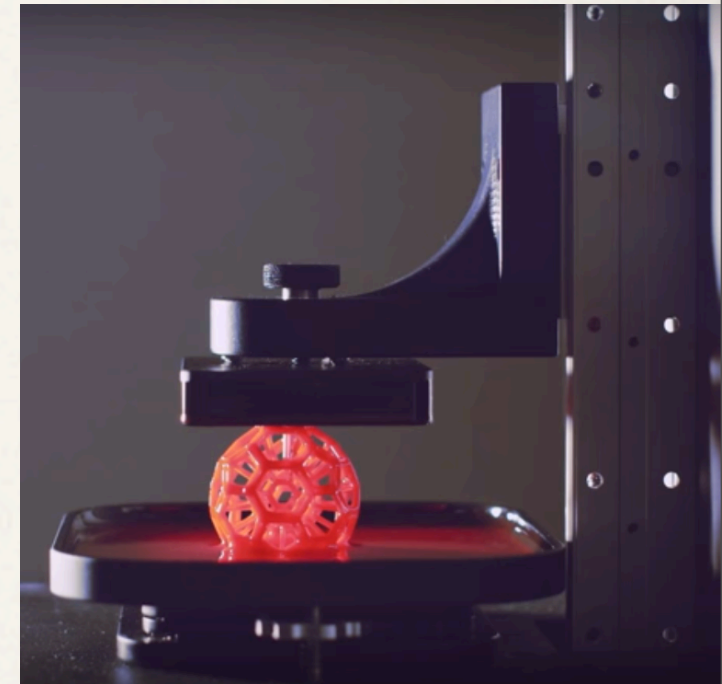
- ❖ Computer Numeric Control
 - ❖ Take drawing from CAD (Computer Aided Design) tools, convert to a series of numbers (GCode), control movement using GCode
- ❖ CNC Machine
 - ❖ Mechanical, software, and electronic components that make up a tool that can create objects designed in CAD
- ❖ CNC Controller
 - ❖ A device with firmware that interprets GCode and outputs motor control signals to control how an object is shaped

3D Print vs Milling

what kind of output do you need?



- ✧ extrusion
 - ✧ layer by layer
 - ✧ low structural integrity
 - ✧ slow
- ✧ photopolymerization:
 - ✧ layer by layer
 - ✧ better structural integrity
 - ✧ faster
 - ✧ create more complex shapes



- ✧ milling (what this project is)
 - ✧ high structural integrity: plastic, wood, metals
 - ✧ fast
 - ✧ less complex shapes

