A WORKSHOP GUIDE

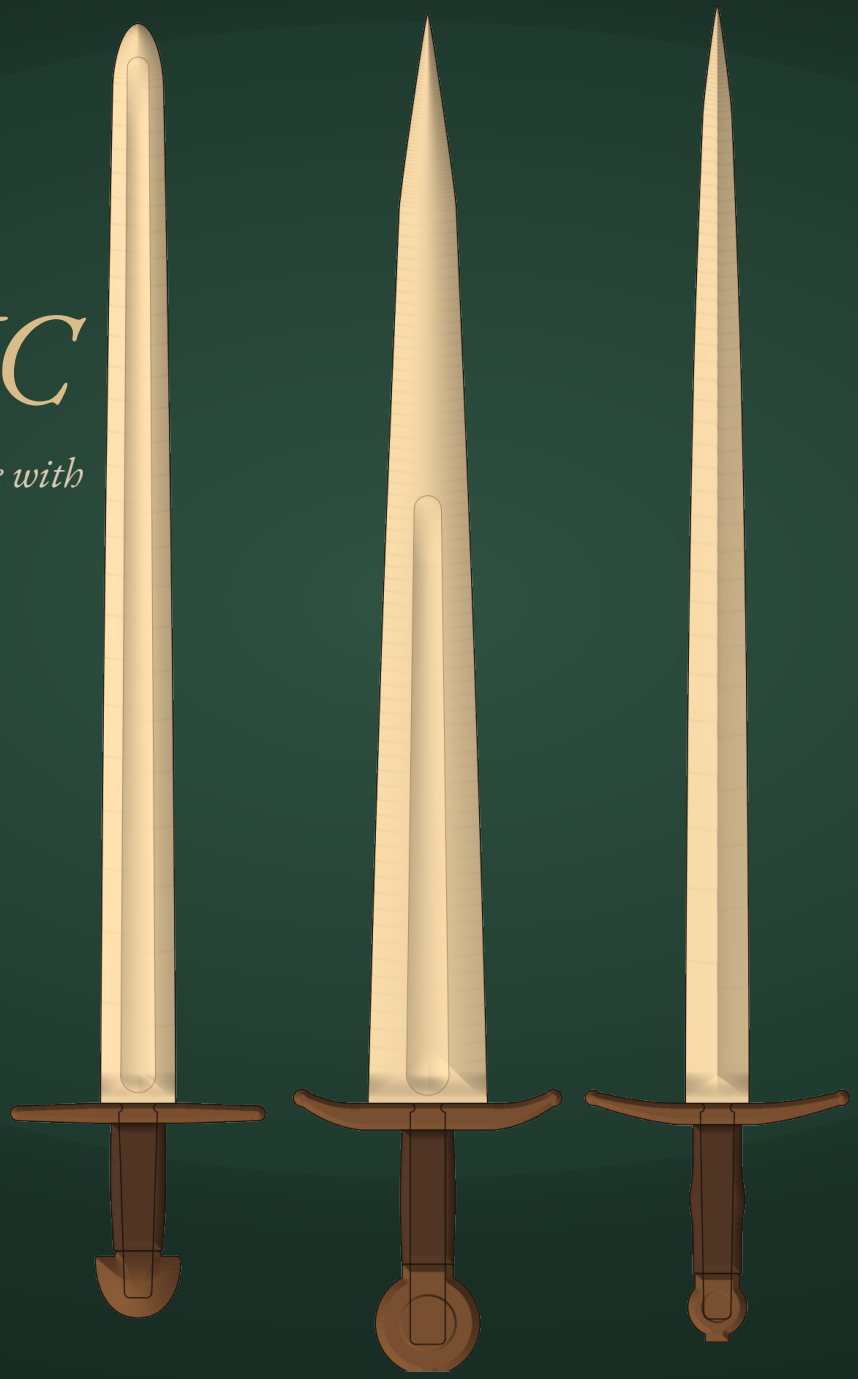
Three Oakeshott Swords *on the CNC*

Making wooden Type X, XIV & XVIII swords at 1:1 scale with two-sided machining on an OpenBuilds gantry router

X Royal Armouries IX.1081 · c.1100

XIV Metropolitan Museum 32.75.225

XVIII after the Albion Kingmaker



Prepared for Dan Pasker

OpenBuilds CONTROL · GRBL · 3/4″ hardwood · 1/4″ tooling

Starter files: /workspace/swords

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3	24	19.05 mm	1/4″	≈1.15 m
SWORDS AT 1:1 SCALE	G-CODE FILES · 2 JOBS × 4 PER SWORD	3/4″ HARDWOOD STOCK	ENDMILL + BALL NOSE	X TRAVEL NEEDED

CHAPTER ONE

The Three Swords

Ewart Oakeshott sorted medieval sword blades into types by shape. This kit gives you one sword from early, middle and late in that story, each one taken from a real museum piece or a researched replica.



You have three full-size wooden swords to make. Each was drawn at 1:1 historical scale, with lengths taken from a museum catalogue or a researched replica. Each is turned into a two-sided CNC job for 3/4″ hardwood. The blade and tang are one piece. The guard, grip and pommel are each two halves that you glue around the tang.

Type X, c.1100 · Royal Armouries IX.1081

This is the Viking-to-Norman arming sword. It has a broad, shallow fuller that runs almost to a rounded point, a straight square-section cross, and a Brazil-nut pommel (the Royal Armouries calls IX.1081's a "beehive"). The overall and blade lengths come from the RA catalogue entry. The 56 mm width is *approx* because IX.1081's width is not published online. It was taken from Type X/Xa replicas (Albion Norman, Albion Jarl, ElGur X-1-A).

Type XIV, c.1300 · Metropolitan Museum 32.75.225

This sword has an "extraordinary width" of 89 mm at the base. Its blade tapers hard to an acute point, and a broad fuller runs about half its length. The cross is long and curved, and the pommel is a J1 wheel. The overall length, blade length and width come from the Met Museum Journal (1969) article. The grip, cross and pommel sizes are approximated.

Type XVIII, 15th c. · after the Albion Kingmaker

This is a late, stiff, thrust-capable blade. It is a flattened diamond with hollow-ground faces and a raised midrib, and it has no fuller. The cross is an arched style 9 and the pommel is a type K wheel with recessed faces. The dimensions come from Albion's published specs and the myArmoury review. It is cross-checked against Royal Armouries IX.949.

Waster-thick on purpose

Real steel blades are 5–7.6 mm thick. These wooden blades keep the full 19.05 mm stock thickness at the spine and run down to a **5 mm blunt edge**. Fullers are 3 mm deep on each face. Sections are a parabolic lens for X and XIV, and a slightly hollow diamond for XVIII.

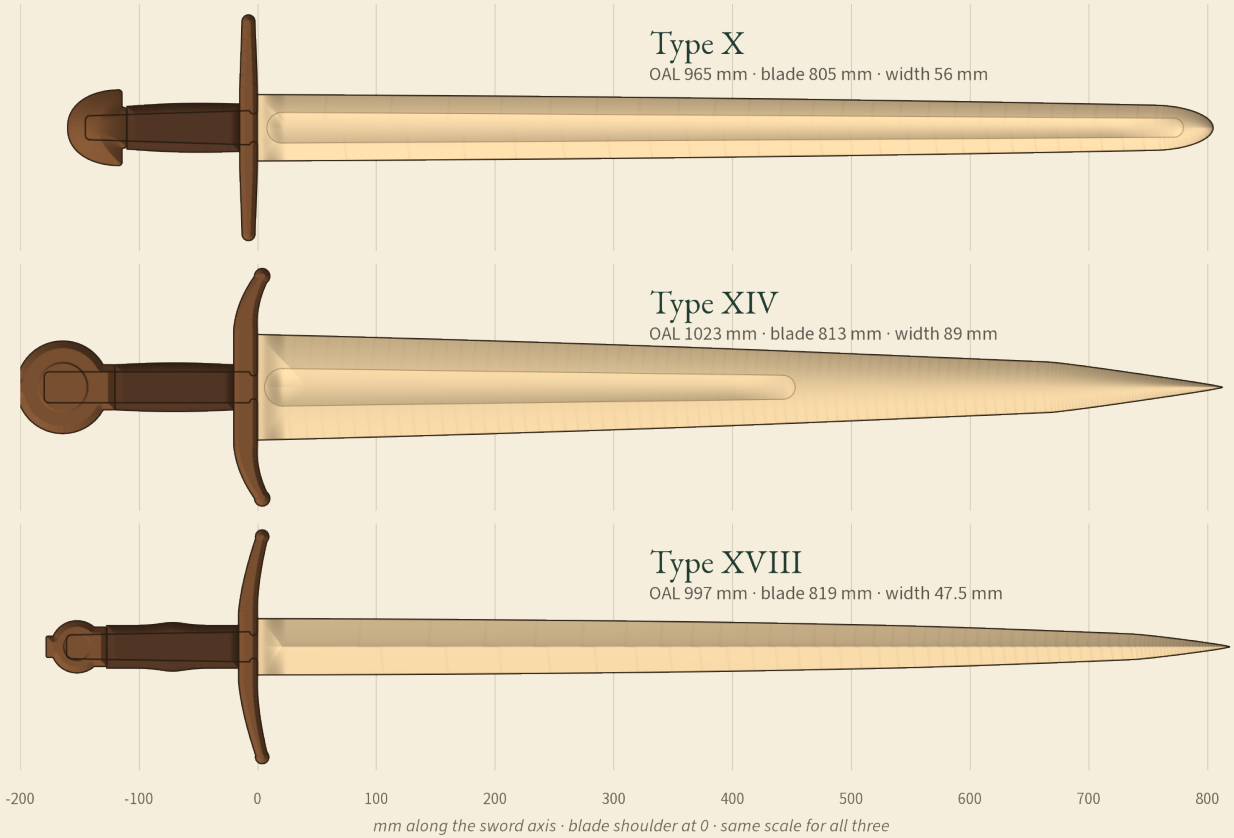


FIG. 1 *The three swords drawn to the same scale. These renders come from the generator's own blade and hilt surfaces, so the fullers, bevels and pommel shapes are what the G-code will carve. Wood colours are for illustration only.*

SWORD	OAL	BLADE	WIDTH AT BASE	GRIP	CROSS	POMMEL	FULLER	TANG W (MM)	TANG L
Type X after Royal Armouries IX.1081, c.1100	965	805	56≈	95	190	50≈	772	30≈ → 20≈	145.0
Type XIV after Metropolitan Museum 32.75.225	1023	813	89	100≈	200≈	90≈	447	26≈ → 26≈	179.6
Type XVIII after Albion 'Kingmaker', 15th c. English pattern	997	819	47.5	111	197	51≈	0	26≈ → 20≈	160.8

All values in mm, from `swords.json` / `swords.csv`. ≈ means the dimension is marked *approx* in the database (estimated from typology averages, replicas or proportion). Everything else is marked *sourced* and has a URL. Tang length comes from `build_report.json`. The XVIII has no fuller: it is a hollow-ground diamond.

SWORD	PERIOD	CROSS	POMMEL	SECTION (HISTORICAL → WOOD VERSION)
Type X	Type in use 9th c. - early 12th c.; reference sword dated c.1100	Style 1 (straight, square section, tapering to tips; 7-8 in long)	Type A (Brazil-nut; RA describes IX.1081's as 'beehive')	Flat lenticular with a broad shallow fuller almost to the point (RA: 'broad fullers'). Wood version: parabolic lens to a 5 mm blunt edge + 3 mm deep fuller each face.
Type XIV	Type c.1270-1340; Oakeshott dates this sword 1st quarter 14th c. (Met catalogue: c.1400)	Style 4 per SAC plate caption 'Type XIV, J1, 4' (long, curved cross)	Type J1 (wheel with raised central panel ringed by a flat band)	Flat section, broad single fuller ~half the blade; Met example has a diamond-section tip. Wood version: parabolic lens + 3 mm fuller each face.
Type XVIII	Type c.1350-1510 ('most widely used 1410-1510'); this pattern mid-late 15th c.	Style 9 (arched cross, faceted)	Type K (wheel with recessed central faces)	Flattened diamond, raised midrib, hollow-ground bevels, no fuller. Wood version: diamond to a 5 mm edge with slightly concave (hollow) faces.

