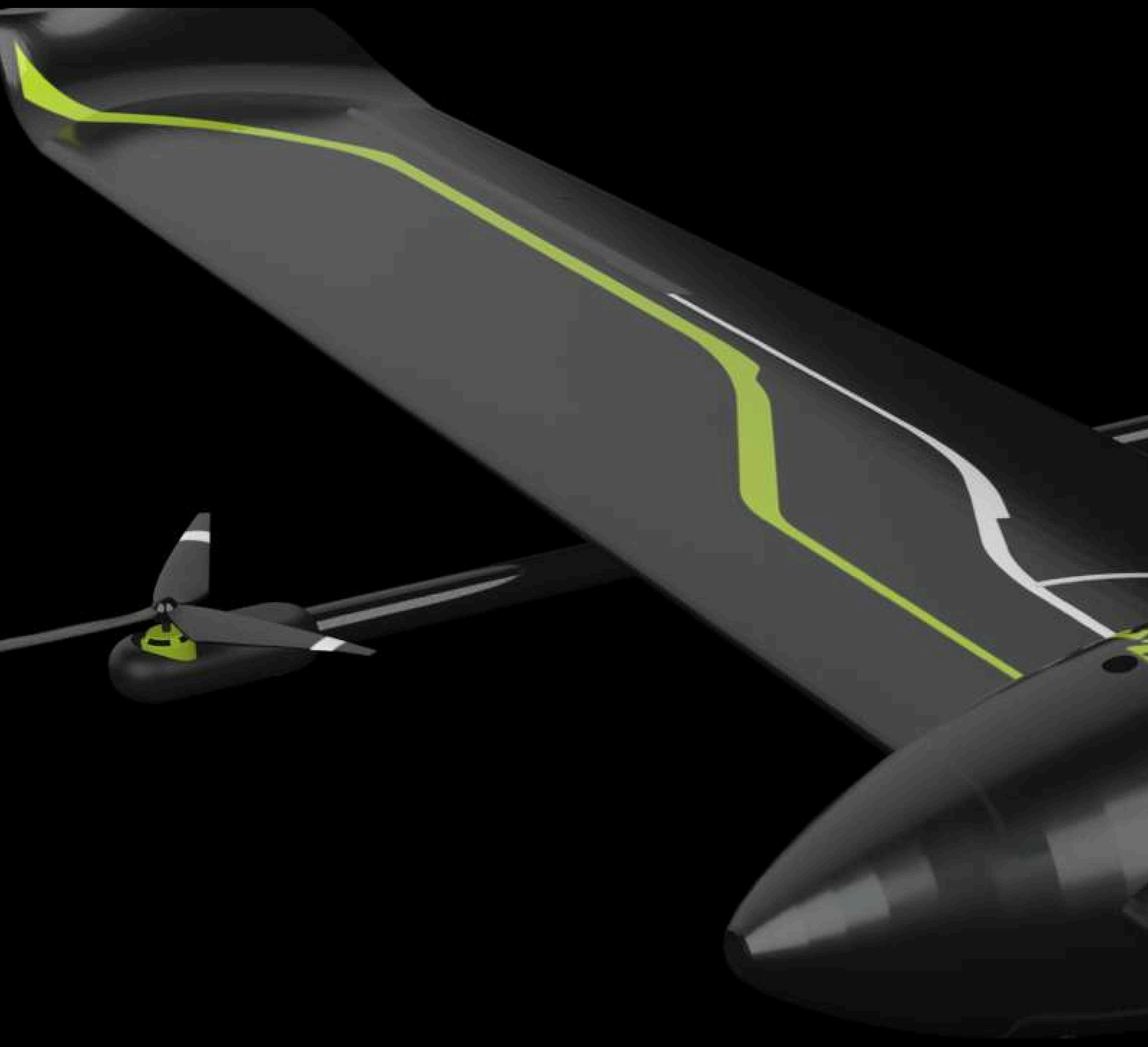
Flight that sees. Maps that matter.



NIKA: ATLAS

60.003 Product Design Studio

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Mission:
Total Terrain Mapping

Our mission

Project Description

Fixed-wing drones usually need a runway, catapult launcher or a specialized mechanism for takeoff and landing. This design limitation is compensated by their aerodynamic shape and wings for sustained flight.

Quadcopters, by contrast, can take off and land vertically (VTOL), making them more versatile in confined areas.

Due to each of their limitations, we have to use 2 types of drones for different purposes but it will be great if we can have hybrid drones that combine the benefits of both designs, such as a Vertical Take-Off and Landing (VTOL) fixed-wing drones. These drones can take off and land vertically like quadcopters but transition to fixed-wing flight for greater efficiency and range.

About our Partner Company

Nika Planet is a Singapore-based spatial computing company that specialises in large-scale geospatial data processing, particularly for nature-based climate solutions. The company's platform leverages a proprietary serverless architecture, allowing users to process massive datasets, from 100 GB to 10 TB, without long-term contracts. This enables cost-effective, scalable solutions for analysing and managing spatial data.

