

DIY, DONE LIKE A MACHINE SHOP

Boaz

One CoreXY printer, built twice: once the way the hobby builds them, once the way a machine shop would. The difference showed up in every part it made.

16 min

Benchy, first attempt

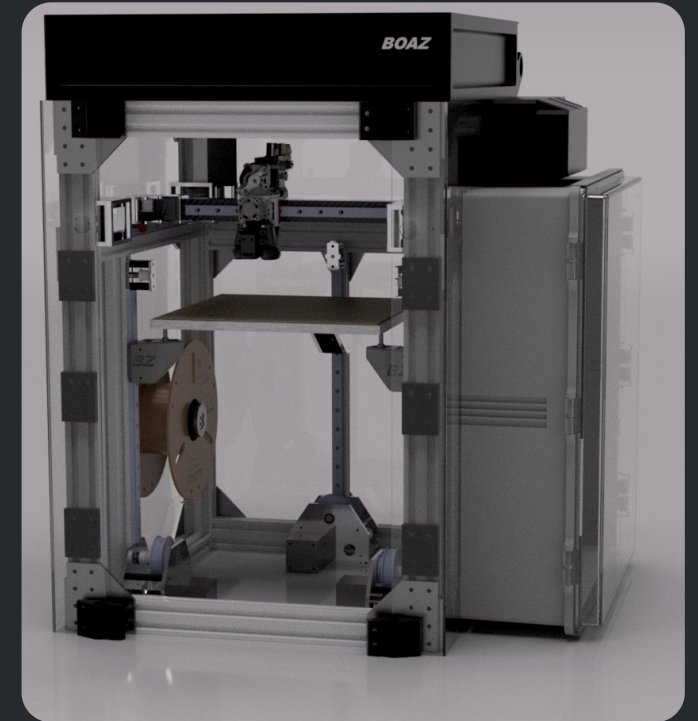
1,000

part PETG contract

< 0.001"

locating runout, TIR

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CoreXY · Klipper · kinematic bed



Why build another printer?

Almost every convention in hobby printing is inherited from RepRap: printed structural parts, idlers on M5 screws, threaded-rod Z, rails aligned by eye. Those choices were optimised for a machine that could copy itself, not for one that could hold a tolerance. Boaz asks a narrower question. What changes if you build the same open machine the way a shop builds a fixture?

- **Gusset joints, not blind joints:** clearance is what lets a frame be trammed
- **Every datum measured:** dial indicator against granite, never against the frame
- **Exact constraint, not force:** a three-point kinematic bed, trammed in firmware
- **Sensing that removes the operator:** eddy probing, accelerometers, driver telemetry

WHERE THE CONVENTIONS CAME FROM

- **1989**
Crump files the controlling FDM patent (Stratasys)
- **2005**
Bowyer founds RepRap at the University of Bath
- **2009**
The patent lapses and desktop FDM commercialises RepRap
- **Today**
Boaz: RepRap openness, machine-shop method

Five habits borrowed from machine building



Sandwich, don't cantilever

Idler stacks are trapped between two sheet-metal plates on machined standoffs. Belt tension then has no post to bend.



Reference against granite

The gantry is squared with a machinist square and a dial indicator on a granite plate. Never align a rail against the frame you are trying to correct.



Constrain exactly

The bed sits on a three-point kinematic coupling. Tramming becomes a firmware routine instead of a wrestling match.



Locate on dowels, not on hope

Ground dowel pins pressed into hand-reamed holes, about 0.05 mm of interference on a 5 mm pin, with the runout verified afterwards.



Sense, then decide

Eddy-current bed probing, accelerometer input shaping, TMC5160 telemetry. Measure the machine before tuning it.

*"Precision is not a part you buy. **It is a procedure you follow.**"*

Machine at a glance



CoreXY motion

Stationary motors, crossed 9 mm reinforced belts. Low moving mass, high acceleration



Triple belted Z

Three geared belt actuators at 1:5 lift the bed. No ballscrews, and the reduction divides the step angle



Kinematic bed

Cast ATP-5 tooling plate on a three-point coupling, trammed by its three motors



Klipper + TMC5160

Raspberry Pi host, SPI drivers tuned live, 48 V on the XY pair for torque at speed



Eddy-current probe

100×100-point meshes in minutes, and first layers nobody has to watch



CPAP part cooling

A remote high-flow blower feeds the toolhead, so cooling costs no carriage mass



623 W on paper

The itemised bound against a 600 W supply. A bound is not an operating point: the realistic worst case is 345 W



Input shaping

Resonances measured with an accelerometer and shaped in firmware. X is clean; Y still shows two modes

What broke first (so yours doesn't have to)



Press fits, misunderstood

Holes reamed to nominal gave clearance, not interference. The pins measured 0.04 mm undersize, other joints were pressed at 0.2 mm, and one idler ran visibly skewed. The rebuild reamed for 0.05 mm of interference and verified every joint.



PCB heatbed

A Prusa MK52 on a partial mount left 1.6 mm of deviation across the bed. No mesh density rescues a warped plate: it took a cast tooling plate to fix.



