OPENWING-UAV

FULL TUTORIAL DRAWING MANUAL

Parametric CAD, internal structure, control system, assembly, simulation and prototype validation

Author: SAMUELSON G

Drawing package revision A | Units: millimetres unless otherwise stated | July 2026

Drawing index and tutorial sequence

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Project baseline and design intent

BASELINE GEOMETRY

Parameter	Value
Aircraft mass	2.5 kg
Full span	1200
Semi-span	600
Root chord	240
Tip chord	160
Wing area	0.240 m2
Aspect ratio	6.0
Taper ratio	0.667
Airfoil	NACA 4412
Dihedral	3 deg each half
Washout	-1 deg mid, -2 deg tip
Cruise speed	15 m/s

STRUCTURAL BASELINE

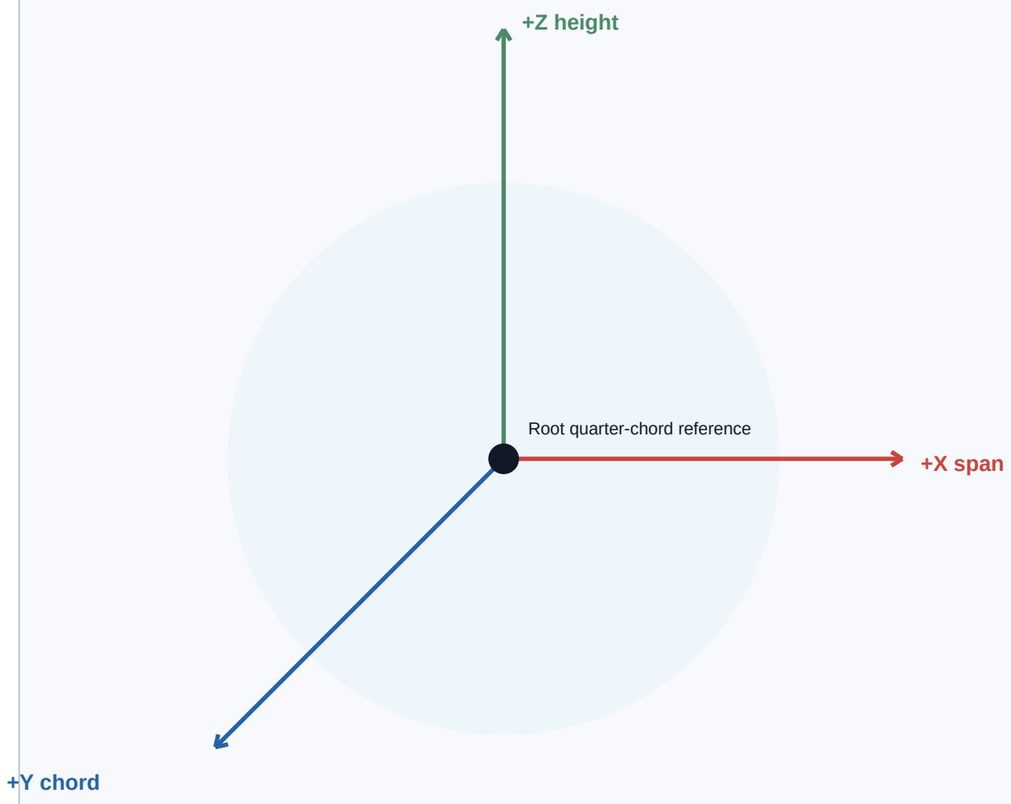
- Main spar at 30% local chord; rear spar at 70% local chord.
- Main web 1.5 thick with 6 x 3 upper/lower caps.
- Rear web 1.2 thick with 4 x 2 upper/lower caps.
- Ribs at 0, 25, 75, 150, 225, 300, 330, 390, 450, 510, 570 and 600.
- Main wing skin 1.0; aileron shell 0.8.
- 18 x 4 V-joiner, 150 insertion each side; rear pin diameter 6.

DESIGN LOADS AND LIMITS

Condition	Half-wing load
Positive limit +3.5g	42.904 N
Positive ultimate +5.25g	64.356 N
Negative limit -1.5g	18.387 N
Negative ultimate -2.25g	27.581 N
Project ultimate factor	1.5

SolidWorks coordinate system and master reference planes

AXIS DEFINITION



MASTER REFERENCES

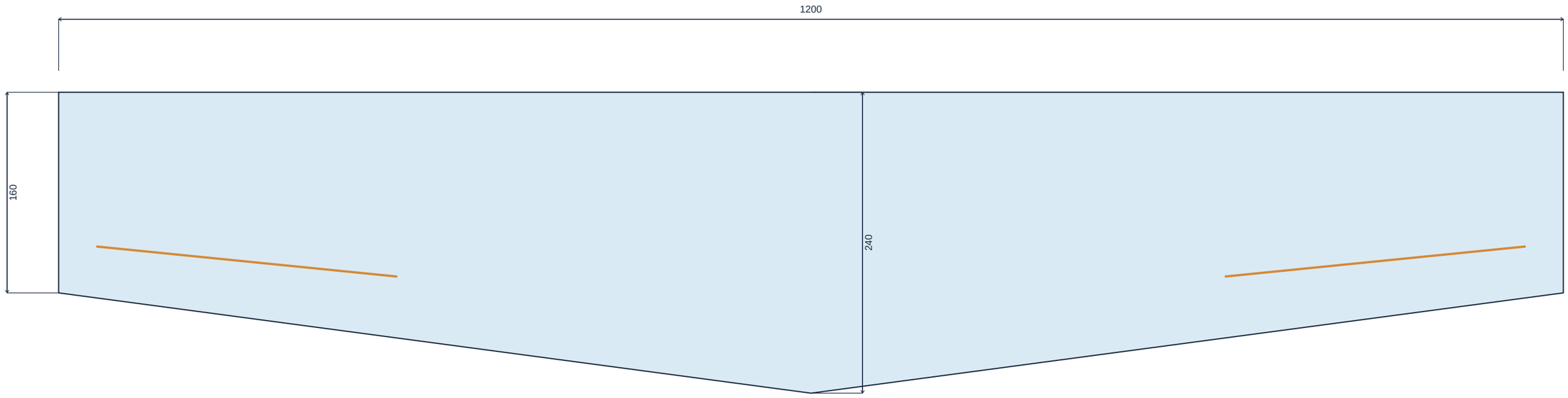
- Root plane: X = 0 symmetry and joiner centre.
- Midspan plane: X = 300, dihedral rise 15.722, twist -1 deg.
- Tip plane: X = 600, dihedral rise 31.445, twist -2 deg.
- All twist rotations are about each section quarter-chord point.
- Chord direction +Y points from leading edge toward trailing edge.
- Use named axes AX_SPAN, AX_AILERON_HINGE and AX_JOINER.

SOLIDWORKS SETUP TUTORIAL

- 1. Create a new metric part and save immediately.
- 2. Insert planes offset 300 and 600 from the root plane.
- 3. Create quarter-chord sketch points on all station planes.
- 4. Apply 3 deg dihedral through Z offsets, then apply twist.
- 5. Lock station sketches to global variables before lofting.

