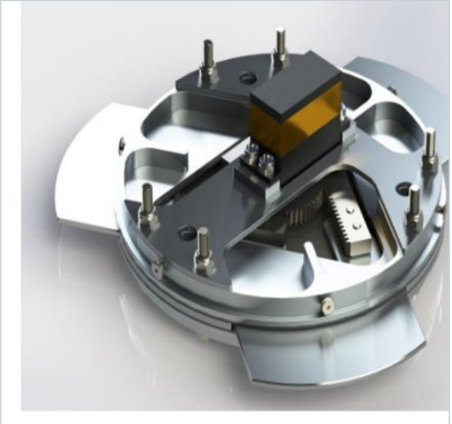
A precision airbrake — and an honest post-mortem

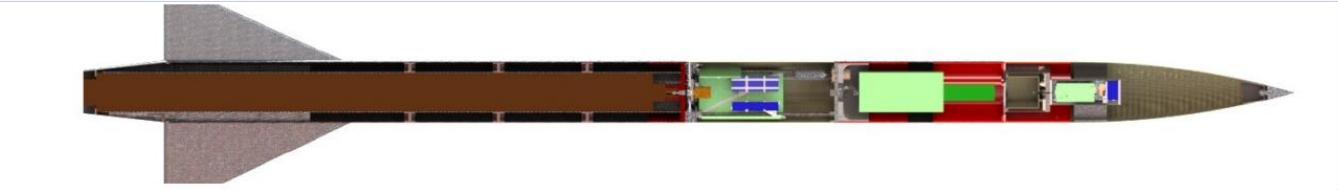
Active apogee control for a supersonic rocket: built to overshoot, then brake back to a 9 km target. Validated to a safety factor of 23. It never deployed on the flight — and the reason was not the mechanism.



Three-flap airbrake — one central gear-rack, one servo. The whole brake moves as a single body.

01 The idea — overshoot on purpose, then brake back to target

A passive rocket lands wherever its drag and motor happen to put it. We wanted to hit 9 km exactly, so we designed Darwin II to **overshoot** — then fitted an active airbrake that opens during the coast phase, adding just enough drag to stop the rocket at the target height. Simple in concept; genuinely hard in practice — which is where the engineering lives.



Cross-section: CFRP airframe (dark) with the brake bay forward of the motor.

VEHICLE	APOGEE	MAX SPEED	LIFT-OFF MASS
Darwin II	**9 km target**	**Mach 1.7**	**~34 kg**
PEAK THRUST	LENGTH	PROGRAMME	MY ROLE
~4.7 kN	**~2.7 m**	**EuRoC 2021**	**Technical lead**

Darwin II was built by Endeavour, the University of Edinburgh student rocketry team (~60). I led the technical effort; the airbrake work shown here was a team build.

02 Two constraints — and two fixes that weren’t the obvious ones

Symmetry — every flap must move as one. The brake may only ever produce axial drag. If one flap opens before another, the asymmetric force yaws the rocket off its trajectory — a lateral push at supersonic speed. The fix: three identical flaps driven by a single central gear-rack on one servo. Mechanically impossible for them to disagree.

Fail-safe — retract on failure, and never stick. Springs were the instinct, but no manufacturer could supply a torsion spring matching the size, force and travel. So fail-safe retraction moved to a redundant control board on its own power supply, which drives the servo shut if the primary dies. And a layer of HDPE between the laser-cut aluminium plates — low-friction and light — keeps the flaps sliding freely under aero load.

03 Validated — the hardware wasn’t the weak link

133 N	11.3 MPa	×23	0.1 mm
load per flap, fully deployed	peak stress · vs 250 MPa yield	safety factor on the aluminium	worst-case flap deflection

FEA in ANSYS, loaded with a deliberately pessimistic drag coefficient of 1.6 — worse than literature — at the 200 m/s deployment limit set to dodge transonic effects. Conclusion at the time: the structure is sound. The real risk lived in the **control system** — model-predictive plus a critically-damped PID, comparing live velocity, acceleration and altitude against a pre-computed ideal trajectory.

04 The real failure — beaten by one scheduling call

On the flight, the airbrake never deployed — and not because the mechanism was wrong. Symmetry, fail-safe and stiffness were all solved and validated. The honest read: we tried to validate a complex closed-loop system for the first time at the competition itself — the one place you can’t afford a first time. A safety factor of 23 can’t protect you from a process decision. **Test the integrated system before it matters, or the cleverest subsystem on the rocket simply won’t fire.**

> Why this is in my portfolio: it’s how I actually work — rigorous where it counts, and honest about what the analysis can’t cover. The same judgement (real options, named tradeoffs, and the failure modes stated plainly) is what a VG Engineering concept study brings to your problem.