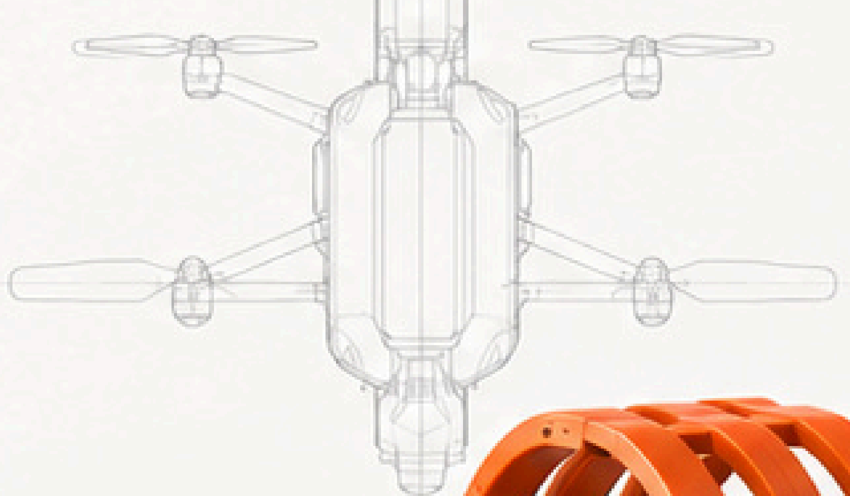
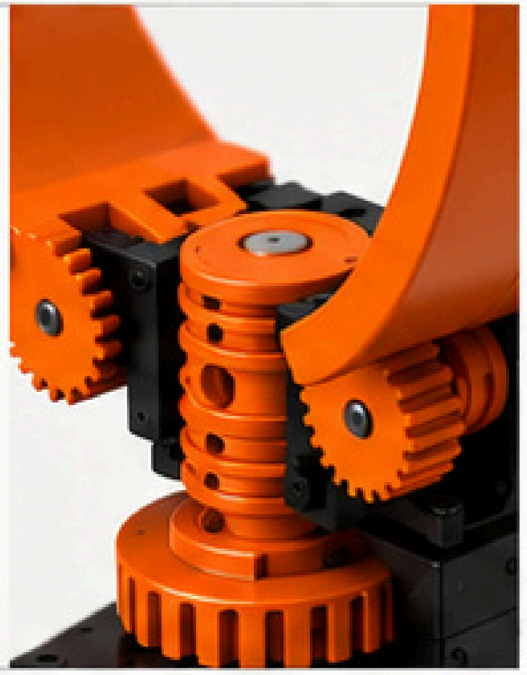
OM SHAH

INDUSTRIAL DESIGN

UAV + ROBOTICS HARDWARE

Designing physical systems from first sketch to tested prototype — combining CAD, mechanisms, embedded hardware and evidence-led iteration.



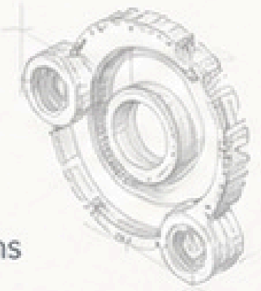


MSc Integrated Industrial Design
Loughborough University

Designer of physical systems.

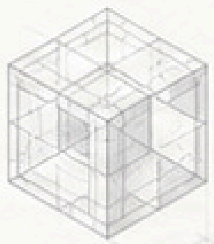
I work at the intersection of product architecture, mechanical design, embedded systems and physical prototyping. My process is built around making ideas testable: CAD the system, build the mechanism, instrument it, learn from failure, and refine the architecture.

MECHANICAL DESIGN



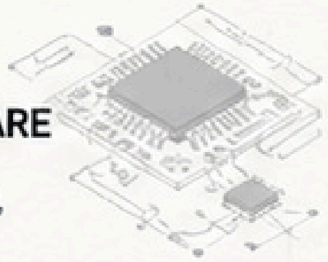
CAD assemblies, mechanism architecture, tolerance decisions and DFM.

PROTOTYPING



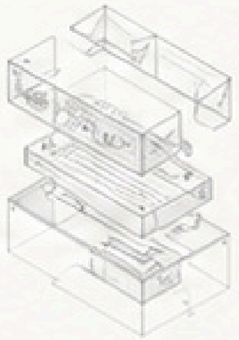
FDM, laser cutting, CNC/CAM, vacuum forming and rapid physical iteration.

EMBEDDED HARDWARE



ESP32, sensors, actuators, UART/I2C interfaces and power integration.

SYSTEM INTEGRATION



Packaging, serviceability, subsystem validation, logging and failure analysis.

THREE PROJECT LENSES

03

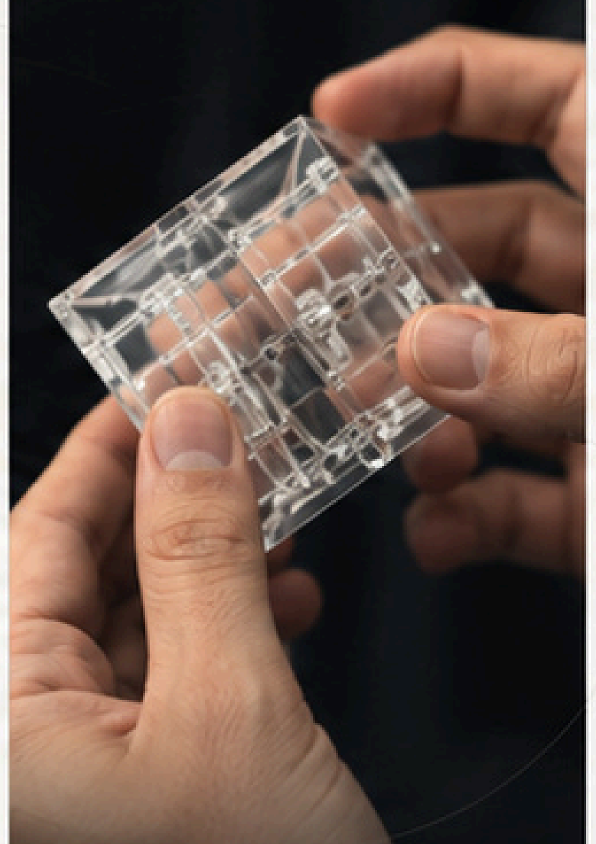
01 EXPLORER

Autonomous perching drone.

UAV
ROBOTICS
HARDWARE

02 THE CUBE

Tactile mechanism exploration.



MATERIALS
MECHANISMS
HUMAN INTERACTION

03 T-REX

AR helmet for military jet engineers.

AR
HUMAN FACTORS
DEFENSE

GOLD AWARD | Inclusive Sports Design 2025-26 / FreeWheel / team project →

01 / EXPLORER

Persistent Forest Monitoring UAV

A flight-capable proof of concept exploring how a UAV can transition from flight into a stationary sensing node through active branch peching and solar-assisted energy recovery.

INDIVIDUAL MSC MAJOR PROJECT

Research · product architecture · CAD · prototyping · electronics integration · software · physical testing

FLEW | PERCHED | SENSED | LOGGED | SOLAR PATH

POC POSITIONING

Built to prove the critical subsystems together — not to claim a finished autonomous swarm.

Perching hook mechanism
Actuated clamp for secure perching on branches and structures.

Compact electronics housing
Integrated mission electronics, power architecture and BMS in a rugged, streamlined shell.

Solar-assisted surfaces
Solar panels integrated into the airframe for extended stationary operation.

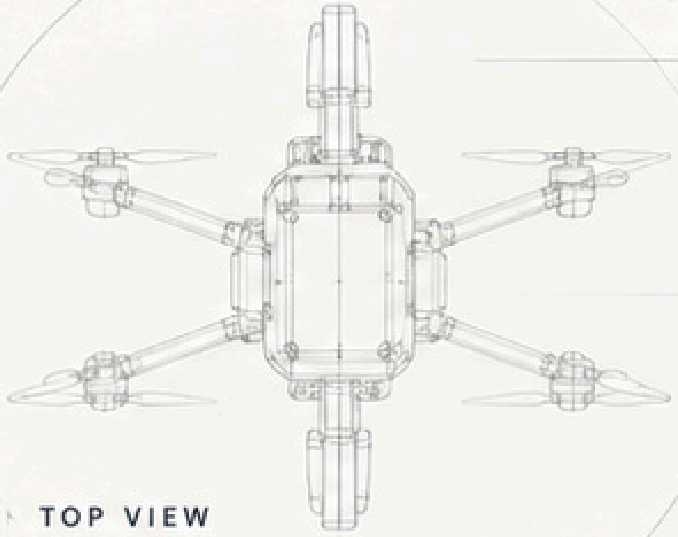
Lightweight quadrotor platform
Carbon fiber structure with optimized geometry for agility and efficiency.

EXPLORER

01 / EXPLORER

The design changes the mission, not just the airframe.

Conventional UAV monitoring is dominated by propulsion energy and return-to-base cycles. Explorer adds a second operating state: perch, stop spending hover energy, continue sensing, and recover usable energy.



TOP VIEW

EXPLORER OPERATING MODEL

Concept render

FROM FLIGHT TO PERSISTENCE

CURRENT

FLY → SURVEY → BATTERY LOW → RETURN

EXPLORER

FLY → PERCH → MONITOR → RECOVER ENERGY → REDEPLOY

REDUCED PROPULSION DEMAND

Motors can stop while the vehicle is supported by a branch.

PERSISTENT POSITION

The aircraft can remain inside the monitoring area instead of repeatedly returning.

FUTURE DISTRIBUTED SYSTEM

A single node becomes the unit architecture for a wider coordinated network.

Perching Mechanism.

