



Engineering Physics Lesson 2 — "Red Wing Simulation"

Doc 1 of 3 · Engineering

Concept to production in a weekend — 80/20, Startup Weekend style.

The question

Can two people and two AIs take a drone idea from a napkin to something you could pitch, in one weekend?

Not build it — **pitch** it. A Startup Weekend doesn't ship hardware. It ships proof: that someone wants it, that it can work, that it can make money, and that you know exactly what you can't do alone. This lesson runs Red Wing through that funnel and keeps score of what each stage actually proves.

Three docs, one weekend

This lesson comes in three parts. **Engineering** (this doc): what we built and what the physics allows. **Business**: who pays, and the weekend pitch. **Law** (regulation, jurisdiction and the visa): what the law lets a non-US founder build, and the green-card route it feeds.

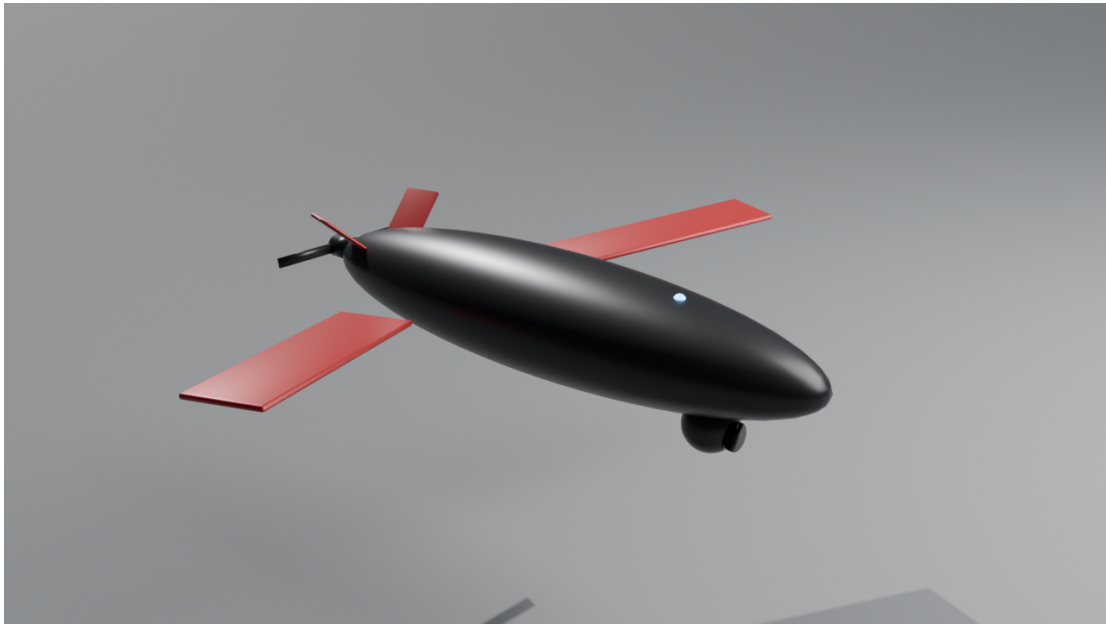
The ladder: concept → production

Each rung proves something new — and **does not** prove the rung above it. Honest labelling is the whole game.

Rung	What we made	What it proves	What it does NOT prove
1. Concept	Red Wing architecture diagram	We can decompose the system	That any of it works
2. Concept render	8-second AI-generated teaser (Muse)	The idea is legible in 8 seconds	Anything physical — label it "concept render"
3. 3D blockout	Blender model, built by script (below)	Shape, layout, proportions	Aerodynamics
4. Simulation	PX4 + Gazebo with our HUD on top	The software loop: sense → track → act	Real-world wind, weight, batteries
5. Proto-type	Jetson + VOXL 2 on an off-the-shelf frame	It flies, on real parts	Scale, certification, cost
6. Production	Partners build the body and the regulated payload	—	—

Rung 2 is the trap. Our first teaser looked premium — and its HUD showed three different distances at once, two clocks running backwards, and a compass reading N / Z / N. Generated video is a mood board. The fix: generate the footage **without** a HUD and composite our real one on top.