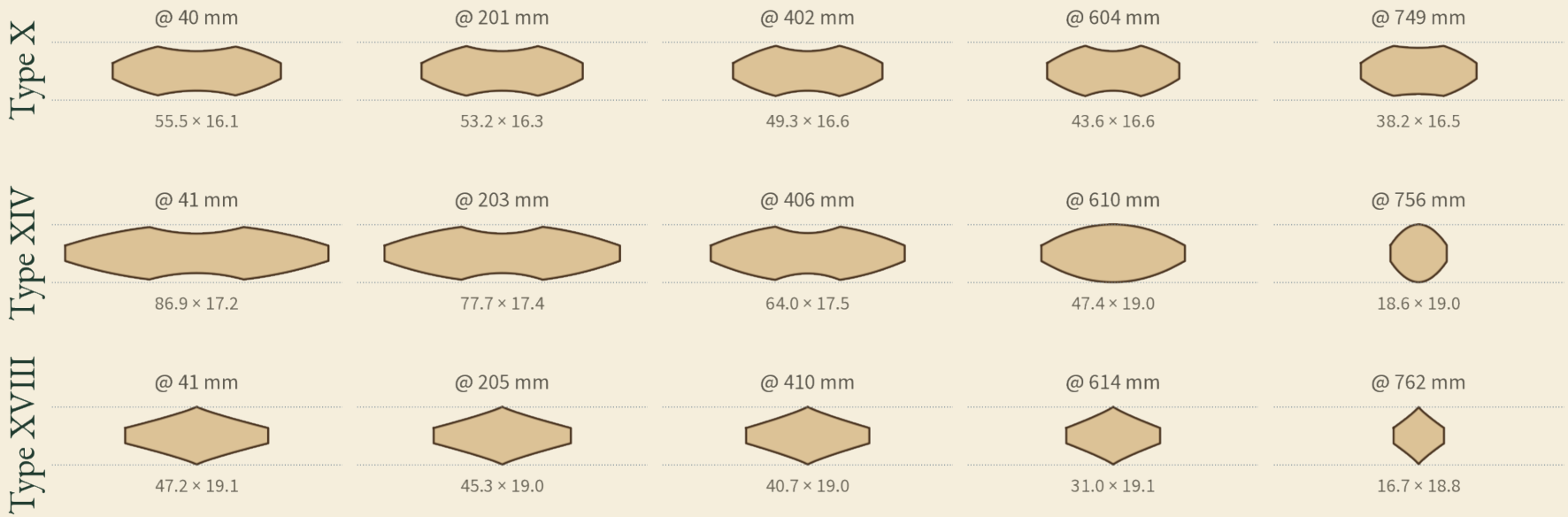


FIG. 2 *Blade cross-sections at five stations, computed from the generator's surface model. Numbers are width × maximum thickness in mm. The dotted lines are the two faces of the 19.05 mm stock. Every edge ends in the 5 mm blunt flat.*

CHAPTER TWO

What's in the Files

There is one folder for each sword, and two flip jobs inside each one: the blade, and a board that holds all six hilt halves. Each job has four G-code files, and each file name tells you its side and its order.



```
/workspace/swords/
├── README.md                    the master notes: workflow, feeds, assumptions, sources
├── sword_params.py              THE DATABASE – edit numbers / add a new type here
├── sword_gen.py                 generator: [--stock 18.7] [--clr 0.15] [--only ID] [--out DIR]
├── verify_dxf.py  → verify_report.txt      mm units, closed paths, OAL/blade/width/cross vs DB
├── gcode_check.py → gcode_report.jsonl     independent G-code parser: bounds, min Z, run time
├── swords.json · swords.csv     every dimension, sourced/approx, URLs
├── build_report.json            stock sizes, pin positions, per-file minutes / min Z
├── overview_comparison.png
└── <ID>/                        X_RA_IX1081 · XIV_MET_32_75_225 · XVIII_ALBION_KINGMAKER
    ├── <ID>_preview.png         assembly, sections, both sides of both flip jobs
    ├── parts/   _blade · _guard_half · _grip_half · _pommel_half · _assembly    (.dxf + .svg)
    ├── setup/   _blade_sideA/B · _hilt_sideA/B    flip layouts with stock, pins, tabs
    └── gcode/
        ├── blade/  A1_pins · A2_blade_faceA_3D · B1_blade_faceB_3D · B2_blade_profile_tabs    .nc
        └── hilt/   A1_pins · A2_hilt_inner_tang_pockets · B1_hilt_outer_shape_3D · B2_hilt_profile_tabs
```

Already verified

`verify_report.txt` ends with **ALL CHECKS PASSED**. Every DXF is in mm with no open cut paths. Overall length, blade length, base width and guard length all match the database exactly, for example Type X 965 / 805 / 56 / 190 mm. `gcode_report.jsonl` comes from a separate parser and repeats every file's bounds, deepest Z and run time.

Nothing has been cut yet

These files have been generated and checked in software, but **none of them has been run on a machine**, not even as an air cut. Treat your first pass through each file as a proving run. Chapter 4 shows how.

Reading the G-code names

The letter is the **side** and the digit is the **order**. `A1` and `A2` run with face A up. You then flip, and `B1` and `B2` run with face B up. Every job is **four files**:

FILE	BLADE JOB	HILT JOB	TOOL
`A1`	pin holes	pin holes	1/4″ endmill
`A2`	face A 3D (fuller + bevels)	inner tang pockets	ball / endmill
`B1`	face B 3D (Y mirrored)	outer faces 3D	1/4″ ball nose
`B2`	profile with tabs	profiles with tabs	1/4″ endmill

The G-code is plain GRBL. It uses only `G21 G90`, `G0/G1` and `M3/M5`, in mm, with absolute coordinates. Each file opens with a comment header that names the tool, the zero convention and what to do next. Every header says **"AIR-CUT / SIMULATE FIRST, CHECK FEEDS FOR YOUR MACHINE."**

Coordinate conventions

- **Part files:** X is the sword axis. The blade points toward +X and the shoulder is at X = 0.
- **Setup files and G-code: X0 Y0 is the centre of registration pin 1** at the left end of the stock. Pin 2 is also on Y = 0.
- **Z0 is the top of the stock on both sides.**
- The flip is **about the X axis**. Side B geometry is side A geometry with Y → −Y. Both pins sit on the flip axis, so **XY zero never changes and only Z is re-zeroed.**

DXF layers

LAYER	WHAT IT IS
`OUTLINE`	closed part profile
`TANG_POCKET`	closed pocket in each hilt half
`FULLER_OUTLINE`	closed fuller boundary
`FULLER_CL` / `RIDGE_CL`	open centre lines, for reference
`CONTOUR_Z-1.0` … `Z-7.0`	closed iso-depth bevel lines from the stock top, for a 2.5D terrace option
`PINS`	6.35 mm circles
`STOCK` · `TABS`	blank outline · tab positions
`HILT_STATIONS`	where guard, grip and pommel sit on the tang

The DXF is the master file. The SVG has the same geometry at 1 unit = 1 mm.

CHAPTER THREE

Shop Preparation

Check the machine travel, mill the stock flat, measure it, and regenerate the files if it is not 19.05 mm. Fit the right bits and plan your clamps before anything moves.



1 · Will it fit? The X-travel check

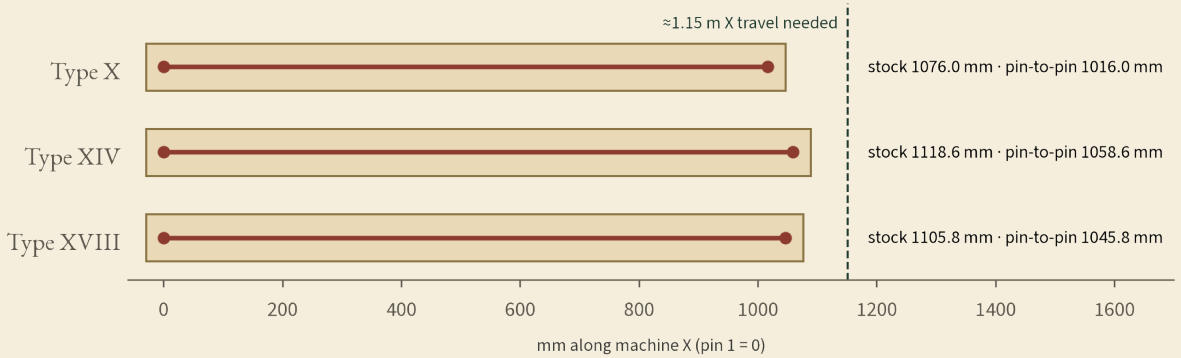


FIG. 3 *Blade blanks and pin spacing along machine X. Pin 1 is X0 and the stock starts 30 mm to its left. The README asks for at least about 1.15 m of X travel.*

The blade blanks are **1076–1119 mm long**, so your gantry needs **at least ~1.15 m of X travel**. The toolpaths themselves run from pin 1 (X 0) to pin 2 (X 1016.0 for Type X, up to X 1058.6 for Type XIV). The stock also has 30 mm of margin beyond each pin.

- [ ] Measure the real travel: home, then jog to the far +X limit and read the position.
- [ ] Make sure the blank fits under the gantry and between any end plates **with clamps fitted**.
- [ ] Check that the dust-shoe brush clears clamps all along the job.

If X is short

The README gives two ways out. You can scale the parameters down in `sword_params.py`, or rotate the job if your Y axis is longer. Rotating means changing the generator or your zeroing. All the files assume the long axis runs along machine X.

2 · Stock

SWORD	BLADE BLANK	PIN 2 X	HILT BLANK	PIN 2 X
Type X	1076.0 × 132.0	1016.0	636.7 × 260.0	576.7
Type XIV	1118.6 × 165.0	1058.6	747.4 × 270.0	687.4
Type XVIII	1105.8 × 123.5	1045.8	681.9 × 267.0	621.9

mm, from `build_report.json`, also drawn on layer `STOCK`. Thickness 19.05 mm (3/4″) for both.

Use straight-grained **hard maple, hickory or ash**, with the **grain running along the blade**. Baltic-birch ply is strong but shows the plies at the bevels. Use **MDF only for display or templates**, because a long MDF blade will snap.

3 · Mill flat, then measure

Plane the stock flat. Both faces are zeroed from the top, so a cupped or twisted board will put the side B surface in the wrong place relative to side A. Measure the finished thickness in several places with calipers.

The generator derives the bevel depth, edge flat and pocket depths from the thickness. The bevel depth is D = (T − 5)/2, which is 7.025 mm at 19.05. The tang pocket is T/2 + clearance, which is 9.775 mm. **If your board is not 19.05 mm, regenerate:**

```
cd /workspace/swords
.venv/bin/python sword_gen.py --stock 18.7      # your
measured thickness, mm
.venv/bin/python verify_dxf.py                  # re-check
→ verify_report.txt
.venv/bin/python gcode_check.py > gcode_report.jsonl
```

> **Measure the hilt board too**
>
> The hilt pockets are cut to half the *configured* thickness plus clearance. Mill both boards to the same thickness so one regeneration covers both, or build each board separately with `--only` and `--out`.

4 · Bits

TOOL	USED FOR	NEED
1/4″ 2-flute carbide upcut or compression endmill, centre-cutting	pins, hilt pockets, profiles	**≥ 1″ (25 mm) cut length**
1/4″ 2-flute carbide ball nose	blade faces, hilt outer faces	≥ 3/4″ cut length
1/2″ 90° V-bit (optional)	chamfer-style bevels in the CAM route	–

All toolpaths assume 1/4″ (6.35 mm) tools. A smaller tool needs regenerated files (set `endmill_d` / `ball_d`). The pin holes are 25 mm deep. If your endmill is short, spot the holes with the CNC and finish them with a 1/4″ brad-point drill.

