

Foil Design Tool for Onshape

User guide, design notes and parameter reference. Build 245 (wing 1.070, stabiliser 4.036, performance 1.030, mast 2.011, fuselage 5.008, mold 2.148).

By JB69. Licensed under Creative Commons Attribution-NonCommercial-ShareAlike 4.0 (CC BY-NC-SA 4.0): share and adapt it for non-commercial use, with credit, under the same licence.

Two things before anything else. First, this is a modelling exercise, not the advice of a foil builder. The tool started as a side quest to the B-series propeller blade generator: sizing a prop needs a drag curve, a drag curve needs a foil, and a nine-hour flight turned that into six features. Second, every number the tool produces is a steady-state, constant-value estimate: one speed, one weight, flat water, a rider who doesn't move. Real foils live in chop, pumping, turns and landings, and they break on peaks and repetition. Trust the trend from one variant to the next; treat absolute numbers, stall speed especially, as optimistic until you have calibrated them against something you have ridden (see 10.1).

This document accompanies the *Foil design* Feature Studio. It explains what the tool does, how the six features work together, what every parameter means and how to use it, and the hydrofoil design and construction knowledge that was worked out while building it. It is written for a rider who designs and builds their own foils: pump, SUP and surf, wing, windfoil, kite and eFoil are all first-class targets.

Contents

1. What the tool is
2. Quick start
3. The six features
4. Reading the results
5. Design knowledge
6. Building knowledge: layup, structure, molds and printing
7. Worked example
8. Parameter reference
9. Console log reference
10. Model limits, versioning and the AI assistant

1. What the tool is

The tool is a single Onshape Feature Studio containing six custom features. Used in order in a Part Studio, they turn a handful of design decisions into a complete hydrofoil: front wing, stabiliser, mast with an optional motor pod, round tube fuselage, a full performance and stability analysis, and a set of 3D-printable molds with a layup schedule and fabric cutting templates.

Feature	What it makes	Reads	Publishes
Foil wing	The front wing, optionally with a tube socket and nacelle for a round fuselage	nothing	area, span, MAC, incidence, zero-lift angle, the analysis model, the socket position
Foil stabiliser	The rear wing, placed by Arm and Height behind the wing, optionally linked to the wing, with the production-style mount pad, tail fairing and bolt holes	the wing (link ratios, the tube socket axis the seat Height is measured from)	area, position, the mount contour and bolt pattern
Foil performance	No geometry. A speed sweep of lift, drag, trim, stability, structure, propulsion and energy	wing, stab, mast, fuselage	the spanwise bending loads used by the mold's stiffness check
Foil mast	The mast: tapered, thickened at the top, with a root fillet into the board plate, optional motor pod with a placeholder cavity, plate with bolt holes	the wing pivot (position only)	the mast law and plate for the mold and the fuselage pocket
Foil fuselage	The round tube: spigot into the wing socket, seat cut to the stab's mount contour, tapped holes matching the stab's bolts, mast pocket	wing socket, stab mount, mast	the fuselage shape for performance
Foil mold	Two-part (mast: three-part) printable molds for the wing, stab or mast: parting curtain, locator keys, pinch-off groove, undersized bolt cones, plugs, printer tiling, plus the layup, material and resin estimate, stiffness check and cut-template plate	the part and every model above	nothing

Frame and conventions. X points downstream (leading edge to trailing edge), Y along the span, Z up. The wing's root pivot, the quarter chord by default, sits at the world origin. Sections are streamwise. Incidence is positive leading edge up. *Decalage* is wing incidence minus stab incidence. Span is the projected tip-to-tip distance seen from above. Area is projected by default and always reported.

Design philosophy, as decided during development.

- Everything is parametric and mathematical: no sketches to draw, no freehand surfaces. Change a number, regenerate, read the notice.
- Foil area is a first-class input. You choose an area and an aspect ratio; the planform is solved to hit them exactly.
- The stab's arm and height are design decisions that belong with the wings. The mast and fuselage are structural parts that read those positions and never set them. The one deliberate exception is the stab's *Height*, which is measured from the wing's tube socket axis so its mount always lands on the fuselage.
- Discipline-neutral: nothing assumes an eFoil. Every tooltip gives typical values by discipline.
- Foils are carbon laid up in printed molds, not printed parts. Structural advice assumes carbon: woven skins, unidirectional caps and carbon tow.

- Every parameter has a short label so its value stays visible in the dialog, and a tooltip with limits, typical values and what the parameter does.
- Warnings tell you which field in which feature fixes the problem.

2. Quick start

1. In a Part Studio, open *Add custom features*, search for **Foil designer** and add it. The six features appear in the toolbar. This guide is the PDF in the same public document: right-click any of the features and choose *Open linked document* to find it again, and that document also has an example Part Studio with all six features placed.
2. Add **Foil wing**. Pick a discipline-appropriate area, aspect ratio and section; leave the rest at defaults. The notice shows the area achieved, span, MAC and root chord.
3. Add **Foil stabiliser**. Set Arm, and Height as the seat offset from the fuselage centreline (−4 mm with the pad on top). Leave *Link to wing* on to size the stab as a fraction of the wing; the decalage is then set by *Link decalage*. Turn on the *Mount pad* if the stab will bolt to a tube fuselage.
4. Add **Foil performance**. Enter rider plus board mass, water, ride depth and the speeds you care about. Read the notice: L/D and power at cruise, stall, take-off margin, trim CG, static margin, root bending and cap thickness. Turn on *Log inputs* and open the FeatureScript console for the full sweep as CSV.
5. Add **Foil mast** and **Foil fuselage** when you want the structure. The performance feature picks up their drag automatically, and *Joint finish* counts the joints, so *Other cm²* is only for fittings.
6. Iterate here, before any mold exists. The wing, stabiliser and performance features regenerate in seconds; a mold takes minutes, and two molds double it, so settle the design first and add the molds last. If a mold is already in the studio, suppress it while iterating, or set its *Detail* to Preview. Change one or two things at a time and compare notices. The console lines (`WING_INPUTS`, `STAB_INPUTS`, and so on) capture every input and are what you paste when asking for help, whether on a forum or to the AI assistant in section 10.3.
7. Add **Foil mold** for each part you will build, once the design is settled. Select the part, set your printer's bed size, and read the layup and stiffness lines. Turn on *Cut templates* to get a plate whose top face exports as one DXF of every fabric shape.
8. Keep any custom geometry that the mold must follow, such as a hand-modelled motor cavity in the pod or fillets and chamfers on the mast's plate, *above* the mold feature in the feature list. The mold cuts its cavity from the part as it stands, and shapes the mast's plate lid and the halves' plate pocket from the plate as modelled.

2.1 The download package

Everything outside Onshape comes as one zip, `foil-design.zip`, from the GitHub repository at <https://github.com/jb69/Foil-Design-Tool> (direct download: <https://github.com/jb69/Foil-Design-Tool/raw/main/foil-design.zip>). Unzip it anywhere; nothing installs. This guide's PDF is in the repository as well, so it can be read in the browser without downloading the zip.

In the zip	What it is for
<code>foil_design.fs</code>	The Feature Studio source. Only needed if you want your own copy of the features rather than the published ones: in your Onshape document create a Feature Studio, select all its text and paste this file over it. The six features then appear under <i>Custom features</i> in that document's Part Studios.
<code>docs/</code>	This guide as PDF and as Markdown, its charts, and <code>parameters.md</code> , a table of every dialog field with its limits, default and tooltip

In the zip	What it is for
assistant/	The AI assistant of section 10.3: the Claude skill, the portable file for other assistants, its four scripts and a README with the setup for each
examples/	Two complete console logs and a speed sweep to try the assistant on before you have a design of your own
LICENSE	CC BY-NC-SA 4.0

Use the package like this: add the features in Onshape (step 1 above, or paste `foil_design.fs` for your own copy), design with the guide open, and when a run needs a second opinion, give the assistant in `assistant/` your console log. the project's design notes is the place to start when you want to model a foil you know: each document lists the dialog values, feature by feature.

3. The six features

3.1 Foil wing

The wing is built from an area-first planform solver: you give target area and aspect ratio (or span and root chord), the chord distribution shape (superellipse of exponent n , linear taper, or double taper), and the solver finds the root chord that hits the area exactly. On top of that: an alignment line (which chord fraction stays straight in plan), power-law sweep, tip drop with an anhedral exponent and optional root dihedral, washout, a thickness distribution from root to tip, incidence about a chosen pivot, a tapered or rounded tip cap, and a minimum tip thickness.

Chord distribution. *Superellipse* gives the rounded outline most wings have: exponent 2 is elliptic, 3 to 4 fuller with squarer tips, and the end ratio sets the small end face. *Linear taper* is a straight taper to a square tip. *Double taper* is two tapers: a steep one from the root to *Break %* of the half span, where the chord is *Mid ratio* of the root, then a gentle one to *Tip ratio*, with *Blend %* rounding the corner between them (0 for a sharp kink). That is the full-base shape of many current stabs, and of a high-aspect wing with a broad centre section. Linear and double tapers end square; *Tip cap* = Rounded + plan shrinks the chord along the cap's quarter-ellipse as well as the thickness, centred on the mid-chord whatever *Align line %* is, so both tip corners round and the area solver allows for it.

Span line. *Tip drop* is the anhedral, how far the tip sits below the root; *Drop shape* is how it is spread. *Power law* with *Drop exp* steepens all the way to the tip (2–3 gives a flat centre with the tips dropping late). *S-curve* is a smoothstep: flat at both ends and steepest in the middle, so the wing levels off again before its tips; that is the gull front view of many surf wings. *Drop from %* and *Drop to %* set where the drop starts and finishes; beyond *Drop to %* the line runs level until a winglet bends it. *Gull dihedral* is the slope leaving the root for a true gull that rises before it falls. With either on, the loft adds stations through the drop, about 17 of them (build 235), so the surface follows its law between them; before that a wing with few *Stations* drooped almost straight from the root over its first span and lay up to 1.6 mm below its own law there, which the mold's parting followed, so the lower half lapped over the thin trailing edge. From build 230 the wing and stabiliser notices say what the span line does in roll: *rolls like x° of anhedral (Cl_beta ..., this surface alone)*, the straight anhedral folded at the root that would roll the same, from a vortex-lattice model of the surface's own drop, gull, winglets and sweep. A 35 mm S-curve on a 900 mm wing reads about 5° ; upturned tips take back about half a degree. It compares shapes; the mast and the rider decide how the whole foil feels in roll.

Winglets. *Winglet Up or Down* bends the outer part of each half span through *Winglet angle* on an arc of *Bend radius*, then straight to the tip. Its size is *Winglet area*: the chord distribution continues along the bend, and the tool solves how much of the half span to bend so that area comes out. For a fin-like winglet use a small radius, 20 to 40 mm; for the smooth upturned tip of a downwind wing set *Bend radius* near the winglet's own length (150 to 250 mm), so the whole winglet is the arc and there is no straight leg to read as a kink. Every section beyond the bend is drawn square to the bent path, so a 90° winglet keeps its true section; the old route, *Tip drop* with a high *Drop exp*, keeps the sections vertical and only suits a gentle upturn. Area and aspect ratio stay the developed values of the whole half span, winglet included; the notice adds the winglet height, its projected area and the projected span. Foil performance credits a winglet as extra effective span for induced drag ($0.9 \times$ its height across the pair, the usual first estimate). Foil mold molds a winglet up to 75°: the parting follows the bent tip, and the mold block grows by the winglet's height; steeper winglets cannot release from a two-part mold pulled vertically.

Leading-edge tubercles. *LE tubercles* puts tubercles on the leading edge: it moves forward and back sinusoidally along the span by *Tubercle amp* peak to trough, every *Tubercle pitch*, between *Tubercles from* and *Tubercles to*, fading in and out over half a pitch at each end. The trailing edge stays where it is, so the chord swells at each peak; the section is stretched there with its thickness in millimetres unchanged. Six stations per pitch are added so the loft draws each tubercle, which slows regeneration. Foil mold follows the tubercles exactly.

The theory. Tubercles come from humpback whale flippers. Each tubercle sheds a pair of streamwise vortices that carry high-energy flow into the boundary layer behind the troughs, so the flow there stays attached to a higher angle of attack, and the wing's stall becomes gradual and partial instead of sudden: wind-tunnel tests (Miklosovic and others, 2004; Johari and others, 2007) show the stall angle rising by several degrees and lift retained well past it, with a small drag penalty below stall and, on some sections, a small loss of maximum lift. On a foil that is take-off, pumping and hard turns, which is where the makers put the claim.

The caveat, and what the tool says instead. *Foil performance's figures ignore the tubercles*. Its lift and drag come from lifting-line theory on the smooth chord distribution and from two-dimensional section polars, and neither can see a spanwise-periodic leading edge: the stall speed, the take-off margin and the drag in the sweep are the plain wing's, always. From build 232 the feature adds a separate line to its notice and a block to its report, *LE tubercles, reported apart*, with the *Tubercles* switch in its Section and drag model group, and it is deliberately never folded into the figures above it. The line has two parts. The charge the tool can compute: the chord swells by half the tubercle height at each peak and shrinks by it in each trough, the loading cannot follow a ripple shorter than a chord, so the local lift coefficient rises in the troughs by the chord's own fraction (2.5 % for 5 mm tubercles on a 111 mm chord) and the first stall begins there, a little earlier; the line gives the take-off loading and stall speed with that trough-first stall. Then the published credits, applied to the same two numbers: a section CL max between -5 % (two-dimensional tests at low Reynolds number) and +6 % (the humpback flipper at Re 0.5 million, Miklosovic 2004), the flipper's +4° of stall angle as a bound, and the lift held past stall that is the real point of tubercles, which the sweep cannot represent at all because its polars have no post-stall branch. The drag before stall is of unknown sign within about 8 % of the wing's profile drag, and the line says so with the glide range it implies. It also says whether the height and pitch, as fractions of the chord, lie inside the tested range. Treat the line as the size of a build choice, and calibrate the stall against a ridden foil as section 5.3 describes; a smooth and a tubercled wing from the same molds is the test that would settle the credits.

Sections. NACA 4-digit is fully parametric (camber, camber position, thickness). Seven published sections are built in as digitised coordinate tables: Eppler E817, Eppler E818, NACA 63-412 and Clark Y, the classic flat-bottomed section whose lower surface is straight from 30 % chord back. A tabulated profile fixes its own camber; Root and Tip thick % scale its thickness. *Tip profile* lets the section change along the span

(give the Foil mold 22 or more *Split stations* when it is on; the parting needs them where the section changes): the root section runs out to *Blend from* % and then blends point by point into the tip section (any of the five, with its own *Tip camber* % and *Tip camb pos* % for NACA), reaching it at the tip, the way production wings run a cambered root out to a flatter, thinner-nosed tip that stalls later. The mold follows the blend, and so does the performance sweep (section 4.4). The trailing edge is held at a real thickness for moldability and thinned automatically near the tip so it never exceeds 3 % of the local chord.

Fuselage joint. Four ways to attach the fuselage, chosen under *Joint*. *Flat mount (bolted through)* is the simplest, and the usual one on home-built foils: the wing's underside sits on a flat fuselage bar and countersunk bolts go straight down through the wing on the centreline into the bar, set by *Bolts*, *Bolt*, *Bolt 1 from* the leading edge, *Bolt pitch* and *Countersink*; each hole is checked against the root chord and the laminate left under its head. A wing bolted straight onto a bar seats on its underside's own line, not at the angle it was drawn: the tool's Clark Y has its flat 2.1° from its chord, and a cambered NACA underside rocks on its curve. So the joint carries a *Mount pad* (on by default, build 227): a flat horizontal face *Pad width* wide and *Pad height* below the underside's lowest point, its top following the root's own lower surface, from *Flat start* behind the leading edge to the trailing edge, faired from the nose by the *Front ramp* or begun square. It is the shim that sets the typed *Incidence* against the bar; the bolts pass through it and the laminate under each head counts it. Where the underside already lies on the pad plane, a Clark Y drawn at 2.1° with *Pad height* 0, no pad body is built. Any other section's face sits at least 0.3 mm below its lowest point (build 238): a face on the point itself touches the skin along a line, and the mold's cavity cut fails there. The notice reports the seat line, the edge of the underside's lower convex hull under the bolts' resultant, and the angle the wing would run at on a bare bar; with the pad off that becomes a warning, with the incidence to type to analyse the wing as built. In the mold the holes come out as pins from both halves, the countersinks on the upper half, and the pad molds in the half that forms the underside. *Round tube socket* is the tool's original: a nacelle blended onto the root with a bore for a round tube, held by cross pins. *Square socket* is the same nacelle with a rectangular bore for a flat-sided tongue or an extruded aluminium flat bar; *Bore corner* rounds the bore's corners as bar stock's are (enter no more than the bar's own radius), and the clearance is split between the two sides as it is for the round bore. *Flat hub with pocket* is what most production wings do: a flat-topped hub on the root, level with the section's apex and running aft from it past the trailing edge with a flat underside at the trailing edge's height, a shallow recessed pocket the fuselage's flat nose drops into, and blind holes for bolts that come down through the fuselage into the wing, into bonded inserts. The hub is a D in plan, a semicircle at the front and a square back, and the pocket runs from its front wall out through that back, open, so it is the start of the fuselage interface: the tongue is located by the front wall and the sides. *Hub above apex* may sink the hub well below the section's centre; the underside then follows it down to keep floor under the pocket, and the notice warns where the pocket floor would break through the lower skin. It gives the thinnest root, the stiffest joint, and a mold with no plug, since the pocket molds from the upper half. The two sockets hold their fuselage with countersunk bolts through the nacelle's top, and *Socket height* moves the bore off the mid-thickness. *Hub* = Standard fixes the hub's dimensions so one fuselage fits every wing built with it: 40 wide by 92 long, a 3 mm join fillet, the pocket 24 wide by 5 deep from 20 mm behind the front, three blind holes at 20 mm pitch from 15 mm behind the pocket's front wall, 10 mm deep, the count and positions the fuselage was drawn with; you choose only the bolt size (*Hub bolt*, M5, M6 or M8) and the position (*Hub from apex*, *Hub above apex*). *Hub* = Custom opens every dimension, so a fuselage you own can be measured and matched, and *Tongue length* is published for the fuselage; the notice reports the wall left under each hole. It also opens *Bolts from* (build 235), which side the bolts come from. *Fuselage* is the joint above, bolts down through the tongue into blind holes. *Wing underside* turns them round for a metal bar sitting in the pocket: a clearance hole for the *Hub bolt* (M5 5.4, M6 6.4, M8 8.4 mm) at each bolt position on the centreline, from the lower skin up to the pocket floor, with a 90° countersink in the lower skin to the head diameter so the heads sit flush, and the bar or the fuselage's tongue is tapped instead. Each hole starts where the wing's underside really is, read off the part by a ray cast up the bolt's axis. The notice gives the laminate left between each countersink and

the pocket floor and warns under 2 mm, as the flat mount does; put the bolts where the root is thick, and keep *Clear joint* on in Foil mold so they pass through solid laminate, not foam. *Fuselage, nut inserts* (build 241) brings the bolts down through the fuselage and right through the wing into flanged nut inserts pushed into the underside, a hand fit: a clearance hole, a bore for the insert's barrel (*Insert dia*, *Insert length*) and a flush recess for its flange (*Flange dia*, *Flange thick*), all at *Insert fit*. A bolt into a nut takes full preload, which tapped carbon cannot hold, and the clamp is what carries twist and yaw at the joint: the notice estimates it (A4-70 at 70 % of yield) with the twist the face holds before it opens, the yaw before it slips, and the bearing under each flange, and warns when an insert reaches within 1 mm of the pocket floor, where the bolt would no longer clamp the laminate. Keep the root solid round the inserts (*Clear joint* and *Core clear* in Foil mold); the mold forms the bores and recesses from its lower half. The Standard hub keeps its bolts from the fuselage. A bar or fuselage in the pocket stands proud of the hub, and production foils fair its front into the wing: *Nose fairing* (rebuilt in build 241, wing 1.070) does that as one lofted body, not a hump with fillets. From a nose point *Fairing length* ahead of the pocket's front wall a ridge rises on the top skin to *Nose height* above the hub's top at the wall, the bar's or fuselage's top, where its back face is flat on the wall's plane for the bar or the hub body to butt against; left at 0 it comes to the hub body's default top (22 mm above the hub's underside), so the tool's own fuselage meets it with nothing typed, and a bar of your own is the custom case. *Top shape* sets the ridge's cross-section from a pointed tent through round to flat (it eases to the bar's flat top over the hub), *Nose fullness* its outline in plan from a straight taper to a blunt ogive, and *Crown round* the back face's top corners to match the bar's edge. Its feet are concave arcs into the skin, scaled with the outline and squeezed by the root fairing's *Fairing spread*; at the wall its section is the root fairing's own, so the side fairing runs on from it as one surface, and the root fairing then runs the sides only, from the wall back. It needs *Root fairing* on, takes the hub's full width at the wall, and its nose point is held 10 % of the chord behind the leading edge. Foil mold's upper half molds it with the rest of the hub, and the cut list adds its volume to the root's solid fill. *Pocket floor* (build 241) shapes the pocket's floor and the fuselage tongue on it: *Flat*, *V groove* (the floor falls from the walls to a V on the centreline) or *V ridge* (it rises to one), *V depth* deep, its apex and shoulders rounded at *V fillet*. The tongue then sits on the V's two faces, so side loads and roll are carried by faces the bolts wedge together rather than by the walls' clearance, and it self-centres. The centreline, where the bolts are, stays at *Pocket depth*: a groove raises the floor at the walls instead, so the laminate under the bolts is what a flat floor leaves, and a ridge adds to it. The notice warns when the walls are left under 1.5 mm tall, or a ridge leaves under 1.5 mm over its crest. The hub body's tongue takes the matching V at the same *Clearance* all round. The join between the hub and the skin is filleted (*Hub fillet*), and the fillet is built so that it cannot fail: a fillet of radius r needs a wall at least r tall along its whole edge, and with the hub's top level with the apex the wall is nothing at the front, so the hub is first made taller than any skin under it by the radius, the part of it below the skin is discarded, the closed loop where its walls meet the top skin is filleted, and the top is then cut back to *Hub above apex* with a tool that has the wing's own shape removed from it. Where the wall was shorter than the radius that leaves the fillet's lower arc, so the top fades into the skin through a flare instead of a step. The filleted part of the hub stops a few millimetres ahead of the trailing edge, checked on the real skin by ray casts at the fillet's feet; the rest, on the thin trailing edge and beyond it, is a plain block. Build 185 adds the hub on the wing; the fuselage's flat tongue follows. *Root fairing* (build 241, wing 1.064) replaces the fillet with a lofted flare: one body runs along the hub's D in plan, round its front and down both sides, each section a concave arc tangent to the hub's wall and running into the skin, its radius *Fairing radius* held under 90 % of the wall's height above the skin so it never reaches the flat top the fuselage sits on. Where the hub runs on past the trailing edge the fairing carries on for *Fairing tail* on a thin web, the trailing edge's upper half on its own height, so its bottom stays on the mold's parting, and leaves the trailing edge on a radius seen from above. A hub sunk under the skin at its front is faired only where it stands out, along its sides. Foil performance then counts the root's junctions as lofted.

Section polar. Analytic (thin-aerofoil theory) is the default. *Polar summary* takes thirteen numbers fitted from an Xfoil or XFLR5 run at two Reynolds numbers; *Built-in* uses stored polars for the tabulated sections,

each fitted at its own thickness and moved to *Root thick %* and *Tip thick %* (a thinner section has less minimum drag, a narrower drag bucket and, for most sections, a lower CL max; the MRC-16 loses little of its CL max). With a polar, stall and profile drag come from the real section rather than from the Section CL max stand-in.

Tube socket. For a round fuselage the wing grows a nacelle with a socket for the tube: tube diameter and clearance, wall, blend and rear extension, depth, and cross pins. *Root fairing* (build 241, round and square sockets, and the flat hub below) lofts the corner where the root meets the nacelle, above and below: the nacelle's sections gain a concave flare each side that runs into the skin, its radius growing aft to *Fairing radius* and easing to nothing ahead of the trailing edge. It is part of the nacelle's own loft, not a fillet on the seam, and Foil performance then counts the root's junctions as lofted. *Fairing spread* sets how flat and wide it is: how far it reaches along the skin for each millimetre it climbs, 1 for a quarter circle, 2 for twice as far out as up. The socket's axis is what the fuselage spigots into and what the stab's Height is measured from.

Notice. Area achieved and definition, span, aspect ratio, MAC, root and tip chord, tip cap, thickness, incidence and washout, and the socket if on.

3.2 Foil stabiliser

The stab shares the wing's geometry core, so every planform, section, twist and tip control is the same. Two of those matter more on a stab: *Double taper* makes the full-base outline of current production stabs, a wide root that carries the mount and bolts flaring into a slim outer stab, and a *Root thick %* below *Tip thick %* keeps that wide root from becoming a tubercle (5 mm on a 68 mm root chord is 7.4 %). What is specific to the stab:

Root tail. The stab's own outline can carry the tail: *Tail length* extends the trailing edge at the centreline and *Tail span %* fades it out, smoothly at both ends, so the root ends in a rounded point behind the trailing edge as on a production stab. The extension is all aft whatever *Align* is, the section keeps its thickness in millimetres and is stretched rather than fattened, and the area solver counts it, so the base chord shrinks a little to pay for it. With it on, the mount pad's *Tail* can be off and the fuselage ends at the stab's trailing edge.

Position and link to wing. Arm is the distance along X from the wing pivot to the stab pivot, the pitching moment arm. Height is the vertical offset. *Link to wing* derives area, aspect ratio, thickness and incidence from the wing's reported values through an area ratio, an AR offset, a thickness offset and a decalage, so the stab follows when the wing changes.

Height is where the seat sits. When the wing has a tube socket, *Height* is the offset of the stab's seat plane, the pad face or the bare root surface, from the fuselage centreline, positive up; 0 puts it on the centreline. The stab is built and then moved so its seat lands exactly there, so resizing or relinking it never moves the joint. With the pad on top, 0 cuts the fuselage flat to half the tube and -4 mm is typical; with the pad underneath (the stab sits on top of the fuselage), +4. A seat plane below the tube is also valid: the fuselage's block carries the stab and the tube stays round. Without a socket on the wing, Height is the pivot's offset from the wing pivot. The notice and the `pivotZ_mm` log field report where the pivot ended up.

Mount side, pad or no pad. *Mount side* says which side of the stab the fuselage is on, Top (the fuselage passes over the stab, bolts up through it, heads countersunk in the underside) or Bottom (the stab sits on the fuselage tail). It stands apart from the pad because some stabs are designed without one: a padless stab seats its bare root skin on that side, the fuselage cuts its flat to that skin, and the countersinks go on the face away from the fuselage.

Mount pad: a fixed interface. Modelled on the flat-pad mount common on production stabs: a flat pad face on the fuselage side, faired up from the leading edge, with a tail fairing behind it that forms the lower half of the fuselage's tail. The mount is pinned to the stab pivot, not to the root section: *Flat start* is where the seat flat begins, *Tail start* is where the fairing and the fuselage tip begin to taper, *Tail end* is where both finish, *Bolt 1 at* and *Bolt pitch* place the bolts; all in millimetres from the pivot. Only the ramp from the leading edge to Flat start adapts to the stab; *Front ramp* off replaces it with a square front face at Flat start, which may then sit as close as 2 mm behind the leading edge (6 mm with the ramp). Where the pad-side skin is already flat at the pad plane over the pad's length, a Clark Y's flat side with *Pad height* 0, no pad body is built at all: the skin is the seat, and the ramp would only have filled the leading edge's round with a small block. The fairing stays full width from the trailing edge to Tail start, so a small stab simply has a longer tail. With a *Root tail* and the tail fairing off, the pad's aft end follows the trailing edge where the tail curves it forward across the pad, so its corners never hang behind the stab. Every stab with the same Arm therefore presents the same seat plane, flat length, tapped-hole pattern and fuselage tip: any stab fits any fuselage built for that arm. The notice warns and holds the geometry when a section does not fit the interface. *Block to body* (off by default from build 228) is for a round tube fuselage: it continues the pad, at Pad width, from the pad face out to the fuselage's centreline, less the tube's round (*Fuselage dia*, typed in because the stab is built before the fuselage), so the stab carries its own mount as a molded rear wing does and the fuselage adds nothing but its flat seat and tapped holes. Its height is minus *Height* by definition, so it grows and shrinks as the stab moves off the centreline; with it off the pad stays exactly *Pad height* whatever *Height* is, which is what a flat bar wants. Where the fuselage's flat at the pad face already spans the pad the block lies inside the tube and nothing shows; where the tube is narrower, cheeks stand beside it; where the pad face is set beyond the tube's radius the block fills down to it.

Mount bolts. Through holes on the centreline, chosen by *Bolt* size (M4 to M10, or custom hole sizes). The stab owns the pattern: it cuts the close-fit clearance hole and, with *Countersink* on, a 90° countersink to the ISO 10642 head diameter on the face away from the pad; the fuselage taps blind holes at the same positions with the matching tapping drill, read from the stab so the two can't disagree; the mold puts undersized cones there to be drilled and countersunk after cure.

Bolt	Clearance hole	Tapping drill	Countersunk head
M4	4.4	3.3	8.96
M5	5.4	4.2	11.2
M6	6.4	5.0	13.44
M8	8.4	6.8	17.92
M10	10.5	8.5	22.4

The mast plate and the wing socket's cross pin use the same dropdown, with the clearance 0.1 mm looser because several holes have to line up across two parts.

Notice. Planform summary, the mount description with the fixed-interface positions, the bolt holes, the seat report, and with a wing present: area as a percentage of the wing, tail volume, geometric and aerodynamic decalage.

3.3 Foil performance

Builds no geometry. It reads every model above and runs a speed sweep from take-off to max speed:

- **Lifting line** for the wing and the stab (span efficiency, lift slope, induced drag), the classic far-field downwash at the stab, and a trim solution at each speed: the body angle and the stab load that carry the mass in level flight.

- **Profile drag** from flat-plate skin friction with a thickness form factor on the real wetted area, plus a lift-dependent term, or the section polar's own drag bucket when one is given.
- **Mast, fuselage and pod drag** computed from the Foil mast and Foil fuselage features: submerged mast friction, summed strip by strip over the wetted span so the taper and any thickening under the waterline count (build 241), plus spray where it pierces the surface, pod friction on its wetted fraction, fuselage body friction.
- **Joint drag** (build 240) under *Joint finish*, counted from the parts' own geometry: the corner where each wing root, each stab root and the mast's foot meets the fuselage, nacelle or pod (Hoerner's interference rule, ΔC_D on $t^2 = 0.75 t/c - 0.0003/(t/c)^2$, nothing below about 7.4 % thick), and the faces that stand square to the flow: the socket's mouth where the tube enters (its nose grows out of the wing over *Blend length*, so it counts as lofted), the flat hub's front and back. *Filletted* (the default, the tool's own joints), *Lofted* (one section carried into the other: what a blended joint would buy) or *Bare*; the JOINTS console line lists each one. The faces cost far more than the corners, so a radius on a face square to the flow is not a fairing. The factors are handbook estimates, a ranking of finishes, not a calibration. *Other cm²* is now only for bolt heads, fittings and cables.
- **Stall** where the first section inboard of 95 % span reaches the section's CL max; **take-off margin** as a percentage of CL max at the take-off speed.
- **Trim CG** (where the rider's mass must sit for level flight) and **static margin** (its distance ahead of the neutral point, as a percentage of MAC) at every speed.
- **Structure**: half-wing root bending at the load factor, the UD cap thickness needed for the chosen cap stress and width, and the spanwise moment distribution published for the mold's stiffness check.
- **Propulsion** (optional): Wageningen B-series open-water propeller, motor kV, cells, gearing, current limit and winding resistance, pack capacity. It solves thrust equals drag at every speed and reports rpm, throttle, current, battery watts, Wh/km, range and top speed, plus the powered trim: the thrust couple, the powered trim CG and the powered static margin.
- **Layout**: from Pod height it decides whether the foil is an eFoil (the pod can never clear the water at a rideable depth) or foil assist (the wing can ride with the pod out), and reports both modes.

Notice. One line: cruise L/D, drag and power, stall, take-off as a percentage of CL max, trim CG and static margin, root bending and caps; with propulsion, rpm, throttle, battery watts, Wh/km, range and top speed, and the powered trim. Warnings turn the notice yellow: stall at take-off, take-off within 15 % of stall, stab CL above 0.8, cavitation number below 1.5, depth under 2 MAC, propulsion out of limits, powered static margin under 5 %.

Console. The full report and a CSV with one row per speed. Its columns are listed in chapter 9.

3.4 Foil mast

The mast is a loft of symmetric NACA 00xx sections along a *mast law*: chord runs linearly from the base width to *Top chord*, with the taper on the leading edge, the trailing edge or both; thickness is constant to *Thicken from* % and then eases with a smoothstep to *Top thick* at the plate. A straight leading edge moves the plate aft relative to the wing, a straight trailing edge the reverse, so the taper side also moves the rider relative to the wing.

Root fillet. A fillet all round the section where it meets the plate's underside, held inside the plate with 2 mm to spare. Onshape will fillet the section's surface but not the 0.8 mm trailing edge line, so the fillet stops there and leaves a notch of trailing edge thickness; the console line `MAST_FILLET` reports the seam edges and the attempt that worked.