OPENWING-UAV **Coordinate system** Tutorial drawing - dimensions in mm - verify before manufacture	**DRAWING** OWU-TUT-003 **SCALE NTS**	**SHEET** 4/28 **REV A**

Full-wing general arrangement



Primary geometry

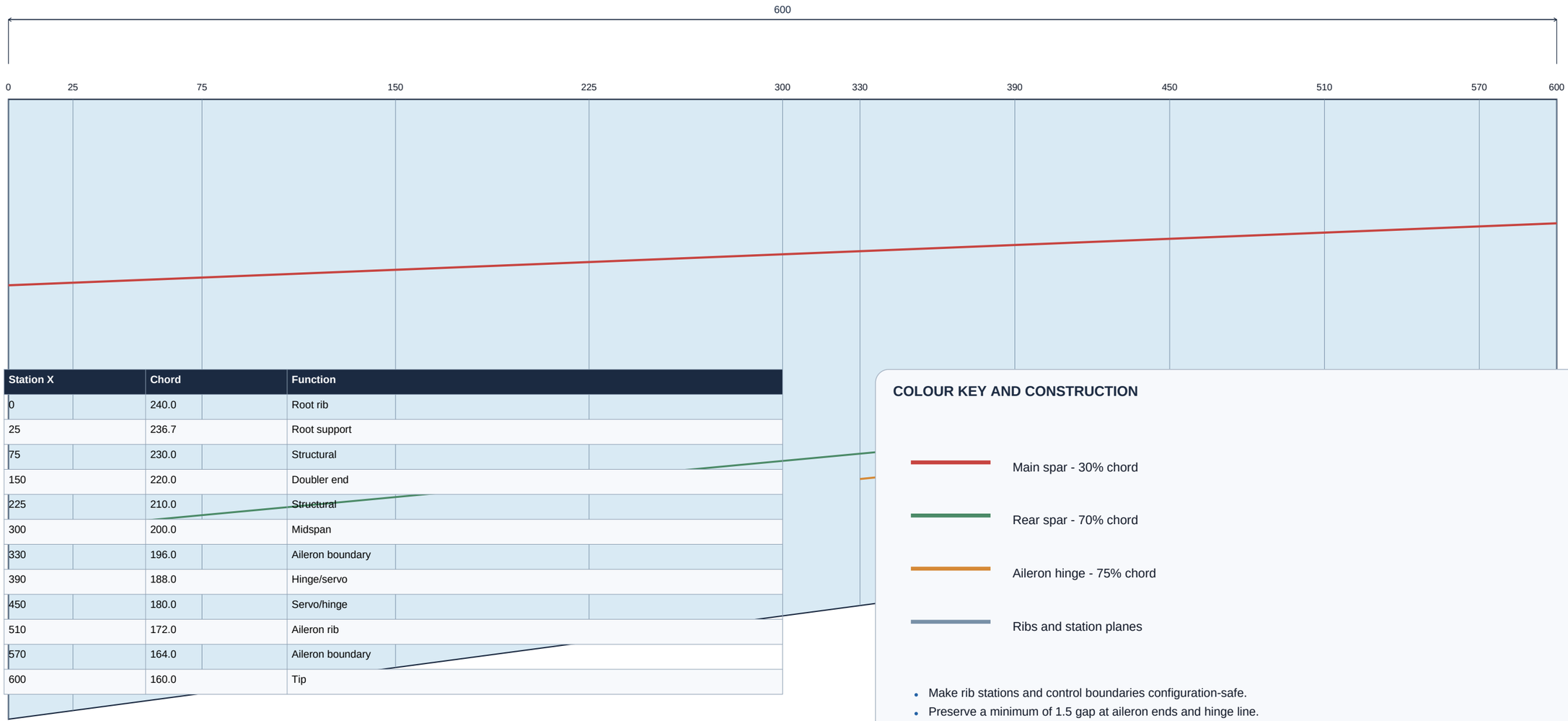
- Straight quarter-chord reference, tapered planform and symmetric left/right layout.
- Ailerons span X = 330 to 570 on each half-wing.
- Hinge line follows 75% of local chord; nominal gap 1.5.
- Left wing is mirrored from the validated right-wing master.

GENERAL DRAWING NOTES

- Do not scale this PDF for CNC cutting; use the supplied DXF profiles.
- Confirm root-interface geometry against the fuselage before manufacture.
- All aerodynamic surfaces must remain smooth and free from local steps.

OPENWING-UAV **Full-wing general arrangement** Tutorial drawing - dimensions in mm - verify before manufacture	**DRAWING** OWU-TUT-100 **SCALE 1:4**	**SHEET** 5/28 **REV A**

Right half-wing structural and station layout



Station X	Chord	Function
0	240.0	Root rib
25	236.7	Root support
75	230.0	Structural
150	220.0	Doubler end
225	210.0	Structural
300	200.0	Midspan
330	196.0	Aileron boundary
390	188.0	Hinge/servo
450	180.0	Servo/hinge
510	172.0	Aileron rib
570	164.0	Aileron boundary
600	160.0	Tip

COLOUR KEY AND CONSTRUCTION

- Main spar - 30% chord
- Rear spar - 70% chord
- Aileron hinge - 75% chord
- Ribs and station planes

- Make rib stations and control boundaries configuration-safe.
- Preserve a minimum of 1.5 gap at aileron ends and hinge line.
- Locate wiring channel through the rib neutral region, clear of spar slots.

OPENWING-UAV

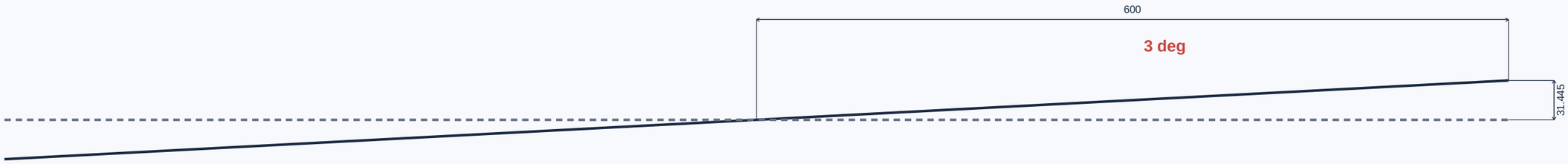
Right half-wing layout

Tutorial drawing - dimensions in mm - verify before manufacture

DRAWING	SHEET
OWU-TUT-110	6/28
SCALE 1:2	**REV A**

Dihedral, station rise and washout

FRONT ELEVATION - 3 DEG DIHEDRAL



SECTION ROTATION ABOUT QUARTER CHORD

ROOT

0 deg

MID X=300

-1 deg

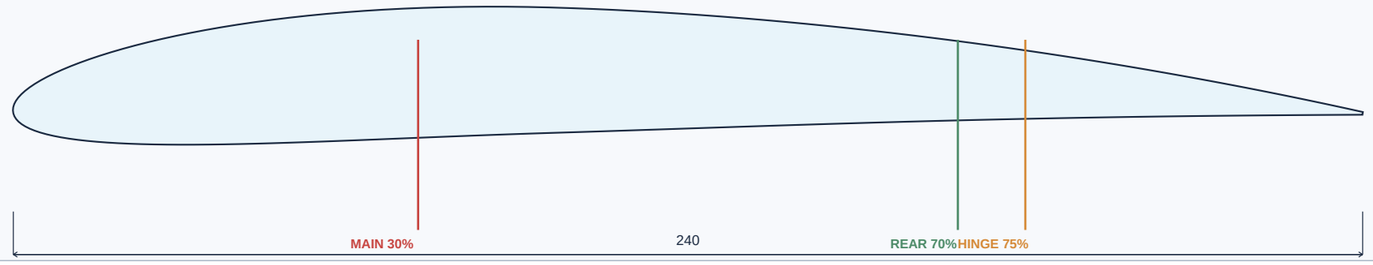
TIP X=600

-2 deg

OPENWING-UAV **Dihedral and washout** Tutorial drawing - dimensions in mm - verify before manufacture	**DRAWING** OWU-TUT-120 **SCALE NTS**	**SHEET** 7/28 **REV A**

