LNRC 2026

Rocket Build Guide

LIGNUM National Rocketry Competition • Kits distributed July 25, 2026 • Competition Day August 15, 2026

Read This First

This guide gives you a BASE ROCKET. It is a starting point that you are meant to change, not a finished competition rocket. Here is exactly what that means:

- **If you build this design exactly as written, your rocket will fly and recover itself. That is ALL it will do.**
- **It will NOT deploy the PicoSat. In this design the PicoSat only rides inside the rocket. Its sensors will still record, but readings taken inside a closed tube are readings of the inside of your rocket - to collect real sky data, the PicoSat must leave the rocket and fall on its own parachute. You must design your own mechanism to make that happen. This is on purpose: the deployment mechanism is your team's creativity, and it is scored.**
- **It does NOT get you to 300 m. This design makes the rocket flight-worthy, nothing more. The only accurate way to predict your peak altitude is an OpenRocket simulation of YOUR rocket with YOUR real, weighed masses (Step 1).**
- **3-inch teams: one motor may not be enough to reach 300 m. Because of the bigger tube's drag, hitting the mark may take more than one motor - a serious design change that is up to you. Remember your team's total allocation is 3 motors.**

Body length, bay sizes, nose shape, fin count, materials, finishes, deployment - all of it is open. Change whatever helps you score. This guide is a floor, not a ceiling.

The Game Manual is the only official rulebook. If this guide and the Game Manual ever disagree, the Game Manual wins. Everything you fly must pass the pre-launch safety inspection.

Your Kit

Tick off every item at pickup on July 25. Anything missing or broken: email lignumpropulsion@gmail.com within 48 hours.

- ☐ 1x Inert demo motor - orange, marked INERT - DEMO. Same size and weight as the real motor. Use it for fit checks and balancing. It cannot fly.
- ☐ 2x Electrical ejection charge - a sealed cylinder that slides into your tube. Your electronics fire it to open the rocket. It has nothing to do with the motor. One is for a ground test, one is for flight.
- ☐ 1x Body tube for your class (2-inch or 3-inch, 24 in long) + 1x matching nose cone
- ☐ 1x Coroplast sheet (18 x 24 in) + 1x balsa sheet (1/8 x 6 x 36 in)
- ☐ 1x Shock cord (4 ft) + 1 yd parachute fabric + 30 ft parachute line
- ☐ 1x Arduino Nano + USB cable + MPU-6050 + BME280 + SD reader + 128 MB card
- ☐ 1x Buzzer + breadboard + jumper wires + on/off switch + 9V battery + 3 connectors
- ☐ 2x Raw eggs - one to practice with, one for competition day. Keep them in the fridge; any raw egg is a fair replacement if one breaks.

NOT in the kit: live motors and igniters - every team has an allocation of 3 motors for the season (test launches plus competition day), kept by Lignum and flown only at official events, a rail button or launch lug (you must supply one), glue, and sandpaper. There is no ready-made motor mount - you build it in Step 4.

Tools You Need

Epoxy (5-minute and 30-minute), hobby knife, scissors, ruler, tape measure, pencil, masking tape, sandpaper, a kitchen scale that reads grams, a computer with OpenRocket and the Arduino IDE, some string, needle and thread (or fabric glue), a rail button or launch lug, and some ballast (coins, washers, or clay).

Safety

- Never try to fly, open, or modify the demo motor or any motor. Live motors only exist at official launch days.
- The ejection charges are sealed energetic devices. Keep them cool and dry, away from flame. Never open one. Only connect one to electronics for a planned, announced ground test, or at the pad.
- Under-18s use knives, soldering irons, and epoxy with an adult supervising. Glue and paint in fresh air. Eye protection when cutting or sanding.
- Full rules: the Safety Policy at lignumpropulsion.com.