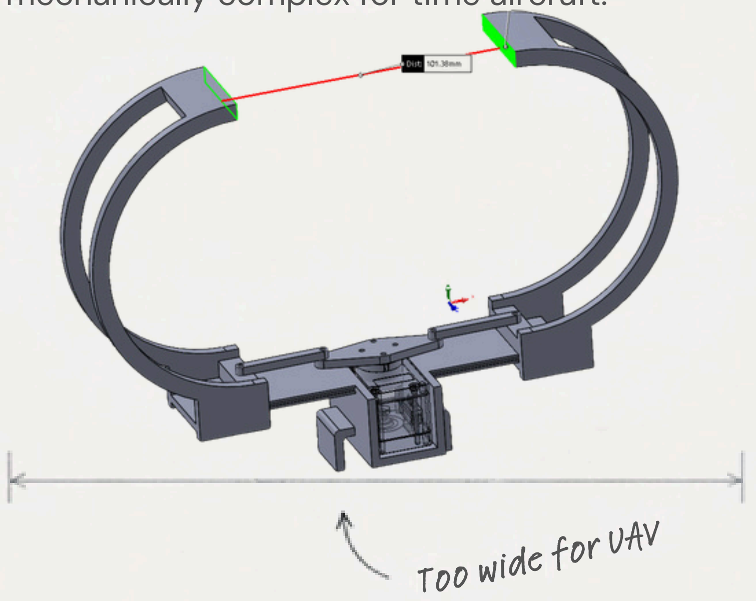
TESTING CHANGED THE ARCHITECTURE.

The mechanism evolved because physical tests exposed width, part-count, alignment and loadRetention problems that CAD alone could not resolve.

DESIGNED TO PERCH. BUILT TO LAST.

01
LARGE LATERAL MECHANISM

Movement proved possible, but the layout became too wide, heavy and mechanically complex for time aircraft.



→

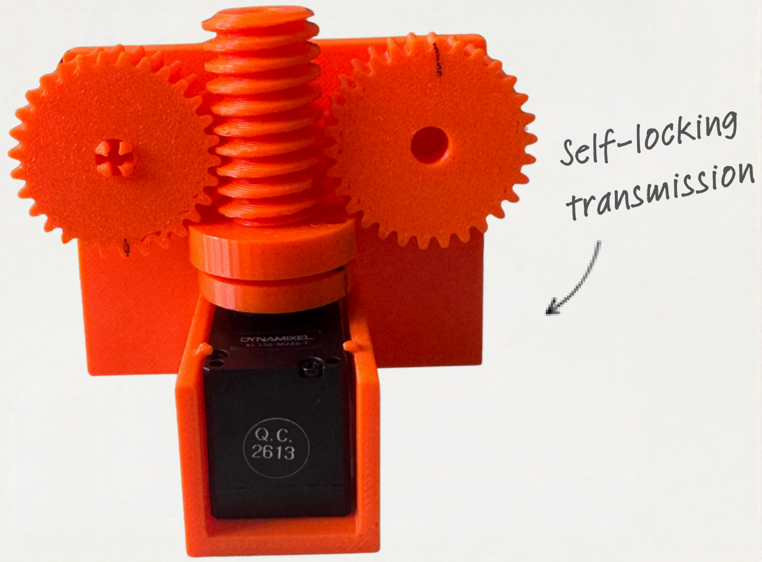
02
DIRECT GEARS

A compact 1:1 concept worked – then testing revealed that the output gears could back-drive under load.

→

03
WORM DRIVE

A secure perch should not depend on the servo continuously holding torque. The architecture shifted toward self-locking transmission.



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04
FINAL APPROVED GEOMETRY

Hook geometry, spacing and clearances were iterated into time final working form used for integration.

FUNCTIONAL TESTING – NOT AESTHETIC PREFERENCE – DROVE THE RESET.

Structure + Packaging.

SEPARATE FLIGHT STRUCTURE FROM BESPOKE INTEGRATION.

The carbon frame carries flight loads. Additive manufacturing is used where custom packaging, cable routing, battery retention and subsystem access create value.

PHYSICAL PACKAGING

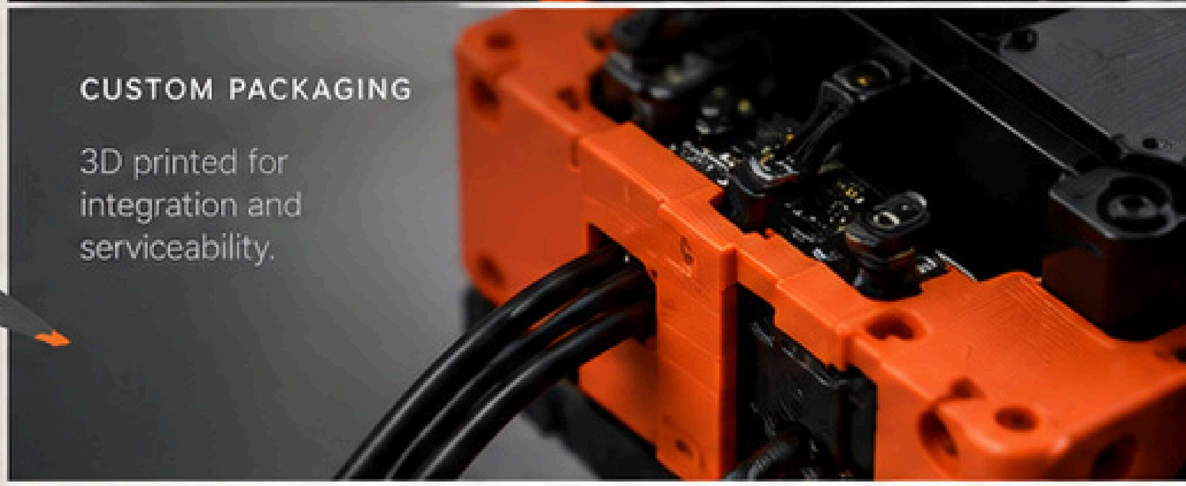
Rough full-system integration established where sensing, actuation, power and propulsion had to coexist.

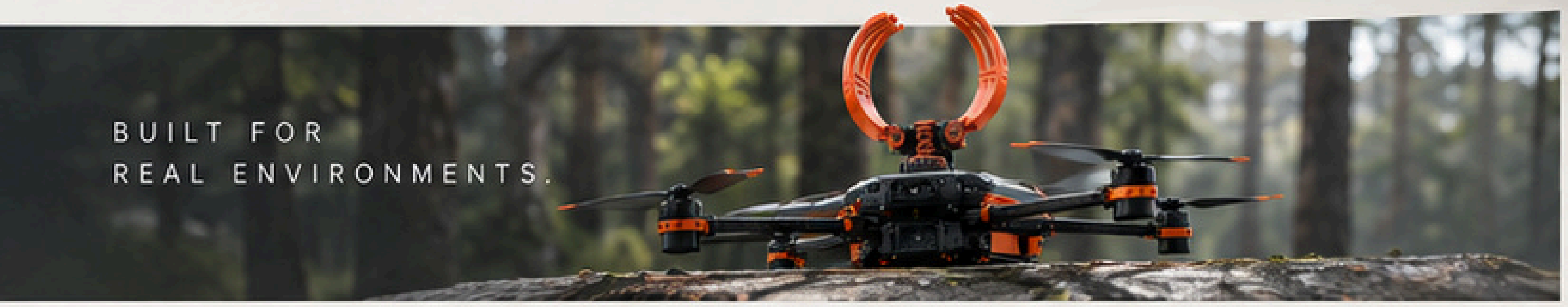
CENTRE OF GRAVITY

Component mass and simplified CAD blocks were used to keep the integrated assembly balanced around the flight centre.

POC → PRODUCTION

Future architecture reduces part count and replaces exposed development modules with integrated, sealed and serviceable hardware.





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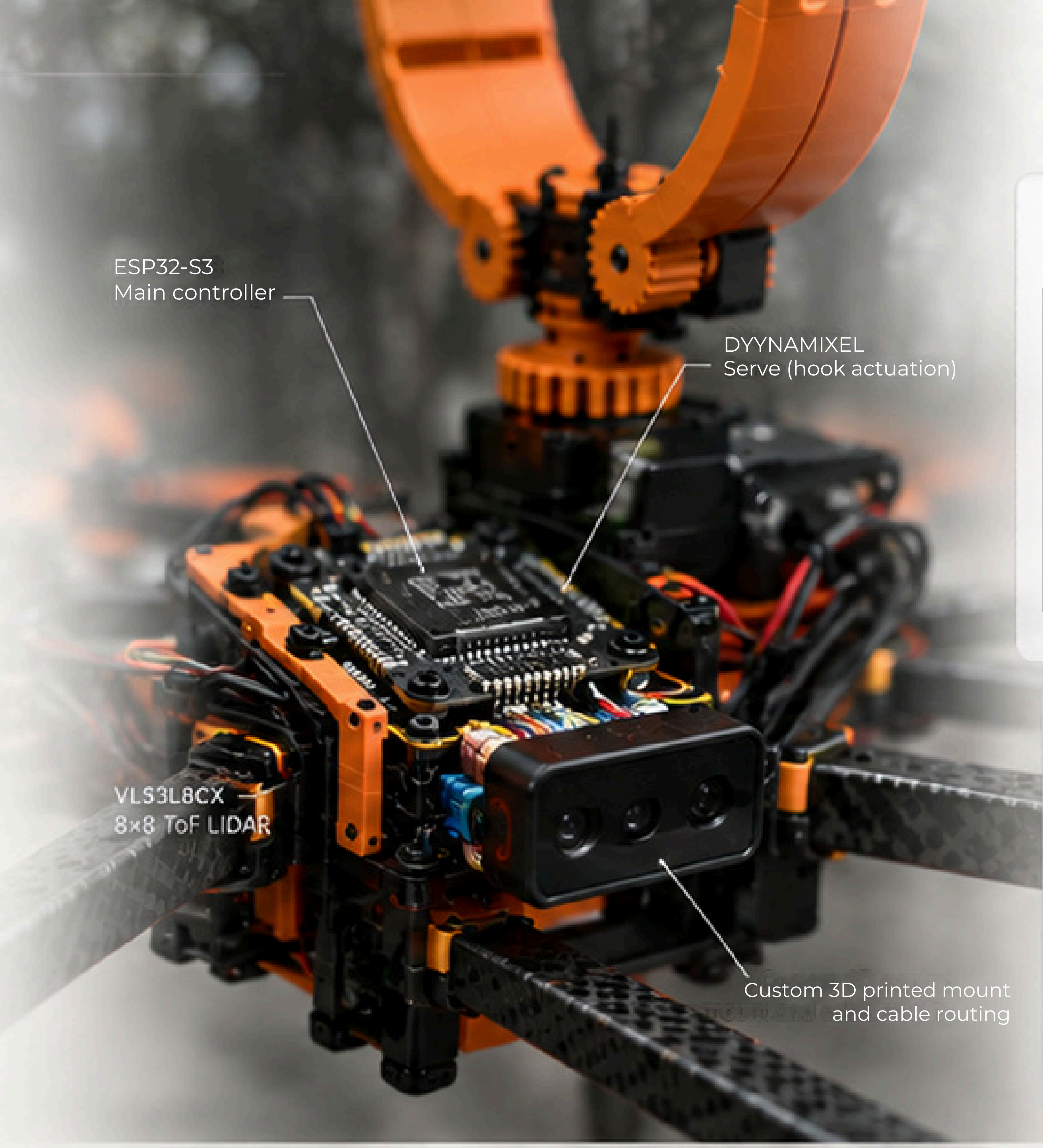
DESIGN RULE

