Ambidextrous Recurve — C2 Rotational Symmetry

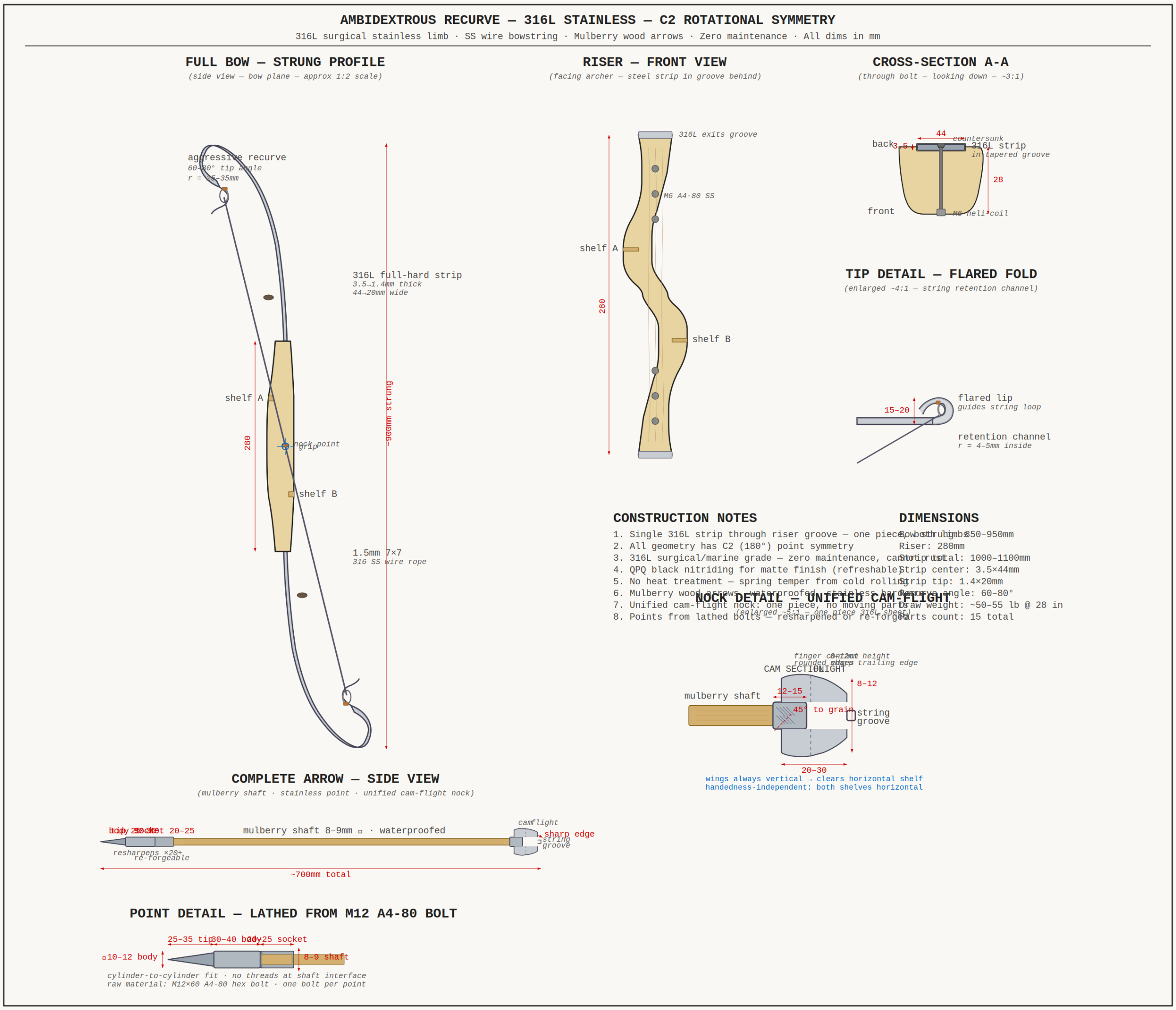

Figure 1: Ambidextrous Recurve — Engineering Diagrams

The Kalashnikov of Archery

The AK-47 succeeded not because it was the most accurate rifle or the most powerful. It succeeded because a conscript could pick one up in the mud, with no training, and it worked. Left-handed, right-handed, didn't matter. Sand in the action, didn't matter. No armorer, no supply chain, no special ammunition — it just worked.

