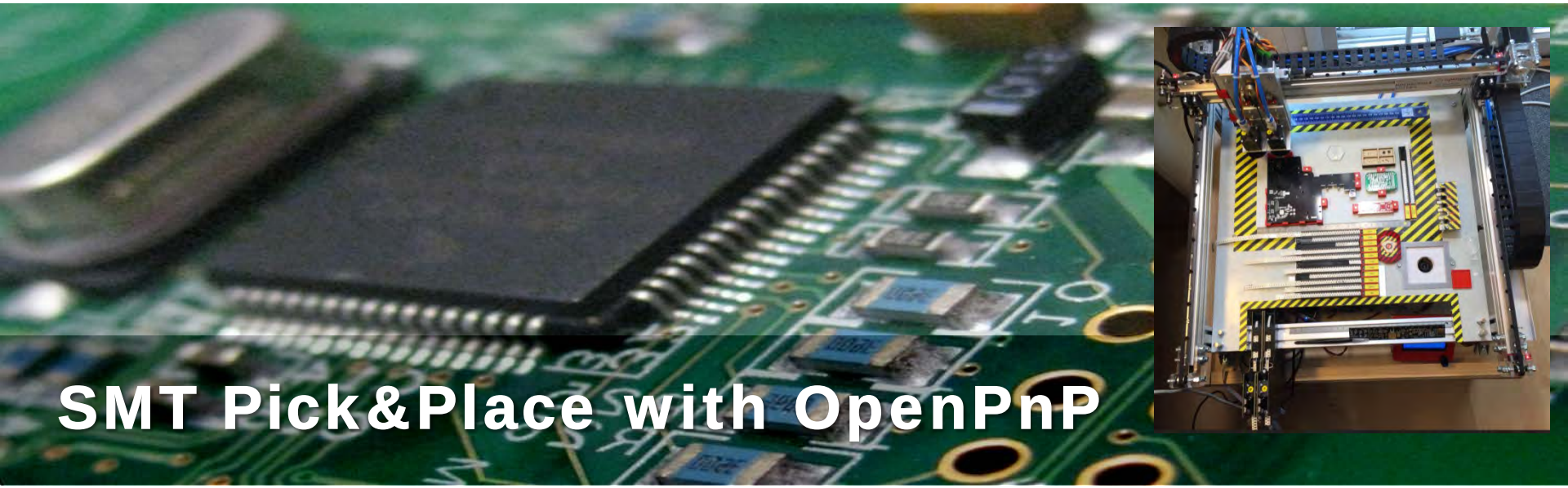
Lucerne University of
Applied Sciences and Arts
HOCHSCHULE
LUZERN
Technik & Architektur



SMT Pick&Place with OpenPnP

«all the small things matter.»

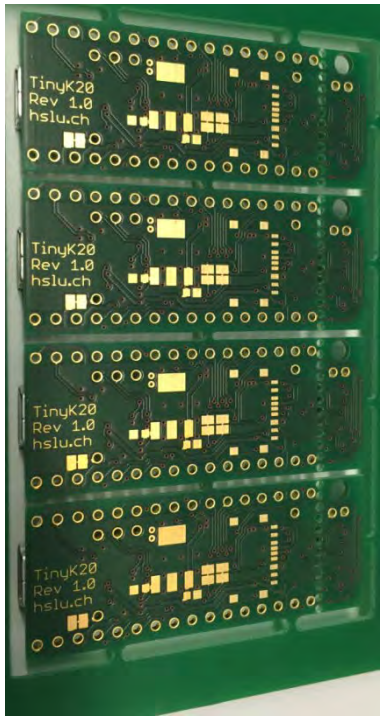
Prof. Erich Styger
CC Electronics
erich.styger@hslu.ch
+41 41 349 33 01

swissIT.meeting
Embedded Computing Conference

From PCB to the finished board

- Printed Circuit Boards (PCB)
- Need to populate with parts (resistors, microcontroller, …)

PCB Production



PCB Assembled

swissT.net swiss technology network
EMBEDDED COMPUTING CONFERENCE

PCB Fabrication ➔ External!

- Incredibly cheap and fast (1 week from Asia)
- Inexpensive, process is automated

Source: PCBWay

PCB Assembly: Extern?

- Price depends on number of parts
- Problems with parts
  - Customer Supply: customs, costs, time
  - Shopping Cart (Mouser, etc): time, availability
  - Assembler Supply: quality, fake parts
  - ~10% is overhead (more parts to supply)
- Time: 3-4 weeks

Pricing And Build Time

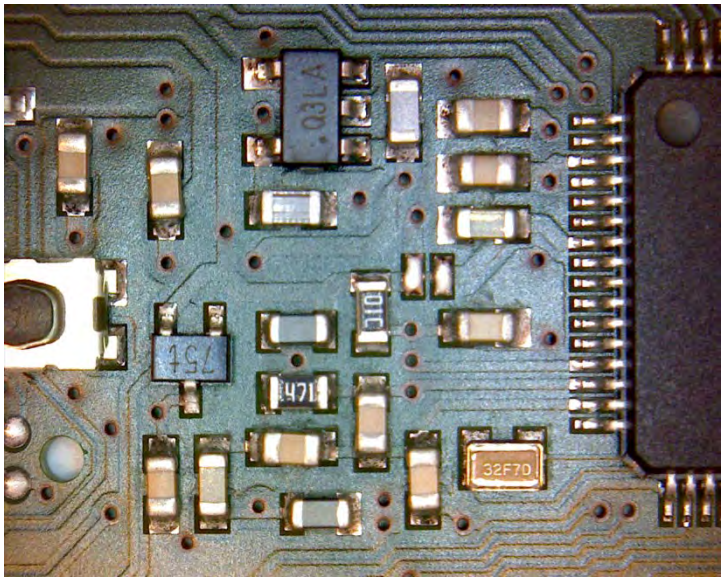
Assembly Service Price

Per Piece	Qty	Total
38.7/pcs	10	$387
20.1/pcs	20	$403
8.6/pcs	50	$432
2.9/pcs	200	$589

swissT.net swiss technology network
EMBEDDED COMPUTING CONFERENCE

The Challenge: SMT Assembly

- Industrie 4.0 ➔ «Lot size 1»
- For startups and small labs
- Prototypes, small batches with 1-50 boards
  a) **external** Assembly (expensive, time)
  b) **internal assembly by hand**



«We have some work for the apprentice!»

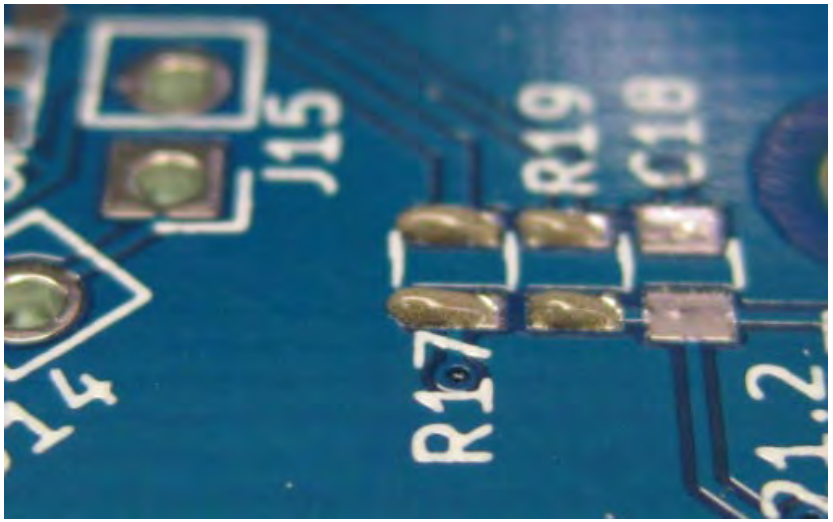
swissT.net swiss technology network
EMBEDDED COMPUTING CONFERENCE

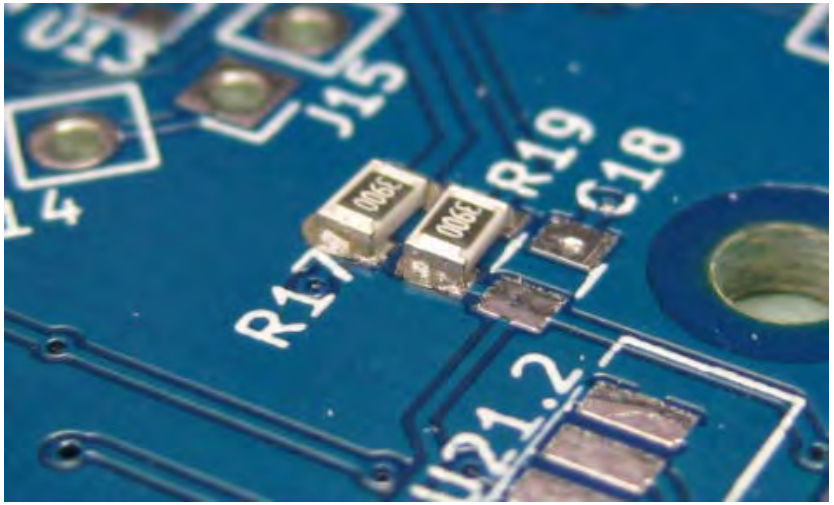
‘Manual’ Assembly

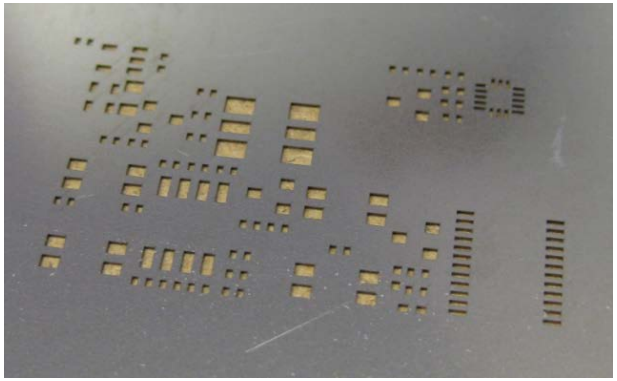
- add solder paste
- populate parts (needs lot of time!)
- ‘bake’ it in reflow oven
- test board