3D-printed structure

Printed Z-actuator bodies bent under standing belt tension and crept near the heated bed. The axis whose only job is position had runout designed into it.



Belt tension is not a dial to max

Tensioning one belt then the other racks the gantry, and the skew lands in every part. Matched tension on proper 9 mm belts removed the slip.

The pattern behind all four: a heuristic fix resolves the symptom and destroys the information you needed to diagnose it.

Upgrades that mattered



Cast tooling-plate bed

ATP-5 on the kinematic coupling. It arrives flat and has no rolling stress to release when heated



BTT Eddy probe

100×100 meshes in minutes, with the firmware computing its own Z offset



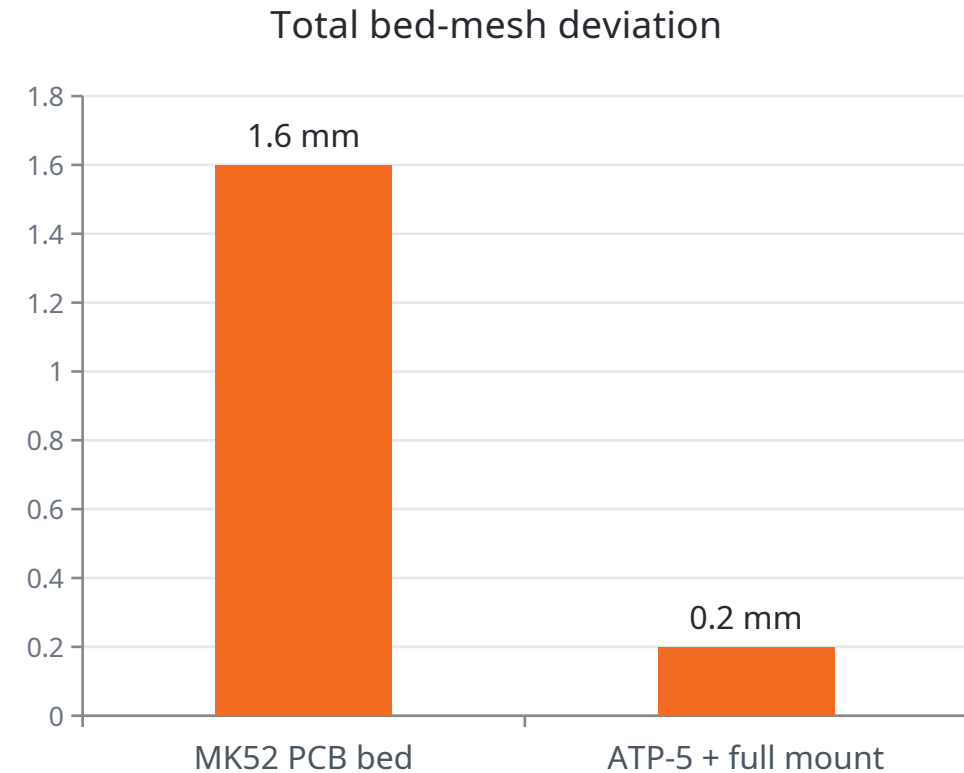
Califlower calibration

Skew too small for a machinist square, measured on a printed artifact and corrected in firmware. Threaded parts then assembled



Input shaping

One peak on X, 20,900 mm/s² under MZV. Two peaks on Y, which caps the machine at 9,500



Bed mesh envelope: 1.6 mm before the rebuild, 0.2 mm after

Did it work? The numbers



16:00

Benchy, first attempt

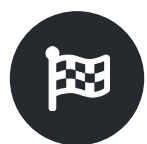
Against a 20 min target, and level with a HevORT at equal time. The smokestack and bow carry fewer artifacts. One paired print is an anecdote.



≈200

toys in a two-month run

Against about 150 from a Prusa i3 alongside it. The comparison flatters Boaz: the new machine got the attention, and was never run overnight.



1,000

parts, real contract

≈50 boxes a day for ten days. A \$300 Elegoo Centauri Carbon alongside it did ≈60. Boaz lost. What the contract proved is that it holds functional tolerance.



≈100

plates, no operator

Roughly a hundred consecutive plates started with no Z-offset jogging. The criterion asked for ten.

Eight criteria fixed before the build, seven met: one at its floor and lost outright as a comparison, one missed on the Y sweep. Full method and caveats in the book.

Six of the eleven rules

01 Stiff frame, large section, gusset joints, and more of them than a strength calculation asks for.

02 Metal for load paths. Printed plastic is for brackets and ducts, nothing that carries force.

03 Locate on ground dowels in reamed holes: about 0.05 mm interference, then verify the runout.

04 Square on granite with an indicator. Never reference the frame you are trying to correct.

05 Exact constraint beats force. A three-point coupling finds its own position every time.

06 Adopt sensing that removes the operator, then re-calibrate after every mechanical change.

Openness and precision aren't opposites.

One machine, built twice, on the same design and largely the same parts. What differs is whether the precision practice was executed, and it shows in every part the machine made.

- Read the book: 29 chapters of theory, failures, and the fixes that worked
- Steal the ideas: sandwich plates, belted Z, kinematic bed, granite and indicator
- Comment or DM to talk precision printing