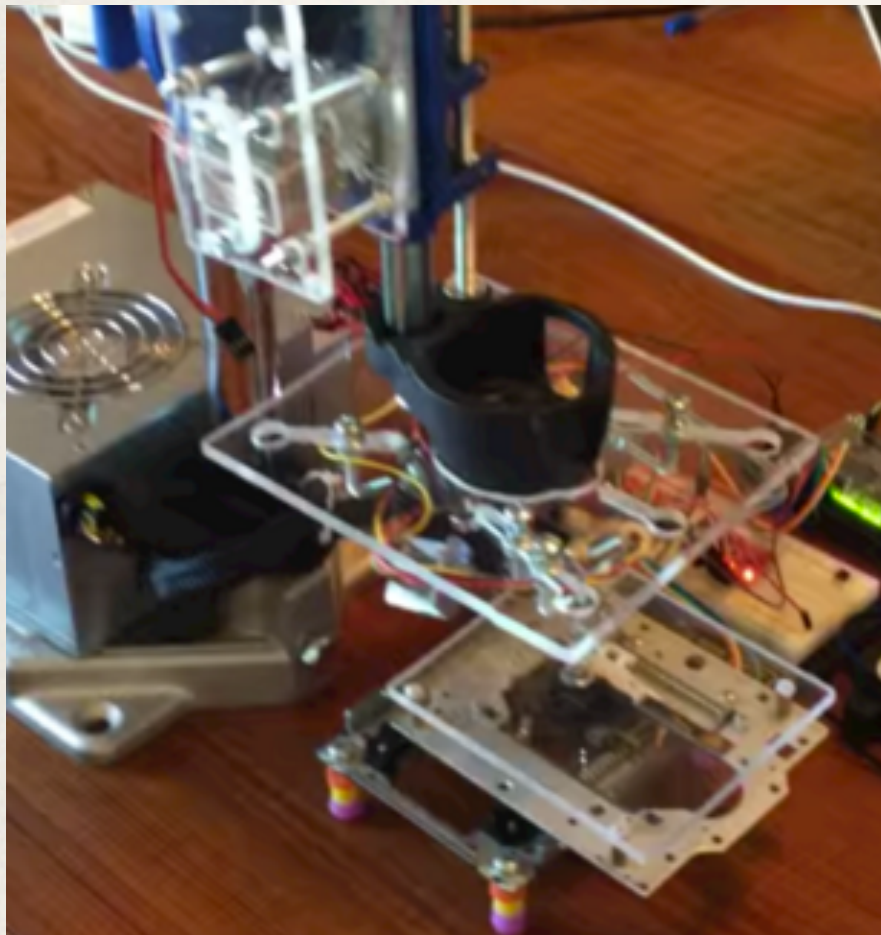


Project Goals

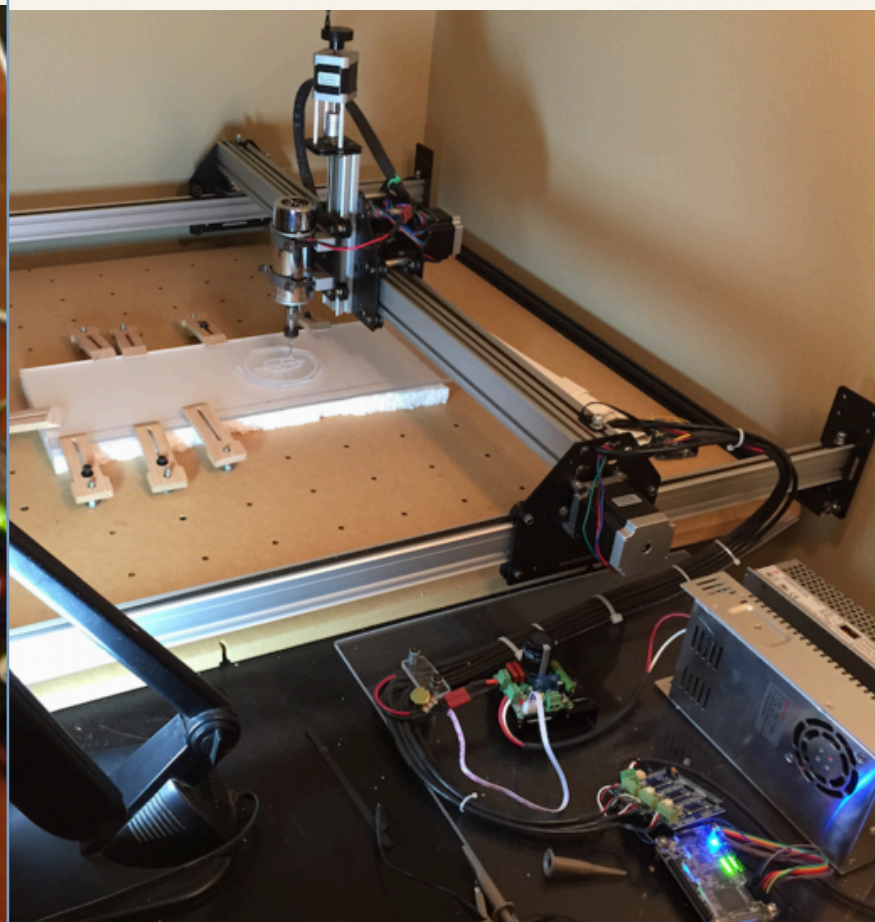
- ❖ Research, Design, and Build a CNC Machine
- ❖ Create CNC controller and make everything OpenSource
 - ❖ Use FPGA to create jitter free movement
 - ❖ great system integration by managing hardware and software
- ❖ End result is a tool usable at home to make designs from CAD quickly and accurately
- ❖ adaptable to any mechanical platform

Adaptable Mechanical Platform

MKI (\$0)



MKII (\$1000)



MKIII (~\$1600)



Why not just buy one?