This bow is designed on the same principle. One riser, either hand. A single strip of surgical-grade stainless steel for the limb — one piece, no joints, no lamination, no adhesive, no rust, no maintenance. Stainless wire bowstring — no stretch, no creep, no replacement, no corrosion. Mulberry wood arrows with stainless steel points and integrated cam-flight nocks. Every structural component is wood or stainless steel. Every part can be made or repaired with a lathe, a forge, and hand tools. Nothing degrades. Nothing corrodes. Nothing requires a specialist supplier. The failure mode of every component is mechanical damage, not rot, UV breakdown, delamination, oxidation, or string fatigue.

The whole bow stands under a meter tall — closer to a compound than a conventional recurve — because steel tolerates recurve geometries that would shatter fiberglass or delaminate wood. A machine shop can make every metal component. A šupa and a saw can season the riser and arrow shafts.

Parts count for a complete bow with six arrows: riser (1), limb (1), bowstring (1), bolts (3), threaded inserts (3), arrows (6). Fifteen components. No consumables. Zero maintenance.

Design Principle

The riser has C2 (180°) point symmetry — flipping it upside down produces the identical functional shape, like an ambigram. Two arrow shelves at symmetric positions (75mm from center), mirrored sight windows, and an S-curve tessellating grip cross-section that feels correct in either hand. No handed bias in any dimension.

- RH mode: hold with shelf A on top, arrow passes right side
- LH mode: flip 180°, shelf B is now on top, arrow passes left side
- Cross-dominant: either orientation, dominant eye picks the side

A single continuous strip of surgical stainless steel passes through a groove carved the full length of the riser, thickest at the center and tapering symmetrically toward both tips. The riser clamps the steel at the midpoint with countersunk bolts into threaded inserts. The steel extends beyond the riser at both ends to form the working limbs, with aggressively recurved tips and flared folds for string retention.

The bowstring is stainless wire rope. The arrows are mulberry wood shafts with stainless steel points machined from bolts, and a unified cam-nock-flight component at the tail — one piece of stainless steel that indexes the arrow during draw, nocks to the string, and provides stabilizing flight surfaces in flight. No deployable mechanism. No moving parts. No consumables.

Overall Dimensions

The aggressive recurve geometry that steel permits — tip radii under 30mm, recurve angles of 60–80° — shortens the bow dramatically compared to conventional recurves.

- Riser length: 280mm (11.0 in)
- Working limb length beyond riser: 250–300mm per side

- Total bow height strung: 850–950mm (33–37 in) — comparable to a compound bow
- Total bow height unstrung: 1000–1100mm (39–43 in)
- Brace height: 180–200mm (7–8 in)

For comparison, a conventional ILF recurve stands 1500–1800mm (60–70 in). This bow is roughly half that height. The penalty is a shorter draw length before stacking, but the aggressive recurve geometry delays stacking well past the 28–29 inch draw that covers most adult archers. The benefit is a bow that fits in a daypack, maneuvers through brush like a compound, and stores in a space no larger than an umbrella.