Motor pod. A streamlined pod on the mast for eFoil: diameter, height on the mast, where the nose starts, fairing length, blend height, aft extension, and *Pod tilt*, which rotates the pod about the span axis so the thrust vector can be aimed. The pod carries a placeholder cavity from its rear face (diameter and length parametric) that you are meant to replace or extend by hand with the real motor shape; the mold shapes its plug from whatever is there.

Plate. The board plate as a block with two rows of bolts on the track spacing, chosen by *Bolt* size (M8 by default), countersunk from below to the standard head diameter.

Notice. Height, chord and taper, thickness law, root fillet result, pod summary, plate.

3.5 Foil fuselage

Two fuselages, chosen under *Body*: by default it follows the wing's joint. **The hub body** (build 208, built from a hand-modelled template) goes with the flat hub. Its nose is the hub's own D in plan sitting on the hub's top face, *Nose height* tall at the front and rising to the body's top at the hub's back, with a tongue in the open pocket and countersunk clearance holes on the hub's bolts; when the wing's bolts come from its underside (*Bolts from* = Wing underside) the nose gets blind tapped holes up from the tongue's underside instead, about 1.5 times the bolt's diameter deep where the nose is tall enough, and the notice warns where it is not. With the wing's *Nose fairing* on (build 241) the body has no nose of its own: it starts with a flat face on the pocket's front wall, the fairing's back face (the hub's width, *Nose height* above the hub's top, the fairing's *Crown round* on its corners), and grows to *Body height* and *Edge round* by the hub's back, so the two read as one surface; the notice says so, and errors if the fairing's top is above the body's. Behind it a rounded body *Body height* tall narrows from the hub's width to *Body width* over *Body length*, its bottom level with the hub's underside, carrying the mast pocket. From there the tail lofts to the stab's seat, so its length follows the stab's Arm, and the seat block, the pad's width by *Tail depth* with its top or bottom on the pad plane, runs to the trailing edge plus Seat margin tapering to *End width*, with the stab's bolts tapped through it. **The round tube** goes with the sockets: a spigot into the wing's socket, a body of the socket's tube diameter running aft, then a tail. With a stab mount present the tail is *seated*: the underside is cut to the stab's published mount contour (ramp then flat), the tip tapers from the stab's Tail start to its Tail end, blind tapped holes are cut at the stab's bolt positions to the chosen depth with the tapping drill for the stab's bolt, and a block under the flat fills the space when the seat is deeper than the tube. A pocket for the mast base and cross-pin holes matching the wing's socket pins are optional. The notice reports the seat, the holes made and any conflict, naming the field in the other feature that fixes it.

3.6 Foil mold

Select the finished part (wing, stab or mast). The mold feature:

- **Parts the mold** along a curtain built from the camber line's silhouette at up to 80 stations, with *Tip bias* packing stations toward the tip where the surface curls fastest. For a stab mount with its tail fairing the parting steps onto the pad plane, which keeps the fairing's rounded underside in the right half; a pad without a tail fairing is simply a pocket in the half it points into. The mast is molded flat in three parts: left and right halves that form the blade and the plate's edges and underside, plus a lid that forms only the plate's board face, with straight pins for the bolt holes. A stab with its pad underneath and a tail fairing is molded upside down, as its mirror image, and turned over after cure; the notice says so. The fuselage (*Source model* = Fuselage) is parted top and bottom along its sections' mid-height, the profile the Foil fuselage publishes: flat under the nose at the hub's top, a small step inside the body's front face, then the body, tail and seat mid-heights. That way the mast pocket is a core on the upper half and the tongue a pocket in the lower, both of which release; a left-right split could not, since a core can only leave a pocket through its opening. The hub's bolt holes and the stab's tapped holes are vertical; each

is filled in the cavity and, with *Bolt cones* on, gets a countersink and tapered cone (countersunk holes) or a straight undersized pin (tapped holes) from the half that forms the face the bolt enters, with a web at the far face, exactly as the stab's bolts are treated. Drill to size after cure. It is tiled, keyed, grooved and bagged like any part, gets a skin template per half whose width is half the section's perimeter, and a stiffness check: a cantilever from the hub carrying the stab's lift at the load factor (skin stress against woven's 300 MPa, deflection at the stab), torsion from a 60/40 split of the wing's and the stab's lift twisting it between the hub and the mast and between the stab and the mast (closed-section shear in the skins against woven's 80 MPa, and the twist in degrees), and the mast's side load, *Mast side g*, bending it sideways from the hub.

A tail core for the fuselage. With *Core* set to Foam core or Printed core on a fuselage mold, only the tail is cored: from *Core from mast* (20 mm) behind the mast's trailing edge to *Core end gap* (5 mm) ahead of the stab's seat block. Everything ahead of it, where the wing's twist, the mast's load and the hub bolts all act, and the seat block with its bolts, is laid up solid woven. UD strips run along the core's top and bottom, their ply count at each station sized so the stab's lift at the load factor stresses them to *Tail UD MPa* (300), and they appear in the cut list and the templates. A printed core comes out as segments for the bed with a dowel across each joint; a foam core as a reference body, or, with *Mold of* = Its foam core, as its own two-piece mold open at both ends. On the hub-body fuselage of a 900 cm², AR 14 pump set at 3 g the tail core saves about 100 g against solid woven, keeps every stress within its limit, and twists 3.1° hub to stab with two skin plies or 2.3° with three; a core through the whole length fails both bending and torsion. The comparison of all five fills, with its charts, is in the fuselage layup report. It gets skins and fill only: no caps, no stiffness check, no templates. Without the tail fairing it is molded the way it is designed, countersink cones in the half that forms the countersunk face. - **Block and flange** of chosen size, **locator keys** (printed frustums or drilled pins), a **pinch-off groove** around the cavity in the lower half so the closing mold squeezes excess resin into a land, kept away from the pod. If a groove outline can't be built the mold finishes without it and warns, rather than failing. - **Plugs** for the wing socket and the motor pod, extracted from the part's own cavities so that hand-customised pod interiors are reproduced. - **Bolt cones** in the stab mount, undersized and tapered for release, on one face only, to be drilled to size after cure; the same for a flat hub bolted from the wing's underside, from the lower half's countersinks to a web under the pocket floor. - **Tiles** the halves to your printer's bed, with staggered joints and keys between tiles, and a keep-out band so joints never fall on the pad, nacelle or pod. *Tile joint* chooses the keys. *Dowels* is the printed keys or dowel holes in the tiles' end faces. *Puzzle inlay* is for a mold milled on a three-axis router, which cannot reach a long tile's end face: a bow-tie pocket cut from the top into the parting-face flange on each side of the cavity, straddling every seam, and a key for each built as its own part, to cut from flat sheet and glue in (section 6.3). - **Parting check.** The parting is ruled between its stations, so where the drop curves it is refined until it stays within 0.15 mm of the drop law (build 235), and after the tiles are cut the feature checks itself: at eight points along the span and beside every seam it casts rays just inside the part's trailing and leading edges and warns if either half wraps round the edge by more than 0.05 mm. The console's `PARTING_CHECK` line gives the worst gap at each edge on every run. - **Slivers.** A knife-edge tip (a tapered tip cap with *Min tip* off and a low *End ratio*) can leave bodies of almost no volume where the cavity cut or the parting meets it; those under 0.05 cm³ are removed and reported on their own line with the fix, rather than counted as loose keys. - **Pry sections** (build 242, on by default under *Closing*). Short 45° V pockets across the parting line on the block's outer faces, *Pry length* 30 mm by *Pry depth* 3 mm into each half, just big enough to start a wedge or a flat bar. They sit in sections, not at the corners and not along the whole edge: one in the middle of every stretch between tile seams, so each tile of either half gets one on each face and none straddles a joint, and more at *Pry spacing* along a long stretch. To open the mold, work wedges into them alternately, a little at each, so the halves part square along the pull. The console's `PRY` line counts them. - **Ejectors** (build 243, under *Closing*: Off, *Dowel holes* the default, or *Printed flush plugs*). Holes through each half into the cavity so a part that stays in a half can be tapped out. They go only where

the part is solid and its faces are smooth, found by rays rather than assumed: the wing's or stab's root zone either side of the joint, nearest the centre, a mast near each end, a fuselage once in each third of its length; four more rays round each spot's rim on both faces reject any spot on the edge of a bolt pin, a pocket or a cone. *Dowel holes*: a plain hole for a stock dowel of *Ejector dia* (6 mm); fill it flush with filleting wax before the layup and tap the dowel in to push the part out, which leaves a small round witness. *Printed flush plugs*: a printed part per hole (*Ejector plug n*) with its head on the cavity side (build 245), 4 mm wider than the shank and 2.5 mm deep in a counterbore in the cavity face, the head's face cut from the half itself so the cavity is unbroken, at *Plug fit* (0.15 mm). Wax it, drop it in from the cavity before the layup; the laminate's pressure seats the head on its shoulder, and a punch from outside pushes the plug and the part inward. It leaves a faint ring at the head's diameter. The console's **EJECT** line gives each spot and the part's thickness there. - **Thin cap ends**. With *Min tip* on (the default) the tip cap also ends at least 0.5 mm thick (build 239): *Cap end %* is raised for the thickness only, and the wing notice says so. The default wing's 0.25 mm end molded with a NACA 4-digit section but failed the lower cavity cut with MRC-16; 0.4 mm molded both. - **Layup** from the part's own volume and surface: woven skins, UD caps sized as a percentage of the core inside the skins over a percentage of the chord, tow for the rest, the mast plate's woven fill, and the mast's cap run-out and tab plies into the plate. It prints the per-cap cut list and the material and resin to buy. - **Stiffness** from that layup against the loads Foil performance published: tip deflection, root cap stress and the largest cap stress along the span with where it is for wings and stabs, and for a foam or printed core the shear it carries between the caps against *Core shear MPa*; for the mast, the side-load case with deflection at the fuselage end, cap stress at the plate and at its worst point along the height, track bolt tension, the junction shear check and the plate's bending. - **Cut templates**: a 1 mm plate beside the mold with every fabric outline cut through it and a row of tally holes under each shape for its cut count. Export the plate's top face as DXF.

4. Reading the results

4.1 The performance notice

Cruise V km/h: L/D x · drag x N · x W | stall x km/h | take-off at x % of CL max | trim CG x mm · static margin x % MAC | root x Nm at n g, caps x mm

- **L/D, drag, power** at cruise. Power is hydrodynamic, drag times speed. For an eFoil, battery power is roughly drag power divided by 0.45 to 0.6 overall efficiency; the Propulsion group computes it properly.
- **Stall** is the speed below which the foil cannot fly level with the whole foil trimmed.
- **Take-off at x % of CL max**: over 85 % is marginal, since gusts, pumping and turning all add load; 100 % means it cannot fly at that speed.
- **Trim CG** is where the combined centre of mass must be, in millimetres aft of the wing pivot, for level flight. The rider places it with their stance. It is an output.
- **Static margin** is the distance from the trim CG forward of the neutral point as a percentage of MAC. Positive is pitch-stable. It is lowest at low speed, so check the take-off row, not just cruise. With a motor pod, judge the powered static margin instead.
- **Root and caps**: half-wing root moment at the load factor and the UD cap thickness needed. "Impossible" means the root section is too thin for that load.

4.2 The CSV

speed_kmh, alpha_deg, CL_wing, CL_stab, Re_wing_M, drag_N, drag_induced_N, drag_profile_N, L_D, power_W, trim_cg_mm, static_margin_pct, max_local_cl_pct, drag_mast_N, drag_body_N and, with propulsion, thrust_N, prop_rpm, J, eta_prop_pct, motor_A, throttle_pct, batt_A, batt_W, Wh_per_kmh, max_thrust_N, in_limits, thrust_couple_Nm, thrust_angle_deg, thrust_vert_N, trim_cg_powered_mm, static_margin_powered_pct.

alpha_deg is the board attitude relative to the flow. The derived quantities that matter most:

- **Best-L/D speed and minimum-power speed.** If best L/D sits well below the cruise you care about, the wing is too big or too cambered for that speed; if above, too small.
- **Drag split.** Induced above profile means the wing is working hard: more span or AR helps. Profile above induced means excess wetted area or thickness: less area, thinner sections or a smaller stab. They are equal at best L/D.
- **Stance shift,** trim CG at take-off minus trim CG at max speed. Large means the rider must move a lot as speed changes, strong speed stability; small means a neutral foil that holds any speed but corrects less.

4.3 Quick scaling rules

- Stall speed goes with $1/\sqrt{(\text{area} \times \text{CL max})}$: 20 % more area gives about 10 % lower stall speed.
- Lift at a given speed and angle goes with $\text{area} \times \text{speed}^2$.
- Induced drag at a given lift goes roughly with $1/\text{span}^2$, so at fixed area with $1/\text{AR}$. It dominates at low speed.
- Profile drag goes roughly with $\text{wetted area} \times \text{speed}^2$, weakly reduced by Reynolds number. It dominates at high speed.
- Tail volume = $\text{stab area} \times \text{arm} / (\text{wing area} \times \text{wing MAC})$.
- Power = $\text{drag} \times \text{speed}$, so at high speed it grows roughly with speed^3 .

5. Design knowledge

4.4 What the sweep sees, and what it doesn't

The geometry features and the performance model are not the same thing, and it pays to know which shapes reach the numbers.

Fully in the figures: area, aspect ratio and span; the chord distribution at every station of the lifting line (superellipse, linear, double taper with its blend, the root tail, plan-rounded tips), so the lift distribution and induced drag follow the outline; incidence, washout and its exponent; the section's zero-lift angle, moment and lift slope, and with a polar its CL max and drag bucket at two Reynolds numbers; a tip section, as a zero-lift angle that varies along the span (aerodynamic twist), a CL max checked station by station against the section that is actually there, and a drag bucket blended by area; the root thickness, through the profile-drag form factor; the wetted area, measured from the solid, so tubercles, winglets, tail and nacelle all pay friction for their real surface; winglets as effective span for induced drag; and the mast, pod and fuselage through their own drag terms.

Not in the figures beyond their surface area: sweep (the lifting line is unswept); tip drop, the S-curve and gull dihedral (no anhedral effect on lift, which a vortex-lattice check puts under 1 %; their roll effect is the

notices' roll number); leading-edge tubercles (their stall delay and post-stall lift: reported apart on their own line, never in the figures); the winglet's own side force; and the change of Reynolds number along the span (the MAC's is used). These are honest gaps: there is no formula at this level of model that would give them a number worth trusting.

5.1 Targets by discipline

Discipline	Area cm ²	Aspect ratio	Take-off km/h	Cruise km/h	Notes
Pump / downwind	900–1500	9–16	8–12	12–18	Glide and low induced drag matter most; high AR, thin-ish sections
SUP / surf	1200–2500	4–7	10–14	14–22	Turning and low-speed lift; lower AR, more sweep and anhedral
Wing	900–1800	6–10	12–16	18–28	All-round compromise
Windfoil	700–1200	6–10	12–18	25–35	Higher speed; cavitation starts to matter
Kite race	300–700	8–12	15–25	30–45+	Small, thin, high speed; cavitation governs section choice
eFoil	1000–2000	5–9	12–16	18–25	Efficiency at cruise sets range; beginners want large area

Scale area roughly with total mass for the same take-off speed.

Section	Typical
Camber %	3–4 pump/SUP/surf, 2–3 wing/eFoil/wind, 1.5–2.5 kite; stab 0, or –1 to –2 inverted
Root thick %	11–14 front wing, 8–10 high speed, 8–11 stab
Section CL max (analytic)	1.0–1.2 for 8–10 % thick low camber, 1.2–1.4 for 12 % with 2–3 % camber, 1.4–1.6 for 14 % with 4 %; lower on small stabs

Stabiliser and pitch	Target	Why
Stab area / wing area	0.15–0.22	Below: weak pitch damping; above: extra drag
Tail volume	about 0.5–0.8	Higher is more stable and damped, slower to pitch
Arm	550–800 mm; 450–550 surf, 700–900+ pump	Longer is more stable, less pitchy
Geometric decalage	1.5–3°	Sets how much stance shifts with speed
Stab CL across the range	within about ± 0.5 ; warning above 0.8	A stab near its own stall is unpredictable
Static margin at take-off	positive; under about 5 % MAC feels twitchy	The lowest point of the range
Stance shift take-off to max	tens of mm normal; over 100 mm is a lot	Depends on decalage and camber
Board attitude at cruise	within a few degrees of level	Riders dislike nose-up or nose-down

Performance sanity	Guide
Take-off % of CL max	under 80–85 %

Performance sanity	Guide
Stall vs take-off	stall 15–25 % below intended take-off
L/D wing + stab only	high teens to mid 20s at best L/D; expect 5–10 points less at cruise once a real mast and fuselage are added
Cavitation number at max speed	should exceed the section's $-C_p$ min; below about 1.5 check with XFOil
Depth / MAC	above 2 to avoid free-surface effects

5.2 Levers: what each change does

Measured with the tool's own maths on a 1200 cm² AR 7 wing with a 200 cm² stab at 650 mm, 100 kg:

- **Decalage is the stance-shift and speed-stability knob.** More decalage (stab incidence more negative, stab camber negative, or wing incidence up) makes the stab push down harder at speed: the trim CG moves forward as speed rises, a large stance shift, a foil that resists speeding up, higher static margin, a little more drag at speed. Less decalage gives a neutral foil that holds any speed with little stance change, but low-speed static margin falls toward zero. Going from decalage 1.5° to 3° roughly doubled the stance shift from 12 to 30 km/h (75 to 118 mm); decalage 0 cut it to 33 mm.
- **Wing incidence does not change stall speed.** It changes board attitude almost one for one and acts like extra decalage. Use it to level the board at cruise, not to fix take-off.
- **Wing camber** lowers the attitude needed and raises the real CL max, but adds nose-down moment: bigger stance shift and worse high-speed drag. Pair more camber with slightly less decalage.
- **Stab area and arm** raise tail volume and static margin and increase stance shift. Stab area adds drag at speed, about one L/D point at 30 km/h for 50 % more stab.
- **Aspect ratio at fixed area** is the big efficiency lever at low and medium speed: AR 7 to 10 gave +3.7 L/D at 12 km/h and +2.5 at 20 km/h, nearly neutral at 30. Costs: a longer, more flexible wing with a higher root moment, slower roll, less turning.
- **Area** trades low-speed for high-speed performance.
- **Powered foils** add the thrust line as a pitch lever: see 5.5.

Symptom	First levers	Watch out for
Stalls at or near take-off	more area; more camber with a realistic CL max	top-end drag
Take-off fine but poor glide or pumping	more AR at the same area	root moment and cap thickness rise with span
Poor top speed, high power at speed	less area, thickness, camber; smaller stab	take-off speed rises
Best L/D well below cruise	wing too big or too cambered for that speed	
Best L/D well above cruise	wing too small: more area or AR	
Large stance shift	less decalage; less wing camber	low-speed static margin falls
Twitchy at low speed	more decalage, larger stab, longer arm	stance shift, drag
Nose-up or nose-down at cruise	wing incidence, and stab incidence by the same amount	
Stab CL near ± 0.8	larger stab, or stab incidence toward the unloading value	
Cavitation warning	thinner, less cambered sections; more depth	low-speed lift

Symptom	First levers	Watch out for
Caps too thick or impossible	thicker root, wider caps, lower span, lower load factor	drag, weight
Twitchy under power	lower Pod height; longer Arm; motor only from a higher speed; then stab area	Pod height also sets eFoil versus foil assist
Stands much further back under power	thrust line far above the drag centroid: lower Pod height	
High Wh/km, short range	ride near the best-Wh/km speed; less drag; higher P/D if throttle is low at cruise	static thrust falls with P/D
Top speed too low	higher P/D, more cells, lower gear ratio if pitch-limited, more current if current-limited	

5.3 Sections: where they came from, and what matters in water

The tool offers one parametric family and seven published sections. Each was designed for a purpose and a flow regime, and none of them was designed for a 1 kg carbon wing under a board. Knowing what each was for makes its numbers easier to read.

Two things separate water from air. First, water is about 800 times denser than air, so a foil carries a rider at speeds where an aircraft wing would barely lift a hand: the section runs at modest lift coefficients most of the time, 0.2 to 0.5 at cruise, and only approaches its CL max at take-off. Where the section's low-drag range sits therefore matters more than how high its CL max is, except at the moment of take-off. Second, water boils at low pressure: where the local pressure on the suction side drops below the vapour pressure the flow cavitates, lift collapses and the surface pits. The cavitation number σ compares the static pressure margin at the foil's depth with the dynamic pressure, and cavitation starts where the section's $-C_p$ min exceeds it. The tool reports σ at V_{max} and $Depth$: about 2.0 at 36 km/h and 600 mm, about 1.1 at 50 km/h. A cambered 12 % section at CL 0.6 can reach $-C_p$ min of 1.5 to 2, so above 45 km/h or so the section, not the planform, decides the top speed. That is why race sections are thin, lightly cambered and shaped for a flat pressure distribution. In between, the Reynolds numbers are those of a model aircraft rather than a full-size one: at a 150 mm chord and 6 m/s, Re is about 0.85 million (water's kinematic viscosity is 1.07×10^{-6} m²/s at 20 °C), where laminar flow is possible on a smooth surface and transition, and therefore drag and stall, are sensitive to finish. Structure is the other constraint: carbon stiffness goes with thickness cubed, so the 9 to 13 % sections of production foils are as much a structural choice as an aerodynamic one, which is what the stiffness check in chapter 6 is for.

NACA 4-digit (1933). Eastman Jacobs and his colleagues at NACA Langley tested 78 related sections in the variable-density wind tunnel and published them as Report 460. The family is defined by three numbers: maximum camber in percent of chord, its position in tenths, and thickness in percent, so a 2412 is 2 % camber at 40 % chord and 12 % thick. The camber line is two parabolic arcs and the thickness a single polynomial, which is why it is fully parametric here: *Camber %*, *Camber pos %*, *Root thick %* and *Tip thick %* give any member of the family, and the zero-lift angle and pitching moment come from the exact thin-aerofoil integral of that camber line. Designed for aircraft at Reynolds numbers of several million, the family is robust: tolerant of roughness, with a gentle stall at moderate thickness and a lift curve that XFOIL and the wind tunnel agree on. Its drawback for a foil is that its pressure distribution has a sharp suction peak near the nose at high lift, so its $-C_p$ min rises faster with CL than a section designed for water. For anything under 40 km/h it is a sound default and the easiest to reason about; the built-in polar for it is a fit across four real XFOIL polars (0008, 0018, 2412, 4412), so it is coarse away from those anchors.

NACA 6-series (1945). The laminar-flow sections came from the same laboratory a decade later, designed inversely from a target pressure distribution to keep the boundary layer laminar over the front of the section,

and summarised in Report 824 (Abbott, von Doenhoff and Stivers), the book most engineers still mean by "the NACA airfoil data". The P-51 Mustang was their famous application. The designation 63-412 reads: series 6; minimum pressure at 30 % chord on the basic thickness form at zero lift; design lift coefficient 0.4; thickness 12 %. Around the design CL the section has a drag bucket, a range of lift where friction drag drops by a third or more because the laminar run is long; outside it the drag rises to that of a conventional section. For a foil the attraction is that bucket, since the cruise CL of 0.3 to 0.5 sits inside it, and the aft-positioned minimum pressure gives a lower $-C_p$ min at the same lift than a 4-digit. The catch is that the bucket exists only on a smooth surface with the transition where the design assumed: a pinch-off seam, a sanded repair or weed on the leading edge closes it, and the section then behaves like an ordinary 12 % section with a slightly earlier stall. XFOil at N crit 9 shows the bucket, which is why the built-in polar looks good; the tool's *Laminar run* % defaults to 0 because hand-laid parts rarely keep it.

Eppler E817 and E818 (1979 to 1981). These are the only sections in the list that were designed for hydrofoils. Richard Eppler at the University of Stuttgart, with Y. T. Shen of the David Taylor Naval Ship Research and Development Center, published "Wing sections for hydrofoils" in the Journal of Ship Research, symmetrical profiles first and cambered ones two years later, using Eppler's inverse design code. The design goal was not minimum drag but the widest cavitation-free range: a pressure distribution flat enough that $-C_p$ min stays low across a band of lift coefficients, so a foil that changes speed and loading, as every ridden foil does, stays clear of cavitation over the whole band. The price is camber carried well aft, peaking near 67 to 69 % chord on both, which makes the zero-lift angle and the nose-down pitching moment larger than a 4-digit of similar camber, so the stab works harder and trim numbers move when you switch to them. They became the reference sections for small-craft and home-built foils because the coordinates were published and the purpose matched. E817 is the thicker of the two at 11.0 %, E818 at 9.4 % is the higher-speed choice; both have a slightly drooped nose that the tool handles by building each section from its own table rather than a camber line. The built-in polars for them come from XFOil at 0.2 and 1 million (E817) and 0.1 and 0.5 million (E818), which is the Reynolds range of a foil's tip rather than its root, so the *Section polar* group with your own run at the root Reynolds number is the better source for a large wing.

Clark Y (1922). Virginus Clark drew it for the U.S. Army Air Service: 11.7 % thick, with a lower surface that is straight from 30 % chord to the trailing edge, so a rib could be built on a flat board and checked with a straight edge. It carried the Spirit of St. Louis across the Atlantic and became the default section of model aircraft and propellers for fifty years, which means it has more test data at low Reynolds numbers than almost any other section. In water that history is the point: its CL max at 0.2 to 1 million is the highest of the four, so it is a good low-speed and take-off section, and its flat side is a build reference and a mating face. A stab built on it can sit flat side up against a fuselage, which is what *Invert section* is for. Two things to know. The flat is not the chord line: it is tilted 2.1° to it, so with the flat level the section is already at $+2.1^\circ$ chord incidence and about 5.5° above zero lift, making lift, and the tool's incidence is measured from the chord. And the tool scales the whole section vertically with *Root thick* %, so a thinner Clark Y keeps a straight flat but loses camber in proportion, and its zero-lift angle, moment and bucket centre scale with it, which is what the built-in polar does.

MRC-16 (1991). Mark Drela drew it at MIT for the Decavitator, the human-powered hydrofoil that still holds the speed record for its class: a foil that had to take off at walking pace under 300 W of rider and then run clear of cavitation at 18 knots. That is a foilboard's problem in miniature, and the section reads like it: 13.9 % thick at 36 % chord, 3.1 % camber, a well-rounded nose and a gentle pressure recovery. In the polars it is unremarkable at cruise lift, where every section here is within 15 % of the others, and it separates from them where a ridden foil spends the rest of its time: the least drag at CL 1.0, a lift curve that keeps climbing to 1.4 and lets go slowly, and the most cavitation margin in a hard carve. A builder who tried it against thinner low-drag sections on the water reported it as the best of them, which is what the numbers say a

steady-state optimiser will never see. It is the all-rounder for anything pumped, carved or taken off slowly, and it carries the spar depth a 1 kg carbon wing needs.

MH 18 (1990s). Martin Hepperle's section for F3D pylon racing, 11.2 % thick and 2.8 % cambered, drawn to be fastest around a course flown at low lift coefficients with a smooth surface. It is the section XFLR5 tends to pick for a foil, because at the trimmed cruise point it is the cheapest of the lot, at the water's Ncrit as well as in the tunnel, and its pitching moment is the smallest, so the stab carries less download. Off that point it is the least forgiving: its lift stops climbing at about CL 1.1 while the drag doubles, and its leading-edge suction at high lift is nearly three times the MRC-16's, so it cavitates or ventilates first in a hard turn. The same builder found it always won the simulation and was only average on the water. It belongs on fast, flat-water wings that live at low lift, and not on anything that is pumped.

H105 (2004). Tom Speer's section for sailing hydrofoils at low Reynolds numbers, drawn to avoid laminar separation and ventilation at slow speeds and moderate angles while keeping the nose velocities low for cavitation at speed: 12.6 % thick at 40 %, 1.7 % camber carried aft at 65 %, with convex velocity profiles that move the suction peak with angle of attack rather than fixing a rooftop the way the E817 does. Its published virtues are a higher maximum lift than the E817 at the cost of some of the cavitation envelope, and its known cost is the pitching moment that aft camber brings: the builder who tried it found it worked well in the water but needed a bigger stab. No Xfoil polar of it is published, so its built-in polar comes from NeuralFoil, an Xfoil-trained model, at 0.5 and 1 million; treat it as a little less certain than the others.

The sections by the numbers. Geometry from the tool's own coordinate tables; thin-aerofoil values from their camber lines; the polar values from the built-in Xfoil fits. The gap between the thin-aerofoil and polar columns is viscous decambering, largest on the aft-loaded Epplers.

Section	t/c max, at	camber max, at	α_0 thin-aerofoil	α_0 polar	C_{m_0} thin / polar	CL max at Re (polar)
NACA 4-digit	as set	as set	exact integral	4-polar fit	exact / fit	fit
NACA 63-412	12.0 % at 35 %	2.2 % at 50 %	-3.1°	-3.0°	-0.083 / -0.075	0.99 at 0.2 M, 1.31 at 0.5 M
Eppler E817	11.0 % at 33 %	2.9 % at 69 %	-4.4°	-3.0°	-0.140 / -0.107	1.06 at 0.2 M, 1.15 at 1 M
Eppler E818	9.4 % at 33 %	2.8 % at 67 %	-4.4°	-2.4°	-0.139 / -0.091	0.89 at 0.1 M, 1.03 at 0.5 M
Clark Y	11.7 % at 28 %	3.4 % at 42 %	-3.4°	-3.6°	-0.084 / -0.085	1.40 at 0.2 M, 1.52 at 1 M
MRC-16	13.9 % at 36 %	3.1 % at 42 %	-3.4°	-3.3°	-0.080 / -0.073	1.32 at 0.2 M, 1.49 at 1 M
MH 18	11.2 % at 30 %	2.8 % at 40 %	-2.6°	-2.1°	-0.051 / -0.038	1.08 at 0.2 M, 1.16 at 1 M
H105	12.6 % at 40 %	1.7 % at 65 %	-3.0°	-2.8°	-0.087 / -0.076	1.17 at 0.5 M, 1.28 at 1 M (NeuralFoil)

Which to use. Pump, surf and wing foils below 35 km/h: MRC-16 first, or NACA 4-digit with 2 to 3 % camber, or Clark Y where take-off matters most and the flat side helps the build. Fast flat-water wings that stay at low lift, kite and wind racing: MH 18, and keep it out of hard turns. Slow, high-lift take-off with a stab sized for the moment: H105. Glide and downwind, where cruise sits in a narrow CL band and speed climbs toward 40 km/h: NACA 63-412 if the surface will be kept, E817 otherwise. Anything expected above 45 km/h: E818 or a thin, lightly cambered 4-digit, and check the cavitation number against an Xfoil pressure

distribution at the top speed and CL, since the tool reports only σ . Production wings run a cambered root section out to a flatter, thinner-nosed tip that stalls later; *Tip profile* does the same, and section 4.4 says how the sweep accounts for it.

Polars and the model. Analytic mode uses thin-aerofoil theory for the zero-lift angle and moment and a flat-plate friction estimate with a thickness form factor for drag, with *Section CL max* as the stall stand-in. The most accurate combination is a tabulated profile with a section polar: the shape from the table, the CL max and drag bucket from a real polar run at the actual Reynolds number. On a polar wing the Section CL max field is ignored; a better polar is the fix, not a bigger number. The stall margin is evaluated at the take-off Reynolds number, interpolated between the polar's two Reynolds numbers; the warning tells you when it is extrapolating. All the polars here are Xfoil at N crit 9, a clean surface in steady flow, so every CL max is optimistic for a foil in chop; calibrate against a foil you have ridden (chapter 10).

5.4 Pitch stability and the linked stab

Static margin is lowest at the lowest speed, and under power it is lowest at the lowest powered speed, usually take-off. On the foil-assist example the pod's thrust line is what sets the lowest margin: see 5.5 and 7.1. The stab's height relative to the wing changes the trim only slightly; on a tube fuselage it is dictated by the fuselage anyway, which is why Height is measured from the fuselage centreline.

5.5 Powered foils: propulsion, thrust line and thrust angle

Layout. Pod height decides what the foil is. If the pod can only clear the water with the wing shallower than two MAC, it is an eFoil and the motor is always in. If the wing can still ride two MAC deep with the pod out, it is foil assist, and both modes are reported at their own depths. Riding with the pod partly submerged is the worst case, friction plus spray on its waterline.

Method. At steady speed thrust equals drag. The B-series polynomials turn the drag at each speed into prop rpm, torque, shaft power and prop efficiency; motor current follows from torque and kV, motor volts from rpm and winding resistance, throttle from pack volts, then battery watts, Wh/km and range. Top speed is where full-power thrust, falling with speed, meets drag rising with speed squared. Static thrust should be several times cruise drag because ploughing before lift-off is not modelled.

Thrust couple. Thrust and drag form a pure couple, so the CG height does not matter. A thrust line above the drag centroid, typical of a high pod, is a nose-down couple: the rider stands further back under power and the powered static margin falls. The couple barely changes with speed while the stab's correcting moment grows with speed squared, so the lowest powered margin is at the lowest powered speed. Lowering the pod is the direct fix; a longer arm and then stab area come next.

Thrust angle. The thrust vector is fixed to the body, so as the board pitches up at low speed the thrust points partly upward: on the foil-assist example it makes 7.3° to the flow at 15 km/h and gives about 9 N of vertical thrust. Pod tilt lets you aim the pod nose-down so the thrust is aligned at cruise and helps at take-off; the console reports the angle, the vertical component and the couple at every speed.

