PROJECT PORTFOLIO

Rizwan Nizar

Aerospace Engineer — Propulsion, Structures, Manufacturing



REGISTER NUMBER	**23AU0020063**
COURSE	**B.Tech, Aerospace Engineering**
DEPARTMENT	**Department of Aeronautical Engineering**
INSTITUTION	**Hindustan Institute of Technology and Science, Chennai**
BATCH	**2023 – 2027** · Semester VII
CONTENTS	**29 engineering projects** across six disciplines, and six industrial internships

This portfolio is the sample-work section of my placement folder. It presents twenty-six engineering projects with one figure each, and the six industrial internships they came out of.

5 Propulsion	**7** Structures	**5** Space systems	**2** Aerospace ML	**7** Electronics

rizwannizar40@gmail.com +91 62384 48351 linkedin.com/in/rizwannizar github.com/rorcoder999

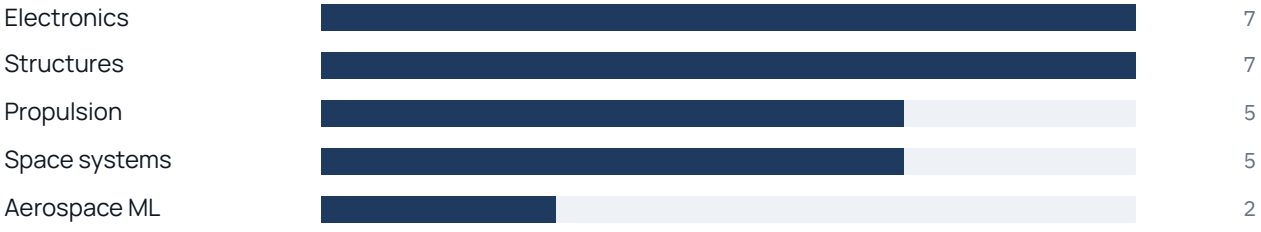
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Figures marked as reserved slots are placeholders for CAD renders, simulation plots and hardware photographs held in the accompanying project files. All other figures are the author's own output.

Portfolio at a glance

Where the twenty-six projects sit, and what they were built with.



29
Figures, one per project

14
Built in a company or team setting

12
Independent builds

28
Distinct tools and frameworks

1 Profile

I am a final-year Aerospace Engineering student at HITS Chennai, working across propulsion design, structural simulation and aerospace component manufacturing.

Across six internships I have optimised an ICBM fuel injector for mixing and machinability, taken a Rotating Detonation Engine from CATIA model to fabricated hardware, and spent a month on an AS9100D shop floor running the full production chain — CAD/CAM, production planning and control, CNC machining and quality inspection.

Alongside the hardware I build the tools that support it: nozzle contour workbenches, aircraft sizing suites, satellite tracking stations and flight-hardware budgeting software. The second half is what makes the first half faster.

6	29	AS9100D	2027
Industrial internships	Engineering projects	Shop-floor experience	B.Tech Aerospace, HITS

01 Ran the full production chain on an AS9100D shop floor — CAD/CAM, production planning and control, CNC machining and quality inspection.

02 Optimised an ICBM fuel injector for mixing while keeping every orifice inside the shop's existing tool library, so the winning geometry needed no new tooling.

03 Carried a Rotating Detonation Engine from CATIA model through CFD to fabricated hardware, and stayed with the parts through manufacture.

04 Practised line maintenance on Cessna 172P and 172S airframes with Lycoming O-320-D2J and IO-360-L2A engines at the Government Flying Training School, Jakkur.

05 Wrote a nozzle design workbench verified against an exact source-flow solution, and a satellite tracking station over 13,130 catalogued objects that runs on a board, a phone and a laptop from one test suite.

2 Technical skills

CAD / CAM CATIA · SolidWorks · NX CAD · AutoCAD · Fusion 360	**Simulation** ANSYS (structural and CFD) · MATLAB / Simulink · SU2 · STK · OpenRocket	**Engineering** CFD · FEA / FEM · Design for manufacturability · CNC machining · Production planning and control · Quality inspection · Rapid prototyping
Electronics KiCad PCB design · Embedded systems · STM32CubeIDE · ESP-IDF · Zephyr · PlatformIO · Arduino	**Software** Python (AI and automation) · FastAPI · React / TypeScript · Kotlin · Docker · Git · Android Studio	**Languages** English · Malayalam · Tamil · Hindi

3 Industrial experience

ORGANISATION	ROLE	PERIOD	DOMAIN
Aero Precision	Aerospace Components Production Intern	May – Jun 2026	Manufacturing
Skyline	Rocket Design Technology Intern	Dec 2025 – Jan 2026	Structures
Prime Toolings	Aerospace Propulsion & Structural Design Intern	May – Sep 2025	Propulsion
Agnirva · IN-SPACe	Space Exploration Program Participant	Jun – Aug 2024	Space sector
Sky Aerospace & GFTS	Aircraft Design & Maintenance Intern	Jun – Jul 2024	Airframes
1Stop	Hybrid Electric Vehicle Systems Intern	Jan – Feb 2024	Powertrain

Aerospace Components Production Intern — Aero Precision · AS9100D certified

May – Jun 2026

- Worked the full production chain in the Aerospace Components Production Division — CAD/CAM, production planning and control, CNC machining and quality inspection.
- Applied AS9100D / ISO 9001:2015 process discipline and industrial safety standards on the shop floor.

Rocket Design Technology Intern — Skyline, Coimbatore

Dec 2025 – Jan 2026

- Built a full rocket model in SolidWorks from mission-level requirements.
- Validated the airframe structurally in ANSYS under flight load cases.

Aerospace Propulsion & Structural Design Intern — Prime Toolings, Bangalore

May – Sep 2025

- ICBM fuel injector optimisation, Rotating Detonation Engine design and manufacture, and non-guided ballistic missile engine boosters.
- Integrated CATIA modelling of propulsion and aerodynamic control systems, with CFD, FEA and DFM applied to live industrial work.

Space Exploration Program Participant — Agnirva · IN-SPACe

Jun – Aug 2024

- Astronomical observation and space exploration fundamentals.
- Space history, the current space sector, space law and the Artemis Accords.

Aircraft Design & Maintenance Intern — Sky Aerospace & Government Flying Training School, Jakkur

Jun – Jul 2024

- Airframe design exposure on Cessna 172P and 172S aircraft.
- Line maintenance practice on Lycoming O-320-D2J and IO-360-L2A engines.

Hybrid Electric Vehicle Systems Intern — 1Stop

Jan – Feb 2024

- Powertrain modelling in MATLAB Simulink.
- HEV architecture fundamentals and energy-flow analysis.

4 Project portfolio

Twenty-six projects, grouped by discipline. Each entry states the problem, the context it was done in, and what was actually decided; the figure below it is the clearest single view of the result.

Propulsion

5 projects

Injector, chamber and nozzle work — internship projects at Prime Toolings, and the design software written around them.

01 ICBM Fuel Injector Optimisation

Reworked injector element geometry for better propellant mixing without moving outside the shop's existing tooling.

CONTEXT Prime Toolings YEAR 2025 ROLE Design intern TOOLS CATIA · CFD · DFM

An impinging-doublet face where the mixing gain and the machinability limit pull in opposite directions. Orifice diameter, impingement angle and element count set how well the two streams mix; every one of them is also a drill setup on the shop floor. I swept the pattern in CATIA, screened candidates on CFD mixing uniformity, and kept only the geometries that stayed inside the existing tool library and drill-depth ratio — so the winning design needed no new tooling to cut.

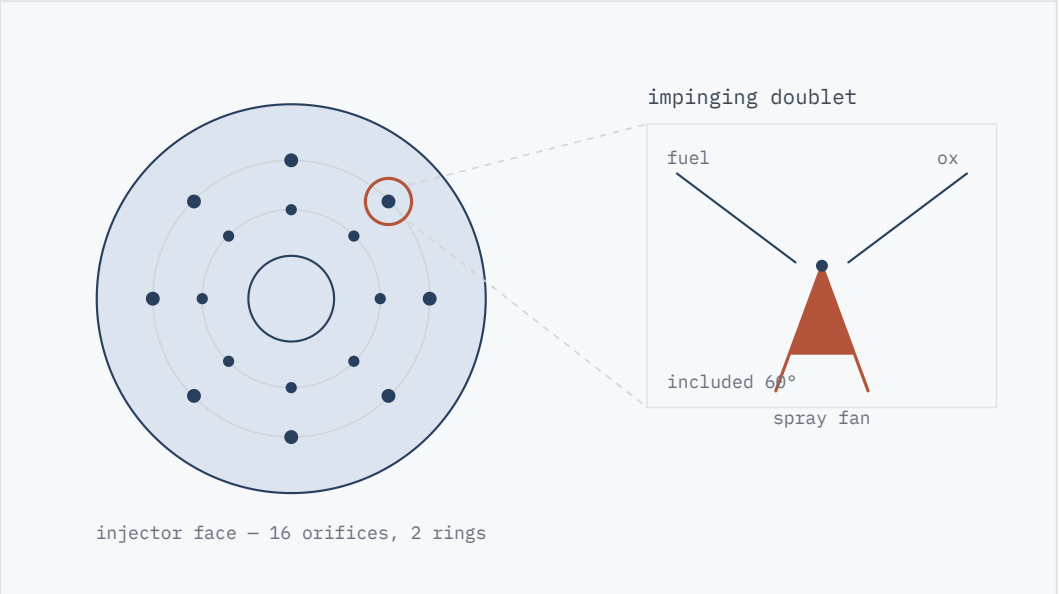


Fig. 1 Face pattern and the impinging-doublet element. Two concentric orifice rings; the detail shows the fan formed where the fuel and oxidiser jets meet.

02 Rotating Detonation Engine

Took an annular RDE from CAD geometry through to fabricated hardware.

CONTEXT Prime Toolings YEAR 2025 ROLE Design intern TOOLS CATIA · CFD · Manufacturing

A detonation wave that laps the annulus continuously, rather than a flame held in place. The design work was the annulus gap, injector plenum and outer-body wall thickness; the manufacturing work was making all three producible in the same part family. I modelled the assembly in CATIA, checked the channel flow in CFD, and stayed with the parts through fabrication — which is where most of the tolerance decisions actually got made.