Dimensions — Riser

- Total length: 280mm (11.0 in)
- Max width: 76mm (3.0 in) at grip
- Min width: 31mm (1.2 in) at throat
- Depth at grip: 28mm (1.1 in)
- Depth at limb groove faces: 14mm per side of the groove
- Shelf offset from center: 75mm each side
- Limb groove: full-length slot through the riser centerline, width matched to steel strip (44mm at center), depth 3.5mm (steel sits in the groove with its faces flush or slightly proud of the riser surface)
- Bolt pattern: 3× M6 countersunk, linear along the groove centerline, 30mm spacing, passing through the riser sidewalls and through the steel strip
- Threaded inserts: M6 stainless heli-coil or press-fit threaded bushings on the far side of the groove

The Single-Piece Limb

This is the structural core of the bow. One continuous strip of stainless steel, symmetrically tapered from center to tips, passing through the riser like a blade through a handle. The riser is a clamp at the midpoint of a single leaf spring. Both limbs are one piece — no joint, no pocket, no mechanical interface between limb and riser other than the bolt clamp. The steel is the bow. The riser is the grip.

Material — Surgical Stainless

316L / 316LVM (Low carbon, Vacuum Melt) austenitic stainless steel in full-hard spring temper condition. This is the same grade used for body piercing jewelry and marine hardware — chosen for absolute corrosion immunity. No oil, no wax, no bluing, no protective coating of any kind. The limb can be submerged in seawater indefinitely. It cannot rust.

316L is not hardenable by heat treatment — it is an austenitic grade. Spring properties are achieved by cold rolling to full-hard temper. The cold work raises yield strength to 690–860 MPa and provides excellent fatigue resistance for cyclic flexion. This is lower than heat-treated carbon spring steel (1200+ MPa), so the strip dimensions are slightly larger to compensate — wider and thicker at the center — while maintaining the same draw weight and energy storage.

316L full-hard strip is a standard industrial product, stocked by Sandvik, Outokumpu, Aperam, Thyssenkrupp, and specialty stainless stockholders across the EU. Search for “316L spring temper strip” or “1.4404 full hard strip” or “AISI 316L Condition C” (Condition C = full hard, >862 MPa UTS).

Dimensions and taper

Total strip length: 1000–1100mm (39–43 in), a single piece.

The taper is continuous and symmetric about the midpoint. Dimensions are slightly increased over carbon steel to compensate for the lower yield strength:

- Center (inside riser): 44mm wide × 3.5mm thick
- At riser exit (140mm from center): 40mm wide × 3.0mm thick
- Mid-limb (250mm from center): 32mm wide × 2.2mm thick
- At recurve onset (350mm from center): 24mm wide × 1.8mm thick
- Tip (before fold): 20mm wide × 1.4mm thick

The groove carved in the riser follows this taper exactly. It is widest and deepest at the center, narrowing toward both ends. The steel strip sits snugly in the groove with no play — the groove is the taper's negative. This continuous contact distributes load along the full 280mm riser length rather than concentrating it at bolt points alone.

Draw weight is governed by the center thickness (cube relationship) and width (linear). A 3.5mm × 44mm center section in 316L full-hard produces approximately 50–55 lb at 28 in draw. Thinner stock (3.0mm center) drops to roughly 35–40 lb. Width changes are linear — narrowing the center to 38mm at 3.5mm thick gives about 43–47 lb. This makes it straightforward to produce a matched set of interchangeable limb strips at different draw weights for the same riser.

Cutting and forming

316L full-hard is tough but machinable. It cannot be annealed-then-hardened like carbon steel — the spring temper comes from the cold rolling mill. All shaping must preserve the cold-worked condition.

Cut the blank as a double-tapered shape — a long, narrow hexagon, widest at the center, tapering symmetrically to both ends. Mark the center clearly. Cut with a waterjet, laser, or abrasive disc (angle grinder with thin cutting disc). A hydraulic shear will work for straight edges. Deburr all edges with a file — any nick or scratch on a tension surface becomes a fatigue crack initiation site.

Grind the thickness taper with a surface grinder or CNC mill. The thickness transition must be smooth and gradual — no steps, no abrupt changes. Do not overheat the steel during grinding — keep it cool. Excessive heat (above ~425°C) will anneal the cold work and destroy the spring properties locally. Use flood coolant or frequent quenching.