Targets. Powered static margin at least 5 % MAC from the lowest powered speed; cruise throttle 40 to 70 %; cruise motor current a third to a half of the limit; foil-assist pod-out depth at least two MAC or it is not a real mode.

5.6 Mast shaping

- **Taper side.** A straight leading edge moves the plate, and so the board and rider, aft relative to the wing; a straight trailing edge moves them forward. The trim CG in the performance output tells you where the

rider needs to be; the taper side is one way to put the board there.

- **Thickness where it counts.** The side-load moment on the mast peaks at the plate, and the top of the mast is dry at ride depth. On the foil-assist example only 340 of 750 mm is submerged at 350 mm depth, so the waterline sits at about 45 % of the height: thickening from 50 to 60 % adds stiffness with no wetted thickness and no drag. Starting the thickening very high bunches all the build-up plies into the top few centimetres, where they do little.
- **The worst stress is where the thickening starts, not always at the plate.** The moment grows all the way up the mast but the section only thickens from *Thicken from* %, so the cap stress peaks just below that height. On the foil-assist example it is 243 MPa at about 500 mm against 198 MPa at the plate. The mold's stiffness line reports both; start the thickening lower or raise *Thickness* to flatten the peak.
- **Cap thickness barely matters once the caps are thick:** thicker caps sit closer to the neutral axis. Section thickness and where the thickening starts are the levers.

5.7 The stab-to-fuselage joint

The common production layout: the stab carries a flat mount pad on top, faired up from the leading edge over roughly the front half of the chord and standing a few millimetres off the section; the tail of the mount continues behind the trailing edge as a fairing that becomes the lower half of the fuselage's tail; two bolts pass up through the stab into the fuselage. The fuselage sits over the stab on a flat seat that matches the pad contour exactly, so there is no gap and no step. Molded bolt holes are made undersized and tapered so the mold releases, then drilled to size after cure, and only from one face so the top and bottom cones never meet. The tool reproduces all of this, pins the interface to the stab pivot so any stab fits any fuselage built for the same arm, and places the seat by its offset from the fuselage centreline. The same joint works upside down, with the stab on top of the fuselage and the pad underneath, which suits a foil-assist fuselage.

5.8 The builder's datum: reading a flat-bottomed plan

A hand-shaped wing is set by eye and straight edge, and every number on such a plan is one a straight edge can check. That is the right way to build a wooden wing, and it is why a plan's numbers need reading at the datum before they go into a tool that thinks in chord lines. Three things recur in any flat-bottomed design.

The angle. When a wing sits with its flat directly on a bar, the flat *is* the bar line, and an angle quoted on the plan is usually the chord line's angle to the flat: the incidence the section carries in its own shape. That is what the tool calls Incidence, so the number can go straight in, negative on a rear wing hung under the bar flat side up, because its chord then points nose-down. The subtlety is the table. The tool's Clark Y has its chord 2.1° from its flat (5.3), and a plan's own section can sit half a degree or so either way where its nose is lower or higher. To model the bar-on-flat mounting exactly with the table's section, type 2.1 (–2.1 on a hung rear wing); to model the plan's chord angles, type those. The difference is a fraction of a degree of decalage and is the plan's own section, not an error in either. From build 227 the front wing's *Mount pad* removes the question: with the pad on, the typed Incidence is the built one whatever the section, and the notice says what the bare underside would have seated at (2.1° for the table's Clark Y at any Incidence).

The section. A plan's station heights may follow a true Clark Y over the front of the chord and then run fuller toward a blunt trailing edge. Nobody measured that; it is what a wooden tail must be to be shaped and not split, and what looks right on the bench. It costs a few percent of profile drag and adds a touch of aft camber, and it is the kind of thing a builder gets right by feel that a tool cannot know it is missing. The tool cannot take custom coordinates; *TE thickness* 1.5 to 2 mm gets the trailing edge closer.

The outline. A plan's printed areas can be box figures, span times chord or a round number, while the drawn outlines integrate to less. The outlines are what was cut, so the drawing is the truth and the printed area is a note. The tool solves the planform from the area typed in, so type the integrated one.

A hand-built plan carries its aerodynamics in the craft rather than in the numbers, and the translation has to be done at the datum, not at the dial: ask what line an angle is measured to, check a section's stations against the table, integrate an outline rather than trusting its label. Then the tool reproduces what the builder saw, and can say why it flies.

6. Building knowledge: layup, structure, molds and printing

6.1 The layup schedule

The mold sizes the layup from the part itself: its volume is the laminate volume, its surface carries the woven skins.

- **Skins:** *Skin plies* of *Skin gsm* woven on each face. On a two-ply skin turn the weave 45° on the outer ply for torsion.
- **UD caps:** *Cap thick %* of the *core inside the skins* (the local section less both skins), over *Cap width %* of the chord about the thickest point. The count is per cap; every UD template is cut twice, one per face. Ply k, outermost first, runs out to the last station where the stack is still k plies thick, so the caps taper along the span and the cut list gives every ply's length and its width at the root and at its end. On a mirrored wing a cap ply is one piece across the centre.
- **Tow:** whatever the skins and caps do not fill, given as a mass and a length at the chosen tex.
- **Cured ply thickness** = $\text{gsm} / (1780 \times \text{fibre volume fraction})$; 300 gsm UD at 50 % is 0.34 mm. This formula has had no real-world weight check yet. The nearest build is a home builder's stab, laid up from fabric skins and strips (glass first, then carbon) in a two-part 3D-printed mold split at the leading and trailing edges. Its 84 g for 60 ml of part is the builder's own estimate ($60 \text{ ml} \times 1.4 \text{ g/cm}^3$), not a weighed part; this formula gives 88 g at 50 % fibre volume. Weight is a weak check in any case: a 60 ml carbon/epoxy part weighs 80 to 90 g anywhere from 30 to 55 % fibre volume, so count the plies that go in and measure the stiffness instead. That build's printed matched mold, PVA release and clamping between wood blocks are the method this feature automates; the molded bolt holes are the tool's addition.
- **Overcharge %** adds material above the exact fill so the closing mold packs the laminate and squeezes flash into the pinch-off. Cloth and resin waste percentages turn the in-part figures into what to buy and mix. Fibre volume 45 to 50 % for a wet layup clamped in a matched mold, 55 to 60 % vacuum bagged or prepreg.
- **Mast:** the cut list runs from the plate down, so the thickened top adds short plies at the plate end; the plate is a solid block of woven fill between its skins, with its own cut count; every cap ply runs out over the root fillet onto the plate; tab plies interleave with the caps, running down the mast and out over the plate, stitching the two surfaces together through the stack.

The core. *Core* chooses what fills the section between the skins and the caps. *Tow fill* is carbon roving laid along the span and wetted out, so the whole part is laminate: the heaviest and stiffest fill, and the tool's original assumption. *Foam core* is a shaped structural foam (Corecell M80, PVC H80, PET at 80 to 110 kg/m³) inside the skins and caps, which is how most production wings are built; the fill volume carries no

fibre and no resin beyond a skim on its surface, so the part is a third to a half lighter, the caps and skins carry all the bending and the stiffness check drops accordingly, and the buy list adds the foam volume and the sheet thickness to cut it from. *Monolithic* fills the section with woven plies at the skin's ply thickness, as on high-modulus production wings: the same weight as tow, bought as cloth. *Printed core* is the foam core's shape 3D printed instead: the mold feature generates it as a part, split along the span to the longest axis of your printer, to be printed flat, glued end to end on a flat table and laid up in the part mold exactly as a foam core would be, with two dowel holes across each joint (along the span, 15 mm into each segment, one either side of the thickest point about a quarter chord apart so the segments cannot rotate on a single pin, each sized at half the core's thickness there, 3 to 8 mm, for a carbon or hardwood rod; a section too narrow for two gets one at the thickest point, and the notice lists them); *Core kg/m³* is then the print's average density with its walls and infill (standard PLA at 10 to 15 % gyroid and two walls is about 600, PLA Aero about 320, ASA Aero about 230, read from the slicer's filament mass over the core volume) and *Core GPa* about 0.5 to 1 for solid PLA, 0.25 to 0.3 for a foamed filament. **A core keeps clear of the tube socket.** With the wing's socket on and *Clear socket* ticked (the default), a foam or printed core starts at the nacelle's radius plus *Core clear* (15 mm) on each side, as two mirrored halves, and the root zone between them is solid laminate: the socket wall and the laminate around it carry the fuselage's bending and the stab arm's moment into the wing, and the bore removes most of the root section anyway. The layup line counts that zone as fill and the printed core comes out as left and right sets of segments; the stiffness check does not see the bore and says so. Untick *Clear socket* to get one core through the root as if there were no socket, for a socket added by hand afterwards or a root cut out on the bench. It needs no core mold, and it is the quickest way to a core whose shape is exactly the tool's. On a 950 cm² surf wing the tow fill weighs 1.33 kg and the M80 foam core 0.62, against about 0.9 kg for a production carbon wing of that size with its mount hub, so the foam core is the honest comparison with a production part.

6.2 Stiffness and strength

Per station, bending stiffness $EI = UD \text{ modulus} \times \text{cap second moment} + \text{woven modulus} \times \text{skin second moment (0.7 of the extreme fibre)} + \text{the fill's modulus} \times \text{a lens-shaped core term (tow's for Tow fill, woven's for Monolithic, Core GPa for a foam or printed core)}$. The section's depth is the thickness law times the chord without a stab's tail, since the tail stretches the section aft but keeps its depth. Curvature M/EI is integrated twice from the root to give the tip deflection; cap stress is $E \times M \times y / EI$ at every station, reported at the root and at its largest, which on a stab with a tail blend is where the blend ends. Wings use the spanwise moment Foil performance publishes at the load factor. On the foil-assist example the wing at 4 g deflects 6.5 mm at the tip with 137 MPa in the caps, and the stab 1.9 mm with 100 MPa.

Core shear. With no shear web, a foam or printed core carries the vertical shear between the caps. The mold checks it at every station as $V \cdot Q / EI$ at mid-depth in the cap band: the shear force (the slope of the published moment; for the mast its side force), times the modulus-weighted first moment of the cap, skin and core above the middle, over the section's stiffness. It skips the solid root zone. The allowable is *Core shear MPa*, or when that is 0 an estimate from *Core kg/m³* as a PVC structural foam: about 1.15 MPa at 80, 2.2 at 130 and 3.5 at 200. A printed lattice has no published strength, so for a printed core the estimate is only a placeholder until a coupon is broken. On a 900 cm², AR 14 pump wing at 3 g the core between the caps sees 2.3 MPa just outboard of the root zone, twice what an 80 kg/m³ foam takes; 200 kg/m³ passes.

Ply drops. Plotting the stress with the real, whole-number ply count at each station instead of the smooth taper shows the drops change the local stress by about 1 % where it matters. The wing is limited by its taper, not by where the plies stop, so lay the drops where convenient and stagger their ends.

Mast side load. The mast is fixed at the plate by the board and rider, and a side force of *Mast side g* times the all-up weight is applied at the fuselage end, so the moment is force $\times$ height and peaks at the plate. The tool reports the deflection at the fuselage end, the cap stress at the plate, the track bolt tension (moment /

track spacing / bolts per row), the plate's bending stress between the tracks, and the junction check below. One g of the whole all-up mass sideways is a severe case; a hard carve is nearer 0.3 to 0.5 g.

The mast-to-plate junction is the weakest point. In a 20 mm section the two caps are only about a centimetre and a half apart, so each carries tens of kilonewtons at the plate; on the foil-assist example about 38 kN. That force has to leave the UD by shear into the plate. With the caps folded 47 mm over the plate and nothing else, the shear would be about 19 MPa against an allowable of 15 (interlaminar shear strength 30 MPa with a factor of 2): the caps would peel off the corner. Four interleaved tab plies per face give nine bonded interfaces and bring it to about 2 MPa. The root fillet gives the plies a radius to turn through instead of a sharp fold. Tab plies take their thickness out of the tow core over the tab length; the layup line warns if there is not enough core.

6.3 Mold design

- **Printed PLA molds, carbon parts.** The molds are two halves parted along the camber line's silhouette so both halves release, with a 20 mm base and a 25 mm flange by default.
- **Stations and tip bias.** The parting curtain is lofted through up to 80 stations. Sections with a curled tip (a 6-series section with a strong tip drop) failed at 40 evenly spaced stations and worked at 50 with a tip bias of 4, which packs the stations toward the tip. If a mold fails to loft, raise the station count and the bias first.
- **Keys and pins.** Printed frustum keys with 12° draft, or drilled pin holes for dowels; pin fit clearance around 0.2 mm.
- **Puzzle inlays.** A mold milled from a block on a three-axis router can be cut only from the top: a dowel hole in a tile's end face means standing a long block on end. *Tile joint* = Puzzle inlay keys the tiles from the top instead. Each seam of each half gets a bow-tie pocket, two dovetails back to back, in the parting-face flange on each side of the cavity: ahead of the leading edge and behind the trailing edge for a seam across the span, at both ends for a seam along it. The pocket sits beyond the cavity edge, the land and the groove, centred in the flange that is left with at least 2 mm to spare each side; where the flange is too narrow it is skipped and the warning gives the *Flange width* it needs, and it moves along its flange to clear the half keys, the plug and pod channels and the bag's vents, or is skipped and named. *Inlay length* (30 mm, centred on the seam), *Inlay width* (12 at the ends) and *Inlay waist* (6 at the seam) set the outline, *Cutter dia* its inside corners, and *Glue gap* (0.1 mm a side) is added to the pocket. The pocket is *Inlay depth* (5 mm) deep, its walls vertical for a three-axis cutter. Because each tile's pocket is milled the same depth below its own parting face, in the same setup as its cavity, the glued key does more than lock the tiles together and stop them parting: it pulls their parting faces, and so the two halves of the cavity, flush. The keys are built as parts in their pockets, named *Tile key upper seam 1 LE* and so on: the pocket's outline less the glue gap, rounded where the cutter leaves the pocket round, *Key flush* (0.15 mm) thinner than the pocket so a key can never stop the mold closing. Export them flat and cut them from sheet; the notice gives the count, the outline, the thickness and the sheet to cut them from. On a drooped wing the floor and the key follow the flange: the floor is a plane fitted to the flange under the key and moved *Inlay depth* into the half along its normal, and the key lies on it as a flat square-edged plate, its face *Key flush* under the parting face all along it; because a tilted plate's square ends lean out of vertical, the pocket is that much longer at each end (0.6 mm at 7°) and the wedge fills with glue. The notice gives the largest tilt and end allowance, and warns over 12° (a shorter *Inlay length*, or another seam position) and where the flange curves off its plane by more than *Key flush*. The half-to-half keys are unchanged, and *Detail* = Preview, which makes one tile per half, has no seams to key.
- **Pinch-off.** A land and a groove around the cavity in the lower half so the closing mold squeezes excess resin out and packs the laminate; kept off the motor pod so the pod's plug is undisturbed. *Land gap*

(build 244, default 0) lowers the land in the lower half so a skin or a glass ply can be carried out of the cavity over it: the halves then bear on the flange outside the groove, and the plies over the land are squeezed to the gap instead of cut through. Set it to the cured thickness of what you carry over, about 0.22 mm per 200 gsm ply at 50 % fibre, and at least 0.2 mm under *Groove depth*.

- **Detail.** *Preview* builds only the two halves with the cavity, parting, plug and cones, skipping the groove, vents, keys, tiling, printed-core segments and the template plate, so a studio with molds regenerates in a fraction of the time while the wing and the joint are being designed; the layup and closing numbers are still reported and the notice says it is a preview. *Print* is the full set for the printer.
- **Plugs and joints.** The wing socket and the motor pod need cores. The mold extracts them from the part's own cavities: the cavity is cut from the part as it stands, which leaves the bore's inside as a core of mold in each half, joined to the block only through the bore's opening; a channel behind the rear face severs it, and the severed cores are joined to a handle in the channel as the plug. So the plug is the bore's own shape, and a hand-modelled motor interior, or any direct edit to the socket placed above the mold in the feature list, is reproduced in it. A round socket gets a round channel and handle, a square socket a rectangular slot and a box handle. The countersunk socket bolts are the part's own: the countersink molds from the upper half, the face it is cut in, as a cone wide at the skin; the shank through each wall would otherwise be a pin tying the core to a half, so it is cleared, with the real skin and bore heights found by ray casts beside each hole, leaving a 0.2 mm witness stub on each outer skin; with *Bolt cones* on, a tapered undersized shank cone hangs from the countersink to a web above the bore. A flat hub needs no plug: its pocket, fillet and blind holes mold as modelled from the upper half; with *Bolt cones* on, the straight pins its holes leave on the pocket's boss are cleared and replaced by tapered cones. Bolted from the underside, its through holes are filled in the copy the cavity is cut from, as the stab's are, and the lower half forms each countersink and a tapered cone to a web under the pocket floor (with *Bolt cones* off they mold as pins from both halves). A nose fairing molds from the upper half with the rest of the hub. Tile seams keep clear of the hub and its fairing, and a foam or printed core keeps clear of its width. Everything undersized is drilled to size after cure.
- **Bolt cones.** Undersized, tapered, standing on the countersunk face in the half that forms it, wide end at the skin, pointing to a web short of the other skin, so the cone releases with its half and the countersink molds above it as the wide end of the same shape. The through hole is filled in the copy the cavity is cut from, so neither half molds a pin; molded holes otherwise become pins in the cavity, and two opposing pins cannot meet. Drill to size after cure; a pad over the far face stays solid above the web. A pad is no longer needed for the cones.
- **The mast mold** is three parts: the mast laid flat, split at mid-thickness into left and right halves that run on through the plate to its board face, plus a lid (build 241). The halves form the blade, the plate's edges and underside, and everything that goes right through the plate, the bolt holes' pins and countersink cones included, as modelled. They are opened from the fuselage end first and then slid down the mast off the pins, which the mast's taper lets them do. The lid forms the board face and the features that open onto it without going through, found by a boolean with the actual plate: the plate's box less the plate, its bolt holes and the columns that run right through, keeping the pockets that reach the board face (a cable channel, say). The notice gives the lid's share in cm³, and a release check slides the lid off the board face and the plate-end tiles down the mast and reports any lock on the console's `MAST_RELEASE` line; check a reported lock by eye, since the check moves whole tiles. Countersunk heads were tried on the old tray and abandoned because they would not release. The lid and the plate pocket follow the plate as it is in the part, not the Foil mast's numbers: the mold splits a copy of the mast at the plate's underside and measures the plate, so a plate you have edited by hand above the mold, with fillets, chamfers, a different outline or a different thickness, is matched. The bolt pins stay on the Foil mast's pattern, so move bolts in the mast's dialog rather than by editing holes. The console's `MAST_PLATE` line reports the measured plate against the nominal one and says when it found edits.

- **Closing.** *Closing* chooses what presses the halves together while the resin cures: clamps on the flanges against a rigid board, or the whole closed mold inside a vacuum bag. In a bag the atmosphere clamps the block uniformly with a force of the bag pressure times the block's plan area, about 5.7 kN on a stab mold and 14.5 kN on a 950 cm² wing mold at 85 kPa, and because the block is larger than the part the laminate sees more than the bag pressure, 1.5 to 4 bar. Choosing the bag rounds the block's outer edges (*Edge round*) so the bag is not cut, and vents the pinch-off groove to the block's outer face at each span end (*Groove vents*), since inside a bag the groove is otherwise a sealed pocket of air the flash cannot enter; the vents let the bag evacuate the groove and the laminate through it. Drop *Overcharge %* to 3 to 5 with a bag. The notice reports the closing force, the pressure on the laminate, and the groove's volume against the flash the overcharge makes, and warns when the groove is too small for either closing.
- **Tiling.** Halves larger than the printer bed are cut into tiles with staggered joints and keys (or puzzle inlays, above), and joints are kept away from the stab pad, the wing nacelle and the mast pod.
- **Cut templates.** The template plate carries the woven skin outline developed along the tip droop, one tapered strip per UD ply, the mast's plate outline, the tab strips with fold notches, and a row of 3 mm tally holes under each shape for its cut count. Right-click the plate's top face in Onshape and export as DXF. A standalone script produces the same DXF from a pasted console log for a shop without Onshape.

The core mold. With *Core* = Foam core, a second Foil mold on the same part with *Mold of* = Its foam core (in the Part group, under *Source model*) molds the foam rather than the skin; the first Foil mold, with *Mold of* = The part, is still the mold for the skins. The feature first builds the core body itself: every section of the part offset inward along its normals by one face's skins, re-read and clipped where the two faces come within 0.6 mm of each other so the core ends in a blunt nose and tail, with a groove in each face where the UD caps run, as deep as the caps are thick at that station and ramped at its edges; the sections follow the part's tubercles and winglet frame and are lofted through the same stations. That body is kept as a part, so the finished core, plus the caps in their grooves, plus the skins is the part. The mold pipeline then runs on it as it would on the part, without socket plug, bolt cones or mount pad, and with one difference at the tips: the outermost core section is carried straight out through the block's side, so the cavity is a channel open at both tips. That is for a poured two-part foam, which expands: it fills the cavity and the excess flows out of the tips instead of bursting the mold. Trim the flash at the tips, and the core is ready for its caps and skins in the part mold.

A milled core. *Core made* = Milled (with *Mold of* = Its foam core) builds no mold: the core body is split along the span into sections that fit the mill's bed (*Printer X* and *Y*) and *Sheet thick* with their droop and twist, each with optional holding tabs out of its leading and trailing edges. With *Tile joint* = Dowels each joint gets two dowel holes along the span, which need drilling into the joint faces. With Puzzle inlay it gets bow-tie inlays instead, cut from the top and bottom faces the mill is already cutting: a pocket in each face straddling the joint, just outside the UD cap band (where the core keeps its full thickness), on the side of the band where the core is thicker, with the same outline settings. Each is *Inlay depth* or a quarter of the core's thickness at the key, whichever is less, so the two pockets together never take more than half of it, and a joint where the core is under 6 mm gets none and a warning. The keys are parts again, *Sand allow* (1 mm) thicker than their pockets: they stand proud of the core and are sanded to its profile after gluing. A milled core in Preview has no inlays.

6.4 Printing the molds

These are starting points, not proven settings: the example molds have not been printed yet. Tune them on a test tile before committing a whole mold.

Which material. The deciding number is heat. Epoxy gives off heat as it cures, and a thick laminate with a fast hardener can reach 50 to 70 °C in the core. PLA starts to soften at about 55 to 60 °C, PETG at about 75 to 80 °C. So:

- **PLA** is fine for the wing and stab molds with a slow hardener, cured at room temperature, and demolded before any post-cure. It prints easily, holds dimensions well and sands cleanly.
- **PETG** is the safer choice for the mast mold, whose 20 mm root and tow core make the most heat, and for any mold you want to post-cure in, up to about 60 °C. It is tougher and less brittle when you clamp it, but harder to print accurately and harder to sand.

Orientation: stand each tile on its end. Print each tile standing on its spanwise end, the flat cut face where it meets the next tile, with the span vertical. Every layer is then a slice through the mold that contains the whole section profile, so the nozzle draws the cavity curve smoothly in one pass per layer, leading edge to trailing edge. The only layer steps run along the span, where the surface changes slowly, and the lines they leave run chordwise with the flow. Printed flat, base down, the same curve would be built from stacked layers and every one would leave a step across the chord in the cavity.

It also helps elsewhere. The end face that sits on the bed is the joint face, so it comes out flat and square. The tile-to-tile keys point straight up and print cleanly. Clamping force acts within each layer rather than trying to peel them apart.

The costs: a tall, narrow print needs a good brim and steady adhesion. The half keys on the flange face now point sideways and need a little support, or can be printed separately and glued in. Each tile's span length must fit your printer's height. The tool sizes tiles for a base-down print: *Printer X* limits the chord, *Printer Y* the span length of each tile, and *Printer Z* the block height. Standing on end, the span length goes up the printer's height and the block height lies across the bed, so enter your printer's height as *Printer Y* and the bed's second dimension as *Printer Z*. On a printer with the same size in all three directions, such as 250 × 250 × 250, nothing changes: the example's 225 mm tiles fit either way.

Setting	PLA	PETG	Why
Nozzle	205-215 °C	235-245 °C	Good layer bonding; the mold is clamped and must not split
Bed	55-60 °C	75-85 °C	The end face on the bed is a joint face; it must stay flat
Cooling fan	100 % after the first layers	30-50 %	PETG bonds better and strings less with less cooling
Speed	50-80 mm/s, outer walls 30-40	40-60 mm/s, outer walls 25-30	The cavity is an outer wall in every layer; slow walls give a smoother surface to fair
Layer height	0.16-0.20 mm	same	Steps now run along the span, where the surface is gentle; thinner layers only help at a strongly drooped tip
Walls	5 perimeters (at least 2 mm)	same	The cavity is a wall now; there must be solid material under the sanding
Top and bottom	4-5 layers	same	Only the tile's two end faces are top and bottom surfaces
Infill	15-20 % adaptive cubic (or gyroid); 40 % only under the flanges and keys, with a modifier	same	The walls make the working surface; the core only carries clamp load to the base. Dense gyroid through the whole block more than doubled the print time on a test slice

Setting	PLA	PETG	Why
Seam	aligned to a back corner of the base, never in the cavity	same	Every layer crosses the cavity, so a random seam would put a dot in it every layer
Brim	8-10 mm, essential	8-10 mm, essential	Tall, narrow tiles on a small end face
Supports	only under the flange half keys, if printed in place	same	Everything else is self-supporting
Elephant's foot compensation	0.1-0.2 mm	0.15-0.25 mm	The bed face is a joint face and must be square to seat the next tile

What it costs. The stab mold for the foil-assist example is five tiles on one 250 mm bed, with the tool's default 25 mm flange and 20 mm base. It sliced as follows:

Settings	Filament	Time
4 walls, light infill	1.17 kg	16 h 38 m
6 walls, dense gyroid infill	1.69 kg	39 h 14 m
5 walls, light infill (recommended)	1.29 kg	19 h 21 m

The dense infill more than doubled the time for almost no benefit; the fifth wall costs about an hour and a half and gives the cavity material to be sanded. For a stab, the tool's block can also shrink: *Flange width* 18 and *Base thickness* 16 still clear the key limits with 12 mm pins and 14 mm keys, and take about a quarter of the plastic off. Print a stab mold in two batches, upper tiles then lower, if one failure costing the whole bed would hurt.

Fit. The tool's *Pin fit* (0.2 mm by default) sets the clearance between each key and its socket. Print one key and socket pair first; if it binds, raise *Pin fit* by 0.05 mm and regenerate rather than sanding every key. Shrinkage over a 250 mm tile is well under half a millimetre, and the keys take it up; you don't need to scale the model.

Bagging the mold. With *Closing* = Vacuum bag: glue the tiles first and let the epoxy cure, since the bag pushes across the joints as well as along them. Wax the cavity, lay up, close on the keys, wrap the whole mold in breather cloth, bag it with a tacky-tape seal, and pull to 80 to 85 kPa. Check the flange gap with feeler gauges before the resin gels; if it will not close, the overcharge is too high, not the pump too weak. Leave it under vacuum for the full cure. Plugs and the mast's lid need no seal: the bag pushes them onto their seats. The mast mold, three pieces plus a plug, is a better bag candidate than a clamp candidate for that reason. Post-curing still happens out of the mold for PLA.

Finishing before the first layup. Under a microscope each layer ridge of an FDM print is rounded with an undercut beneath it, so resin cast against it keys in and the part locks to the mold like meshing gears (Easy Composites' pattern tutorial shows it with a knife blade). The ridges must be sanded flat or bridged by a coating before any resin touches the cavity.

1. Glue the tiles together on their keys with epoxy or CA, clamped on a flat surface; key the joint faces with sandpaper first.
2. Sand the cavity and parting faces, working from about 120 to 400 grit, until the layer lines are gone, or at least key the whole surface with 240 grit for a coating to bridge them.
3. Seal the surface: two thin brushed coats of laminating epoxy or a dedicated epoxy coating resin, applied like gloss paint, the second coat when the first is at its B-stage (firm but tacky) so they bond without sanding between; or a high-build epoxy primer, sanded between coats. Raw PLA and PETG are porous and epoxy will bond to them.

4. Wet sand the sealed surface 800 then 1200 grit, then buff with a polishing compound. The mold finish is the part's finish.
5. Release: five or more coats of mold release wax, buffed between coats, then optionally a PVA film release; or a mold cleaner and a chemical release agent in several coats. Re-wax before each layup.
6. Avoid solvents on the mold: acetone attacks PLA and softens PETG.
7. Before opening a mold, sand round the flange edge to break the lock where resin ran over the barrier; never pry against the cavity edge.

Two things from Easy Composites' directly printed mould tutorial: never print a mold in ABS, since epoxy bonds to it; and for a one-off the sanding and sealing can be skipped altogether, a brushed PVA film levelling the layer lines of a raw PETG print, with the finishing done on the part instead (400 grit key, voids dammed with flash tape and filled, two B-staged coats of coating resin, 800 and 1200 wet, polish). An open wet layup with no bag reaches about 36 % fibre volume, three 210 gsm plies to a millimetre, so expect edge voids and repair them; the matched mold's clamping is what lifts that to 45 to 50 %. The written version of both tutorials (Dynamism with Easy Composites) adds that a printed mold must never be cured hot under a bag, since it warps before the plastic softens; that a pattern for a cast mold is modelled 0.25 mm inside the part surface to allow for its coating; that an open hand layup takes equal weights of fibre and resin; and that a laminate over 3 mm is laid in stages unless a mold clamps it, which is the case for the slow hardener and PETG on a thick tow-filled root.

The 80 to 85 kPa above is for clamping a closed mold. A wet layup bagged in an open mold under peel ply and breather wants only about 20 % vacuum, which a domestic vacuum cleaner in a clothes storage bag happens to give, or a perforated release film under the breather at full vacuum; otherwise the breather dries the laminate. Hold it about six hours to initial cure, then release (Easy Composites' wet layup and vacuum bag tutorial).

The other way round: print the part, cast the mold. A printed mold suits a few parts cured at room temperature. For many parts, a hot cure (prepreg, or a post-cure in the mold) or a surface taken from a polished pattern, the composites trade prints the *part* as a pattern, finishes it as above, and casts a composite mold off it: two B-staged coats of epoxy gelcoat backed by about 10 mm of epoxy moulding paste or a glass laminate, released after sanding the flange edge, post-cured for oven use; Easy Composites rate such a mold at hundreds of parts and 120 °C. The tool's part bodies print directly as patterns (draft settings and light infill are fine, the coating carries the surface), and a low-detail print of the lower mold half serves as the parting board for casting the upper half. Whole cast molds go into an envelope vacuum bag exactly as *Closing* = Vacuum bag does with printed ones.

Forged parts in a compression mold. The matched molds above suit plies. A small solid part that plies cannot follow, a bracket, a hub, an arm, is made as forged carbon: chopped tow and epoxy loaded into an open lower cavity and compressed by a parallel-sided piston with a stroke of about twice the part's depth, the lower tool split into two or three pieces so it releases without draft on the piston (a drafted piston leaves a gap that traps fibres, and the part stays embedded), the piston's sliding faces offset 0.1 mm for a running fit. Through holes are waxed metal dowels driven out after cure, threads are knurled heat-set inserts bolted through the mold wall and laminated round, since a tapped forged thread is weak. The charge is weighed, never judged: part mass = volume $\times$ 1.4 g/cm³, 60 % of that mass fibre, which is the same 47 % fibre volume as the tool's clamped layup. The 60 % is of the mass, not of the volume in ml: 50 ml makes 70 g, so 42 g of fibre, where 60 % of the 50 ml (30 g) would leave the part about a third fibre; about 30 % of the fibre as continuous tow along the load path makes the part stiffer than bi-directional sheet. These molds see a vice or a press, so they are printed in PETG at 0.1 mm layers, five walls and 75 % infill, not the light infill above, released with a spray wax and a filleting wax on every bolt, and closed slowly so the resin can escape and the print survives; 24 hours clamped (Easy Composites' forged-carbon mould design tutorial).

Printing a core. The mold settings above (five walls, dense infill under the flanges) are wrong for a core, which is thin and carries nothing. The first core for a 950 cm² surf wing, sliced with mold settings, came out at 510 g and 11 hours, 340 g of it inner walls: on a 16 mm section five walls a side is most of the volume, and the print was near solid PLA (about 1000 kg/m³). For a core use two walls, 10 to 15 % gyroid, 0.2 mm layers, no top or bottom solid layers beyond the walls, and stand each segment on its joint end face as the mold tiles stand on theirs, so the layers carry the section profile, the cap grooves print clean and nothing needs support; a brim holds it. Re-sliced that way the same core came to 297 g and 6 h 43 m, 190 g of it the two walls, which on a thin section stay the biggest share; 8 to 10 % infill would take another 40 g off. That is 580 kg/m³, and the wing with it weighs about 0.87 kg, in line with a production carbon wing of that size. Whatever the slicer reports, set *Core kg/m³* to its filament mass divided by the core volume the LAYUP line gives, so the weight and stiffness lines describe the core you actually printed.

