Bed Tramming

Bed tramming is the alignment of the bed plane with the XY gantry to minimize the need for mesh compensation (which is when Z adjusts continuously as X and Y move). This can be done manually as a part of machine setup, or automatically using a bed probe and independent Z actuators.

Manual Tramming

When a machine doesn't provide (fully) independent Z tilt control, the bed must be trammed manually. Some machines have no native support for this at all, relying on their construction to be "close enough" and compensating the rest of the way using a bed probe and mesh compensation.

Manual tramming enables the use of more robust Z linear motion systems compared to automatic tramming systems, but they should be checked and adjusted periodically, and the ideal alignment may vary with bed or chamber temperature.

Manually-trammed beds are supported by a number of compliant supports such as silicone columns and held down by screws. The stiffer the support the more rigidly the bed will be coupled to the printer structure (good).

Non-adjustable machines may use rigid columns that can be swapped for something slightly compliant if desired, such as the "silicone tube mod" for i3-style machines such as Prusas and Sovol SV06. However, on bedslingers, a rigid connection is better.

Three-point

On rigid, well-made beds that are trusted to be relatively flat, tramming manually only needs three points of support to control tilt in all axes. This cannot correct for any deformations in the bed, though.

Four-point

Cheaper machines with simple aluminum PCB beds may use four screws to adjust for a potato-chip-shaped bed. This has the disadvantage of possibly letting the user *induce* a potato-chip shape in the bed by adjusting one screw at a time.

Multi-point

Many machines with no adjustability mount the bed in 8, 9, or more locations. Modding them with silicone tubes as springs offers much finer control over the bed shape prior to mesh compensation.

Automatic Tramming

When the Z mechanism provides control over either the gantry or the bed tilt, tramming can be an automatic process performed as part of homing the machine, using the bed probe near the edges of the bed.

Gantry Tilt

Bedslinger

Bedslingers with independent Z motion for the two sides of the X gantry can tram automatically, but in only one direction. Fore/aft tilt of the bed must still be trammed manually, and the other axis of the bed is ideally trammed for perpendicularity to minimize skew of the print that must be calibrated out.

This requires that the gantry have some degree of articulation where it attaches to the Z linear guides.

Triple Z Flying Gantry

This isn't very common, but when the entire XY gantry is rigid and hoisted on three independent Z actuators, the gantry can be trammed to be level relative to the bed.

This requires that the gantry have some degree of articulation where it attaches to the Z linear guides.

Quadruple Z Flying Gantry

When the XY gantry has some flex and is hoisted on four independent Z actuators on the corners, the gantry can be trammed to be level and de-skewed relative to the bed.

This requires that the gantry have some give to handle the skew adjustment.

Bed Tilt

Two Point

Why do they do this? This is dumb. Some printers have only two independent Z actuators moving the bed so they can control one axis of bed tilt, but not the other. So you get some automatic tramming but you still need to manually tram, and it's often not even stiffly-enough constrained in the other tilt axis...

Three-Point

When the bed is hoisted on three independent Z actuators, the bed can be trammed relative to the gantry.

This is good.

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