swissT.net swiss technology network
EMBEDDED COMPUTING CONFERENCE

Manual Assembly: Solder Paste

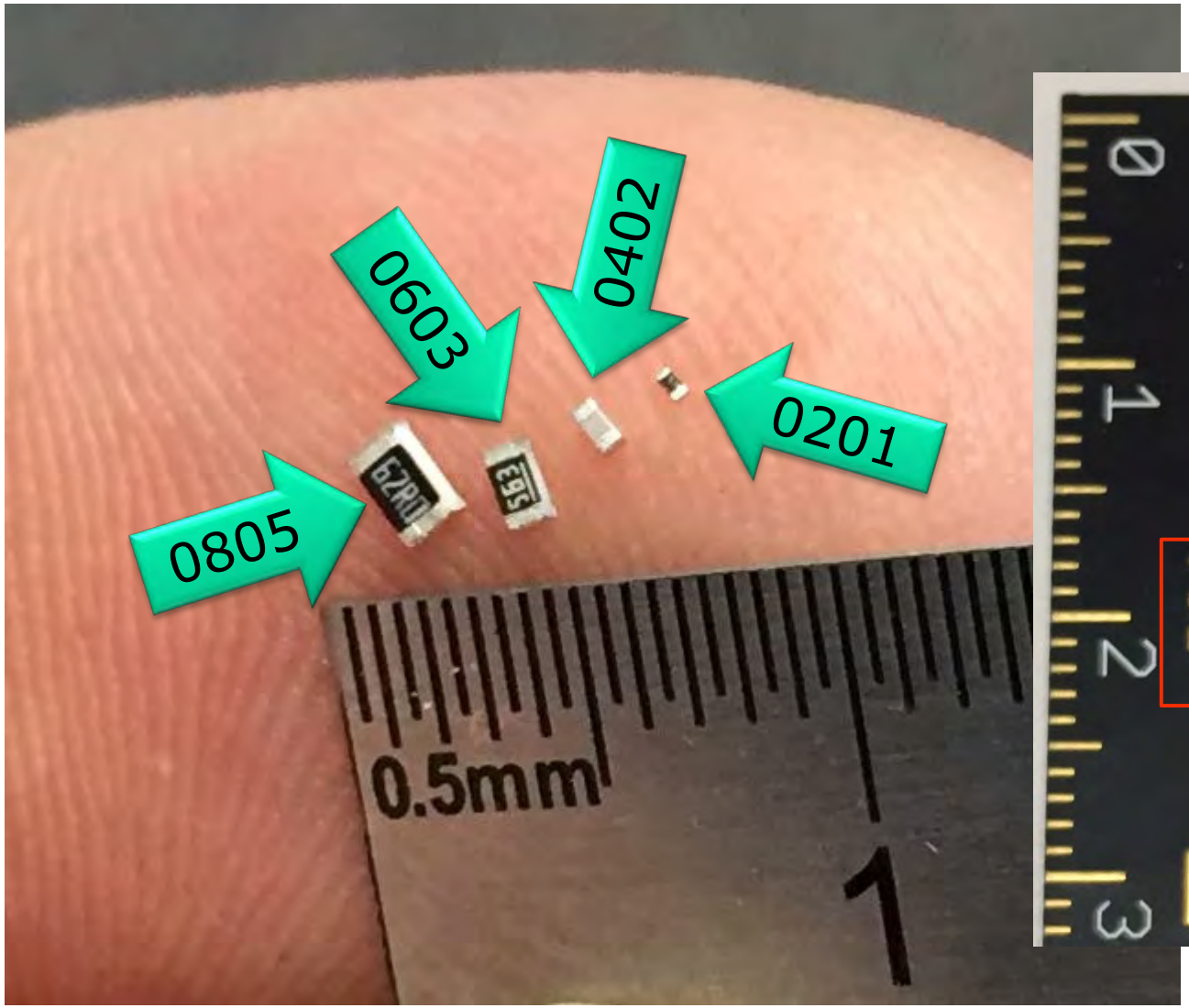


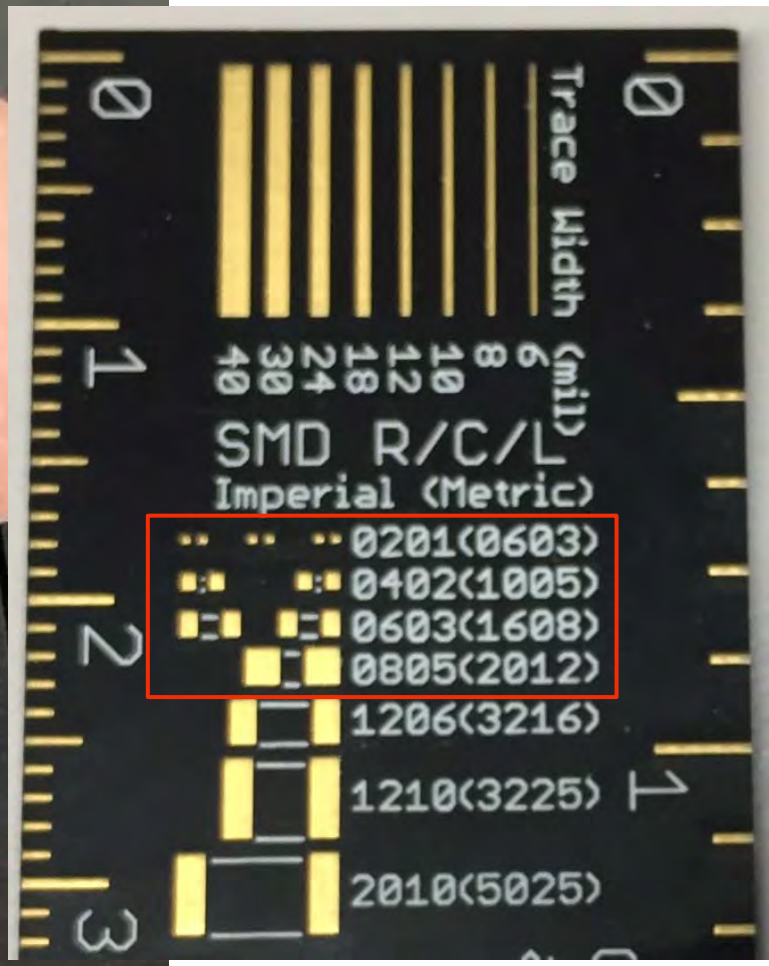




swissT.net
swiss technology network
EMBEDDED COMPUTING CONFERENCE

SMD Passives





swissT.net swiss technology network
EMBEDDED COMPUTING CONFERENCE

Manual Pick & Place

swissT.net
swiss technology network
EMBEDDED COMPUTING CONFERENCE

Reflow Oven

- ‘baking’ PCBs in reflow oven
- Controlled temperature profile

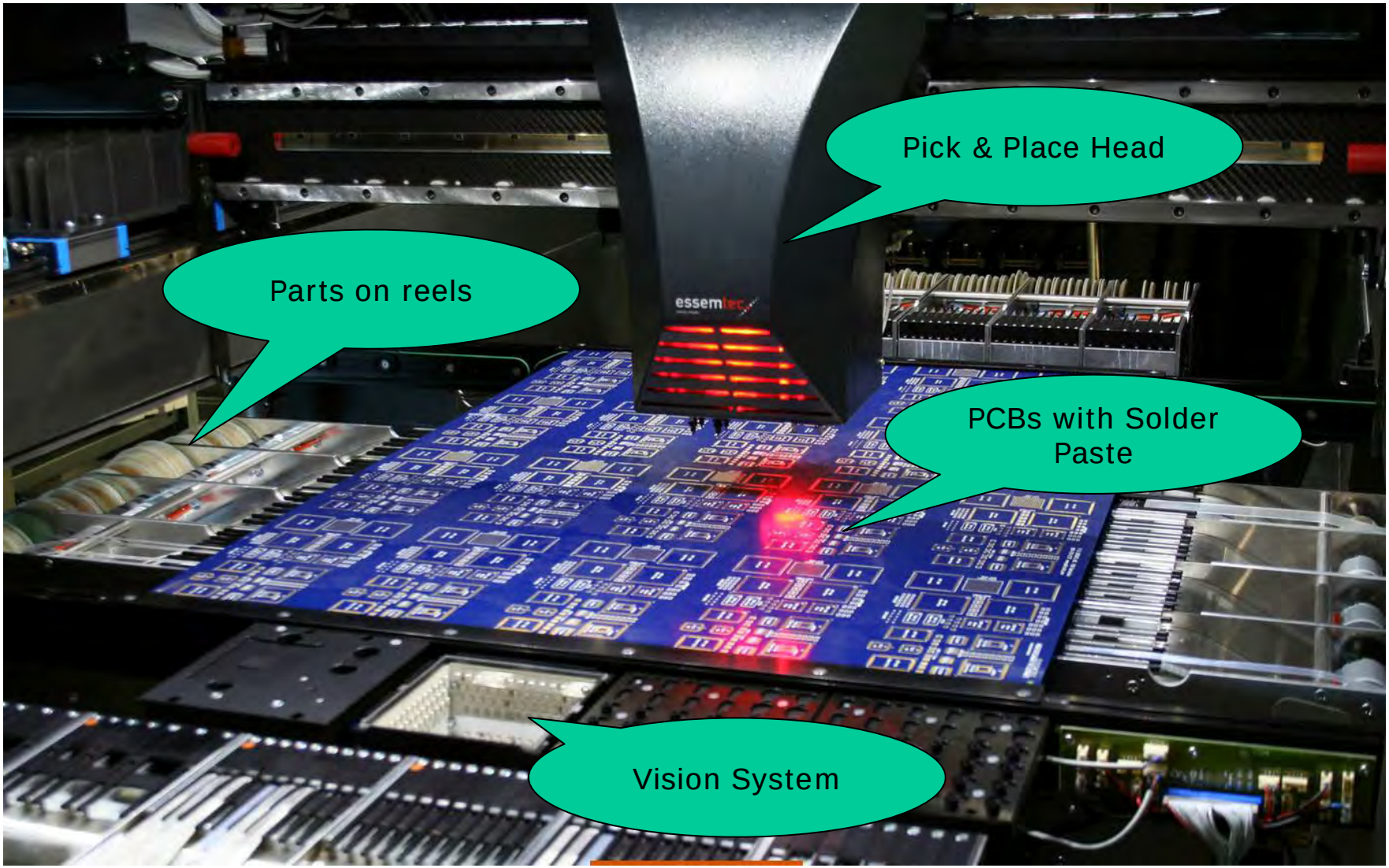
swissT.net
swiss technology network
EMBEDDED COMPUTING CONFERENCE

Professional SMT Assembly Machine

Source: essemtec

swissT.net
swiss technology network
EMBEDDED COMPUTING CONFERENCE

SMT Assembly



Source: essemtec, Youtube

swissT.net swiss technology network
EMBEDDED COMPUTING CONFERENCE

SMT Assembly

Source: essemtec, Youtube

«Vale of Tears»

1-3 PCBs	4-50 PCBs	50+ PCBs
Internal!	**Internal** or **External**?	External!
Simple, fast, efficient	Internal: painful External: slow	Setup costs, time

Source: aliexpress

Source: ImageStock

Source: essemtec

Need for a machine!

SMT Pick&Place Machine from China?

JAGUAR
捷豹

View larger image

Add to Compare Share

smt pick and place machine Juki JX 350 SMT machine X,Y Axis stoke:500*600mm

FOB **Reference** Price: Get Latest Price

1-1	>=2
US $60000.00	US $50000.00

Supply Ability: 100 Set/Sets per Month

Port: shenzhen

Contact Supplier

Chat Now!

Payment: VISA TT e-Checking More

Shipping: Less than Container Load (LCL) Service to US Get shipping quote

- Transparent and fair price
- 24/7 online support
- Online tracking

Source: alibaba

Desktop Pick&Place from China?

View larger image

Add to Compare Share

New product with 46 feeders Qihe TVM802BX high accuracy pcb chip mounter SMT pick and place machine

FOB **Reference** Price: Get Latest Price

US $4600.00

Supply Ability: 299 Piece/Pieces per Month

Port: SHENZHEN,NINGBO,SHANGHAI

Contact Supplier | Start Order

Chat Now!

Seller Support: Trade Assurance – To protect your orders from payment to delivery

Payment: VISA TT e-Checking More

Shipping: Less than Container Load (LCL) Service to US Get shipping quote

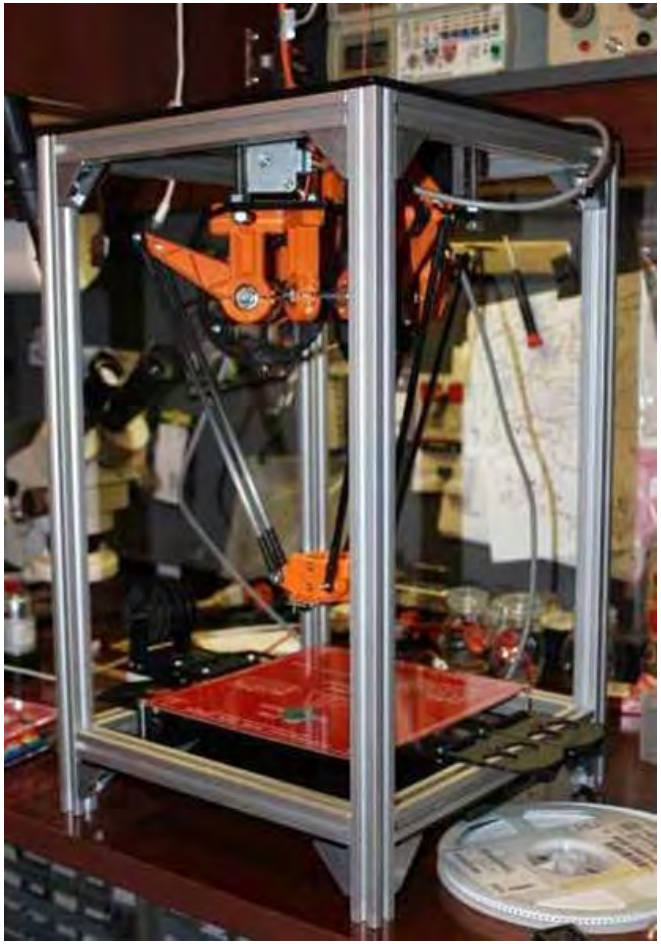
- Transparent and fair price
- 24/7 online support
- Online tracking

Source: alibaba

swissT.net swiss technology network
EMBEDDED COMPUTING CONFERENCE

The age of 3D Printer and Laser Cutter

- Do-It-Yourself!?!
- Goals
  - Costs: < CHF 1000.—
  - cph: 300-500
  - Parts: 0402, 0603, 0805, SOP, TQFP, QFN
  - Extendibility, Usability
  - Integration with CAD (Eagle, KiCAD, Altium, ...)
  - Reels & Loose Parts
  - Precision: 0.01 mm
  - Dual Vision System
  - **Open Hardware**
  - **Open Software**