NACA 4412 root, midspan and tip sections

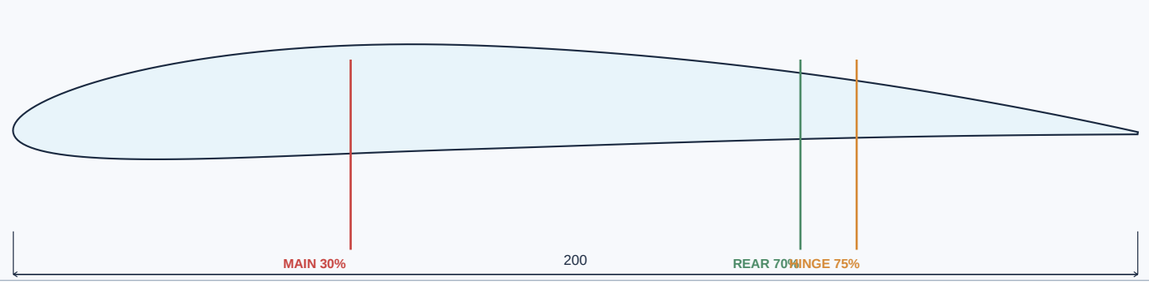
ROOT X=0



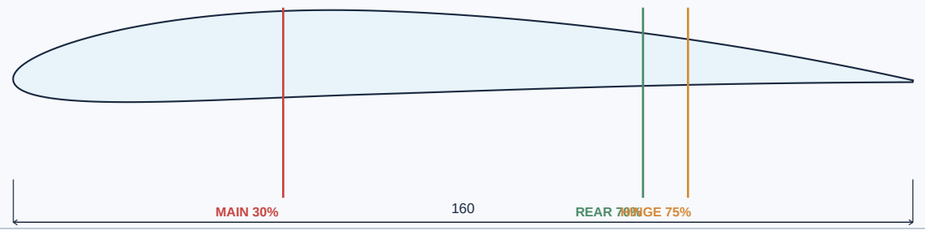
PROFILE IMPORT TUTORIAL

- Import XYZ points to each station plane.
- Fit a closed spline with the trailing-edge points coincident.
- Place the leading edge at the local chord origin.
- Rotate around the 25% chord point for washout.
- Use identical point order to prevent loft twisting.

MID X=300



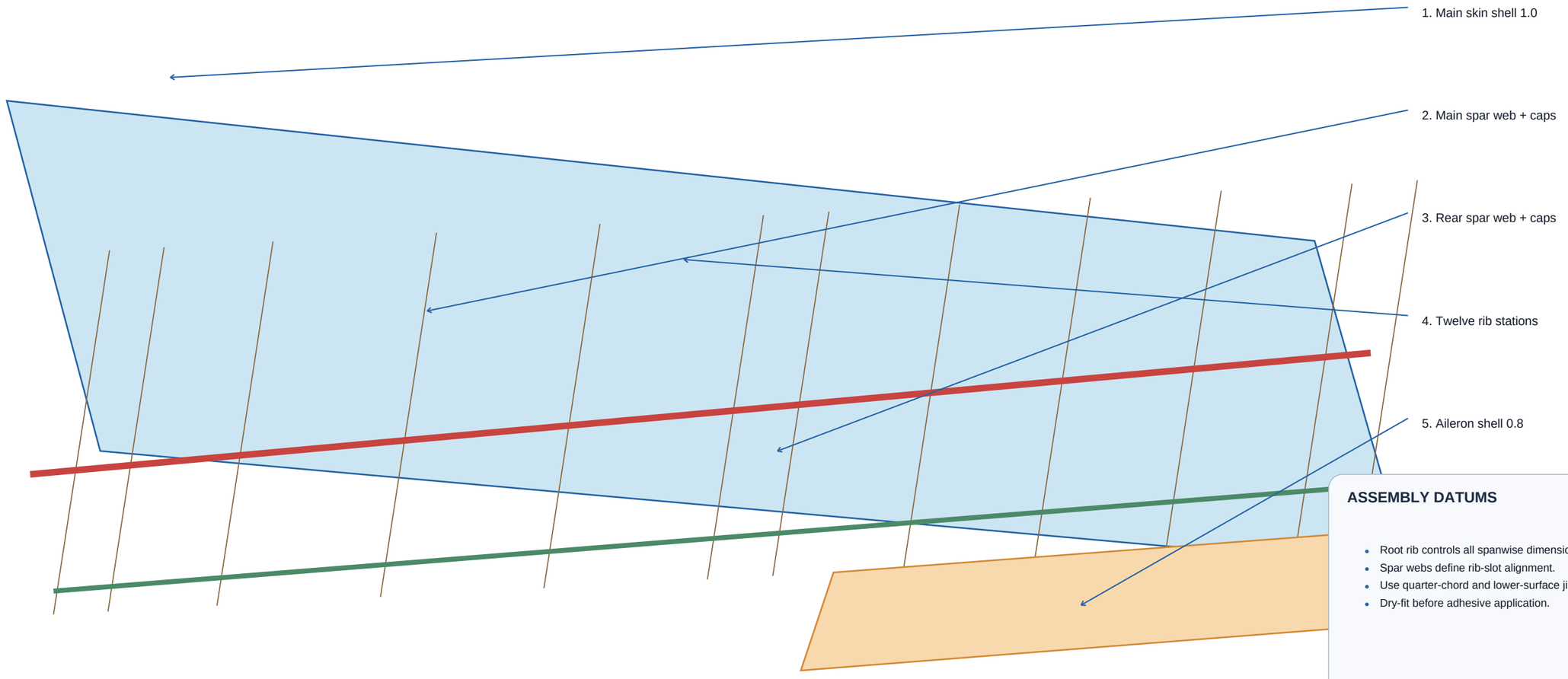
TIP X=600



Educational engineering package. Not a certification or flight-release drawing.

OPENWING-UAV **Airfoil sections** Tutorial drawing - dimensions in mm - verify before manufacture	**DRAWING** OWU-TUT-130 **SCALE NTS**	**SHEET** 8/28 **REV A**

Exploded internal structural architecture



ASSEMBLY DATUMS

- Root rib controls all spanwise dimensions.
- Spar webs define rib-slot alignment.
- Use quarter-chord and lower-surface jigs.
- Dry-fit before adhesive application.

OPENWING-UAV

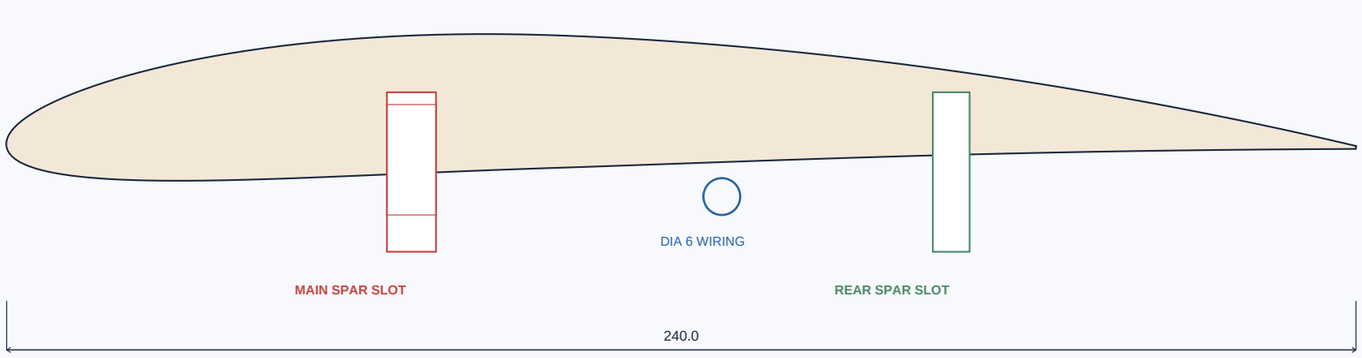
Internal structure

Tutorial drawing - dimensions in mm - verify before manufacture

DRAWING	SHEET
OWU-TUT-200	9/28
SCALE NTS	**REV** A

Root rib and root-support interface

RIB PROFILE AT X = 0



FEATURE TUTORIAL

- Use 3.0 thick root rib.
- Add joiner cavity 18.4 x 4.4 and joiner box outer size 22.4 x 8.4.
- Provide rear-pin bore diameter 6 with appropriate fit and edge distance.
- Add root grommet diameter 8 for wiring.
- Keep root face square to the span axis.