Drill three M6 clearance holes (6.5mm) along the centerline of the strip at the midpoint, matching the bolt pattern on the riser. Countersink each hole on the back side (the side away from the archer when assembled).

Tip folds — flared string retention

At each end, the last 15–20mm of steel is folded back to form the string retention channel. With 316L full-hard, the fold requires significant force — the material is strong and work-hardened. Use a press brake or hydraulic bender, not a vise and hammer.

The fold is flared outward like a trumpet bell. When the bow is shot, the limbs snap forward violently. The string loops, seated in the tip folds, must slide freely in the channel during this motion. A tight fold creates an edge that the string loop can catch on during the dynamic whip of the limb tip — loss of energy, string wear, wire fatigue. A flared fold eliminates this. The string loop sits in the deepest part of the bell, and as the limb whips forward, the loop rides up the flare and releases cleanly. No edge contact, no catch, no wear point.

Bend the first 10mm back at 130° over a 5mm mandrel on a press brake. Then use a radiused die or swage to flare the remaining 10mm outward, opening the fold to approximately 90° at the outer lip. The cross-section at the tip looks like a J rotated backward — a curved channel that opens into a smooth ramp.

Round all edges of the fold and flare thoroughly. File, then 220 grit, then 400 grit. Every surface the string contacts must be mirror-smooth. 316L polishes easily and stays polished.

Recurve forming — aggressive geometry

This is where steel diverges most dramatically from conventional limb materials. Fiberglass-laminated limbs can tolerate recurve tip angles of 20–30° before delamination risk becomes unacceptable. Wood self-bows can manage 15–20° at most. 316L full-hard, with its excellent fatigue resistance, will cycle indefinitely at recurve angles of 60–80°.

Form the recurve using a press brake with a radius die. The last 80–120mm of each limb tip (measured from the fold base) is bent forward (away from the archer) through 60–80° of arc. The bend radius should be 25–35mm. The recurve section is a smooth arc, not a sharp kink. Both tips must match exactly — form them over the same die.

No heat treatment required

Unlike carbon spring steel, 316L requires no hardening, tempering, or quenching. The spring properties are inherent in the cold-rolled strip as delivered from the mill. This eliminates the most skill-intensive and failure-prone step in the carbon steel version. The strip is ready to use as-delivered after cutting, tapering, drilling, and bending.

Surface finish — QPQ black nitriding

The one disadvantage of stainless steel limbs is the shiny, reflective surface. The solution is QPQ treatment (Quench-Polish-Quench), also known as Tufftride or salt bath ferritic nitrocarburizing.

QPQ is a thermochemical process, not a coating. The part is immersed in a molten cyanate salt bath at 580°C for 1–4 hours. Nitrogen and carbon diffuse into the steel surface, forming a compound layer of iron nitride and chromium nitride 10–25μm deep. The result is a deep, uniform matte black finish that is integral to the metal — not paint, not plating, not a film that can peel or chip.

Properties of QPQ on 316L: deep black matte finish; compound layer hardness 800–1200 HV; wear resistance 5–10× untreated; corrosion resistance maintained or improved; light scratches expose more black nitride, not bare metal; can be re-processed to refresh the finish after decades of abrasion.

Temperature caution: The 580°C salt bath is above the ~425°C threshold where 316L begins to lose cold-work hardening. QPQ will partially anneal the strip, reducing yield strength by roughly 20–30%. To compensate, either start with slightly thicker/wider strip, or verify spring-back after treatment and adjust dimensions if needed. The compound layer itself adds surface hardness that partially compensates for substrate softening.

Alternative black finishes if QPQ is unavailable: black passivation (Inox Black) at room temperature, no strength reduction, less durable; Cerakote ceramic coating at 150°C, no strength reduction, widely used on firearms; or simply leave it shiny and tape the limbs with camo tape for hunting.

In Croatia, search for "nitrokarburiranje" or "Tenifer obrada" — any company that does nitriding for automotive or tool steel parts can process the limb strip. Typical turnaround is 1–3 days.