5 · Workholding and spoilboard

- Clamp or screw **only in the outer 30 mm waste margin**, the hatched band on every setup drawing (Figs. 8–10 and 11–13). You will clamp **twice**, once for each side, so choose screw positions that stay clear of the gantry, the dust-shoe brush and the pin holes on both faces.
- The pins go **6 mm into the MDF spoilboard**. The hilt profile cuts **0.3 mm into** it, and the blade profile never reaches it. Surface the spoilboard flat first so Z0 on the stock top means the same thing everywhere.
- The 1/4″ dowel pins must sit **below the stock top**, because the tool crosses the pin locations. Cut each dowel shorter than 19.05 + 6 mm.

CHAPTER FOUR

Loading and Proving in OpenBuilds CONTROL

Open a file, read its header, look at it in the 3D viewer, then run it in the air. Only after that does it touch wood.



Loading a file

1. **Connect and home.** Connect to the controller in OpenBuilds CONTROL. Home the machine if it has homing switches, so you can get back to a known XY after a power cycle.
2. **Open the G-code.** Load one file at a time from `<ID>/gcode/blade/` or `…/hilt/`, in order: A1 → A2 → B1 → B2.
3. **Read the header.** The first lines name the tool, for example `( TOOL: 6.35 mm (1/4 in) BALL NOSE - Z zero the tip on stock top )`, and the units/zero line `( UNITS mm | X0 Y0 = centre of registration pin 1 | Z0 = TOP of stock )`. A2 and the hilt pockets end with `( after this: … FLIP ABOUT X AXIS onto the pins, re-zero Z only )`.
4. **Check it in the 3D viewer.** The path should start near X0 Y0 and stay inside the stock outline. Compare it with Figs. 4 and 14. All four files of a job share one origin, so their extents should line up.

FILE	DEEPEST Z	WHAT THAT MEANS
A1_pins	−25.05	19.05 stock + 6 mm into spoilboard
blade A2 / B1	−7.025	moat floor = edge level
blade B2	−12.525	through the 5 mm web + 0.5
hilt A2	−9.775	tang pocket depth
hilt B1	−12.05 (X) / −9.698	face to thickness + shaping
hilt B2	−19.35	0.3 mm into spoilboard

Values from `gcode_report.jsonl`. If the viewer shows anything deeper, stop. You have the wrong file or the wrong stock setting.

The air cut (do this first)

The README's dry-run method is simple. **Zero Z about 25 mm above the stock and run the program in the air.** Everything happens 25 mm higher than it will for real, so even the −25.05 pin plunge stays clear of the wood.

Air-cut checklist · every file, first time

- [ ] Correct tool fitted for the header
- [ ] X0 Y0 set at pin 1's position; Z0 set 25 mm above the stock top
- [ ] Router **off** (or on, if you also want to check spindle start and the G4 P4 pause). Hand on the e-stop / feed hold.
- [ ] Path stays inside the stock, and the gantry and dust shoe miss every clamp
- [ ] No soft-limit or travel alarm at the far +X end (the travel check)
- [ ] Program ends with M5 and returns to X0 Y0
- [ ] Note the real run time against the estimate

Speed up the proving run

The 3D files are long: 1.5–2.5 h each. For the air cut you can raise the feed override and watch the extents, the corners and the far end. At full feed, watch the first and last few minutes, where the raster reaches the tang and the point.

Zeroing for the real cut

- **X0 Y0:** jog to the pin 1 location, about 30 mm in from the left end and centred on the stock width. Set X and Y zero. The long edge must be roughly parallel to machine X.
- **Z0:** on the stock top, with a probe or a sheet of paper. Re-zero Z **after every tool change and after the flip**, with the tip of whatever tool is fitted.
- **Never re-zero X or Y after A1.** The pins are your XY reference from then on.

What the 3D viewer should show

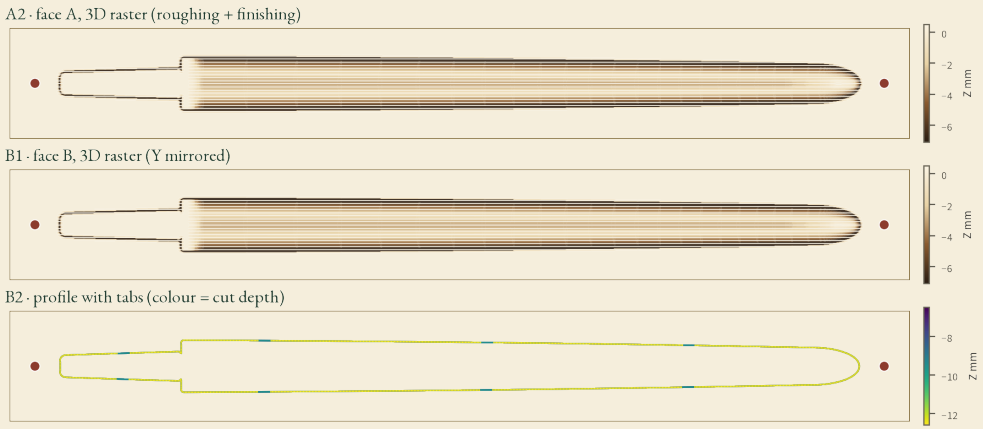


FIG. 4 *What the files actually contain: Type X blade toolpaths plotted straight from the .nc files, coloured by Z. In B2 the lighter marks along the path are the tabs, where the cutter lifts to leave web.*

CHAPTER FIVE

Cutting the Blade, Side by Side

Pins, face A, flip, face B, then a profile pass that cuts only a thin web. The two dowel pins carry the alignment through the flip.



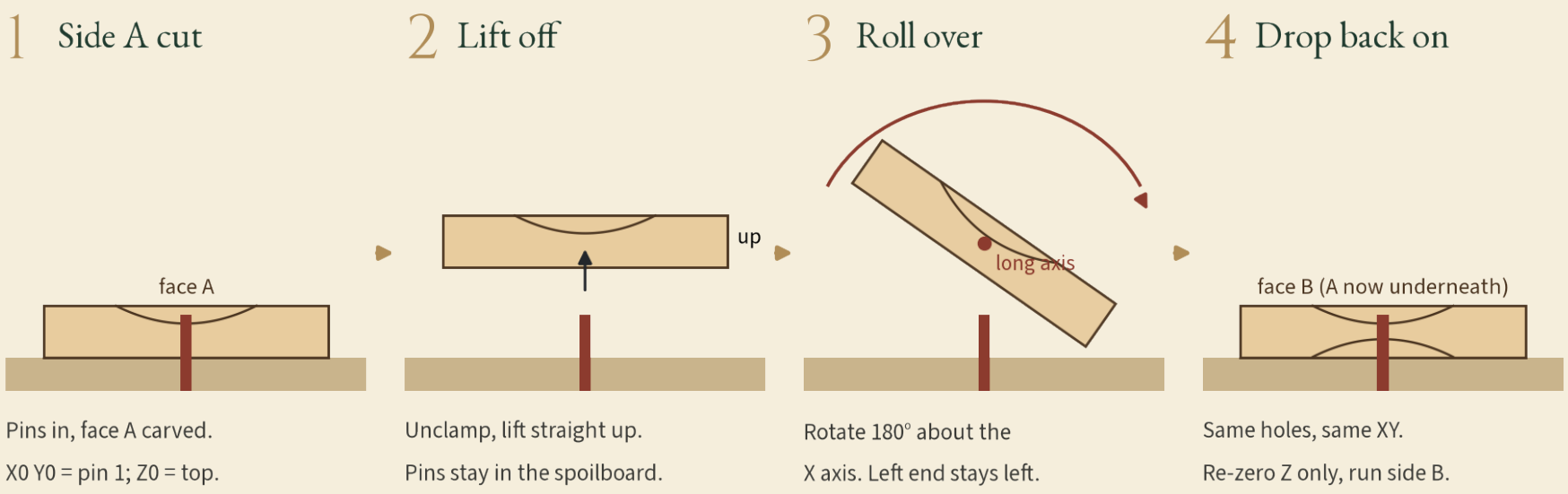


FIG. 5 *The flip, seen end-on. Both pins sit on the flip line, so after the roll the board drops back onto the same holes, XY zero is unchanged, and only Z is re-zeroed.*

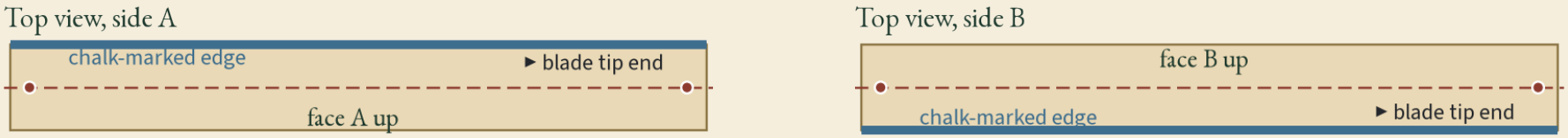


FIG. 6 *Seen from above, the left end stays left. Anything at +Y moves to −Y, shown by the chalk-marked edge. That is exactly how* `B1` *and* `B2` *were generated (Y → −Y). If the tip end swaps sides, you rolled the board end-for-end. Lift it and roll it the other way.*

How the blade is held

Each face is lowered into an **8 mm "moat"** around the blade, down to edge level (7.025 mm on each side). After both faces, the blade hangs in a waste frame by a **5 mm edge web**. The profile pass cuts only that web. It never reaches the spoilboard, and the **tabs (about 8 mm wide × 2.5 mm high)** sit in the web. Fig. 7 shows this in section.

SWORD	A1	A2	B1	B2	TOTAL
Type X	1.2	105.2	105.2	5.1	**3.6 h**
Type XIV	1.2	126.5	126.5	5.4	**4.3 h**
Type XVIII	1.2	92.3	92.3	5.2	**3.2 h**

Minutes per file from `gcode_report.jsonl`. Tool changes, zeroing and the flip are not included.

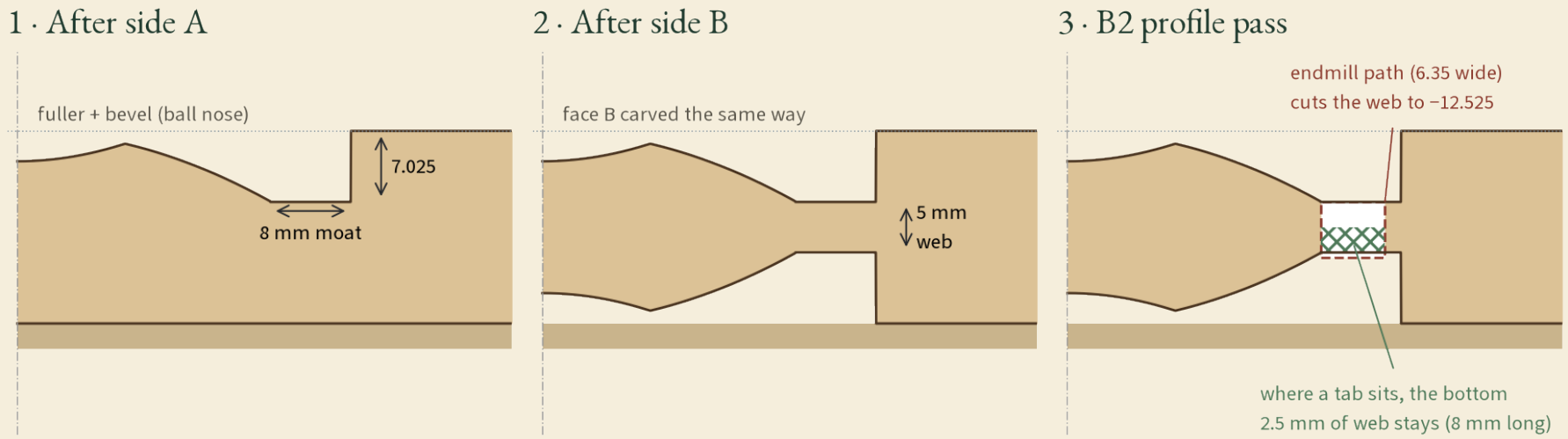


FIG. 7 *Blade section through the moat and web (Type X at 45 % of blade length, from the generator's model). The profile pass cuts only the 5 mm web, and the tabs leave its lower 2.5 mm in place.*

Side A

1. **Fix the stock.** Clamp or screw it in the 30 mm waste margin, with the long edge roughly parallel to X and the grain along the blade. Chalk-mark one long edge.
2. **Fit the 1/4″ endmill and zero.** Set X0 Y0 at pin 1 (about 30 mm in from the left end, centred on the width) and Z0 on the stock top.
3. **Run `A1_pins.nc`.** It drills two 1/4″ holes through the stock and 6 mm into the spoilboard, in 2 mm pecks. That takes about a minute.
4. **Push in 1/4″ dowel pins.** They should be snug in the spoilboard and **below the stock top**.
5. **Change to the ball nose and re-zero Z only** on the stock top, using the ball tip.