- ❖ Cost
 - ❖ high cost even for a CNC mill with small milling area
 - ❖ Customizable
 - ❖ add on laser cutter, plastic extruder, plasma cutter, exacto knife, ... anything you want
 - ❖ Full understanding of how the machine works and its limits
-
- ❖ base system for future use
 - ❖ FPGA based systems are complex and painful to setup but is powerful; this project will be used as a starting point for future projects



Design

Linear motion hardware

ball screw

- *almost no backlash
- *low friction (good for moving but bad for stopped)
- *will tend to rotate away from loads
- *must use oversized loads to mitigate back driving loads
- *expensive



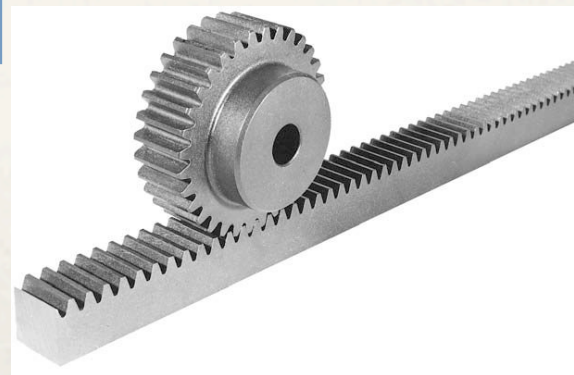
acme

- *will hold a load in place by design
- *backlash; unexpected play due to clearance or looseness of mechanical parts
- *limited size
- *not so expensive



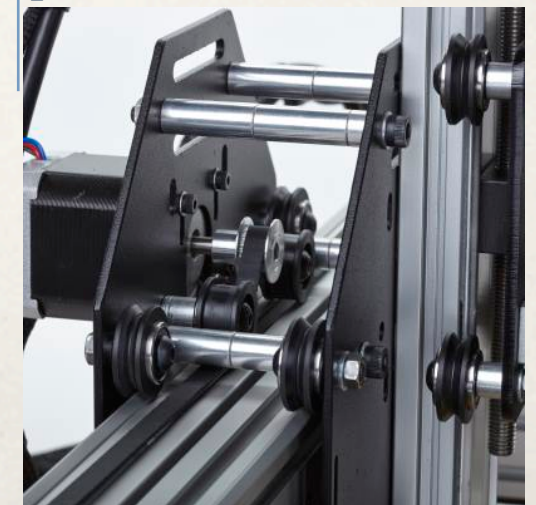
rack and pinion

- *easily expandable to larger machines
- *complex; requires proper gear reduction and other hardware to eliminate radial load on the motor shaft
- *can become expensive if performance desired



belt drive

- *can accommodate semi large machine
- *simple
- *not so great at high speeds
- *typically used by hobbyists because its one of the cheaper options for performance