Source: Firepick Delta

swissT.net swiss technology network
EMBEDDED COMPUTING CONFERENCE

Liteplacer

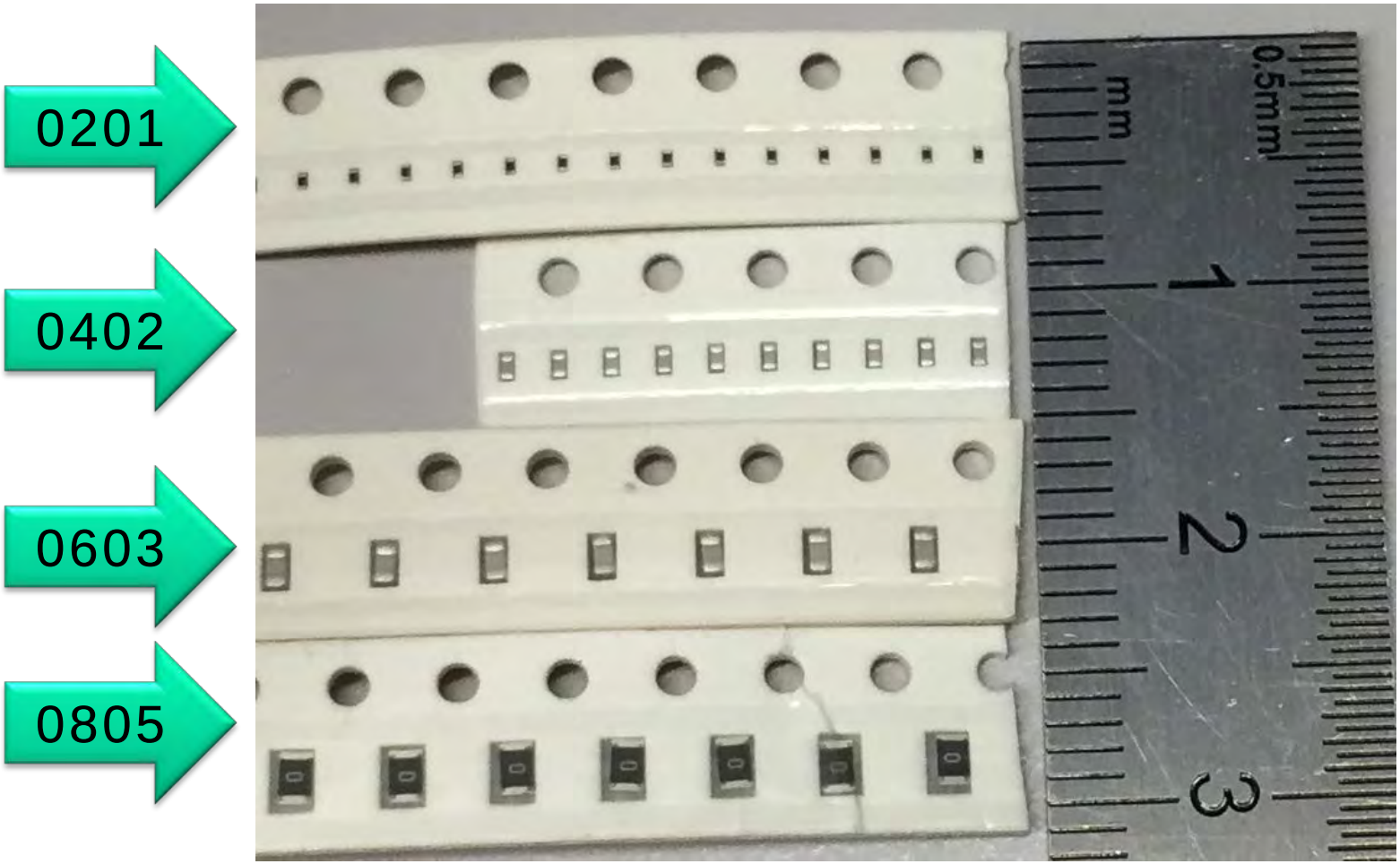
- 1,699.00€
- Kit **without** cables, power supply, cable chain, base plate, ...
- Open Design, Windows

Source: liteplacer.com

swissT.net swiss technology network
EMBEDDED COMPUTING CONFERENCE

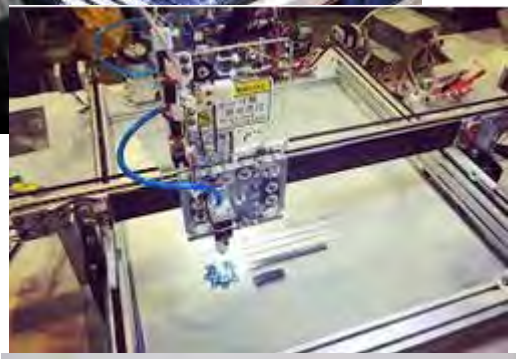
SMT Cut Tape

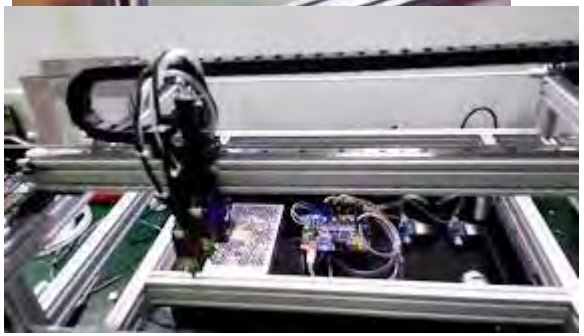
- Example: 8mm tape with, 4 or 2 mm part pitch



swissT.net
swiss technology network
EMBEDDED COMPUTING CONFERENCE

OpenPnP.org





Home Downloads Hardware Documentation Code Issues

openpnp

OpenPnP is an Open Source SMT pick and place system that includes ready to run software, and hardware designs that you can build and modify. You can also use OpenPnP software to run a pick and place machine of your own design, or with existing commercial machines, giving them abilities they never had with their OEM software.

Getting Started

To get started with OpenPnP, read through the **Quick Start Guide**. This short guide will help you download and install the software, run through a sample job and take you to the next step of building or configuring your hardware.

If you'd like some ideas on how to build your own machine, check out the **Hardware** section for free, Open Source, designs that you can build yourself.

Community

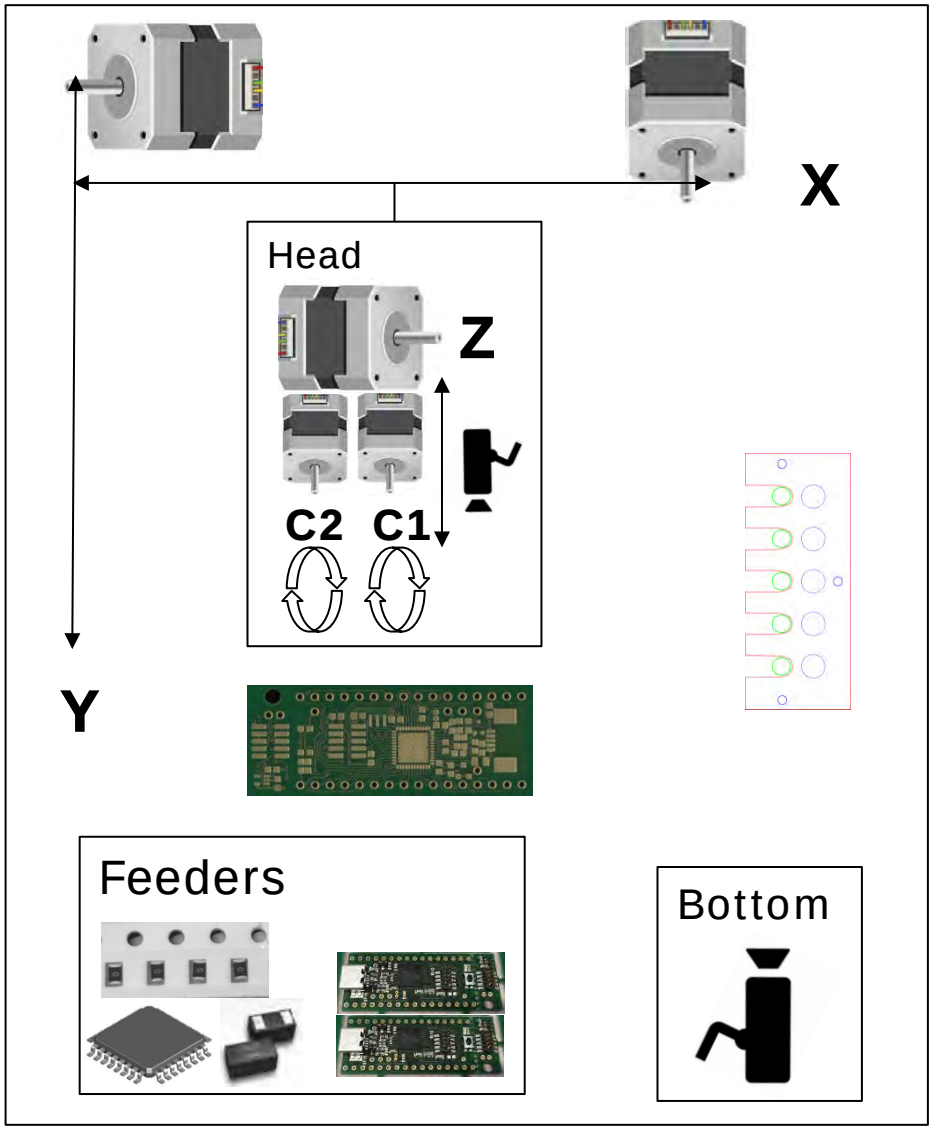
If you'd like to join the conversation you can **join the discussion group**, or come chat with us on **Freenode IRC at #openpnp**. If you don't have an IRC client, you can **use this web based one**. You can also **watch this project on GitHub**, and check out **our Twitter**.

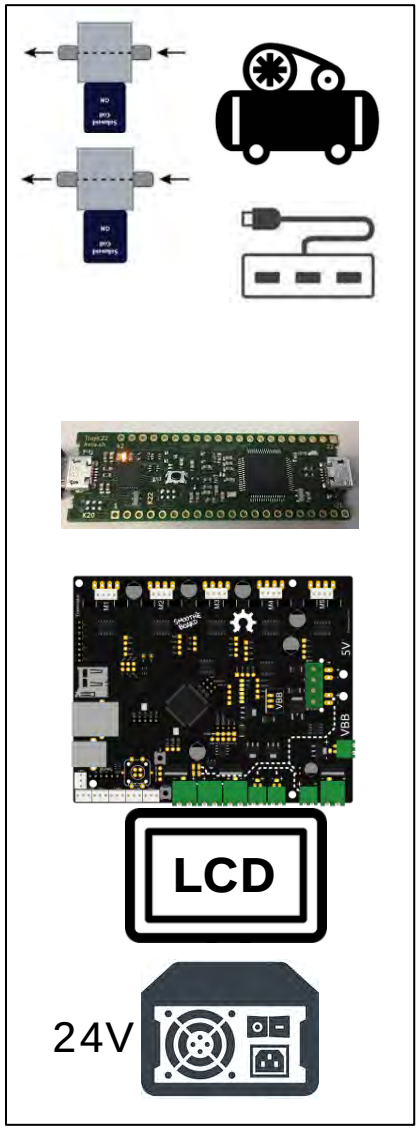
Budget

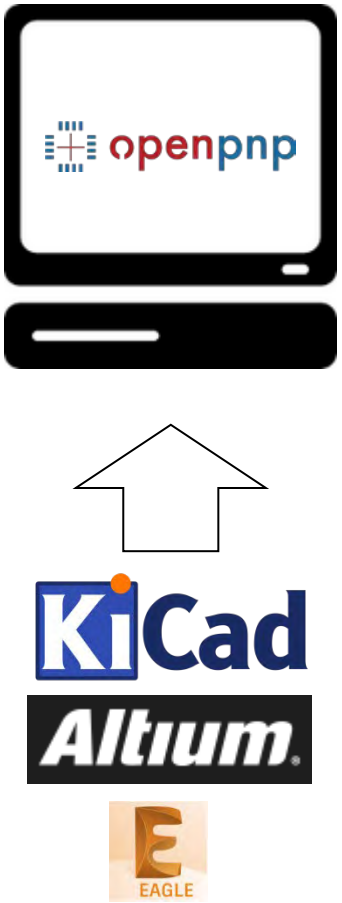
Item	CHF
Aluminium frame, nuts, bolts, ...	100.--
Linear rails	90.--
Stepper motors	120.--
End-Stops, belts, wheels, ...	60.--
SMT nozzles und holders	100.--
Vacuum pump, solenoids, air pipes	60.--
Cameras, LED rings	70.--
Controller board, LCD	200.--
Power supplies	100.--
Cables, small parts	100.--
Host machine, 3D-Pringing, Laser Cutting, time, ...	*na*
Total	**1000.--**