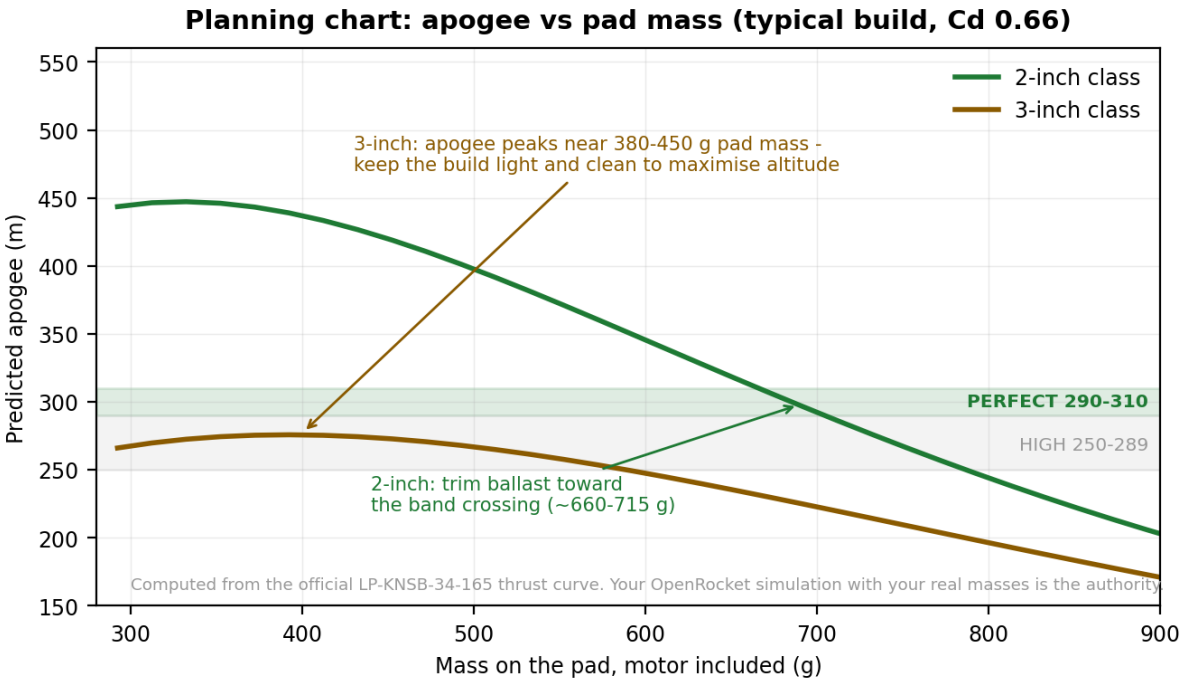
Step 1 - Set Up OpenRocket (30 min)

Do this before you build anything. OpenRocket is the only accurate way to know how high your rocket will go.

1. Install OpenRocket (free, openrocket.info).
2. Download the motor file: lignumpropulsion.com/LP-KNSB-34-165.eng. Save it somewhere permanent.
3. In OpenRocket: Edit > Preferences > General tab > "User-defined thrust curves" > add your .eng file. Click OK.
4. Restart OpenRocket.
5. In Motors & Configuration, click Select motor and search "LPKNSB". The motor shows up as LPKNSB34165PVC. That is the right one.

