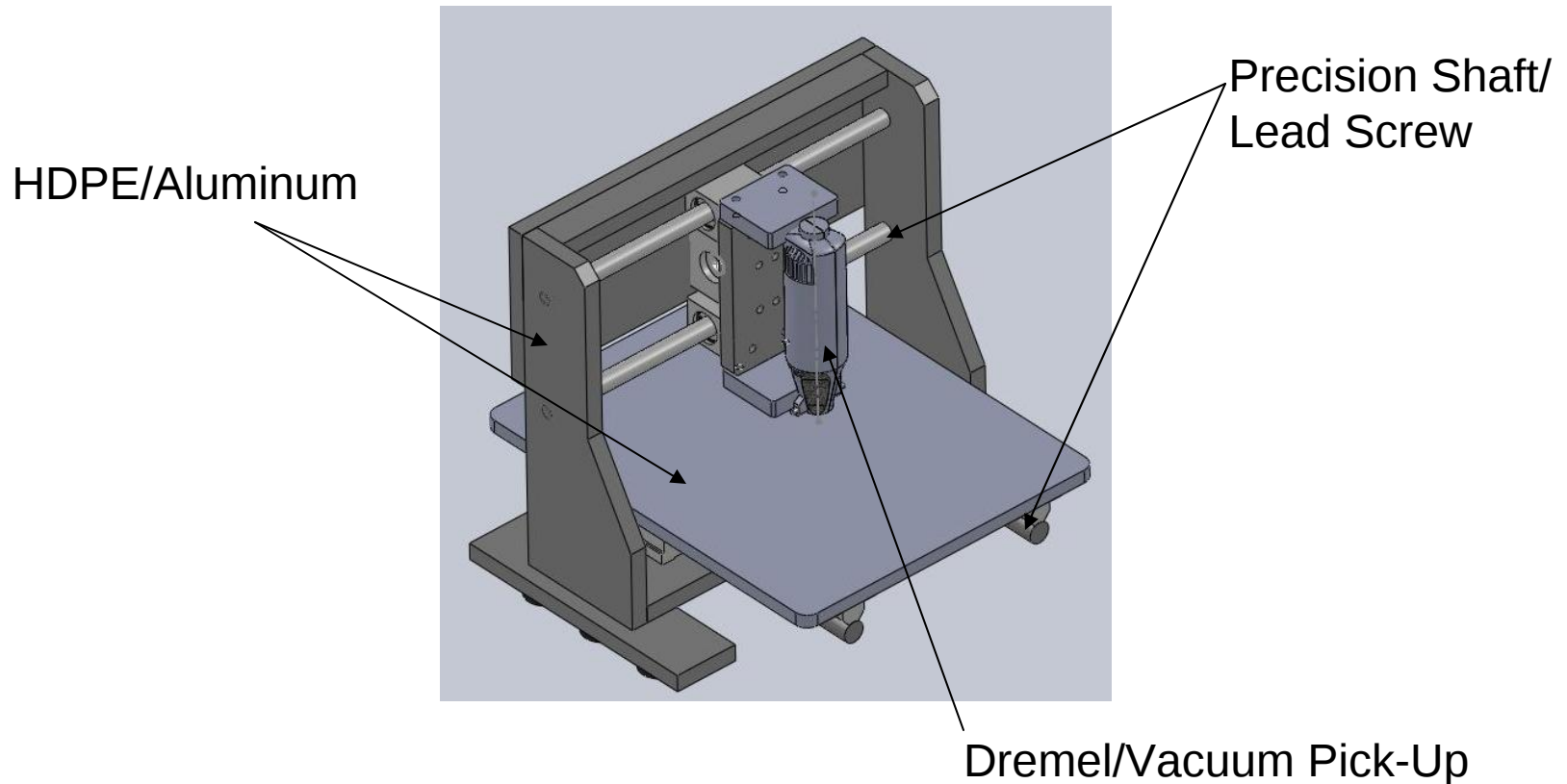


Manufacturing Process - Mechanical

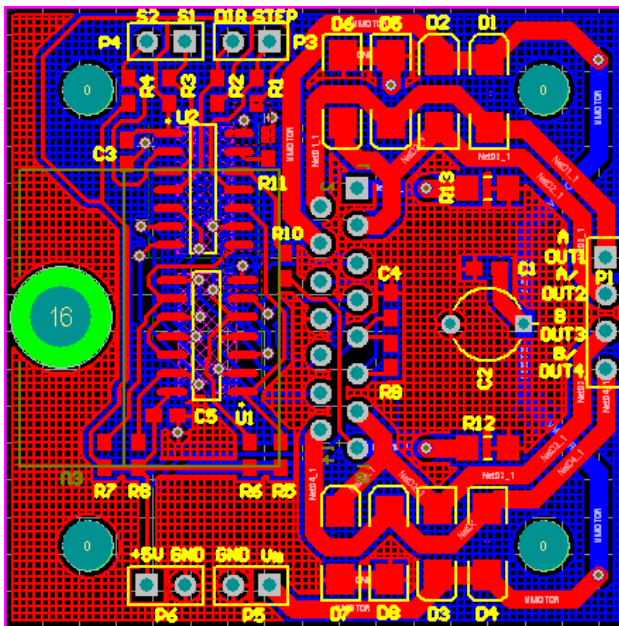
- CNC Milling, Water Jet, Laser Cut



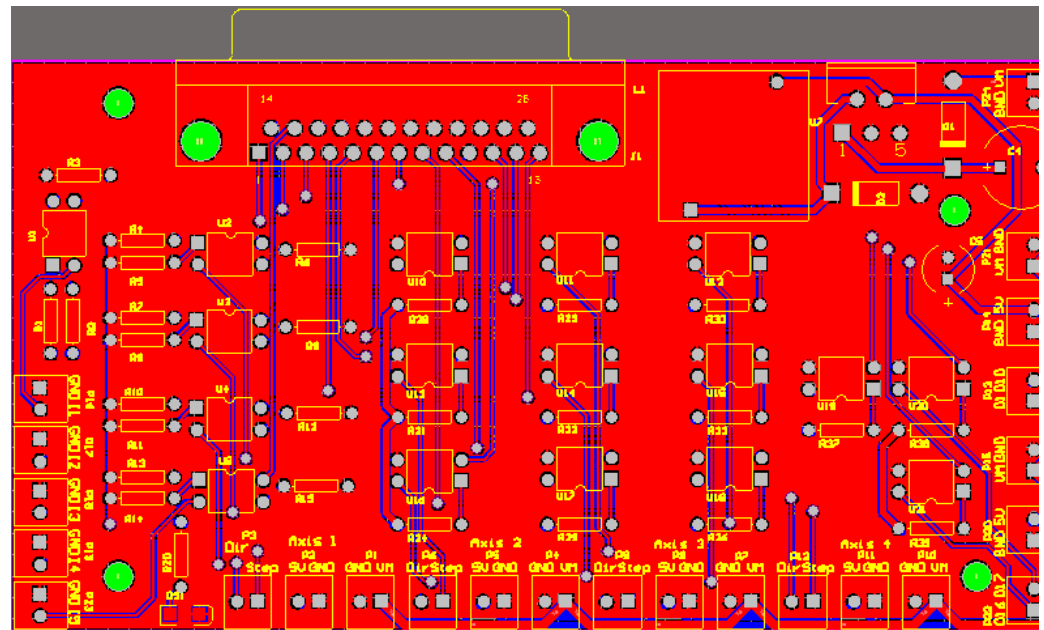
Manufacturing Process – Electrical

