Pelican-500 Cliff-Launch Ekranoplan (WIG) Glider — Specification (Rev A)

1) Scope & Mission

- Cliff-launchable wave-riding ground-effect (WIG) **glider** optimized to carry a **500 lb (227 kg)** payload along long-period ocean swell using **ground effect** and **wave-slope soaring (WSS)**.
- Optional **13 kW electric pusher** provides launch assistance, recovery, and contingency thrust; normal cruise uses little to no power in favorable swell.

2) Performance

- **All-up mass (AUM, baseline):** 500 kg
  (Payload 227 kg; empty 260–280 kg; systems 18–25 kg; optional battery/drive 18–30 kg)
- **Stall speed (sea level, CLmax≈1.5):** ~19.5 m/s (38 kt)
- **GE cruise speed (normal):** 22–28 m/s (43–54 kt)
- **Ground-effect height (H):** 0.5–0.7 m nominal (min 0.4 m; max 1.0 m)
- **Drag @ 25 m/s in GE:** ~278 N (Cd≈0.052) → **~6.9 kW** equivalent shaft power
- **L/D (GE trim):** ~16–18 (est.)
- **Climb (electric, 13 kW):** Marginal out of GE; intended for recovery/loiter, not sustained climb
- **Turn limits (GE):** Bank ≤ 12° nominal
- **Operating sea state (WSS mode):** Long-period clean swell **H 1.5–3.0 m; T 12–18 s**; ambient wind ideally ≤ 8 m/s
  (Operate as GE-only craft if boundary layer is turbulent or swell is messy)

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3) Geometry

- **Span (b):** 11.00 m
- **Wing area (S):** 14.00 m²
- **Aspect ratio:** 8.64
- **Planform:** Reverse-delta mainplane with large **endplate sponsons**
- **Root chord:** 1.80 m; **Tip chord:** 0.80 m; **LE sweep offset at tip:** ~0.60 m aft
- **Washout:** −2.0° at tip; **main wing incidence:** 0.0°
- **Endplates:** 0.55 m height × 0.85 m chord; lower 120 mm sacrificial skid
- **Canard (all-moving):** span 2.60 m; chord 0.35 m; mount ~1.25 m above keel; hinge at ~25% chord
- **Fuselage (canoe):** length ~6.20 m; beam ~1.20 m; payload bay 2.0 × 0.9 × 0.9 m (L×W×H)

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4) Weights & Balance

- **CG nominal:** 26% MAC; allowable range 22–30% MAC (payload on CG rails ±200 mm)
- **Static margin:** 8–12% at cruise
- **Design load factors: +3.5 / −1.5 g** (gust near surface)
  Proof factors: +1.5× limit on spar caps and endplate roots

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5) Aerodynamics

- **Design CL (GE cruise @ 25 m/s):** ~0.92
- **CLmax (flaperon deflection):** ~1.5 (target 1.6 with LE cuff or VG tape)
- **Airfoils:** WIG-oriented 10% root / 9% tip cambered sections; canard ~9% symmetrical with generous LE radius
- **Induced drag mitigation:** Fences/endplates, low **H/b** (≈0.05–0.06), and tight height control

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6) Stability & Control

- **Primary controls:** Full-span **elevons** (30% chord), **all-moving canard**, optional **spoilers** near endplates
- **Throws:** Elevons ±20° (flaperon −10°…+10°); Canard −3°…+8° incidence; Spoilers 0–35°
- **Roll/yaw:** Endplates add roll damping; twin fins blended into endplates (or short T-mast) for yaw stability
- **Servo spec:**
  - 6 × waterproof **≥40 kg·cm** for elevons/canard
  - 2 × **≥20 kg·cm** for spoilers
    Metal-gear; IP-rated; ball-link pushrods, dual-shear horns at surfaces

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7) Structures & Materials

- **Wing skins (root):** Glass 200 g/m² / Glass 300 g/m² / **Carbon UD spar caps (top/bot)** / Glass 200 g/m² over PVC (H80) foam core (15 mm)

- **Wing skins (tip):** Lightened layup; foam 10 mm
- **Spar caps:** ~600 g/m² UD equivalent; 120 mm cap width at root tapering to 50 mm by 0.7 b
- **Shear webs:** ±45° biax 600 g/m² both sides; 6–10 mm core
- **Endplates:** Glass 2×200 + 1×300 each side over 10 mm core; internal rib ~40% chord; skid shoe on lower edge
- **Fuselage:** Glass/epoxy shells with marine-ply frames; anodized 6061-T6 hardpoints
- **Coatings:** Marine epoxy paint; LE polyurethane guards; anti-erosion tape near spray zones

Manufacturing tolerances (minimum):

- Planform linear dims ±3 mm critical, ±10 mm general
- Incidence and washout ±0.2°
- CG location ±5 mm after payload installation
- Surface waviness: ≤ 0.8 mm over 500 mm span on lifting surfaces

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8) Electrical Power (13 kW package)