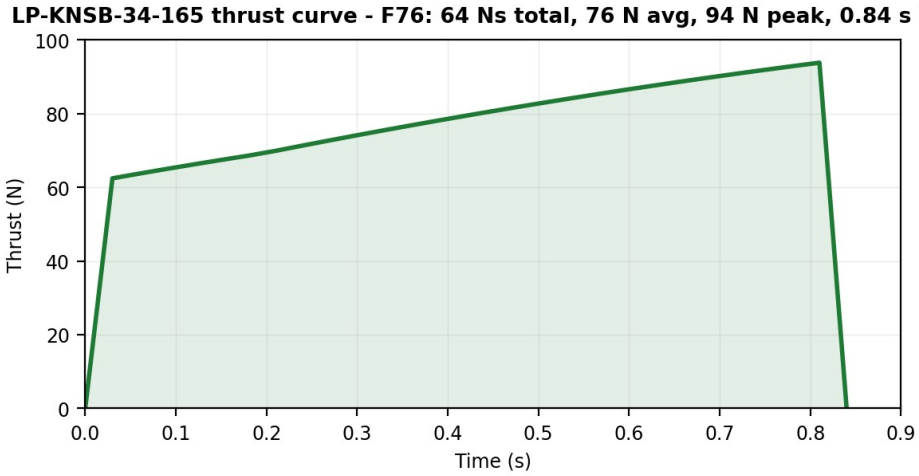
Step 2 - Plan Your Weight (1-2 h)

Every team flies the same motor, so height comes down to weight and drag. Sketch your rocket in OpenRocket first. This chart shows roughly what to expect:

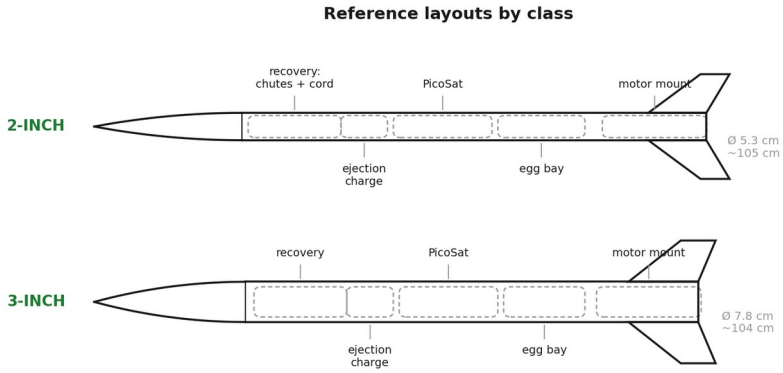


2-INCH: a light 2-inch flies way past 300 m. You control your height by adding weight - plan a ballast spot near the nose (washers on a bolt, or clay) and expect roughly 660-715 g on the pad when trimmed. About 10 g of weight = 5 m of height, so weigh everything.

3-INCH: the big tube has so much drag that a single motor may not reach 300 m at all - the curve peaks around 380-450 g and goes down from there. Build light and clean, and put your energy into the accuracy, egg, and data points (worth up to 1,200 combined). If your team wants to chase 300 m anyway, it may take more than one motor - your call, your design, and remember the allocation is 3 motors total.



Step 3 - Lay Out the Rocket (1 h)



Order from the tail up: motor mount, egg, PicoSat, ejection charge, recovery. The charge sits directly beneath the recovery bay so firing it pushes the nose and chutes out. Rules: overall length 90 to 168 cm.