6. **Run `A2_blade_faceA_3D.nc`.** This is a level-by-level raster along X for roughing (0.3 mm left), then a finishing raster. It takes about 1.5–2.1 h.

Before you flip

- [ ] A2 finished, spindle stopped, tool parked at X0 Y0
- [ ] Face A looks right: the fuller is centred, there are no gouges, and the moat floor is even
- [ ] Vacuum the chips out of the pin holes and the moat
- [ ] Note which clamp positions you used

The flip

1. **Unclamp and lift** the board straight up off the pins.
2. **Roll it over its long axis.** The left end stays left, and the chalked edge moves to the other side (Fig. 6).
3. **Drop it back onto the same pins** and clamp it in the waste. Keep the clamps clear of where face B will be cut.
4. **Do not touch X/Y zero.** Re-zero **Z** on the new top, which is face B.

Lost XY?

If you power-cycled without homing, lower the 1/4″ endmill into **pin hole 1** and set X0 Y0 again. The holes are the reference, not the machine's memory.

Side B

1. **Ball nose fitted, Z zeroed on the tip** on face B.
2. **Run `B1_blade_faceB_3D.nc`.** It is the same raster with Y mirrored, and the same run time as A2.
3. **Change to the endmill and re-zero Z.**
4. **Run `B2_blade_profile_tabs.nc`**, the outside profile with eight tabs. Six are along the blade edges at about 12 %, 45 % and 75 % of its length, and two are on the tang. It takes about 5 minutes.

Side B checklist

- [ ] The board sits flat on the spoilboard and the pins are fully engaged
- [ ] Z re-zeroed after the flip and again after the tool change
- [ ] The B1 fuller lines up with face A's at the tip and shoulder (check the first passes)
- [ ] The blade is still held by its tabs when B2 finishes. Leave it clamped until the spindle stops.

The three blade layouts



FIG. 8 *Type X blade flip job (* `setup/X_RA_IX1081_blade_sideA/B.dxf` *): blank 1076.0 × 132.0 mm, pins at X 0 and 1016.0. Darker band = 8 mm moat.*

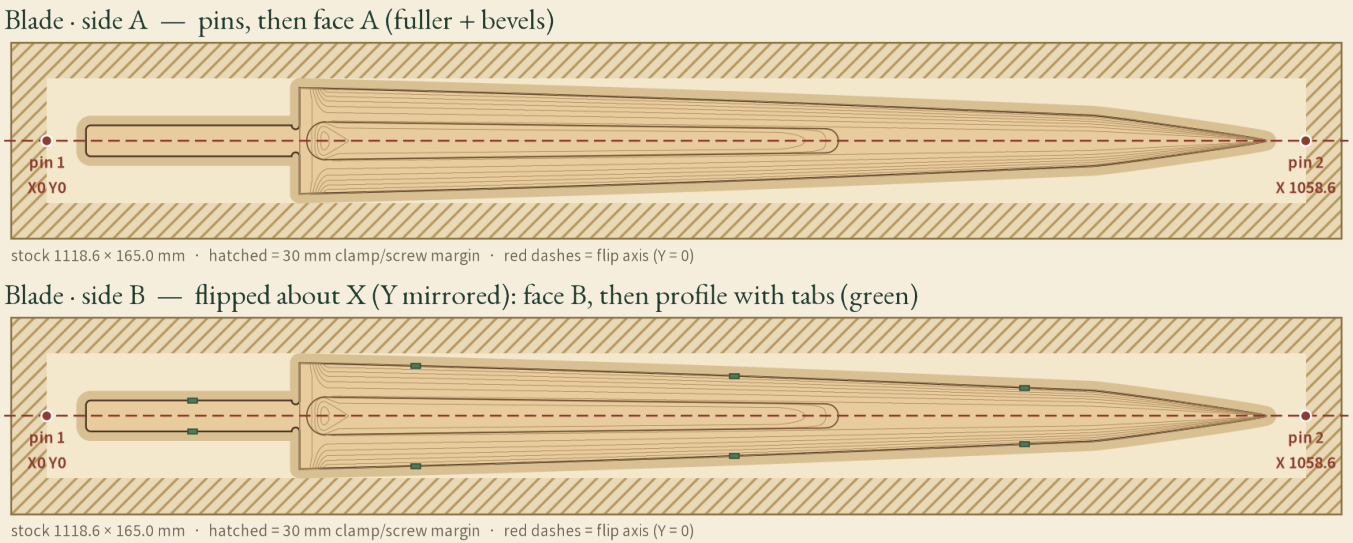


FIG. 9 *Type XIV blade flip job (* `setup/XIV_MET_32_75_225_blade_sideA/B.dxf` *): blank 1118.6 × 165.0 mm, pins at X 0 and 1058.6. Darker band = 8 mm moat.*

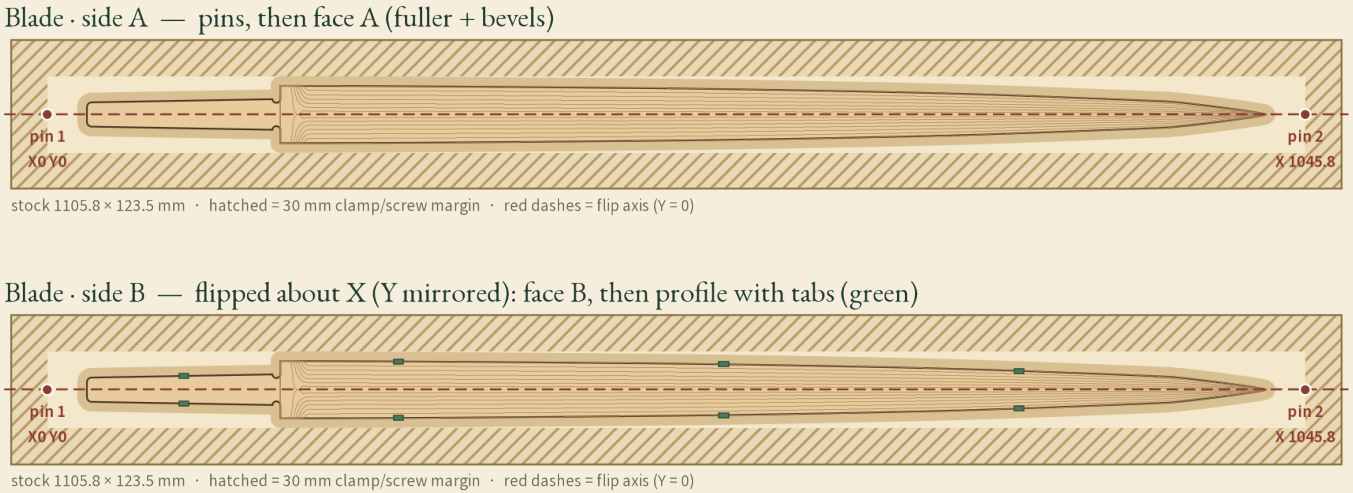


FIG. 10 *Type XVIII blade flip job (* `setup/XVIII_ALBION_KINGMAKER_blade_sideA/B.dxf` *): blank 1105.8 × 123.5 mm, pins at X 0 and 1045.8. Darker band = 8 mm moat.*

CHAPTER SIX

Cutting the Hilt Parts

All six halves come from one board, using the same pins and the same flip. The pockets are cut first, on the faces that will be glued.



The hilt job follows the same four-file pattern. The difference is that side A cuts the **inner** faces (the tang pockets) with the endmill, and side B shapes the **outer** faces with the ball nose before the endmill cuts the profiles **right through** the board.

1. **Fix the hilt board** in its 30 mm margin. Zero X0 Y0 at pin 1 and Z0 on top, with the 1/4″ endmill fitted.
2. **Run** `A1_pins.nc` and seat the dowels below the surface.
3. **With no tool change, run** `A2_hilt_inner_tang_pockets.nc`**.** The pocket depth is 9.78 mm, which is half the tang (9.53) plus 0.25 clearance. Guard and grip pockets are open at both ends. Pommel pockets are blind.
4. **Flip about the X axis** onto the pins and re-zero Z only.
5. **Fit the ball nose, zero Z on its tip, and run** `B1_hilt_outer_shape_3D.nc`**.** This faces each half to thickness (guard 15, grip 15, pommel 16 mm) and carves the roundovers, chamfers and pommel detail.
6. **Fit the endmill, re-zero Z, and run** `B2_hilt_profile_tabs.nc`**.** It cuts the outside profiles 0.3 mm into the spoilboard, leaving tabs. Each guard half has four tabs, and each grip and pommel half has two.

SWORD	HILT BLANK	A1	A2	B1	B2	TOTAL
Type X	636.7 × 260.0	0.9	13.0	123.1	11.6	**2.5 h**
Type XIV	747.4 × 270.0	1.0	16.6	146.6	13.1	**3.0 h**
Type XVIII	681.9 × 267.0	0.9	12.5	104.6	11.8	**2.2 h**

Minutes from `gcode_report.jsonl`. The README rounds these to about 1.7–2.5 h for the hilt outer faces and 5–17 min for each profile or pocket op.

Why the pockets go first

The pocket faces are the glue faces. Cutting them on side A, while the board is still flat and full thickness, keeps the joint surfaces true. Side B then removes material from the *outside* only.

Through-cut on the hilt

Unlike the blade, the hilt profile goes all the way through, to −19.35. Make sure the spoilboard is under the whole board and the clamps are outside the parts. Small pieces depend on their tabs.