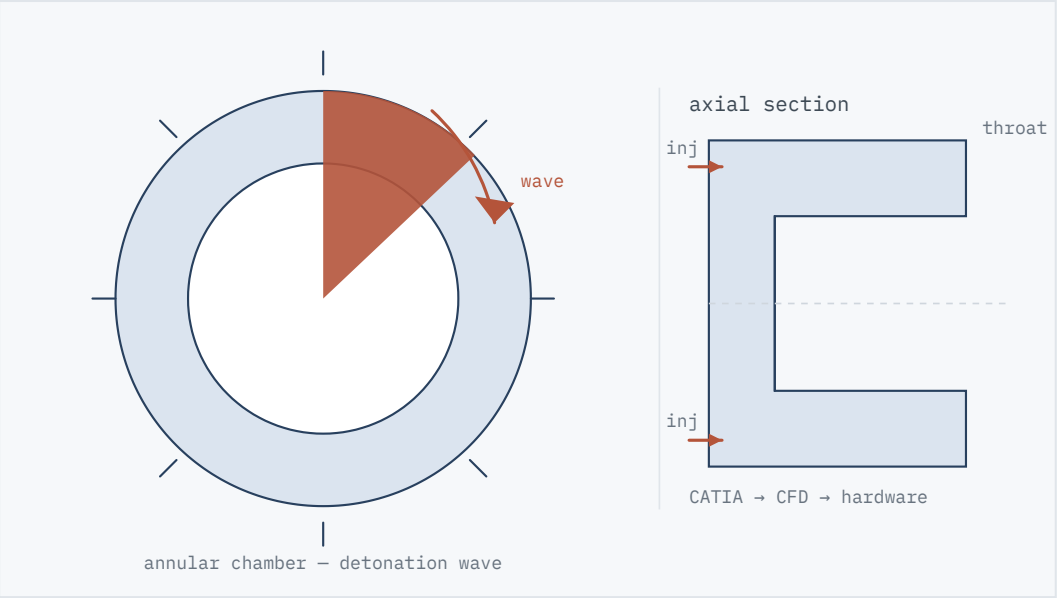


Fig. 2 Annular chamber with the travelling detonation wave, and the axial section through injector plenum, channel and throat.

03 Non-Guided Ballistic Missile Engine Booster

Sized a solid booster — grain port, casing and nozzle — for a fixed impulse requirement.

CONTEXT Prime Toolings YEAR 2025 ROLE Design intern TOOLS CATIA · Internal ballistics · FEA

Thrust history is written by the grain geometry before any other part of the motor gets a say. A star-perforate grain sets the burning-surface history, which sets chamber pressure, which sets casing wall thickness and nozzle expansion ratio. I worked that chain in order rather than in parallel, then checked the casing in FEA at peak pressure.

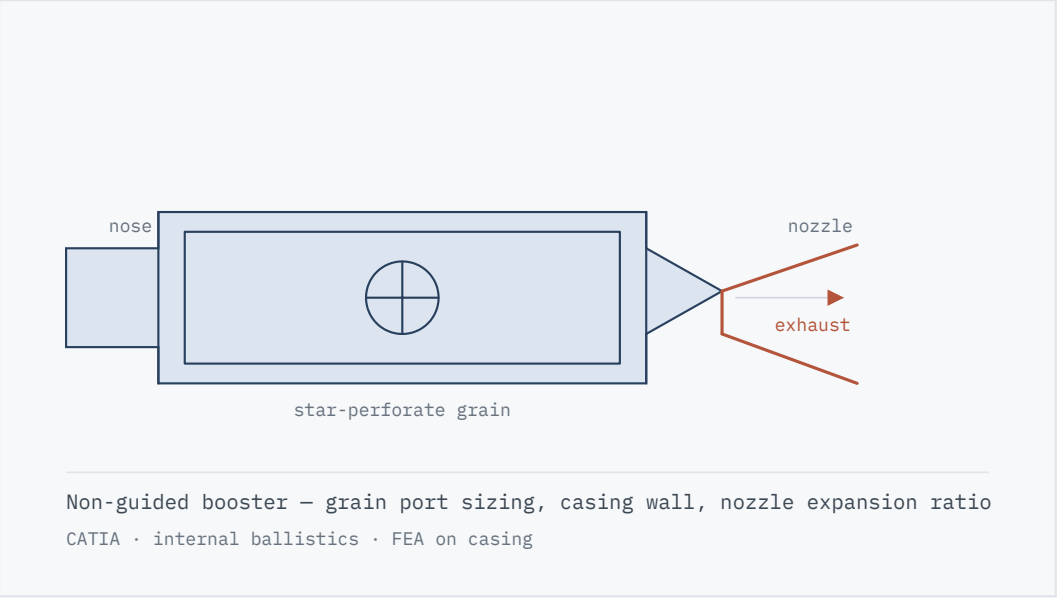


Fig. 3 Longitudinal section: nose, star-perforate grain, casing and convergent-divergent nozzle.

04 BELLWETHER — Nozzle Design Workbench

Surveys hundreds of nozzle contours in the time one RANS case takes, and hands the survivors to CFD.

CONTEXT Personal YEAR 2026 ROLE Sole author TOOLS Python · Method of characteristics · SU2

It runs ahead of the CFD. One SU2 case is hours; a sweep across inflection area ratio, extension family and extension length is hundreds of cases. Axisymmetric method-of-characteristics contour generation across conical, truncated-ideal, Rao-bell and dual-bell families, with separation-based transition prediction and an altitude-swept

performance model. Exports SU2-ready geometry directly. 643 tests green; the MOC solver is verified against an exact source-flow solution.

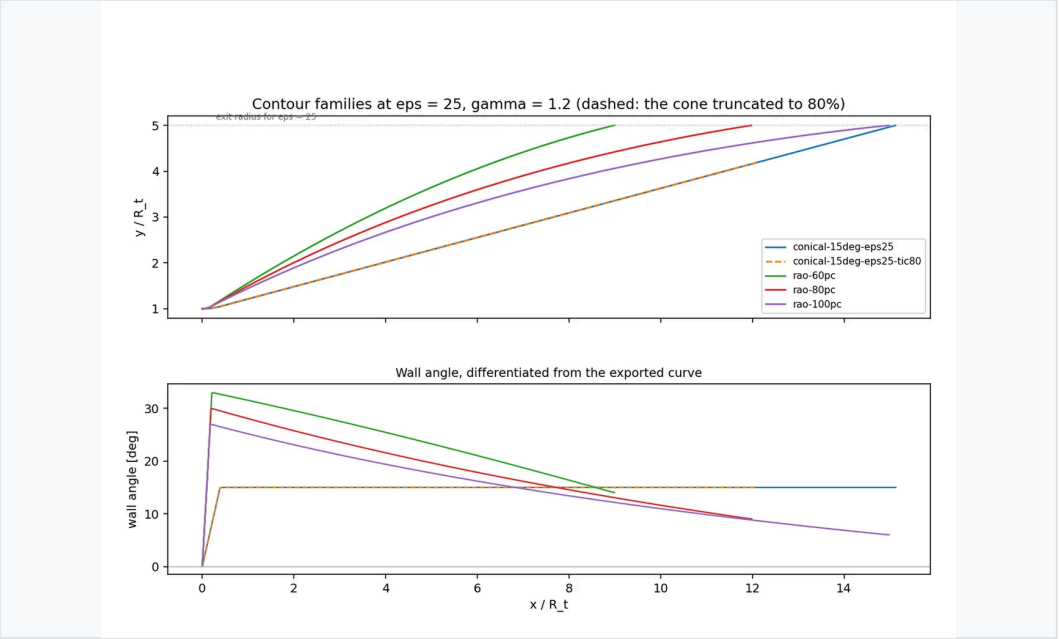


Fig. 4 Contour families at ε = 25, γ = 1.2, with wall angle differentiated from the exported curve. The dashed line is the cone truncated to 80%.

05 Ethanol as an Aviation Gasoline Additive

Assessed whether ethanol blending is viable in avgas once every property moves at once.

CONTEXT HITS YEAR 2025 ROLE Author TOOLS Fuels · Trade study

Ethanol buys knock resistance and gives back energy density and vapour-lock margin. A property-by-property comparison of 100LL against E10 and E20 blends: octane rating, gravimetric and volumetric energy, vapour pressure, and material compatibility with legacy fuel-system elastomers. The conclusion is a range rather than a yes — the blend that helps a high-compression engine hurts the fuel system it sits behind.



Fig. 5 Property deltas for an E20 blend against neat AVGAS 100LL. Higher knock resistance is bought with lower volumetric energy and a vapour-lock risk.

Aerodynamics & CFD

2 projects

External and internal flow solved in ANSYS Fluent, with convergence treated as evidence rather than a formality.

06 Converging–Divergent Nozzle CFD

Resolved the pressure drop and velocity rise through a CD nozzle in Fluent, and checked the core flow stayed attached.

CONTEXT HITS YEAR 2025 ROLE Sole author TOOLS ANSYS Fluent · Compressible flow · Meshing

The throat is where a nozzle earns its keep — and where a mesh that is merely adequate stops telling the truth. A two-dimensional converging–divergent passage solved in ANSYS Fluent. Static pressure falls from 1.64 × 10^6 Pa at the inlet to its minimum through the throat and recovers only partly downstream; velocity magnitude peaks at 1.36 × 10^3 m/s along the centreline. The interesting part is not the peak but the walls: the velocity contour shows the boundary layer thickening steadily through the divergent section, and the particle pathlines show the core staying attached over the whole length rather than separating off the diverging wall. Both were checked before any number was quoted, because a nozzle solution that looks right on a centreline plot can still be wrong at the wall.

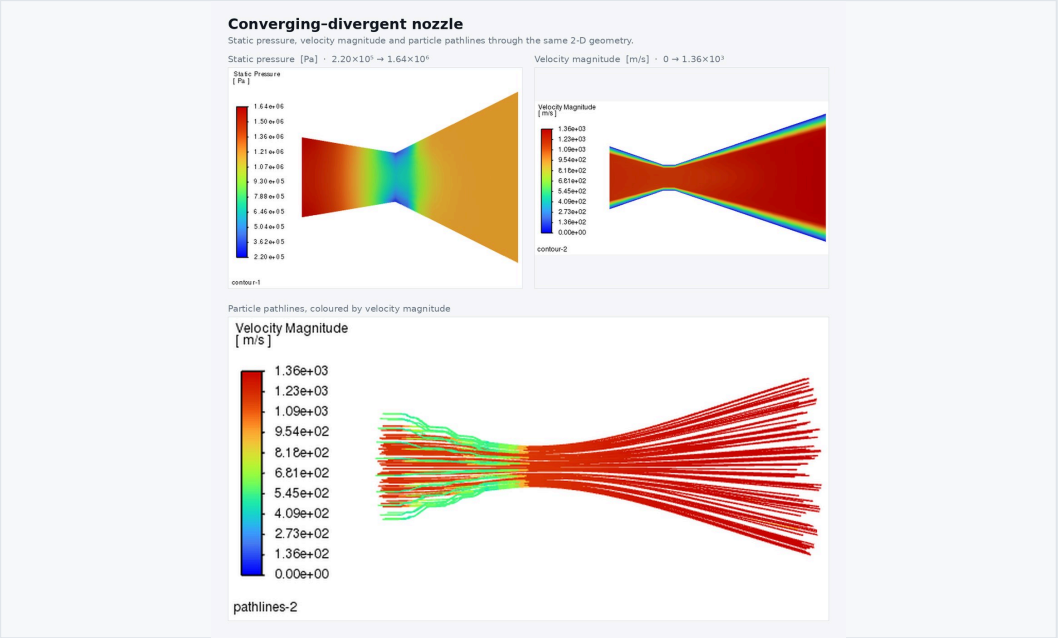


Fig. 6 Static pressure, velocity magnitude and particle pathlines through the same geometry. Pressure minimum sits at the throat; the pathlines show the core attached the full length of the divergent section.