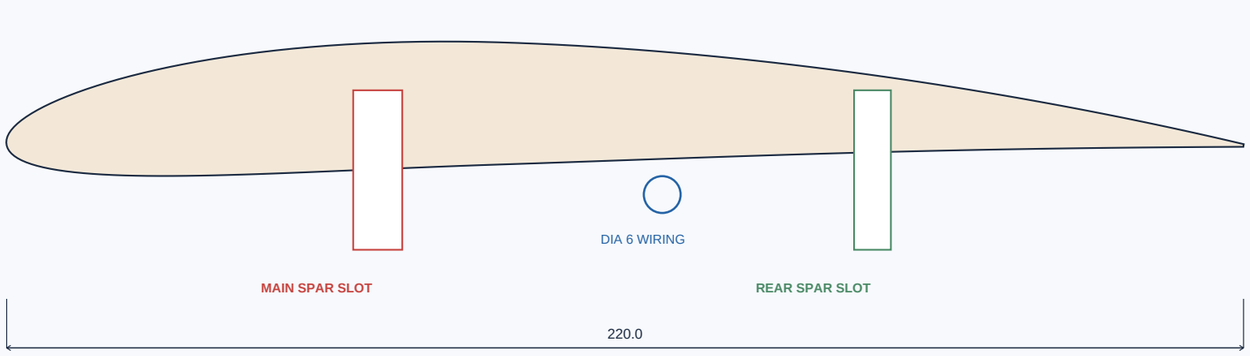
MANUFACTURING NOTES

- Cut from specified birch plywood.
- Keep grain direction generally chordwise unless tested otherwise.
- Deburr all slots without enlarging them.
- Use DXF, not this PDF, for toolpath generation.
- Trial-fit spar and wiring components before bonding.

OPENWING-UAV **Root rib and root-support interface** Tutorial drawing - dimensions in mm - verify before manufacture	**DRAWING** OWU-TUT-210 **SCALE 1:1**	**SHEET** 10/28 **REV A**

Typical standard rib

RIB PROFILE AT X = 150



FEATURE TUTORIAL

- Use 2.0 nominal standard-rib thickness.
- Main spar slot follows 1.5 web plus assembly clearance.
- Rear spar slot follows 1.2 web plus assembly clearance.
- Keep at least 3 material around the wiring hole.
- Number every rib permanently before assembly.

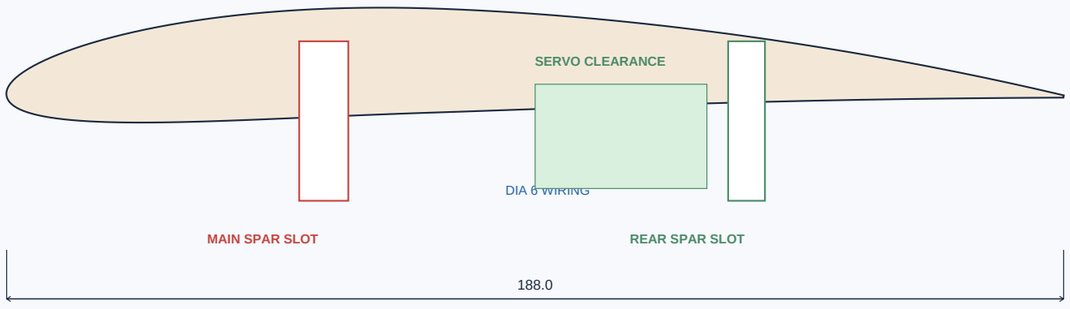
MANUFACTURING NOTES

- Cut from specified birch plywood.
- Keep grain direction generally chordwise unless tested otherwise.
- Deburr all slots without enlarging them.
- Use DXF, not this PDF, for toolpath generation.
- Trial-fit spar and wiring components before bonding.

OPENWING-UAV **Typical standard rib** Tutorial drawing - dimensions in mm - verify before manufacture	**DRAWING** OWU-TUT-211 **SCALE 1:1**	**SHEET** 11/28 **REV A**

Servo-bay and control-system rib

RIB PROFILE AT X = 390



FEATURE TUTORIAL

- Use the X=390 and X=450 ribs to bound the servo bay.
- Preserve clearance for a 24 x 13 x 25 generic micro-servo envelope.
- Provide tray attachment lands without weakening spar slots.
- Align pushrod path with the aileron horn and avoid side loading.
- Check full +20 / -15 deg aileron travel in assembly.

MANUFACTURING NOTES

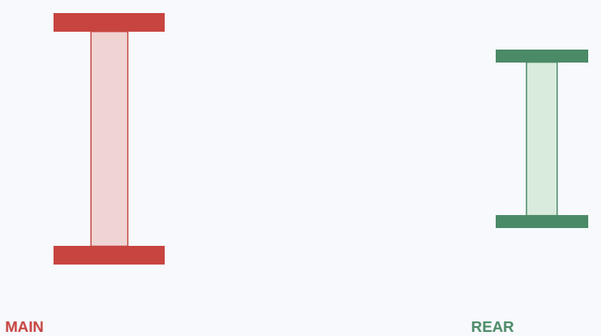
- Cut from specified birch plywood.
- Keep grain direction generally chordwise unless tested otherwise.
- Deburr all slots without enlarging them.
- Use DXF, not this PDF, for toolpath generation.
- Trial-fit spar and wiring components before bonding.

OPENWING-UAV **Servo-bay and control-system rib** Tutorial drawing - dimensions in mm - verify before manufacture	**DRAWING** OWU-TUT-212 **SCALE 1:1**	**SHEET** 12/28 **REV A**

Main and rear spar system

SPANWISE ELEVATION

CROSS-SECTIONS



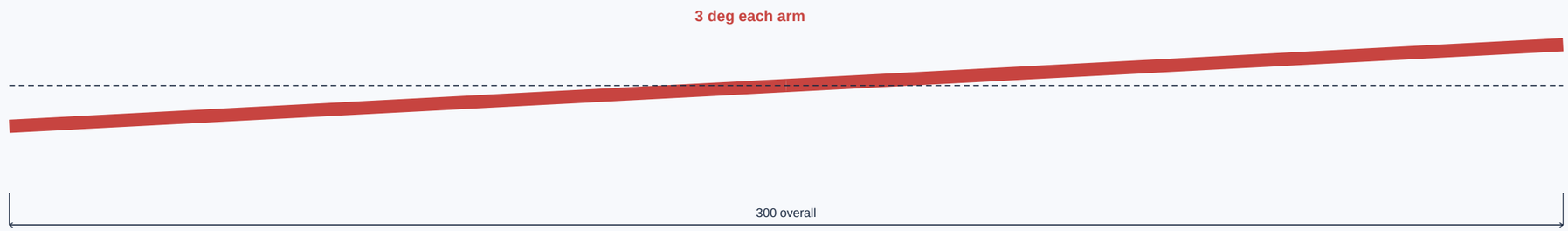
DESIGN AND ASSEMBLY NOTES

- Cap fibres run continuously in the span direction.
- Bond caps to prepared web faces using controlled adhesive thickness.
- Stagger doubler termination or taper it to reduce abrupt stiffness change.
- Check cap clearance against joiner box and skin at every station.