Rung 3: the blackout



Red Wing v0 — Blender blackout, built entirely by a Python script.

Red Wing v0 is a stretched sphere, two bevelled slabs, a V-tail and a pusher prop — about 80 lines of Python, rendered in 13 seconds. No clicking. The first render had the wings sweeping *forward*; one sign flip fixed it. That's the point of a blackout: cheap mistakes, caught early.

Rung 5: the kit

[Holybro](#) [X500](#) [V2](#) [PX4](#) [Development](#) [Kit](#) — about
US\$609 direct from Holybro (resellers 769–945).

- **Why this one:** it is the default drone in PX4's Gazebo simulator (`gz_x500`). The rung-4 simulation and the rung-5 prototype are the same airframe, so code that flies in simulation carries straight over.
- **Not in the box:** a 4S LiPo battery + charger and an RC transmitter/receiver — budget roughly US\$150–250 more.
- **Before flying in Canada:** at ~1.5 kg it needs registration and the Basic RPAS pilot certificate.
- **Order of operations:** simulation first, then buy. If the X500 model flies our code in Gazebo, the purchase is earned.

The physics: can it carry water?

We swapped the mission from search-and-rescue to **firefighting** — spot a hotspot on thermal, then hose it. That one change breaks the airframe. Here's why.

Lift (Anderson, *Introduction to Flight*, §5.3 — in our corpus):

$$L = \frac{1}{2} \rho v^2 S C_L$$

Our v0 wings: $S \approx 0.18 \text{ m}^2$. At 15 m/s, sea-level air ($\rho = 1.225 \text{ kg/m}^3$), and a generous $C_L = 1.0$:

$$L \approx \frac{1}{2} \times 1.225 \times 15^2 \times 0.18 \times 1.0 \approx \mathbf{24 \text{ N} \approx 2.5 \text{ kg}}$$
 — for the *whole aircraft*.

Ten litres of water is 10 kg. The fixed-wing Red Wing can't lift its own tank. **The mission picks the airframe**, so the firefighter becomes a heavy-lift VTOL — rotors, not wings.

Hover power (actuator-disk momentum theory — standard, but NOT in our corpus; Anderson Ch. 9 covers propellers, not hovering rotors):

$$P_{\text{ideal}} = T^{1.5} / \sqrt{2 \rho A}$$

A 25 kg VTOL (15 kg drone + 10 kg water) needs $T \approx 245 \text{ N}$. Four 0.4 m rotors give $A \approx 0.50 \text{ m}^2$:

$$P_{\text{ideal}} \approx 245^{1.5} / \sqrt{2 \times 1.225 \times 0.50} \approx \mathbf{3.5 \text{ kW}}$$
, or **~4.9 kW** at a realistic figure of merit of 0.7.

A 2 kWh battery (about 10 kg of cells) gives **~24 minutes** of hover, before any reserve.

The honest boundary: one sortie carries 10 L. A firefighter's 1.5-inch hose line moves roughly 360 L a minute — so a full Red Wing tank equals **under two seconds of one hose**. Drones don't put out forest fires. They **find** them early and knock down spot fires before they grow. That is the real product, and it is a better pitch than the fantasy.

The scorecard

- **Physics verified against the corpus:** the lift equation (Anderson §5.3).
- **Physics from knowledge, flagged:** hover momentum theory — the corpus gap is rotorcraft. A helicopter or multicopter text is the next book to shelve.
- **The pivot the numbers forced:** fixed-wing recon → VTOL first-strike firefighter.

- **The partner ask, now concrete:** we build the brain (thermal tracking, HUD, autonomy); partners build the body and the regulated parts.