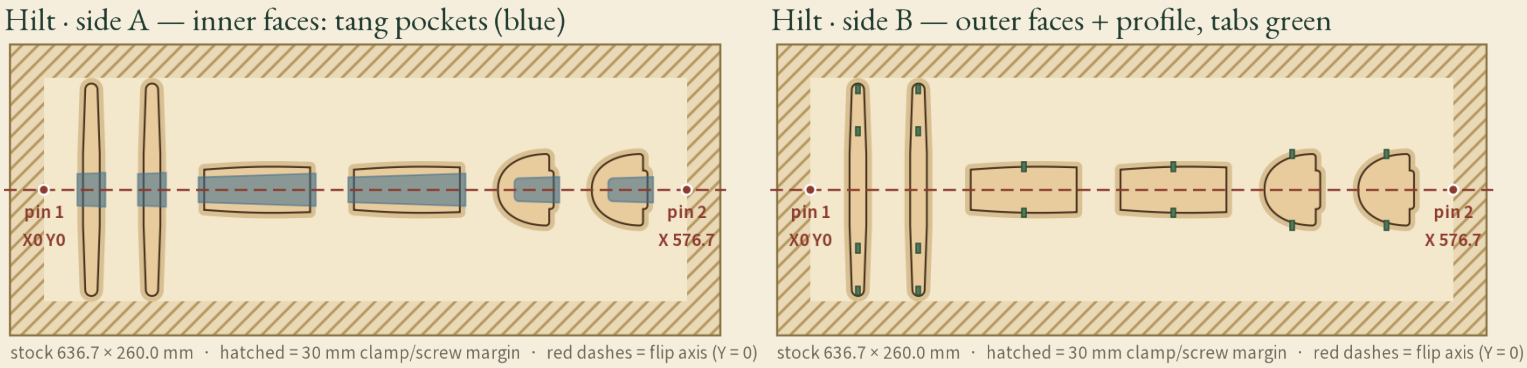


FIG. 11 *Type X hilt board (* `setup/X_RA_IX1081_hilt_sideA/B.dxf` *). There are two each of guard, grip and pommel halves in one row on the flip axis. Side A cuts the tang pockets in the inner faces. Side B shapes the outer faces and cuts the profiles.*

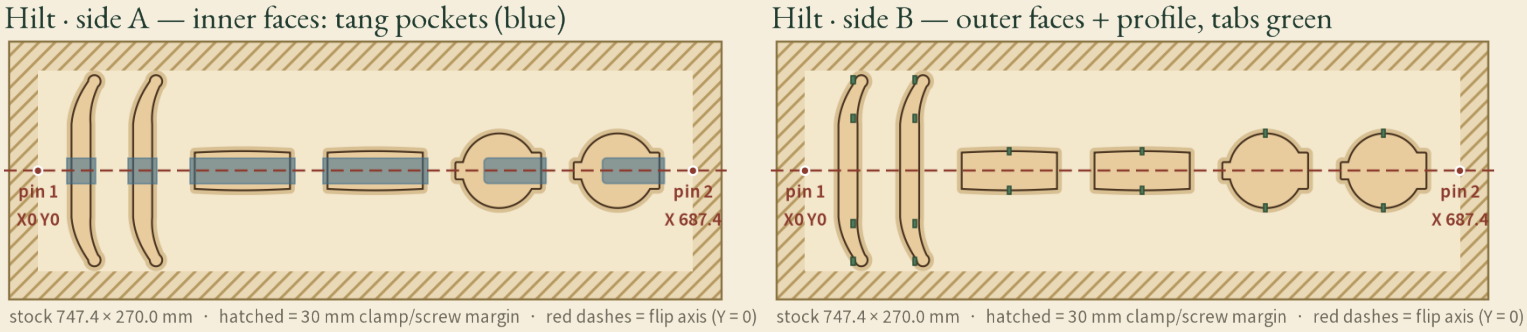


FIG. 12 *Type XIV hilt board (* `setup/XIV_MET_32_75_225_hilt_sideA/B.dxf` *). There are two each of guard, grip and pommel halves in one row on the flip axis. Side A cuts the tang pockets in the inner faces. Side B shapes the outer faces and cuts the profiles.*

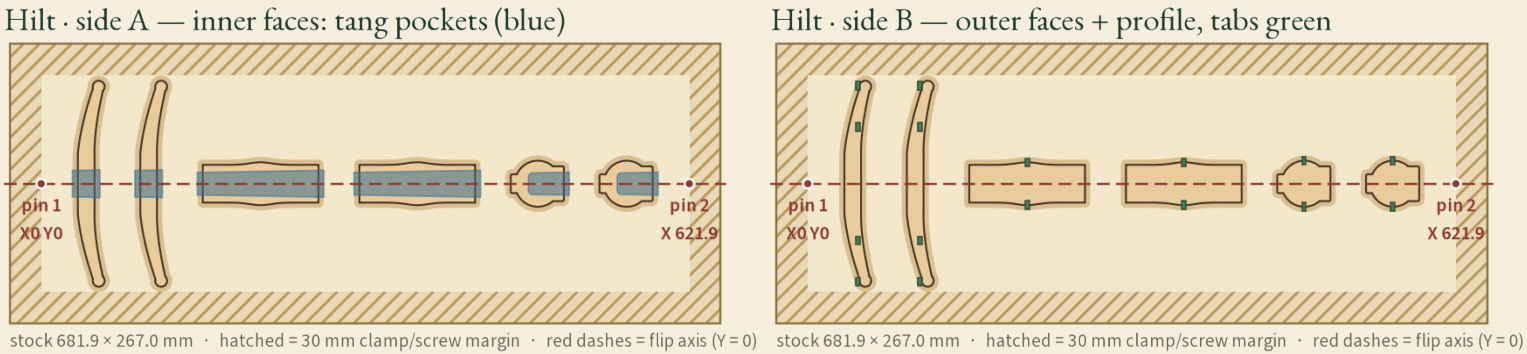


FIG. 13 *Type XVIII hilt board (* `setup/XVIII_ALBION_KINGMAKER_hilt_sideA/B.dxf` *). There are two each of guard, grip and pommel halves in one row on the flip axis. Side A cuts the tang pockets in the inner faces. Side B shapes the outer faces and cuts the profiles.*

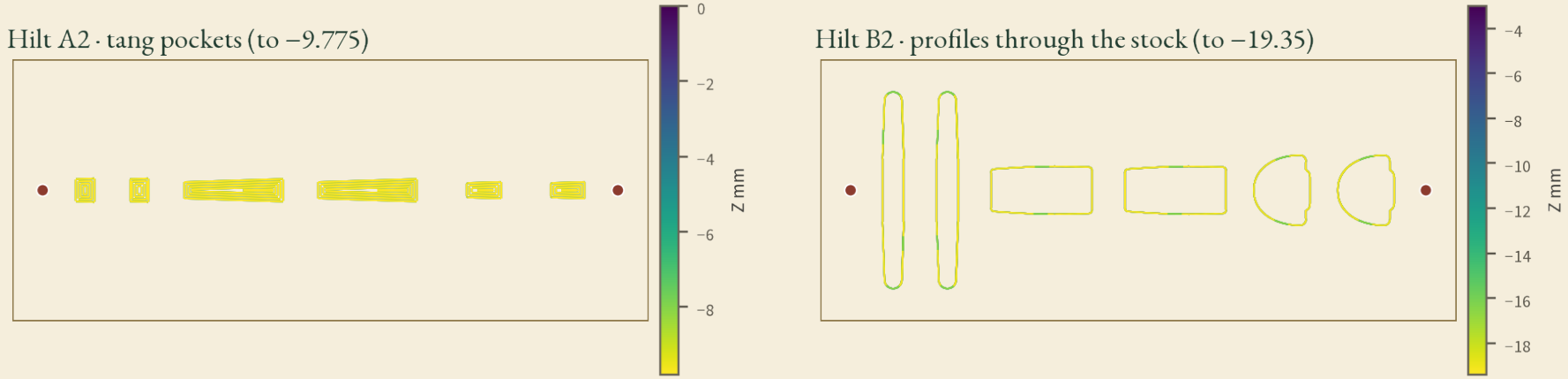


FIG. 14 *Type X hilt toolpaths plotted from the .nc files. Left: A2 tang pockets. Right: B2 through-profiles, where the colour change marks the tabs.*

CHAPTER SEVEN

The OpenBuilds CAM Route

Option B. Build your own 2.5D toolpaths from the setup DXFs. It is faster and less three-dimensional, with stepped bevels that you sand smooth.



If you would rather build toolpaths yourself, or want to try a cheaper MDF template first, the setup DXFs are ready for **OpenBuilds CAM**. They use the same origin (pin 1), the same flip and the same pins. Only the bevels change, from a smooth 3D raster to **terraces** that follow the `CONTOUR_Z-k` layers.

1. **Import** `setup/<ID>_blade_sideA.dxf` in **mm**.
2. **Pins:** layer `PINS` → *Drill: Peck (centered)*, depth = stock + 6 mm.
3. **Fuller:** *CNC: Pocket* on `FULLER_OUTLINE` with the 1/4″ ball nose, 2–3 mm deep. You can also run a 1/2″ core-box bit with *Cut on Path* along the fuller centre line.
4. **Bevels:** *CNC: Cut on Path* with the ball nose on each `CONTOUR_Z-k` layer at depth **k mm**. This gives stepped terraces that you sand smooth. A 90° V-bit is an alternative for chamfer-style bevels.
5. **Flip,** import `_sideB.dxf`, and repeat.
6. **Finish** with *CNC: Cut Outside* on `OUTLINE`.

Tabs on curves

According to the OpenBuilds forum, OpenBuilds CAM puts tabs only on straight segments. The blade outline is all curves, so its tabs may not generate. You have three options: use the supplied `B2_*` G-code for the profile, hold the part with screws or tape + CA, or leave a **0.5 mm onion skin** and trim it off.

Mixing routes

The CAM route shares the pin-1 origin and the Y-mirrored side B. That means you can mix routes, for example terraced faces from CAM followed by the supplied `B2_blade_profile_tabs.nc`. Keep the moat in mind, though. The supplied B2 expects the web to be at edge level.

V-bit chamfer option

BIT	RPM	FEED	PLUNGE	DEPTH/PASS
1/2″ 90° V-bit	~16,000	800–1000	300	≤ 2 mm

CHAPTER EIGHT

Finishing

Remove the tabs, sand out the scallops, ease the edges, and put a finish on the wood.



Releasing the parts

1. **Cut the tabs** with a flush-cut saw or a chisel. On the blade they are in the edge web. On the hilt they are around each half.
2. **Pare the stubs flush** with the profile. Work from both faces toward the middle so you don't split the 5 mm edge flat.
3. **Release the blade evenly.** It is over a metre long and only 5 mm thick at the edge. Support it along its length as you cut the last tabs so it can't lever on one tab and crack.

Sanding

The ball-nose finishing pass uses a 1.0 mm stepover. That leaves about a 0.04 mm scallop, so a light sanding removes it. Sand **along the blade**, with the grain. Keep the 5 mm blunt edge flat and crisp, or round it slightly. Don't sand it thin. It is there to make a wooden blade survive contact.

The hilt halves get the same treatment, but **don't sand the glue faces or the pocket walls**. Their fit was set by the clearance.

Edges and the CAM-route terraces

If you used the OpenBuilds CAM route, the bevels come out stepped every 1 mm of depth. Sand the steps down to the smooth curve between the contour lines, using a long flat block on the bevels and a dowel-wrapped strip in the fuller.

Finish

Choose any finish that suits a handled wooden object, such as a penetrating oil or a wipe-on varnish. Finish the blade and the hilt **after** glue-up, and keep finish off the glue surfaces until then. Several thin coats look better on maple and ash than one heavy one.

> **Grain check**
>
> Before any finish goes on, look at the grain along the blade. A grain run-out line that crosses the blade near the shoulder is a weak spot. That blade should be for display only.

CHAPTER NINE

Assembly and Joinery

The halves sandwich a full-thickness tang. You can dry-fit, tune the clearance, glue, and add a cross-pin if you want one.



How the joint works

- **Blade and tang are one piece**, cut from full-thickness stock. The tang is not thinned, so it stays as strong as possible.
- The tang **tapers**: Type X goes 30 → 20 mm, XIV stays a parallel 26 mm, and XVIII goes 26 → 20 mm. Its end has 4 mm corner radii. It stops **blind inside the pommel**.
- Two small **dog-bone reliefs** at the shoulder let the guard seat flush, because a 1/4″ endmill cannot cut a sharp inside corner. They are hidden inside the guard.
- Guard, grip and pommel are each **two halves split in the blade plane**. Each half has a **pocket = half the tang thickness + clearance**, which is 9.525 + 0.25 = **9.78 mm**.
- The glued thicknesses are guard **30**, grip **30** and pommel **32 mm**. The walls around the tang are at least 5.2 mm thick (checked).