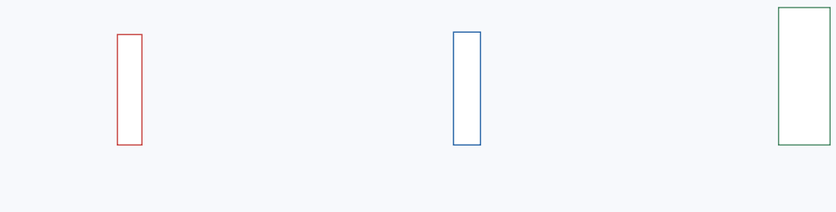
OPENWING-UAV **Spar system** Tutorial drawing - dimensions in mm - verify before manufacture	**DRAWING** OWU-TUT-220 **SCALE NTS**	**SHEET** 13/28 **REV A**

V-joiner, joiner box and removable root interface

V-JOINER GEOMETRY



JOINER / CAVITY / BOX SECTIONS



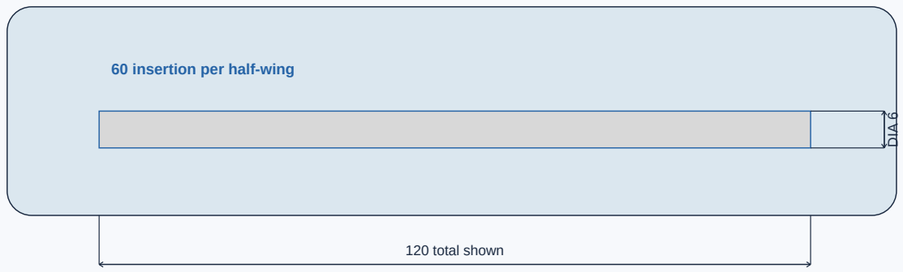
ROOT ASSEMBLY TUTORIAL

- Insert joiner 150 into each half-wing.
- Use a fit gauge before bonding the joiner box.
- Align both root ribs on a flat centre fixture.
- Add rear anti-rotation pin only after joiner alignment is verified.
- Apply release agent to any component intended to remain removable.

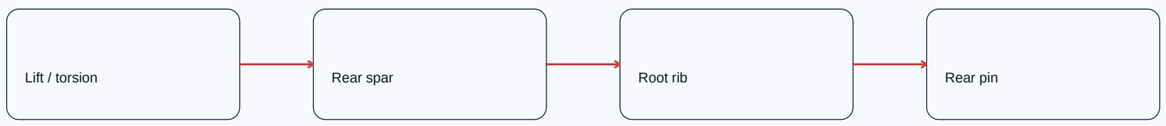
OPENWING-UAV **V-joiner and root box** Tutorial drawing - dimensions in mm - verify before manufacture	**DRAWING** OWU-TUT-230 **SCALE NTS**	**SHEET** 14/28 **REV A**

Rear anti-rotation pin and root load path

REAR PIN DETAIL



ROOT LOAD PATH



INSTALLATION AND CHECKS

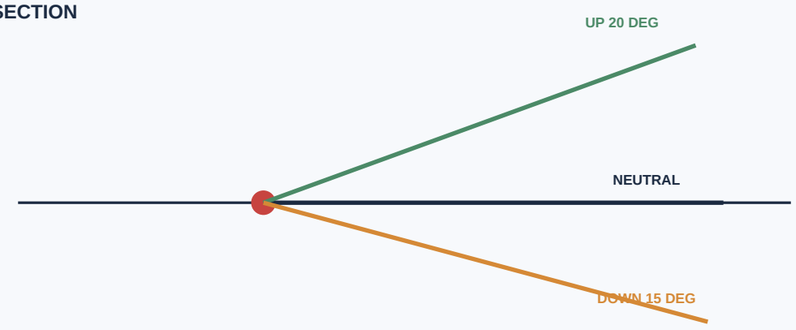
- Drill with the root drilling jig after the main joiner alignment is locked.
- Use a reamed or accurately printed guide bore for repeatable fit.
- Maintain sufficient edge distance in root ribs and local doublers.
- Check that the pin does not carry the primary bending moment.
- Inspect for ovalisation, fretting and looseness after every proof test.
- Provide a positive retention feature appropriate to the aircraft installation.

OPENWING-UAV **Rear anti-rotation pin** Tutorial drawing - dimensions in mm - verify before manufacture	**DRAWING** OWU-TUT-231 **SCALE NTS**	**SHEET** 15/28 **REV A**

Aileron geometry, gaps and motion envelope

AILERON PLANFORM

MOTION SECTION



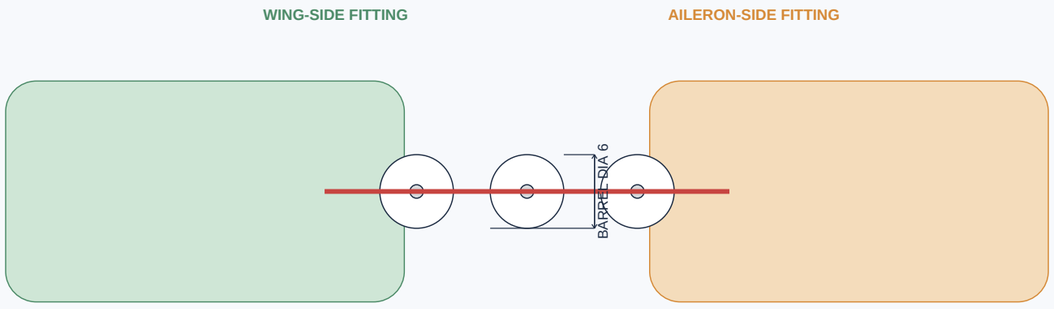
CONTROL-SURFACE NOTES

- Nominal hinge-line and end gaps: 1.5.
- Aileron shell nominal thickness: 0.8.
- Hinge stations: X = 360, 450 and 540.
- Check motion under servo stall and wing deflection.

OPENWING-UAV **Aileron geometry** Tutorial drawing - dimensions in mm - verify before manufacture	**DRAWING** OWU-TUT-300 **SCALE NTS**	**SHEET** 16/28 **REV A**

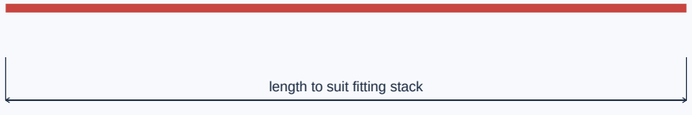
Aileron hinge fitting and pin

HINGE ASSEMBLY DETAIL



DIA 2 pin / DIA 2.2 bore

PIN DETAIL



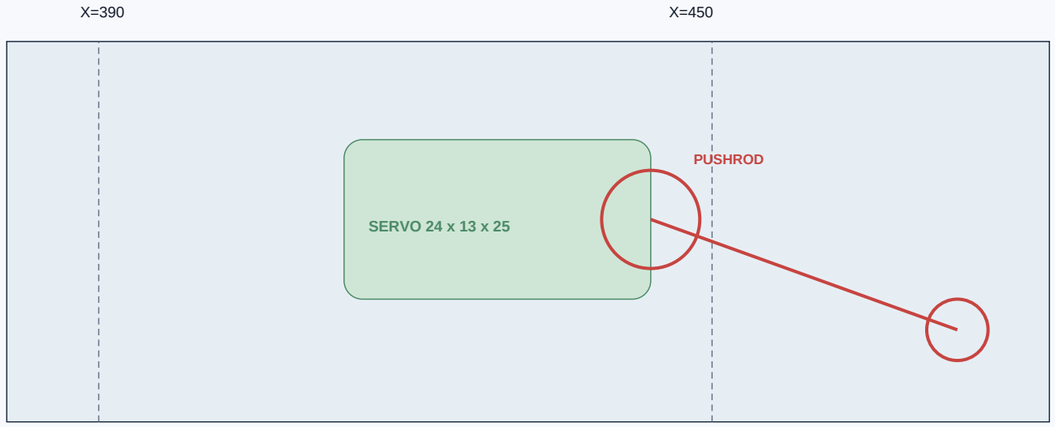
INSTALLATION TUTORIAL

- Locate fittings at X = 360, 450 and 540.
- Align all barrels using a temporary straight mandrel before bonding.
- Maintain 1.5 control-surface gap throughout full motion.
- Use actual printed-material orientation and tested bearing properties.
- Pin should rotate freely without visible play.
- Inspect barrel opening, bore wear and layer cracking after cycling.