swissT.net swiss technology network
EMBEDDED COMPUTING CONFERENCE

System Overview



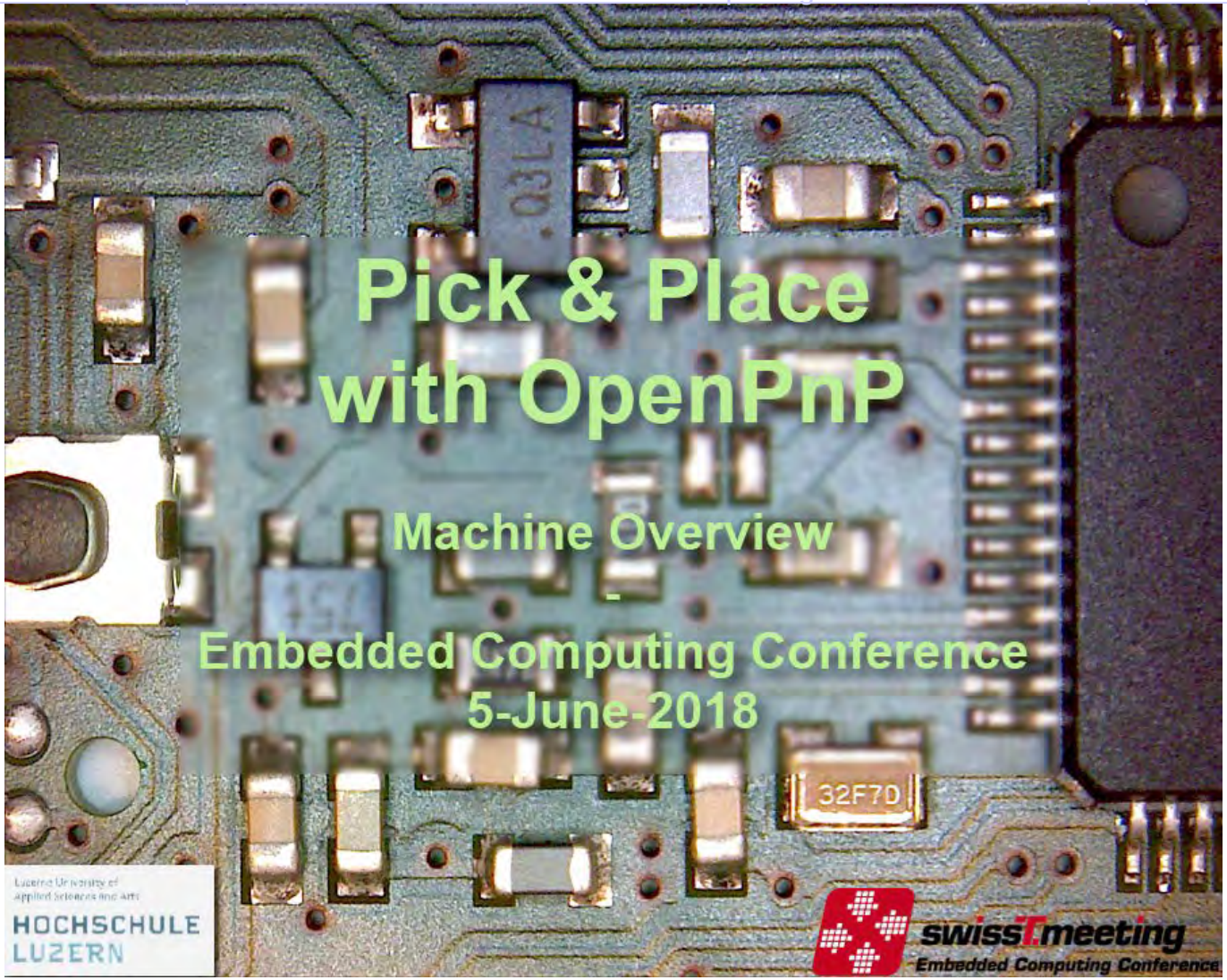




swissT.net
swiss technology network
EMBEDDED COMPUTING CONFERENCE

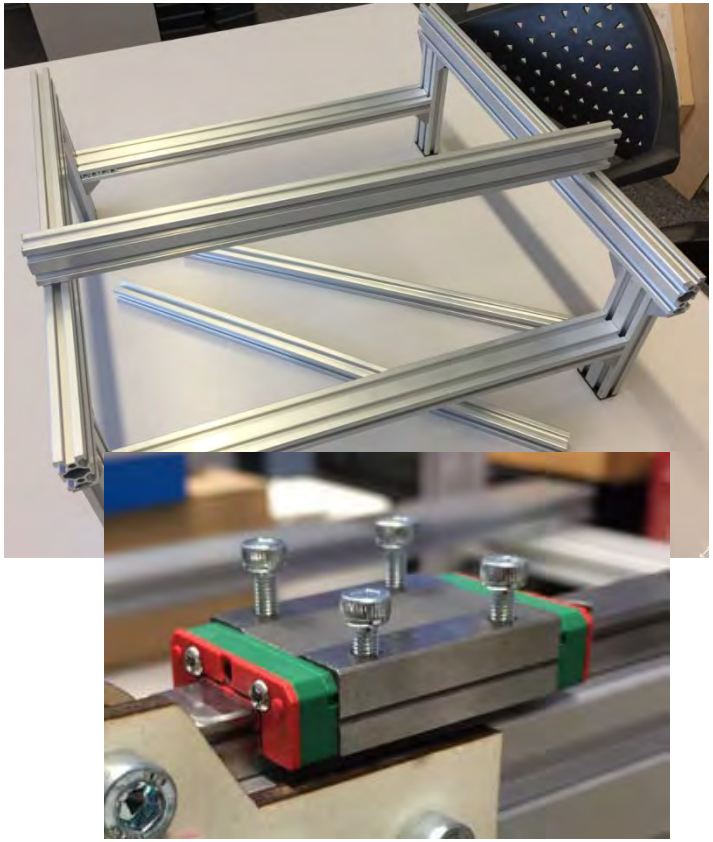
Machine Overview

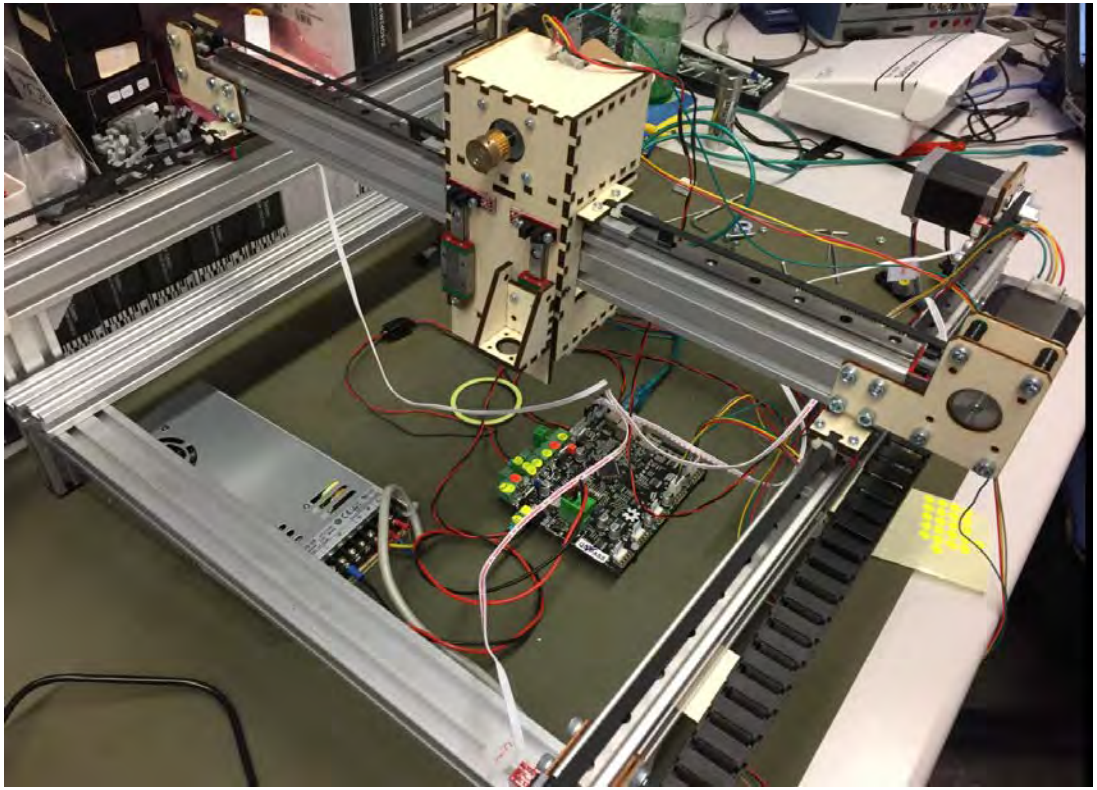
https://mcuoneclipse.com/2018/06/03/embedded-computing-conference-2018-pickplace-overview-video/



Frame

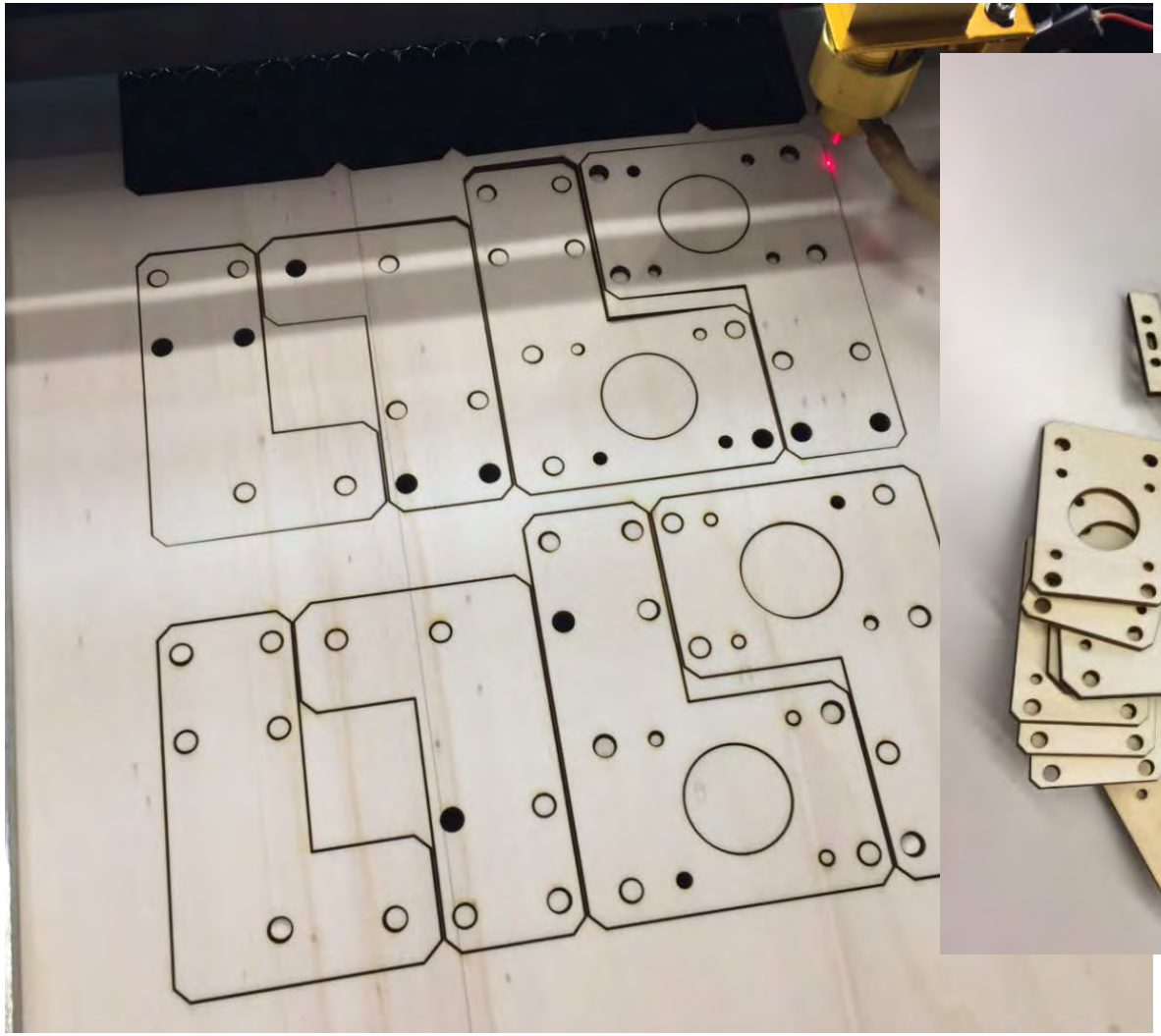
- Standard 4020 Aluminum Profile
- 12 mm linear rails with 2mm belt