07 NACA 0012 Angle-of-Attack Sweep

Swept a NACA 0012 through 5°, 10° and 20° on one mesh, and used the convergence history to decide which results were usable.

CONTEXT HITS YEAR 2025 ROLE Sole author TOOLS ANSYS Fluent · C-grid meshing · Convergence

The most useful result in the sweep was the one that refused to converge. A structured C-grid around a NACA 0012, wall-clustered so the boundary layer is resolved, with the same mesh and the same steady solver settings reused at every angle so the only variable is incidence. At 5° and 10° the flow stays attached and both the drag and lift coefficients flatten inside roughly a hundred iterations. At 20° neither settles — they oscillate for the full thousand iterations without ever converging, and the velocity field shows why: the flow has separated off the upper surface into a wake far thicker than the aerofoil. That is not a solver failure to be tuned away. A steady formulation is being asked to hold a flow that is physically unsteady, so the 20° case is reported as a stall indication rather than as a coefficient, and a proper answer there needs a transient run.

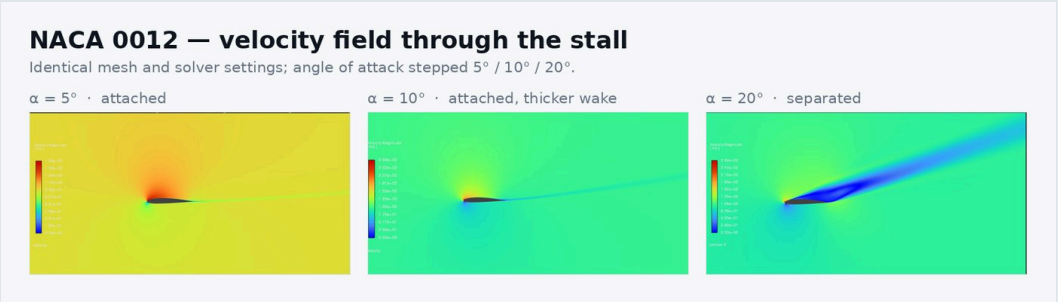


Fig. 7 Velocity magnitude at 5°, 10° and 20°. Attached at 5° and 10°; at 20° the wake opens out over the upper surface.

Structures

7 projects

Airframes, rotor dynamics and morphing structures, from modal analysis to actuated hardware.

08 Vibration Analysis of an Aircraft Engine

Identified which rotor modes are excited inside the operating band, and how close they run.

CONTEXT HITS YEAR 2025 ROLE Author TOOLS ANSYS · Modal analysis · FEA

A mode is only a problem if an engine order crosses it somewhere the engine actually runs. Modal extraction in ANSYS gave the first bending, second bending and first torsional frequencies; plotting those against engine-order lines showed which crossings fall inside the operating band and therefore need either a stiffness change or a restricted dwell.

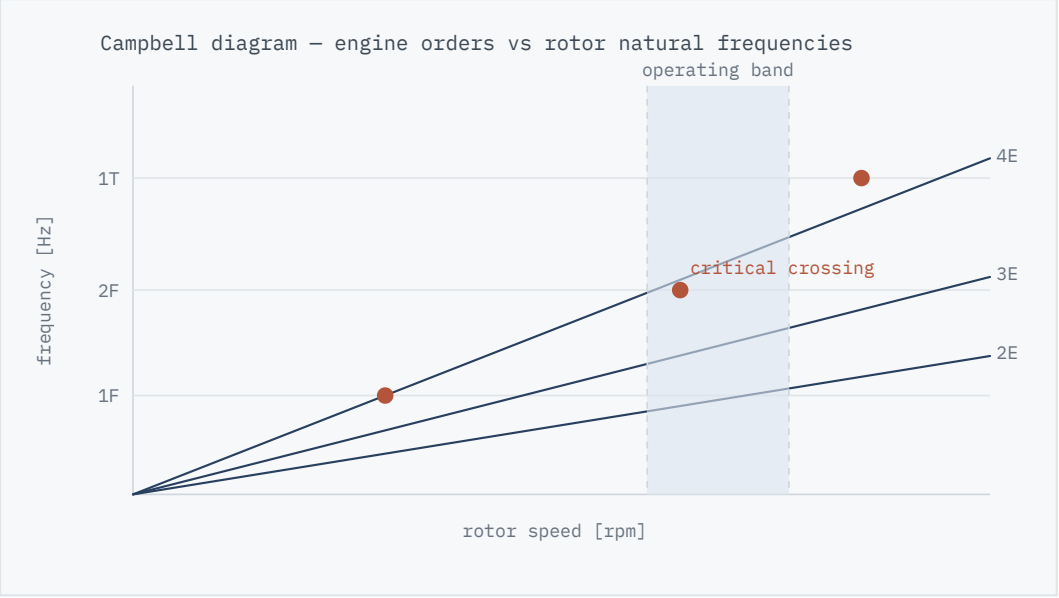


Fig. 8 Campbell diagram. Engine-order lines against rotor natural frequencies; marked crossings inside the shaded operating band are the ones that matter.

09 W-ZERO — Preliminary Aircraft Sizing Suite

Converges takeoff gross weight from a mission spec, then produces a matched design point and first-cut geometry.

CONTEXT Personal YEAR 2026 ROLE Sole author TOOLS Python · Constraint analysis · Pyodide

The name is the deliverable: W_0, takeoff gross weight, is what the whole sizing loop converges on. Given a mission specification and an aircraft class it converges W_0, runs a T/W–W/S constraint analysis, selects a design point and draws a dimensioned three-view. The browser UI runs the same Python as the tests through Pyodide, so there is no second

copy of the equations to drift. 727 tests; validated against reference aircraft, with unverified figures reported as blocked rather than quietly passed.

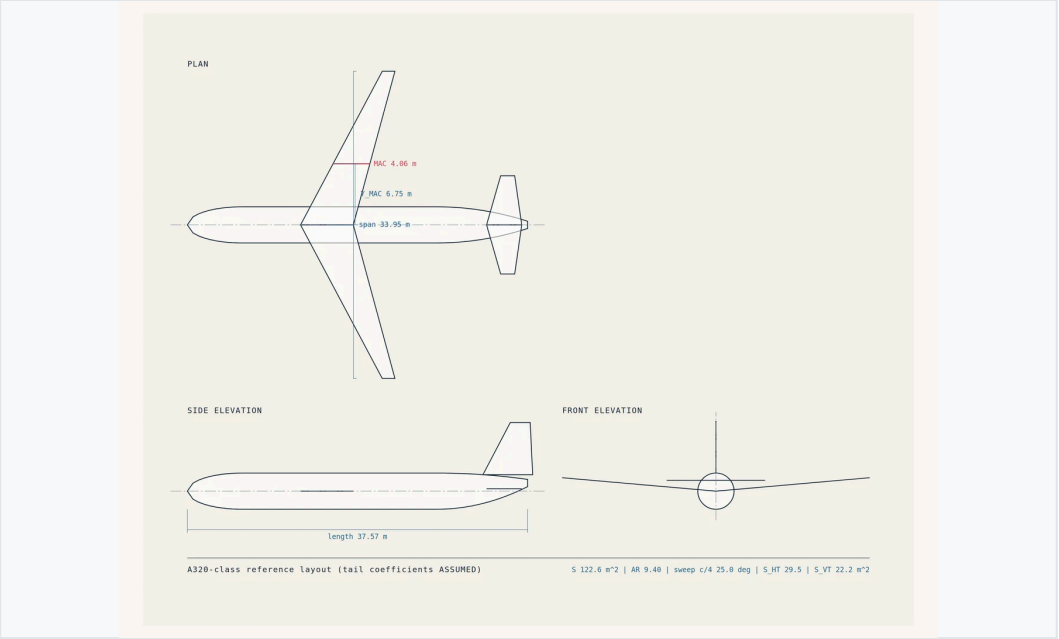


Fig. 9 Dimensioned three-view generated from the converged mission spec — A320-class reference layout.

10 AIRFORGE — Ducted-Fan Reconnaissance Quadcopter

Team airframe for the NIDAR competition: ducted rotors, carbon-fibre decks, and a payload bay that had to close a mass budget.

CONTEXT Team Air Forge, HITS YEAR 2026 ROLE CAD & structures TOOLS CAD · Carbon fibre · KiCad · ESP-IDF

Ducting the rotors buys thrust and crash tolerance, and costs you every millimetre of tip clearance. A 500 mm wheelbase on 10-inch props, 799 mm across the guarded diagonal. Three carbon decks on M3 standoffs, 16×14 mm CF arm tubes into clamped motor mounts, full-annulus prop guards carrying the ToF sensor pockets, and a LiDAR mast on the centreline. The guards set the envelope that actually matters — the diagonal you have to fit through a doorway or a net is the guarded one, not the motor-to-motor figure. The whole airframe was built to a written mass budget and an interface control document, so every part that grew had to take the growth from somewhere else.

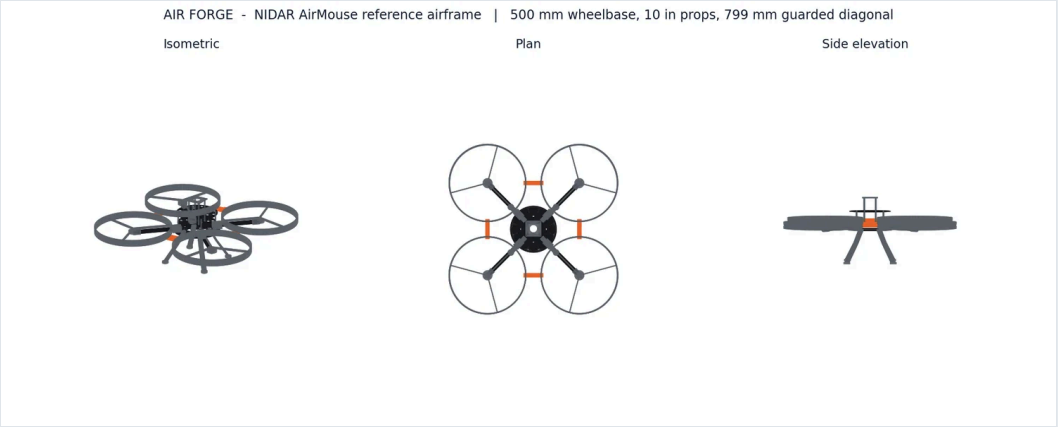


Fig. 10 Reference airframe, three views. 500 mm wheelbase, 10-inch props, 799 mm across the guarded diagonal.

11 Reconnaissance & Surveillance Drone

Airframe and payload layout for an extended-endurance surveillance mission.

CONTEXT HITS YEAR 2025 ROLE Author TOOLS SolidWorks · Layout · cg analysis

Endurance is a layout problem before it is an aerodynamics problem. Bay volumes were allocated first — gimbal, avionics and link, fuel and battery — then the wing was sized around the resulting cg travel rather than the other way round. Modelled in SolidWorks with the cg limits carried as construction geometry so a bay change shows up immediately.