PRIMARY STRUCTURE = CARBON
BESPOKE PACKAGING = ADDITIVE

LIGHTER
SIMPLER
MORE INTEGRATED
FIELD-READY

Embedded Control + LiDAR.



MAKE EACH SUBSYSTEM RELIABLE BEFORE INTEGRATION.

Reliable communication, sensing and data logging were validated individually before being integrated into the full system.

01 ACTUATION PATH

RC ELRS
Plot input (telemetry)

→

FLIGHT CONTROLLER
Control logic (UART)

→

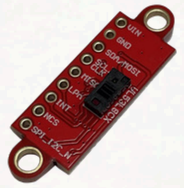
DYYNAMIXEL
Position control (half-duplex)

→

HOOKS
Perching mechanism

Reliable half-duplex communication and repeatable position control were validated before the mechanism was committed to final geometry.

02 SENSING + DATA PATH



VL53LBCX
8x8 Tof depth sensing (12C)

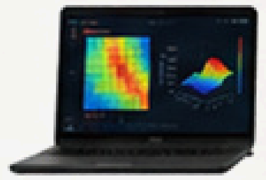
→

ESP32-S3
Data processing + logging (PCSV)

→

LITTLEFES
Onboard logging (PCSV)

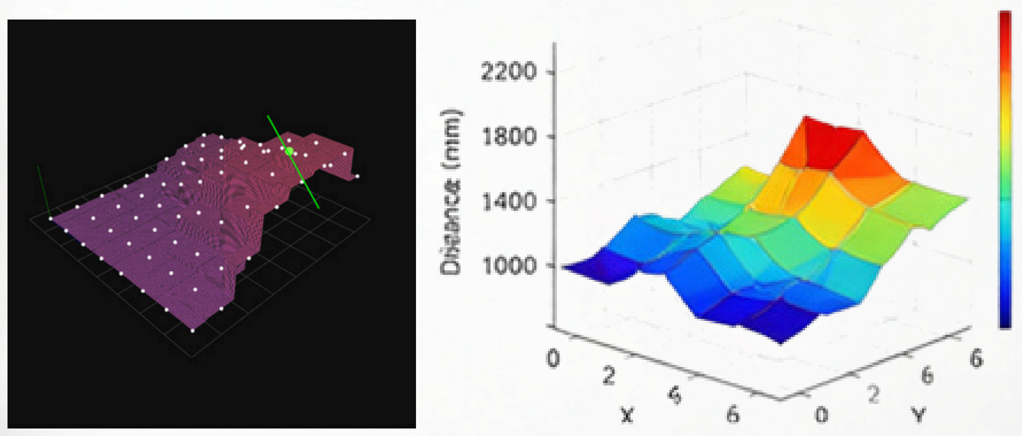
→



LIVE USB
Real-time visualisation (PC)

Distance data from the VL53LBCX was visualised as an 8x8 grid and logged for analysis.

LIDAR 8XB VISUALISATION



SERIOR OUTPUT (SAMPLE)

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[14, 31, 42, 59, 68, 69, 67, 63]
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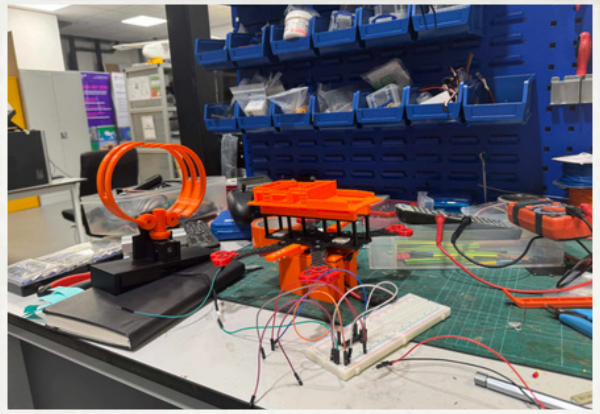
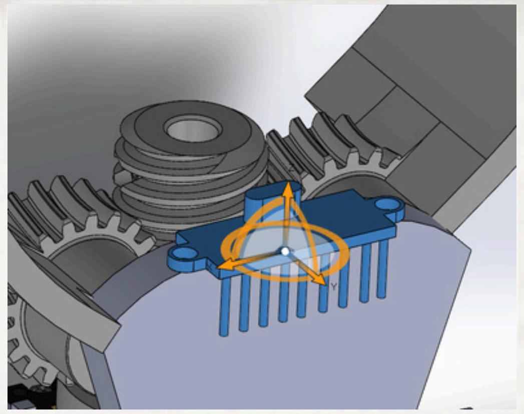
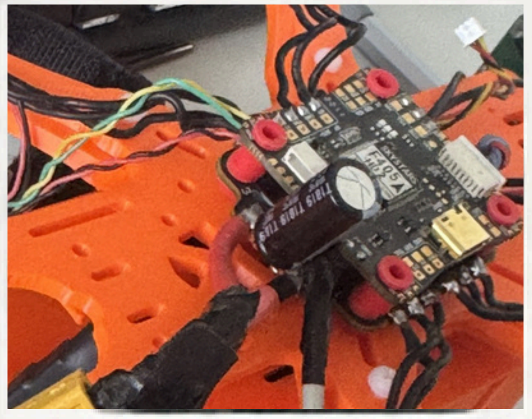


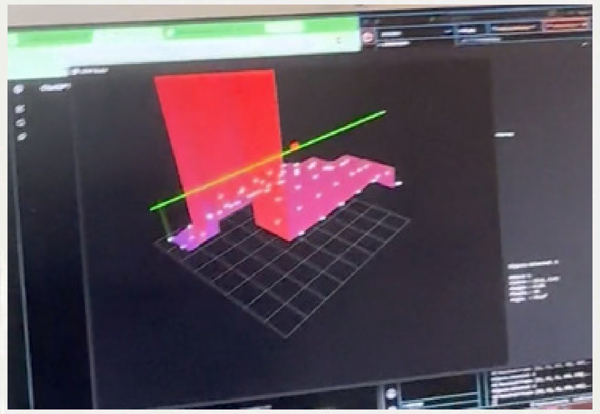
FULL SYSTEM INTEGRATION



LIDAR MODULE



CONTROL ELECTRONICS



LIVE VISUALISATION

From Prototype to the Forest.

PHYSICAL TESTING & VALIDATION

Real-world testing validated the integrated system — flight performance, perching function, sensing and data logging — and informed key design refinements.

TEST
LEARN
REFINE
REPEAT

NOT JUST A DRONE. A LONGER PRESENCE IN THE FOREST.

FORESTS NEED PERSISTENCE.

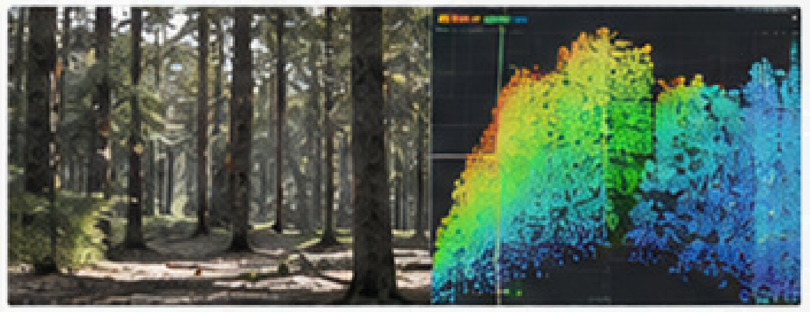
01 FLIGHT TESTING

Validated stability, control and payload integration in real outdoor conditions.

02 PERCHING TESTING

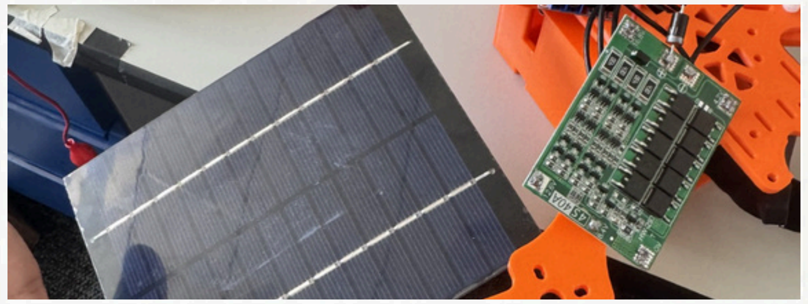
Tested approach, alignment, grasp reliability and load retention on real branches.