swissT.net swiss technology network
EMBEDDED COMPUTING CONFERENCE

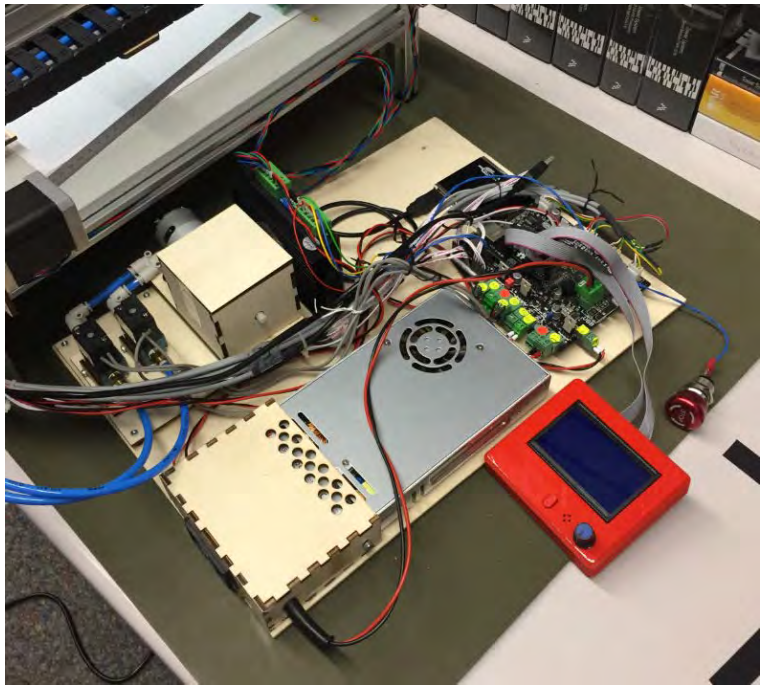
Prototypes with Laser Cutter



swissT.net swiss technology network
EMBEDDED COMPUTING CONFERENCE

Electronics

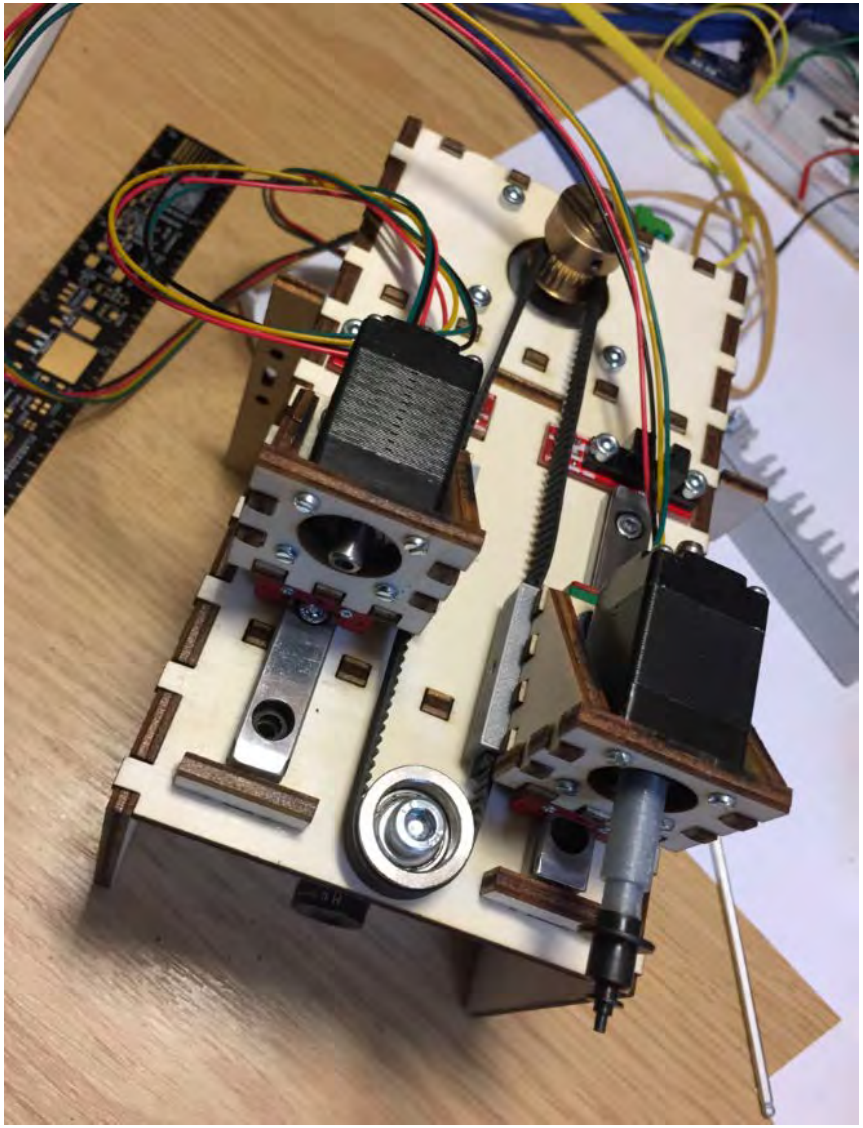
- 24V power supply
- Smoothieboard (ARM Cortex-M3 NXP LPC1769)
- http://smoothieware.org/
- LCD



swissT.net
swiss technology network
EMBEDDED COMPUTING CONFERENCE

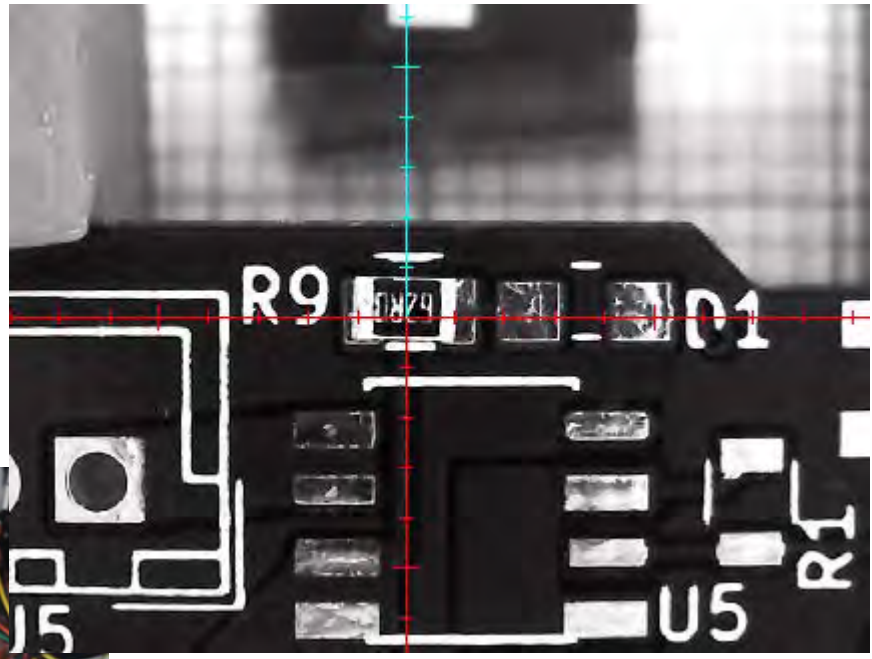
Pick and Place Head

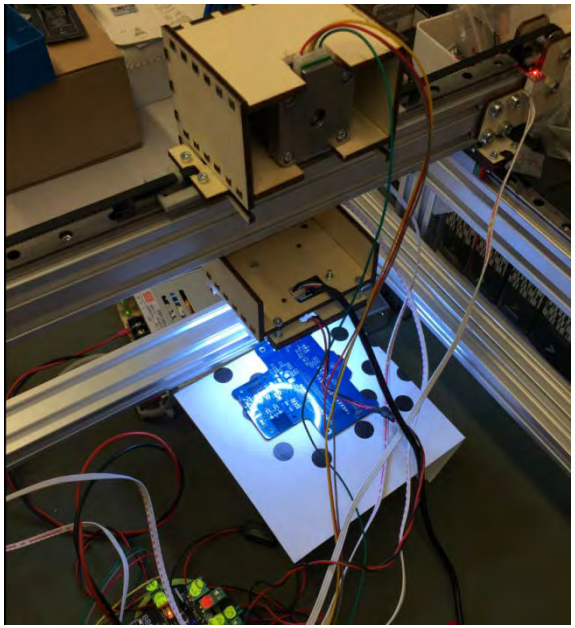
- Stepper Motor for Z axis
- Belt driven
- Optical end stops
- Linear rails
- Special stepper motors with hollow shaft
- C1 und C2 axis are 360° motors

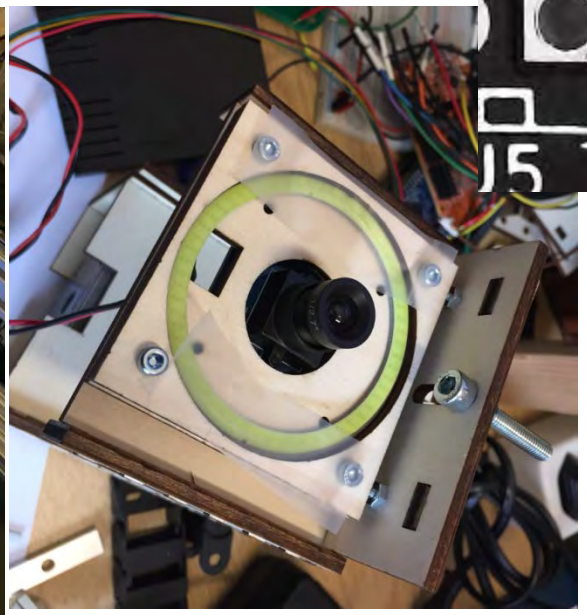


Head Camera

- 1M Pixel Vision Camera
- Recognizes parts and stripes
- Fiducial support
- LED ring