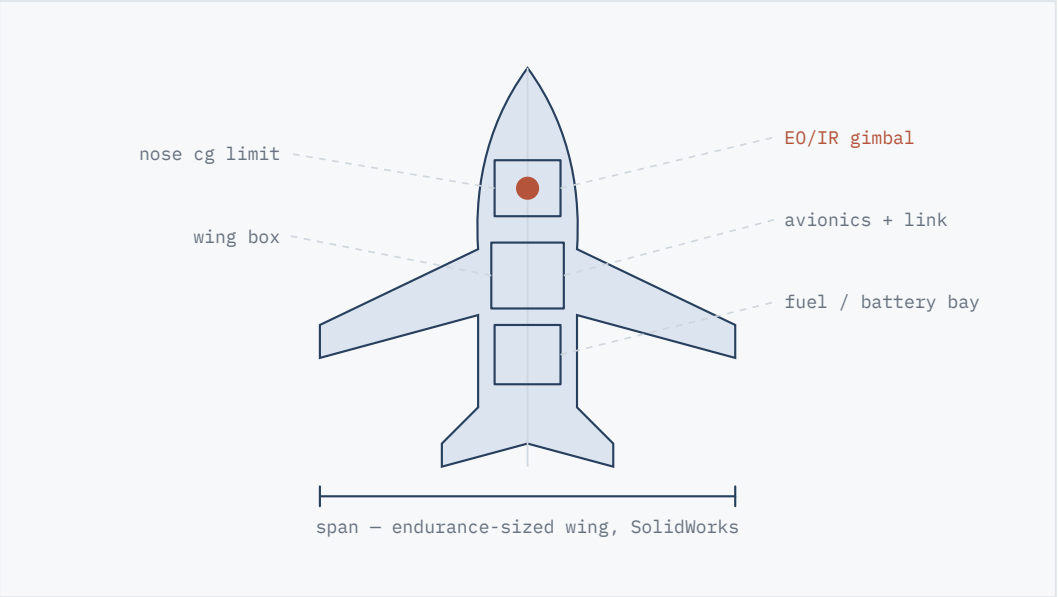


Fig. 11 Plan view with the payload bays called out, and the cg limits the layout has to stay between.

12 Observation Payload Fairing

Aerodynamic shell and mounting structure for the downward-looking sensor that feeds the urban heat work, carried under a drone.

CONTEXT Bharatiya Antariksh Hackathon YEAR 2026 ROLE CAD & structures

TOOLS Fusion 360 · Shell design · Sensor integration

The sensor has to see straight down through a hole in a body that is also trying not to add drag. A 322 × 187 × 99.5 mm teardrop shell in two sections, forward and aft, splitting near mid-length so the payload can be laid in rather than threaded through an end. The wall is 2.5 mm throughout, stiffened by longitudinal ribs rather than thickness, because the mass sits under a drone that has to carry it and the fairing earns nothing by being heavy. A central aperture on the underside gives the sensor its downward view, with an internal surround that both locates the optics and keeps the cut-out from becoming the weak point in the shell. Side apertures take the harness out without breaking the external line.

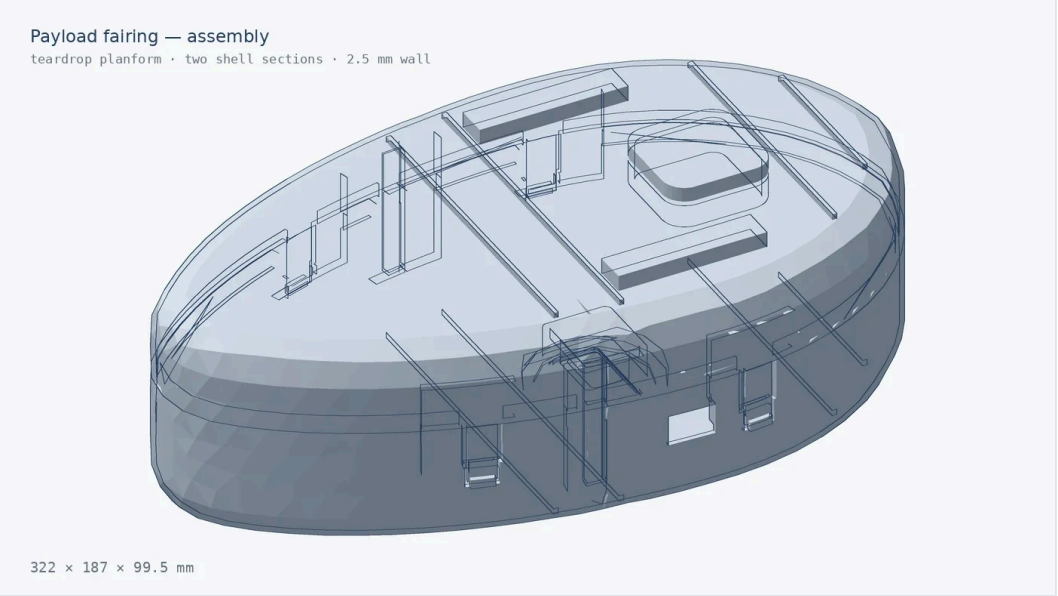


Fig. 12 Assembly, isometric. Teardrop planform with the forward and aft shell sections joined near mid-length.

13 Parabolic Solar Oven

Built and tested a parabolic concentrator sized from its rim angle and receiver spot.

CONTEXT HITS YEAR 2024 ROLE Builder TOOLS Thermal · Sheet metal · Testing

A reflector is only as good as the flat pattern you can actually cut and fold. Focal length follows from aperture and rim angle; the receiver is then sized to the concentrated spot rather than guessed. The reflector was developed into flat segments so it could be cut from sheet and assembled without a forming tool.

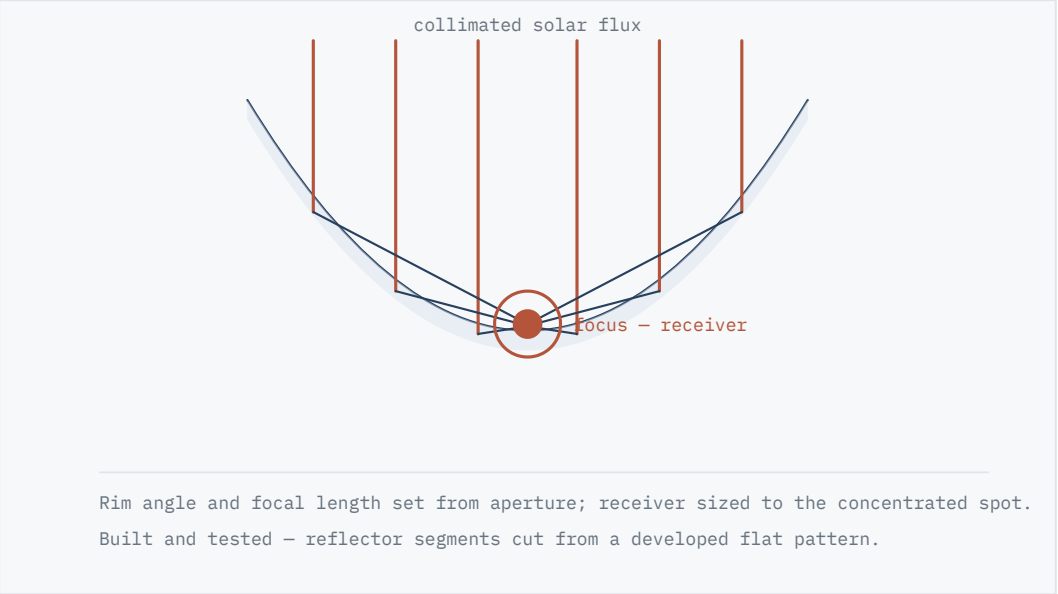


Fig. 13 Collimated flux reflected onto the focal receiver. Rim angle and focal length are set from the aperture.

14 Morphing Wing Kinematic Commander

Drives an SMA-actuated fishbone wing rib and shows the camber it is commanding, live, from a browser.

CONTEXT Personal YEAR 2026 ROLE Sole author TOOLS ESP32 · SMA actuation · AsyncWebServer

A shape-memory alloy wire has no position feedback. What it has is a duty cycle and a thermal limit. The controller runs the SMA on a 1 kHz PWM channel with a hard sixty-second actuation cutoff and an emergency kill, because the failure mode of a shape-memory wire is not a stall — it is overheating quietly while nothing on screen changes. Two modes: static hold at a commanded power, and an aero-cyclic sweep. The board runs as its own access point and serves the whole interface offline, so the rig works on a bench with no network. The rib kinematics are drawn as SVG from the same power value that is driving the wire, so the animation cannot show a deflection the hardware was not asked for.

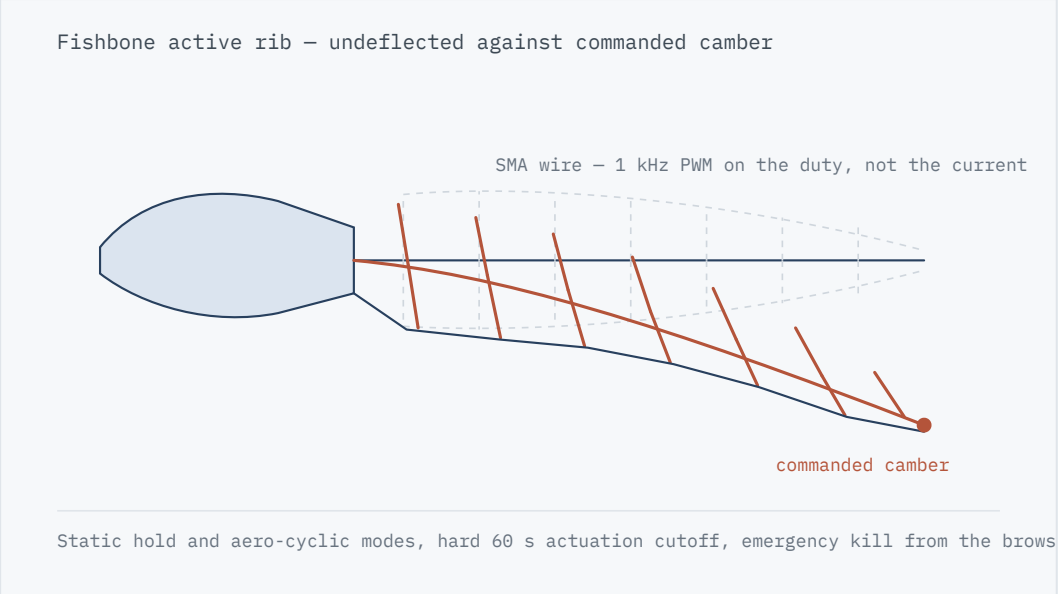


Fig. 14 Compliant fishbone rib. Dashed is the undeflected spine and rib set; solid is the commanded camber, with the SMA wire running along the lower surface.