- Rapid PCB Prototype

Stepper Motor Driver

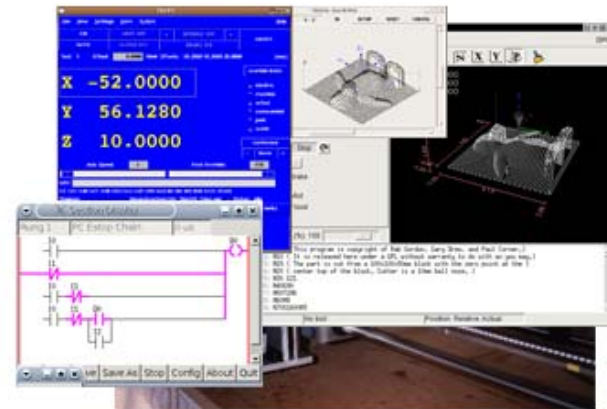


Parallel Port IO



Manufacturing Process – Software

- Linux Ubuntu and Linux CNC – Free, Open Source



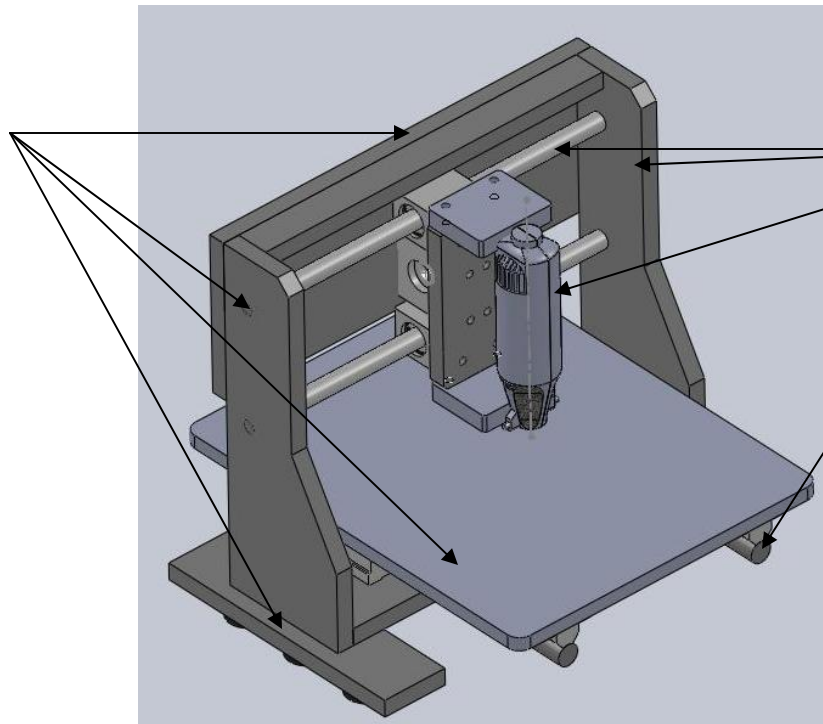