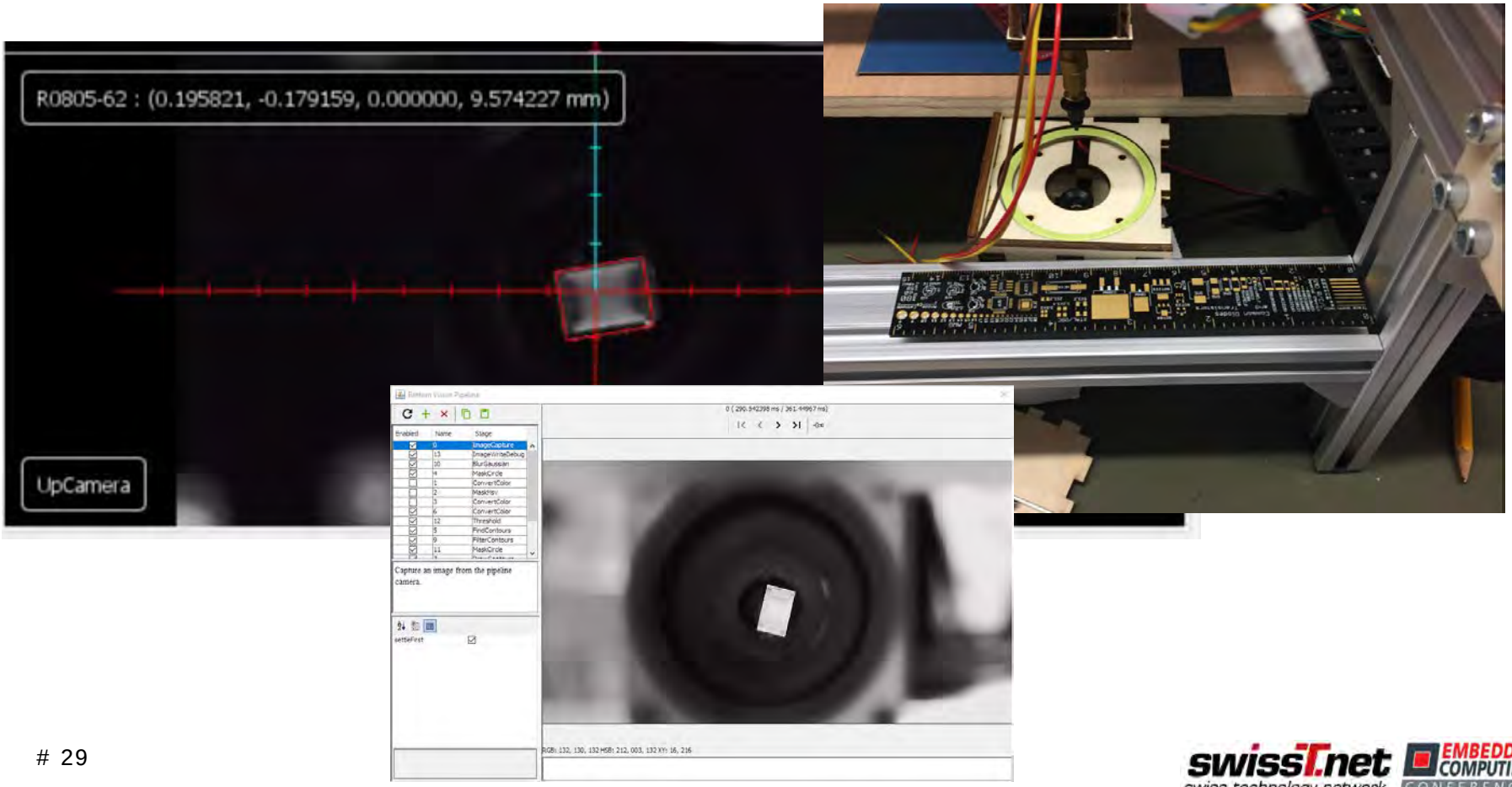




swissT.net swiss technology network
EMBEDDED COMPUTING CONFERENCE

Bottom Camera

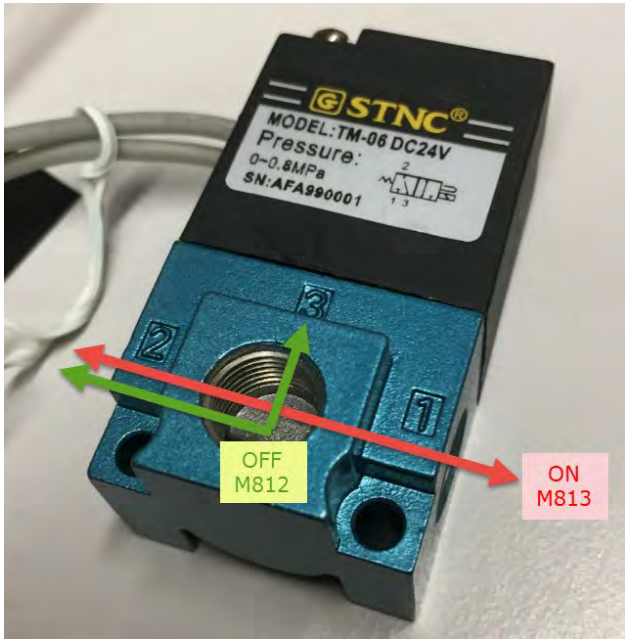
- Measures parts from the bottom
- Corrects angle (rotation) and offset (X, Y)



swissT.net
swiss technology network
EMBEDDED COMPUTING CONFERENCE

Pneumatic System

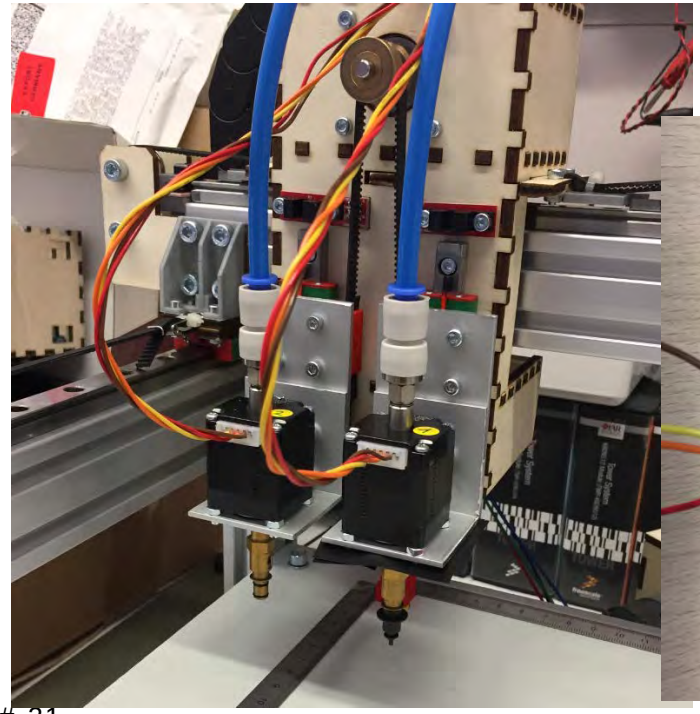
- Diaphragm pump
- Solenoids for each head (C1 & C2)



swissT.net
swiss technology network
EMBEDDED COMPUTING CONFERENCE

Pick and Place Dual-Head

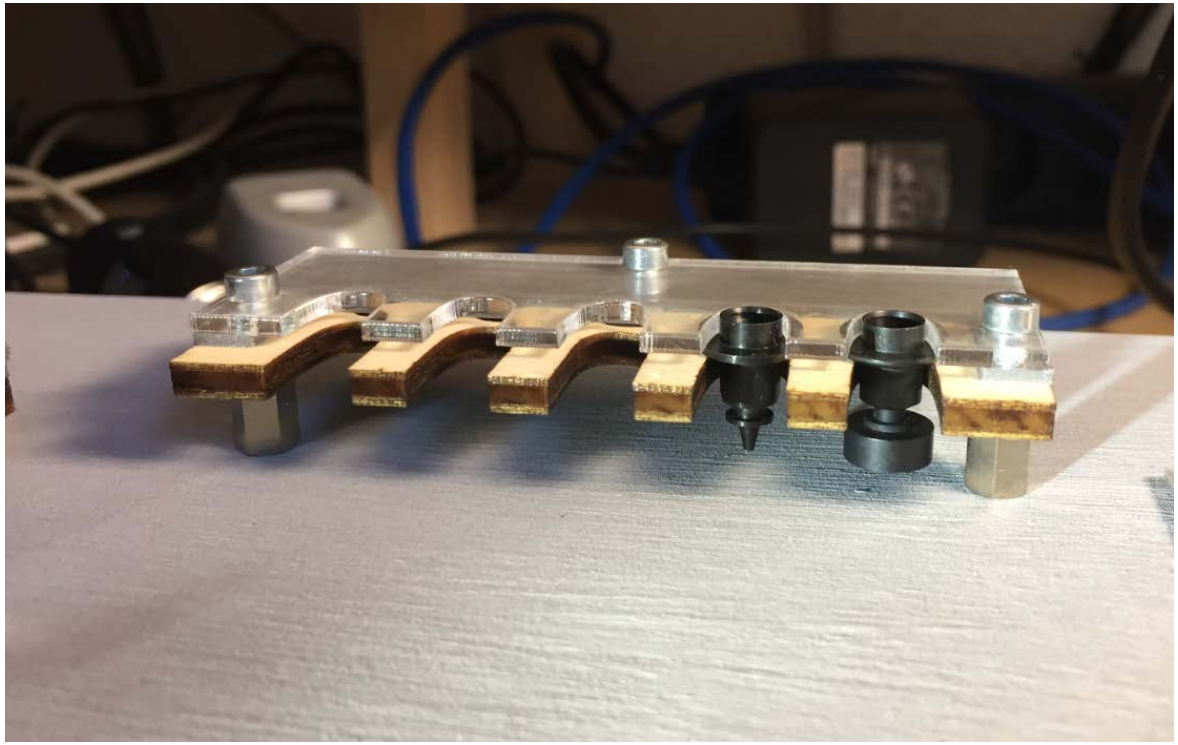
- Aluminum Profile version
- Hollow shaft NEMA11 stepper motors
- 360° pneumatic coupling
- CP40 nozzle adapter



swiss.net swiss technology network
EMBEDDED COMPUTING CONFERENCE

Nozzle Changer

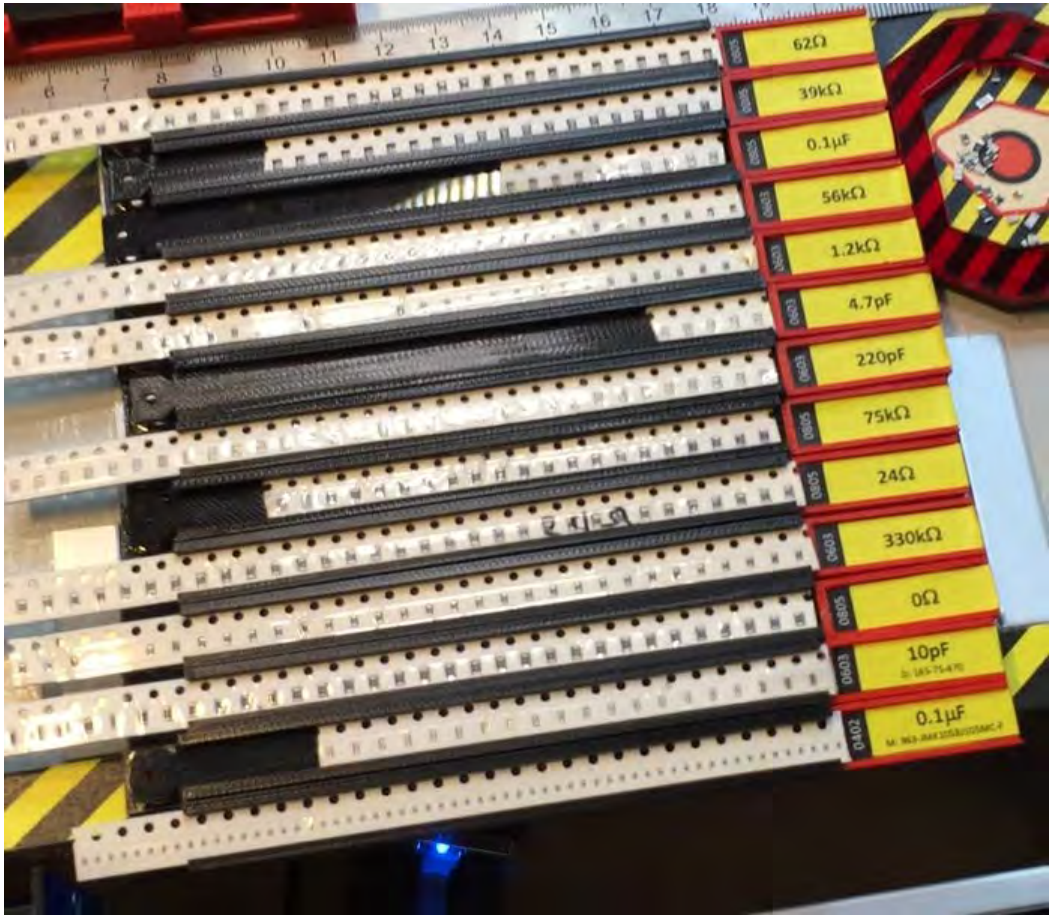
- Different nozzles for different part sizes
- Machine changes tool/nozzle
- Magnets to hold nozzles in holder



swissT.net swiss technology network
EMBEDDED COMPUTING CONFERENCE

SMT Cut Tape Holder

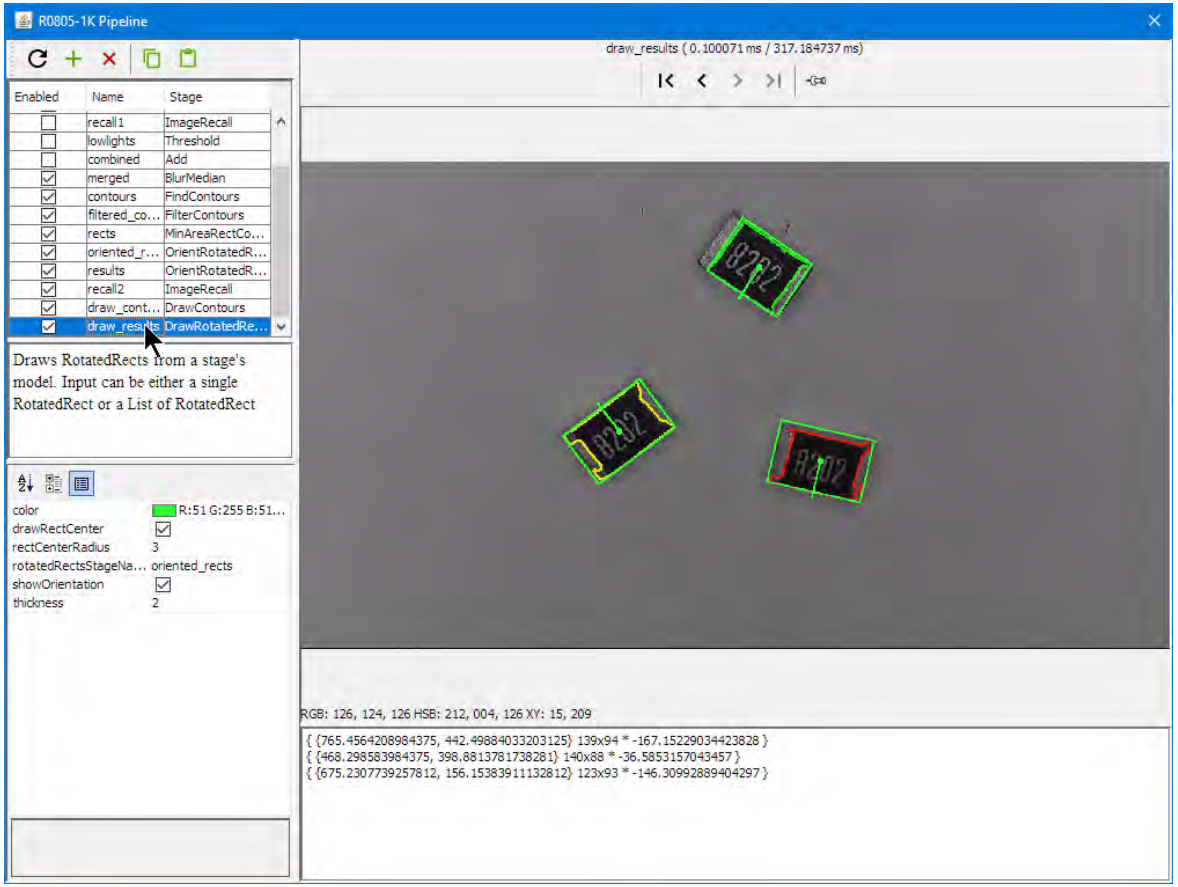
- 3D printed
- Magnets to stick on base plate
- easy changeable
- Vision System
  - Detects tape holes
  - Orientation
  - follows tape direction