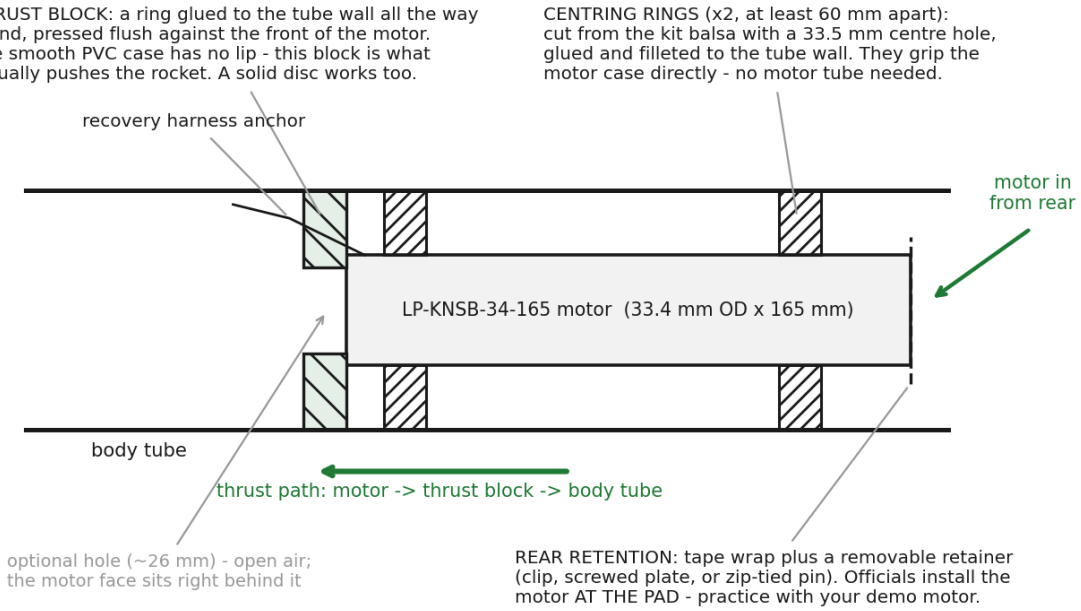
Mark the bays on your tube with pencil and tape, from the tail up: MOTOR MOUNT, EGG BAY, PICOSAT, EJECTION CHARGE, RECOVERY. The charge sits right under the recovery bay: when it fires, it pushes the nose and parachutes out. Keep total length between 90 and 168 cm. Put ballast near the nose. 2-inch teams: check your electronics actually fit through a 50.8 mm tube before you commit.

IMPORTANT: in this layout the PicoSat only rides inside - nothing here gets it OUT of the rocket. You must add your own PicoSat ejection (Step 6).

Step 4 - Build the Motor Mount (2-3 h + overnight glue)

Get this right - it is the one part where a mistake ends your flight. The motor pushes forward with up to 94 N (about 9.6 kgf), and its case is smooth PVC with no lip. So the mount needs two jobs done: something solid in front for the motor to push on, and something at the back so it cannot fall out.

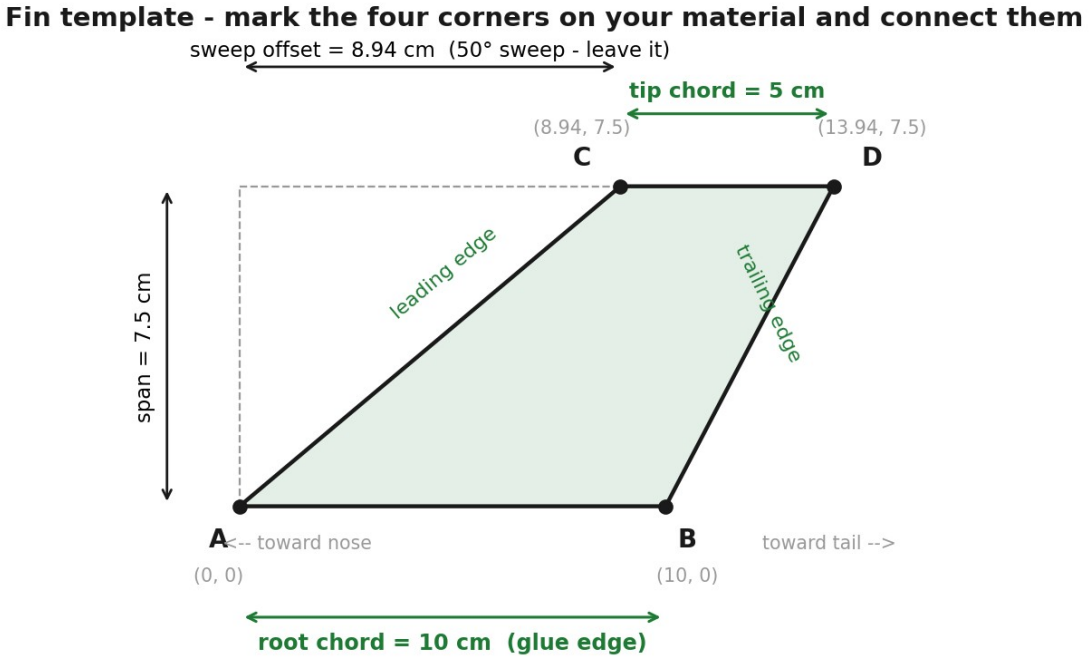
Direct motor mount - the finished mount must hold at least 20 lb (~9 kg) of forward force