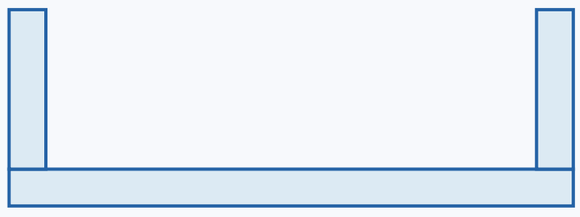
OPENWING-UAV **Hinge fitting** Tutorial drawing - dimensions in mm - verify before manufacture	**DRAWING** OWU-TUT-310 **SCALE NTS**	**SHEET** 17/28 **REV A**

Servo bay, tray and linkage geometry

SERVO INSTALLATION



TRAY SECTION



Tray nominal thickness 2.0

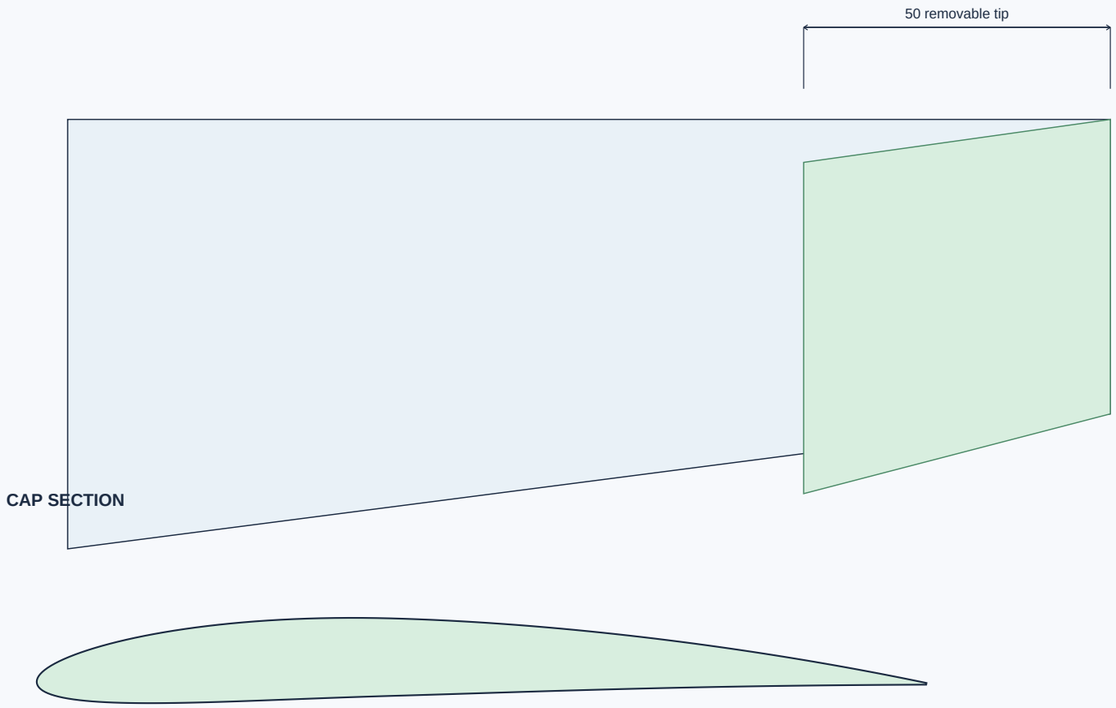
CONTROL CHECKLIST

- Confirm servo torque at the intended supply voltage.
- Keep pushrod close to perpendicular at neutral.
- Use adequate horn edge distance and secure fasteners.
- Check tray-boss, rail and rib stresses under 1.5 x stall torque.
- Route wiring through the 6 mm channel with strain relief.
- Perform neutral, up 20 deg and down 15 deg interference checks.

OPENWING-UAV **Servo bay and linkage** Tutorial drawing - dimensions in mm - verify before manufacture	**DRAWING** OWU-TUT-320 **SCALE NTS**	**SHEET** 18/28 **REV A**

Removable 50 mm wingtip cap

TIP CAP GEOMETRY



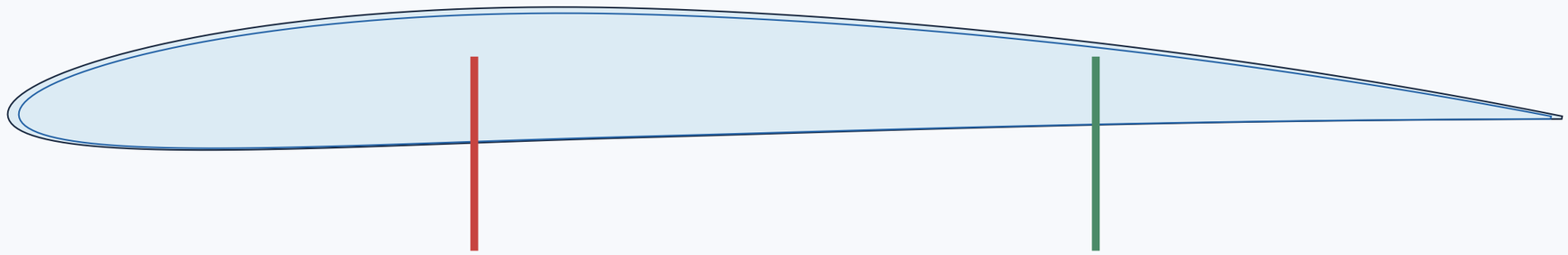
PRINT AND FIT TUTORIAL

- Print as a separate part to simplify repair and finishing.
- Orient layers to resist handling loads and fastener pull-out.
- Use a keyed or indexed fit so the cap cannot be installed reversed.
- Preserve the designed tip washout and external aerodynamic contour.
- Provide a removable retention method without exposed sharp hardware.
- Dry-fit and sand only the mating flange, not the aerodynamic surface.

OPENWING-UAV **Wingtip cap** Tutorial drawing - dimensions in mm - verify before manufacture	**DRAWING** OWU-TUT-330 **SCALE NTS**	**SHEET** 19/28 **REV A**

Wing skin, aileron shell and adhesive bonding sequence

TYPICAL STRUCTURAL SECTION



Main skin nominal 1.0 inward shell

BONDING SEQUENCE

- 1. Abrade and clean all bond surfaces.
- 2. Bond caps to spar webs and cure in straight jigs.
- 3. Bond ribs to spars using alignment jigs.
- 4. Install wiring and servo tray before closing skin.
- 5. Bond lower skin, inspect, then bond upper skin.
- 6. Keep control gaps and removable root interfaces free of adhesive.

QUALITY CONTROLS

- Control adhesive mix, batch, cure and bond-line thickness.
- Prevent local skin waviness at unsupported bays.
- Confirm no adhesive blocks wiring or hinge movement.
- Weigh the wing before and after skin closure.

OPENWING-UAV **Skin and bonding** Tutorial drawing - dimensions in mm - verify before manufacture	**DRAWING** OWU-TUT-400 **SCALE NTS**	**SHEET** 20/28 **REV A**

Assembly sequence A - root, spars and ribs

STEP 1 - Prepare parts

Deburr ribs, clean caps/webs, verify joiner fit.