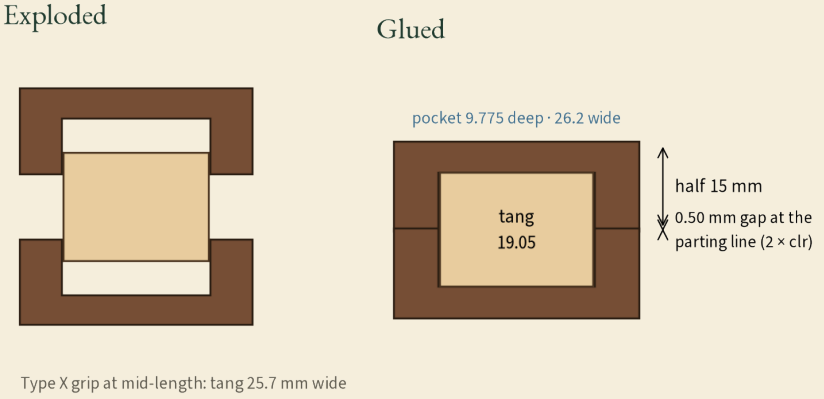


FIG. 18 *A section through the Type X grip. With the default 0.25 mm clearance, the pocket is 0.25 mm wider than the tang on each side and 0.25 mm deeper on each half. The halves therefore sit 0.5 mm apart at the parting line, and the glue fills that gap.*

Dry fit first

1. **Slide on the guard halves** against the shoulder. They should seat flush over the dog-bones.
2. **Add the grip halves, then the pommel halves.** The tang should bottom out in the blind pommel pocket.

3. **Check the fit.** Look for rocking, any gap at the guard face, and whether the parts line up with the blade's centre plane. Look along the sword from the pommel.

Clearance tuning

The fit is set by `fit_clr`, the clearance per side. The default is 0.25 mm and the README suggests a range of **0.1–0.4 mm**, depending on your machine's accuracy and the glue.

```
.venv/bin/python sword_gen.py --clr 0.15     # tighter
.venv/bin/python sword_gen.py --clr 0.35     # looser
```

Only the pockets change, so you only need to re-run the **hilt** job. Other knobs in `sword_params.py` include `hilt_half_t`, tang `w0/w1`, grip `w_ends / w_mid / riser`, guard `tip_h / sag` and the pommel sizes.

Glue-up

Glue each pair of halves around the tang. Gap-filling epoxy suits the 0.5 mm parting-line gap and the pocket clearance. Clamp each component across its two halves, keep the halves registered on the blade's centre plane, and clean out squeeze-out at the guard face before it cures.

Cross-pin (optional)

After glue-up, you can drill a **1/4″ cross-pin** through the pommel and tang and glue in a dowel. This mechanically locks the blind tang.

Alternative: one-piece guard

The README mentions a one-piece guard with a through slot as an alternative. It is not generated, but would be a small addition to the script.

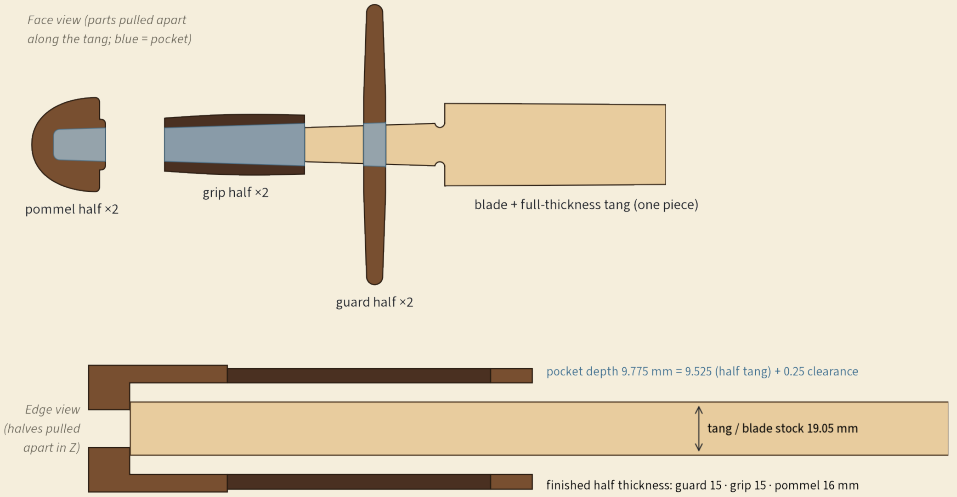


FIG. 15 *Type X hilt from the generator's part geometry: face view pulled apart along the tang (above) and edge view with the halves split in the blade plane (below).*

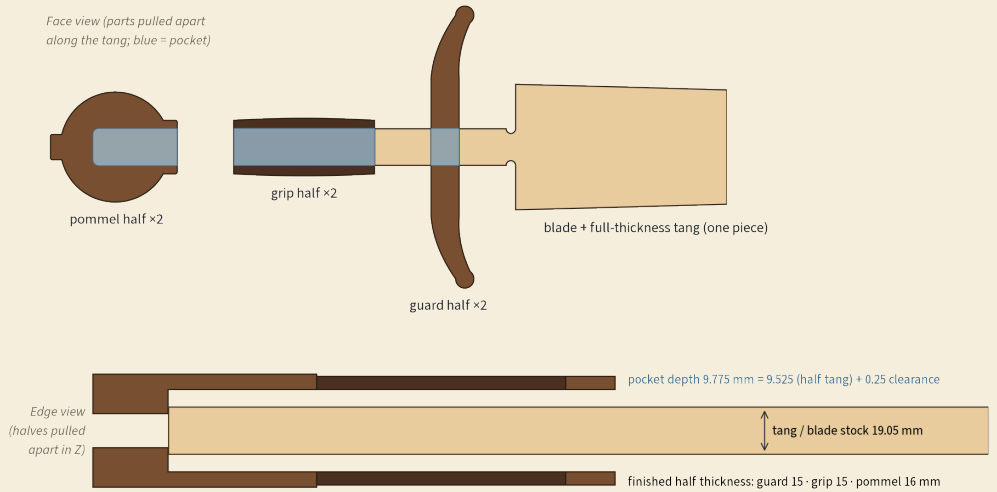


FIG. 16 *Type XIV hilt from the generator's part geometry: face view pulled apart along the tang (above) and edge view with the halves split in the blade plane (below).*

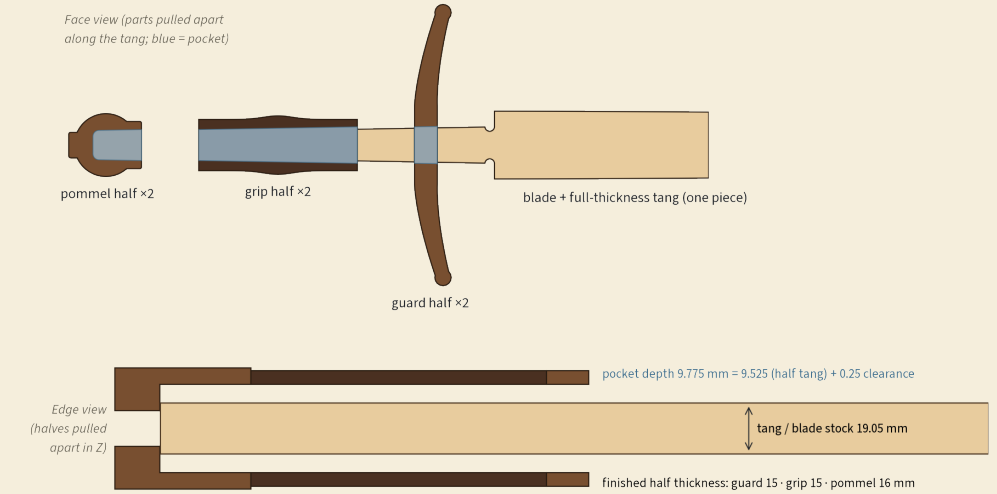


FIG. 17 *Type XVIII hilt from the generator's part geometry: face view pulled apart along the tang (above) and edge view with the halves split in the blade plane (below).*

CHAPTER TEN

Safety

These are wooden display and training swords. The router, the dust and the long blank are where the real hazards are.



> **WHAT THESE SWORDS ARE**
>
> These are **wooden display or training swords (wasters)**. They are not sharpened steel. They are waster-thick on purpose, with a 5 mm blunt edge and full stock thickness at the spine. They are **not** a substitute for purpose-made sparring gear. Check every waster for cracks and grain run-out before any use. Retire any blade that is cracked, and never use an MDF blade except as a template or for display.

At the machine

- **Eyes and ears:** wear safety glasses for every cut. A trim router running for hours at about 18,000 rpm calls for hearing protection.
- **Dust:** run the dust shoe and a collector or shop vac for every file, especially the 3D rasters, which make fine dust for hours. Add a respirator when you sand.
- **Never leave a long run unattended.** The 3D files are 1.5–2.5 h each. Stay within reach of the e-stop / feed hold.
- **Clamps:** only in the 30 mm waste margin, checked with the air cut. A dust-shoe brush snagging a clamp can lift the gantry or the work.
- **Tool changes:** switch the router off at its own switch before touching the bit, and only then re-zero.
- **Through-cuts:** the hilt profile goes 0.3 mm into the spoilboard. Keep your hands and the vacuum hose away from small parts as the last tabs are cut.

Fire

Rubbing or burning means the feed is too slow for the rpm. The README says to raise the feed or lower the rpm before doing the reverse. Keep fine chips away from the router's cooling vents. Rags soaked in oil finish can self-heat, so dry them flat or put them in a sealed metal can.

Handling the long blank

A 1.1 m board leaning off a bench is a lever. Support both ends when you lift it off the pins for the flip. Get a helper for the XIV blank (1118.6 × 165 mm).

CHAPTER ELEVEN

Troubleshooting

Most two-sided problems come down to one of three things: XY moved, Z is wrong, or the work moved.



SYMPTOM	LIKELY CAUSE	FIX
Side B misaligned with side A (fuller off-centre, bevels uneven)	XY zero moved after A1; the board did not seat fully on the pins; the pins are loose in the spoilboard; or the board was rolled end-for-end instead of about its long axis.	Never re-zero XY after A1. Recover XY by lowering the endmill into pin hole 1. Make the pins snug, and vacuum the chips out of the holes before the flip. The left end must stay left (Fig. 6).
Side B cuts too deep or too shallow, or the web is not 5 mm	The stock is not the thickness the files were built for; Z was zeroed on the wrong tool or before a tool change; or the board is not flat.	Measure the stock and run `sword_gen.py --stock <measured>`. Re-zero Z after every tool change and after the flip. Plane both faces flat.
Tear-out on bevels or at the edge web	Grain running across the blade; a dull bit; or an upcut endmill lifting fibres on the top face.	Run the grain along the blade. Use a sharp carbide ball nose. A compression endmill helps on profiles. The finishing raster (1.0 mm stepover) should clean up roughing marks.
Chatter or ringing	A loose router mount or a flexing V-slot gantry; too much stick-out; or the stock not held firmly enough.	Tighten the eccentric nuts and router clamp, and shorten the tool stick-out. Add screws in the waste margin. Reduce the feed override slightly while you diagnose. The feeds are already cautious (about 0.03–0.04 mm chip load).
Burning or rubbing sounds	The chip load is too low.	Per the README, raise the feed or lower the rpm before doing the reverse. Check your router's speed-dial chart against about 18,000 rpm.
A tab breaks and the blade shifts	The long blade levers on the remaining tabs, or vibration builds near the point.	Add a strip of tape + CA or a screw in the waste near the point. On the CAM route, leave a 0.5 mm onion skin. Keep the dust shoe from dragging on the freed part.
Tabs did not generate in OpenBuilds CAM	CAM puts tabs only on straight segments, and the blade outline is all curves.	Use the supplied `B2_*` profile G-code, screws or tape + CA, or a 0.5 mm onion skin.
Hilt halves too tight or too loose on the tang	Machine accuracy differs from the 0.25 mm clearance assumption.	Regenerate with `--clr` between 0.1 and 0.4 mm and re-run the hilt job only.
Pin holes not deep enough	The endmill cut length is shorter than 25 mm.	Spot the holes with the CNC, then finish them with a 1/4″ brad-point drill.
Soft-limit alarm near the end of the blade	The X travel is shorter than the job.	This should show up in the air cut. You need at least about 1.15 m of X travel. Otherwise scale the parameters down, or rotate the job if Y is longer.

CHAPTER TWELVE

Quick-Reference Cards

One page per sword, to print and pin up beside the machine.