1. Cut two centring rings from the kit balsa: discs that fit your tube, each with a 33.5 mm hole in the middle. Test them on the demo motor - snug, no wobble.

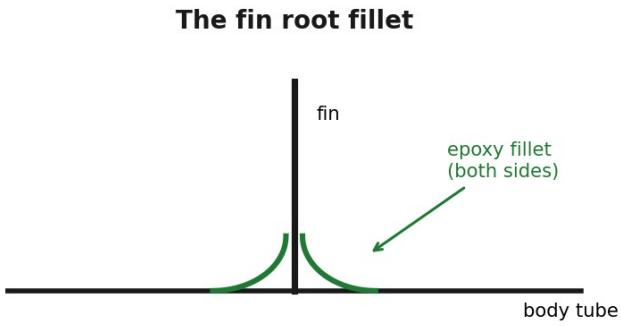
2. Cut one more ring: the thrust block. It sits flush against the FRONT of the motor. Give it a smaller hole (~26 mm) or no hole at all - either works, it just has to be smaller than the motor case so the motor has something to push on.
3. Glue all three into the tube with epoxy fillets on both faces, rings at least 60 mm apart. Look through the tube before the glue sets - a crooked motor makes a corkscrewing rocket. Let it cure overnight.
4. SAFETY CHECK: the finished mount must hold at least 20 lb (about 9 kg) of forward push. Stand the rocket on the demo motor and press down hard to prove it.
5. Back end: wrap the motor case in masking tape for a snug fit, plus a removable retainer (clip, screwed plate, or zip-tied pin). Officials put the live motor in at the pad - practice the fit with your demo motor until it takes under a minute.
6. Tie your recovery harness around the motor mount - it is the strongest point in the rocket.

Step 5 - Fins (3-5 h + overnight glue)



Cut 3 or 4 identical fins from the kit coroplast or balsa. Mark the four corner points on your material, join them, and cut: A (0,0) to B (10,0) is the 10 cm edge that glues to the tube; C (8.94, 7.5) and D (13.94, 7.5) make the 5 cm tip. The 8.94 cm sweep gives a 50° angle - leave it. Make the fins smooth, straight, and clean-edged.

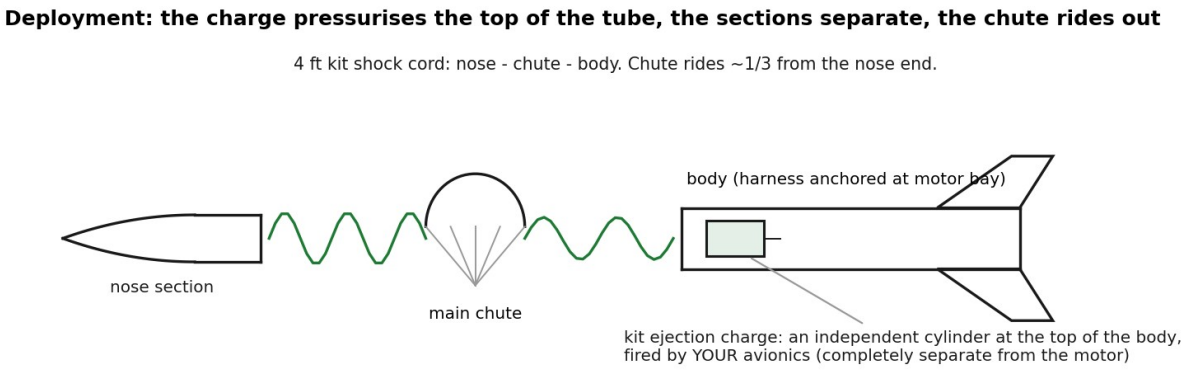
Wrap a strip of paper around the tube to mark evenly spaced fin lines (every 120° for 3 fins, 90° for 4). Glue each fin on, look down the tube to check they are straight, then run an epoxy fillet along both sides of every joint and cure overnight:



A smooth bead of 30-minute epoxy run along each side of the root joint.
The fillets, not the butt joint, carry the flight loads - never skip them.

The fillets do the real work - never skip them. If you use coroplast, run the flutes from tube to tip and scuff the glue line first. Fit your rail button or launch lug now, parallel to the tube.

Step 6 - Parachutes & Getting Things Out of the Rocket (3-5 h)



Cut your parachutes from the kit fabric - the Kit Contents document has a proven example (24 in main, 16 in PicoSat) and there is a video on the website. Tie the 4 ft shock cord from the motor mount to the nose section, with the main chute about a third of the way from the nose. A smaller PicoSat chute with a small hole in the centre drifts less - that helps your accuracy score.

Main deployment (opening the rocket)

The motor does nothing here - it burns out and is done. Put an ejection charge at the top of its bay with the wires running to your Arduino (the official flight code raises pin D9 for 1.5 seconds at apogee, exactly for this). When it fires, the tube pressurises, the nose pushes off, and the main chute comes out. Use

your FIRST charge for one full ground test - outside, tube pointed away from everyone, announced loudly - and fly the SECOND. A servo pin with a spring works too, if you prefer no charge.

PicoSat deployment (getting the PicoSat OUT) - you design this

THIS GUIDE GIVES YOU NO PICOSAT EJECTION MECHANISM, ON PURPOSE. Built as-is, the PicoSat stays inside and its data stays rocket-data, not sky-data. Getting it out - a piston, a spring tray, a bay that opens at separation, gravity after the nose comes off - is the design problem every team must solve for itself.

The rule you are designing for: after deployment the PicoSat must fall as its own free unit - no cord or tether to the part of the rocket holding the motor - on its own parachute. If the piece that comes off is half the rocket or more, that is not a PicoSat deployment. A PicoSat still tied to the body scores as not deployed.

Pack every chute loose enough that it slides out when you tip the tube upside down. Check this every single time you pack.

Step 7 - Wire the Electronics (3-6 h)

Everything fits on the 400-point breadboard. Wire in this order: power, then the two sensors, then the SD module, then the buzzer. The tables say where every pin goes. Every GND must connect together.

Power

Connection	Goes to	Notes
Nano 5V	**red (+) rail**	feeds all modules
Nano GND	**blue (-) rail**	common ground
9V battery (+)	**switch, then Nano VIN**	switch OFF for transport
9V battery (-)	**blue (-) rail**	

BME280 (pressure / temperature / humidity)

Pin	Goes to	Notes
VCC	**+ rail**	
GND	**- rail**	
SDA	**A4**	shared with MPU
SCL	**A5**	shared with MPU
CSB	**+ rail**	sets I2C mode
SDO	**- rail**	sets address 0x76

MPU-6050 (gyro + accelerometer)

Pin	Goes to	Notes
VCC	**+ rail**	
GND	**- rail**	

SDA	**A4**	shared with BME
SCL	**A5**	shared with BME
AD0	**- rail**	sets address 0x68
XDA / XCL / INT	**leave empty**	

SD card module

Pin	Goes to	Notes
VCC	**+ rail (5V)**	
GND	**- rail**	
CS	**D10**	
SCK	**D13**	
MOSI	**D11**	
MISO	**D12**	

Buzzer and deploy pin

Pin	Goes to	Notes
Buzzer (+)	**D8**	beeps for status + recovery
Buzzer (-)	**- rail**	
DEPLOY	**D9**	goes HIGH for 1.5 s at apogee - fire your ejection from here

The official flight code

Download picosat_flight.ino from lignumpropulsion.com/picosat_flight.ino. It logs height, temperature, humidity, pressure, and motion 25 times a second, spots liftoff, apogee and landing, raises D9 at apogee, and beeps after touchdown so you can find the PicoSat. In the Arduino IDE, install the Adafruit BME280 library (say yes to its helpers), then upload.