03 SENSING & LOGGING



Collected and logged LiDAR data in forest environments to validate sensing range and accuracy.

04 SOLAR RECOVERY



Evaluated solar panel integration and charging potential during stationary perching.

KEY OUTCOMES

- ✓ Stable flight with integrated mechanism
- ✓ Reliable perching on natural branches
- ✓ Functional LIDAR sensing and data logging
- ✓ Initial validation of solar-assisted energy recovery
- ✓ Design improvements fed into final architecture

Validation.

REAL EVIDENCE / SYSTEM FEASIBILITY

The physical POC was evaluated through real flight, retention, sensing and failure-based learning. The goal was to demonstrate subsystem integration and feasibility, rather than full autonomy.

REAL TESTING. REAL INSIGHTS.

DESIGNED FOR REAL CONDITIONS.

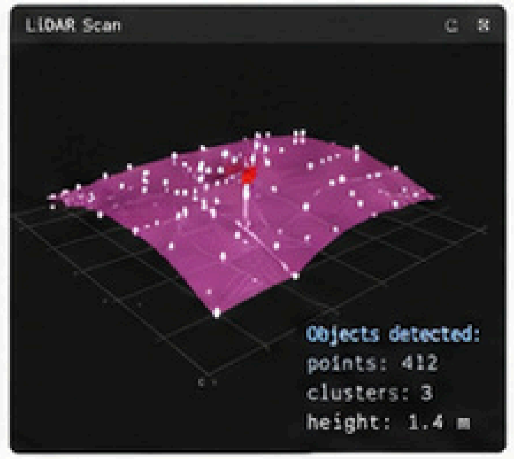
01 FLIGHT TESTING

Demonstrated stable flight and controllable behaviour.

02 PERCHING / RETENTION

Manual hook test showed secure load retention even without power.

03 SENSING & LOGGING



Validated LiDAR visualisation and branch-like feature detection workflow.

04 CRASH / FAILURE LEARNING

Impact events exposed robustness limits and informed next-iteration requirements.

DEMONSTRATED

- ✓ Stable controllable flight
- ✓ Manual perch / retention proof
- ✓ LiDAR sensing and data visualisation
- ✓ Integrated subsystem feasibility
- ✓ Initial solar-assisted architecture integration

NOT DEMONSTRATED

- ✗ Autonomous branch approach
- ✗ Autonomous capture / perch
- ✗ Closed-loop perception-to-actuation
- ✗ Full autonomous forest deployment
- ✗ Swarm coordination

FINAL TAKEAWAY

THE POC PROVES SYSTEM FEASIBILITY — NOT FULL AUTONOMY.

THE CUBE.

A fabrication-led project focused on one deceptively hard problem: create a repeatable, intuitive mechanical connection between two acrylic cubes without magnets.

A WHAT

Two 50 mm acrylic cubes with a mechanical interface across two faces.

B WHY

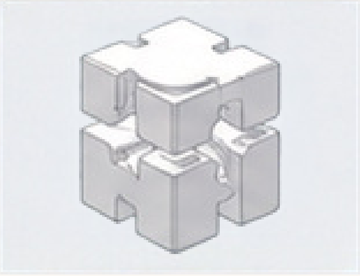
Secure alignment, clear attachment feedback and no magnets.

C HOW

10+ prototypes exploring insert, twist, rails, blades, friction and locking.

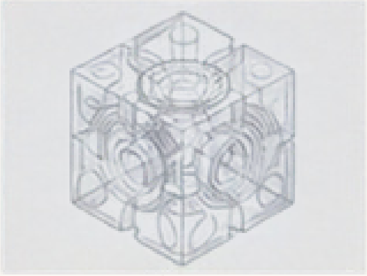
ITERATION SNAPSHOT

FROM SKETCH → PROTOTYPE → REFINED SOLUTION →



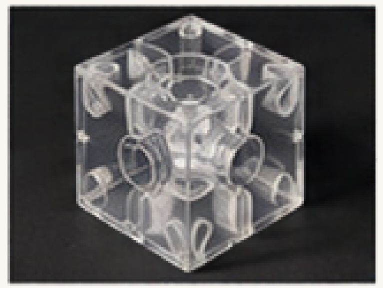
01 / EARLY CONCEPTS
Insert + twist exploration.

→



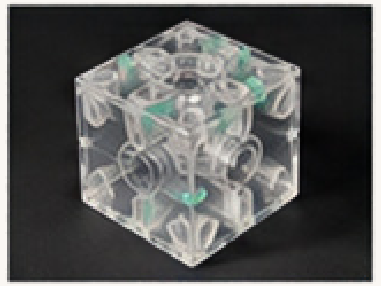
02 / MANY ITERATIONS
Pins, rails, blades, paths.

→

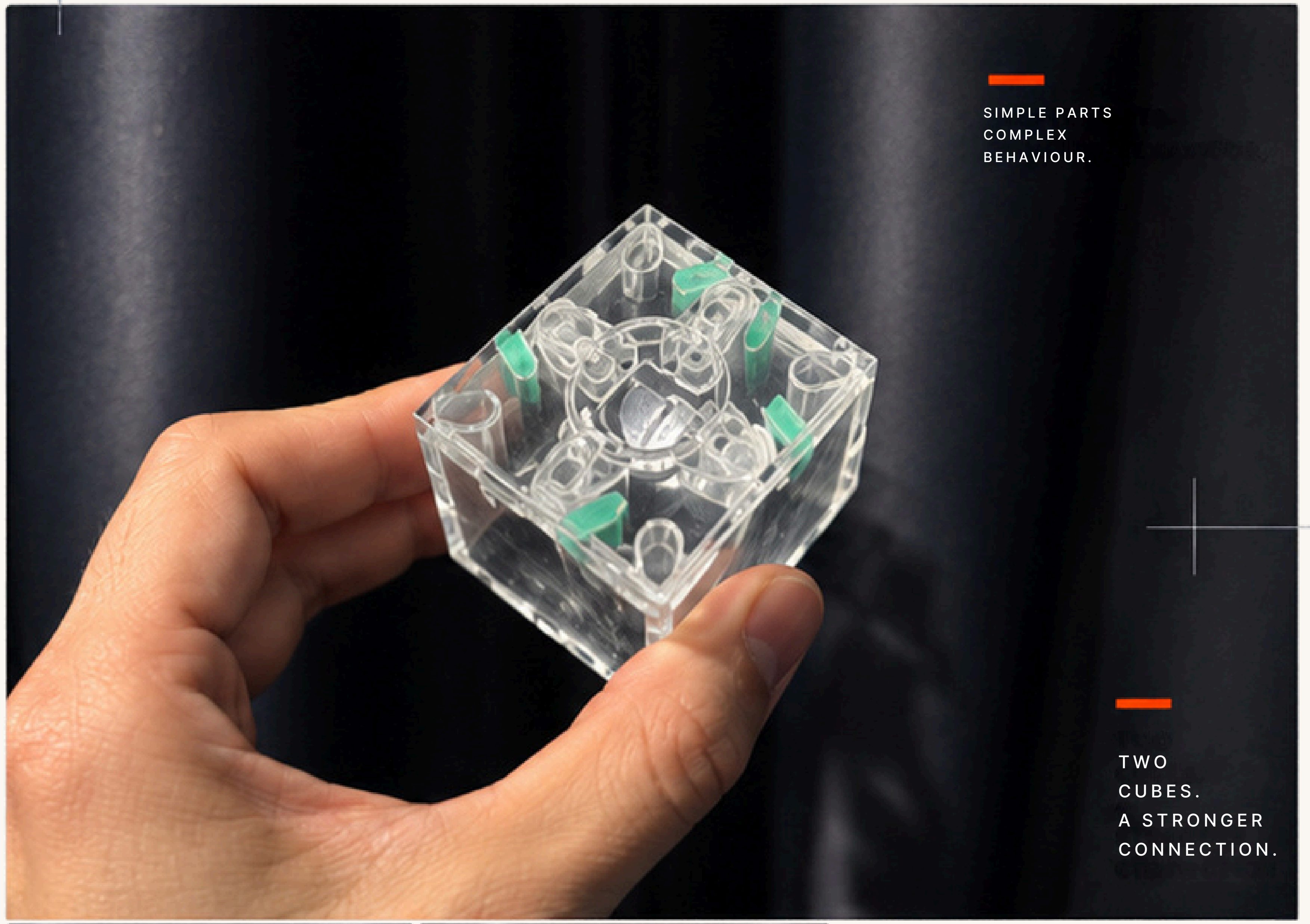


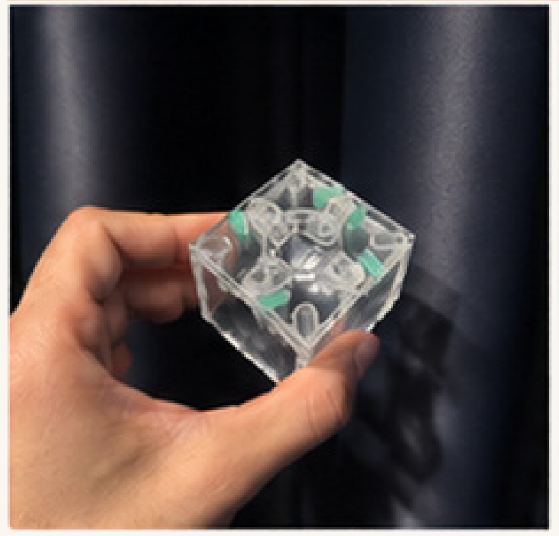
03 / SIMPLIFIED PATHS
Fewer parts, clearer motion.