7. Worked example

7.1 A prone wave foil assist, 95 kg all-up

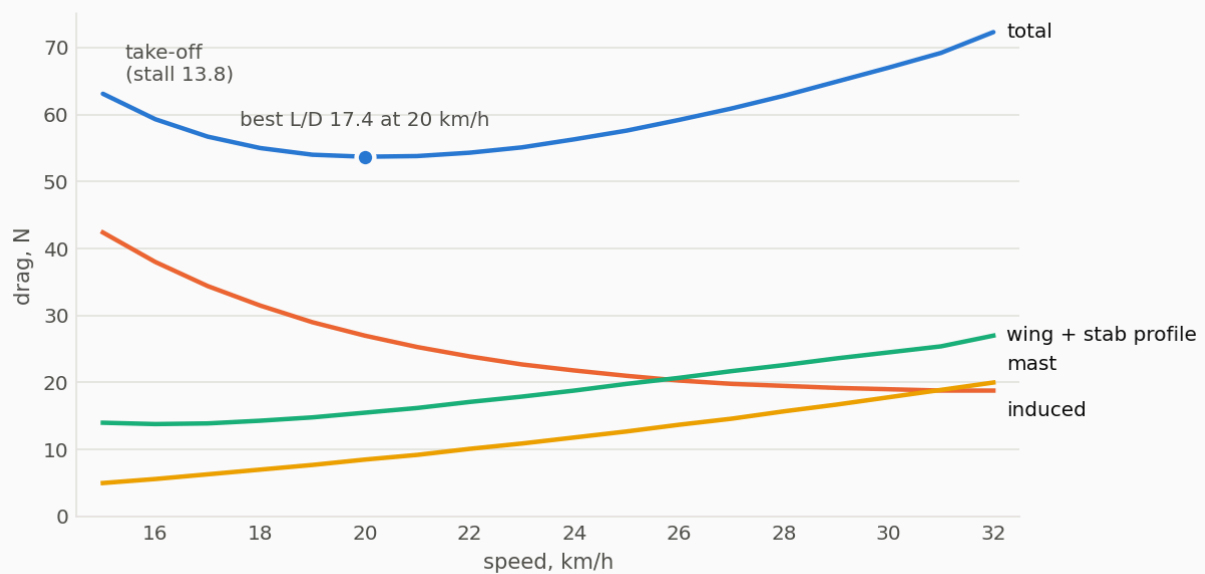
A foil built to test the theory. More examples, built from published parameters of real foils, may follow. Rider 80 kg, board and kit 15 kg. Wing 1000 cm², AR 7.2, 850 mm span, NACA 4-digit with 3 % camber, 12/10 % thick, 100 mm tip sweep, 30 mm tip drop, 1° washout, 1.5° incidence, 1 mm minimum tip. Stab linked at 18 % (180 cm², AR 5.7, symmetric 10/8 %) at −1.5°, 660 mm behind the wing, its seat 4 mm below the fuselage centreline (*Height* −4), two M5 bolts at 35 mm. Mast 750 mm, 100 to 110 mm chord, 16 mm thick rising to 22 mm at the plate from 60 % height, 12 mm root fillet, 63 mm pod at 550 mm so it is out of the water once foiling. 24 mm tube fuselage. Drive: 160 mm three-blade prop, P/D 0.8, 140 kV direct on 10S, 120 A, 20 Ah.

Pod out, steady state:

km/h	Board angle	CL wing	CL stab	Drag N (induced / profile / mast / fuselage)	L/D	W to hold speed
15	7.4°	1.04	+0.05	63.1 (42.4 / 14.0 / 5.0 / 1.6)	14.8	263
18	4.1°	0.74	−0.09	55.0 (31.5 / 14.3 / 7.0 / 2.3)	16.9	275
20	2.7°	0.62	−0.15	53.7 (27.0 / 15.5 / 8.5 / 2.8)	17.4	298
25	0.4°	0.42	−0.25	57.6 (21.0 / 19.8 / 12.7 / 4.1)	16.2	400
30	−0.8°	0.32	−0.30	67.0 (19.0 / 24.5 / 17.8 / 5.8)	13.9	558

Where the drag comes from

Prone foil assist, 95 kg all-up, 1000 cm² wing, pod out, steady state



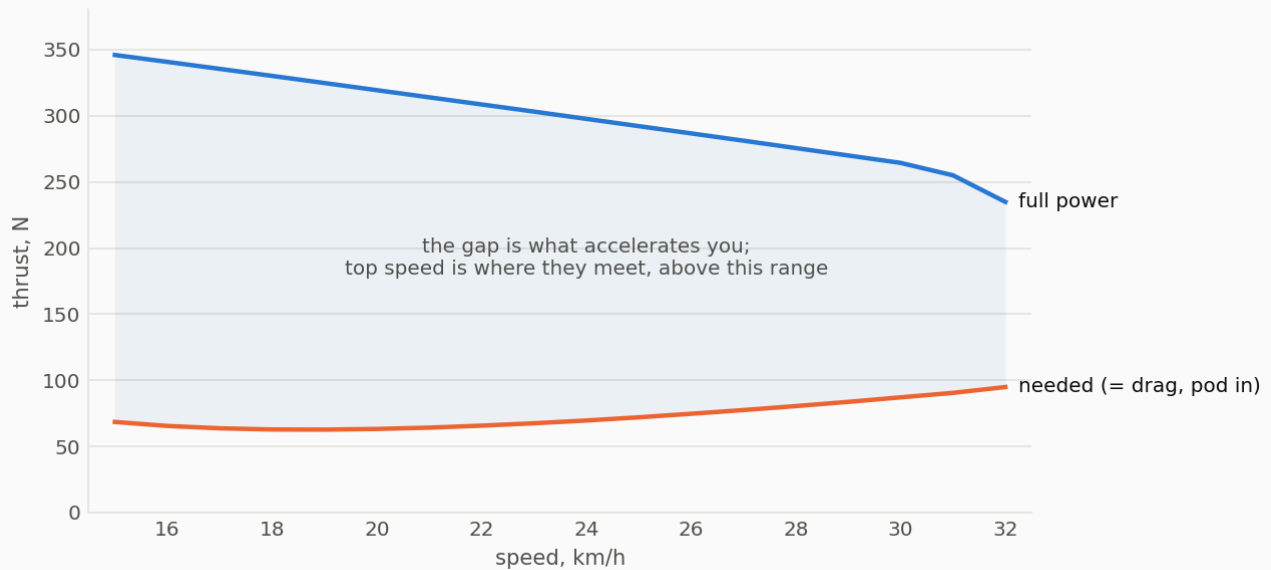
The model's stall is 13.8 km/h, with take-off at 15 at 86 % of the section's CL max. An experienced builder's estimate for a real foil like this is nearer 18 km/h, which corresponds to an effective CL max of about 0.75 against the section's 1.27: see 10.1 before trusting a stall speed. Best L/D 17.4 at 20 km/h. With the pod in the water, drag rises about 7 N and L/D falls to 14.7.

Motor on, pod in:

km/h	Thrust N	rpm	Prop eff.	Motor A	Throttle	Battery W	Wh/km
15	68.5	2160	69 %	31	46 %	539	36
20	63.2	2600	64 %	34	55 %	718	36
25	72.0	3140	59 %	44	67 %	1116	45
30	87.1	3710	55 %	57	79 %	1730	58

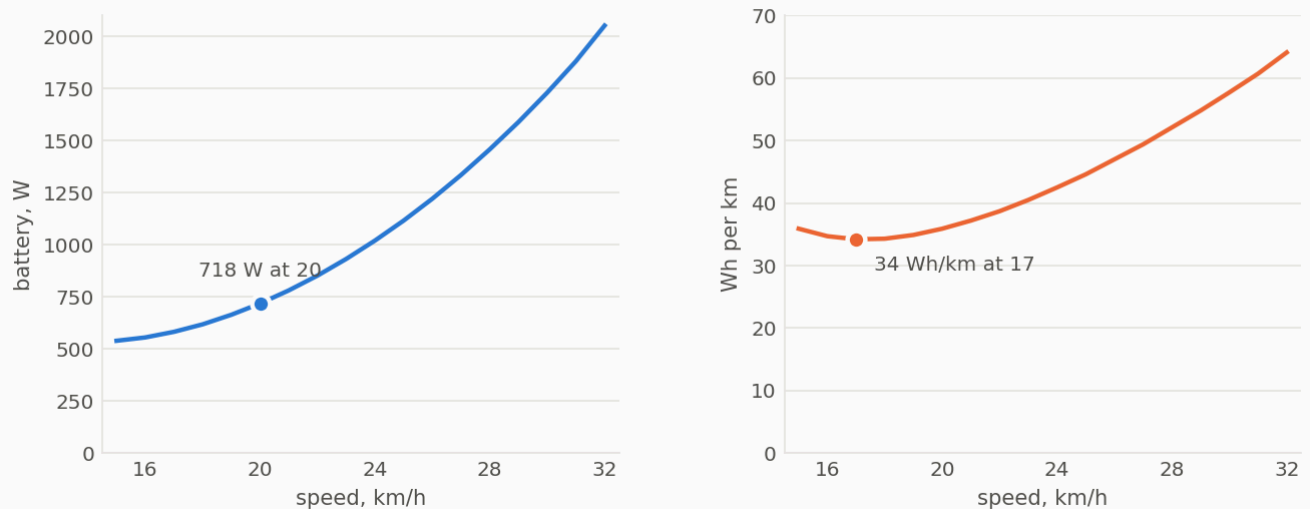
Thrust available against thrust needed

Motor on, pod in: 160 mm prop, P/D 0.8, 140 kV on 10S, 120 A limit



What the pack pays

Motor on, pod in. Left: battery watts. Right: watt-hours per kilometre, lowest around 17-20 km/h

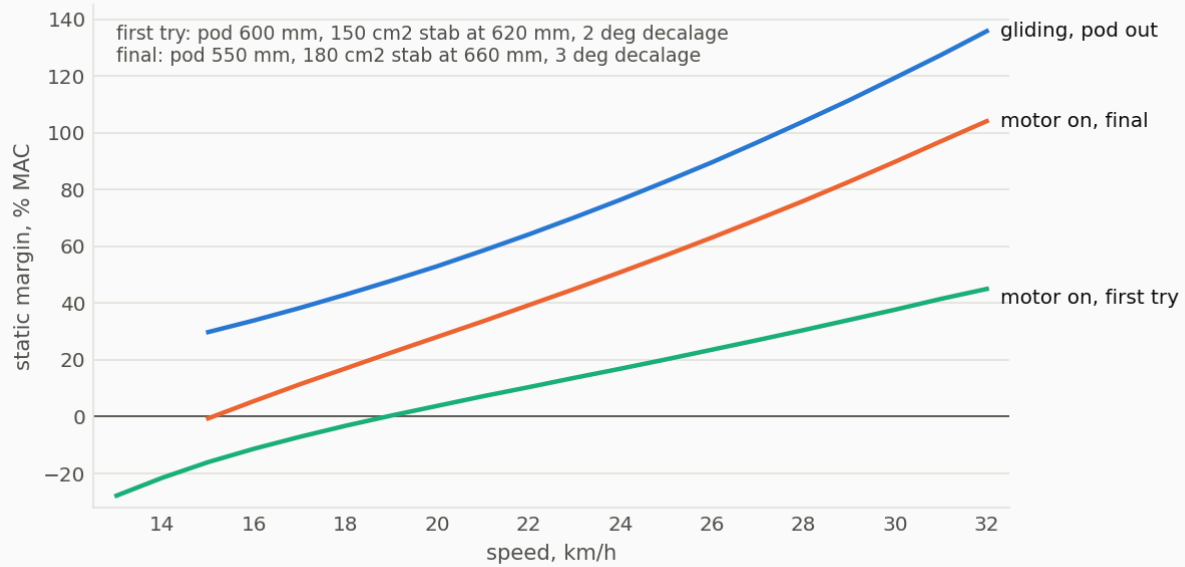


Static thrust 41 kgf, top speed 37 km/h, 18.5 km or about 56 minutes of continuous powered cruising.

Pitch. Gliding, the static margin is 30 % of MAC at take-off and 53 % at cruise. Under power the thrust line is 560 mm above the wing and 450 mm above the drag centroid, a 34 Nm nose-down couple at take-off, and the powered margin at 15 km/h is -0.6% , rising to $+5.5\%$ at 16: neutral at take-off. The first version, with the pod 50 mm higher, a 150 cm^2 stab at 620 mm and 2° decalage, read -16% . Foil assist trades powered stability for a dry pod, and pod height is the lever.

Pitch stability with the motor on and off

Static margin, % of wing MAC. Positive is stable; the lowest point is at take-off



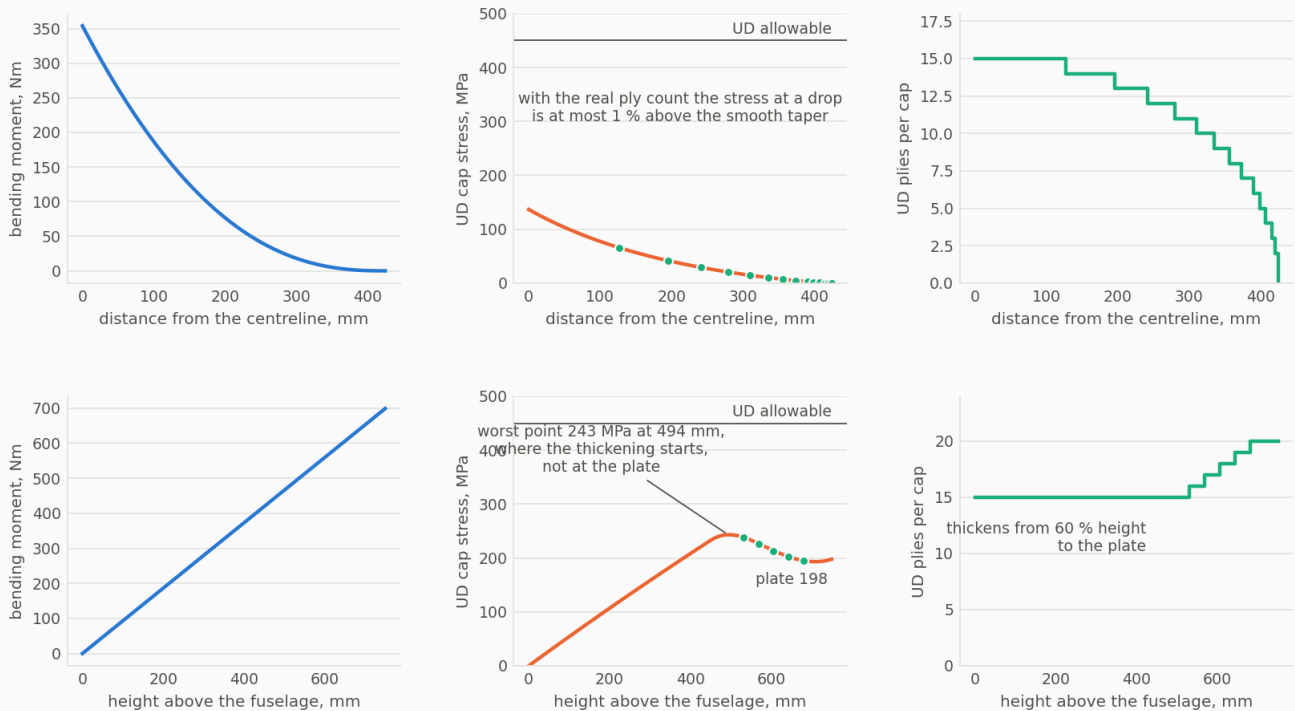
Structure, from the layup the mold feature wrote:

Part	Load case	Layup	Deflection	Cap stress
Wing	4 g, 354 Nm at the root	2 × 200 g woven each face, 15 UD plies per cap tapering to 4, tow core	6.5 mm at the tip	137 MPa
Stab	4 g	same skins, 5 UD per cap	1.9 mm	100 MPa
Mast	1 g sideways at the fuselage, 932 N	20 UD per cap at the plate, 15 at the foot, 4 tabs per face into the plate	53 mm at the fuselage end	198 MPa at the plate, 243 MPa at 488 mm

Mast junction: 38 kN cap force, 2.1 MPa shear against 15 allowed, 3.9 kN per track bolt, 96 MPa in the plate.

Loads and stresses, from the layup the mold feature wrote

Top: wing at 4 g, 354 Nm at the root. Bottom: mast with 1 g sideways at the fuselage end, 932 N, plate fixed. Dots mark ply drops



Materials at 50 % fibre volume: wing 1.6 kg cured (0.43 m² woven, 1 m² UD, 600 g tow, 830 g resin mixed), stab 0.13 kg, mast with plate 1.9 kg; about 3.7 kg of carbon and epoxy for the three molded parts. Wing mold 225 × 899 × 91 mm in nine tiles for a 250 mm bed, stab mold in two halves with the bolt cones, mast mold in three.

8. Parameter reference

Every dialog field of every feature, with its limits, default and the tooltip text, generated from the Feature Studio itself. Fields marked as appearing only when a checkbox or dropdown enables them are hidden otherwise.

Generated by `tools/gen_parameters.py` from the Feature Studio (build 245; wing 1.070, stab 4.036, perf 1.030, mast 2.011, fuselage 5.008, mold 2.148). Do not edit by hand - re-run the script when the .fs changes.

Exact dialog labels, limits and defaults (min / default / max). Use these labels when recommending a change. The meaning column is the Onshape tooltip. Some fields only appear when a checkbox or dropdown above them enables them.

Foil wing

Section

Label	Min / default / max	Meaning
Profile	dropdown: NACA 4-digit, Eppler E817, Eppler E818, NACA 63-412, Clark Y, Drela MRC-16, Hepperle MH 18, Speer H105 (default NACA 4-digit)	Section family. NACA 4-digit is fully parametric (camber, camber position, thickness) - use it for anything except matching a known published section. Named sections are digitised tables, thickness-scaled to Root/Tip thick % (Camber % fixed, hidden). Where each fits, from builders' results and the polars: MRC-16 (Drela, 13.9 %, Decavitator hydrofoil): anything pumped, carved or taken off slowly; the all-rounder, gentle stall, most cavitation margin in a hard turn. MH 18 (Hepperle, 11.2 %, pylon racing): fast flat-water wings at low lift; cheapest at cruise, tops out near CL 1.1, cavitates first in a turn. H105 (Speer, 12.6 %, sailing foils): slow high-lift take-off, a bigger stab for its nose-down moment (NeuralFoil polar). Clark Y: flat-bottomed home builds; most lift, biggest moment. E817/E818: widest cavitation-free band at speed. NACA 63-412: laminar bucket on a clean surface.
Camber %	0 / 3 / 9	Maximum camber as % of chord. Limits 0-9 %. 0 = symmetric. Typical front wing: 3-4 % pump/SUP/surf (early lift), 2-3 % wind/eFoil, 1.5-2.5 % kite/high speed. More camber = more lift at low speed but more drag and a bigger nose-down pitching moment. Only shown for NACA 4-digit - the tabulated profiles carry their own fixed camber.
Camber pos %	10 / 40 / 90	Position of maximum camber as % of chord from the leading edge. Limits 10-90 %. Typical 30-50 %, 40 % is the classic NACA choice. Further forward = gentler stall; further aft = more aft loading and a stronger nose-down moment. Ignored when camber is 0. Only shown for NACA 4-digit.
Root thick %	4 / 12 / 25	Root section thickness as % of chord. Limits 4-25 %. Typical front wing 11-14 %, high-speed/kite 8-10 %. Thicker = stiffer, more room for spar caps and a more forgiving stall; thinner = less drag and later cavitation.
Tip thick %	4 / 10 / 25	Tip section thickness as % of chord. Limits 4-25 %. Typical 8-11 %, usually 1-3 points thinner than the root. Blend between root and tip is set by the thickness exponent.
Tip profile	dropdown: Same as root, NACA 4-digit, Eppler E817, Eppler E818, NACA 63-412, Clark Y, Drela MRC-16, Hepperle MH 18, Speer H105 (default Same as root)	Section at the tip. Same as root: one section along the whole span, as before. Any other: the root section changes into this one from Blend from % outward, point by point along the section, so a cambered root can run out to a flatter, thinner-nosed tip the way production wings do. Foil performance uses it: the zero-lift angle varies along the span (aerodynamic twist, so the lift distribution and trim move), the stall check compares each station against ITS section's CL max, and the drag bucket is blended by area. Foil mold follows the blend. With Section data = Built-in the tip gets its own fitted polar; with Polar summary the root's numbers are used for both (one set of 13).
Tip camber %	-6 / 2 / 8	Maximum camber of the tip section as % of chord. Limits -6 to 8. Negative = inverted. Typical 1-2.5 on a front wing whose root has 3-4, so the tip stalls later and flies flatter; 0 for a symmetric tip.
Tip camb pos %	10 / 40 / 90	Position of the tip section's maximum camber, % of chord from the leading edge. Limits 10-90. Typical 35-45.
Blend from %	0 / 40 / 95	Limits 0-95, per half span. Out to here the section is the root's; from here it blends smoothly into the tip section, reaching it at the tip. 0 = a straight blend across the whole span. Typical 30-60: keep the root section where the chord and the bending are, change it over the outer half.

Label	Min / default / max	Meaning
TE thickness	0.1 / 0.8 / 5 mm	Limits 0.1-5 mm, and at most 3 % of the root chord. Held constant along the span, then thinned automatically near the tip so it never exceeds 3 % of the local chord. Typical 0.6-1.0 mm for wet-laid carbon in printed molds (room for 2-3 plies to wrap the edge), 0.3-0.5 mm for prepreg in machined molds. Thicker = tougher edge but more base drag and a risk of humming (vortex shedding).
Points/surface	10 / 40 / 120	Limits 10-120. Typical 30-50. Cosine-spaced, so the leading edge is well resolved even at low counts. Above about 60 slows regeneration for no visible gain.

Planform

Label	Min / default / max	Meaning
Planform input	dropdown: Area + aspect ratio, Span + root chord (default Area + aspect ratio)	Area + aspect ratio (recommended): enter the area everyone quotes and the shape; span and root chord are solved. Span + root chord: enter the geometry directly (e.g. to copy an existing foil); area becomes an output.
Area cm ²	100 / 1100 / 5000	Target wing area in cm ² . Limits 100-5000 cm ² . Typical front wing: 1500-2500 SUP/surf/beginner eFoil, 1000-1600 intermediate eFoil/wind, 900-1500 pump/downwind (high aspect), 300-700 kite race.
Aspect ratio	2 / 9 / 20	Limits 2-20, projected span ² / projected area. Typical front wing: 4-6 surf/beginner, 6-9 all-round/eFoil/wind, 9-14+ pump/downwind, 8-12 kite race. Higher = less induced drag and better glide, but less roll agility and more root bending.
Area definition	dropdown: Projected area, Developed area (default Projected area)	Which area the target refers to. Projected (top view) is what sets lift and what most brands quote. Developed is measured along the curved span line and is larger with anhedral or gull. Both are reported.
Span	100 / 800 / 3000 mm	Limits 100-3000 mm, projected tip to tip (top view). Typical front wing: 700-950 mm SUP/surf/eFoil, 900-1300 mm pump/downwind, 700-1000 mm wind, 600-900 mm kite race.
Root chord	20 / 180 / 600 mm	Limits 20-600 mm. Typical front wing 140-250 mm (low/medium aspect) or 90-140 mm (high aspect, kite).
Chord distribution	dropdown: Superellipse, Linear taper, Double taper (default Superellipse)	Superellipse: $c = c_0 (1 - (s \cdot 2y/b)^n)^{1/n}$, cut off at the end chord ratio, giving a rounded tip. Linear: straight taper to a square tip. Double taper: a steep taper from the root to Break %, then a gentler one to the tip - a wide root flaring into a slim outer wing (the full-base stab, or a high-aspect wing with a broad centre); Blend % rounds the corner between the two. Linear and double taper end in a square tip: Tip cap = Rounded + plan rounds it in plan view too.
Exponent n	1.2 / 3 / 8	Limits 1.2-8. 2 = elliptic (lowest induced drag for an untwisted wing). 2.5-4 = fuller, squarer tips as on many surf/eFoil wings. Below 2 = pointier, glider-like tips. Above 5 approaches a rectangle with rounded corners. Typical 2-3 for most wings, 3-4 for surf/eFoil.
End ratio	0.02 / 0.05 / 0.6	Limits 0.02-0.6. Chord of the small end face where the superellipse is cut off, as a fraction of root chord. The leading and trailing edges follow the curve all the way to this chord, so the tip is rounded in plan view. Typical 0.04-0.08 for a fully rounded tip; 0.15-0.3 gives a curved but blunt tip. The trailing edge is thinned automatically near the tip.
Break %	5 / 28 / 60	Limits 5-60, per half span. Where the steep root taper ends and the gentle outer taper begins, as a percentage of the half span. Typical 20-30 for a full-base stab, 30-50 for a high-aspect wing with a broad centre section.

Label	Min / default / max	Meaning
Mid ratio	0.2 / 0.62 / 1	Limits 0.2-1.0. Chord at the break as a fraction of root chord. The root taper runs from 1 to this over Break %; the outer taper from this to Tip ratio over the rest. Must be at least Tip ratio. Typical 0.55-0.7 for a full-base stab, 0.7-0.9 for a wing.
Blend %	0 / 10 / 30	Limits 0-30, per half span. Rounds the corner where the two tapers meet: the outline follows a smooth curve from Blend % before the break to Blend % after it, tangent to both tapers, instead of a sharp kink. 0 = sharp. Typical 8-15. Clamped so the blend never reaches the root or the tip.
Tip ratio	0.1 / 0.4 / 1	Limits 0.1-1.0. Tip chord as a fraction of root chord; the tip is square in plan view. Typical 0.3-0.6 for linear taper (about 0.4 gives near-elliptic loading for an untwisted wing; below 0.3 the tips load up and stall first), 0.15-0.3 for double taper, where it is the chord at the end of the outer taper and must not exceed Mid ratio.
Min tip	checkbox, default off	On = the tip chord is widened automatically until the section at the tip cap start is at least Min tip mm thick, by raising End ratio (or Tip ratio) above the value entered. The notice reports the ratio used. Guards a thin, small-chord tip that cannot be laid up; especially useful on a stab linked to a wing, where the link sets area, aspect ratio and thickness but the tip chord is still this feature's own.
Min tip mm	0.2 / 1 / 5 mm	Minimum section thickness at the tip cap start (the last full section before the cap tapers out). Limits 0.2-5 mm. Typical 1-1.5 mm for a carbon layup: two skin plies plus a little UD; the cap beyond it is tow and resin. Only the tip chord is changed, never the thickness %. From build 239 the cap's end is also held at 0.5 mm or more (Cap end % raised for the thickness only, said in the notice): thinner, the mold's cavity cut can fail on some sections.
Stations	3 / 9 / 30	Limits 3-30, per half span. Typical 11-15 for a rounded superellipse tip, 5-9 for linear or double taper. Superellipse stations are spaced evenly around the tip curve; the tapers use sine spacing, and double taper adds stations through the break (five across the blend) so the corner is followed. Tip-cap stations are added on top, and with Tip drop or Gull dihedral about 17 through the drop (build 235), so the wing follows its drop law and the mold's parting stays inside the trailing edge. More = slower regeneration.
Mirror to full span	checkbox, default on	On = complete foil. Off = right half only, for faster edits and section inspection. Reported metrics are always full-span values.

Sweep, alignment and anhedral

Label	Min / default / max	Meaning
Align line %	0 / 25 / 100	Limits 0-100 %. The chord line that stays straight (apart from Sweep aft); chord is added around it. Typical 25 for a classic elliptical superellipse (both edges curve), 60-100 for modern pump/downwind and many surf wings (100 = straight trailing edge, leading edge curves back), 0 for a double taper that should keep a straight leading edge with the root flare all on the trailing edge (the full-base stab look). Independent of the incidence pivot. Moving it aft sweeps the quarter-chord line back at the tips, moving the lift centre aft. Plan-view tip rounding (Tip cap = Rounded + plan) is centred on the mid-chord regardless, so both tip corners round.
Sweep aft	-100 / 100 / 400 mm	Limits -100 to +400 mm, positive = aft. How far the alignment line sits aft at the tip, relative to the root. 0 = alignment line straight across. Typical 20-80 mm for all-round wings, 80-200 mm for surf/carving wings with a curved leading edge. More sweep = more yaw/pitch stability and forgiveness, less efficiency.
Sweep exp	0.5 / 2 / 4	Limits 0.5-4. Shape of the sweep line $x = \text{offset} (2y/b)^m$. 1 = straight swept line (kinked at the root), 2-3 = curved 'banana' leading edge that is tangent at the root, below 1 = sweep concentrated near the root, 3-4 = raked tips. Typical 2-3.

Label	Min / default / max	Meaning
Tip drop	-100 / 50 / 200 mm	Limits -100 to +200 mm, positive = down (anhedral). Vertical drop of the tip pivot below the root pivot (net, including any gull dihedral); negative = tips up. Typical 0-40 mm for all-round wings, 30-80 mm for surf wings. Anhedral loosens roll and helps carving; too much reduces effective span and can create mold undercuts.
Drop shape	dropdown: Power law, S-curve (default Power law)	How the drop is spread between Drop from % and Drop to %. Power law: $z = -\text{drop } u^e$ with Drop exp, steepening all the way to the tip (2-3 = flat centre, tips dropping late). S-curve: a smoothstep, flat at both ends and steepest in the middle, so the wing levels off again before the tip - the gull front view of many surf wings.
Drop exp	1 / 2 / 6	Limits 1-6. Typical 2-3. Shape of the drop $z = -\text{drop } (2y/b)^e$. 1 = straight anhedral from the root, 2-3 = flat centre with tips falling away, higher = droop only near the tips.
Drop from %	0 / 0 / 70	Limits 0-70, per half span. Where the drop begins: the span line is flat (or on the gull dihedral line) out to here, then drops by Tip drop over the rest with the Drop exp shape. 0 = the drop starts at the root, the plain law. Typical 0, or 15-30 for a flat centre with a break. A flat centre with a distinct break and a near-straight drop, as on some surf wings (about 20 with Drop exp 1.3), needs this; the winglet gives the tip rise on top of it.
Drop to %	30 / 100 / 100	Limits 30-100, per half span. Where the drop is complete: beyond it the span line runs level at the full Tip drop (until a winglet bends it). Typical 100, or 85-95 for a wing that levels off before its tips.
Gull dihedral	-10 / 0 / 20 deg	Limits -10 to +20 deg, positive = up. Slope of the span line leaving the root, for gull wings: the wing rises inboard, then the drop term pulls the tips down to the tip drop. Needs a drop exponent above 1 (no effect at 1). Typical 0 (plain anhedral) or 3-8 deg with tip drop 20-60 mm and exponent 2.5-4 for a gull. Creates a V at the root; large values can cause mold undercuts.
Winglet	dropdown: Off, Up, Down (default Off)	Off: the tip follows Tip drop and Gull dihedral only. Up / Down: the outer part of each half span bends through Winglet angle on an arc of Bend radius and then runs straight, with every section drawn square to the bent path, so the winglet keeps its true section at any angle up to 90 deg. Its size is Winglet area: the chord distribution continues along the bend, and the tool solves how much of the half span to bend so that area comes out. Area and aspect ratio stay the developed values of the whole half span, winglet included; the notice adds the winglet height and the projected span. Foil performance credits a winglet as extra effective span for induced drag (0.9 x its height across the pair). Foil mold molds it up to 75 deg; steeper cannot release from a vertical pull.
Winglet area	1 / 30 / 500	Area of each winglet, cm^2 , measured along the bend. Limits 1-500. Typical 20-60 for a front wing. The bend starts where the outer chord distribution has this much area left to the tip, so it must fit: the winglet cannot start inside 30 % of the half span.
Winglet angle	10 / 60 / 90 deg	Limits 10-90 deg from the span plane. 90 = vertical. Typical 45-70 for a foil winglet; small angles are just a stronger tip drop and Tip drop does that with a smooth curve.
Bend radius	5 / 30 / 300 mm	Limits 5-300 mm, on the span line. The bend is an arc of this radius through Winglet angle, then straight to the tip. Typical 20-40 mm. If the arc would be longer than the winglet, the radius is reduced so the whole winglet is the bend, and the notice says so.
LE tubercles	checkbox, default off	Leading-edge tubercles (as on humpback flippers and on some production wings): the leading edge moves forward and back sinusoidally along the span while the trailing edge stays put, so the chord swells at each peak. Published tests (Miklosovic 2004, Johari 2007) show a softer stall and lift kept beyond it, for a little drag and sometimes a little maximum lift before stall; for a foil that is take-off, pumping and hard turns. GEOMETRY ONLY in the sweep: Foil performance uses the smooth chord distribution and never credits or charges them in its figures; from build 232 it reports what they would do on a separate line (its Tubercles switch). Foil mold follows them exactly. Adds six stations per tubercle pitch, so regeneration slows.

Label	Min / default / max	Meaning
Tubercle amp	0.5 / 4 / 15 mm	Limits 0.5-15 mm. Peak-to-trough travel of the leading edge. Typical 3-6 on a front wing (about 3-4 % of the local chord). The section is stretched at a peak and compressed at a trough with its thickness in mm unchanged.
Tubercle pitch	20 / 70 / 300 mm	Limits 20-300 mm. Spanwise distance from one peak to the next. Typical 50-90 on a front wing, five to eight tubercles per half span. The tubercles fade in and out over half a pitch at each end of their range.
Tubercles from	3 / 15 / 90	Limits 3-90, % of the half span. Where the tubercles start, from the centreline. Some production wings start them near the centre (from about 5), others outboard (from 12-20). Typical 10-20. Not 0: a tubercle starting on the centreline broke the mold's cavity cut (build 164), and a real wing has its mount there anyway.
Tubercles to	10 / 92 / 100	Limits 10-100, % of the half span. Where the tubercles end; must be beyond Tubercles from by at least one pitch. Typical 90-95, leaving the tip cap clean.

