OSSO board fabrication process, v3 (concept A)

Compiled Oct 16, 2026 at about 11:00 AM ET from JOURNAL.md (process review entries from 10:46 to 10:55 AM) and drawings/base_v2u.py.

Basis

- **Blank:** 140x140mm FR4, 2-layer, R4 corners. It comes prefabbed with full copper, mask and silk on both sides. It has ENIG pads, including 40x pogo Ø2.0, 4x corner rings Ø7 around plated M3 Ø3.2 holes with a Ø9 isolation, and 32x companion lap pads 2.0x1.0. It is also predrilled: vias Ø0.6, TH zones, M2 anchors, and the window and slot cutouts.
- **Laser:** 10W UV galvo with a 150x150mm field. When the blank is centered, each board edge is about 5mm from the field edge.
- **Jig:** hard-mounted to the optical table, with adjustment screws. A microscope camera is fixed rigidly to the galvo, and the operator aligns by eye on a large display.
- **Marks (v3 concept A, adopted; drawings/base_v3a.py):**
- Fiducials **A (22,22)** and **B (118,22)** are Ø0.3 plated holes with an ENIG ring (2.0 outer / 1.0 inner), a Ø4.0 mask-free ring and a Ø5.0 silk keep-out. They are visible from both sides, and A and B land on each other when the board is flipped left-to-right.
- Fiducial **C (118,112)** is a top-side surface mark used only as the orientation check. On the bottom it appears at (22,112) as C'.
- The pin-1 triangle stays at the top left.
- A **Ø3.0 non-plated tooling hole at (70,4.0)** and a **2.0x3.0 non-plated slot at (70,136.0)** sit on the flip axis x=70. They take a round dowel and a diamond dowel in the jig.
- These replace the v2 fiducials at (12,12), (128,128) and (128,12).
- **Scope:** top-side SMT only, with a single reflow. The bottom side carries traces and pads only.
- **Image layers:** the Spec-to-Object tool generates all of these from the design, per side. They are listed as L-SILK, L-MASK, L-CU, L-PASTE and L-REG (registration check).

Process steps

1. Fixture and register (top)

- **Purpose:** put the board coordinate system on the galvo coordinate system.
- **Tool:**
- Load the blank top-up onto the jig dowels: the round dowel goes in the tooling hole (70,4.0) and the diamond dowel in the slot (70,136.0). The dowels set x, y and rotation mechanically.
- Clamp only on the edge-stop zones (the y=0 and y=140 edges, x 15-125). Never clamp on the x=0 edge or within Ø13 of a corner power ring.
- Camera: go to A and then B using the calibrated camera offset and a known jig move. Use the crosshair overlay or blob detection to measure the offsets, then trim with the screws or apply them as a transform on the galvo job.
- Go to C and confirm the orientation. If C is not found, the board is loaded rotated 180° or wrong side up.
- **Input:** L-REG (positions of A, B and C, and the verification cross).
- **Check:** residual error at A and B is ≤0.05mm, C is present, and the verification cross in scrap margin is on target.
- **Risk:** dowel wear or slop, and debris on the dowels. Clean and gauge the dowels regularly.

2. Top silk removal

- **Purpose:** remove every bit of silk that should not remain.
- **Laser:** low-power fill hatch. It should ablate the silk but not the mask.
- **Input:** L-SILK-T. This is the outline minus kept silk, ENIG pads, cutouts and drills. The blank's silk must stop about 0.2mm short of all ENIG pads.
- **Check:** the mask is intact and unmarked, and no silk is left on future pad areas.
- **Risk:** mask burn-through, and silk residue that blocks the mask cut in the next step.

3. Top mask opening for SMT pads

- **Purpose:** expose copper for SMT pads.
- **Laser:** mask ablation that must not cut deep into the copper.
- **Input:** L-MASK-T, with openings 0.05-0.1mm larger than each pad.
- **Check:** the copper is clean and bright, and the edges are sharp.
- **Risk:** the new openings are bare copper, not ENIG, and will oxidize. Keep the time to reflow short and use flux or OSP.

4. Top copper isolation

- **Purpose:** define the traces. Everything not isolated stays as ground fill tied to the − corner bus.
- **Laser:** cut the negative outlines through mask and copper. The number of passes depends on copper weight.
- **Input:** L-CU-T, with 0.15-0.2mm gaps.
- **Check:** the gaps are clear down to the FR4 under the microscope, and the outline is continuous.
- **Risk:** incomplete cuts or copper slivers can short nets. Charring or delamination of the FR4 is also possible.