Able To Do – Electronic SMT Assembly

- Assembly SMT components – e.g. 0603 resistors (1.8 mm Length, 0.8 Width, 0.3 Height)
- Positioning Accuracy – 10 mils (0.254 mm).



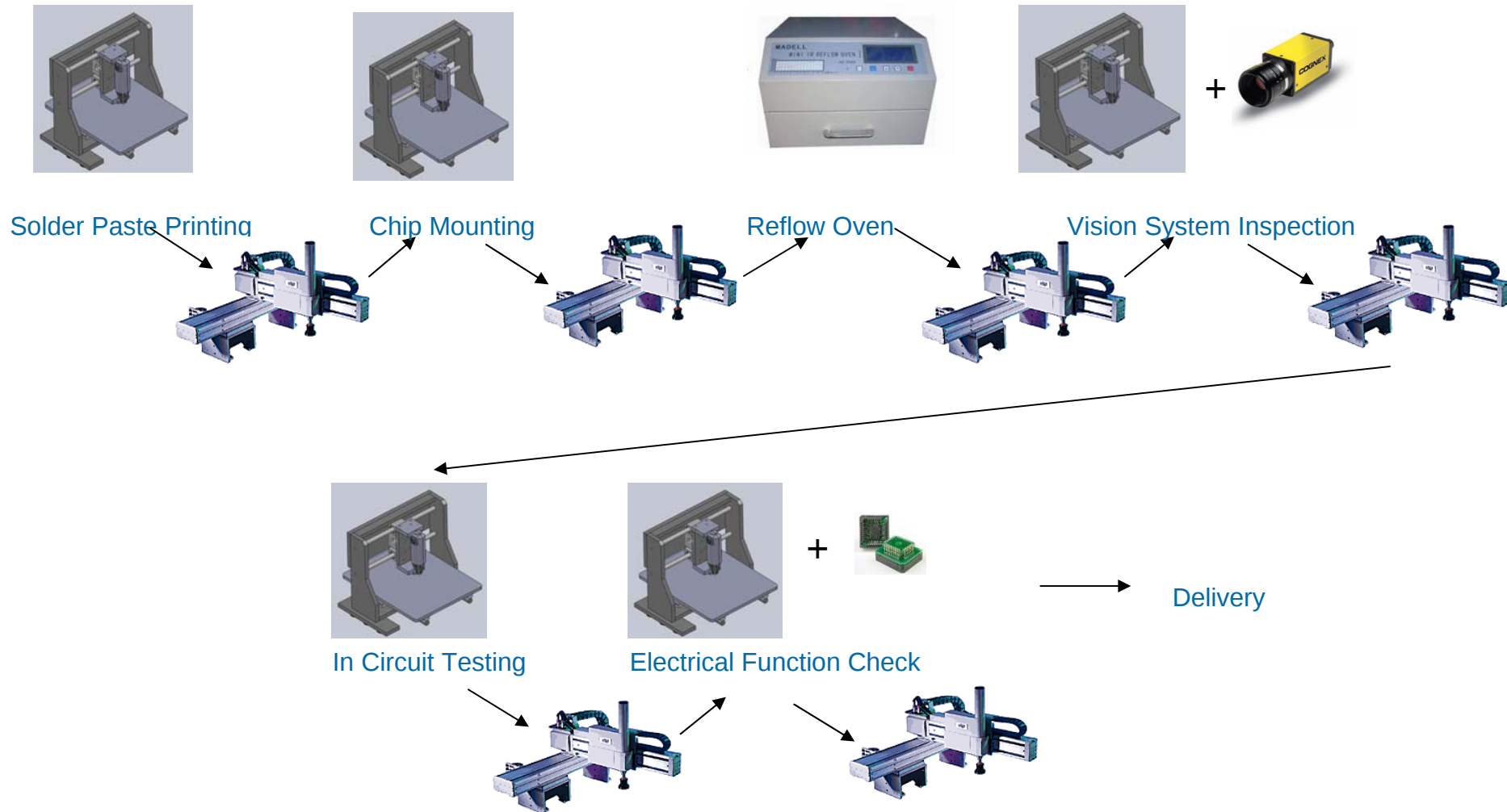
Able To Do – Manufacture It's Own Structure