Twist and thickness distribution

Label	Min / default / max	Meaning
Washout	-5 / 0 / 8 deg	Limits -5 to +8 deg, relative to the root incidence; positive = tip leading edge down. Typical 0-3 deg. Washout unloads the tips so the root stalls first (gentler stall, better tip-breach behaviour) at a small cost in induced drag. Negative = wash-in (rarely useful).
Washout exp	0.5 / 1 / 4	Limits 0.5-4. Twist follows washout $(2y/b)^w$. 1 = linear, 2-3 = twist concentrated towards the tips, below 1 = twist concentrated near the root. Typical 1-2.
Thickness exp	0.5 / 1.5 / 4	Limits 0.5-4. Thickness % follows root + (tip - root) $(2y/b)^p$. 1 = linear, 2-3 = keeps the root thickness (and stiffness) further out before thinning, below 1 = thins quickly away from the root. Typical 1-2.

Incidence

Label	Min / default / max	Meaning
Incidence	-10 / 0 / 10 deg	Limits -10 to +10 deg, measured from the fuselage axis (X), positive = leading edge up. Typical front wing +0.5 to +2.5 deg. Aim for a wing-minus-stab difference (decalage) of 1.5-3 deg; the stabiliser feature reports it.
Pivot	dropdown: Quarter chord, Leading edge, Trailing edge (default Quarter chord)	Point each section rotates about for incidence and washout, and the line that follows the drop curve. The root pivot sits at the world origin. Quarter chord (recommended) keeps the lift centre fixed as angles change. Plan-view shape is set by the alignment line, not the pivot.

Tip

Label	Min / default / max	Meaning
Tip cap	dropdown: Rounded tip, Rounded + plan, Flat tip (default Rounded tip)	Rounded tip: section thickness falls along a quarter-ellipse over the cap length, rounding the tip in front view; plan-view rounding then comes only from the superellipse end ratio. Rounded + plan: the chord also shrinks along the same quarter-ellipse over the cap length, to Cap end % of the chord at the cap start, so a linear or double taper gets a rounded tip in plan view as well (the area solver allows for it). Flat tip: thickness is unchanged to the end face.
Cap length	2 / 15 / 80 mm	Limits 2-80 mm, and at most 30 % of the half span. Typical 10-25 mm. Longer looks smoother but thins more of the working span.

Label	Min / default / max	Meaning
Cap end %	5 / 25 / 80	End-face thickness as % of the tip section thickness. Limits 5-80 %. Typical 15-30 %. Lower = rounder, thinner tip; very low values with a thick trailing edge give a wafer-thin end that is hard to lay up.

Section polar

Label	Min / default / max	Meaning
Section data	dropdown: Analytic, Polar summary, Built-in (default Analytic)	Built-in: fitted XFOIL data, nothing to type in. E817/E818/NACA 63-412/Clark Y/MRC-16/MH 18 use one real XFOIL polar each (H105 a NeuralFOIL one, no XFOIL polar being published), moved to your Root/Tip thick % by a NeuralFOIL fit. NACA 4-digit uses the exact zero-lift angle/moment for your Camber %/Camber pos %, plus lift slope, CLmax and drag bucket fitted from real NACA polars at your thickness/camber - coarser than the fixed profiles (a fit across a family, not one measured shape); use Polar summary for higher accuracy at your exact section. Analytic (default): thin-aerofoil model - camber-line angle/moment, fixed lift slope, skin-friction drag, Section CL max from Foil performance. Polar summary: your own XFOIL/XFLR5 numbers at your own Reynolds numbers, via the fields below. Run scripts/polar_summary.py (developer skill) on your polar - the tool never invents section data.
Zero-lift	-8 / -2 / 4 deg	Zero-lift angle of attack from the polar, deg (usually negative for a cambered section). Limits -8 to 4 deg. Replaces the thin-aerofoil estimate. Typical -1 to -3 deg for a few % camber. For the built-in profiles (E817, E818, NACA 63-412, Clark Y, MRC-16, MH 18, H105) use Section data = Built-in instead of typing these in.
Lift slope	4 / 6 / 7.5	Section lift-curve slope from the polar, per radian. Limits 4-7.5. Thin-aerofoil theory gives $2\pi = 6.28$. Replaces the fixed analytic value. Typical 5.5-6.5 depending on thickness and Reynolds number. For the built-in profiles (E817, E818, NACA 63-412, Clark Y, MRC-16, MH 18, H105) use Section data = Built-in instead of typing these in.
Cm c/4	-0.15 / -0.05 / 0.05	Section pitching moment about the quarter chord from the polar (usually fairly constant with CL below stall). Limits -0.15 to 0.05. Replaces the thin-aerofoil Cm0. Typical -0.03 to -0.11 for a cambered section, near 0 for symmetric. For the built-in profiles (E817, E818, NACA 63-412, Clark Y, MRC-16, MH 18, H105) use Section data = Built-in instead of typing these in.
Re 1 (M)	0.1 / 0.35 / 5	First Reynolds number the polar data below is from, in millions. Limits 0.1-5. Values are interpolated (log Re) between Re 1 and Re 2, and held flat outside that range. Typical: near your take-off Reynolds number (about 0.2-0.5 M for a wing, lower for a stab). For the built-in profiles (E817, E818, NACA 63-412, Clark Y, MRC-16, MH 18, H105) use Section data = Built-in instead of typing these in.
CLmax @Re1	0.6 / 1 / 1.8	Maximum section lift coefficient at Re 1. Limits 0.6-1.8. Real CLmax usually drops noticeably below the higher-Re value, which is why a single fixed CL max (the analytic fallback) can be optimistic at take-off. Typical 0.85-1.1 at low Re. For the built-in profiles (E817, E818, NACA 63-412, Clark Y, MRC-16, MH 18, H105) use Section data = Built-in instead of typing these in.
Cdmin @Re1	0.004 / 0.01 / 0.03	Minimum section drag coefficient at Re 1 (the bottom of the drag bucket). Limits 0.004-0.03. Friction drag rises as Re falls. Typical 0.008-0.018 at low Re. For the built-in profiles (E817, E818, NACA 63-412, Clark Y, MRC-16, MH 18, H105) use Section data = Built-in instead of typing these in.
CL@Cdmin 1	-0.3 / 0.3 / 1	The lift coefficient at which Cdmin occurs at Re 1 - the centre of the drag bucket. Limits -0.3 to 1.0. Typical 0.3-0.7. For the built-in profiles (E817, E818, NACA 63-412, Clark Y, MRC-16, MH 18, H105) use Section data = Built-in instead of typing these in.

Label	Min / default / max	Meaning
k @Re1	0.005 / 0.013 / 0.05	Drag-rise rate at Re 1: $C_d = C_{dmin} + k (CL - CL@C_{dmin})^2$. Limits 0.005-0.05. For your own polar, read it off two points on the drag bucket away from C_{dmin} and solve for k, or use polar_summary.py to fit it automatically. Typical 0.005-0.04. For the built-in profiles (E817, E818, NACA 63-412, Clark Y, MRC-16, MH 18, H105) use Section data = Built-in instead of typing these in.
Re 2 (M)	0.1 / 0.9 / 5	Second Reynolds number, in millions. Limits 0.1-5. Must differ from Re 1 for interpolation to do anything. Typical: near your cruise or max-speed Reynolds number. For the built-in profiles (E817, E818, NACA 63-412, Clark Y, MRC-16, MH 18, H105) use Section data = Built-in instead of typing these in.
CLmax @Re2	0.6 / 1.2 / 1.8	Maximum section lift coefficient at Re 2. Limits 0.6-1.8. Typical 1.0-1.3 at higher Re. For the built-in profiles (E817, E818, NACA 63-412, Clark Y, MRC-16, MH 18, H105) use Section data = Built-in instead of typing these in.
Cdmin @Re2	0.004 / 0.007 / 0.03	Minimum section drag coefficient at Re 2. Limits 0.004-0.03. Typical 0.004-0.008 at higher Re. For the built-in profiles (E817, E818, NACA 63-412, Clark Y, MRC-16, MH 18, H105) use Section data = Built-in instead of typing these in.
CL@Cdmin 2	-0.3 / 0.3 / 1	The lift coefficient at which C_{dmin} occurs at Re 2. Limits -0.3 to 1.0. Typically close to CL@Cdmin 1, since the drag bucket centre moves less with Re than CLmax does. Typical 0.3-0.4. For the built-in profiles (E817, E818, NACA 63-412, Clark Y, MRC-16, MH 18, H105) use Section data = Built-in instead of typing these in.
k @Re2	0.005 / 0.01 / 0.05	Drag-rise rate at Re 2. Limits 0.005-0.05. Typical 0.01-0.035. For the built-in profiles (E817, E818, NACA 63-412, Clark Y, MRC-16, MH 18, H105) use Section data = Built-in instead of typing these in.

Fuselage joint

Label	Min / default / max	Meaning
Fuselage joint	checkbox, default on	Adds the joint chosen in Joint to the wing root. The two sockets start hidden inside the wing at the root's thickest point, blend smoothly out of the upper and lower surfaces to a nacelle (round for the Round tube socket, a rounded rectangle for the Square socket), and continue behind the trailing edge to a rear face where the tube or bar enters, its axis through the middle of the root thickness (Socket height moves it). The Flat hub and the Flat mount add no nacelle. Turn off for a clean wing (molding, analysis, or a different mount).
Joint	dropdown: Round tube socket, Square socket, Flat hub with pocket, Flat mount (bolted through) (default ROUND)	How the fuselage attaches. Round tube socket: a bore in a nacelle on the root for a round tube, held by countersunk bolts (the original joint). Square socket: the same nacelle with a rectangular bore for a flat bar or tongue. Flat hub with pocket: what production wings do - a flat-topped hub on the root, a recessed pocket the fuselage's flat nose or a bar drops into, bolts down through the fuselage or (Custom) up from the wing's underside; no nacelle, no plug in the mold, the stiffest joint; pocket and bolts are inputs to match a fuselage you own. Flat mount (bolted through): a home-build flat-bar layout - the wing sits on a flat bar and countersunk bolts go down through it on the centreline; a Mount pad under the root seats it at the modelled Incidence (bolted straight onto a bar a wing takes its underside's own angle).

Label	Min / default / max	Meaning
Hub	dropdown: Standard hub (40 x 92, 3 bolts), Custom (default STANDARD)	Standard hub: fixed dimensions so one fuselage fits every wing built with it - 40 wide x 92 long, 3 mm join fillet, pocket 24 wide x 5 deep from 20 mm behind the front, open at the square back, three blind holes of the Hub bolt size at 20 mm pitch from 15 mm behind the pocket's front wall, 10 mm deep (build 208): the fuselage's bolt count and positions, fixed by the standard, its bolts always down through the fuselage. Only its position changes: Hub from apex and Hub above apex (its fuselage template was drawn with the hub's top 3 mm above the apex: set Hub above apex to 3 to match it). Custom: every dimension below is yours, Bolts from included. More standards will join the list as production pockets are measured.
Hub from apex	-30 / 0 / 100 mm	Where the hub starts, measured back from the root's apex (the thickest point of the section). Limits -30 to 100 mm. Typical 0: the hub begins at the apex and runs aft, so it only fills the space behind the highest point of the skin. Negative moves its nose ahead of the apex, where it would stand proud of the profile.
Hub above apex	-40 / 0 / 20 mm	How far the hub's flat top stands above the root profile's apex; negative sinks it into the section, and it may go below the section's centre (build 200). Limits -40 to 20 mm. Typical -1 to 0 for a hub level with or a little below the apex, the least frontal area; +3 with the Standard hub, where its fuselage template puts the top. Positive stands the hub proud of the root profile along its whole length and lifts the fuselage's nose by the same amount. Sunk deep, the top emerges from the skin further aft and the underside follows it down to keep 4 mm of floor under the pocket; the notice warns where the pocket floor would break through the lower skin.
Hub bolt	dropdown: M4, M5, M6, M8, M10, Custom hole sizes (default M8)	The bolts that hold the fuselage or bar to the hub: M5, M6 or M8 (M4 and M10 allowed; Custom takes Hole dia). With the Standard hub this is the one bolt choice you make - the standard fixes three of them at 20 mm pitch, 15 mm behind the pocket's front wall, 10 mm deep, the pattern the fuselage template was drawn with (build 209). Bolts from the fuselage: sets the hub's tapping drill (M8 6.8, M6 5.0, M5 4.2 mm) and the fuselage's clearance holes and countersinks. Bolts from the wing's underside (Custom hub): sets the wing's clearance holes (M5 5.4, M6 6.4, M8 8.4 mm) and their countersinks, and the fuselage's tapping drill.
Hub width	16 / 40 / 80 mm	Width of the flat hub across the span. Limits 16-80 mm. Typical 28-40: the fuselage's tongue plus 4-8 mm of wall each side of the pocket.
Hub length	30 / 150 / 400 mm	Length of the hub along the chord, from the hub's front (the root's apex + Hub from apex) aft. Limits 30-400 mm. Typical 120-160: production hubs run past the trailing edge as a block, and this one does too, its underside flat at the trailing edge's height.
Hub fillet	0 / 3 / 10 mm	Fillet radius where the hub's sides meet the wing's skin. Limits 0-10 mm. Typical 2-4: takes the sharp corner out of the laminate and the mold. 0 for none; if Onshape refuses the fillet the hub is left sharp and the notice says so.
Pocket width	10 / 24 / 60 mm	Width of the fuselage's tongue across the span (the pocket is this plus twice the Clearance). Limits 10-60 mm. Typical 20-32; measure your fuselage's nose.
Tongue length	30 / 100 / 300 mm	Length of the fuselage's tongue along the chord, published for the Foil fuselage. The pocket itself is open at the hub's square back (build 200: it is part of the fuselage interface), so the tongue is located by the pocket's front wall and its sides and may be shorter or longer than the hub. Limits 30-300 mm. Typical 80-140; measure your fuselage.
Pocket from	0 / 20 / 200 mm	Where the pocket's front wall is, measured back from the hub's front end; the pocket runs from there out through the hub's square back. Limits 0-200 mm. Typical 10-30.

Label	Min / default / max	Meaning
Pocket depth	1 / 5 / 12 mm	Depth of the recess the tongue drops into, below the hub's top. Limits 1-12 mm. Typical 3-5: enough to locate against the stab's side loads. With the top at the apex the floor is inside the section, so the depth is not limited by the hub's own height.
Clearance	0 / 0.15 / 1 mm	Gap between the tongue and the pocket walls, each side. Limits 0-1 mm. Typical 0.1-0.2 for a bolted fit.
Bolts from	dropdown: Fuselage, Wing underside, Fuselage, nut inserts (default FUSELAGE)	Which side the hub's bolts come from (build 235). Fuselage: down through the tongue or the bar into blind holes in the hub, tapped or with inserts. Fuselage, nut inserts: down through the fuselage and right through the wing into flanged nut inserts in the underside (fields below), so the bolts take full preload. Wing underside: up through the wing, a clearance hole (M5 5.4, M6 6.4, M8 8.4 mm) on the centreline at each bolt, from the lower skin to the pocket floor, countersunk 90 deg so the heads sit flush; the bar or the tongue is tapped instead. The notice warns under 2 mm of laminate between a countersink and the pocket floor. Typical nut inserts for a molded fuselage (the strongest clamp), Wing underside for a metal bar in the pocket. Set Foil mold's Core clear so the bolts pass through solid laminate, not foam.
Hub bolts	0 / 3 / 4	Bolts on the centreline between the fuselage's tongue (or the bar) and the wing: down through the tongue with Bolts from = Fuselage, up through the wing with Wing underside. Limits 0-4. Typical 2 or 3.
Hole dia	0 / 0 / 14 mm	Bolts from the fuselage: diameter of the blind hole in the hub, 0 = the bolt's tapping drill (M6: 5.0 mm), otherwise the outside diameter of the insert you will bond in (8-9 for an M6 brass insert). Bolts from the wing's underside: the through hole, 0 = the Hub bolt's clearance hole (M6 6.4 mm; 6.4 for Custom), otherwise your own. Limits 0-14 mm. Typical 0. The mold forms the hole undersized and tapered; drill to size after cure.
Bolt pitch	15 / 25 / 150 mm	Spacing of the hub bolts along the chord. Limits 15-150 mm. Typical 25-40.
Bolt 1 from	5 / 10 / 150 mm	Where the first bolt sits, measured back from the pocket's front end. Limits 5-150 mm. Typical 15-30. The rest follow at Bolt pitch. With Bolts from = Wing underside, put them where the root is thick: the notice gives the laminate under each head.
Hole depth	5 / 12 / 40 mm	Depth of each blind hole below the pocket floor (Bolts from = Fuselage). Limits 5-40 mm. Typical 10-15, and never through the lower skin: the notice says how much wall is left under each hole.
Insert dia	4 / 11 / 20 mm	Bolts from = Fuselage, nut inserts (build 241): the bolts come down through the fuselage and right through the wing into flanged nut inserts pushed into the wing's underside, a hand fit. This is the insert's barrel diameter; the bore is this plus Insert fit. Limits 4-20 mm. Typical M5 7, M6 9, M8 11 mm: measure yours. With a nut the bolt can be torqued to full preload, which tapped carbon cannot hold, and the clamp is what carries twist and yaw at the joint.
Insert length	3 / 12 / 30 mm	The insert's length under its flange, the barrel's depth into the wing from the underside. Limits 3-30 mm. Typical 10-15 mm for M8. Its top must stay at least 1 mm under the pocket floor so the bolt clamps the laminate between them; the notice warns when it does not, and gives the laminate left above it.
Flange dia	6 / 16 / 30 mm	The insert's flange diameter: a recess this size plus Insert fit is cut into the lower skin so the flange sits flush, and the flange spreads the clamp into the skin and the solid laminate between the skins. Limits 6-30 mm. Typical M5 10, M6 13, M8 16 mm. The notice gives the bearing stress under it at the bolt's preload.
Flange thick	0.5 / 1.5 / 5 mm	The flange's thickness, the depth of its flush recess in the lower skin. Limits 0.5-5 mm. Typical 1-2 mm.

Label	Min / default / max	Meaning
Insert fit	0 / 0.1 / 1 mm	Clearance across the bore and the flange recess for a hand fit (the insert is pushed in by hand, then bonded or held by the bolt). Limits 0-1 mm. Typical 0.05-0.15 mm; 0 for a press fit. The mold forms the bore and the recess from its lower half at this size; ream if the print runs tight.
Pocket floor	dropdown: Flat, V groove, V ridge (default FLAT)	The shape of the pocket's floor and of the fuselage tongue on it (build 241). Flat: every earlier build. V groove: the floor falls from the walls to a V on the centreline and the tongue's underside is the same V, so side loads and roll are carried by the V's faces, wedged by the bolts' preload, and it self-centres. The centreline (the bolts) stays at Pocket depth; the floor at the walls rises by V depth, so the laminate under the bolts is unchanged, and the notice warns when the walls are left under 1.5 mm tall. V ridge: the floor rises to a ridge, the tongue grooved to match; the same location, more laminate under the bolts. Both mold from the upper half without undercut. The hub body's tongue follows it at the same Clearance all round.
V depth	0.5 / 3 / 10 mm	How far the V's apex on the centreline lies below the floor at the walls (V groove) or above it (V ridge). Limits 0.5-10 mm. Typical 2-4 mm on a 24 mm pocket (a 15-20 deg slope each side): steeper locates harder but wedges more under the bolts. Held to Pocket depth less 0.5 mm. A groove raises the floor at the walls by this much and keeps the centreline (the bolts) at Pocket depth; a ridge raises the centreline. The notice warns when either leaves under 1.5 mm: the walls' height for a groove, the depth over the crest for a ridge.
V fillet	0 / 2 / 10 mm	Radius on the V's apex and on its two shoulders where it meets the pocket's walls: no sharp inside corner in the laminate or the mold, and no knife edge on the tongue. Limits 0-10 mm. Typical 1-3 mm. The tongue's corners take the radius less the Clearance where the pocket's corner is convex and plus it where it is concave, so the gap is the Clearance all round.
Nose fairing	checkbox, default off	A faired nose on the wing ahead of the pocket (build 241, wing 1.070), as production foils fair the fuselage's front: a ridge on the top skin from a point Fairing length ahead of the pocket's front wall, rising to Nose height above the hub's top at the wall, its feet sweeping into the skin, lofted as one body (no fillets). It takes the hub's full width at the wall and its back face is flat on the wall's plane, so a bar in the pocket or Foil fuselage's hub body butts against it; the hub body then drops its own nose and starts with that face (Foil fuselage 5.008). Its sides run on into the Root fairing (which it needs on) as one surface. Shape it with Top shape and Nose fullness. Unioned with the wing, so Foil mold's upper half molds it; the mold's cut list adds its volume to the root's solid fill. Off (default): the hub's rounded front as before.
Fairing length	10 / 50 / 150 mm	How far ahead of the pocket's front wall the fairing's nose point lies on the skin. Limits 10-150 mm. Typical 40-60: about 2.5 to 3 times Nose height for a gentle ramp; it reaches the hub's full width by the hub's front, so a length under Pocket from + 10 makes a blunt nose. Held 10 % of the root chord behind the leading edge, with a note.
Nose height	0 / 0 / 40 mm	The fairing's height above the hub's flat top at the pocket's front wall, the fuselage's or bar's top there. 0 (default): Foil fuselage's hub body at its default Body height, 22 mm above the hub's underside, so the two meet flush with nothing to type (the notice gives the height it came to). For a bar of your own: its height less Pocket depth (a 25 mm bar in a 6 mm pocket gives 19; a 30 mm bar in a 12 mm pocket 18), so the ridge meets the bar's top level and its back face is the bar's front. Limits 0-40 mm. Typical 8-12 for the hub body, 13-20 for a bar. The hub body errors if it is set lower than this.

Label	Min / default / max	Meaning
Top shape	1 / 1.5 / 8	The ridge's cross-section along the nose, a superellipse exponent: 1 a pointed ridge (a tent), 1.5 a soft point (default), 2 round, 4 and more flat-topped. It eases to the bar's flat top over the hub, from 70 % of the way along the nose to the wall. Limits 1-8. Typical 1.2-2. A pointed top sheds water cleanly off the nose; a flat one gives the flattest ramp for a tall bar.
Nose fullness	1 / 1.5 / 3	The nose's outline in plan, a superellipse exponent on the foot line from the nose point to the hub's full width at the hub's front: 1 a straight taper (pointed), 1.5 an ogive (default), 2 elliptical, 3 blunt. Limits 1-3. Typical 1.3-2. The feet scale with the outline; the crown keeps the wall's share of the width along the nose.
Crown round	0 / 5 / 10 mm	Radius on the two top corners of the fairing's back face at the wall, to match the bar's or the fuselage's edge: 5 (default) is Foil fuselage's default Edge round, which the hub body takes for its first section; 0 for a square bar. Limits 0-10 mm. Typical 3-5 for the hub body, 0-1 for a bar.
Bore width	10 / 19 / 60 mm	Width across the span of the rectangular bore for a flat-sided fuselage bar. Limits 10-60 mm. Typical 19-25; the default 19 is a home-build plan's extruded aluminium flat bar (19 wide x 25 high), so that bar slides straight in.
Bore height	6 / 25 / 40 mm	Height of the rectangular bore. Limits 6-40 mm. Typical 12-25; the default 25 is that bar standing on edge, as the plan uses it, which makes the nacelle 35 mm tall with the 5 mm wall. Lay the bar flat (Bore width 25, Bore height 19) for a lower nacelle if the fuselage is your own.
Bore corner	0 / 1 / 5 mm	Radius of the bore's four corners, to match the rounded corners of an extruded aluminium flat bar. Limits 0-5 mm. Measure the bar and enter no more than its own radius - a bore corner larger than the bar's will not let the bar in, a smaller one only leaves a hair of gap in the corners; Typical 0.5-1.5 mm: 1 mm suits most 19-25 mm flat bar, 0 for a machined tongue. Half the clearance is added to it, as to the sides; the plug's handle and channel in the mold use the same corner.
Bolts	1 / 4 / 6	Number of bolts down through the wing on the centreline, from Bolt 1 from at Bolt pitch. Limits 1-6. Typical 3-4 (a flat-bar home-build plan uses four M6 at 25 mm). Each hole is checked against the root chord and the laminate left under its head, and skipped with a warning when it falls outside the chord.
Bolt	dropdown: M4, M5, M6, M8, M10, Custom hole sizes (default M6)	The bolt size: sets the clearance hole (M5 5.4, M6 6.4, M8 8.4 mm) and the countersink's head diameter. Typical M6 for a front wing; Custom takes the hole from Bolt dia and a head twice it.
Bolt dia	3 / 6.5 / 12 mm	Clearance hole diameter (Custom only). Limits 3-12 mm. Typical 6.5 mm.
Bolt 1 from	5 / 35 / 300 mm	The first bolt's centre behind the root leading edge. Limits 5-300 mm. Typical 25-40 % of the root chord, so the row straddles the section's thickest part where there is most laminate under the heads; the last bolt must stay inside the chord.
Bolt pitch	10 / 25 / 150 mm	Spacing of the bolts along the chord. Limits 10-150 mm. Typical 20-30 mm (a flat-bar plan: 25, with the bar tapped at 25 mm so the wing can shift a hole). Ignored with one bolt.
Countersink	checkbox, default on	Sinks each head into the top skin with a 90 deg countersink to the head diameter, so the heads sit flush (the mold forms the countersinks from the upper half). Off: plain through holes for button heads or washers on top. Typical on.

Label	Min / default / max	Meaning
Mount pad	checkbox, default on	Adds a pad under the root that seats the wing on the flat bar at the modelled Incidence: a flat horizontal face, Pad width wide and Pad height below the underside's lowest point, its top following the root's own lower surface, from Flat start to the trailing edge (build 227). The bolts pass through it and the laminate under each head counts it. Off: bare underside, and the notice reports the angle the wing would seat at instead.
Pad width	5 / 20 / 80 mm	Width of the pad face across the span, centred on the root. Limits 5-80 mm. Typical the bar's width: 19 for a 19 x 25 mm flat bar on edge, 25 for one laid flat. Wider than the bar only adds wetted area; narrower leaves the bar's edges unseated.
Pad height	0 / 2 / 20 mm	How far the flat face sits below the underside's lowest point at the root. Limits 0-20 mm. Typical 1-3 mm: enough that the face is a full flat rather than a line touching the skin. 0 puts the face exactly on the lowest point, so a section whose underside already lies flat at the modelled Incidence (a Clark Y drawn at 2.1 deg) gets no pad body at all: its own flat is the seat. Any other section gets a face at least 0.3 mm below its lowest point (build 238): on the point itself the face would touch the skin along a line, which the mold cannot cut.
Flat start	2 / 20 / 300 mm	Where the flat face begins, in mm behind the root leading edge; it runs from here to the trailing edge. Limits 2-300 mm. Typical 15-25 % of the root chord: at or just ahead of the underside's lowest point, so the face begins where the section already reaches the pad plane, and ahead of the first bolt. Held at least 5 mm inside the chord at both ends, with a warning.
Front ramp	checkbox, default on	Fairs the pad's front from just behind the leading edge down to the flat face at Flat start with a smooth ramp, closing the gap between the bar and the wing's nose. Off: the pad begins at Flat start with a square front face, for a bar that starts there. Typical on.
Tube dia	10 / 24 / 60 mm	Round tube socket: outside diameter of the round fuselage tube. Limits 10-60 mm. Typical 20-30 mm for carbon or aluminium tube. The Square socket is sized by Bore width and Bore height instead (build 233: hidden there).
Clearance	0 / 0.2 / 2 mm	Clearance between the bore and what goes in it, across the bore: Round, added to Tube dia; Square, added to Bore width and to Bore height (half each side), and half of it to Bore corner. Limits 0-2 mm. Typical 0.1-0.3 mm for a firm slip fit that is then bolted or bonded.
Wall	2 / 5 / 15 mm	Nacelle wall thickness round the bore, which sets the nacelle's size: Round, Tube dia + 2 x Wall across (the Clearance comes out of the wall); Square, the bore (Bore width or Bore height + Clearance) + 2 x Wall each way. Limits 2-15 mm. Typical 4-6 mm for carbon. Thicker is stronger but adds frontal area and drag. Mouth wall % sets how much of it the rear face keeps.
Blend length	10 / 70 / 300 mm	Length over which the socket grows out of the wing, from the root's thickest point (where it starts hidden inside the wing) to the full nacelle diameter. Limits 10-300 mm. Typical 50-90 mm - longer is a gentler, lower-drag blend. Should reach full diameter before or just after the trailing edge.
Rear extension	0 / 90 / 400 mm	How far the socket extends behind the root trailing edge to its rear face, where the tube enters. Limits 0-400 mm. Typical 60-120 mm; with Socket depth this sets how much tube is held and how far the joint sits behind the wing.
Rear fairing	5 / 25 / 150 mm	Taper at the back of the socket, from the full nacelle down to the rear face, where the wall is thinned to Mouth wall % of Wall - this is what keeps the fuselage slender: Foil fuselage matches the diameter this taper actually produces, not the nacelle's peak diameter. Limits 5-150 mm. Typical 20-40 mm; longer is gentler and lower drag. 0 is refused, since it would force the whole fuselage to the wide nacelle diameter. No taper with Mouth wall % at 100.

Label	Min / default / max	Meaning
Mouth wall %	25 / 50 / 100	Wall left round the bore at the socket's rear face, its mouth, as % of Wall; Rear fairing tapers the nacelle down to it (build 233). Round socket: that wall, less half the Clearance at 100. Square socket: its section shrinks in proportion to the larger side, so the walls come out near it, the narrower side's a little thicker. Limits 25-100 %. Typical 50 (the taper every earlier build made) for a round carbon tube in a slim fuselage; 75-100 for a metal bar in the Square socket, whose bending moment is largest at the mouth, where a thin lip splits first. 100 = no taper: the full nacelle ends square at the rear face, and a Foil fuselage on a Round socket is as wide as the nacelle.
Socket depth	20 / 80 / 300 mm	How far the bore runs forward from the rear face - the length of tube or bar inside the socket. Limits 20-300 mm. Typical 3-4 x Tube dia (Square: x Bore height); longer carries bending better. It may not reach forward into the blend. Shorter than Rear extension (the defaults) leaves the whole bore behind the root trailing edge, a pod behind the wing; the notice says so and gives the depth that brings 10 mm of it under the wing.
Socket height	-15 / 0 / 15 mm	Moves the bore's axis up (+) or down (-) from the root section's mid-thickness at its thickest point. Limits -15 to 15 mm. Typical 0; a few mm up puts the fuselage higher on the wing. The nacelle still starts hidden inside the wing, so a large offset makes it stand out of one skin more than the other.
Bolts	0 / 2 / 3	Vertical countersunk bolts through the nacelle and the tube or bar, spread along the socket, heads sunk into the nacelle's top. Limits 0-3. Typical 2. 0 = no holes (bonded joint).
Bolt	dropdown: M4, M5, M6, M8, M10, Custom hole sizes (default M6)	The cross bolt (or pin) through the nacelle and the tube or bar: sets the clearance hole here and in the Foil fuselage's matching holes (M5 5.5, M6 6.5, M8 8.5 mm, 0.1 mm looser than a close fit so the two parts line up). Typical M6 for a 24 mm tube or a 19-25 mm bar; the hole must be under half the tube diameter, or under half the Bore width on the Square socket (the bar's side it passes through). Custom hole sizes: type the hole below (a plain dowel, for instance).
Bolt dia	3 / 6.5 / 12 mm	Pin or bolt clearance hole diameter (Custom only). Limits 3-12 mm. Typical 6.5 mm (M6) for a 24 mm tube; under half the tube diameter, or half the Bore width on the Square socket.
Bolt pitch	10 / 35 / 150 mm	Spacing of the socket bolts along the tube, centred on the socket. Limits 10-150 mm. Typical 30-40; all must fit within Socket depth. Ignored with one bolt.
Root fairing	checkbox, default off	Lofts the corner where the wing root meets the joint, instead of leaving a hard corner or a small fillet (build 241). Sockets: the nacelle's own sections gain a concave flare each side, tangent to the nacelle and running into the skin, above and below. Flat hub: a flare round the hub's sides and front, tangent to its walls and running into the skin, in place of Hub fillet. Its radius is Fairing radius, held so it never climbs over the nacelle or the hub's top; behind the trailing edge it carries on for Fairing tail, else it eases to nothing just ahead of the trailing edge. Foil performance then counts the wing's two root junctions as lofted. Typical on for a low-drag joint; off keeps the joint as before build 241.
Fairing radius	2 / 10 / 100 mm	The root fairing's largest radius. Held under 90 % of how far the nacelle (or the hub's wall) stands above or below the skin at each station, so it never climbs over the nacelle's top or reaches the hub's flat top, and its foot 3 mm behind the leading edge; with a tail it is also the radius, seen from above, where the tail leaves the trailing edge. Limits 2-100 mm (wide open while it is tested). Typical 8-15 mm on a 30-40 mm nacelle, up to the wall's height on a flat hub; larger is a gentler corner and a wider foot on the skin.