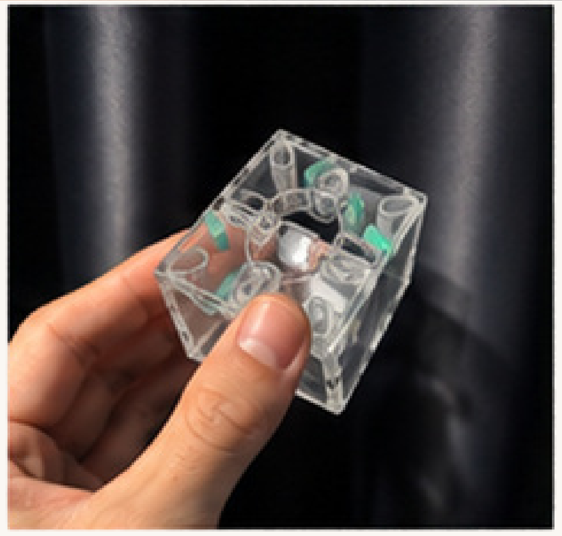
→



04 / FINAL DESIGN
Stable, repeatable, intuitive.







The mechanism got simpler.

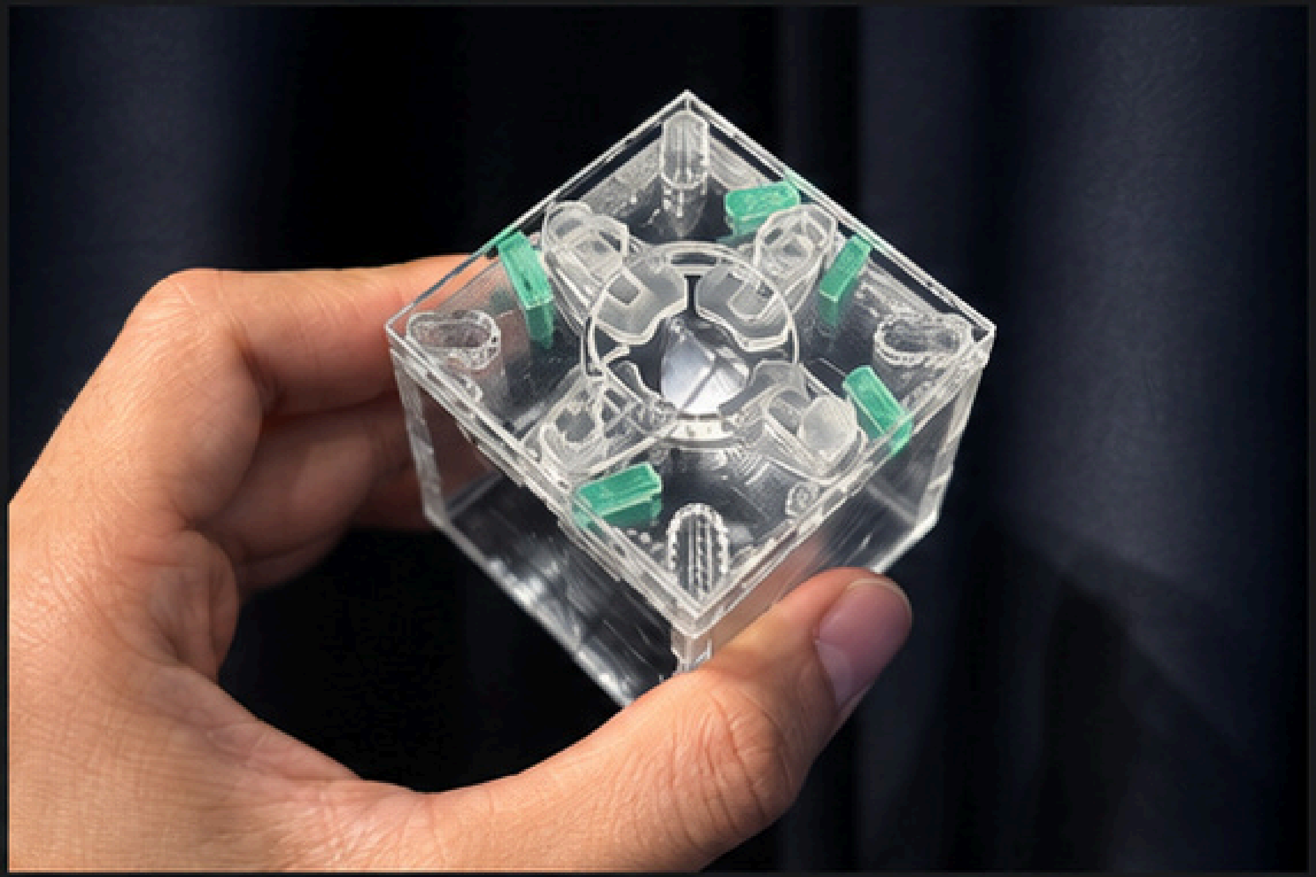
REAL SKETCHES / REAL PROTOTYPE FAILURES / REAL ACRYLIC MECHANISMS

Repeated iteration simplified the geometry, improved alignment, reduced part count and clarified the tactile locking action.

DESIGN LESSON

Simplifying the geometry increased reliability and produced clearer tactile feedback.

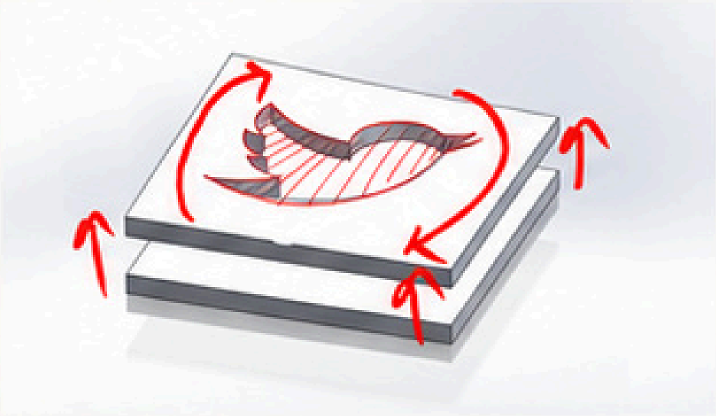
- ✓ Fewer parts
- ✓ More reliable motion
- ✓ Better alignment
- ✓ Clearer tactile lock



FINAL PHYSICAL PROTOTYPE

50 mm acrylic cube with the refined locking mechanism.

SIMPLE
RELIABLE
TACTILE
BUILDABLE



01 / INSERT + TWIST

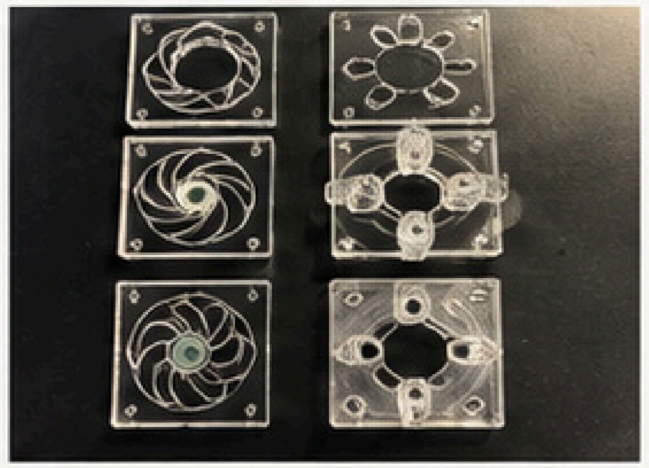
Early sketch exploring insertion, rotation and a guided locking motion.

→

02 / IRIS / TOO MANY PARTS

A physical iris prototype proved movement, but revealed excessive complexity and poor suitability at this scale.

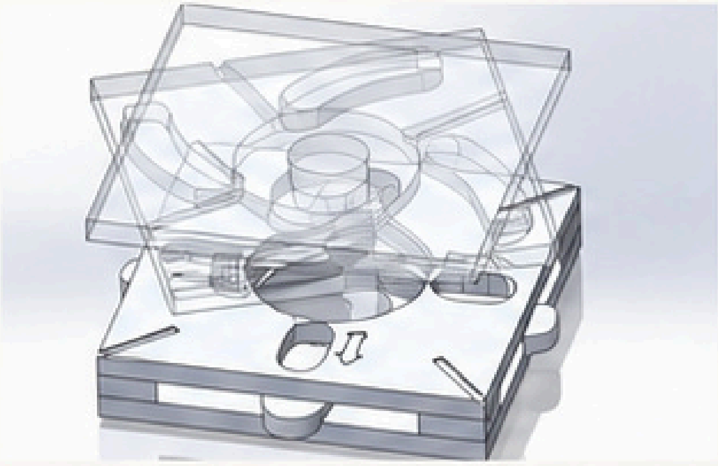
→



03 / ACRYLIC TEST SERIES

Laser-cut acrylic trials exposed kerf, friction, alignment and tolerance behaviour across multiple geometries.

→



04 / FINAL LOCKING GEOMETRY

The final mechanism reduced part count and clarified the locking path inside the cube.

EACH FAILURE REMOVED COMPLEXITY — UNTIL THE INTERACTION BECAME SIMPLE, REPEATABLE AND BUILDABLE.

Manufacturing Strategy.

DESIGNING FOR THE PROCESS.

The final form was not simply modelled and sent to manufacture. Draft, radii and toolpaths were redesigned around CNC machining, mould release and vacuum-forming behaviour.