SWORD	FOLDER	BLADE BLANK (MM)	HILT BLANK (MM)	BLADE JOB	HILT JOB	SPINDLE TOTAL
Type X	`X_RA_IX1081/`	1076.0 × 132.0	636.7 × 260.0	3.6 h	2.5 h	**6.1 h**
Type XIV	`XIV_MET_32_75_225/`	1118.6 × 165.0	747.4 × 270.0	4.3 h	3.0 h	**7.3 h**
Type XVIII	`XVIII_ALBION_KINGMAKER/`	1105.8 × 123.5	681.9 × 267.0	3.2 h	2.2 h	**5.3 h**

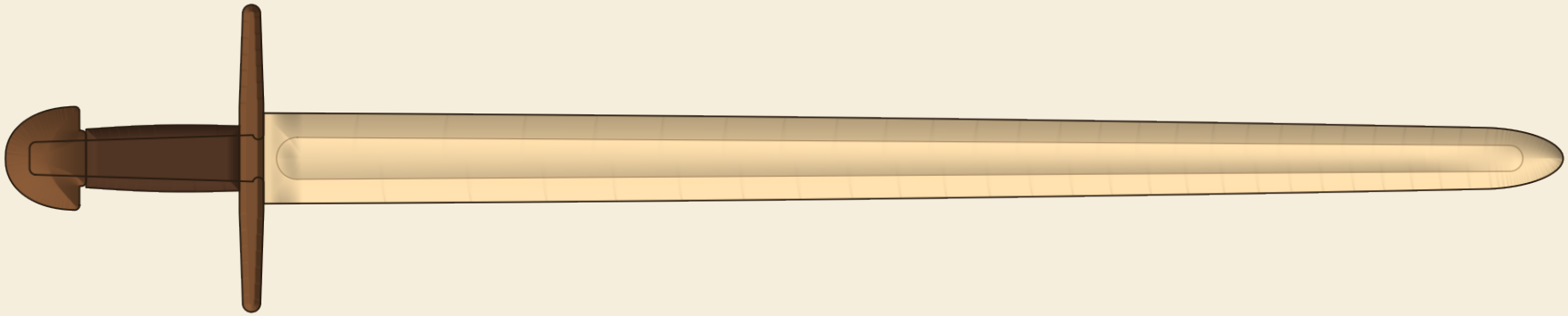
The same sequence for every job

1. **A1 · endmill.** Set X0 Y0 at pin 1 and Z0 on top. Drill the pins and seat the dowels below the surface.
2. **A2.** Blade: ball nose, re-zero Z. Hilt: same endmill.
3. **Flip** about the long axis onto the pins. The left end stays left. Re-zero Z only.
4. **B1 · ball nose,** Z zeroed on the tip.
5. **B2 · endmill,** re-zero Z. Profile with tabs.

> **EVERY FILE, FIRST TIME**
>
> Air-cut with Z0 set 25 mm above the stock, and check the file in the OpenBuilds CONTROL 3D viewer. None of these programs has been run on a machine yet.

Type X · The Arming Sword

X_RA_IX1081/



DIMENSIONS (MM)

Overall · blade · base width	965 · 805 · 56≈
Grip · cross · pommel height	95 · 190 · 50≈
Fuller length	772
Tang w (shoulder → end) · length	30≈ → 20≈ · 145.0
Pocket depth / half	9.775

STOCK (19.05 MM HARDWOOD, GRAIN ALONG BLADE)

Blade blank	1076.0 × 132.0
Blade pins (X)	0 · 1016.0
Hilt blank	636.7 × 260.0
Hilt pins (X)	0 · 576.7

Style 1 (straight, square section, tapering to tips; 7-8 in long) · Type A (Brazil-nut; RA describes IX.1081's as 'beehive')

BLADE JOB · GCODE/BLADE/ · 3.6 H

FILE	TOOL	ZERO	MIN Z	MIN
A1_pins	endmill	set X0 Y0 + Z0	-25.05	1.2
A2_blade_faceA_3D	ball	Z only	-7.025	105.2
B1_blade_faceB_3D	ball	FLIP · Z only	-7.025	105.2
B2_blade_profile_tabs	endmill	Z only	-12.525	5.1

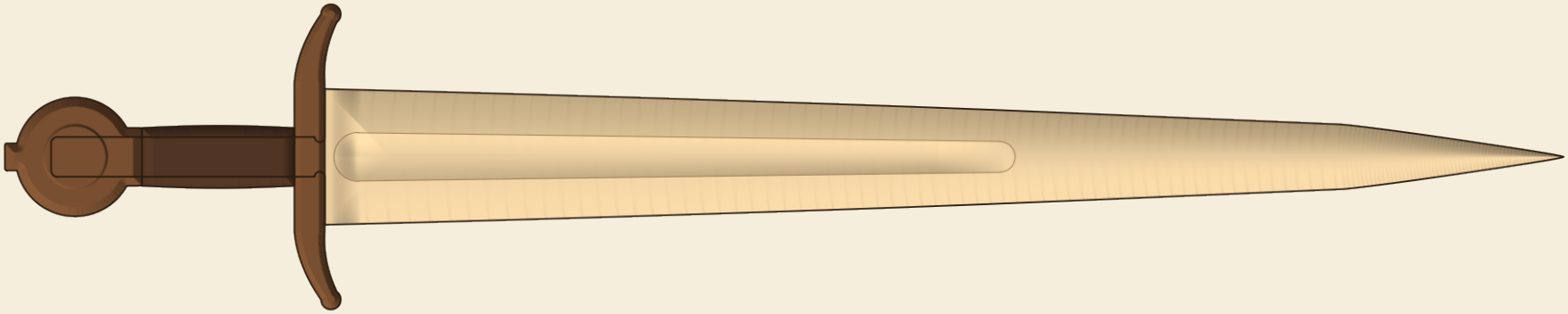
HILT JOB · GCODE/HILT/ · 2.5 H

FILE	TOOL	ZERO	MIN Z	MIN
A1_pins	endmill	set X0 Y0 + Z0	-25.05	0.9
A2_hilt_inner_tang_pockets	endmill	no change	-9.775	13.0
B1_hilt_outer_shape_3D	ball	FLIP · Z only	-12.05	123.1
B2_hilt_profile_tabs	endmill	Z only	-19.35	11.6

Air-cut each file first (Z0 25 mm above the stock). XY is never re-zeroed after A1. Flip about the long axis, left end stays left.

Type XIV · The Broad Knightly Sword

`XIV_MET_32_75_225/`



DIMENSIONS (MM)

Overall · blade · base width	1023 · 813 · 89
Grip · cross · pommel height	100≈ · 200≈ · 90≈
Fuller length	447
Tang w (shoulder → end) · length	26≈ → 26≈ · 179.6
Pocket depth / half	9.775

STOCK (19.05 MM HARDWOOD, GRAIN ALONG BLADE)

Blade blank	1118.6 × 165.0
Blade pins (X)	0 · 1058.6
Hilt blank	747.4 × 270.0
Hilt pins (X)	0 · 687.4

Style 4 per SAC plate caption 'Type XIV, J1, 4' (long, curved cross) · Type J1 (wheel with raised central panel ringed by a flat band)

BLADE JOB · GCODE/BLADE/ · 4.3 H

FILE	TOOL	ZERO	MIN Z	MIN
`A1_pins`	endmill	set X0 Y0 + Z0	-25.05	1.2
`A2_blade_faceA_3D`	ball	Z only	-7.025	126.5
`B1_blade_faceB_3D`	ball	FLIP · Z only	-7.025	126.5
`B2_blade_profile_tabs`	endmill	Z only	-12.525	5.4

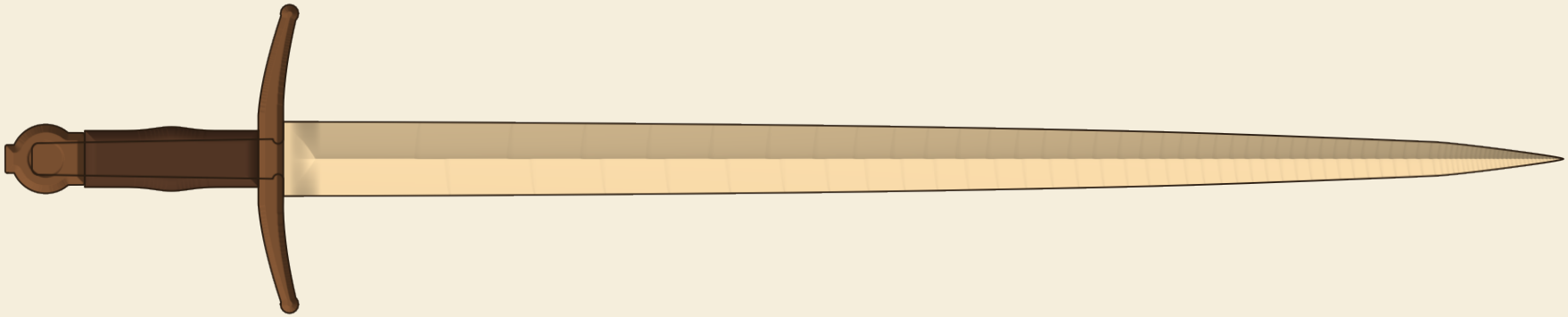
HILT JOB · GCODE/HILT/ · 3.0 H

FILE	TOOL	ZERO	MIN Z	MIN
`A1_pins`	endmill	set X0 Y0 + Z0	-25.05	1.0
`A2_hilt_inner_tang_pockets`	endmill	no change	-9.775	16.6
`B1_hilt_outer_shape_3D`	ball	FLIP · Z only	-9.698	146.6
`B2_hilt_profile_tabs`	endmill	Z only	-19.35	13.1

Air-cut each file first (Z0 25 mm above the stock). XY is never re-zeroed after A1. Flip about the long axis, left end stays left.

Type XVIII · The Kingmaker

`XVIII_ALBION_KINGMAKER/`



DIMENSIONS (MM)

Overall · blade · base width	997 · 819 · 47.5
Grip · cross · pommel height	111 · 197 · 51≈
Fuller length	0
Tang w (shoulder → end) · length	26≈ → 20≈ · 160.8
Pocket depth / half	9.775

STOCK (19.05 MM HARDWOOD, GRAIN ALONG BLADE)

Blade blank	1105.8 × 123.5
Blade pins (X)	0 · 1045.8
Hilt blank	681.9 × 267.0
Hilt pins (X)	0 · 621.9

Style 9 (arched cross, faceted) · Type K (wheel with recessed central faces)

BLADE JOB · GCODE/BLADE/ · 3.2 H

FILE	TOOL	ZERO	MIN Z	MIN
`A1_pins`	endmill	set X0 Y0 + Z0	-25.05	1.2
`A2_blade_faceA_3D`	ball	Z only	-7.025	92.3
`B1_blade_faceB_3D`	ball	FLIP · Z only	-7.025	92.3
`B2_blade_profile_tabs`	endmill	Z only	-12.525	5.2

HILT JOB · GCODE/HILT/ · 2.2 H

FILE	TOOL	ZERO	MIN Z	MIN
`A1_pins`	endmill	set X0 Y0 + Z0	-25.05	0.9
`A2_hilt_inner_tang_pockets`	endmill	no change	-9.775	12.5
`B1_hilt_outer_shape_3D`	ball	FLIP · Z only	-9.698	104.6
`B2_hilt_profile_tabs`	endmill	Z only	-19.35	11.8

Air-cut each file first (Z0 25 mm above the stock). XY is never re-zeroed after A1. Flip about the long axis, left end stays left.

CHAPTER THIRTEEN

Regenerating and Customizing

The whole kit comes from one parameter file. Change a number, re-run, and re-verify.