Label	Min / default / max	Meaning
Fairing spread	0.5 / 1 / 4	How flat and wide the root fairing is: how far it reaches out along the skin for each mm it climbs the nacelle or the hub's wall. 1 is a quarter circle (Fairing radius both ways, every build before this field); 2 runs twice as far out as it climbs, flatter and wider, a gentler blend into the skin with a wider foot; under 1 is steeper and narrower. Fairing radius stays the height it climbs, and the caps on it are unchanged. Limits 0.5-4. Typical 1-2.5; the wider the foot, the more of the skin near the root it reshapes.
Fairing tail	0 / 50 / 100 mm	Where the socket or the hub runs on behind the trailing edge, the fairing keeps its full radius to the trailing edge and carries on behind it for this length: the root's trailing edge continues as a thin web on the trailing edge's own height (its bottom on the mold's parting), leaving the trailing edge on a radius seen from above, its fillets shrinking to nothing, as wind-tunnel fillets that grow aft and run past the trailing edge onto the body do. Held to the socket's Rear extension less 3 mm, or to the hub's back. Limits 0-100 mm (capped while it is tested). Typical 40-80 mm, longer is gentler. 0, or a joint that ends at the trailing edge, eases the fairing to nothing just ahead of the trailing edge instead.
Log inputs	checkbox, default on	Prints every parameter on this feature to the FeatureScript console as one line, so the whole set can be pasted elsewhere (e.g. back to an AI assistant) along with the notice or CSV.

Foil stabiliser

Section

Label	Min / default / max	Meaning
Profile	dropdown: NACA 4-digit, Eppler E817, Eppler E818, NACA 63-412, Clark Y, Drela MRC-16, Hepperle MH 18, Speer H105 (default NACA 4-digit)	Section family. NACA 4-digit is fully parametric (camber, camber position, thickness) - use it for anything except matching a known published section. Named sections are digitised tables, thickness-scaled to Root/Tip thick % (Camber % fixed, hidden). Where each fits, from builders' results and the polars: MRC-16 (Drela, 13.9 %, Decavitator hydrofoil): anything pumped, carved or taken off slowly; the all-rounder, gentle stall, most cavitation margin in a hard turn. MH 18 (Hepperle, 11.2 %, pylon racing): fast flat-water wings at low lift; cheapest at cruise, tops out near CL 1.1, cavitates first in a turn. H105 (Speer, 12.6 %, sailing foils): slow high-lift take-off, a bigger stab for its nose-down moment (NeuralFoil polar). Clark Y: flat-bottomed home builds; most lift, biggest moment. E817/E818: widest cavitation-free band at speed. NACA 63-412: laminar bucket on a clean surface.
Camber %	-6 / 0 / 6	Maximum camber as % of chord. Limits -6 to +6 %. Typical 0 for stabs. 0 = symmetric (most common stab section). Negative = inverted camber that lifts downward, trimming with less negative incidence; typical -1 to -2 % if used. Positive only for lifting stabs (rare). Only shown for NACA 4-digit - the tabulated profiles carry their own fixed camber.
Camber pos %	10 / 40 / 90	Position of maximum camber as % of chord from the leading edge. Limits 10-90 %. Typical 30-50 %. Ignored when camber is 0. Only shown for NACA 4-digit.
Root thick %	4 / 10 / 20	Root section thickness as % of chord. Limits 4-20 %. Typical 8-11 %. Thinner = less drag; below about 8 % stabs get flexible and stall abruptly.
Tip thick %	4 / 8 / 20	Tip section thickness as % of chord. Limits 4-20 %. Typical 7-10 %. Blend between root and tip is set by the thickness exponent.

Label	Min / default / max	Meaning
Tip profile	dropdown: Same as root, NACA 4-digit, Eppler E817, Eppler E818, NACA 63-412, Clark Y, Drela MRC-16, Hepperle MH 18, Speer H105 (default Same as root)	Section at the tip. Same as root: one section along the whole span, as before. Any other: the root section changes into this one from Blend from % outward, point by point along the section, so a cambered root can run out to a flatter, thinner-nosed tip the way production wings do. Foil performance uses it: the zero-lift angle varies along the span (aerodynamic twist, so the lift distribution and trim move), the stall check compares each station against ITS section's CL max, and the drag bucket is blended by area. Foil mold follows the blend. With Section data = Built-in the tip gets its own fitted polar; with Polar summary the root's numbers are used for both (one set of 13).
Tip camber %	-6 / 2 / 8	Maximum camber of the tip section as % of chord. Limits -6 to 8. Negative = inverted. Typical 0 on a stab, or the root's own value with a flatter shape.
Tip camb pos %	10 / 40 / 90	Position of the tip section's maximum camber, % of chord from the leading edge. Limits 10-90. Typical 35-45.
Blend from %	0 / 40 / 95	Limits 0-95, per half span. Out to here the section is the root's; from here it blends smoothly into the tip section, reaching it at the tip. 0 = a straight blend across the whole span. Typical 30-60: keep the root section where the chord and the bending are, change it over the outer half.
TE thickness	0.1 / 0.6 / 3 mm	Limits 0.1-3 mm, and at most 3 % of the root chord. Thinned automatically near the tip. Typical 0.5-0.8 mm for wet-laid carbon in printed molds, 0.3-0.5 mm for prepreg. Thicker = tougher edge but more base drag and a risk of humming.
Points/surface	10 / 36 / 120	Limits 10-120. Typical 30-40. Cosine-spaced towards the leading edge. Above about 60 slows regeneration for no visible gain.

Planform

Label	Min / default / max	Meaning
Planform input	dropdown: Area + aspect ratio, Span + root chord (default Area + aspect ratio)	Area + aspect ratio (recommended): enter the area everyone quotes and the shape; span and root chord are solved. Span + root chord: enter the geometry directly (e.g. to copy an existing foil); area becomes an output.
Area cm ²	30 / 165 / 1000	Target stab area in cm ² . Limits 30-1000 cm ² . Typical 15-22 % of the front wing: 150-350 cm ² for surf/eFoil/pump, 80-150 for kite race. Larger = more pitch stability and damping, more drag. The notice reports the ratio to the wing.
Aspect ratio	2 / 7.5 / 14	Limits 2-14, projected span ² / projected area. Typical 4-6 surf/eFoil, 6-9 pump/downwind/race. Higher = more efficient stab and more pitch damping per area, but more tip-breach risk and flex.
Area definition	dropdown: Projected area, Developed area (default Projected area)	Which area the target refers to. Projected (top view) is what sets lift and what most brands quote. Developed is measured along the curved span line and is larger with anhedral or gull. Both are reported.
Span	80 / 330 / 1200 mm	Limits 80-1200 mm, projected tip to tip (top view). Typical 250-450 mm.
Root chord	20 / 75 / 300 mm	Limits 20-300 mm. Typical 60-110 mm.
Chord distribution	dropdown: Superellipse, Linear taper, Double taper (default Superellipse)	Superellipse: $c = c_0 (1 - (s \cdot 2y/b)^n)^{1/n}$, cut off at the end chord ratio, giving a rounded tip. Linear: straight taper to a square tip. Double taper: a steep taper from the root to Break %, then a gentler one to the tip - a wide root flaring into a slim outer wing (the full-base stab, or a high-aspect wing with a broad centre); Blend % rounds the corner between the two. Linear and double taper end in a square tip: Tip cap = Rounded + plan rounds it in plan view too.

Label	Min / default / max	Meaning
Exponent n	1.2 / 2.5 / 8	Limits 1.2-8. 2 = elliptic. 2.5-4 = fuller tips (common on stabs, keeps area outboard for damping). Above 5 approaches a rectangle with rounded corners. Typical 2.5-4.
End ratio	0.02 / 0.08 / 0.6	Limits 0.02-0.6. Chord of the small end face as a fraction of root chord. Typical 0.06-0.12 for a rounded tip (stab chords are small, so keep the end face above about 5 mm); 0.15-0.3 for a blunt tip.
Break %	5 / 28 / 60	Limits 5-60, per half span. Where the steep root taper ends and the gentle outer taper begins, as a percentage of the half span. Typical 20-30 for a full-base stab: the wide root carries the mount and the bolts, so the mount pad can be shorter and the root thinner in percent without a tubercle.
Mid ratio	0.2 / 0.62 / 1	Limits 0.2-1.0. Chord at the break as a fraction of root chord. Must be at least Tip ratio. Typical 0.55-0.7 for a full-base stab.
Blend %	0 / 10 / 30	Limits 0-30, per half span. Rounds the corner where the two tapers meet: the outline follows a smooth curve from Blend % before the break to Blend % after it, tangent to both tapers, instead of a sharp kink. 0 = sharp. Typical 8-15. Clamped so the blend never reaches the root or the tip.
Tip ratio	0.1 / 0.5 / 1	Limits 0.1-1.0. Tip chord as a fraction of root chord; the tip is square in plan view. Typical 0.4-0.7 for linear taper, 0.15-0.3 for double taper, where it is the chord at the end of the outer taper and must not exceed Mid ratio.
Min tip	checkbox, default off	On = the tip chord is widened automatically until the section at the tip cap start is at least Min tip mm thick, by raising End ratio (or Tip ratio) above the value entered. The notice reports the ratio used. Guards a thin, small-chord tip that cannot be laid up; especially useful on a stab linked to a wing, where the link sets area, aspect ratio and thickness but the tip chord is still this feature's own.
Min tip mm	0.2 / 1 / 5 mm	Minimum section thickness at the tip cap start (the last full section before the cap tapers out). Limits 0.2-5 mm. Typical 1-1.5 mm for a carbon layup: two skin plies plus a little UD; the cap beyond it is tow and resin. Only the tip chord is changed, never the thickness %. From build 239 the cap's end is also held at 0.5 mm or more (Cap end % raised for the thickness only, said in the notice): thinner, the mold's cavity cut can fail on some sections.
Stations	3 / 11 / 30	Limits 3-30, per half span. Typical 9-13 for a rounded superellipse tip, 5-7 for linear taper. Tip-cap stations are added on top, and with Tip drop or Gull dihedral about 17 through the drop (build 235), so the stab follows its drop law and the mold's parting stays inside the trailing edge.
Root tail	checkbox, default off	On = the stab's own outline carries a tail: the trailing edge is extended aft at the centreline by Tail length, fading to nothing over Tail span %, so the root ends in a rounded point behind the trailing edge like a production stab's, and the fuselage tip can be the stab itself. The extension is all behind the trailing edge whatever Align is; the section keeps its thickness in mm and is stretched aft, so the tail is thin. The area solver includes it. With it on you can turn the mount pad's Tail off; the fuselage then ends at the stab's trailing edge.
Tail length	5 / 40 / 200 mm	How far the trailing edge extends behind the root trailing edge at the centreline. Limits 5-200 mm. Typical 30-60 mm for a stab; about half the root chord gives the V of a full-base stab.
Tail span %	5 / 25 / 60	Over what part of the half span the tail fades to nothing, from the centreline. Limits 5-60 %. The fade is smooth at both ends: flat across the centreline (a rounded tail nose) and tangent to the outline where it ends. Typical 20-35.
Mirror to full span	checkbox, default on	On = complete foil. Off = right half only, for faster edits and section inspection. Reported metrics are always full-span values.

Sweep, alignment and anhedral

Label	Min / default / max	Meaning
Align line %	0 / 50 / 100	Limits 0-100 %. The chord line that stays straight (apart from Sweep aft). Typical 100 for a superellipse stab with a straight trailing edge, 25-50 for both edges curving, 0 for a double-taper full-base stab: straight leading edge, the flare and the root tail all on the trailing edge. Independent of the incidence pivot. Plan-view tip rounding is centred on the mid-chord regardless, so both tip corners round.
Sweep aft	-50 / 30 / 200 mm	Limits -50 to +200 mm, positive = aft. How far the alignment line sits aft at the tip. Typical 10-50 mm. More sweep = more yaw stability and a longer effective tail arm.
Sweep exp	0.5 / 2 / 4	Limits 0.5-4. Shape of the sweep line $x = \text{offset} (2y/b)^m$. 1 = straight (kinked at the root), 2-3 = curved and tangent at the root, 3-4 = raked tips. Typical 2.
Tip drop	-50 / 20 / 100 mm	Limits -50 to +100 mm, positive = down (anhedral). Typical 0-15 mm; negative (tips up) is used on some stabs for yaw stability. Large values can create mold undercuts.
Drop shape	dropdown: Power law, S-curve (default Power law)	How the drop is spread between Drop from % and Drop to %. Power law: $z = -\text{drop } u^e$ with Drop exp, steepening all the way to the tip (2-3 = flat centre, tips dropping late). S-curve: a smoothstep, flat at both ends and steepest in the middle, so the wing levels off again before the tip - the gull front view of many surf wings.
Drop exp	1 / 2 / 6	Limits 1-6. Typical 2-3. Shape of the drop $z = -\text{drop} (2y/b)^e$. 1 = straight from the root, 2-3 = flat centre with tips falling away.
Drop from %	0 / 0 / 70	Limits 0-70, per half span. Where the drop begins: the span line is flat (or on the gull dihedral line) out to here, then drops by Tip drop over the rest with the Drop exp shape. 0 = the drop starts at the root, the plain law. Typical 0, or 15-30 for a flat centre with a break. A flat centre with a distinct break and a near-straight drop, as on some surf wings (about 20 with Drop exp 1.3), needs this; the winglet gives the tip rise on top of it.
Drop to %	30 / 100 / 100	Limits 30-100, per half span. Where the drop is complete: beyond it the span line runs level at the full Tip drop (until a winglet bends it). Typical 100, or 85-95 for a wing that levels off before its tips.
Gull dihedral	-10 / 0 / 20 deg	Limits -10 to +20 deg, positive = up. Gull term as on the wing; rarely used on stabs. Typical 0. Needs a drop exponent above 1.
Winglet	dropdown: Off, Up, Down (default Off)	Off: the tip follows Tip drop and Gull dihedral only. Up / Down: the outer part of each half span bends through Winglet angle on an arc of Bend radius and then runs straight, with every section drawn square to the bent path, so the winglet keeps its true section at any angle up to 90 deg. Its size is Winglet area: the chord distribution continues along the bend, and the tool solves how much of the half span to bend so that area comes out. Area and aspect ratio stay the developed values of the whole half span, winglet included; the notice adds the winglet height and the projected span. Foil performance credits a winglet as extra effective span for induced drag ($0.9 \times$ its height across the pair). Foil mold molds it up to 75 deg; steeper cannot release from a vertical pull.
Winglet area	0.5 / 8 / 200	Area of each winglet, cm^2 , measured along the bend. Limits 0.5-200. Typical 4-15 for a stab. The bend starts where the outer chord distribution has this much area left to the tip, so it must fit: the winglet cannot start inside 30 % of the half span.
Winglet angle	10 / 60 / 90 deg	Limits 10-90 deg from the span plane. 90 = vertical. Typical 45-70 for a foil winglet; small angles are just a stronger tip drop and Tip drop does that with a smooth curve.
Bend radius	5 / 30 / 300 mm	Limits 5-300 mm, on the span line. The bend is an arc of this radius through Winglet angle, then straight to the tip. Typical 20-40 mm. If the arc would be longer than the winglet, the radius is reduced so the whole winglet is the bend, and the notice says so.

Label	Min / default / max	Meaning
LE tubercles	checkbox, default off	Leading-edge tubercles (as on humpback flippers and on some production wings): the leading edge moves forward and back sinusoidally along the span while the trailing edge stays put, so the chord swells at each peak. Published tests (Miklosovic 2004, Johari 2007) show a softer stall and lift kept beyond it, for a little drag and sometimes a little maximum lift before stall; for a foil that is take-off, pumping and hard turns. GEOMETRY ONLY in the sweep: Foil performance uses the smooth chord distribution and never credits or charges them in its figures; from build 232 it reports what they would do on a separate line (its Tubercles switch). Foil mold follows them exactly. Adds six stations per tubercle pitch, so regeneration slows.
Tubercle amp	0.3 / 2 / 8 mm	Limits 0.3-8 mm. Peak-to-trough travel of the leading edge. Typical 1.5-3 on a stab. The section is stretched at a peak and compressed at a trough with its thickness in mm unchanged.
Tubercle pitch	10 / 35 / 150 mm	Limits 10-150 mm. Spanwise distance from one peak to the next. Typical 25-50 on a stab. The tubercles fade in and out over half a pitch at each end of their range.
Tubercles from	3 / 15 / 90	Limits 3-90, % of the half span. Where the tubercles start, from the centreline. Some production wings start them near the centre (from about 5), others outboard (from 12-20). Typical 10-20. Not 0: a tubercle starting on the centreline broke the mold's cavity cut (build 164), and a real wing has its mount there anyway.
Tubercles to	10 / 92 / 100	Limits 10-100, % of the half span. Where the tubercles end; must be beyond Tubercles from by at least one pitch. Typical 90-95, leaving the tip cap clean.

Twist and thickness distribution

Label	Min / default / max	Meaning
Washout	-5 / 0 / 8 deg	Limits -5 to +8 deg, relative to the root incidence; positive = tip leading edge down. Typical 0 deg; stabs are normally untwisted.
Washout exp	0.5 / 1 / 4	Limits 0.5-4. Twist follows washout $(2y/b)^w$. 1 = linear, 2-3 = twist concentrated towards the tips. Typical 1.
Thickness exp	0.5 / 1.5 / 4	Limits 0.5-4. Thickness % follows root + (tip - root) $(2y/b)^p$. 1 = linear, 2-3 = keeps root thickness further out. Typical 1-2.

Incidence

Label	Min / default / max	Meaning
Incidence	-10 / -1.5 / 5 deg	Limits -10 to +5 deg, measured from the fuselage axis (X), positive = leading edge up. Typical -1 to -3 deg. Aim for a wing-minus-stab difference (decalage) of 1.5-3 deg; the notice reports geometric and aerodynamic decalage.
Pivot	dropdown: Quarter chord, Leading edge, Trailing edge (default Quarter chord)	Point each section rotates about for incidence and washout, and the line that follows the drop curve. The root pivot sits at the stab position. Quarter chord (recommended) keeps the lift centre fixed as angles change. Plan-view shape is set by the alignment line, not the pivot.

Position and link to wing

Label	Min / default / max	Meaning
Arm	200 / 650 / 1500 mm	Limits 200-1500 mm, positive = aft. Distance along the fuselage axis from the wing root pivot (world origin) to the stab root pivot. This sets the pitching moment arm and, with stab area, the tail volume - it is a design decision, not a fuselage detail. Typical 550-800 mm; short (450-550) for surf/carving, long (700-900+) for pump/downwind. Longer = more pitch stability and damping, slower pitch response. A fuselage, if you add one later, is built to match this arm rather than the other way round.
Height	-100 / 0 / 100 mm	Where the stab's seat plane sits relative to the fuselage centreline (the axis of the wing's socket, Round tube or Square), positive = up; 0 = on the centreline. The seat plane is the pad face, or the bare root surface without a pad. Pad on top (fuselage over the stab): 0 cuts the fuselage flat to half the tube under the seat, -4 leaves a flat $2 \times \sqrt{R^2 - 16}$ wide and more tube (typical -3 to -5); below the axis only. Pad underneath (stab on top): +4 does the same the other way; above the axis only. The stab is placed to this after it is built, so resizing or relinking it never moves the seat. With no socket on the wing (none, Flat hub or Flat mount) it is the stab pivot's offset from the wing pivot instead, so turning a socket on or off moves the stab; the notice says which applies. Limits -100 to +100 mm. Typical -4 (pad on top), +4 (pad underneath), 0 to +20 with no socket.
Link to wing	dropdown: Independent, Linked to wing (default Independent)	Independent: every stab parameter below is typed in directly. Linked to wing: area, aspect ratio, thickness and incidence are derived from the wing's reported values instead, using the ratios and offsets below. Camber, planform shape, sweep, anhedral, twist and tip stay independent either way.
Area ratio	0.05 / 0.15 / 0.4	Limits 0.05-0.4. Stab projected area as a fraction of the wing's projected area. Typical 0.15-0.22. Replaces the direct area input; aspect ratio still sets the span/chord split.
AR offset	-8 / -1.5 / 4	Limits -8 to +4. Added to the wing's aspect ratio to get the stab's. Typical -2 to 0: a lower-AR stab is common for extra pitch damping and robustness.
Thick offset	-6 / -2 / 2	Limits -6 to +2 %. Added to the wing's root and tip thickness % to get the stab's, so the stab reliably stays thinner (or thicker) than the wing. Typical -3 to -1.
Decalage	0 / 1.5 / 6 deg	Limits 0-6 deg. Stab incidence is set to the wing's incidence minus this value, so you tune the one number that actually sets trim instead of two absolute angles. Typical 1.5-3 deg geometric. The notice still reports the resulting geometric and aerodynamic decalage.

Tip

Label	Min / default / max	Meaning
Tip cap	dropdown: Rounded tip, Rounded + plan, Flat tip (default Rounded tip)	Rounded tip: section thickness falls along a quarter-ellipse over the cap length, rounding the tip in front view; plan-view rounding then comes only from the superellipse end ratio. Rounded + plan: the chord also shrinks along the same quarter-ellipse over the cap length, to Cap end % of the chord at the cap start, so a linear or double taper gets a rounded tip in plan view as well (the area solver allows for it). Flat tip: thickness is unchanged to the end face.
Cap length	2 / 8 / 40 mm	Limits 2-40 mm, and at most 30 % of the half span. Typical 5-12 mm.
Cap end %	5 / 30 / 80	End-face thickness as % of the tip section thickness. Limits 5-80 %. Typical 20-35 % (stab tips are small; keep the end face layable).

Section polar

Label	Min / default / max	Meaning
Section data	dropdown: Analytic, Polar summary, Built-in (default Analytic)	Built-in: fitted XFoil data, nothing to type in. E817/E818/NACA 63-412/Clark Y/MRC-16/MH 18 use one real XFoil polar each (H105 a NeuralFoil one, no XFoil polar being published), moved to your Root/Tip thick % by a NeuralFoil fit. NACA 4-digit uses the exact zero-lift angle/moment for your Camber %/Camber pos %, plus lift slope, CLmax and drag bucket fitted from real NACA polars at your thickness/camber - coarser than the fixed profiles (a fit across a family, not one measured shape); use Polar summary for higher accuracy at your exact section. Analytic (default): thin-aerofoil model - camber-line angle/moment, fixed lift slope, skin-friction drag, Section CL max from Foil performance. Polar summary: your own XFoil/XFLR5 numbers at your own Reynolds numbers, via the fields below. Run scripts/polar_summary.py (developer skill) on your polar - the tool never invents section data.
Zero-lift	-8 / -2 / 4 deg	Zero-lift angle of attack from the polar, deg (usually negative for a cambered section). Limits -8 to 4 deg. Replaces the thin-aerofoil estimate. Typical -1 to -3 deg for a few % camber. For the built-in profiles (E817, E818, NACA 63-412, Clark Y, MRC-16, MH 18, H105) use Section data = Built-in instead of typing these in.
Lift slope	4 / 6 / 7.5	Section lift-curve slope from the polar, per radian. Limits 4-7.5. Thin-aerofoil theory gives $2\pi = 6.28$. Replaces the fixed analytic value. Typical 5.5-6.5 depending on thickness and Reynolds number. For the built-in profiles (E817, E818, NACA 63-412, Clark Y, MRC-16, MH 18, H105) use Section data = Built-in instead of typing these in.
Cm c/4	-0.15 / -0.05 / 0.05	Section pitching moment about the quarter chord from the polar (usually fairly constant with CL below stall). Limits -0.15 to 0.05. Replaces the thin-aerofoil Cm0. Typical -0.03 to -0.11 for a cambered section, near 0 for symmetric. For the built-in profiles (E817, E818, NACA 63-412, Clark Y, MRC-16, MH 18, H105) use Section data = Built-in instead of typing these in.
Re 1 (M)	0.1 / 0.2 / 5	First Reynolds number the polar data below is from, in millions. Limits 0.1-5. Values are interpolated (log Re) between Re 1 and Re 2, and held flat outside that range. Typical: near your take-off Reynolds number (about 0.2-0.5 M for a wing, lower for a stab). For the built-in profiles (E817, E818, NACA 63-412, Clark Y, MRC-16, MH 18, H105) use Section data = Built-in instead of typing these in.
CLmax @Re1	0.6 / 0.85 / 1.8	Maximum section lift coefficient at Re 1. Limits 0.6-1.8. Real CLmax usually drops noticeably below the higher-Re value, which is why a single fixed CL max (the analytic fallback) can be optimistic at take-off. Typical 0.85-1.1 at low Re. For the built-in profiles (E817, E818, NACA 63-412, Clark Y, MRC-16, MH 18, H105) use Section data = Built-in instead of typing these in.
Cdmin @Re1	0.004 / 0.01 / 0.03	Minimum section drag coefficient at Re 1 (the bottom of the drag bucket). Limits 0.004-0.03. Friction drag rises as Re falls. Typical 0.008-0.018 at low Re. For the built-in profiles (E817, E818, NACA 63-412, Clark Y, MRC-16, MH 18, H105) use Section data = Built-in instead of typing these in.
CL@Cdmin 1	-0.3 / 0.3 / 1	The lift coefficient at which Cdmin occurs at Re 1 - the centre of the drag bucket. Limits -0.3 to 1.0. Typical 0.3-0.7. For the built-in profiles (E817, E818, NACA 63-412, Clark Y, MRC-16, MH 18, H105) use Section data = Built-in instead of typing these in.
k @Re1	0.005 / 0.013 / 0.05	Drag-rise rate at Re 1: $C_d = C_{dmin} + k (CL - CL@Cdmin)^2$. Limits 0.005-0.05. For your own polar, read it off two points on the drag bucket away from Cdmin and solve for k, or use polar_summary.py to fit it automatically. Typical 0.005-0.04. For the built-in profiles (E817, E818, NACA 63-412, Clark Y, MRC-16, MH 18, H105) use Section data = Built-in instead of typing these in.

Label	Min / default / max	Meaning
Re 2 (M)	0.1 / 0.5 / 5	Second Reynolds number, in millions. Limits 0.1-5. Must differ from Re 1 for interpolation to do anything. Typical: near your cruise or max-speed Reynolds number. For the built-in profiles (E817, E818, NACA 63-412, Clark Y, MRC-16, MH 18, H105) use Section data = Built-in instead of typing these in.
CLmax @Re2	0.6 / 1 / 1.8	Maximum section lift coefficient at Re 2. Limits 0.6-1.8. Typical 1.0-1.3 at higher Re. For the built-in profiles (E817, E818, NACA 63-412, Clark Y, MRC-16, MH 18, H105) use Section data = Built-in instead of typing these in.
Cdmin @Re2	0.004 / 0.007 / 0.03	Minimum section drag coefficient at Re 2. Limits 0.004-0.03. Typical 0.004-0.008 at higher Re. For the built-in profiles (E817, E818, NACA 63-412, Clark Y, MRC-16, MH 18, H105) use Section data = Built-in instead of typing these in.
CL@Cdmin 2	-0.3 / 0.3 / 1	The lift coefficient at which Cdmin occurs at Re 2. Limits -0.3 to 1.0. Typically close to CL@Cdmin 1, since the drag bucket centre moves less with Re than CLmax does. Typical 0.3-0.4. For the built-in profiles (E817, E818, NACA 63-412, Clark Y, MRC-16, MH 18, H105) use Section data = Built-in instead of typing these in.
k @Re2	0.005 / 0.01 / 0.05	Drag-rise rate at Re 2. Limits 0.005-0.05. Typical 0.01-0.035. For the built-in profiles (E817, E818, NACA 63-412, Clark Y, MRC-16, MH 18, H105) use Section data = Built-in instead of typing these in.
Invert section	checkbox, default on	Mount the stab's tabulated profile (E817, E818, NACA 63-412, Clark Y, MRC-16, MH 18, H105) upside down, camber down, so it makes the downforce a stab is there for - the convention for a cambered stab section. The right way up it LIFTS at cruise and throws the trim CG far aft. No effect on NACA 4-digit, where the sign of Camber % does this (negative = inverted).

Mount pad

Label	Min / default / max	Meaning
Mount side	dropdown: Top (fuselage above), Bottom (fuselage below) (default TOP)	Which side of the stab the fuselage is on, pad or no pad (build 199: separate from the pad, as some stabs are designed without one). Top: the fuselage passes over the stab and the bolts go up through it into the fuselage (the common production layout); the bolt heads countersink into the stab's underside and Height sets the seat at or below the centreline. Bottom: the stab sits on top of the fuselage tail and bolts down into it; heads on top, Height at or above the centreline. Without a pad the seat is the bare root skin on that side, and the Foil fuselage cuts its flat to it.
Mount pad	checkbox, default on	Adds the production-style mount to the stab root, modelled on a common production rear wing: a flat pad face on the fuselage side, faired in from the leading edge, the full root chord long, with an optional tail fairing running aft of the trailing edge to close the fuselage's end. The Foil fuselage seats on this face and the Foil mold puts bolt cones in it. Off = bare root, the fuselage seats on the curved skin.
Pad width	5 / 22 / 80 mm	Width of the pad face across the span, centred on the root. Limits 5-80 mm. Typical 20-24 mm; match or slightly under the fuselage Tail dia so the seat is full width. Also the width of the tail fairing where it leaves the trailing edge.
Pad height	0 / 6 / 20 mm	How far the flat pad face stands above the section's highest point at the root (on the pad side). Limits 0-20 mm. Typical 5-8 mm: room for the fuselage seat to be full width and the bolt heads or threads to bite. 0 puts the flat exactly on the section's highest point, so the pad is only the flat face and its ramp, no raised block (build 201). Sets the pad plane the fuselage seats on.

Label	Min / default / max	Meaning
Flat start	-100 / -5 / 100 mm	Where the flat pad face begins, in mm from the stab pivot along X (negative = ahead of it). Limits -100 to 100 mm. Typical -10 to 0 (just ahead of the quarter-chord pivot). The ramp fairs up from the leading edge to here, so it adapts to the stab; everything aft of here is the fixed interface the fuselage seats on. Must be at least 6 mm behind the leading edge with Front ramp on (room for the ramp), 2 mm with it off (a square front) - the notice warns and holds it there if not. The notice gives the leading edge's X; with a Root tail it stays where the base chord puts it, the tail being all aft.
Front ramp	checkbox, default on	Fairs the pad's front from just behind the leading edge up to Flat start with a smooth ramp. Off: the pad begins at Flat start with a square front face (build 202). Either way, where the pad-side skin is already flat at the pad plane over the pad's length - a Clark Y's flat side with Pad height 0 - no pad body is built at all: the skin itself is the seat and there is nothing to ramp or step.
Block to body	checkbox, default off	For a round tube fuselage: continues the pad as a block of Pad width from the pad face out to the fuselage's centreline, less the tube's round (Fuselage dia), so the stab carries its own mount as a molded rear wing does and the Foil fuselage only cuts its flat seat and taps the holes (build 198). Its height is minus Height by definition, so it grows and shrinks as Height moves: nothing where the tube's flat at the pad face is as wide as the pad, cheeks beside a narrower tube, a fill under the tube when the pad face is beyond its radius. Off (the default from build 228): the pad stays exactly Pad height whatever Height is - right for a flat bar, or a fuselage that brings its own seat. Typical off; on for a round tube set below the pad face.
Fuselage dia	8 / 24 / 60 mm	The Foil fuselage's diameter where the stab seats (its Tail dia), for the block's saddle. Limits 8-60 mm. Typical 20-30 (the fuselage's default 24). Type the fuselage's own value: the stab is built before the fuselage and cannot read it.
Tail fairing	checkbox, default on	Continues the pad aft of the trailing edge as a tail: full Pad width from the trailing edge to Tail start, then tapering to End width x End thick at Tail end, flat on the pad side. Its top is the same seat plane, so the fuselage's flat runs from Flat start to Tail end and its tip tapers from Tail start, whatever the stab's chord. Off = the pad ends at the trailing edge and the interface is no longer fixed.
Tail start	0 / 85 / 300 mm	Where the tail fairing and the fuselage tip begin to taper, in mm aft of the stab pivot. Limits 0-300 mm. Typical 80-100: at or a little behind the trailing edge of your biggest stab (root chord x 0.75 from a quarter-chord pivot). A stab whose trailing edge is behind this is warned and the taper starts at its trailing edge instead.
Tail end	10 / 125 / 400 mm	Where the tail fairing and the fuselage end, in mm aft of the stab pivot. Limits 10-400 mm. Typical Tail start + 35-50. Must be at least 5 mm behind Tail start and the trailing edge.
End width	1 / 4 / 30 mm	Plan width of the tail at its end. Limits 1-30 mm. Typical 3-6 mm. The taper from Pad width is concave - fast at first, then easing - like a fuselage tail.
End thick	1 / 6 / 20 mm	Thickness of the tail at its end, from the pad plane to the far surface. Limits 1-20 mm. Typical 5-7 mm: the far surface slopes from the trailing edge up to here.

Mount bolts

Label	Min / default / max	Meaning
Stab bolts	0 / 2 / 6	Through holes on the centreline for the bolts that hold the stab to the fuselage. Limits 0-6. Typical 2. The stab owns this pattern: the Foil fuselage taps its blind holes to match and the Foil mold puts undersized cones at the same positions. 0 = no holes.