Manufactured
Parts



Purchased
Parts
(e.g. Bearings,
Precision Shafts
LeadScrew)

Able To Do – Electronic SMT Assembly



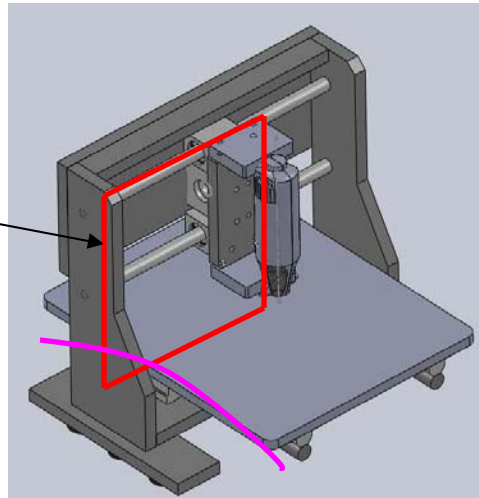
Not Able To Do - Self Assembly

- Machine will not be able to assemble a replicated version of itself

Benefits Over Current Process

- Current Process requires big, extremely expensive machines.
- New process uses a small structural loop to achieve the same rigidity and accuracy of a huge machine.

Small Structural Loop

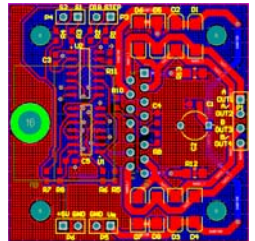
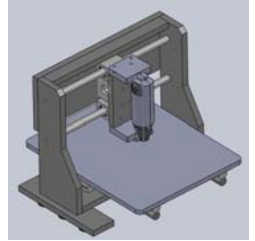


Benefits Over Current Process

- Low Cost < \$1000
- Can be built in Garage

System Components

- Mechanical Structure
- Electronic Controls and Motors
- Software (Ubuntu and LinuxCNC)
- Customized Software for integrating SMT assembly line machines



Parts that Require Development

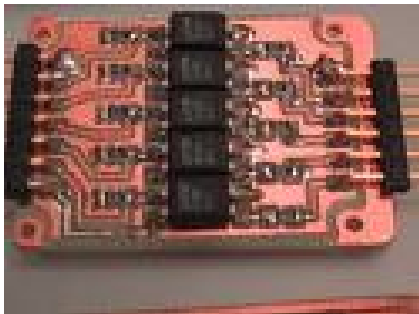
- Mechanical Structure
- Motor Controls
- Customized Software for integrating SMT assembly line machines

Design to Output

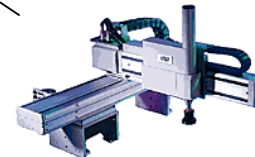
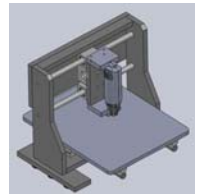
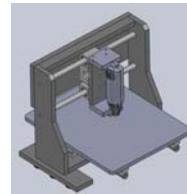


PCB Layout
Gerber Files
Drill Files
Pick and Place/
Placement Files

Customized Software for
Translating PCB layout,
Drill Files and
Components
Placement Files to
G Codes.



← ... ←



Cost – Basic Self-Replicating Unit

- < \$1000
- Structure
 - Aluminum/HDPE \$300
 - Lead Screws \$200
 - Precision Shafts \$100
- Motors
 - 3 Stepper Motors \$130
- Motor Drivers & Parallel Output Cards
 - 3 axis driver \$200
- Software
 - Ubuntu and LinuxCNC Free
- P4 Notebook/PC
 - Reuse Free

Speed

- $800\text{mm/min} = 13.33\text{ mm/sec} = 0.5\text{"/Sec}$
- Not very fast
- Can increase speed by raising the first resonance of the entire structure (adding rigidity), thereby increasing speed.
- Need Finite Element Analysis

Consumables

- Solder Paste
- Copper Clad PCB
- Electronic Components