- **Motor:** 13 kW continuous BLDC, 48–60 V, ~120–160 Kv, IP55 (sealed bearings), folding 24–28" prop (2–3 blade)
- **ESC:** 150 A, 48–60 V, telemetry capable; conformal coat; spray shield
- **Battery:** 12S Li-ion, **5–6 kWh** total (e.g., 21700 cells), BMS ≥200 A, cell/pack temp monitoring
- **Protection:** Main fuse **200 A ANL**; **NTC precharge** + main contactor (BMS-controlled)
- **DC-DC:** 48–60 V → 12 V, 20–30 A for avionics/servos
- **Harness:** HV 8–10 AWG silicone wire; LV 16–20 AWG as needed; tinned marine copper
- **Connectors (examples):** HV AS150 anti-spark / SB175; LV sealed automotive (AMP/Tyco or Deutsch DT)
- **Ingress protection:** Battery/BMS bay IP54; ESC bay shielded from spray; motor pylon with IP67 cable glands

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9) Avionics & Sensors

- **Flight controller:** Pixhawk-class (ArduPilot/PX4), IMU-based **pitch/roll rate damping**
- **Radar altimeter:** 24 GHz, range 0–5 m; primary feedback for **height-hold at 0.5–0.7 m**
- **Wave sensing (WSS mode):** Short-range lidar or stereo camera; estimate wave vector and phase speed; compute crab angle to keep groundspeed projection ~wave c
- **GNSS + baro:** For speed checks and fallback altitude cues (not used for near-surface height)
- **Telemetry:** 900 MHz/2.4 GHz link; logging of H, bank, airspeed surrogate, motor power, GPS

Autopilot modes:

- **HOLD(H):** Radar-alt PI loop; bandwidth limited to prevent porpoising
- **WAVE-LOCK:** Track swell inflection line; command small crab (5–15°) to match phase speed while holding airspeed margin ≥ 1.25·Vs
- **ROLL DAMPER:** Maintain |bank| ≤ 8° nominal (12° limit)

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10) Controls, Linkages & Surfaces

- Dual pushrods per primary surface (redundant if weight allows)
- Ball links; stainless clevis pins with safety keepers
- Surface gaps sealed (Mylar or fabric seals) for spray reduction
- Control stop screws set to protect horns/servos at max throw

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11) Launch, Flight & Recovery

- **Cliff launch height:** ~150 ft (45.7 m) over clear water (no rocks/breakers below)
- **Wind:** 3–8 m/s onshore preferred; avoid strong shear at rim
- **Pre-trim:** Flaperon +5°, canard +2°, CG at 26% MAC; spoilers armed; motor idle
- **Release:** Level attitude, clean drop on a lull; shallow dive to **≥25–27 m/s** by ~25 m AGL

- **Intercept GE:** Level to **H≈1.0 m**, trim to **H≈0.6 m**, align with swell, **WAVE-LOCK**
- **Abort/Recovery:** Spoiler pulse + shallow flare onto sponsons; or throttle up, extend alongshore, re-acquire clean swell

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12) Environmental & Operational Limits

- **Air temp:** 0–40 °C (electronics derate >35 °C)
- **Water temp/spray:** 5–30 °C; rinse salt with fresh water post-flight
- **Wind:** WSS optimum ≤ 8 m/s; GE-only OK to ~12 m/s with discretion
- **Sea state:** Favor non-breaking, long-period swell; avoid cross-seas and steep shoaling zones

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13) Inspection & Maintenance

- **Pre-flight:** LE guards, endplate skids, canard bearings, hinge play, servo health (telemetry), BMS status, contactor/precharge check
- **Post-flight:** Rinse; corrosion check; ESC/motor temp log; fastener torque audit (initial 10 hr at 2-hr intervals)
- **Composite:** Visual NDI (tap test) at 25 hr; endplate root reinforcement inspection at 10 hr initial

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14) Safety & Human Factors

- **Crew:** Two-person hold or trolley at cliff edge; radio to safety boat
- **Emergency options:** Spoiler-assisted splashdown; tow boat recovery anchor points fore/aft
- **Clearances:** Keep ≥ 100 m from people/surf zones; wildlife standoff per local regs

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15) Documentation & Deliverables

- 2D outlines (DXF/PDF) for wing, ribs, fuselage top/side, endplates, canard
- Wiring schematic (SVG/PDF) with connector/cable gauges and protection

- BOM with classes/specs (see list you already have; vendor PN to be added on selection)
- CAD constraints: dimensions above; incidence/washout; CG rails; servo placement; hardpoints

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16) Open Choices (to finalize with you)

- **Airfoil family** (WIG-tuned section selection for final loft)
- **Prop diameter/pitch** and **motor Kv** (optimize for your typical sea state and target thrust margin)
- **Battery chemistry & pack layout** (Li-ion NMC vs $LiFePO_4$; module form factor; 12S capacity)
- **Endplate planform** (square vs. rounded LE for spray)
- **Autopilot stack** (PX4 vs ArduPilot) and sensor brand selections

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Quick Reference (numbers)

- b / S: **11.0 m / 14.0 m²**
- Vs (CLmax≈1.5): **~19.5 m/s**; 1.3·Vs: **~25.4 m/s**
- Cruise (GE): **22–28 m/s** at **H 0.5–0.7 m**
- Drag @25 m/s: **~278 N** → **~6.9 kW**
- Motor package: **13 kW**, 48–60 V, ESC **150 A**, battery **5–6 kWh**, main fuse **200 A**
- Servos: **6× ≥40 kg·cm**, **2× ≥20 kg·cm**
- Load factors: **+3.5/−1.5 g**; CG **26% MAC** (22–30% allowable)