Label	Min / default / max	Meaning
Bolt 1 at	-100 / 0 / 200 mm	First bolt's position in mm from the stab pivot along X (negative = ahead). Limits -100 to 200 mm. Typical 0 (the quarter chord, where the section is thickest). Fixed to the pivot, so the fuselage's tapped holes are the same for every stab. Keep it on the flat (at or behind Flat start) for a seat of constant depth.
Bolt pitch	5 / 35 / 200 mm	Spacing between bolts along X. Limits 5-200 mm. Typical 30-40 mm. Every bolt must sit inside the root or the tail; the notice warns if one does not.
Bolt	dropdown: M4, M5, M6, M8, M10, Custom hole sizes (default M5)	The bolt that holds the stab to the fuselage (standard: two M5, build 208). Sets the stab's clearance hole (close fit: M4 4.4, M5 5.4, M6 6.4, M8 8.4, M10 10.5 mm) and, through the published pattern, the Foil fuselage's tapping drill (3.3 / 4.2 / 5.0 / 6.8 / 8.5 mm), so the two can never disagree. Typical M6, M8 for a big stab. Custom hole sizes: type the clearance hole here and the tapping drill in the fuselage yourself.
Bolt dia	2 / 8.4 / 14 mm	Clearance hole diameter in the stab (Custom only). Limits 2-14 mm. Typical 8.4 (M8) or 6.4 (M6). This is the finished hole: the mold makes an undersized cone and it is drilled to this after cure. Set the matching tapping drill in Foil fuselage's Stab bolt dia.
Countersink	checkbox, default on	90 deg countersink on the face away from the pad, where the bolt heads sit (the underside with the pad on top), to the ISO 10642 head diameter of the chosen Bolt (M6 13.4, M8 17.9 mm; Custom: twice the hole). Cut in the model for fit; on the molded part it is drilled and countersunk after cure like the hole itself. Skipped for a bolt behind the trailing edge.
Log inputs	checkbox, default on	Prints every parameter on this feature to the FeatureScript console as one line, so the whole set can be pasted elsewhere (e.g. back to an AI assistant) along with the notice or CSV.

Foil performance

Load and water

Label	Min / default / max	Meaning
Total mass kg	20 / 75 / 250	Rider + board + foil (+ battery for eFoil), in kg. Limits 20-250. Typical 75-110 kg for an adult rider with board and foil; add 10-20 kg of battery for eFoil. The weight the foil must lift at every speed.
Pitch Nm	-500 / 0 / 500	External pitching moment about the centre of mass, N m, positive = nose up. Limits -500 to +500. Typical 0 unless modelling propulsion or sail forces. 0 for pump/SUP/surf (rider weight only). eFoil: with Propulsion on and a motor pod, the thrust/drag couple is added automatically, so leave this 0 unless something else acts. Wind/kite: sail or harness force times its height above the CG. Shifts the trim CG position; does not change drag.
Density kg/m ³	990 / 1025 / 1040	Water density. Limits 990-1040. Typical 1025 (sea) or 998 (fresh). 1025 seawater, 998 fresh water. Fresh water needs about 1.3 % more speed for the same lift.
Water temp C	0 / 20 / 35	Water temperature in deg C. Limits 0-35. Typical 15-25 C. Sets viscosity (Reynolds number, skin friction) and vapour pressure (cavitation). Cold water raises friction drag slightly.
Wing depth	100 / 600 / 3000 mm	Depth of the front wing below the surface. Limits 100-3000 mm. Typical 400-800 mm when riding. Used for the cavitation number and a free-surface warning: below about 2 MAC the surface causes lift loss and wave drag that are not modelled.

Speeds

Label	Min / default / max	Meaning
Take-off km/h	3 / 15 / 60	Speed at which you want to be foiling. Limits 3-60 km/h. Typical 8-12 pump/SUP, 12-16 eFoil/surf, 12-18 wind, 15-25 kite race. The notice shows how close to stall the wing is here.
Cruise km/h	4 / 20 / 80	Main operating speed; headline L/D, drag, power, trim and structure are reported here. Limits 4-80 km/h. Typical 12-18 pump/downwind, 18-25 eFoil/wind, 30-45 kite race.
Max km/h	5 / 30 / 100	Top of the analysed range, used for the cavitation check. Limits 5-100 km/h. Typical 25-35 eFoil/wind, 45-70 kite race.
Step km/h	0.5 / 1 / 5	Speed step for the CSV sweep printed to the FeatureScript console, from take-off to max speed. Limits 0.5-5 km/h. Typical 1 km/h.

Section and drag model

Label	Min / default / max	Meaning
Section CL max	0.6 / 1 / 1.8	Maximum lift coefficient of the section. Used only when the wing's Section polar (in Foil wing) is set to Analytic - if it is set to Polar summary, the polar's own CLmax (interpolated at the take-off Reynolds number) is used instead and this field is ignored. Limits 0.6-1.8. Typical 1.0-1.2 for 8-10 % thick low-camber sections, 1.2-1.4 for 12 % with 2-3 % camber, 1.4-1.6 for 14 % with 4 % camber. Real values drop at low Reynolds number. Local lift in the outer 5 % of span is ignored.
Laminar run %	0 / 0 / 60	Portion of the chord in laminar flow before transition. Limits 0-60 %. Typical 0-20 % for molded carbon parts. 0 = fully turbulent (conservative; realistic for a hand-finished or scratched surface). 20-40 % for a smooth, fair finish on a NACA 4-digit; 50-60 % only for laminar sections with a polished finish.
Joint finish	dropdown: Filleted, Lofted, Bare (hard corners), Not counted (default FILLET)	How the joints are finished, for their drag, counted from the parts' own geometry: the corners where the wing roots, stab roots and the mast's foot meet the fuselage, nacelle or pod (Hoerner: $dCD \text{ on } t^2 = 0.75 \frac{t}{c} - 0.0003/(t/c)^2$), and faces square to the flow (the socket's mouth where the tube enters, the flat hub's front and back; the socket's nose grows out of the wing over Blend length and counts as lofted). Filleted (default, the tool's joints): corners halved, faces Cd 0.15. Lofted, one section carried into the other: corners a tenth, faces 0.04 front, 0.02 back. Bare, hard corners and square edges: faces 0.8 front, 0.2 back. Not counted: as before build 240. Handbook estimates, not measurements; Lofted shows what a blended joint would buy (about 5 % of cruise drag on a socket eFoil).
Other cm ²	0 / 0 / 200	Extra drag area (Cd x area) in cm ² for anything NOT modelled. Limits 0-200. Typical 1-3 cm ² . The mast (submerged part + spray), motor pod and fuselage come from the Foil mast and Foil fuselage features, and the joints (wing, stab and mast junctions, the nacelle's and hub's faces) from Joint finish, so do not include them here; use this for bolt heads, fittings, cables and anything else.
Tubercles	checkbox, default on	With leading-edge tubercles on the Foil wing, reports what they would do as a separate line of the notice and a block of the report, never folded into the sweep's figures (build 232). The charge the lifting line can compute: a trough-first stall, the local lift rising in the troughs by the chord's share of half the tubercle height. Then the published credits on the same take-off loading and stall speed: section CL max -5 % (two-dimensional tests at low Re) to +6 % (the humpback flipper at Re 0.5 million), the flipper's +4 deg stall angle as a bound, lift held past stall; and drag before stall of unknown sign within 8 % of the wing's profile drag, as a glide range. Typical on. Nothing happens without tubercles on the wing; off hides the line.

Structure

Label	Min / default / max	Meaning
Load factor g	1 / 3 / 8	Multiple of the cruise wing lift used for the root bending check. Limits 1-8. Typical 3 for general riding, 4-5 for pumping, jumps and hard landings, 6+ for kite freestyle.
Cap stress MPa	100 / 450 / 1500	Allowable stress in the unidirectional carbon spar caps, MPa. Limits 100-1500. Typical 300-500 for wet-laid UD carbon with a safety factor (compression governs, roughly half the tensile strength), 600-900 for prepreg. Lower = more conservative.
Cap width %	10 / 35 / 70	Width of each spar cap as % of root chord. Limits 10-70 %. Typical 25-40 %. Wider caps can be thinner for the same strength.

Propulsion

Label	Min / default / max	Meaning
Propulsion	checkbox, default off	eFoil / foil-assist drivetrain. At steady speed prop thrust equals foil drag, so from the drag at each speed this finds the prop rpm (Wageningen B-series open-water KT/KQ, the same polynomials as the B-series blade feature), then motor current, throttle, battery power, Wh/km, range, top speed, and the thrust/drag couple in trim (thrust on the pod axis). Off for pump, SUP, surf, wing, wind and kite. Open-water estimate, about +/- 20 %: no pod or mast wake, no free surface, no cavitation or ventilation.
Prop dia	60 / 140 / 400 mm	Propeller diameter. Limits 60-400 mm. Typical 120-160 mm for eFoil, 100-140 mm for foil assist. The prop axis is taken as the motor pod axis for the immersion check. Bigger turns slower and more efficiently but needs more depth to stay submerged.
Prop P/D	0.5 / 0.8 / 1.4	Pitch / diameter at 0.7R. Limits 0.5-1.4 (the B-series fitted range). Typical 0.8-1.0 for eFoil. Higher pitch raises top speed and cruise efficiency, lower pitch gives more static thrust. Top speed is roughly pitch x no-load rpm less slip.
Prop EAR	0.3 / 0.3 / 1.05	Expanded blade area ratio. Limits 0.3-1.05 (the B-series fitted range). Typical 0.3-0.55 for eFoil. More area spreads the load (less cavitation) but adds blade friction.
Blades	2 / 3 / 7	Number of blades. Limits 2-7 (the B-series fitted range). Typical 2-3 for eFoil.
Prop hub	0 / 0 / 300 mm	Hub diameter at the blade roots, mm. Limits 0-300. Typical 52-63 for a direct-drive outrunner (the motor's own diameter), 30-40 on a geared inrunner drive; 0 uses the polynomials' own $0.167 \times D$ hub. The B-series polynomials were fitted on a $0.167 D$ hub, so a bigger hub blanks the inner blade: thrust is scaled by $1 - (h^3 - 0.167^3)$ and torque by $1 - (h^4 - 0.167^4)$, $h = \text{hub} / D$ (a 63 mm hub on a 140 mm prop: thrust x 0.91, torque x 0.96). With Torque const 9.55 this brings static thrust within 7 % of the e-Foil Holland measurements.
Motor kV	50 / 450 / 1000	Motor speed constant, rpm per volt at no load. Limits 50-1000. Typical 100-160 for a direct-drive 63-series outrunner, 300-500 geared. No-load prop speed = $kV \times \text{cells} \times \text{Cell V} / \text{gear ratio}$; torque per amp = $\text{Torque const} / kV$.
Cells (S)	1 / 12 / 30	Lithium cells in series; pack voltage = cells x Cell V. Limits 1-30. Typical 10-14 S for eFoil (12 S at 3.7 V = 44.4 V).
Cell V	3.0 / 3.7 / 4.2	Volts per cell under load. Limits 3.0-4.2. Typical 3.7 (nominal, mid-discharge); 4.0-4.1 for a fresh pack under load, which is what a VESC log shows on the first run; 3.4 near empty. Sets the no-load speed and the back-EMF headroom, so it moves the top speed and the cruise throttle; the pack Wh for range also scale with it.

Label	Min / default / max	Meaning
Torque const	5 / 9.55 / 12	Motor torque constant x kV, Nm per amp times rpm per volt; torque per amp = this / kV. Limits 5-12. Typical 9.55, the ideal 60 / (2 pi) that a datasheet's mNm/A x kV comes to (Flipsky 6384: 67.4 mNm/A x 140 kV = 9.44); enter the datasheet product when you have it. 8.27 was the figure builds before 229 used, which read about 13 % low on static thrust.
Gear ratio	1 / 4 / 10	Motor turns per prop turn. Limits 1-10. Typical 1 (direct drive) or 3-5 for a geared outrunner. Higher gives more prop torque, less prop rpm.
Current lim A	1 / 120 / 600	Motor current limit set in the ESC, A. Limits 1-600. Typical 80-150 A for eFoil. Sets the full-power torque, so the static thrust and the top speed.
Winding mOhm	0 / 12 / 500	Motor winding (phase) resistance, milliohm. Limits 0-500. Typical 5-40 for eFoil motors; 12 matches the B-series blade feature's check of a 450 kV 12 S drive. Near no-load rpm it caps the current the pack voltage can push. 0 = ignore (optimistic top speed).
Gearbox eff %	80 / 95 / 100	Gearbox efficiency, %. Limits 80-100. Typical 95 for one planetary stage, 100 for direct drive. The blade feature ignores gear loss, so set 100 to compare with its numbers.
ESC eff %	80 / 97 / 100	ESC efficiency, %. Limits 80-100. Typical 95-98. Motor copper loss is in the winding resistance; iron and no-load losses (550-900 W on a 63-series outrunner at speed, from a production eFoil's logs) are not modelled, so Wh/km reads low.
Pack Ah	1 / 20 / 100	Battery pack capacity, amp hours. Limits 1-100. Typical 12-30 Ah for eFoil. With Cells (S) x Cell V and Usable % this sets the range.
Usable %	50 / 90 / 100	Share of the nameplate pack energy you actually use before cut-off or voltage sag ends the ride, %. Limits 50-100. Typical 80-90.
Print report	checkbox, default on	Prints the full report and a CSV speed sweep to the FeatureScript console, ready to paste into a spreadsheet.

Foil mold

Part

Label	Min / default / max	Meaning
Part	selection	The wing or stabiliser solid to mold (the whole body, tube socket or mount pad included). One Foil mold per component - add a separate instance for the wing and for the stab.
Source model	dropdown: Wing, Stabiliser, Mast, Fuselage (default Wing)	Which feature built Part; it must match the body selected above. Wing / Stabiliser: the parting follows that feature's own planform, twist, droop and section. Fuselage (build 213): parted top and bottom along its sections' mid-height, the profile the Foil fuselage publishes, so the mast pocket is a core on the upper half and the tongue a pocket in the lower; the vertical bolt holes (the hub's, countersinks included, and the stab's) are filled in the cavity - drill and countersink after cure; no caps, stiffness check or templates. Mast: laid flat 400 mm below the origin, parting on its mid-plane, three parts (left, right and a tray for the plate); the plate and the motor pod are molded with it, the pod with a plug from its cavity. Cavities and the tray are cut from the part as it stands, so direct edits above this feature are followed; only the bolt pins stay on the Foil mast's pattern.

Label	Min / default / max	Meaning
Detail	dropdown: Print: the full set, Preview: halves only, fast (default PRINT)	Print: everything for the printer - groove and vents, tile seams and keys, printed-core segments, the template plate. Preview: only the two halves with the cavity, parting, plug and cones, one tile each, so a studio with molds regenerates in a fraction of the time while the wing and the joint are still being designed; the layup, stiffness and closing numbers are still reported and the notice says PREVIEW. Switch to Print once for the STLs.
Mold of	dropdown: The part, Its foam core (default PART)	The part: the two halves form the part's outside, as always. Its foam core: needs Core = Foam core in the layup group; the feature first builds the core body itself - the part's sections offset inward by the skins, with a groove in each face where the UD caps run, so the finished core plus caps plus skins is the part - and then, by Core made, either molds THAT (the foam cast or shaped in a mold) or splits it into sections to mill from foam sheet, tabbed in frames for two-sided cutting. No socket plug, bolt cones or mount pad in a core mold. Add it as a second Foil mold on the same part; the molded core body is left as its own part for reference.
Core made	dropdown: Molded, Milled (default MOLDED)	How the foam core is made. Molded: the core body plus a two-half mold of it, so the foam is cast or shaped in the mold (as before). Milled: no mold - the core body alone, split along the span into sections that fit Printer X / Y (the mill bed here) and Sheet thick with their droop and twist, optionally with tabs at its mid-height sticking out of the leading and trailing edges (Tabs per edge, spread along the section) to hold it in the stock while both faces are milled - the span ends stay clean for the glue joint, and the leading and trailing edges are sanded to shape once the tabs are cut: mill the top face, turn the stock over, mill the bottom face, cut the tabs. The stock itself is not modelled - set it in your CAM so the tabs reach it, or leave Hold tabs off and let the CAM hold the part its own way. Dowel holes cross every joint as for the printed core.
Sheet thick	5 / 25 / 100 mm	Thickness of the foam sheet the sections are milled from. Limits 5-100 mm. Each section is cut short enough to fit inside it, droop and twist included (more sections for a thinner sheet); the notice reports what the tallest section needs and warns when the sheet is still thinner. Typical 20-30 mm for a wing core, 10-15 for a stab.
Hold tabs	checkbox, default on	Model the holding tabs on each section: Tabs per edge on the leading edge and as many on the trailing edge, spread along the section's length, at the section's mid-height, reaching Hold tab len out into the stock and Hold tab in into the foam. On the edges, not the span ends, so the joint faces the sections glue on stay clean; cut the tabs after the second side and sand the leading and trailing edges back to shape (at a thin trailing edge the tab stands proud of the surface). Off = plain sections; add the tabs in your CAM instead (most 2.5D and 3D CAM can hold a two-sided part with its own tabs or a fixture).
Tabs per edge	1 / 2 / 6	How many tabs along each edge of a section, spread evenly along its length (2 = at a quarter and three quarters). Limits 1-6. Typical 2; 3 or 4 on a long section or a soft foam, 1 on a short tip section.
Hold tab len	5 / 25 / 100 mm	How far each tab reaches out from the leading or trailing edge into the stock. Limits 5-100 mm. Typical 20-30 mm: long enough to bridge the cutter's path round the section and sit in uncut stock. The bed check counts a tab length ahead of and behind the section.
Hold tab in	2 / 12 / 50 mm	How far each tab reaches into the section from its edge, so it is held by the foam and not just the edge. Limits 2-50 mm. Typical 10-15 mm; more at a thin trailing edge, where the bar stands proud until the edge is sanded, less if the cap groove must stay clear (the tabs sit at mid-height, below the grooves).
Hold tab wide	3 / 8 / 30 mm	Width of the tabs along the span. Limits 3-30 mm. Typical 6-10 mm in foam.

Label	Min / default / max	Meaning
Hold tab thick	1 / 3 / 10 mm	Thickness of the tabs, centred on the section's mid-height. Limits 1-10 mm. Typical 2-4 mm; where the section is thinner than this the tab stands proud and is sanded back after cutting.
Parts group	dropdown: Closed: one entry in the parts list, Open: parts stay listed, group under Composite parts, Off: loose parts (default OFF)	Off (default): every mold piece is a normal part, named. Closed / Open collect everything this feature makes - shells, tiles, plugs, pins and the template plate - into one composite part named after the source (Wing mold, Stab mold, Mast mold). Closed: the parts list shows one expandable entry and the pieces live inside it (expand it to reach a tile; export from there). Open: the pieces stay listed as parts and the group appears under Composite parts, which is how Onshape treats open composites. Closed can hide every piece inside a group that is itself hidden, which is why the default is Off.
Split stations	5 / 15 / 80	Spanwise stations used to build the parting surface, root to tip. Limits 5-80. Typical 15-25; 22 or more for a wing with a Tip profile (a surf wing with a NACA tip needed 22, and failed at 15); 40-80 for a tip with all its sweep and droop concentrated in the last fifth of the span (Sweep exp / Drop exp of 3-4), where the parting must turn sharply. Each station is a sketch and a ruled loft, so regeneration time grows with the count. Packed toward the tip by Tip bias.
Tip bias	1 / 2 / 4	How strongly the stations crowd toward the tip: station i of n sits at span fraction $1 - (1 - i/n)^{\text{bias}}$. Limits 1-4. Typical 2. 1 = evenly spaced; 2 = close to the cosine packing used before; 3-4 = most stations in the outer third, for planforms whose sweep and droop are concentrated there. Raise this before raising Split stations.

Mold body

Label	Min / default / max	Meaning
Flange width	10 / 25 / 60 mm	Mold material around the planform, from the part's edge to the outside of the block. Limits 10-60 mm. Typical 20-30 mm for a clamped printed mold: wide enough to seat clamps and a pinch-off groove, narrow enough not to waste print time. The parting surface runs out through the flange, so the two halves meet on it all the way round.
Base thickness	5 / 20 / 40 mm	Mold material between the cavity and the outer (clamped) face of each half, measured at the deepest point. Limits 5-40 mm. Typical 15-25 mm for a printed mold clamped against a rigid board: enough not to flex between clamps or print through to the cavity, without a long print, and it is the layer the tile keys sit in (at least Pin dia + 4 mm and Key height + 4 mm). The slicer sets walls and infill; the body is solid here.

Socket

Label	Min / default / max	Meaning
Socket plug	checkbox, default on	Wing molds only, when the Foil wing has a Round tube socket or a Square socket on. The socket's bore is not molded by the halves (two half cores would leave a seam down the bore): the cavity is cut from the wing as modelled, the bore's core is severed from the halves by a channel behind the rear face and becomes the plug - the bore's own shape, direct edits included - on a handle Plug extension long in the channel. Both halves get a channel behind the nacelle's rear face that holds the plug coaxial when the mold is closed: half-round for the Round socket, for the Square socket the bore's rounded rectangle, its corner the bore's corner + Pin fit. Pull the plug after cure and drill the bolt holes to the wing's pattern. Off = the bore and bolt holes are molded as half cores (not recommended).

Label	Min / default / max	Meaning
Plug extension	10 / 20 / 60 mm	How far the plug reaches behind the nacelle's rear face into the channel in the flanges. Limits 10-60 mm, and at most Flange width - 3 mm. Typical 15-20 mm: enough to hold it square and to grip when pulling. Pin fit sets the channel clearance.

Bolt cones

Label	Min / default / max	Meaning
Bolt cones	checkbox, default on	Tapered cones in the bolt holes, wide at the face the bolt enters, ending Cone web short of the far face: each hole comes out undersized and on pattern and releases with its half; drill to size after cure. Stab: at each Mount bolt, from the countersunk face, the through hole filled so neither half molds a pin. Wing: the Flat hub's blind holes from the pocket floor in the upper half, or with Bolts from = Wing underside its through holes from the lower half's countersinks to Cone web under the floor, the holes filled; with Socket plug on, the socket's bolt shanks from their countersinks. Fuselage: every hole, from the face its bolt enters. Never the Flat mount's holes. Off: the stab's and the flat mount's holes mold as pins from both halves, the hub's from the upper half (both halves from the underside); the socket's shanks and the fuselage's holes are filled, to drill after cure.
Cone dia	2 / 5 / 12 mm	Diameter of each cone at the pad face, the wide end. Limits 2-12 mm. Typical 4-5 mm for M6-M8, leaving 1.5-2 mm a side to drill out to clearance. Keep it below the fuselage's Stab bolt dia so the drilled hole cleans the molded surface.
Cone taper	2 / 6 / 15 deg	Half-angle of the cone. Limits 2-15 deg. Typical 5-8 deg: enough draft to pull a clamped part off without levering, on a hole that will be drilled anyway.
Cone web	0.5 / 1 / 5 mm	Laminate left between the cone tip and the top surface, so the cone never touches the upper half and the hole is closed by a thin web you drill through. Limits 0.5-5 mm. Typical 1-1.5 mm.

Pinch-off

Label	Min / default / max	Meaning
Pinch-off groove	checkbox, default on	A channel in the lower half's parting face running right round the cavity: a narrow land at the cavity edge where the closing mold pinches the laminate and squeezes the excess resin and fibre out, then a groove for that flash to run into. Follows the planform (leading edge, tips, trailing edge, the socket's nacelle) and the parting surface down the dropped tips. Off for a mold you will bag rather than clamp.
Land width	1 / 3 / 10 mm	Flat land between the cavity edge and the groove. Limits 1-10 mm. Typical 2-4 mm: narrow enough to build real pinch pressure, wide enough to print cleanly and survive the clamps.
Groove width	1 / 4 / 10 mm	Width of the flash groove. Limits 1-10 mm. Typical 3-5 mm.
Groove depth	0.5 / 1.5 / 5 mm	Depth of the flash groove below the parting face. Limits 0.5-5 mm. Typical 1-2 mm for a clamped mold at 5 % overcharge; 3 mm with a 6 mm groove for a bagged mold, whose groove is also the vent path. The notice reports the groove's volume against the overcharge's flash and warns when it is too small.

Label	Min / default / max	Meaning
Land gap	0 / 0 / 2 mm	How far the land sits below the parting face (build 244). 0: the halves touch on the land and pinch whatever runs out of the cavity to nothing, the earlier behaviour. Above 0: the lower half's land is lowered by this much, so the skin or a glass ply carried out of the cavity across the land is squeezed to this thickness instead of cut, and the halves bear on the flange outside the groove. Limits 0-2 mm, and at least 0.2 mm under Groove depth. Typical 0.2-0.5: the cured thickness of the plies you carry over, about 0.22 mm per 200 gsm ply at 50 % fibre.

Closing

Label	Min / default / max	Meaning
Closing	dropdown: Clamps against a board, Vacuum bag round the mold (default CLAMPS)	How the closed mold is pressed shut while the resin cures. Clamps: G or F clamps on the flanges against a rigid board, the default, any force you like but concentrated at the clamp points. Vacuum bag: the whole closed mold, tiles glued, goes inside a bag with breather over it and the atmosphere clamps it, uniformly, with a closing force of the bag pressure times the block's plan area (about 5.7 kN on a stab mold, 14.5 kN on a 950 cm ² wing mold at 85 kPa) and a pressure on the laminate of that force over the part's plan area, 1.5-4 bar. With the bag: the block's outer edges are rounded so the bag is not cut, the pinch-off groove is vented to the outside at each span end so the bag can evacuate it (a sealed groove is a pocket of air the flash cannot enter), and Overcharge should drop to 3-5 %. Reported in the notice with the groove volume against the flash volume.
Bag vacuum kPa	50 / 85 / 100	Vacuum the pump holds in the bag, below atmospheric, in kPa. Limits 50-100. Typical 80-90 for a shop pump (100 kPa is a perfect vacuum, unreachable). Sets the closing force and the pressure on the laminate the notice reports.
Groove vents	checkbox, default on	A 1 mm slot from the pinch-off groove out through the flange to the block's outer face at each span end, in the lower half, as deep as the groove. Inside a bag the groove is otherwise a sealed pocket of air at atmospheric pressure, so the flash cannot flow into it and the halves stop short; the vents let the bag evacuate the groove, and the laminate through it, before the resin gels. Needs the Pinch-off groove on.
Edge round	0 / 5 / 10 mm	Radius on the block's twelve outer edges so the bag wraps them without being cut. Limits 0-10 mm. Typical 4-6. 0 leaves them sharp (the tiles' joint faces and the parting face are never rounded). Not applied to the mast's plate tray.
Pry sections	checkbox, default on	Short V pockets across the parting line on the block's outer faces, just big enough to start a wedge or a flat bar between the halves (build 242). Not at the corners and not the whole edge: one in the middle of every stretch between tile seams, so each tile of either half gets one on each face and none straddles a joint, and more at Pry spacing along a long stretch. Open the mold by working the wedges in alternately, a little at each, so the halves come apart square along the pull. Off: plain faces.
Pry length	10 / 30 / 100 mm	Length of each pry section along the face. Limits 10-100 mm. Typical 25-40: room for a plastic wedge or a flat screwdriver, no more. Longer sections give less flange for the clamps.
Pry depth	1 / 3 / 8 mm	How far each 45 deg pocket runs into each half from the face, so the V opens 2 x this across the parting. Limits 1-8 mm. Typical 3: a wedge's tip goes in 6 mm wide. Keep it well short of the keys and the pinch-off land.
Pry spacing	60 / 150 / 600 mm	Largest gap between pry sections along a stretch of face between two seams. Limits 60-600 mm. Typical 150. A tile shorter than this gets one, in its middle.

Label	Min / default / max	Meaning
Ejectors	dropdown: Off, Dowel holes (wax-filled), Printed flush plugs (default DOWEL)	Holes through each half into the cavity so a part that stays in a half can be pushed out (build 243). Placed only where the part is solid and both faces are smooth, checked by rays: the wing or stab root zone either side of the joint, near each end of a mast, along a fuselage. Dowel holes: a plain hole of Ejector dia; fill it flush with filleting wax before the layup, tap a dowel in to push the part out (a small round witness). Printed flush plugs (build 245): a printed plug with its head on the cavity side, in a counterbore in the cavity face, the head's face cut from the cavity; drop it in from the cavity before the layup, the laminate's pressure seats it, a punch from outside pushes it and the part inward (a faint ring at the head). Off: none.
Ejector dia	3 / 6 / 12 mm	Diameter of each ejector hole: a stock dowel's, or a printed plug's shank. Limits 3-12 mm. Typical 6. Bigger spreads the push over more laminate, but needs a wider smooth patch to land on.
Plug fit	0.05 / 0.15 / 0.5 mm	Diametral clearance between a printed plug and its hole. Limits 0.05-0.5 mm. Typical 0.15 for PETG on a tuned printer: tight enough that resin does not run past it, loose enough to punch out. The plug's head, on the cavity side, is 4 mm wider than the shank and 2.5 mm deep, in a counterbore in the cavity face.

Printer

Label	Min / default / max	Meaning
Printer X	50 / 250 / 1000 mm	Build volume across the chord (tile width). Limits 50-1000 mm. Typical 200-300. The report shows how many tiles each half needs; a tile can be rotated on the bed, so enter the bed's shorter side here and its longer side as Printer Y.
Printer Y	50 / 250 / 1000 mm	Build volume along the span (tile length). Limits 50-1000 mm. Typical 200-300.
Printer Z	50 / 250 / 1000 mm	Build height. Limits 50-1000 mm. Typical 200-300. Each half is printed cavity-up, so this only has to clear the half's own height (cavity depth plus Base thickness).
Tile margin	0 / 5 / 30 mm	Clearance kept between a tile and the printer's limits in every axis. Limits 0-30 mm. Typical 5 mm for brims, skirts and bed-edge adhesion.
Stagger joints	checkbox, default on	Offsets the upper half's spanwise cuts by half a tile from the lower half's, so no joint runs through both halves at the same place: the assembled mold braces itself and the seams never line up through the laminate. The upper half then has one extra tile (two half-length end tiles). Off = the same cuts in both halves.

Joints

Label	Min / default / max	Meaning
Tile joint	dropdown: Dowels, Puzzle inlay (default DOWELS)	How the tiles of each half are joined across their seams (build 235). Dowels (every earlier build): printed keys or dowel holes in the tiles' end faces, in the base layer (Key style, Pin dia). Puzzle inlay: for molds milled on a 3-axis router, which cannot reach a tile's end face - a bow-tie pocket cut from the top into the parting-face flange on each side of the cavity, straddling every seam, with a key built as a part for each, to cut from flat sheet and glue in: it locks the tiles together, and since each pocket floor is milled the same depth below its own parting face, in the cavity's setup, it pulls the parting faces, and so the cavities, flush. A milled core (Core made = Milled) gets the same pockets on its top and bottom faces across every joint. The half keys are unchanged.

Label	Min / default / max	Meaning
Inlay length	10 / 30 / 80 mm	Length of each bow-tie key across its seam, centred on it. Limits 10-80 mm. Typical 25-40; longer grips more of each tile. On a drooped wing the pocket's floor and its key tilt with the flange, and the pocket grows at its ends to let the square-edged key in (the notice gives the tilt and that allowance).
Inlay width	5 / 12 / 40 mm	Width of the bow-tie at its two ends. Limits 5-40 mm. Typical 10-14; with 2 mm each side it must fit the flange left beyond the land and the groove ($25 - 3 - 4 = 18$ mm with the defaults), or that pocket is skipped with the Flange width it needs.
Inlay waist	2 / 6 / 38 mm	Width of the bow-tie at the seam, its narrowest; at most Inlay width - 2 mm. Limits 2-38 mm. Typical half the Inlay width: the flanks' angle is what locks the tiles together, so a narrower waist locks harder but leaves less key across the seam.
Inlay depth	2 / 5 / 10 mm	Depth of each pocket into its half, measured along the normal of the flange under it: the floor follows the flange (a plane fitted to it), the walls stay vertical. Limits 2-10 mm. Typical 4-6 in a mold. A milled core's pockets take this or 25 % of the core's thickness at the key, whichever is less, below a flat floor.
Cutter dia	1 / 3 / 8 mm	Diameter of the end mill that cuts the pockets: it sets their inside corners' radius, and the keys' outside corners are rounded the same so they drop in; the keys keep the round it leaves in their waist, and the pockets' waist corners are rounded to clear it by the Glue gap. Limits 1-8 mm. Typical 3-4.
Glue gap	0 / 0.1 / 0.5 mm	Gap each side between a key and its pocket, added to the pocket's outline. Limits 0-0.5 mm. Typical 0.1 for epoxy, 0 for a press fit.
Sand allow	0 / 1 / 3 mm	Milled core only: extra thickness on each key over its pocket's depth, so it stands proud of the core and is sanded to the core's profile after gluing. Limits 0-3 mm. Typical 1.
Key flush	0 / 0.15 / 1 mm	How far each key sits below the parting face, along the flange's normal: its thickness is Inlay depth less this, so a key can never stop the mold closing. Limits 0-1 mm. Typical 0.1-0.2.
Key style	dropdown: Printed keys, Dowel holes (default Printed keys)	How tiles locate on each other and the halves on one another. Printed keys: a tapered round boss on one side of every joint and a matching socket on the other, printed with the mold - nothing to buy. Bosses always point +Y (span joints), +X (chord joints) and up from the lower half, so they print without support with the halves cavity-up. Dowel holes: a plain hole either side of every joint for a steel or wooden dowel. With Tile joint = Puzzle inlay it sets the half keys only.
Pin dia	3 / 12 / 30 mm	Diameter at the base of each tile-joint key (or the tile dowel). Limits 3-30 mm, and at most Base thickness - 4 mm (the keys sit in the base layer) and Flange width - 4 mm. Typical 10-16 mm for printed keys, 6-8 mm for steel dowels. Two per spanwise joint sit in the front and rear flanges; one per tile crosses each chordwise joint under the cavity. All of them sit in the base layer of each half, so none can break into the cavity.
Half keys	checkbox, default on	Registration between the two halves: a key (or dowel hole) through the parting surface in the front and rear flanges, one pair per spanwise tile a quarter tile in from the tile joint - clear of every cut and tile key in both halves. Printed keys stand up from the lower half into sockets in the upper. Off = the halves locate on the clamps and board alone.
Key dia	3 / 14 / 30 mm	Base diameter of the half-to-half keys (or dowel). Limits 3-30 mm, and at most Flange width - 4 mm. Typical 12-20 mm for printed keys, 6-8 mm for dowels.
Key height	2 / 8 / 25 mm	Height of every printed boss above its face; the socket is 0.3 mm deeper so the boss bottoms on the joint face, not in the socket. Limits 2-25 mm, and at most Base thickness - 4 mm (the socket must not break through the other side). Typical 8-12 mm. Taller locates better but the tip must stay over 2 mm across (see Key draft).
Key draft	3 / 12 / 30 deg	Taper of the boss sides, so it finds its socket as the parts come together. Limits 3-30 deg. Typical 10-15 deg. Tip diameter = base - 2 x height x tan(draft), and must stay over 2 mm.