Space Systems

5 projects

Orbital mechanics, ground stations and attitude control.

15 APOGEE — Satellite Tracking Station

Tracks the full public catalogue, predicts passes 48 hours out, and runs the same on a single-board computer, a phone and a laptop.

CONTEXT Personal YEAR 2026 ROLE Sole author TOOLS Python · SGP4 · three.js · Kotlin

13,130 catalogued objects, SGP4 propagation, 48-hour pass prediction — headless on an Arduino UNO Q, as an Android app, and as a Windows service. The board build drives the UNO Q's LED matrix as a physical pass indicator and serves a mission-control GUI to any browser on the LAN. The Android build turns the phone into both station and display, correcting heading to true north from the rotation-vector sensor because the browser compass is wrong in three separate, silent ways. 185 tests against reference values, and all three builds pass the same suite.

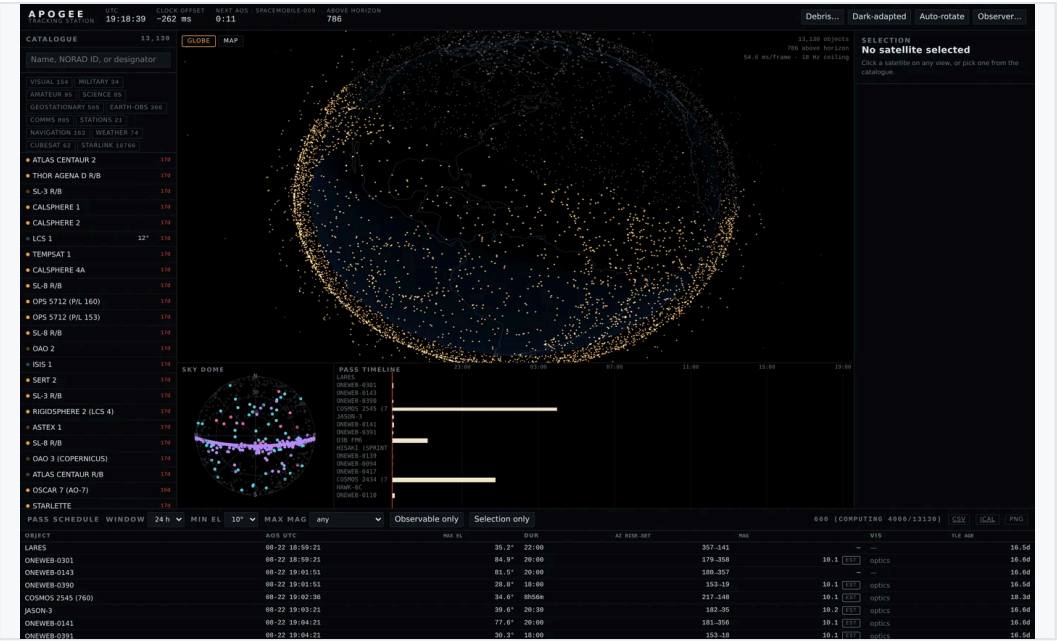


Fig. 15 Mission-control GUI. Catalogue on the left, three.js globe with propagated objects, pass schedule along the bottom.

16 OVERPASS — Pass Planner & Link Budget

Answers two questions at once: where do I point the antenna, and will the radio link actually close while it is up?

CONTEXT Nebula Astro Club, HITS YEAR 2026 ROLE Sole author TOOLS Python · SGP4 · Link budget

A margin number you cannot take apart is a number you cannot trust. TLE/OMM ingest, reference SGP4 with correct frame handling, ground tracks, station look angles against a real horizon mask, and an elevation-swept link budget that produces an actual margin in dB with every line of the budget attached to its reason. Propagation is validated against Vallado's test vectors, Skyfield and Heavens-Above — three independent implementations.



Fig. 16 ISS over Chennai, 31 Aug 2026. Polar plot of the pass on the left; link margin across the pass on the right, for two antenna choices.

17 SPINDOWN — CubeSat ADCS Simulator

Six-DOF attitude simulation with the truth model kept rigorously separate from the flight algorithms.

CONTEXT Personal YEAR 2026 ROLE Sole author TOOLS Python · ADCS · MEKF

Named for the phase that kills student satellites. A CubeSat that never detumbles never does anything else. Attitude dynamics with IGRF magnetic field, B-dot detumble on magnetorquers, reaction-wheel pointing with magnetic momentum dumping, and a multiplicative EKF for attitude determination. The architectural boundary is enforced by test: the flight algorithms cannot import the truth model.

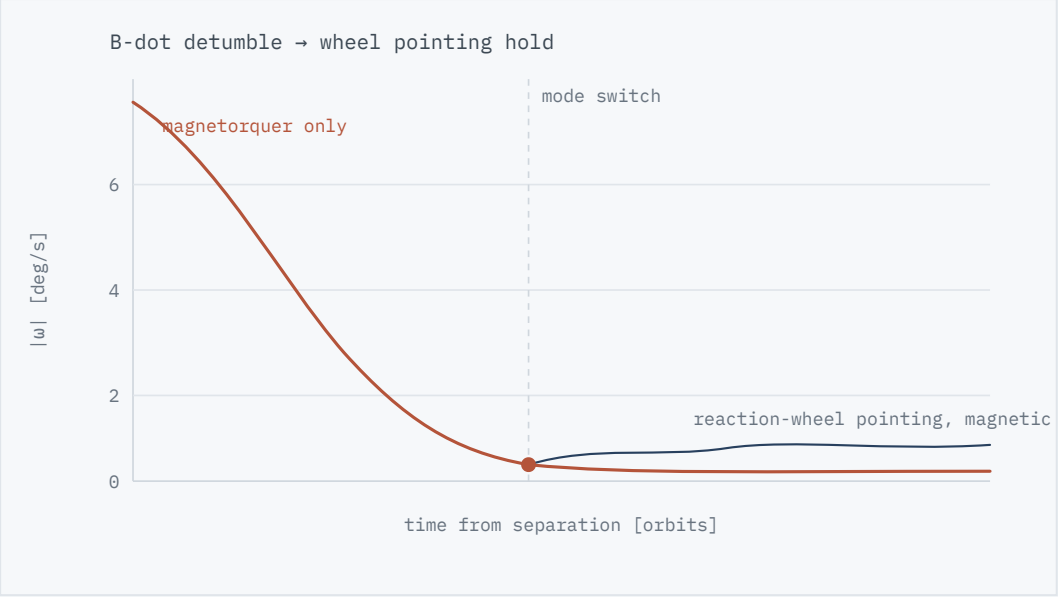


Fig. 17 Body-rate magnitude from separation. Magnetorquer-only detumble down to the mode-switch threshold, then reaction-wheel pointing hold.

18 Payload Architect

Fixed envelope, cg and harness routing for a sounding payload before any component was chosen.

CONTEXT HITS YEAR 2025 ROLE Author TOOLS Layout · Mass budget · CAD

Choose the volume and the cg first; the parts list is downstream of both. A stacked-tray architecture with mass and power allocated per tray, so a component that grows has to be traded against its neighbours rather than against the whole vehicle. Recovery at the top, battery at the base, flight computer between the two sensor trays.

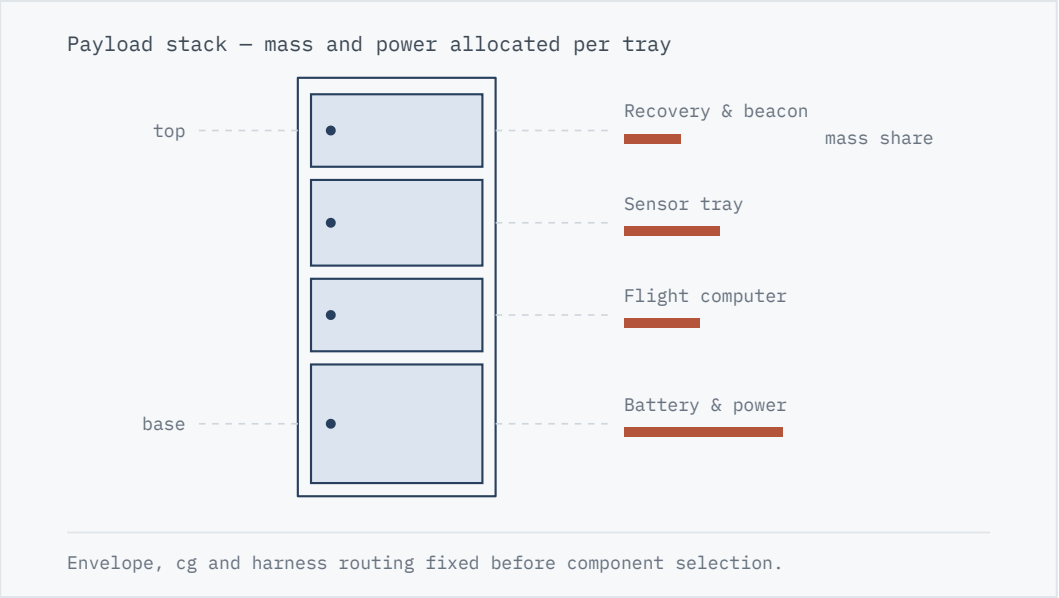


Fig. 18 Tray stack with mass share per tray. Envelope, cg and harness routing were fixed before component selection.

19 Model of a Space Station

Modular station layout — pressurised modules, docking node, airlock and array booms.

CONTEXT HITS YEAR 2024 ROLE Author TOOLS CAD · Systems layout

Every module has to reach the node, and every array has to see the sun without shadowing its neighbour. A central node with radial berthing ports, lab and hab modules on the long axis, airlock and cupola on the radial ports, and array booms outboard of the truss. Built as a study in how docking geometry constrains growth: what you can add later is decided by the node you build first.

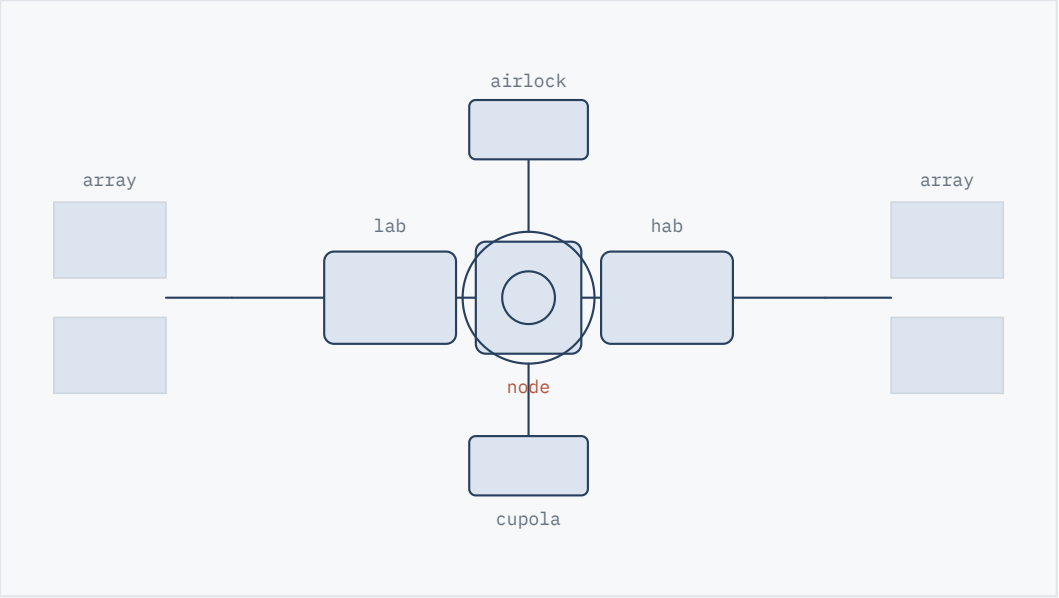


Fig. 19 Layout: node with radial ports, lab and hab on the long axis, airlock and cupola radial, arrays outboard.