- Format the SD card as FAT32 first.
- After switch-on, keep the PicoSat still for 3 seconds - it is calibrating to the pad.
- Three rising beeps = everything works. One long low buzz = something is wired wrong - check the tables.
- The code is a starting point. Change anything you want - it is your flight software.

Making the code fire your ejection charge

The code as provided does NOT fire anything - pin D9 just goes HIGH at apogee and nothing is connected to it. To use your ejection charge, you connect its firing circuit to D9 and, if you want different behaviour, add code yourself. Two ways to do it:

OPTION 1 - FIRE AT APOGEE: already built into the provided code. These lines do it - when the rocket starts falling, D9 goes HIGH for 1.5 seconds:

```
if (alt < maxAlt - APOGEE_DROP) {              // apogee detected
  phase = DESCENT;
```

```
    digitalWrite(DEPLOY, HIGH);                  // D9 fires here
    deployActive = true; tDeploy = now;
  }
```

Connect your charge to D9 and apogee ejection works with no code changes.

OPTION 2 - FIRE ON A TIMER: fire a fixed number of seconds after liftoff. Get the time-to-apogee from YOUR OpenRocket simulation, then ADD these pieces to the provided code:

```
// 1) near the other tuning values at the top:
const unsigned long EJECT_DELAY_MS = 6000;   // 6.0 s after liftoff - use YOUR sim time
unsigned long liftoffAt = 0;
bool timedFired = false;
// 2) in loop(), replace the PAD case line with:
case PAD:
  if (alt > LIFTOFF_ALT) { phase = ASCENT; liftoffAt = now; }
  break;
// 3) in loop(), just after the switch(phase) block:
if (!timedFired && liftoffAt > 0 && now - liftoffAt >= EJECT_DELAY_MS) {
  digitalWrite(DEPLOY, HIGH); deployActive = true; tDeploy = now;
  timedFired = true;
}
```

Both options work - it is your call which to fly, and you can also use both at once (D9 fires at whichever happens first). Whatever you choose, bench-test the logic with nothing connected to D9 and watch the behaviour before any charge is ever involved.

EJECTION CHARGE SAFETY - READ EVERY WORD:

- **NEVER plug in an ejection charge while ejection code is uploaded and the board is powered. Upload first, test the logic with nothing connected, and connect the charge LAST - at the pad, or immediately before a planned outdoor ground test.**
- **NEVER run ejection code with a charge connected unless you are OUTDOORS, everyone stands behind or beside the rocket, and nobody is in front of the charge or in front of anything it will push out.**
- **Treat a connected charge as live at all times. Disconnect it before touching the electronics, changing code, or opening the rocket.**
- **Announce every ground test loudly before you arm. One test, one charge: your second charge is for flight.**

Step 8 - Egg Bay & PicoSat Box (1-2 h)

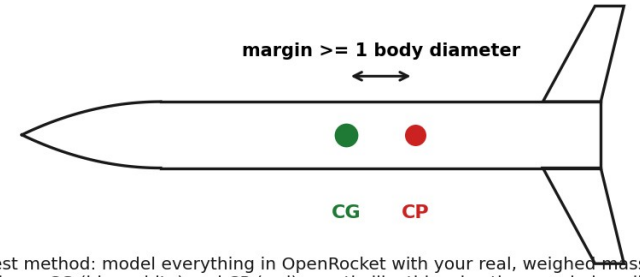
- Egg: cushion it on all sides (foam or bubble wrap) in a bay you can open and close in seconds - officials check the egg after the flight. Your kit includes 2 raw eggs: practice with one, fly the other. If one breaks, any raw egg from the shop is a fair replacement.
- PicoSat: move your working breadboard into a protective box made from kit materials. The arming switch must be reachable from outside the closed rocket, the buzzer must not be muffled, its parachute attached, and your ejection mechanism (Step 6) proven on the bench.