STEP 2 - Build main spar

Bond upper/lower caps to the 1.5 web in a straight fixture.

STEP 3 - Build rear spar

Bond 4 x 2 caps to the 1.2 rear web.

STEP 4 - Install root system

Fit root rib, support rib, box, doubler and rear-pin guides.

STEP 5 - Install ribs

Slide ribs onto both spars in station order.

STEP 6 - Square and cure

Use rib-alignment jigs; check span, sweep and dihedral.

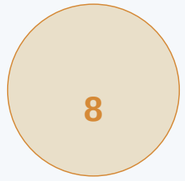
OPENWING-UAV **Assembly sequence A** Tutorial drawing - dimensions in mm - verify before manufacture	**DRAWING** OWU-TUT-410 **SCALE NTS**	**SHEET** 21/28 **REV A**

Assembly sequence B - systems, skins and controls

STEP 7 - Install systems

Route wiring, install servo tray and verify access.

STEP 8 - Bond lower skin



Support aerodynamic contour; maintain root and tip openings.

STEP 9 - Bond upper skin

Check twist, tip rise and trailing-edge alignment before cure.

STEP 10 - Cut/fit aileron

Maintain 1.5 gaps and straight hinge axis.

STEP 11 - Install hinges

Align three barrels with a temporary mandrel.

STEP 12 - Final closure

Install tip cap, servo, pushrod and retention hardware.

OPENWING-UAV

Assembly sequence B

Tutorial drawing - dimensions in mm - verify before manufacture

DRAWING	SHEET
OWU-TUT-411	22/28
SCALE NTS	**REV** A

SolidWorks 2023 modelling workflow

01

Master equations

Create span, chords, dihedral, washout, spar fractions and station dimensions.

02

Profile planes

Create X=0, 300 and 600 planes; add quarter-chord points and Z rises.

03

Airfoil sketches

Import NACA 4412 XYZ data; scale to 240, 200 and 160 chords.

04

Guide curves

Create leading-edge and trailing-edge guides; verify pierce relations.

05

Wing envelope

Use Boundary Surface or Loft; knit and close to create a reference solid.

06

Skin shells

Offset inward 1.0 for wing and 0.8 for aileron; split at control boundaries.

07

Spars and ribs

Create equation-driven spar surfaces/solids and rib intersections.

08

Root and controls

Add joiner box, rear pin, servo bay, hinges, wiring and tip cap.

09

Assemblies

Create right wing, mirrored left wing and full-wing assembly.

10

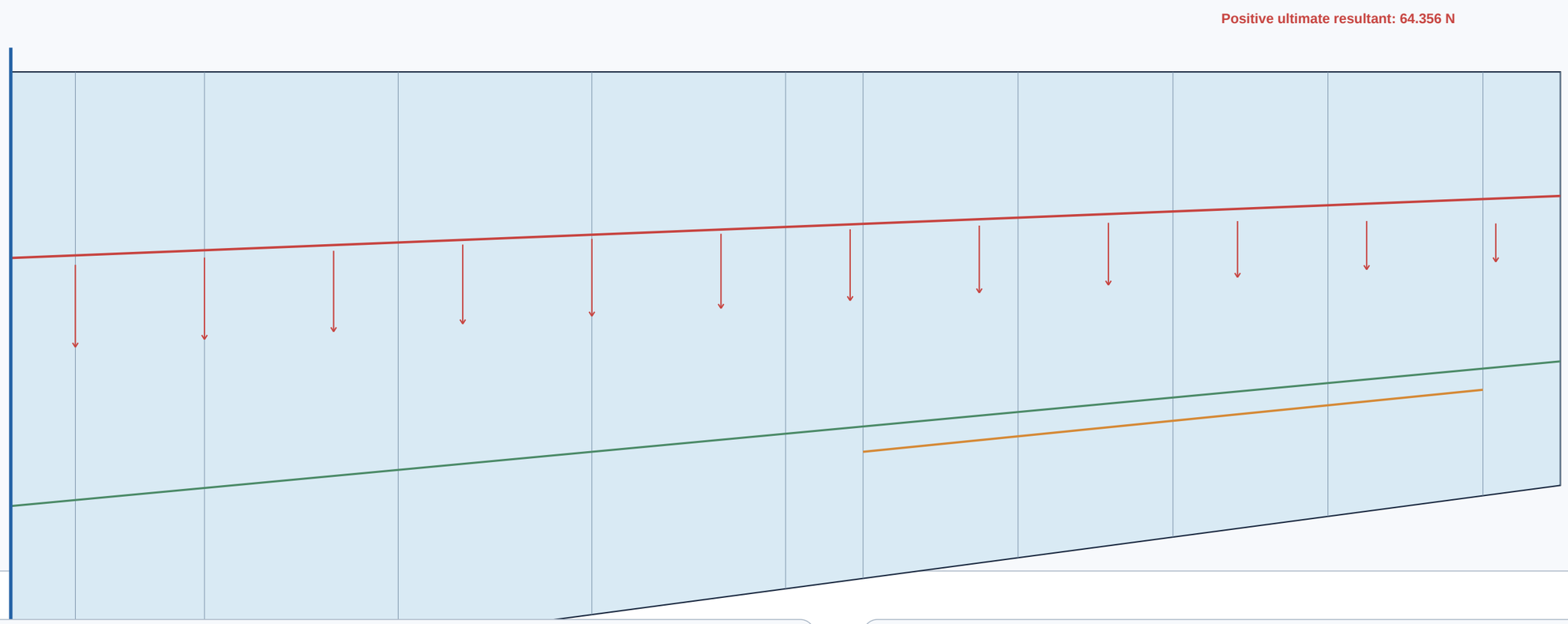
Drawings/exports

Create A3 drawings; export STEP, STL/3MF and DXF by released revision.

OPENWING-UAV **SolidWorks modelling workflow** Tutorial drawing - dimensions in mm - verify before manufacture	**DRAWING** OWU-TUT-500 **SCALE NTS**	**SHEET** 23/28 **REV A**

Static structural simulation setup

HALF-WING LOAD MAPPING



MESH STRATEGY

- Coarse: 20 global / 4 local.
- Medium: 12 global / 2.5 local.
- Fine: 8 global / 1.5 local.
- Converge displacement and critical non-singular stress.

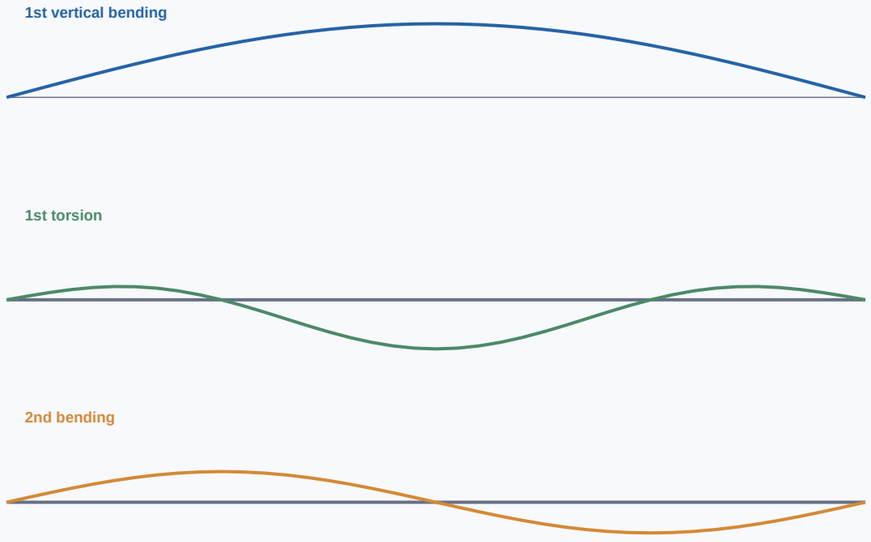
REQUIRED OUTPUTS

- Tip displacement and twist.
- Spar, joiner and root reactions.
- Composite or material failure indices.
- Load equilibrium and mesh-convergence table.