Riser Groove and Clamping

The riser is carved with a full-length groove — a slot running the entire 280mm along the back face (away from the archer), precisely shaped to match the steel strip's taper profile. The strip sits in this groove like a tang in a knife handle.

Groove geometry

- At center: 44mm wide × 3.5mm deep
- At each end of the riser: 40mm wide × 3.0mm deep
- Smooth, continuous taper between these points
- Bottom of groove: flat, perpendicular to the bolt axis
- Walls of groove: vertical, snug to the strip edges with 0.3–0.5mm clearance for insertion

Bolt-through clamping

Three M6 countersunk socket-head cap screws (stainless, A4-80 / 316 grade) pass through the riser from the back face, through the steel strip, and into stainless heli-coils seated in the front face. Spaced 30mm apart, centered on the riser midpoint. Torque to 8–10 Nm.

The countersinks on the steel strip are convex-radiused — smooth domes, not sharp cones — so no stress concentration exists on the tension side of the strip.

Limb interchange

To change draw weight: loosen three bolts, slide out the steel strip, slide in a different one, tighten. Allen key and 30 seconds. Like changing a blade.

Steel Wire Bowstring

316 stainless steel wire rope, 1.5mm diameter, 7×7 construction. Standard marine rigging wire. Same alloy family as the limb. Breaking strength approximately 200 kg. No serving, no wax, no replacement schedule.

Form a loop at each end through a stainless crimp ferrule, swaged with crimping pliers. Each loop wraps around a stainless thimble. Crimp a small stainless ferrule at the nocking position. Thread two rubber or leather damper discs at 1/5 string length from each end before crimping.

A steel wire string transfers force more abruptly than polymer — the acceleration spike is higher. Mulberry wood shafts handle this at moderate draw weights (up to ~55 lb) because the wood's natural elasticity absorbs the shock along the shaft length.

Arrows — Mulberry Shafts with Stainless Steel Hardware

The arrows follow the same philosophy as the bow: wood and stainless steel, nothing else, nothing that degrades.

Shaft — Mulberry Wood

A straight-grained mulberry dowel, turned on a lathe to 8–9mm diameter, spine-matched to the bow's draw weight. Mulberry's combination of density (~690 kg/m^3), straight grain, and natural resilience makes it an excellent arrow shaft material — it was used historically across the Middle East and Central Asia for this purpose.

Select straight, knot-free mulberry branches or split billets. Season to 8–12% MC. Turn on a lathe to consistent diameter, sanding to 400 grit. The shaft must be straight to within 1mm over its full length — roll on a flat surface to check, straighten with gentle hand pressure while warm (heat gun or steam).

Waterproof by full immersion soak in the rosin-wax-turpentine mixture (same as the riser), 3–5 days. This stabilizes the spine regardless of humidity.

Both ends of the shaft are plain cylinders — no taper, no reduction. The point socket and nock socket both accept the raw shaft diameter directly.

Point — Lathed from Stainless Steel Bolts

The arrow point is machined from a 316 stainless steel hex bolt on a lathe. The bolt provides raw material at low cost in a convenient starting geometry.

The finished point has three zones:

Socket (rear): A cylindrical bore matching the arrow shaft diameter (8–9mm), 20–25mm deep. The shaft press-fits or is glued into this socket with rosin or thin CA. Pure cylinder-to-cylinder interface — no threads on the shaft connection.

Body (middle): A cylindrical section, 10–12mm diameter, extending 30–40mm forward from the socket. This is the forward-of-center weight that stabilizes the arrow in flight. The body diameter is larger than the shaft, so the point acts as a step-down shoulder preventing the shaft from being driven rearward on impact.