Aerospace ML

2 projects

Machine learning applied to satellite imagery and geospatial decision support.

20 Cloud Motion Prediction using Diffusion Models

Short-term cloud forecasting from INSAT-3DR/3DS imagery with a generative model instead of optical flow.

CONTEXT HITS YEAR 2026 ROLE Author TOOLS Python · PyTorch · Satellite imagery

Optical flow moves the clouds it can see. A diffusion model can also grow and dissipate them. Half-hourly IR brightness-temperature composites from INSAT-3DR and 3DS are used to condition a denoising diffusion model on the previous frames, which then samples the field ninety minutes ahead. Evaluated frame-to-frame against the observed field, not only against a persistence baseline — persistence is hard to beat at short lead times and easy to beat on paper.

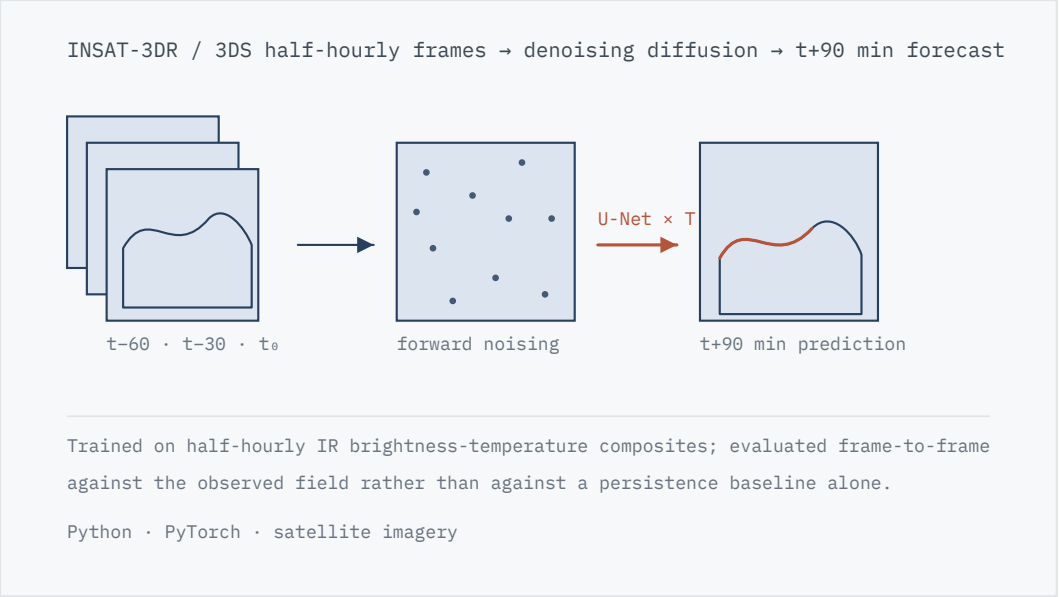


Fig. 20 Pipeline: three conditioning frames, forward noising, iterative denoising, and the sampled t+90 min field.

21 UHI-Optimizer — Urban Heat Mitigation

Locates urban heat stress from satellite land-surface temperature, attributes it to physical drivers, and picks cooling interventions under a budget.

CONTEXT Bharatiya Antariksh Hackathon YEAR 2026 ROLE Author TOOLS Python · FastAPI · GIS

Finding the hot cells is the easy half. Choosing what to spend on them is the decision. Thirty-three clear Landsat scenes over the Greater Chennai Corporation frame, March to June, 2016–2023, reduced to four observed fields before any model touches them: mean land-surface-temperature anomaly, the urban heat island index as excess over a 500 m ring, hotspot persistence as the share of clear days above +2 K, and the sea-breeze differential. Those are measurements, not predictions — the figure is labelled *no model* for exactly that reason. Driver attribution then runs against urban form pulled from OpenStreetMap: building footprint fraction, road density, green-space fraction and distance to coast. Only after that does the optimiser choose interventions — canopy, cool roofs, permeable paving, shade — under a budget, ranked by ΔT potential per rupee.

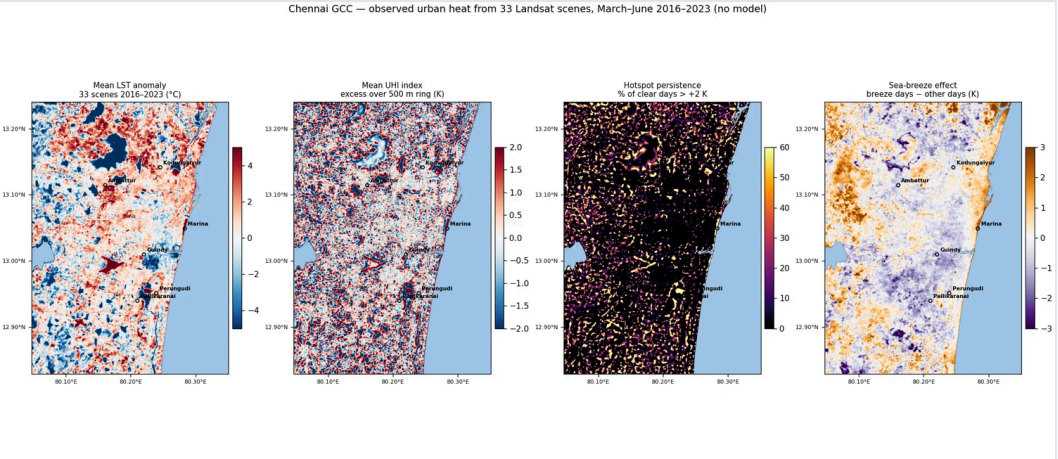


Fig. 21 Observed urban heat across 33 Landsat scenes, 2016–2023. Mean LST anomaly, UHI index as excess over a 500 m ring, hotspot persistence, and the sea-breeze effect. No model — these are the measurements everything else is built on.

Electronics

8 projects

Flight-hardware electronics — instrumentation, telemetry and firmware.

22 Cockpit Cluster

An embedded instrument cluster driving live attitude, airspeed and altitude from a flight model.

CONTEXT HITS YEAR 2025 ROLE Author TOOLS STM32 · KiCad · Embedded C

An instrument that stutters is worse than one that reads slightly stale. STM32 firmware driving an attitude indicator with airspeed and altitude tapes, on a four-layer board laid out in KiCad. The refresh had to hold steady at 50 Hz with the link active, which meant the rendering loop could not share time with the bus handler.

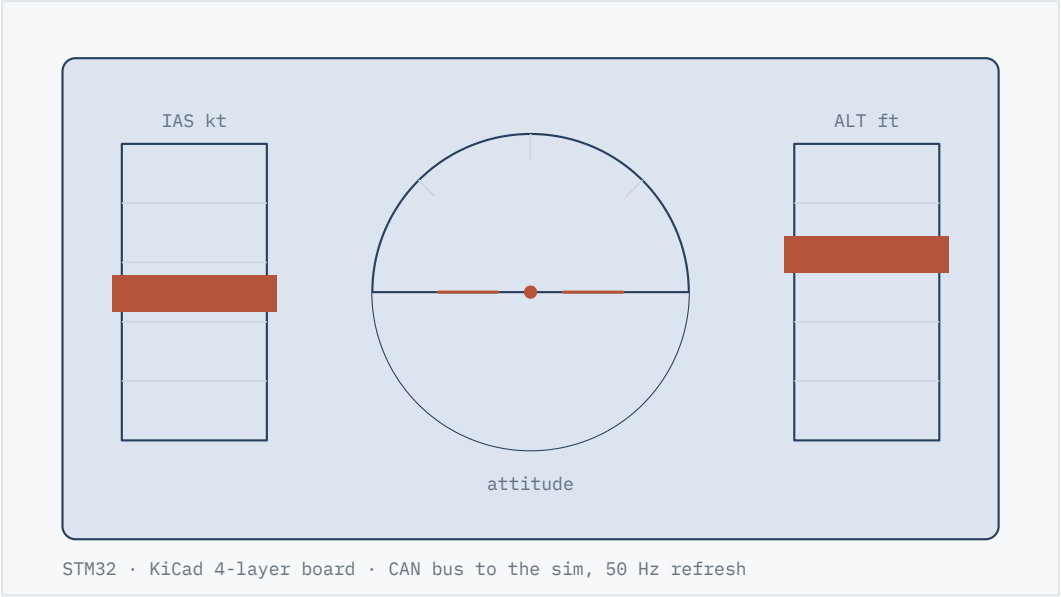


Fig. 22 Cluster layout: attitude indicator centre, airspeed tape left, altitude tape right, with the current-value windows highlighted.

23 LUMEN — Perceptually Linear LED Dimming

Two LEDs on the same STM32 running the same brightness curve, where only one of them looks smooth.

CONTEXT Personal YEAR 2026 ROLE Sole author TOOLS STM32 · PlatformIO · DMA

Linear duty is not linear brightness. The eye is the part of the system that is nonlinear. A 256-entry, 12-bit gamma-corrected lookup driven by timer DMA, so the fade uses no CPU at all — the update event raises a DMA request and the channel writes the next table entry straight into the compare register. Proved by shipping a blocking three-second command mid-fade: the breathe does not stutter, because the main loop was never driving it.