OPENWING-UAV **Static simulation setup** Tutorial drawing - dimensions in mm - verify before manufacture	**DRAWING** OWU-TUT-600 **SCALE NTS**	**SHEET** 24/28 **REV A**

Modal, buckling and dynamic-screening setup

MODAL STUDY



BUCKLING STUDIES

- Positive and negative global buckling.
- Upper- and lower-skin local panels.
- Main- and rear-spar web local buckling.
- Interpret critical load as BLF x applied load.
- Use imperfections of 0.25t, 0.5t and 1.0t in nonlinear sensitivity.

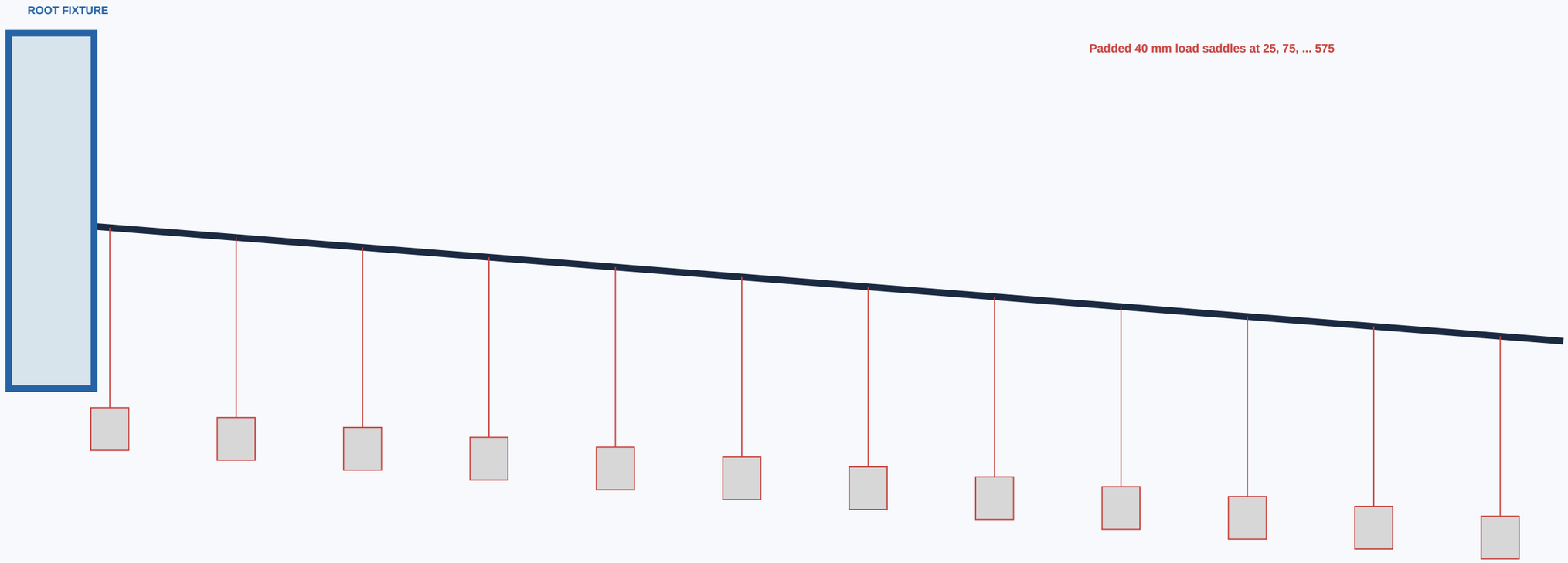
DYNAMIC SCREENING

- Extract at least 20 modes and classify bending, torsion, chordwise and local modes.
- Compare natural frequencies with 1/rev, blade-passing and harmonic motor/propeller excitation.
- Use project screening bands: less than 10% separation = red; 10-20% = amber; above 20% = green.
- Modal analysis alone does not establish flutter safety; retain aerodynamic coupling as a separate task.

OPENWING-UAV **Modal and buckling setup** Tutorial drawing - dimensions in mm - verify before manufacture	**DRAWING** OWU-TUT-610 **SCALE NTS**	**SHEET** 25/28 **REV A**

Prototype proof-load fixture and twelve-band loading

INVERTED POSITIVE-LIFT TEST ARRANGEMENT



LOAD TARGETS

Test	Half-wing load
Positive limit proof	42.904 N
Negative limit proof	18.387 N
Positive ultimate sacrificial	64.356 N
Negative ultimate sacrificial	27.581 N

SAFETY AND MEASUREMENT

- Use remote loading, barrier and weight-catch system.
- Measure tip LE/TE displacement, cap strain and root rotation.
- Stop for cracking, slip, unstable deflection or sensor limit.

OPENWING-UAV

Prototype proof-load fixture

Tutorial drawing - dimensions in mm - verify before manufacture

DRAWING	SHEET
OWU-TUT-700	26/28
SCALE NTS	**REV** A

Manufacturing plan and bill of materials

Group	Representative parts	Material / process	Qty full wing
Skin	Main wing shells; ailerons	Composite shell	2 + 2
Ribs	12 stations per side	Birch plywood CNC	24
Main spar	Web; upper/lower caps; doubler	Plywood + carbon	2 sets
Rear spar	Web; upper/lower caps	Plywood + carbon	2 sets
Root interface	V-joiner; rear pin	6061-T6 + steel/aluminium	1 each
Control	Hinge fittings; pins; servo trays	Printed nylon/PETG + steel	6 hinge sets
Tip/tooling	Tip caps; alignment/drilling jigs	PETG/PLA	As required

CNC PARTS

- Ribs from DXF with tabs and finish pass.
- Spar webs and root doubler.
- V-joiner profile only after stock and machine review.

ADDITIVE PARTS

- Servo tray and hinge fittings.
- Removable tip cap.
- Rib, drilling and fit-check jigs.

RELEASE FILES

- Native CAD and drawings.
- STEP, STL/3MF, DXF.
- BOM, material register and revision manifest.

Final inspection, documentation and release checklist

- [ ] All CAD features rebuild without errors and all external references are controlled.
- [ ] Right and left wings have matching span, root interface, dihedral and control travel.
- [ ] Root chord 240, tip chord 160 and semi-span 600 are verified physically.
- [ ] Tip rise is 31.445 and twist progresses from 0 to -2 deg.
- [ ] Main and rear spars are continuous, straight and correctly bonded.
- [ ] All rib stations and thicknesses match the released drawings.
- [ ] Joiner insertion is 150 per side and rear pin is correctly retained.
- [ ] Servo, pushrod and aileron operate freely through +20 / -15 deg.
- [ ] Wiring is protected, strain-relieved and clear of control hardware.
- [ ] Surface finish is smooth; no unacceptable waviness, delamination or gaps.
- [ ] Mass and centre of gravity are recorded for each half-wing.
- [ ] Static, modal and buckling studies use the final mass/material configuration.
- [ ] Proof-load and modal-test data are correlated with the final FEA revision.
- [ ] DXF/CAM files are simulated for the actual machine before manufacture.
- [ ] All released files have revision, date and SHA-256 manifest entries.

RELEASE STATEMENT

This tutorial drawing set describes the project architecture and build sequence. Final manufacturing and flight use require verified native CAD, material data, solver results, machine-specific CAM review and physical test evidence.

OPENWING-UAV **Inspection and release** Tutorial drawing - dimensions in mm - verify before manufacture	**DRAWING** OWU-TUT-900 **SCALE NTS**	**SHEET** 28/28 **REV A**