3°	3 mm	0.01 mm
MIN. DRAFT	**MIN. FILLETS**	**CAM TOLERANCE**
release	CNC corners	finish

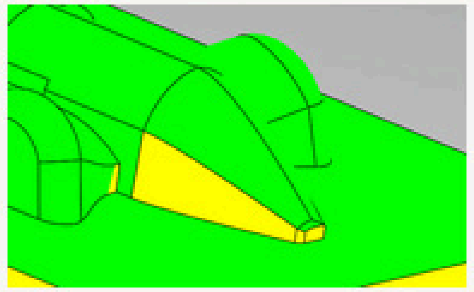
PHYSICAL OUTCOME


CNC MACHINED MOULD


VACUUM-FORMED SHELL

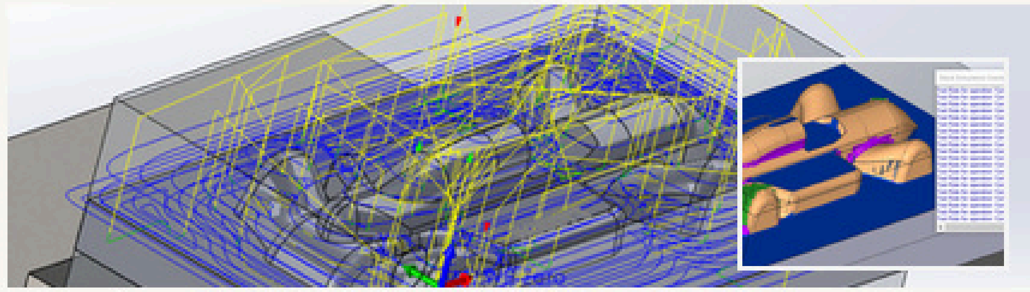

MOULD ITERATIONS

01 DFM GEOMETRY



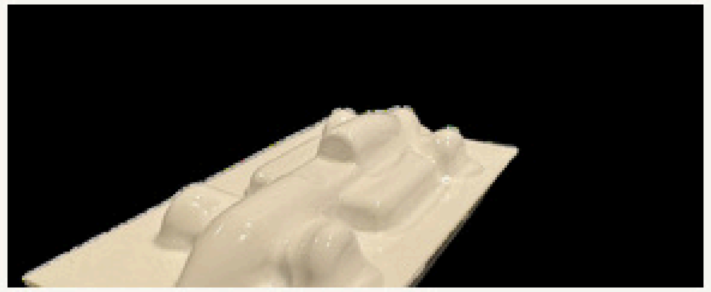
3° draft, 3 mm fillets and softer transitions improved tool access and release.

02 CAM ITERATION



Stepover, clearing and feed strategy were refined to reduce chatter, air-cutting and wasted motion.

03 MAKE → FORM → CHECK



The machining and forming trials confirmed surface quality, release behaviour and the final manufacturing route.

DFM — TOOLPATH — MACHINING — MOULD — VACUUM FORM — VALIDATE

MANUFACTURING CONSTRAINTS DID NOT FOLLOW THE DESIGN — THEY SHAPED IT.

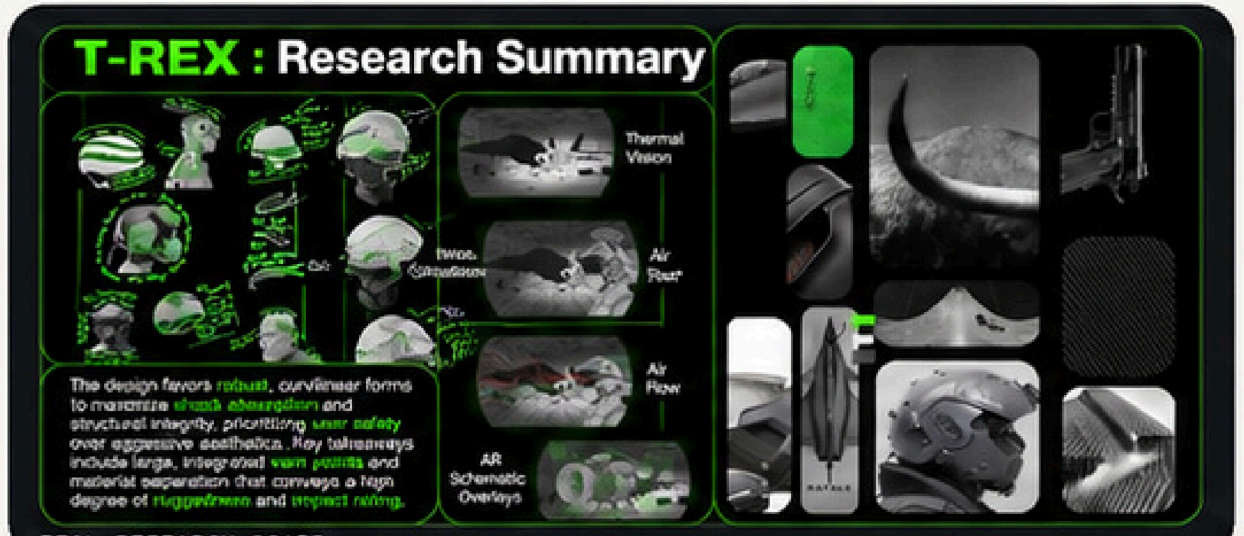
Designing for the flight line.

RESEARCH + IDEATION

A **defence-context helmet** concept for military jet engineers, built around protection, airflow, noise reduction and hands-free visual information.

RESEARCH SYNTHESIS

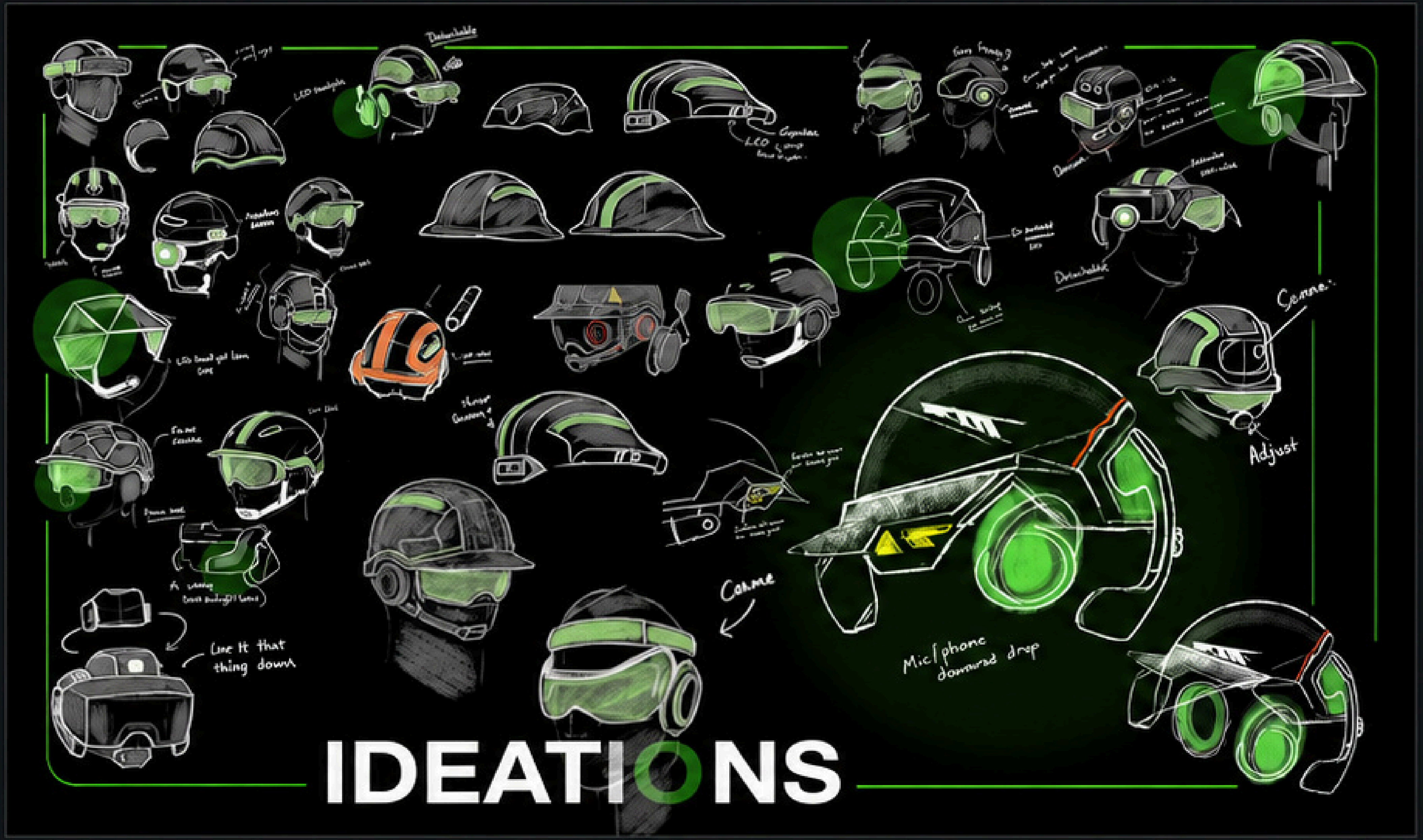
01	**PROTECTION**	Full-face coverage against fumes + debris
02	**AIRFLOW**	Large integrated ventilation paths
03	**INFORMATION**	AR guidance without handheld tools
04	**USABILITY**	Glove-friendly controls + secure fit



REAL RESEARCH BOARD

IDEATION BREADTH

FORM / FIT / INTERACTION



30+ FORM STUDIES

Exploring shell coverage, venting, visor integration, side modules and control placement.

PROTECT	**VENT**	**SEE**	**OPERATE**
Full-face shell	Integrated airflow	AR information	Glove-first controls

RESEARCH SET THE REQUIREMENTS. IDEATION TESTED HOW THEY COULD BECOME ONE WEARABLE SYSTEM.

Prototype. Find the failure.

REAL PHYSICAL PROTOTYPE + FAILURE-LED ITERATION

Building and testing a physical prototype exposed critical flaws in ventilation, ergonomics, adjustment mechanisms and overall clearance. These insights invalidated the initial concept and led to a reset of the brief with a clearer set of requirements.