Command line

```
cd /workspace/swords
.venv/bin/python sword_gen.py
# build all three
.venv/bin/python sword_gen.py --only XIV_MET_32_75_225
.venv/bin/python sword_gen.py --stock 18.6          #
measured thickness
.venv/bin/python sword_gen.py --clr 0.15            # tang
fit per side
.venv/bin/python sword_gen.py --out /some/other/dir
# write elsewhere
# then re-check:
.venv/bin/python verify_dxf.py
.venv/bin/python gcode_check.py > gcode_report.jsonl
```

Each run rewrites that sword's `parts/`, `setup/`, `gcode/` and preview PNG, plus `swords.json`, `swords.csv` and `build_report.json`. With more than one sword it also rewrites `overview_comparison.png`. **Regenerated G-code is new G-code.** Air-cut it again.

> **Overwrites in place**
>
> By default the generator writes into `/workspace/swords`. Use `--out` to keep a variant beside the originals, for example one build for each board thickness.

sword_params.py: the database

`MACHINE` holds the shop defaults. `SWORDS` holds one dict per type. To add a new type, copy a dict, change the numbers and re-run. Each dimension is recorded as `d(mm, "sourced"|"approx", source, note)`, so the provenance stays with the number.

MACHINE KEY	DEFAULT	MEANING
`stock_t`	19.05	stock thickness. Set it to the measured value.
`edge_flat`	5.0	blunt edge thickness
`fit_clr`	0.25	tang→pocket clearance per side
`endmill_d` · `ball_d` · `pin_d`	6.35	1/4″ tools and pins
`pin_into_spoil`	6.0	pin depth in spoilboard
`pin_margin` · `stock_margin`	25 · 30	pin to part · clamp margin
`band` · `band_hilt`	8 · 5	moat width, blade · hilt
`res` · `safe_z`	0.4 · 5	heightfield grid · rapid height
`tab_w` · `tab_h`	8 · 2.5	holding tabs
`hilt_half_t`	15/15/16	guard / grip / pommel half thickness

Per-sword geometry knobs

- `body_stations` : blade width at fractions of its length; `point_start` , `point_n` shape the point.
- `section_exp` : 2.0 gives a lens (X, XIV); 0.85 gives the hollow diamond (XVIII).
- `fuller` : start, end, w0, w1, depth (3.0), fade.
- `tang` w0/w1 · `guard` style/tip_h/sag · `grip` w_ends/w_mid/riser · `pommel` kind and sizes.

> **Scaling for a short machine**
> If your X travel is under about 1.15 m, the README suggests scaling the parameters down. The blade length and the body stations drive the blank length. Stock length = blade outline + 2 × (8 mm moat + 25 mm pin margin + 30 mm stock margin).

APPENDIX

Feeds, Speeds and Run Times

The numbers behind the files: cautious hardwood starting points for a trim router on a V-slot gantry, and the time each file is estimated to take.



A · Bits and conservative starting feeds (hardwood, trim router)

OPERATION	BIT	RPM	FEED MM/MIN	PLUNGE	DEPTH/PASS	STEPOVER
Pins, pockets, profiles	1/4″ 2-flute carbide upcut/compression, ≥1″ (25 mm) cut length	~18,000	1200	300	3.0 mm	2.5 mm
3D roughing	1/4″ 2-flute carbide ball nose, ≥3/4″ cut length	~18,000	1200	300	2.0 mm	2.4 mm (leaves 0.3)
3D finishing	same ball nose	~18,000	1500	300	–	1.0 mm (~0.04 mm scallop)
Chamfer (option)	1/2″ 90° V-bit	~16,000	800–1000	300	≤ 2 mm	–

Reading the feeds

These are cautious numbers, about 0.03–0.04 mm chip load. If you hear rubbing or see burning, **raise the feed or lower the rpm** before doing the reverse. Check your router's speed-dial chart for the dial setting that gives about 18,000 rpm. Every file starts the spindle with `M3 S18000` and then pauses for 4 s (`G4 P4`).

Two run-time estimates

`build_report.json` holds the generator's own estimate. `gcode_report.jsonl` comes from `gcode_check.py` , a separate parser that also counts rapids (it assumes 3000 mm/min) and plunges. They agree to within about a minute. Neither includes tool changes, zeroing or the flip.

B · Run times, file by file

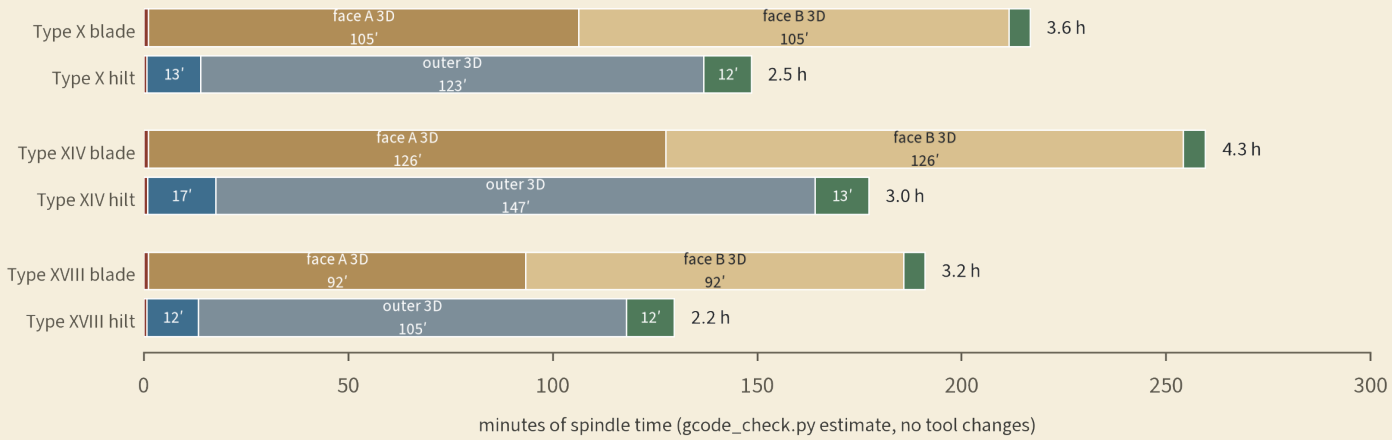


FIG. 19 *Spindle time per job, from gcode_check.py. The 3D files make up nearly all of it.*

SWORD	FILE	LINES	GEN. MIN	CHECK MIN	FEED M	PLUNGES	MIN Z	CUT X RANGE	CUT Y RANGE
Type X	`blade/A1_pins.nc`	99	0.8	1.2	0.1	26	-25.05	0.0 … 1016.0	0.0 … 0.0
Type X	`blade/A2_blade_faceA_3D.nc`	16,249	105.2	105.2	116.1	414	-7.025	25.4 … 990.6	-34.8 … 34.8
Type X	`blade/B1_blade_faceB_3D.nc`	16,248	105.2	105.2	116.1	414	-7.025	25.4 … 990.6	-34.8 … 34.8
Type X	`blade/B2_blade_profile_tabs.nc`	7,489	5.1	5.1	6.0	19	-12.525	29.8 … 986.2	-31.2 … 31.2
Type X	`hilt/A1_pins.nc`	99	0.7	0.9	0.1	26	-25.05	0.0 … 576.7	0.0 … 0.0
Type X	`hilt/A2_hilt_inner_tang_pockets.nc`	1,103	12.8	13.0	11.8	104	-9.775	33.2 … 543.6	-12.1 … 12.1
Type X	`hilt/B1_hilt_outer_shape_3D.nc`	54,938	123.0	123.1	100.3	2,546	-12.05	30.4 … 546.0	-99.2 … 99.2
Type X	`hilt/B2_hilt_profile_tabs.nc`	16,061	11.4	11.6	13.0	74	-19.35	32.0 … 544.7	-98.2 … 98.2
Type XIV	`blade/A1_pins.nc`	99	0.8	1.2	0.1	26	-25.05	0.0 … 1058.6	0.0 … 0.0
Type XIV	`blade/A2_blade_faceA_3D.nc`	35,500	126.4	126.5	135.4	666	-7.025	25.4 … 1033.0	-51.3 … 51.9
Type XIV	`blade/B1_blade_faceB_3D.nc`	35,499	126.4	126.5	135.4	666	-7.025	25.4 … 1033.0	-51.3 … 51.9
Type XIV	`blade/B2_blade_profile_tabs.nc`	7,936	5.4	5.4	6.4	19	-12.525	29.8 … 1028.8	-47.7 … 47.7
Type XIV	`hilt/A1_pins.nc`	99	0.7	1.0	0.1	26	-25.05	0.0 … 687.4	0.0 … 0.0
Type XIV	`hilt/A2_hilt_inner_tang_pockets.nc`	1,135	16.4	16.6	15.9	120	-9.775	33.2 … 654.2	-10.1 … 10.1

SWORD	FILE	LINES	GEN. MIN	CHECK MIN	FEED M	PLUNGES	MIN Z	CUT X RANGE	CUT Y RANGE
Type XIV	`hilt/B1_hilt_outer_shape_3D.nc`	61,802	146.5	146.6	118.2	2,652	-9.698	30.4 … 656.8	-104.2 … 103.8
Type XIV	`hilt/B2_hilt_profile_tabs.nc`	18,329	12.9	13.1	14.8	72	-19.35	32.0 … 655.4	-103.2 … 103.2
Type XVIII	`blade/A1_pins.nc`	99	0.8	1.2	0.1	26	-25.05	0.0 … 1045.8	0.0 … 0.0
Type XVIII	`blade/A2_blade_faceA_3D.nc`	18,591	92.2	92.3	102.5	449	-7.025	25.4 … 1020.2	-30.6 … 31.1
Type XVIII	`blade/B1_blade_faceB_3D.nc`	18,590	92.2	92.3	102.5	449	-7.025	25.4 … 1020.2	-30.6 … 31.1
Type XVIII	`blade/B2_blade_profile_tabs.nc`	7,654	5.2	5.2	6.1	19	-12.525	29.8 … 1016.0	-26.9 … 26.9
Type XVIII	`hilt/A1_pins.nc`	99	0.7	0.9	0.1	26	-25.05	0.0 … 621.9	0.0 … 0.0
Type XVIII	`hilt/A2_hilt_inner_tang_pockets.nc`	1,039	12.3	12.5	11.7	96	-9.775	33.2 … 588.7	-10.1 … 10.1
Type XVIII	`hilt/B1_hilt_outer_shape_3D.nc`	53,937	104.5	104.6	89.3	2,298	-9.698	30.4 … 591.2	-102.7 … 102.1
Type XVIII	`hilt/B2_hilt_profile_tabs.nc`	16,439	11.6	11.8	13.3	72	-19.35	32.0 … 589.9	-101.7 … 101.7

C · Sources

Oakeshott type definitions. myArmoury spotlights: Type X myarmoury.com/feature_spotx.html · Type XIV myarmoury.com/feature_spotxiv.html · Type XVIII myarmoury.com/feature_spotxviii.php. Albion typology summary: albion-swords.com/articles/oakeshott-typology.htm.

Type X. Royal Armouries IX.1081, royalarmouries.org/collection/object/object-139 (965 mm OAL, 805 mm blade, c.1100, square-section quillons, “beehive” pommel). Width from replicas: Albion Norman (albion-swords.com/product/the-norman/; myArmoury review_alb_norm), Albion Jarl, ElGur X-1-A.

Type XIV. Metropolitan Museum 32.75.225 (metmuseum.org/art/collection/search/23367). Dimensions from “A Knightly Sword with Presentation Inscriptions,” *Metropolitan Museum Journal* v.2 (1969). Oakeshott, *The Sword in the Age of Chivalry*, plate caption “Type XIV, J1, 4.” Grip comparison: Albion Sovereign.

Type XVIII. Albion Kingmaker, albion-swords.com/product/the-kingmaker/ (and the earlier Albion product page). myArmoury review review_alb_king.html. Kult of Athena listing (grip 4 3/8″, 7.6 mm thickness at base). Cross-check: Royal Armouries IX.949 (1097 mm OAL, 887 mm blade).

The full URL list, with a status and note for every dimension, is in `swords.json` and `sword_params.py` (`SOURCES`).