5. Flip, re-register, and repeat steps 2-4 on the bottom

- **Purpose:** process the bottom side while the board is still flat, before any paste or reflow.
- **Tool:**
- Flip left-to-right ($x \to 140-x$). The tooling hole and slot lie on x=70, so the board goes back onto **the same dowels**.
- The plated holes A and B swap places, so the camera re-registers on the same physical holes from the bottom side.
- Check C' at (22,112) for orientation.
- **Input:** L-SILK-B, L-MASK-B and L-CU-B, mirrored, plus L-REG-B.
- **Check:** residual error at A and B is ≤0.05mm. Also check the alignment of the bottom features to the drills (vias, TH zones).
- **Risk:** top-to-bottom misregistration is now limited mainly by the drill and dowel tolerance.

6. Clean debris

- IPA wipe or ultrasonic bath, then dry fully. Debris under the film causes leaks and poor adhesion.

7. Stencil film, then laser-cut paste windows (top)

- **Purpose:** an in-place stencil that registers itself to the board.
- **Material:** adhesive polyimide film, about 0.1-0.13mm thick. Film thickness sets the paste height. It must peel clean with no residue.
- **Laser:** cut the film without marking the copper underneath. Use low power and several passes.
- **Input:** L-PASTE-T, with windows at about 90% of pad area. Companion lap pads **get paste**. Pogo and corner ENIG pads **stay covered**.
- **Check:** every window has fully released. Use the camera to check for slugs left in place.
- **Risk:** marking or oxidizing the copper, and bubbles or lift at the film edges.

8. Squeegee paste, then peel film

- One firm pass while the jig holds the board flat. Peel slowly at a low angle while the paste is still wet. A film border or pull tab helps.
- **Check:** paste deposits are complete and there is no bridging. The ENIG pads are clean.

9. Place components

- Hand or tweezer placement. The jig camera can guide it.

10. Reflow

- Use a soak profile, because the large ground fill acts as a heat sink. Keep the board flat and support the window and slot areas.
- **Risk:** cold joints on ground pads, tombstoning, and board warp.

11. Clean

- IPA or wash, then dry fully. Keep the ENIG pogo and corner pads bright, and add no coating there.

12. Inspect and test

- Inspect under the microscope camera, especially the joints and the isolation gaps.
- Run continuity and short tests between nets and from each net to ground. Isolation slivers are the main defect to look for.

13. Optional coat

- Conformal coat or OSP on any bare copper that is left. Mask off the pogo, corner, lap and TH pads.

Required laser parameter tests (on coupons from the same blank lot)

1. **Silk off mask:** find the power, speed, hatch and passes that remove all silk with no mask damage.
2. **Mask off copper:** clean copper with minimal copper loss. Record the pass count.
3. **Copper isolation through mask:** passes to full isolation at 0.15 and 0.2mm, for the actual copper weight, plus a check for FR4 char.
4. **Film cut without marking copper:** polyimide windows release cleanly and the copper underneath stays unmarked.
5. (Recommended) **Galvo field calibration:** a grid across the full 150mm field to measure scale and distortion.
6. (Recommended) **Test mark visibility:** the marks used in steps 1 and 5 are easy to see on the camera.

Log each result as a parameter set (power, speed, frequency, hatch spacing, passes) in laser-test/.

Recommended changes: board marks and alignment (ALL ADOPTED in v3 concept A, Oct 16, 2026)

Implemented in drawings/base_v3a.py, osso_exploded_v3a.py and base_v3a_side.py, and in the proposal drawing drawings/align_proposal_v3a.png. One change from the proposal: the tooling hole and slot moved inward from y=3.5 to **y=4.0 and y=136.0**, which gives a 2.5mm edge web and keeps 1.5mm to the edge-via pads, still under the interposer ring.

Recommendations marked **[BOARD]** change the board drawing (base_v2u). Recommendations marked

[JIG/SW] do not.

R1. ADOPTED: Let the jig locate the board mechanically, and use the screws only to trim. [BOARD + JIG] Add 2 non-plated tooling holes on the flip axis x=70: - a round hole Ø3.0 at (70,4.0) - a slot 2.0 wide by 3.0 long at (70,136.0), running along y

They fit to a round dowel and a diamond (or smaller) dowel in the jig. The hole fixes x and y, and the slot fixes rotation without over-constraining the board, which is the kinematic choice.

Both holes sit on x=70, so the left-to-right flip maps each hole onto itself. **One jig works for both sides**, and the dowels set the top-to-bottom registration directly, at about the drill tolerance. With 133mm between the holes and about 0.05mm clearance, rotation error is about 0.02°.