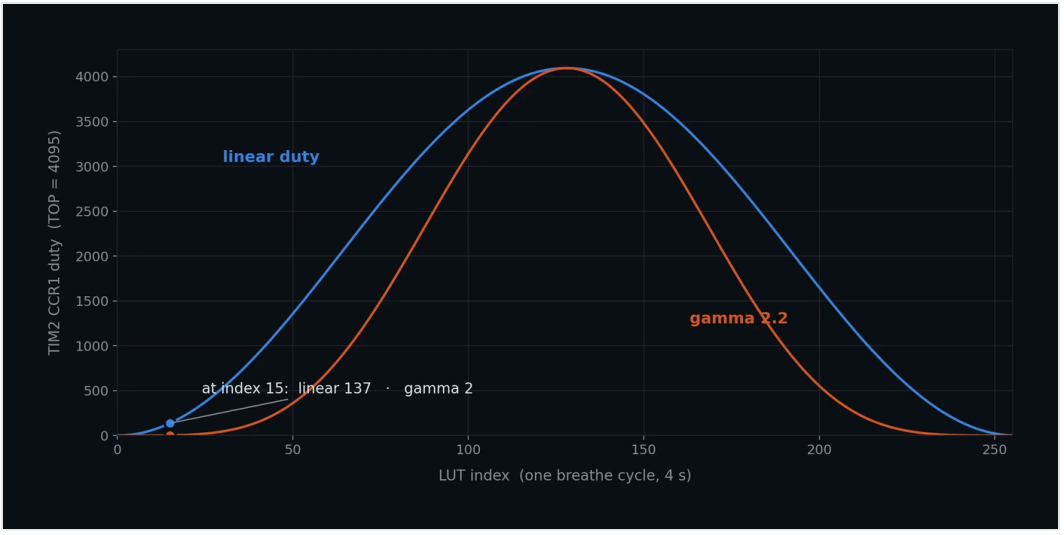


Fig. 23 Both LEDs run the identical brightness curve. Linear duty rushes up then bunches at the bright end; gamma 2.2 tracks perceived brightness.

24 Embedded System Parametric Optimizer

An offline workstation for planning flight hardware — MCU choice, pinout, buses, power and battery — before anything is bought.

CONTEXT Personal YEAR 2025 ROLE Sole author TOOLS HTML/JS · Monte Carlo · Offline

One file, no install, no server, no network. Opens on a laptop or a phone in the field. Eleven MCUs and forty peripherals with real electrical data, a visual pin grid with auto bus allocation, and live validation for I²C address collisions, bus bandwidth saturation, flash and RAM overflow, wire gauge, voltage drop and junction temperature. A time-stepped discharge simulation integrates charge with Peukert derating and internal-resistance sag; Monte Carlo over component tolerance bands returns the P5/P50/P95 runtime spread.

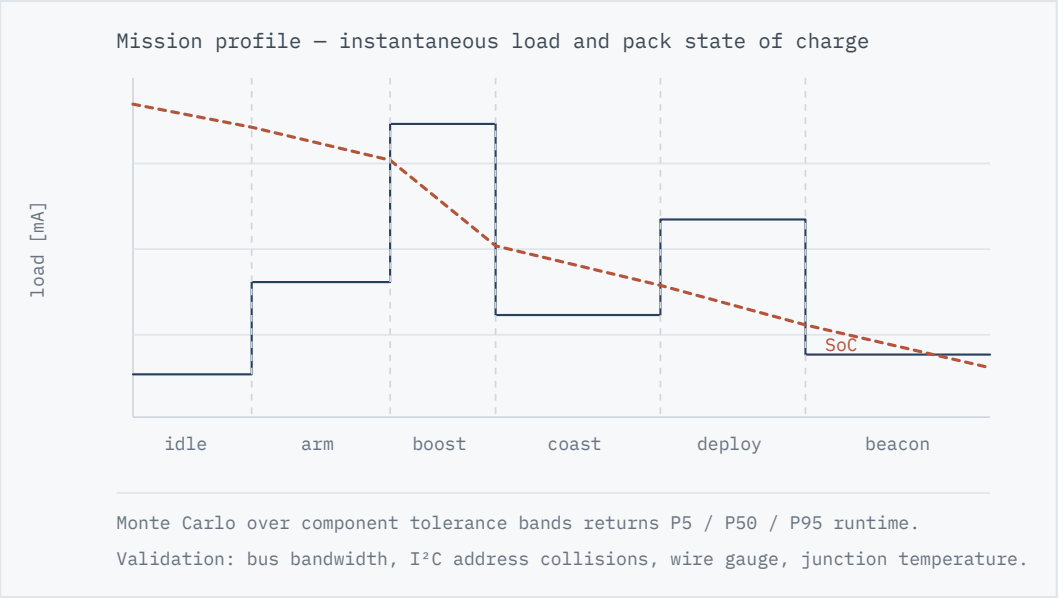


Fig. 24 Mission profile: instantaneous load per phase against pack state of charge, stepped through a one-shot rocket flight sequence.

25 LED Matrix Studio

Pixel editor and text scroller for the Arduino UNO Q's 8×13 matrix, driven from a browser on the board itself.

CONTEXT Personal YEAR 2026 ROLE Sole author TOOLS Zephyr · Linux SoC · Router Bridge

A dual-core board where an STM32U585 running Zephyr owns the matrix and a Debian SoC serves the UI. The two cores talk over the Router Bridge, so the browser never touches the panel directly. The scroll engine is non-blocking by construction — there is no delay() anywhere in the firmware, because the reflex is to sleep between frames and on a board whose job is answering the Linux side, sleeping is the one thing it cannot do.

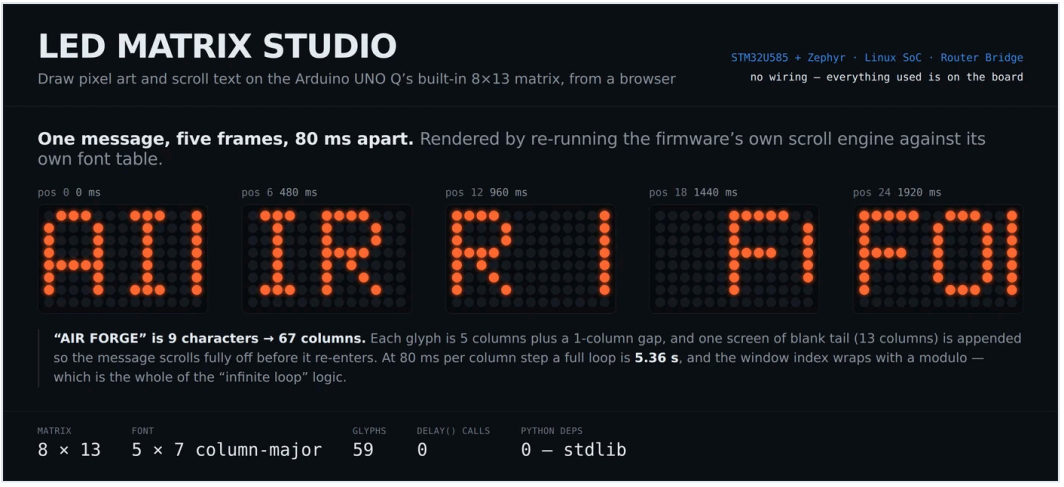


Fig. 25 One message, five frames, 80 ms apart, rendered by re-running the firmware's own scroll engine against its font table.

26 mmWave Presence Radar Scope

Radar-style presence display for a 24 GHz mmWave sensor, built around what the sensor can honestly measure.

CONTEXT Personal YEAR 2026 ROLE Sole author TOOLS ESP32 · UART protocol · SSD1306

The sensor has one receive element, so it knows how far away you are and not which way — and the display had to say only that. A Waveshare HMMD module on an ESP32, decoded over UART and drawn on a 128 × 64 OLED. The obvious build is a radar sweep with a blip on it, and the obvious build is a lie: a 1T1R antenna has nothing to phase a bearing

against, so a point at a specific angle would be invented data dressed up as a measurement. What the scope draws instead is an arc at the measured range spanning the sensor's real ±60° field, which is exactly the set of places the target could be. The sweep line stays, marked in the source as decoration. Underneath it, the frame parser is a byte-at-a-time state machine so the render loop never blocks on serial, a length longer than the buffer is rejected before anything is stored, and going 2.5 seconds without a decoded frame puts NO LINK on the screen rather than leaving a stale target sitting there looking live. The sensor's hardware presence pin is read in parallel, so the display still tells the truth on a unit whose command codes differ from the ones assumed.

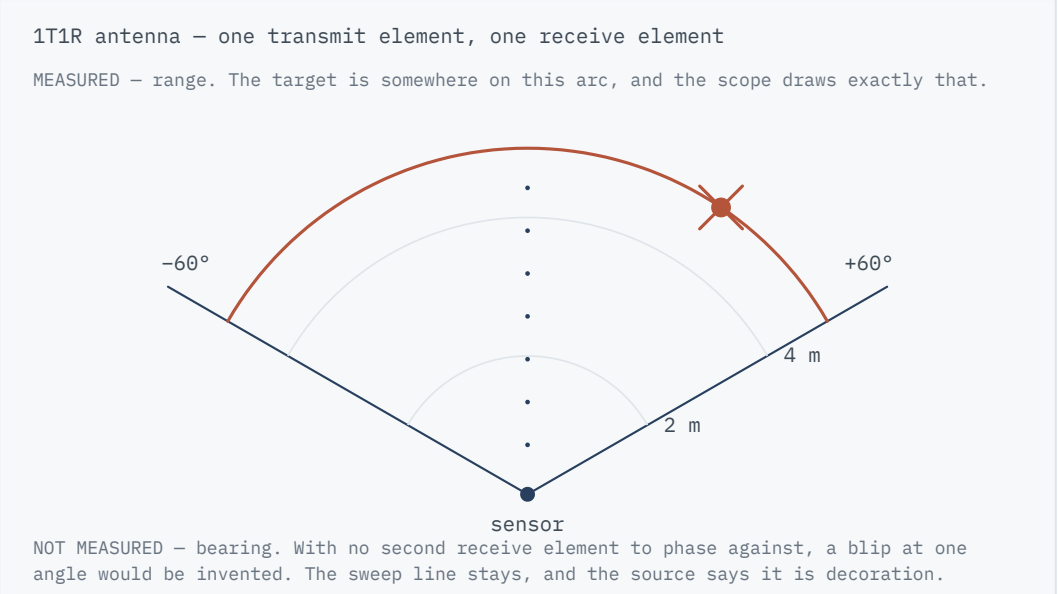


Fig. 26 Why an arc and not a point. Range is measured and bearing is not, so the arc is the honest shape of the answer — a blip at one angle would claim a measurement the antenna cannot make.

27 SKYDECK — ESP32 Telemetry Ground Station

Fuses IMU, barometer and GPS into an attitude solution and streams it to a glass-cockpit page over WiFi.

CONTEXT Personal YEAR 2026 ROLE Sole author TOOLS ESP32 · Madgwick AHRS · WebSocket · LittleFS

A GY-91 and a NEO-6M, fused to a quaternion at 100 Hz and pushed to the browser at 20 Hz. I2C addresses are probed at boot with documented fallbacks, so the board reports every detection decision instead of silently half-working. Gyro, accelerometer, magnetometer and barometer calibration routines are exposed over HTTP and persisted to NVS. The UI is gzipped at build time by a pre-build script — 63 KB of source down to 17.9 KB on flash — and the static handler serves the compressed sibling with the right Content-Encoding, so there is no runtime cost. WebSocket clients are capped at three: at 20 Hz, unbounded clients fragment the heap.