swissT.net swiss technology network
EMBEDDED COMPUTING CONFERENCE

Loose Parts

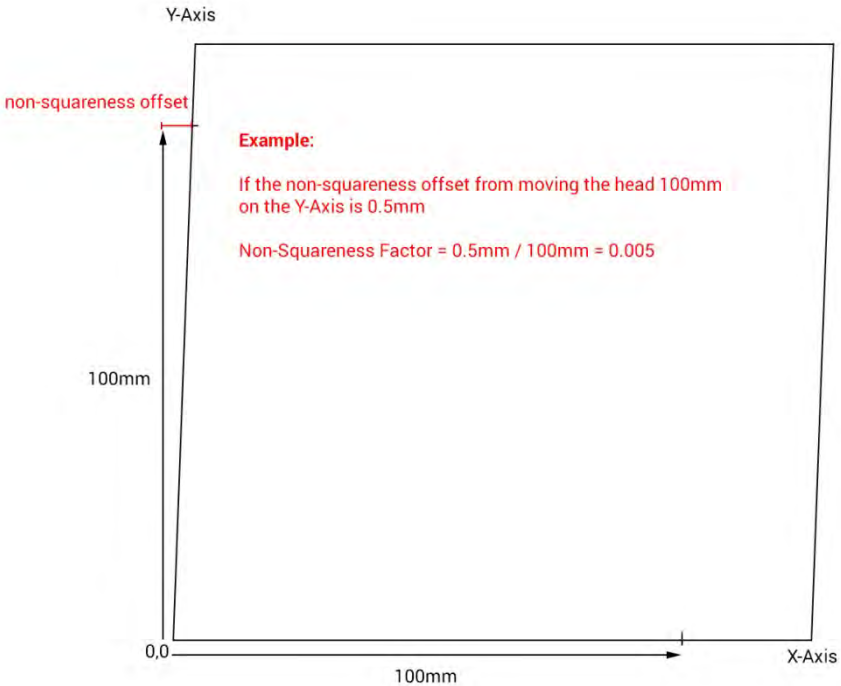
- Head vision system recognizes parts and orientation
- Vision Pipeline configurable with footprints



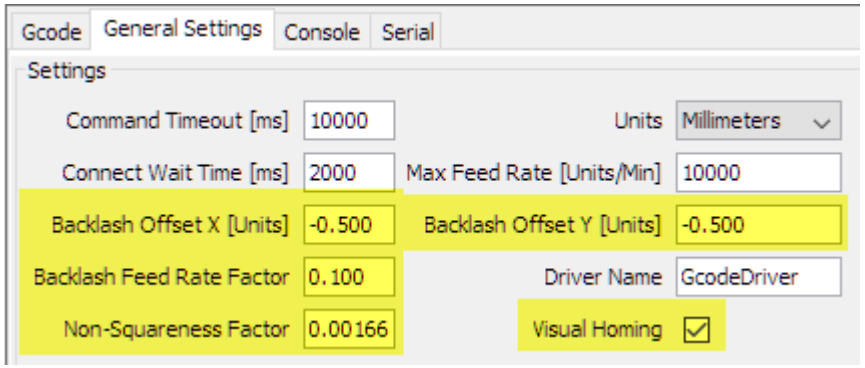
swissT.net swiss technology network
EMBEDDED COMPUTING CONFERENCE

Precision

- 0.01 mm stepper motors
- Visual Homing
- Backlash compensation
- Non-Squareness compensation



Source: OpenPnP.org

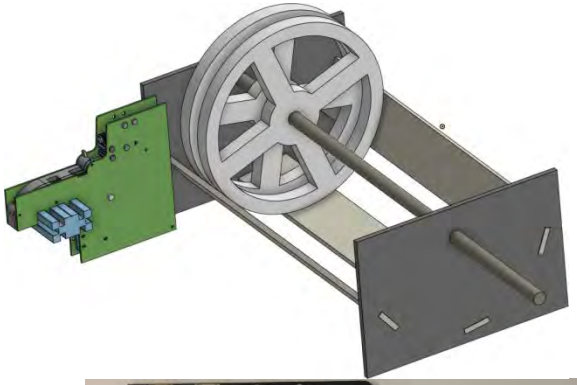



```
G0 {BacklashOffsetX:X%.4f}
{BacklashOffsetY:Y%.4f} {Z:Z%.4f}
{Rotation:E%.4f} F{FeedRate:%.0f} ;
Send standard Gcode move
(MOVE_TO_COMMAND) with Backlash
compensation
G0 {X:X%.4f} {Y:Y%.4f} {Z:Z%.4f}
{Rotation:E%.4f}
F{BbacklashFeedRate:%.0f}
M400 ; Wait for moves to complete before
returning
```