Tip (front): A tapered cone or ogive, 25–35mm long, tapering from body diameter to a sharp point. The tip length is deliberately generous — 25–35mm of taper provides ample material for repeated field sharpening with a file or stone. When the tip becomes too short or damaged to resharpen, it can be cheaply re-forged (heated and re-drawn on an anvil) to restore the original taper geometry and linearity. The re-forging operation is trivial — propane torch, anvil, hammer.

Why bolts as raw material: Stainless hex bolts in M10 to M16 are available everywhere, in known grades (A4-80 = 316), at commodity prices. An M12×60 A4-80 bolt provides enough material for one complete point. A box of 50 bolts costs less than a set of commercial broadheads, and each bolt becomes a point that can be resharpened dozens of times.

Machining sequence: Chuck the bolt by the hex head. Face the threaded end. Bore the shaft socket with a drill and boring bar. Turn the body to diameter. Form the tip taper with a compound slide or CNC. Part off at the desired total length. Deburr and polish. Optional QPQ black finish.

Nock — Unified Cam-Flight Component

A single piece of stainless steel that serves three functions simultaneously: nocking to the bowstring, indexing the arrow's rotational orientation during the draw, and providing stabilizing flight surfaces. No moving parts. No deployment mechanism. No separate fletching.

The cylinder: The base is a rolled 316L stainless steel cylinder, 8–9mm ID (matching shaft OD), 12–15mm long. The interior is threaded with a coarse thread at 45° to the grain direction of the shaft. This is critical: a thread parallel to the grain splits the wood along the fibers; a thread perpendicular to the grain has no fiber engagement and strips out. At 45°, the thread spirals across grain boundaries at every revolution, engaging both longitudinal fibers and cross-grain structure. This maximizes pull-out resistance without creating a splitting plane.

The 45° thread is achieved by cutting the thread on a lathe with the cylinder mounted at 45° in a tilting fixture, or using a tap ground with a 45° lead-in angle. The result is a thread that looks slightly elliptical from the end but provides dramatically better holding power in end-grain wood.

The wings: Two flat steel wings extend rearward from the cylinder, 180° apart. Each wing is 20–30mm long and 8–12mm tall. The wings are formed from the same sheet as the cylinder — the flat stock is cut to a cross shape (cylinder blank at center, two wing blanks extending), the center is rolled into the cylinder, and the wings extend from the rolled edge as flat fins.

Each wing has a dual-purpose profile:

Forward section (cam surface), first 10–15mm: A shallow helical twist. When the archer's fingers contact these surfaces during the draw, finger pressure exerts torque on the arrow, rotating it into the correct indexed orientation. The forward edges and surfaces are rounded and smooth — no sharp edges where the operator's fingers contact the nock during handling.

Rear section (flight surface), last 10–15mm: A flat or slightly twisted vane — the stabilizing flight surface. The trailing edge IS sharp — a crisp thin edge improves aerodynamic efficiency. The leading edge (transition from cam section) is rounded.

Two wings at 180° provide adequate stabilization for the effective range of this bow (20–40m). The cam surface indexes the arrow so the wings are always oriented in the bow's vertical plane (one up, one down), and both shelves are horizontal. The wings never contact the shelf during the shot. This is handedness-independent — the same orientation clears both shelves because the C2 riser geometry places both shelves in the same horizontal plane relative to the arrow.

String groove: A shallow transverse groove between the two wing roots at the trailing edge of the cylinder. Standard nock geometry, 2–3mm deep, radiused to match the 1.5mm wire string.

Fabrication: Start with 316L strip, 0.8–1.0mm thick. Cut the cross-shaped blank (laser, waterjet, or jeweler's saw). Roll the center into a cylinder on a mandrel. Cut the 45° internal thread. Form the cam twist on forward wing sections. Sharpen trailing edges of flight sections. Polish all hand-contact surfaces. Optional QPQ finish.

Assembly: Thread the nock onto the rear of the mulberry shaft. The 45° thread bites across the grain and locks. A drop of rosin or thin CA secures against vibration loosening. To replace: heat gently, unscrew, thread on a new one.