Label	Min / default / max	Meaning
Pin length	10 / 24 / 60 mm	Total tile dowel length, half in each tile. Limits 10-60 mm. Typical 20-30 mm.
Key length	8 / 16 / 40 mm	Total half-to-half dowel length, half in each half. Limits 8-40 mm, and at most 2 x (Base thickness - 3 mm) so the hole never breaks through the thinner half at a dropped tip. Typical 16-20 mm.
Pin fit	0 / 0.2 / 0.5 mm	Clearance added on the radius of every socket over its key, or to the hole diameter over the dowel. Limits 0-0.5 mm. Typical 0.15-0.25 mm for printed key in printed socket (add more if your printer prints holes small); 0.1-0.2 for a steel dowel.

Layup

Label	Min / default / max	Meaning
Skin plies	0 / 2 / 10	Bidirectional (woven) plies on each face of the part, full planform, laid first against the mold. Limits 0-10. Typical 1-2 for a foil wing or stab, 2-3 for a mast. They give the surface finish and torsional stiffness; the UD caps and tow carry the bending. Sized from the part's own surface area.
Skin gsm	50 / 200 / 800	Areal weight of the woven skin cloth, g/m2. Limits 50-800. Typical 160-245 (2x2 twill), 100-200 for a fine finish. Cured ply thickness is derived from this and Fibre vol %: $\text{gsm} / (1780 \times V_f)$, which gives 0.22 mm for 200 gsm at 50 %.
UD gsm	50 / 300 / 1200	Areal weight of the unidirectional spar-cap fabric, g/m2. Limits 50-1200. Typical 200-300 wet layup, 150-300 prepreg, 400-600 for a thick root. Sets the cured UD ply thickness ($\text{gsm} / (1780 \times V_f)$) and so the cap ply count.
Cap width %	10 / 40 / 70	Width of the UD spar caps as % of local chord, centred on the section's thickest point. Limits 10-70 %. Typical 35-50 %. Wider caps move fibre from tow into UD, which is where bending strength comes from, at the cost of more UD to cut.
Cap thick %	0 / 60 / 100	Thickness of the two UD caps together (top + bottom) as % of the core thickness at the thickest point - the local section less both skins. Limits 0-100 %. Typical 50-70 %. The cap ply count follows the section taper, dropping plies along the span - the console prints the cut list, per cap: cut every UD template twice, one for each face. What the skins and caps do not fill is filled with tow, so fewer skin plies means more UD at the same %.
Core	dropdown: Tow fill, Foam core, Monolithic, Printed core (default Tow fill)	What fills the section between the skins and the UD caps. Tow fill: carbon roving laid along the span, wetted out, the whole part is laminate (the heaviest and stiffest fill). Foam core: a shaped structural foam (Corecell, PVC, PET) inside the skins and caps, the way most production wings are built - a third to a half lighter, and the caps and skins carry all the bending, so the stiffness check drops; a second Foil mold with Mold of = Its foam core makes it, molded or milled from sheet (Core made). Monolithic: woven plies fill the section, as on high-modulus production wings; same weight as tow, bought as cloth. Printed core: the same core shape as the foam core, 3D printed instead - this feature generates it as a part, split to your printer bed along the span, to be glued end to end and laid up in the part mold like a foam core; no core mold needed.
Core kg/m ³	30 / 85 / 1300	Density of the core as built. Limits 30-1300. Typical: foam 80-100 (Corecell M80 and PVC H80 about 85 and 80, PET 100-110), 60 for a light core in a big low-speed wing, 130-200 for a hard core under a mast plate. Printed: the print's average density, walls and infill together - PLA at 15 % gyroid with 2 walls is about 350-450, PETG similar, 1240 for solid PLA.

Label	Min / default / max	Meaning
Core GPa	0.02 / 0.1 / 5	Modulus of the core along the span, for the stiffness check. Limits 0.02-5. Typical: foam 0.08-0.12 for an 80-100 kg/m ³ structural foam (Corecell M80 about 0.1), 0.2-0.3 at 200. Printed: about 0.5-1 for PLA at 15-20 % infill with walls, 3.5 solid; PETG 20 % lower. Small against carbon either way: the caps and skins do the work.
Core shear MPa	0 / 0 / 20	Shear strength of the core, for the check of the shear it carries between the UD caps (wing, stab and mast). Limits 0-20 MPa. 0 (the default) estimates it from Core kg/m ³ as a PVC structural foam: about 1.15 at 80, 2.2 at 130 and 3.5 at 200. Enter the maker's figure for another foam (Corecell M80 about 1.0, PET 100 about 0.9). Typical: foam 1-3.5, a printed lattice unknown - it has no published figure: break a coupon of the same layup in three-point bending and enter what it gives; until then the estimate is only a placeholder.
Core from mast	0 / 20 / 100 mm	Fuselage only: the core starts this far behind the mast's trailing edge; everything ahead of it - the nose, the hub bolts, the mast pocket and the stretch the wing's twist and the mast's load pass through - is laid up solid woven (build 219). Limits 0-100 mm. Typical 15-30 (default 20). The core ends Core end gap ahead of the stab's seat block, which stays solid for the stab's bolts.
Core end gap	0 / 5 / 50 mm	Fuselage only: how far ahead of the stab's seat block the core stops, so the seat and its tapped holes are solid laminate. Limits 0-50 mm. Typical 5-10.
Tail UD MPa	100 / 300 / 600	Fuselage only: the working stress the UD strips on the tail core's top and bottom are sized to under the stab's lift at the load factor (Foil performance). Limits 100-600. Typical 250-350 (default 300, two thirds of UD's 450); lower for more plies and a stiffer tail. The ply count per station and the cut list come from it.
Clear joint	checkbox, default on	Wing with a joint on (Round tube or Square socket, Flat hub or Flat mount): keep the core clear of it. On: the core is two halves starting Core clear outboard of the joint's half width - the nacelle's, the hub's, or for the Flat mount the bolt heads' radius + 3 mm or half the Mount pad's width, whichever is wider - and the root zone between them is solid laminate, counted in the layup. The core mold (Mold of = Its foam core) clears the same zone. Off: one core through the root as if there were no joint, which is what to choose when the joint is added by hand afterwards or the root is cut out on the bench; the core then occupies the joint's space in the model and the layup counts core where its wall or bolts will be. No effect without a joint.
Core clear	0 / 15 / 100 mm	With Clear joint on: the core stops this far outboard of the joint's half width on each side (the nacelle's, the hub's, or the Flat mount's bolt heads + 3 mm or half its pad, whichever is wider), and the root zone between the two core halves is solid laminate (counted in the layup as tow fill). Limits 0-100 mm. Typical 10-25: the joint and the laminate around it carry the fuselage's bending and the stab arm's moment into the wing, so nothing hollow belongs there. 0 stops the core at the joint's edge. No effect without a joint.
Tow tex	100 / 800 / 4000	Linear density of the carbon tow (roving) that fills the lens core, leading and trailing edges and the socket nacelle, g/km. Limits 100-4000. Typical 800 (12k); 3k = 200, 24k = 1600 tex. Used only to turn the tow mass into a length to buy.
Fibre vol %	30 / 50 / 65	Fibre volume fraction of the cured laminate. Limits 30-65 %. Typical 45-50 wet layup clamped in a matched mold, 55-60 vacuum-bagged or prepreg, 35-40 wet hand layup with no pressure. Sets the cured ply thicknesses and the split of the part's volume between carbon (1.78 g/cm ³) and epoxy (1.15 g/cm ³).

Label	Min / default / max	Meaning
Overcharge %	0 / 8 / 30	Extra material laid over the exact cavity fill, as %. Limits 0-30 %. Typical 5-10 % for a clamped matched-die mold: closing under pressure squeezes the excess out as flash at the pinch-off, which is what packs the laminate void-free; 3-5 % with Closing = Vacuum bag, whose 1-4 bar closes to the land but cannot force much flash out. The notice compares the flash volume with what the groove holds. 0 for a loose vacuum bag. Scales the ply counts and every material figure.
Cloth waste %	0 / 25 / 100	Cutting waste added to the woven and UD areas to buy. Limits 0-100 %. Typical 20-30 % (bias cuts, tapered UD plies, selvage).
Resin waste %	0 / 40 / 150	Resin mixed beyond what stays in the part: mixing-pot loss, wet-out of the tow, brushes, and the flash squeezed out at the pinch-off. Limits 0-150 %. Typical 30-50 % wet layup, 10 % prepreg (only the tow needs wetting).
Cap run-out	0 / 0 / 100 mm	Mast only. Length each UD cap ply runs past the plate's underside, folded outward over the root fillet onto the plate between its fill plies, so the cap's tension enters the plate by shear instead of peeling off the corner. Limits 0-100 mm. 0 = as far as the plate edge allows (2 mm short of it). Typical 30-50 mm; the stiffness line says how much the junction needs.
Tab plies	0 / 4 / 12	Mast only. UD tab plies per face interleaved with the cap plies at the plate: each runs Tab length down the mast face and Cap run-out out over the plate, alternating with the caps so the two surfaces are stitched together through the stack rather than by one bond line. Limits 0-12. Typical 3-5. They take their thickness from the tow core over Tab length; the layup line warns if that core runs out.
Tab length	10 / 50 / 200 mm	Mast only. How far each tab ply runs down the mast face from the plate. Limits 10-200 mm. Typical 40-80 mm, at least the Cap run-out.

Stiffness

Label	Min / default / max	Meaning
UD GPa	80 / 120 / 200	Tensile modulus of the cured UD carbon along the fibre. Limits 80-200. Typical 110-130 at 50 % fibre volume wet layup, 140-160 prepreg, 200+ for high-modulus fibre. Sets the spar caps' contribution to bending stiffness.
Woven GPa	30 / 60 / 100	In-plane modulus of the cured woven skin along the span. Limits 30-100. Typical 55-65 for a 0/90 twill at 50 % fibre volume; about 15 if the skin is laid at 45 deg, in which case it adds torsion, not bending.
Tow GPa	10 / 30 / 80	Effective modulus of the tow-filled core along the span. Limits 10-80. Typical 30 for tow laid roughly along the span, 10 for chopped or random fill. A foam core uses Core GPa, a monolithic fill uses Woven GPa.
Mast side g	0.2 / 1 / 3	Mast load case: a sideways force of this many times the all-up weight, applied at the fuselage end with the plate held by the board and rider, bending the mast about its chord - a hard carve or a fall. Limits 0.2-3. Typical 0.5-1. Reported as the deflection at the fuselage end and the UD cap stress at the plate, with the mast's own layup, taper and thickening; the moment peaks at the plate, which is why the top is thickened.
Shear allow	10 / 30 / 80	Interlaminar shear strength of the cured laminate, MPa, for the junction check at the mast plate: the cap force at the plate divided by the bonded run-out area (the cap's plate face plus both faces of every tab ply) against this value with a factor of 2. Limits 10-80. Typical 25-35 wet layup, 50-70 prepreg. The line says the run-out the junction needs at this allowable.

Cut templates

Label	Min / default / max	Meaning
Cut templates	checkbox, default off	Makes a flat 1 mm plate beside the mold with every fabric shape cut through it: the woven skin outline (the planform developed along the droop, cut once per skin ply per face) and one tapered strip per UD cap ply from the cut list (cut twice, one per face - the tally holes say so), each grown by Trim margin. Right-click the plate's top face in Onshape and Export as DXF to get every outline in one file for a cutter or a printed paper template. The console prints the order they appear in. Off = no plate.
Trim margin	0 / 5 / 20 mm	Allowance added round every template outline, for trimming and for the fabric's own slack. Limits 0-20 mm. Typical 5 mm woven, 3-5 mm UD.
Template gap	5 / 10 / 40 mm	Space between neighbouring outlines on the plate. Limits 5-40 mm. Typical 10 mm.
Log inputs	checkbox, default on	Prints every parameter on this feature to the FeatureScript console as one line, so the whole set can be pasted elsewhere (e.g. back to an AI assistant) along with the notice.

Foil mast

Mast

Label	Min / default / max	Meaning
Height	300 / 750 / 1300 mm	Mast length from its base (top of the fuselage) to the underside of the board plate. Limits 300-1300 mm. Typical 600-1000 mm; eFoil masts often 650-850 mm. Longer = more clearance in chop, more drag and more bending at the base.
Width	60 / 120 / 200 mm	Mast chord (fore-aft width). Limits 60-200 mm. Typical 100-140 mm. Wider = stiffer in bending and torsion, more wetted area and drag.
Thickness	6 / 16 / 40 mm	Maximum mast thickness (side to side). Limits 6-40 mm, and 4-25 % of Width. Typical 13-19 mm (about 11-15 % of chord). Thinner = less drag and spray; thicker = stiffer and stronger. The notice reports the resulting t/c.
TE thickness	0.1 / 0.8 / 3 mm	Trailing edge thickness of the mast section. Limits 0.1-3 mm, and at most 3 % of Width. Typical 0.6-1.0 mm for wet-laid carbon in printed molds.
Points/surface	10 / 36 / 120	Limits 10-120. Typical 30-40. Cosine-spaced points on each side of the symmetric NACA 00xx mast section.

Taper and top

Label	Min / default / max	Meaning
Top chord	30 / 120 / 400 mm	Chord of the mast at the top, where it meets the plate; Width is the chord at the base. Limits 30-400 mm. Typical equal to Width (no taper), or 10-30 % more for stiffness where the bending moment peaks, or less for a slimmer mast where it pierces the surface.
Taper side	dropdown: Symmetric, Straight leading edge, Straight trailing edge (default Symmetric)	Where the chord change goes. Symmetric: both edges move equally about the mid-chord. Straight leading edge: the leading edge stays vertical and the trailing edge moves. Straight trailing edge: the trailing edge stays vertical and the leading edge moves. Only matters when Top chord differs from Width.

Label	Min / default / max	Meaning
Top thick	4 / 16 / 40 mm	Section thickness at the top of the mast; Thickness is the value at the base. Limits 4-40 mm, and 4-25 % of the local chord. Typical equal to Thickness, or 20-50 % more to carry the bending and torsion where the mast meets the plate. The section stays a NACA 00xx, scaled.
Thicken from %	0 / 70 / 95	Height, as % of Height from the base, where the thickness starts to grow from Thickness toward Top thick, following a smooth S-curve to the top. Limits 0-95 %. Typical 60-80 %: the lower mast keeps its drag-optimised section and only the loaded top end thickens.
Root fillet	0 / 10 / 30 mm	Fillet radius where the mast meets the plate's underside, all round the section. Limits 0-30 mm. Typical 8-15 mm; 0 = sharp corner. Gives the UD caps and the tab plies a radius to turn through into the plate instead of a 90 deg fold, and spreads the peel at the corner where the side-load moment peaks. Held to 2 mm less than the room between the section and the plate edge. The fillet runs round the section's surface and stops at the trailing-edge line (a 0.8 mm edge cannot carry it), leaving a notch of TE thickness there; the console's MAST_FILLET line reports the seam and the attempt used.

Position

Label	Min / default / max	Meaning
Mast X	-300 / -20 / 300 mm	Mast leading edge position along X relative to the wing root pivot (world origin), positive = aft. Limits -300 to +300 mm. Typical -40 to 0 mm, i.e. the mast sits over the forward part of the wing. With a Round or Square socket on the wing it must stand behind the socket's rear face, on the tube or bar; the notice warns when it is ahead of it. This is where the rider's weight enters the foil, so compare it with the Foil performance trim CG.
Base height	-150 / 30 / 150 mm	Z of the mast's bottom end, measured from the wing root pivot. Limits -150 to +150 mm; negative is normal when the mast sits in a Foil fuselage pocket, whose floor can be below the pivot. Typical: the value the Foil fuselage warning asks for, so the mast sits on the pocket floor.

Motor pod

Label	Min / default / max	Meaning
Motor pod	checkbox, default off	Adds a streamlined motor pod on the mast (eFoil). Off for pump, SUP, surf, wing, wind and kite foils.
Motor dia	30 / 70 / 150 mm	Pod outside diameter (motor can plus housing). Limits 30-150 mm. Typical 60-90 mm for eFoil motors.
Pod height	0 / 150 / 1200 mm	Height of the pod centreline above the mast base. Limits 0-1200 mm, and the pod must stay within the mast height. Typical 100-250 mm; lower keeps the prop deeper, higher keeps it away from the wing.
Nose start %	0 / 5 / 80	Where the blend starts along the mast chord, as % from the mast leading edge. Limits 0-80 %. Typical 2-10 %: an early start gives the longest, gentlest blend and least drag. The first section matches the mast's own thickness there, so the pod grows out of the mast faces and never protrudes ahead of the mast.
Fairing length	20 / 150 / 400 mm	Length of the blend from the mast section to the full motor diameter. Limits 20-400 mm. Typical 2-3 x Motor dia; longer means a gentler flank angle and lower drag. Must fit between the nose tip and the rear face.

Label	Min / default / max	Meaning
Blend height %	30 / 100 / 100	Height of the first blend section as % of the motor diameter. Limits 30-100 %. Typical 70-100 %. 100 % = the pod starts at full motor height and grows only in width out of the mast faces; lower also tapers it vertically for a softer entry.
Aft extension	0 / 100 / 400 mm	How far the pod extends behind the mast trailing edge, ending in a flat rear face for modelling the motor mount by hand. Limits 0-400 mm. Typical 60-150 mm, enough to clear the mast for the motor and prop.
Cavity dia	5 / 20 / 140 mm	Diameter of the placeholder motor cavity in the pod's rear face. Limits 5-140 mm, and at most Motor dia minus 4 mm (2 mm of pod wall each side). Typical 20 mm as a placeholder, a small locating pocket to open out to the motor by hand. The Foil mold molds the pod's outside with the mast and makes a plug of this cavity, pulled after cure.
Cavity length	2 / 10 / 400 mm	Depth of the placeholder cavity from the pod's flat rear face forward. Limits 2-400 mm; shortened if it would run into the nose blend. Typical 10 mm as a placeholder, then the motor can length plus 5 mm once it is chosen.
Pod tilt	-15 / 0 / 15 deg	Rotation of the whole pod about its centre, nose-down positive. Limits -15 to 15 deg. Typical 5-8 deg for an eFoil: the board rides nose-up at low speed, so a nose-down pod keeps the prop nearer the flow at take-off and its thrust's downward component behind the CG lifts the nose against the thrust-height couple. 0 = axis parallel to the fuselage. Foil performance reports the thrust angle to the flow at every speed.

Plate

Label	Min / default / max	Meaning
Plate length	80 / 165 / 300 mm	Board plate length along X. Limits 80-300 mm. Typical 150-180 mm.
Plate width	60 / 120 / 200 mm	Board plate width across Y; must exceed Track spacing plus a bolt diameter. Limits 60-200 mm. Typical 110-130 mm.
Plate thick	4 / 10 / 30 mm	Board plate thickness. Limits 4-30 mm. Typical 8-12 mm; must be deeper than the countersink.
Track spacing	30 / 90 / 180 mm	Distance between the two rows of bolts (the board's two tracks). Limits 30-180 mm. Typical 90 mm, the common twin-track spacing; check your board.
Bolts/row	1 / 2 / 4	Bolts in each of the two rows. Limits 1-4. Typical 2.
Bolt pitch	10 / 40 / 200 mm	Spacing between bolts along each row, centred on the plate. Limits 10-200 mm. Typical 40-60 mm. Ignored with one bolt per row.
Bolt	dropdown: M4, M5, M6, M8, M10, Custom hole sizes (default M8)	The track bolts. Sets the plate's clearance hole (M6 6.5, M8 8.5 mm: 0.1 mm looser than the stab's close fit, since four holes must line up with the tracks) and the countersink. Typical M8 (most boards), M6 on some. Custom hole sizes: type the hole below.
Bolt dia	3 / 8.5 / 12 mm	Bolt clearance hole diameter (Custom only). Limits 3-12 mm. Typical 8.5 mm for M8, 6.5 mm for M6.
Countersink	checkbox, default on	90 deg countersink for flat-head bolts on the plate's underside (the mast side), to the ISO 10642 head diameter of the chosen Bolt (M6 13.4, M8 17.9 mm; Custom: twice the hole). Bolts go in from below, through the plate, into the board's track nuts, so the heads sit flush with the underside.
Log inputs	checkbox, default on	Prints every parameter on this feature to the FeatureScript console as one line, so the whole set can be pasted elsewhere (e.g. back to an AI assistant).

Foil fuselage

Body

Label	Min / default / max	Meaning
Parallel aft	0 / 40 / 300 mm	How far the full-diameter body continues behind the mast trailing edge before it tapers. Limits 0-300 mm. Typical 20-60 mm.
Tail dia	6 / 24 / 60 mm	Body diameter under the stab, after the taper. Limits 6-60 mm; clamped to the body diameter. Typical: equal to Tube dia (no taper before the stab - the fuselage is a high-stress part and the stab block needs a full body under it), tapering only in the tip. Smaller only for a lightly loaded foil.
Overhang	-200 / 60 / 300 mm	Where the fuselage ends: the X of its pointed tip, measured from the stab root trailing edge. Positive = behind the stab, negative = the tip ends under the stab. Limits -200 to +300 mm. Typical 40-80 mm (tip fully behind the stab, untouched by the seat).
Tip length	5 / 40 / 200 mm	Length of the elliptical tip, from Tail dia down to a point. Independent of Overhang, so the tip is always a full ellipse. Limits 5-200 mm. Typical 2-3 x Tail dia; longer is lower drag.

Stab seat

Label	Min / default / max	Meaning
Seat margin	0 / 3 / 30 mm	Extra seat (and block) length beyond the stab root chord at each end (never past the fuselage tip). Limits 0-30 mm. Typical 2-5 mm.
Stab bolt dia	3 / 6.8 / 10 mm	Tapping drill for the stab bolts, used ONLY when the Foil stabiliser's Bolt is set to Custom hole sizes; with a named bolt (M4-M10) the drill comes from the stab (M6 5.0, M8 6.8 mm) and this field is ignored. Limits 3-10 mm. Typical 6.8 (M8) or 5 (M6). The positions come from the stab's Mount bolts (Bolt 1 at, Bolt pitch), so the two always match.
Bolt depth	3 / 14 / 40 mm	Depth of each blind tapped hole from the seat plane into the body. Limits 3-40 mm. Typical 1.5-2 x bolt diameter. With the fuselage over the stab (the stab's Mount side Top) the hole goes up: the depth available is the pad plane's drop below the axis plus the local radius, less 1 mm of wall (about 15 mm on a 24 mm tail seated 4 mm under the axis). A hole that would break through is skipped with the fix named.

Mast pocket

Label	Min / default / max	Meaning
Mast pocket	checkbox, default on	Cuts a pocket in the top of the fuselage for the mast's bottom end, shaped to the Foil mast's own section plus Clearance. Its position AND depth follow the mast: the floor is at the mast's Base height, so moving the mast reshapes the pocket. Needs a Foil mast feature above this one.
Clearance	0 / 0.2 / 2 mm	Gap between the mast and the pocket walls, all round. Limits 0-2 mm. Typical 0.1-0.3 mm for a bonded or bolted fit.

Hub body

Label	Min / default / max	Meaning
Body	dropdown: Follow the wing's joint, Round tube (socket), Hub body (flat hub) (default AUTO)	Which fuselage this is. Follow the wing's joint (default): the round tube when the wing has a Round tube socket, the hub body when it has the flat hub; a Square socket is refused (build 233: it takes a flat bar, which this feature does not model - use your own bar). Hub body (build 208, from the user's template): a nose the shape of the hub sitting on its top with a tongue in the pocket, bolted down through it; a rounded body carrying the mast; a tail to the stab's seat whose length follows the stab's Arm; a seat block the stab bolts to. Round tube: the socket fuselage, whatever the wing has.
Nose height	1 / 5 / 20 mm	Height of the nose above the hub's top face at its front; it rises from there to the body's top at the hub's back. Limits 1-20 mm. Typical 4-6 (template 5).
Body height	10 / 22 / 40 mm	Height of the body from the hub's underside (its bottom is level with the hub's) to its top, all the way to section 1. Limits 10-40 mm. Typical 20-24 (template 22): the top must clear the hub's top by 3 mm, and the mast pocket goes down from it to the mast's Base height.
Body width	12 / 24 / 40 mm	Width of the body at section 1, where it stops narrowing from the hub's width. Limits 12-40 mm. Typical 22-26 (template 24); wider than the mast pocket's thickness plus 6 mm.
Body length	50 / 160 / 400 mm	From the hub's back (section 3) to section 1, where the tail's taper to the stab begins. Limits 50-400 mm. Typical 150-170 (template 163); the mast must lie within it, and the tail from section 1 to the stab's seat takes whatever the stab's Arm leaves.
Tail depth	4 / 8 / 20 mm	Height of the section at the stab's seat and of the seat block, on the far side of the pad plane from the stab. Limits 4-20 mm. Typical 8 (template 7.7); the stab's bolts tap through it when Bolt depth is more than this.
End width	2 / 6 / 20 mm	Plan width of the seat block at its end, Seat margin behind the stab's trailing edge. Limits 2-20 mm. Typical 4-8 (template 7).
Edge round	0 / 5 / 10 mm	Radius on the nose's top edges and the corners of every section. Limits 0-10 mm. Typical 4-5 (template 5); held to 45 % of a section's smaller half-size.
Nose countersink	checkbox, default on	Countersinks the hub's bolt holes into the nose's top to the bolt's head diameter, so the heads sit flush. Off: plain holes for button heads.
Wing pin holes	checkbox, default on	Holes through the spigot matching the wing socket's Pins, Pin bolt and Pin pitch, at the same clearance size.
Log inputs	checkbox, default on	Prints every parameter on this feature to the FeatureScript console as one line, so the whole set can be pasted elsewhere (e.g. back to an AI assistant).

9. Console log reference

Turn on *Log inputs* on a feature to print its inputs to the FeatureScript console. The keys are stable so a log can be pasted back to an assistant or into the scripts.

Key	Feature	Content
WING_INPUTS , STAB_INPUTS , MAST_INPUTS , FUSELAGE_INPUTS , PERFORMANCE_INPUTS , MOLD_INPUTS	each	every input of the feature, with its version as the first field

Key	Feature	Content
FUSELAGE_SEAT	fuselage	the seat and the tapped holes made, or the conflict and the fix
MAST_FILLET	mast	the seam edges found at the plate and the fillet attempt that worked
===== FOIL PERFORMANCE ===== block	performance	the full report, the propulsion block and the CSV
UD_CAP_PLIES	mold	per-cap cut list: ply, length, width at root, width at end
UD_TABS	mold (mast)	tab plies per face, size, fold position, interleave
LAYUP	mold	volumes, masses, plies, tow, resin, what to buy
STIFFNESS	mold	deflection, EI, cap stress; mast: stress at the plate and at its worst point, bolt tension, junction, plate
STAB_CONES	mold (stab)	the bolt cones made and their positions
MAST_PLUG	mold (mast)	the pod plug's cores and depth
TEMPLATES	mold	the order of shapes on the template plate and their cut counts
PARTING_CHECK	mold (wing, stab)	the points checked and the worst gap at the trailing and leading edges between a half's first face and the part's skin (build 235)

Each feature's version is printed as the first field of its log line; the file's build number is in the Feature Studio header. If a pasted log shows a version older than the file you have, the Feature Studio was not pasted over.

10. Model limits, versioning and the AI assistant

10.1 Model limits

- Leading-edge tubercles and winglets are geometry only, apart from the winglet's effective-span credit: the performance sweep neither credits nor charges the tubercles. What they would do is reported apart, on the notice's *LE tubercles* line (3.1), never inside the sweep's figures.
- Results are best for comparing variants. Profile drag is about $\pm 20\text{--}30\%$ absolute; induced drag within $5\text{--}10\%$ for modest sweep.
- With the analytic section model, stall comes entirely from the Section CL max input; use a polar for real behaviour.
- **Stall speed is optimistic.** It is the speed at which the most loaded section of a perfect, clean section reaches its 2D CL max in dead steady flight. Hand finish, the fuselage junction, wake, free surface and the margin a rider needs all lower the usable CL max. Stall speed goes with $1/\sqrt{\text{CL max}}$, so calibrate: take one foil you know, find the Section CL max (or polar CL max) that reproduces its real take-off speed, and use that value for new designs.
- **One section family per surface.** Thickness ratio varies root to tip and Min tip holds an absolute floor, but camber and profile are the same along the span. Blending a cambered root to a flatter tip is not modelled yet.

- Lifting line ignores sweep and anhedral except for moving the aerodynamic centre; strongly swept or drooped wings will differ. Their roll effect is reported separately (build 230), for the surface alone.
- Downwash at the stab is the classic far-field estimate.
- Not modelled: free-surface effects beyond the two MAC warning, ventilation, cavitation onset (only the cavitation number is reported), pumping and unsteady motion, board and rider aerodynamics, ploughing before lift-off, acceleration, junction drag between mast and fuselage, pod base drag.
- Propulsion is the B-series open-water estimate, about $\pm 20\%$, with fixed motor losses; no wake, no prop cavitation, no thermal limits.
- Structure: a spar-cap estimate with a simple EI model; no shear, torsion, buckling, fatigue, core or insert design; the junction check ignores peel at the fillet and the tabs' own anchoring.

10.2 Versioning

The Feature Studio header carries the build number and every feature's version. The build number goes up on every delivery; a feature's version goes up only when that feature changes, by 0.001 for an ordinary change and to the next whole number for a redesign. A changelog comment above the version constants records every change and why. The `toolVersion` field in each console log line tells you which version produced it.

10.3 The AI assistant and its scripts

The foil design assistant is a skill for AI assistants that reads what the features print and helps you decide what to change next. Its files are in the `assistant/` folder of the download package (section 2.1). Paste your console log and it explains the results, checks them against the targets in chapter 5, and recommends a few changes in the dialog's own labels, with the expected effect and the cost. Then it compares the next run with the last.

Assistant	Setup
Claude (desktop app, claude.ai, Claude Code)	Add <code>foil-design-assistant.skill</code> . It loads when you paste foil output and runs the scripts itself.
ChatGPT	Use <code>foil-design-assistant-portable.md</code> as a custom GPT's instructions, with <code>parameters.md</code> and the scripts as knowledge, and Code Interpreter on. Or attach both files to a chat.
Other assistants	Give them <code>foil-design-assistant-portable.md</code> and <code>parameters.md</code> at the start of the chat. Without code execution they follow the manual method in the file.

What to paste. Turn on *Log inputs* on every feature, regenerate, and copy the whole FeatureScript console, plus the notice of any feature showing a warning. One paste then carries every input and output, so every recommendation can be checked.

The scripts. Four Python 3 scripts come with the assistant, standard library only. An assistant that can run code runs them for you. To run them yourself, save the console to a text file and use a terminal:

```
python3 analyse_sweep.py run.txt [previous_run.txt] python3 pitch_sweep.py run.txt --vmin 15
python3 polar_summary.py polar_re1.txt polar_re2.txt python3 cut_templates.py run.txt
templates.dxf
```

- `analyse_sweep.py` summarises a run: best L/D, minimum power, take-off loading, stance shift, static margin, drag split and, with propulsion, the lowest Wh/km, throttle range, top speed and lowest powered margin. Given two runs, it compares them.

- `pitch_sweep.py` rebuilds the design's trim from the log, checks it against the tool's own numbers, and finds the smallest stab, arm and decalage that reach a target static margin, including the effect of moving a motor pod.
- `polar_summary.py` turns one or two XFoil or XFLR5 polar files into the thirteen numbers the Section polar group takes.
- `cut_templates.py` writes the skin and UD ply outlines as a DXF from the log, for cutting without Onshape.