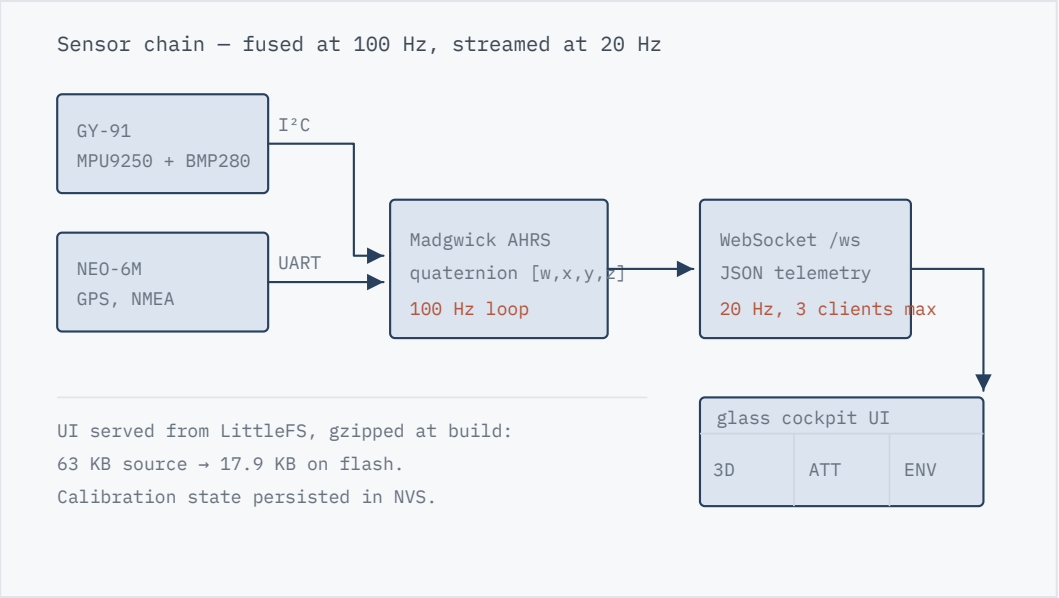


Fig. 27 Signal chain. Two sensor buses into a Madgwick filter at 100 Hz, quaternion out over WebSocket at 20 Hz, into a six-tile cockpit page.

28 Two-Node Wireless Telemetry & Servo Link

One ESP32 carries the sensors and the actuator; a second serves the dashboard and sends commands back.

CONTEXT Personal YEAR 2026 ROLE Sole author TOOLS ESP32 · UDP · MPU9250 · Servo

Splitting sensing from serving means the node holding the servo never has to render anything. Node 1 reads a nine-axis MPU9250 and a BMP280, drives an SG90 on GPIO 18, and broadcasts twelve telemetry fields over UDP. Node 2 hosts the dashboard, renders live attitude as SVG, and sends servo angles back on a separate port. Neither node has the other's address compiled in — node 2 learns node 1 from the first packet it receives, so the pair works on any hotspot without reflashing. A simulation mode drives the whole interface from synthetic data when no radio link is up.

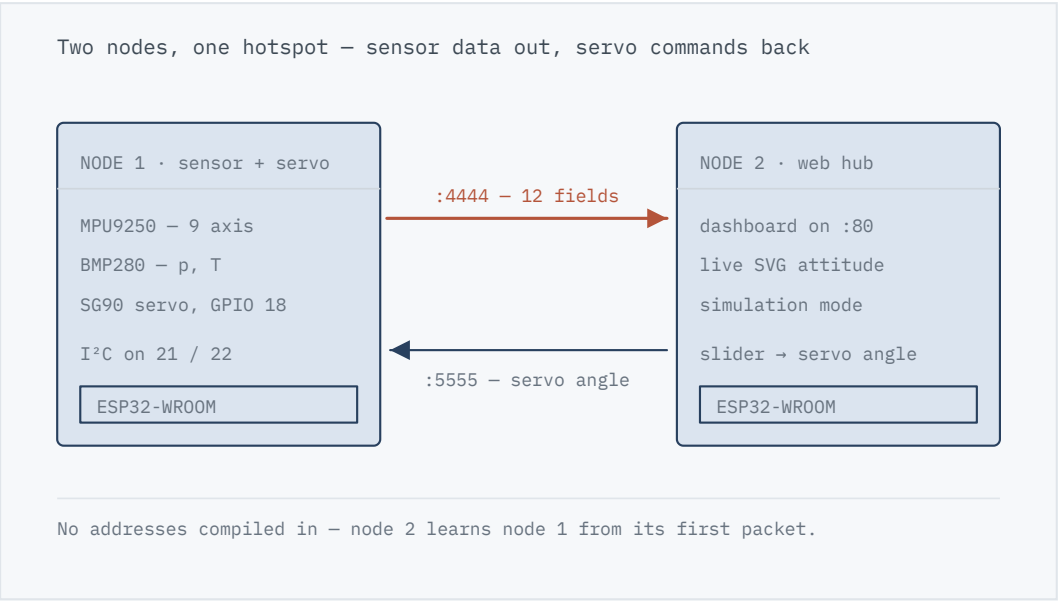


Fig. 28 Node roles and the two UDP ports. Telemetry broadcasts on 4444; servo commands return on 5555.

29 Vibration Monitor — Instrumented Test Rig

Counts piezo pulses against attitude and environment data, and reports on an OLED and a web page at once.

CONTEXT Personal YEAR 2026 ROLE Sole author TOOLS ESP32 · ISR · SSD1306 · MPU9250

A vibration sensor produces edges, not a number. The number is whatever window you choose to count over. Rising edges from a KY-002 piezo are latched in an IRAM-resident interrupt handler and counted over a one-second window, so the count is never lost to a busy main loop. Alongside it the MPU9250 supplies pitch, roll and yaw and the BMP280 supplies pressure and temperature. Everything appears twice: on a 128×64 SSD1306 at the rig, and on a browser dashboard with a rolling motion graph for whoever is not standing next to it.

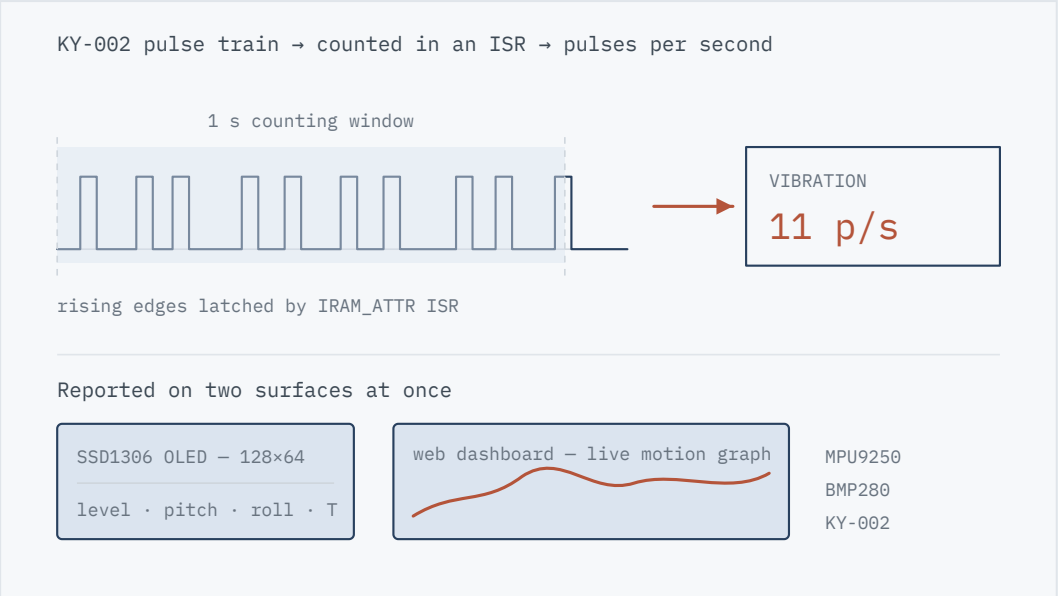


Fig. 29 Pulse train latched by the ISR and counted over a one-second window, then reported to the OLED and the web dashboard together.

5 Supporting software

Further builds outside the aerospace line — shipped, tested and in use.

AI-Workbench	Ultra-low-RAM desktop shell for every AI service in one window, each in its own OS webview. Tauri v2, React 19, TypeScript.
AI/ML Training Studio	Fully offline workbench for training, comparing and deploying models across tabular, image, text and time-series data. Nine taught scenarios.
LANDROP	Self-hosted cross-device file server with resumable, byte-exact uploads that survive a SIGKILL mid-transfer. No cloud, no account.
Draftbench	On-device document and image tools for Android. No internet permission, no machine learning.
Expense Tracker	Native Android expense tracker in Kotlin and Compose. Every one of fifteen text pairs measured against WCAG 2.1 before it shipped.
DeepSeek Telegram Bot	Mode-driven bot on DeepSeek V4, deployed as a single Render web service in webhook mode with SQLite on a mounted disk. 140 tests.

Team Telegram Bot	Runs the Air Forge team's design reviews and CAD deadlines. The model proposes; Python decides. 173 tests, all tool calls mocked.

6 Education and certifications

EDUCATION

B.Tech, Aerospace Engineering	Hindustan Institute of Technology and Science, Chennai Department of Aeronautical Engineering · Register number 23AU0020063	2023 – 2027
Higher Secondary (12th)	GHSS Ayyankoickal, Kollam, Kerala	2021 – 2023
Secondary (10th)	GHSS Ayyankoickal, Kollam, Kerala	2020 – 2021

CERTIFICATIONS AND TRAINING

Certificate of Completion	Aero Precision — AS9100D / ISO 9001:2015 certified facility	2026
Rocket Design Technology	Skyline Space, Coimbatore	2026
ECU Tuning & Remaps, Level 1	Techmaghi	2026
Advanced Drone (Air Taxi) Workshop	BSERC	2025
Computational Methods for Multiphysics	IIITDM Kancheepuram	2025
Space Internship Program	Agnirva, with IN-SPACe	2024
Mechnovate 25 ORBITRON	VIT Vellore — certificate of participation	2025

7 Leadership and activities

General Secretary	Nebula Astro Club, HITS — near-space balloon payload experiments	2025 – present
Technical Head	Ys Men International	2023 – 2025
Chief Magazine Editor	KITES	2019
NSS Member	Kollam	2021 – present
Student Police Cadet	Kollam City	2018 – 2020
CanSat Competition	Team 1025 — scored 93	
Team AIRFORGE	NIDAR drone innovation competition — CAD and structures	2026
Craft	Photography, video editing and graphic design — team graphics and technical figures	

8 Contact

EMAIL	**rizwannizar40@gmail.com**
PHONE	**+91 62384 48351**
LINKEDIN	**linkedin.com/in/rizwannizar**
GITHUB	**github.com/rorcoder999**
ADDRESS	Placheril House, Kollam, Kerala — 691585

I declare that the projects presented in this portfolio are my own work, carried out either as part of my coursework at Hindustan Institute of Technology and Science, during the industrial internships named against each entry, or independently. Figures are my own output unless marked as a reserved slot.

Signature

Rizwan Nizar

B.Tech Aerospace Engineering · 23AU0020063

Place and date

Chennai, Tamil Nadu

Verified by (Department / CPCD)