The site is free: - x=70 is the gap in the edge via rows (k=0 is skipped). - y=4.0 and y=136.0 are outside the via rows at 7.5 and 132.5. - Both sit under the interposer ring band (0.5-6.5) and center spine, so no routing is lost.

Sizes are placeholders; use whatever is drilled in the blank stage. If the jig uses the corner M3s for location, it will scratch the plated power rings, so do not use them as locators.

R2. ADOPTED: Add a camera move that is known, rather than leaving the camera fixed in one spot. [JIG/SW] Because the camera is rigid on the galvo, it sees one point. Pick one option: - **(a) Preferred:** calibrate the camera's offset from the galvo center once. Mark a cross with the laser, then measure it in the image. After that, move the *jig* on a known x/y stage between marks A and B, or - **(b)** put 2 cameras over marks A and B, or - **(c)** use the galvo's own red guide or aiming beam at low power to check marks B and C after A is centered.

Whichever option is used, measure rotation from 2 marks that are far apart.

R3. ADOPTED: Move the marks inward and make them asymmetric. [BOARD] The current marks are 17mm from the field edge, where galvo distortion is worst. Move them to about 20-25mm from the board edge, for example A(22,22), B(118,22) and C(118,112), so they stay well inside the calibrated field.

A deliberately asymmetric set, with C offset so it is not at (118,118), rejects a 180° load. The pin-1 triangle should not be the only orientation cue.

R4. ADOPTED: Use marks that both sides can see. [BOARD] Make 2-3 of the fiducials small plated holes (Ø0.6-1.0 drill with an ENIG ring), so the same physical point registers both sides. They are part of the drill file, so they line up exactly with the vias and TH holes.

With R1 in place, these marks become verification marks rather than the primary locators.

Check where each mark lands under the flip (x→140−x). Put bottom-side surface marks so they mirror cleanly. For example, the current (128,128) mirrors to (12,128), which touches the pin-1 triangle (vertex at 13,127) on that side.

R5. ADOPTED: Design the marks for a microscope. [BOARD] - ENIG ring OD 2.0 / ID 1.0 with a Ø0.3 center dot, in a Ø4 mask-free ring of bare FR4 or mask for contrast. Or use an ENIG crosshair, 2mm with a 0.15 line. - Keep silk at least 0.5mm away. - ENIG on dark mask gives the highest contrast under ring light. - Size the mark to fill about 1/3 of the camera's field at working zoom.

R6. ADOPTED: Calibrate and verify every step. [JIG/SW] - Mark a grid on scrap or anodized aluminum across the field. Measure the scale and distortion and load the correction table into the galvo software. Repeat monthly or after any optics change. - Add a small L-REG verification cross in scrap margin to every layer, or engrave it the first time, and check it under the camera before each step.

R7. ADOPTED: Add software alignment as a low-cost upgrade. [SW] - Overlay a target crosshair on the camera feed. Use simple blob or circle detection to find the center of the ring or dot, and read out dx/dy in µm plus the rotation from 2 marks. - Better still, apply the measured offset and rotation as a transform on the galvo job instead of turning screws.

OpenCV plus a USB camera is enough for this.

R8. ADOPTED: Resolve conflicts with existing board features. [BOARD/JIG] - **Companions at x=0:** during fabrication the companions are not mounted yet, so edge stops are fine. After assembly, though, the lap pads at x 7.4-9.4 and the parts at the board edge rule out a hard stop on the x=0 edge (or x=140 when flipped). This is another reason to locate on dowels (R1) rather than on edges. If edge stops are used, put them only on the y=0 and y=140 edges, between x 15 and x 125. - **Corner standoff rings:** keep jig clamps and stops off the Ø9 isolation zones and the ENIG rings, and don't clamp on ENIG. - **Window and slot cutouts:** support the board near them when squeegeeing and during reflow. - **Fiducial (128,12):** this is clear of the TH zones (x 120.4-128, y 40.3-53 and y 87-99.7), so no conflict.

Summary of board-drawing changes: R1 tooling hole and slot; R3 mark positions; R4 plated fiducial holes; R5 mark design; R8 pin-1 clearance check.

Rule update (Oct 16, 2026 11:02 AM ET)

No bare copper: all laser-exposed copper is soldered via paste and reflow, including no-populate pads. Every other pad is factory ENIG. Step 13 (optional coat/OSP) is removed.

PINNED open item (Oct 16, 2026 11:04 AM ET)

Protection of isolation-cut copper edges: method TBD (film-masked conformal coat, accept with tarnish test, or other).