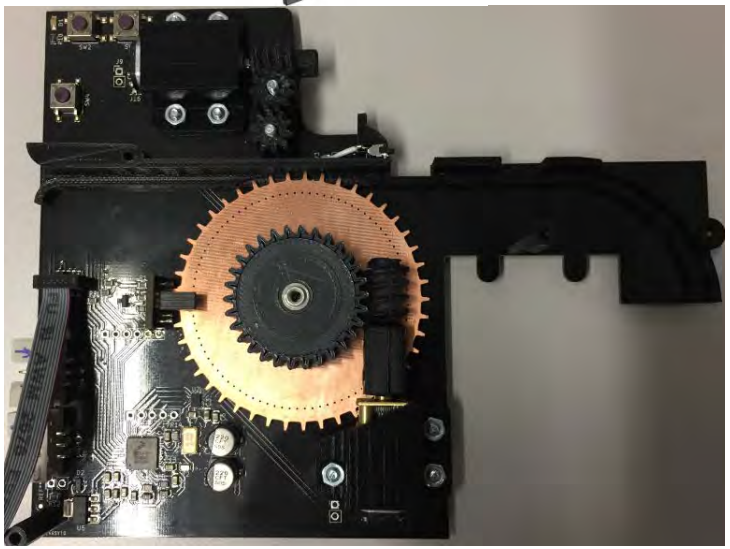

swiss.net swiss technology network
EMBEDDED COMPUTING CONFERENCE

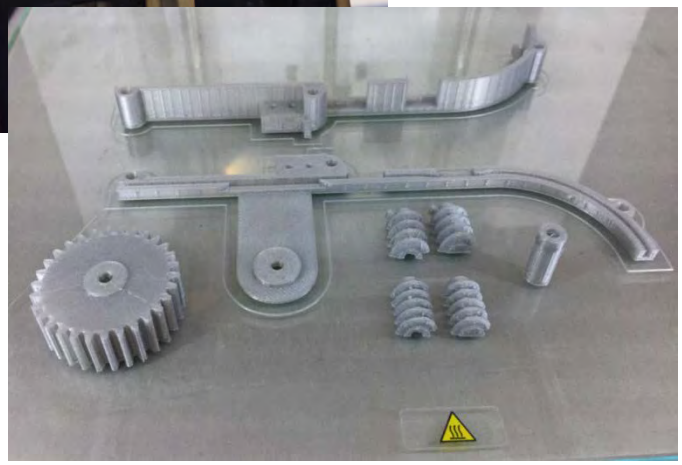
Auto-Feeder

- 8, 12, 16mm reels
- 2mm steps forward/backward



Source:
PAIND Huber Simon

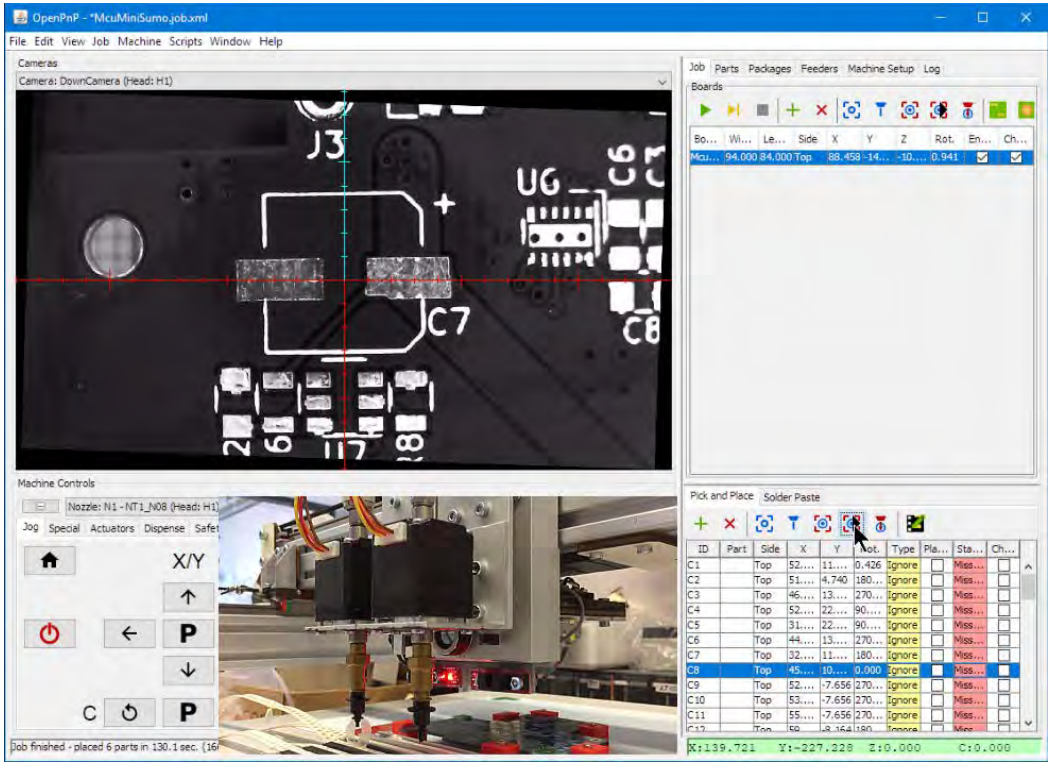




swissT.net swiss technology network
EMBEDDED COMPUTING CONFERENCE

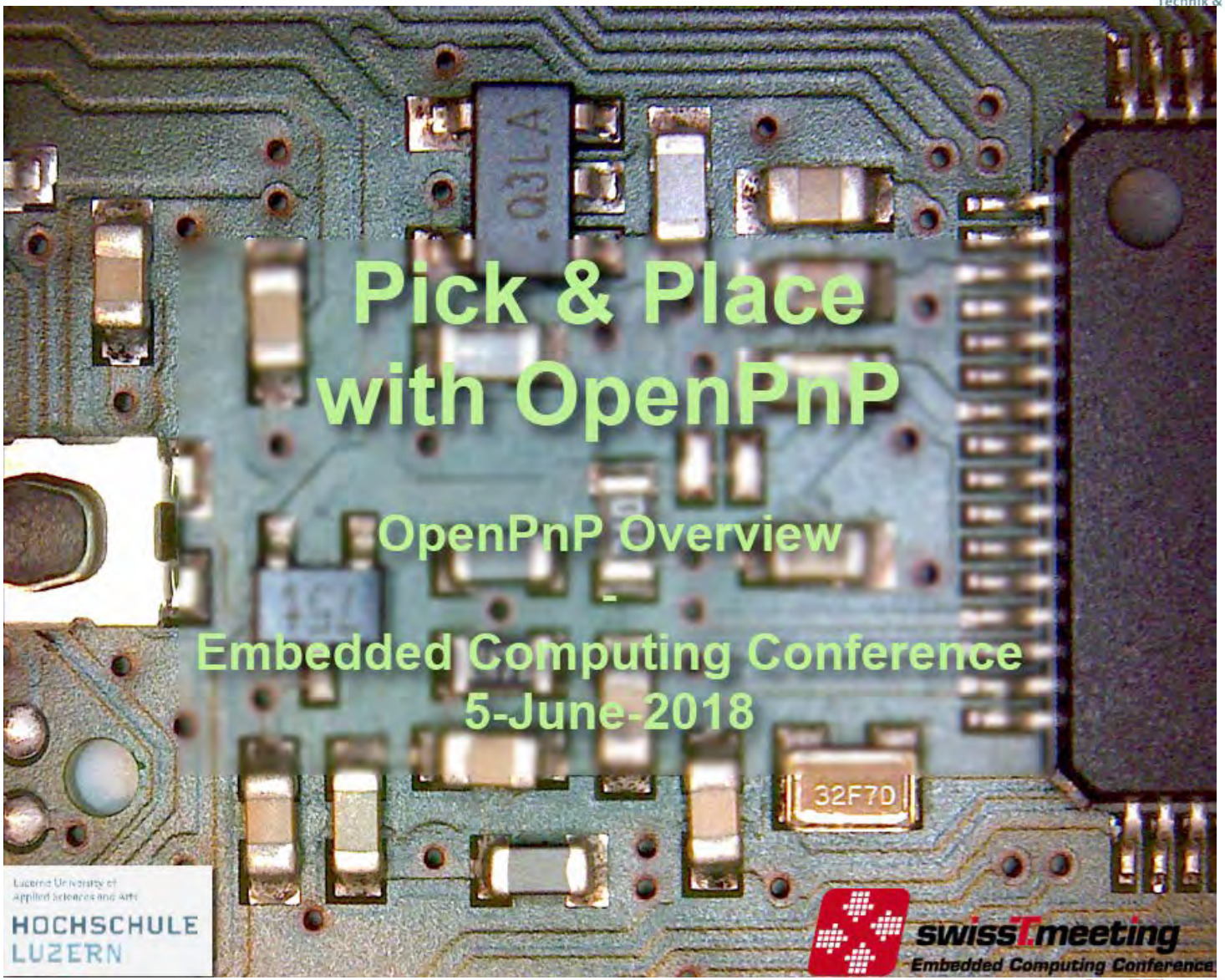
Software: OpenPnP, Open Source

- Java, plugins, machine configuration uses XML
- Packages ➔ Parts ➔ Jobs
- Imports CAD Position files (ID and Position)
- Job Editor



swissT.net swiss technology network
EMBEDDED COMPUTING CONFERENCE

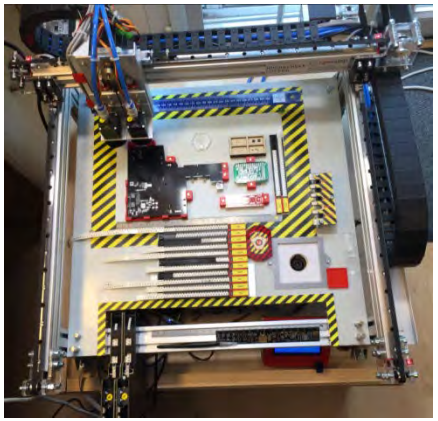
OpenPnP



swissT.net
swiss technology network
EMBEDDED COMPUTING CONFERENCE

Assembly with OpenPnP

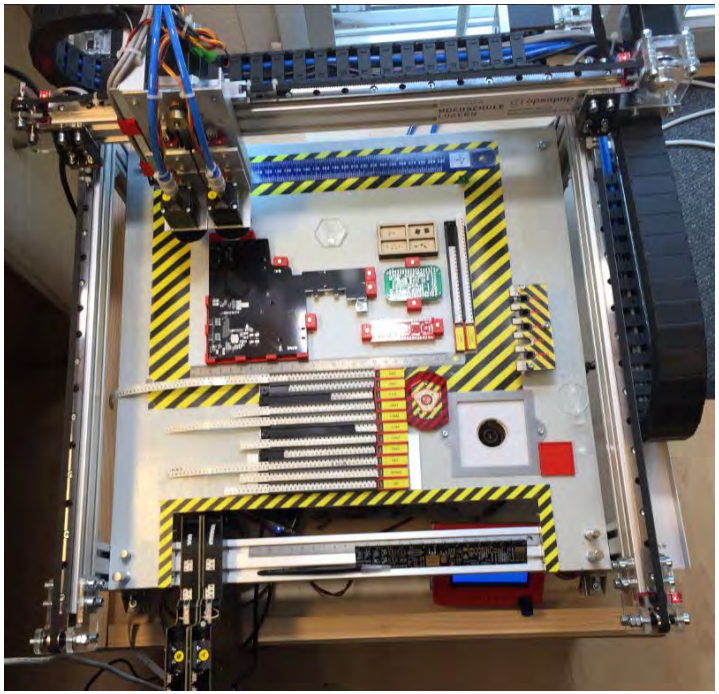
- **Configure Job**
- Apply solder paste ➔ stencil
- **Execute PnP Job**
- ‘bake’ in Reflow Oven
- Test board

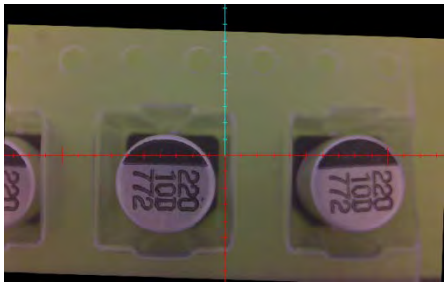


swissT.net
swiss technology network
EMBEDDED COMPUTING CONFERENCE

Results

- Speed: 400-600 cph
- Reliable up to0402
- Clear-Tape parts ➔ Auto-Feeder
- Part height > 8 mm ➔ manual assembly
- Time savings: already from 1-2 Boards ☺
- Next features
  - more auto feeders
  - Solder paste dispenser
  - Loose parts vibration motor (flip parts)
  - Vacuum sensor



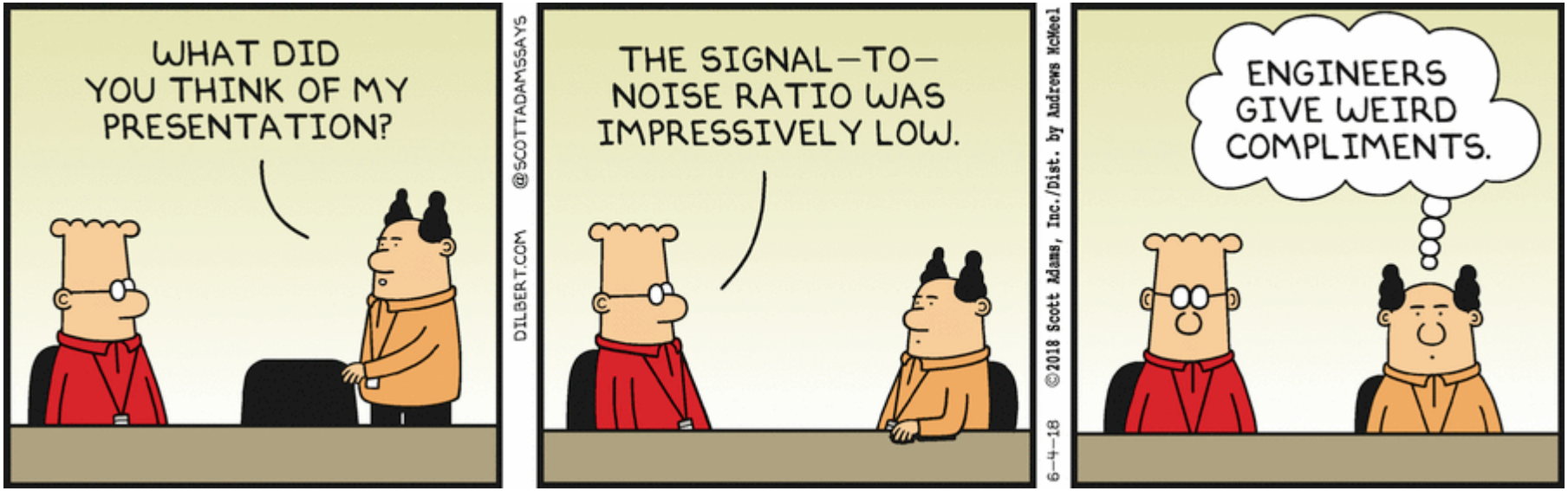


swissT.net swiss technology network
EMBEDDED COMPUTING CONFERENCE

Thank you!

CC Electronics , erich.styger@hslu.ch
https://www.hslu.ch/cce
Blog: https://mcuoneclipse.com/tag/**openpnp**/

swissT.net swiss technology network
EMBEDDED COMPUTING CONFERENCE

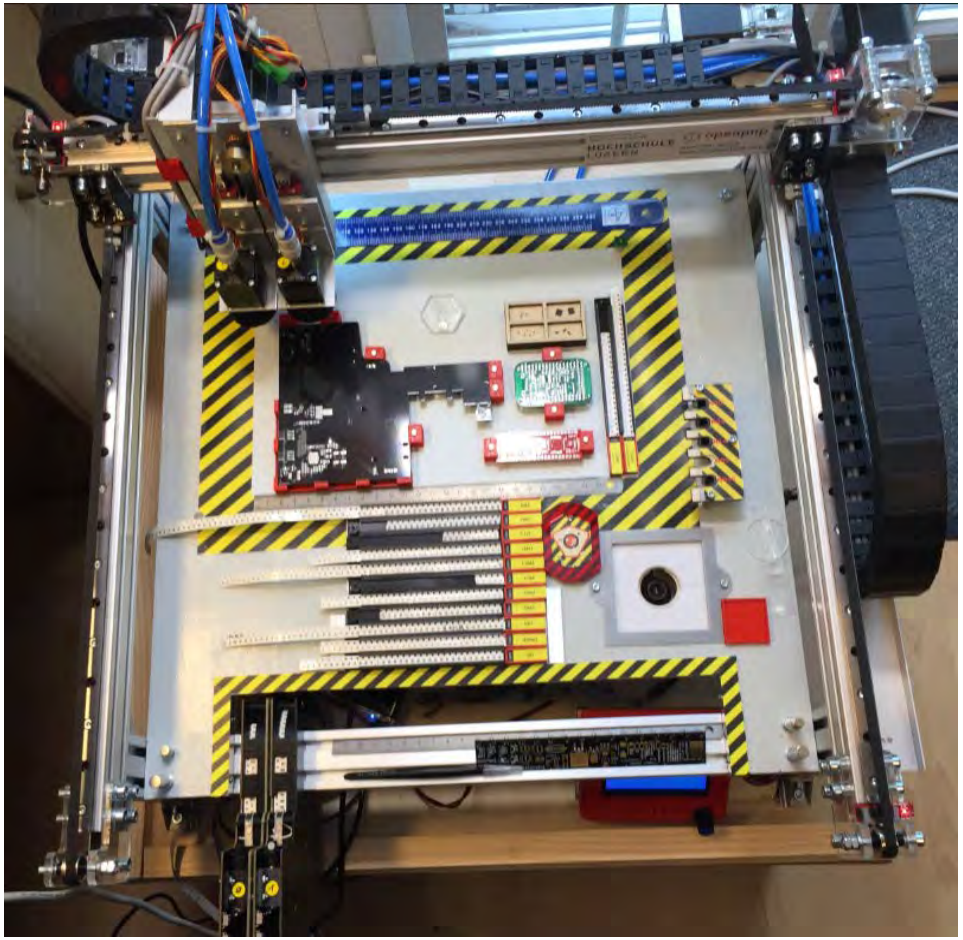


Quelle: Dilbert.com

swissT.net swiss technology network
EMBEDDED COMPUTING CONFERENCE

Open Source Pick & Place Maschine

- Costs < CHF 1000.—
- Assembles 300-600 parts/h
- Reliable up to 0402
- Dual-Vision System
- Dual-Head, automatic nozzle changer
- Parts: loose, cut-cape and motorized feeders
- Works with position data (KiCAD, Eagle, Altium, ...)
- G-Code with Smoothieboard
- OpenPnP Software



https://mcuoneclipse.com/tag/openpnp/