PROTOTYPING PROCESS

01	**BUILD**	Created physical prototype using mock components
02	**TEST**	Evaluated fit, airflow, adjustment and clearance
03	**IDENTIFY**	Found critical flaws and usability issues
04	**RESET**	Revised the brief with new core requirements

REAL PROTOTYPE TESTING

PHYSICAL MODEL / USER TEST / FAILURE EVIDENCE

WHAT THE PROTOTYPE EXPOSED

VENTILATION
Airflow was not adequate.
Helmet felt warm during use.

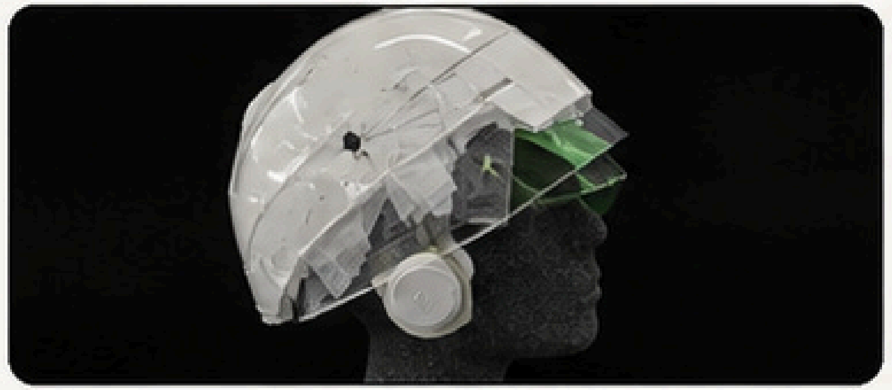
ERGONOMICS
Fit and comfort assumptions were wrong. Caused pressure points.

ADJUSTMENT
The modular adjustment concept was unstable / non-functional.

CLEARANCE
The architecture needed more protection and usable space.

REVISED DIRECTION

Move to a full-face, secure architecture with simpler side scroll controls and bottom-mounted buttons for ease of use.



PHYSICAL PROTOTYPING EXPOSED FAILURE EARLY — AND MADE THE BRIEF SHARPER.

Refined CAD.
Final system.

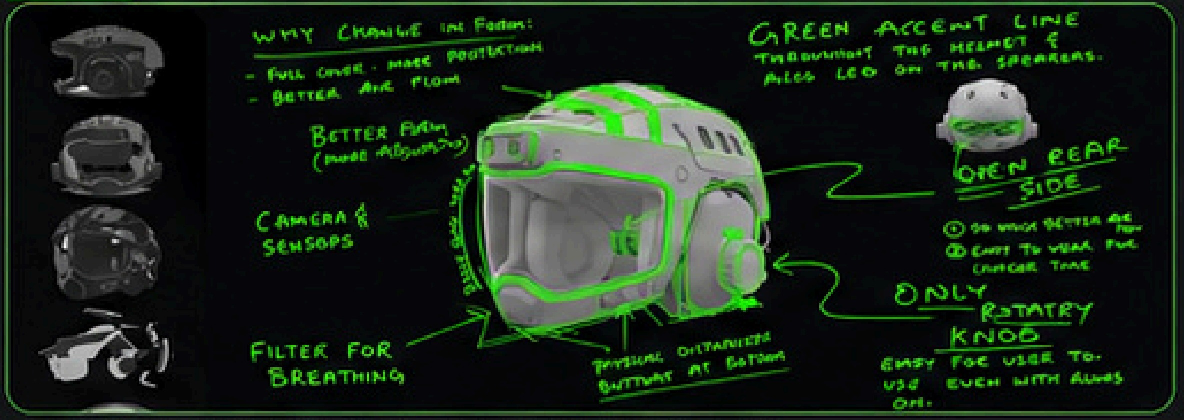
FROM FAILURE-LED RESET TO PRODUCT ARCHITECTURE

The physical prototype exposed the wrong assumptions. The final direction translates those lessons into a coherent full-face helmet with better airflow, clearer controls and integrated sensing.

RESOLVED DESIGN DECISIONS

01	FULL-FACE PROTECTION	more coverage + packaging
02	OPEN REAR AIRFLOW	improved long-wear comfort
03	ROTARY CONTROL	simple glove-first interaction
04	FRONT SENSING	camera / diagnostics integration

ACTUAL CAD DEVELOPMENT



FORM / AIRFLOW / SENSOR / CONTROL INTEGRATION

FINAL PRODUCT VISION

T-REX / TACTICAL REAL-TIME EXPERT SYSTEM

REAR / SIDE / FRONT

USER POV

Hands-free information layer for diagnostics.

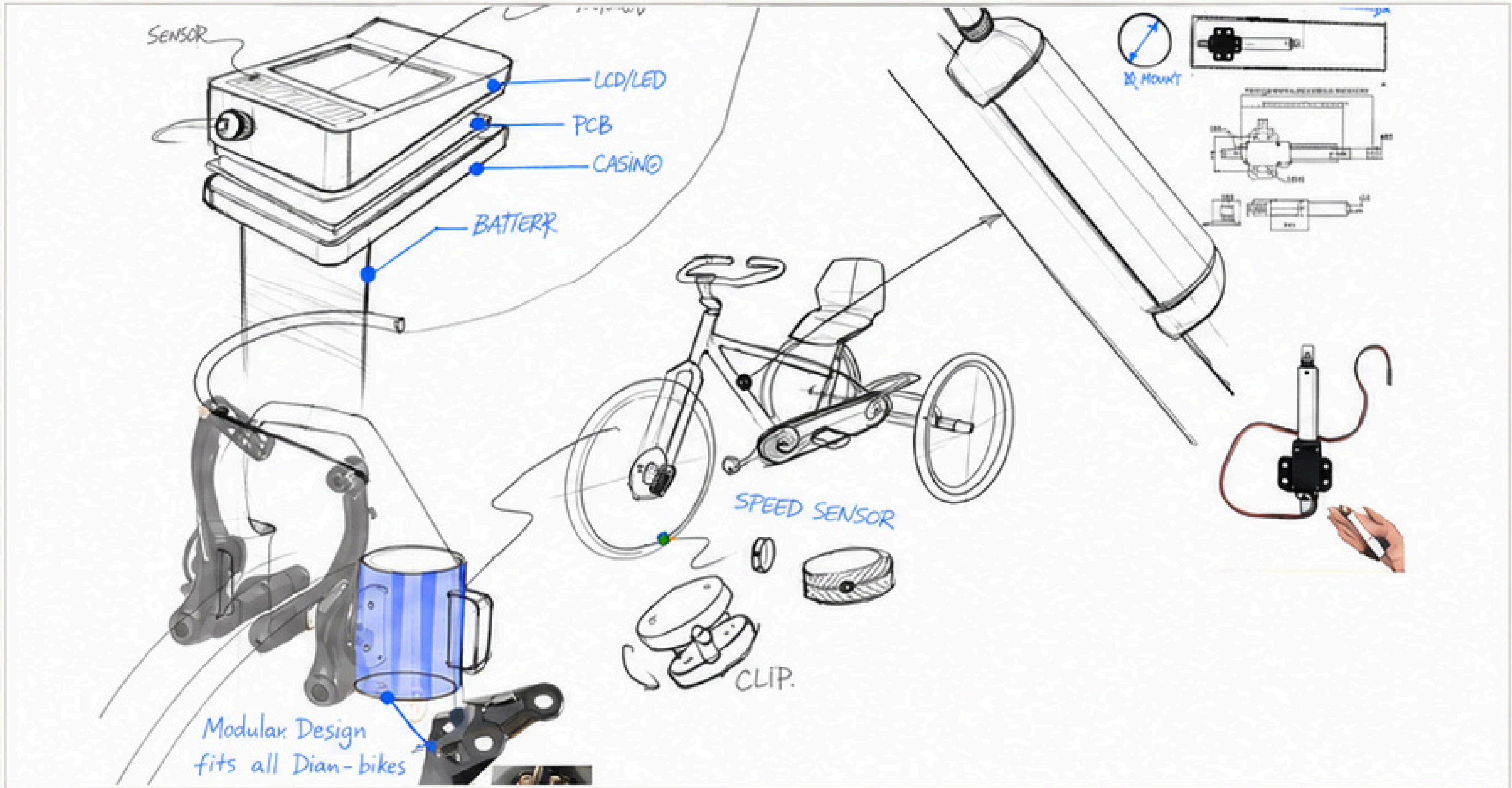
AR	diagnostics
THERMAL	vision
COMMS	integrated
CONTROL	quick-access

THE FINAL SYSTEM IS NOT A STYLING EXERCISE — IT IS THE RESULT OF THE FAILURE-LED RESET.

Inclusive cycling — designed as a system, not a single part.

Team project exploring a modular retrofit braking system for riders who need lower-force or anticipatory braking support. The concept layers a mechanical baseline, adaptive interface and automated safety intervention onto existing bicycles.