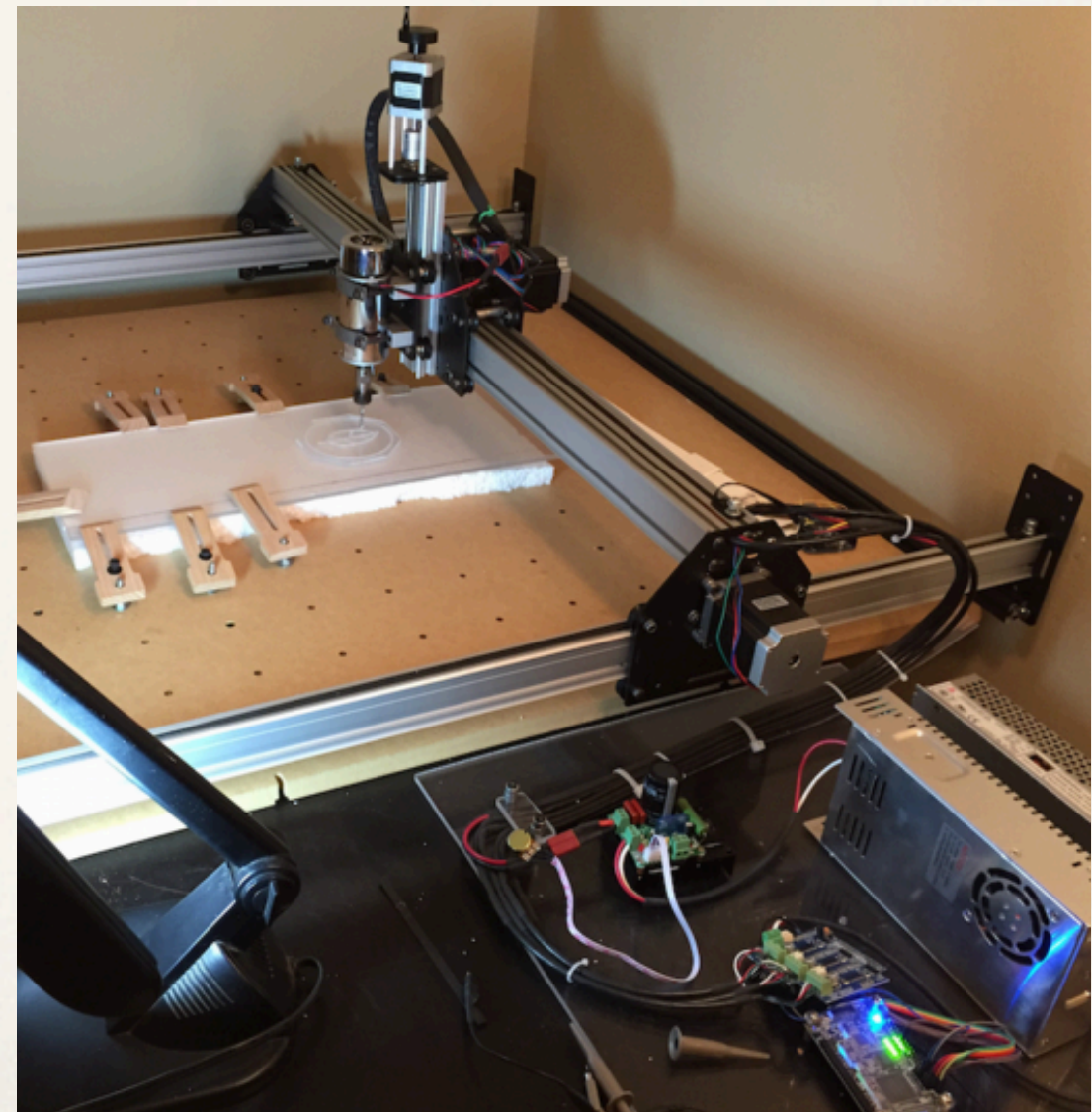


Hardware

Modified OpenHardware [Shapeoko 2](#) 1000mm x 1000mm rails

	A	B	C
1	Mechanics Summary		
2	Item	Qty	Total
3	Stepper Motor - NEMA 17	1	\$16.94
4	MakerSlide	4	\$87.36
5	Flat Washer	2	\$5.00
6	Socket Head Cap Screw	2	\$6.18
7	Socket Head Cap Screw	1	\$3.14
8	Hex Nuts	1	\$2.00
9	Flat Washer	2	\$4.00
10	Aluminum Spacers	2	\$5.22
11	GT2 Belting - Open Ended	15	\$29.85
12	Aluminum GT2 Pulley	3	\$19.41
13	End Mill Starter Set, 1/8 in Shank	2	\$39.90
14	Desktop 3D Carving (CNC Mill) Kit - Shapeoko 2	1	\$300.00
15	Button Head Cap Screw	2	\$4.70
16	Knob with Crank	1	\$8.40
17	Clamp Set	2	\$59.80
18	Carbide V Bit	1	\$13.50
19	Carbide V Bit	1	\$13.50
20	Microswitch	6	\$15.00
21	Enclosed Power Supply	1	\$42.25
22	ER11-A Collets, Nuts and Wrenches	1	\$6.65
23	ER11-A Collets, Nuts and Wrenches	1	\$5.84
24	Quiet Cut Spindle	1	\$79.85
25	Spindle Speed Controller	1	\$35.00
26	Enclosed Power Supply	1	\$64.75
27	Waste Board with Threaded Inserts	1	\$103.00
28	gShield	1	\$49.99
29	Stepper Motor - NEMA 23	3	\$117.00
30	Subtotal:	\$1,138.23	
31	Shipping Cost:	\$106.93	
32	Grand Total:	\$1,245.16	

- ✧ Altera DE-0 Nano development board
 - ✧ Using Nios II/e core (free)
- ✧ [gShield](#) OpenHardware stepper motor driver



note: quantity above indicate number of sets