Step 9 - Put It All Together & Weigh It (1-2 h)

Assemble everything: demo motor, practice egg, PicoSat, packed chutes, nose on. Weigh the whole rocket and type the real number into OpenRocket - this is the only prediction that counts. 2-inch: trim your ballast toward the Step 2 target. 3-inch: remove every gram you can find.

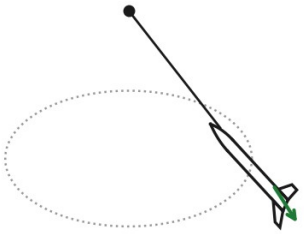
Step 10 - Check Stability (1-2 h, do it in week 3)

Check stability in OpenRocket



Best method: model everything in OpenRocket with your real, weighed masses - it shows CG (blue-white) and CP (red) exactly like this, plus the margin in calibres. Healthy zone: 1.0 to 2.5 cal. Below 1.0 fails inspection.

Swing test (confirmation)



Physical double-check: hang from string at the CG, swing overhead. Nose leads = stable. Tumbles = add nose ballast.

In OpenRocket, with your real weights entered, read the stability margin. You need at least 1.0 calibre (the CG at least one tube-width ahead of the CP) - it is checked at inspection. 1.0 to 2.5 is the sweet spot. Then check reality: balance the fully loaded rocket on a ruler edge to find the real CG and compare it with the model. Want certainty? Tie string at the CG and swing it overhead - nose leads means stable, tumbling means add nose weight. If reality disagrees with the model, believe reality and fix the model.

Competition Day Checklist

- ☐ Fins solid, fillets unbroken, nothing rattles
- ☐ Demo motor OUT (officials fit the live motor at the pad), retention practiced
- ☐ Flight charge packed safely; connect only at the pad when told
- ☐ Rail button / lug solid and straight
- ☐ Chutes packed loose, lines untangled, harness tied; separation ground-tested
- ☐ PicoSat ejection proven; PicoSat leaves free, no tether
- ☐ Fresh 9V plus a spare; SD in, FAT32; three rising beeps on arming; switch OFF for travel
- ☐ Egg bay padded and opens fast; your competition egg packed safely for the trip
- ☐ Pad weight matches your simulation (bring the scale and ballast)
- ☐ Landing-prediction worksheet ready (chute sizes, PicoSat weight, wind check plan)
- ☐ Signed Participant Agreement for every member

Common Mistakes

- No thrust block because the motor "fits snug". Friction will not hold 94 N.
- Crooked fins or a crooked motor from rushing the glue. Look down the tube, then let it cure overnight.
- Flying a deployment that was never ground-tested. That is what your first charge is for.
- Assuming the PicoSat "will come out somehow". It will not. Design its exit, test its exit.
- A chute packed so tight it never leaves the tube. Tip-test every pack.
- MOSI and MISO swapped on the SD module - the classic "SD failed". Check D11/D12.
- Moving the PicoSat during its first 3 seconds - ruins the calibration. Switch on, hold still.
- One loose jumper at the range. Tug every wire; a dab of hot glue holds them.
- Skipping the weigh-in. If the real rocket is 50 g off the simulation, the prediction is fiction.
- Painting the night before - paint is weight and it moves your balance. Re-weigh, re-simulate.

Questions

Rules: the Q&A form at lignumpropulsion.com/#qa (answered every Monday). Kit problems: lignumpropulsion@gmail.com. The Game Manual always wins.