ADAPT EXISTING BICYCLES FOR A WIDER RANGE OF RIDERS



MODULAR RETROFIT ARCHITECTURE


Inclusive Sports Design 2025-26

Gold Award

AWARDED TO

Will Baxter, Wei-Sheng Tu, Ying Teng, Alexander Crasneanscki, Om Shah

Loughborough University

FOR

FreeWheel

IN CATEGORY OF

Brief D

SUPPORTED BY

Grampian Inclusive Cycling Bothies

Fiona Smith
GICB Lead Project Activator
Grampian Inclusive
Cycling Bothies

Prof. Russell Marshall
Associate Dean (Education & Student Experience)
School of Design and Creative Arts

Loughborough Sport · CP SPORT cerebral palsy sport · Special Olympics Great Britain · BOCCIA ENGLAND · Loughborough University

GOLD AWARD | Inclusive Sports Design 2025–26 / Brief D

MY DOCUMENTED PRESENTATION RESPONSIBILITIES

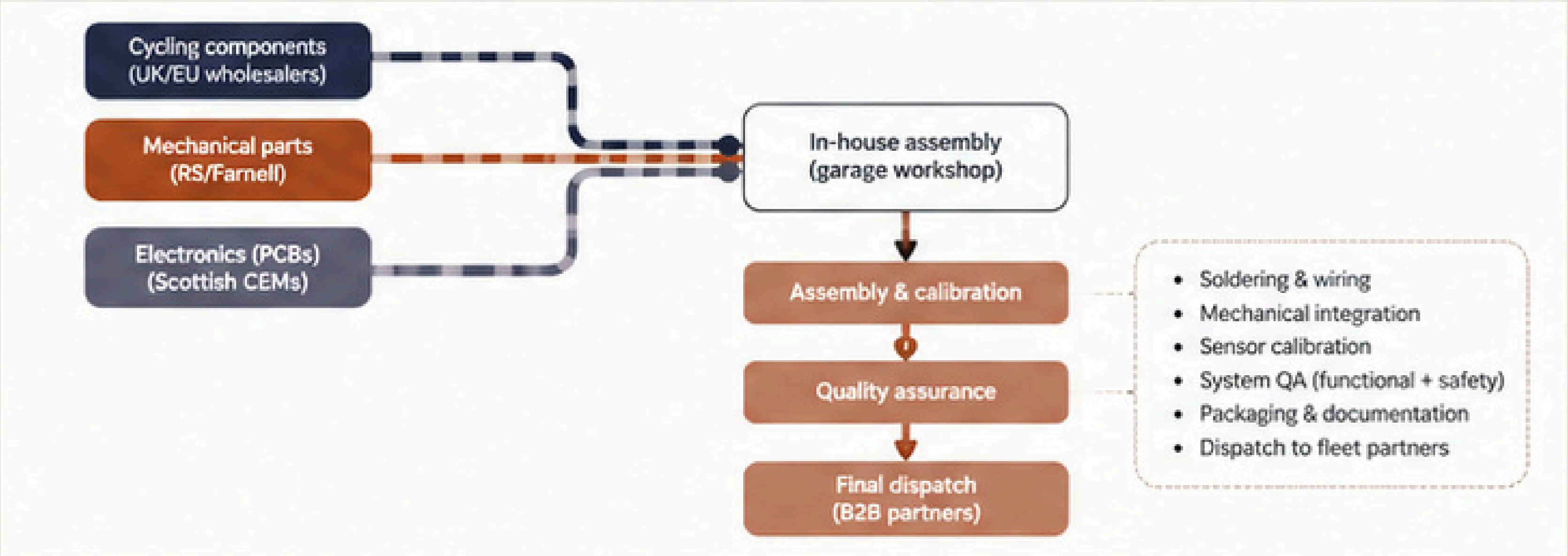
Customer segments · market sizing · customer relationships. Team project; the wider report also developed the product, manufacturing and commercial model.

Product design extended into sourcing, QA and route to market.

FROM DESIGN INTO REAL-WORLD DEPLOYMENT

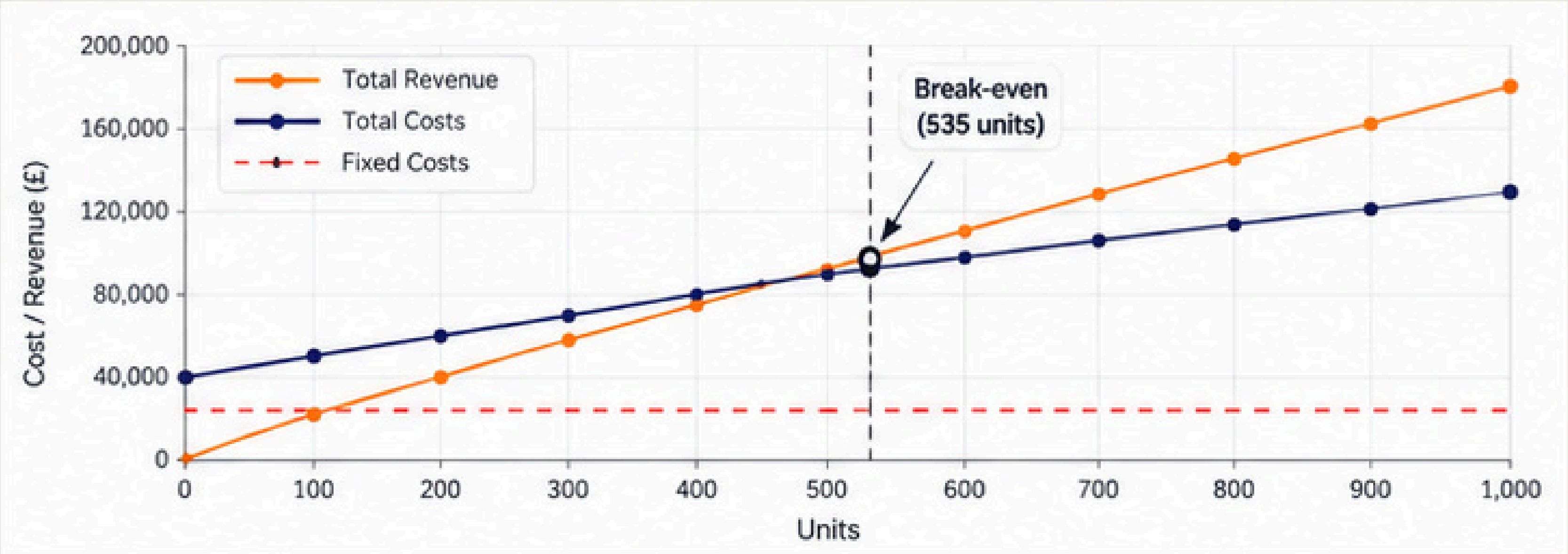
The project treated commercialisation as a design problem: standard components where possible, custom parts only where they add value, local small-batch assembly, and a retrofit architecture intended to remain serviceable.

SOURCE standard cycling + electronics → **CUSTOMISE** PCB / brackets / housing → **ASSEMBLE** solder / wire / calibrate → **VERIFY** mechanical + sensor + system QA → **DELIVER** B2B fleets + B2C



MANUFACTURING FLOW

This diagram maps the end-to-end supply chain from component sourcing through to final dispatch. It shows three procurement streams (cycling wholesalers, RS/Farnell for mechancial parts, and Scottish CEMs for custom PCBs) converging at the in-house garage workshop for final assembly, calibration and quality assurance before delivery to B2B partners.



UNIT ECONOMICS + SCALE MODEL

The financial model identifies a break-even point of **535 units**. At this volume, total revenue (£130,900) covers all fixed and variable costs, validating the project's financial sustainability within the first year of operation.

REPORT MODEL: APPROX. £152 BOM → £244 TARGET RETAIL / RETROFIT-FIRST / SMALL-BATCH LOCAL ASSEMBLY

Breadth without diluting the main story.

Four compact case studies show soft-goods design, AI product thinking, design research and sustainability methods. Keep these online as expandable work; the main PDF stays focused on hardware development.

SOFT GOODS / PRODUCT ARCHITECTURE

YATRA

Gaming + travel backpack with detachable pouch and tailored internal organisation.

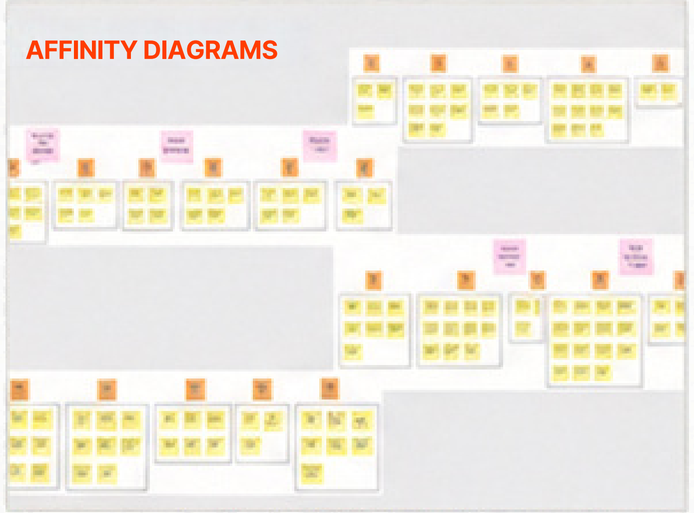
VIEW CASE STUDY →

EDGE AI / SPORTS SYSTEMS

22-YARD ANALYST

Concept for pitch-condition sensing using multispectral + IMU data and TinyML.

VIEW CASE STUDY →



FIELD RESEARCH / SYNTHESIS

DESIGN RESEARCH

Observation + interview triangulation around pet owners, air quality and the say/do gap.

VIEW CASE STUDY →

SUSTAINABILITY / FEA / LCA

ECO-NEST

Passive bio-composite thermal retention concept using digital thermal and lifecycle modelling.

VIEW CASE STUDY →

DESIGN. BUILD. TEST. REFINE.

IDEAS
INTO
REAL-WORLD
IMPACT

Industrial design for UAVs, robotics and advanced hardware — with a bias toward working prototypes, manufacturing reality and honest validation.

DESIGN

- Product architecture
- CAD assemblies
- Mechanisms
- DFM / tolerance
- Sketching + research

BUILD

- FDM prototyping
- Laser cutting
- CNC / CAM
- Vacuum forming
- Electronics + soldering

TEST

- Bench validation
- Physical test rigs
- Sensor logging
- Failure analysis
- Iteration + refinement

TOOLS

- SolidWorks
- Fusion 360
- ESP32 / Arduino
- Python
- Dynamixel / ToF LiDar

OM SHAH | EMAIL | LINKEDIN