Wood Selection — Riser and Arrow Shafts

All species grow in or are readily available in Baranja, eastern Croatia.

Mulberry (dud, Morus spp.) is recommended for both riser and shafts. Density ~690 kg/m³, excellent compression strength, good elasticity, natural rot resistance. Grows abundantly. Arrow shafts can be turned from smaller-diameter straight branches or split billets.

Alternatives: black locust / bagrem (770 kg/m³, exceptionally rot-resistant); walnut / orah (650 kg/m³, prized for gunstocks); hornbeam / grab (800 kg/m³, extremely hard, excellent for arrow shafts); turkey oak / cer (dense, requires careful grain selection); wild service tree / brekinja (very dense, fine-grained, excellent for shafts).

Preparing the Raw Wood

Debark immediately. Season to 8–12% MC — air-dry in a šupa for 6–12 months per 25mm thickness. Check grain quality: reject reaction wood, spiral grain, knots. Rough-mill and stabilize (rest a week, check for warping). Cut the groove and install inserts while the riser blank is still rectangular for accurate reference faces. Turn arrow shafts to ~12mm oversize, stabilize, then final-turn to 8–9mm.

Waterproofing — Self-Sufficient Method

Applied to both riser and all arrow shafts. Pine resin from Slavonian uplands (Papuk, Psunj, Požega), beeswax from local pčelar. Distill resin in a kazan: turpentine comes off as vapor at 155–185°C, rosin remains. Mix 1 part beeswax + 1 part rosin + 3–4 parts turpentine at ~90°C. Full immersion soak: 5–7 days for riser, 3–5 days for shafts. Cure 2–3 weeks in ventilated space.

Rosin hydrogen-bonds to cellulose and bridges nonpolar wax into polar wood cell walls. When turpentine evaporates, rosin solidifies and locks wax throughout the wood structure — chemically anchored, not just pore-filling.

Bill of Materials — Complete System

Component	Material	Source	Qty	Consumable?
Riser	Mulberry or black locust heartwood	Local harvest, Baranja	1	No
Threaded inserts	M6 stainless heli-coil	Željezarija / marine supplier	3	No

Component	Material	Source	Qty	Consumable?
Limb strip	316L full-hard spring temper, tapered	Stainless stockholder, EU	1	No
Limb bolts	M6 × 20mm countersunk A4-80 (316)	Željezarija	3	No
Bowstring	1.5mm 7×7 316 SS wire rope	Marine chandlery	1	No
String ferrules	1.5mm stainless crimp sleeves	Marine chandlery	4	No
String thimbles	1.5mm wire rope thimble, SS	Marine chandlery	2	No
Nocking point	Small stainless ferrule	Marine chandlery	1	No
String dampers	Rubber or leather discs	Scrap / hardware	2	Decades
Arrow shafts	Mulberry heartwood, turned, waterproofed	Local harvest	6+	No
Arrow points	316 SS, lathed from M12 A4-80 bolts	Željezarija	6+	Resharpened
Cam-flight nocks	316L sheet, formed, one piece	Stainless stock + shop	6+	No
QPQ treatment	Salt bath nitriding	Industrial nitriding service	—	Refreshable
Waterproofing	Beeswax + rosin + turpentine	Local harvest	—	Self-renewing

Assembly

1. Slide the steel strip into the riser groove, centering it so equal lengths protrude from each end.
2. Align bolt holes. Insert M6 countersunk screws from back face into threaded inserts. Tighten to 8–10 Nm.
3. Seat one bowstring loop in the tip retention channel. Flex the bow and seat the second.
4. Check brace height.
5. Thread point onto arrow front, cam-flight nock onto rear.
6. Nock arrow. Cam surfaces index rotation as fingers close into draw — wings align vertically, clearing shelf.
7. Draw. Aim. Release.

Assembly from parts: under two minutes. Disassembly: under one minute. Packed in a

1100mm tube. Strung and ready, under a meter tall.