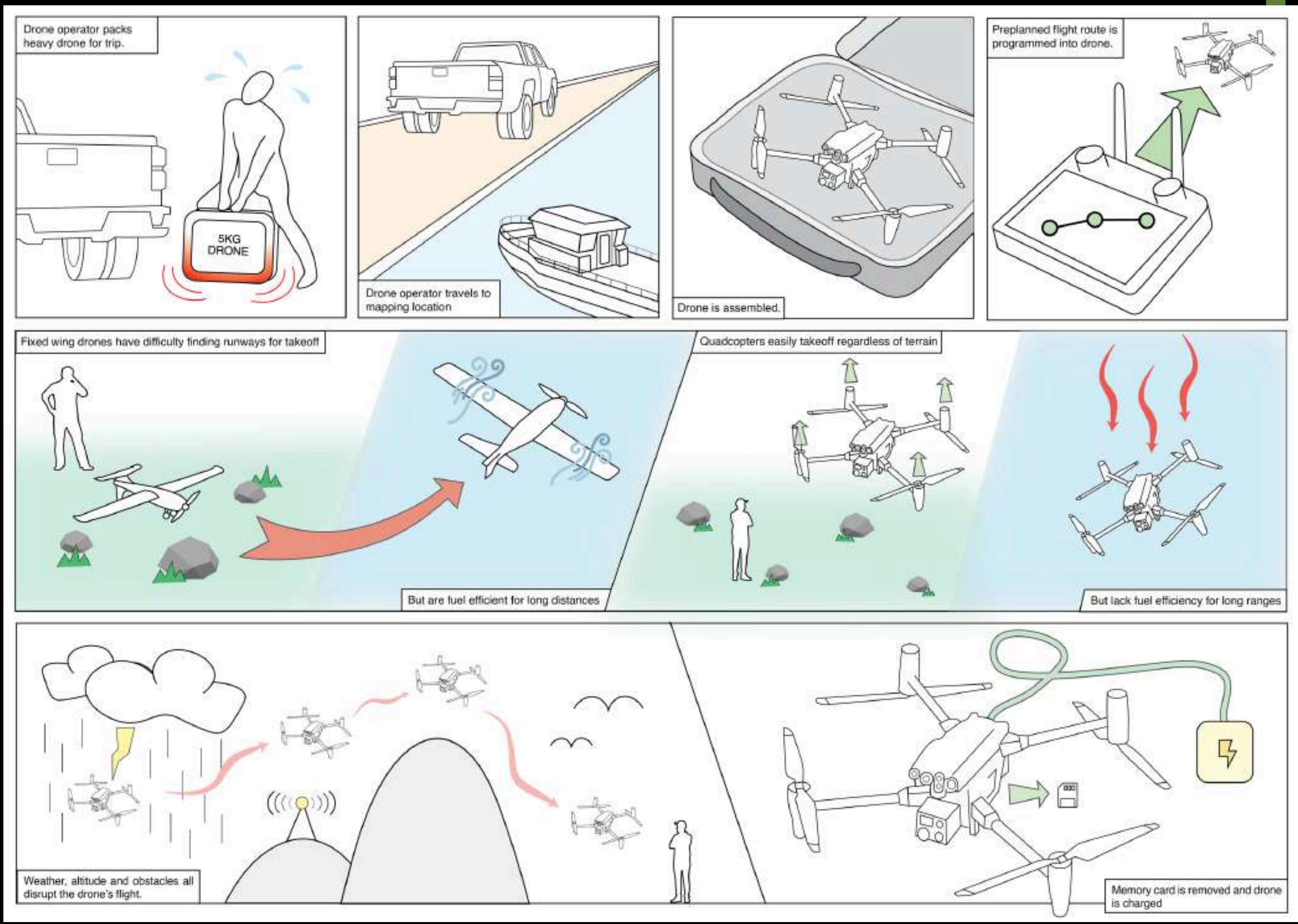
Focused on the full lifecycle of carbon offset projects, NikaPlanet provides services including pre-feasibility assessments, feasibility studies, and project design. Their tools integrate AI, remote sensing, and geospatial analytics to support accurate carbon modelling and ensure climate projects meet critical standards for additionality, baseline, leakage, and permanence.

With a strong commitment to data quality and precision, Nika Planet empowers clients to make informed environmental and business decisions through advanced spatial intelligence.

Redefined Problem Statement

How might we increase flight duration, while ensuring ease of launching and landing as well as portability for efficient geospatial data collection?

Geospatial mapping



We set out to craft a solution that fuses the benefits of VTOL and fixed-wing flight to maximise efficiency and range to collect geospatial data.

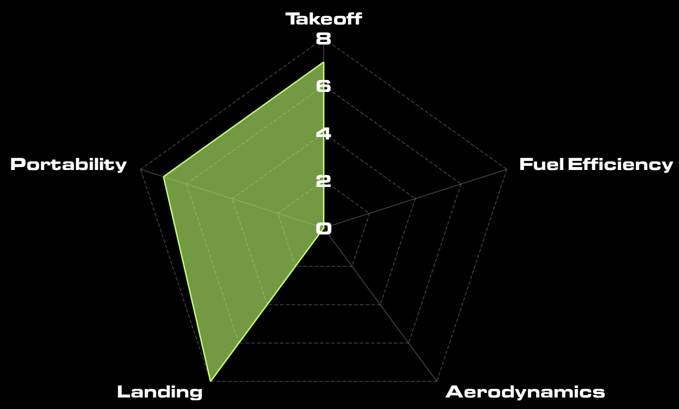
What does geospatial data collection look like today?

The mission starts with the drone operator lugging a heavy drone for the trip. Next, he drives, or even sails, to the target mapping location. Afterwards, the operator assembles the drone and preprograms its flight path before activating the drone.

Fixed-wing drones have difficulty taking off due to runway restrictions but can fly long distances. Quadcopters, on the other hand, can take off with ease anywhere but are power hungry and unable to fly for long.

Both drones may also experience difficulties traversing terrain due to weather, and at the end of the mission, the memory card is removed for processing, and the drone is charged

Baseline Technology



Before we could innovate, we needed to understand what's already working — and what's not.

So we studied one of the most respected industry drones out there: the DJI M30T. It is widely used in inspection, mapping, and public safety, and for good reason.

Flight statistics

Dimensions
Length: 470mm
Width: 585mm
Height: 215mm

Max Horizontal Speed
23m/s

Max Hover Time
36 min

Weight
3770g

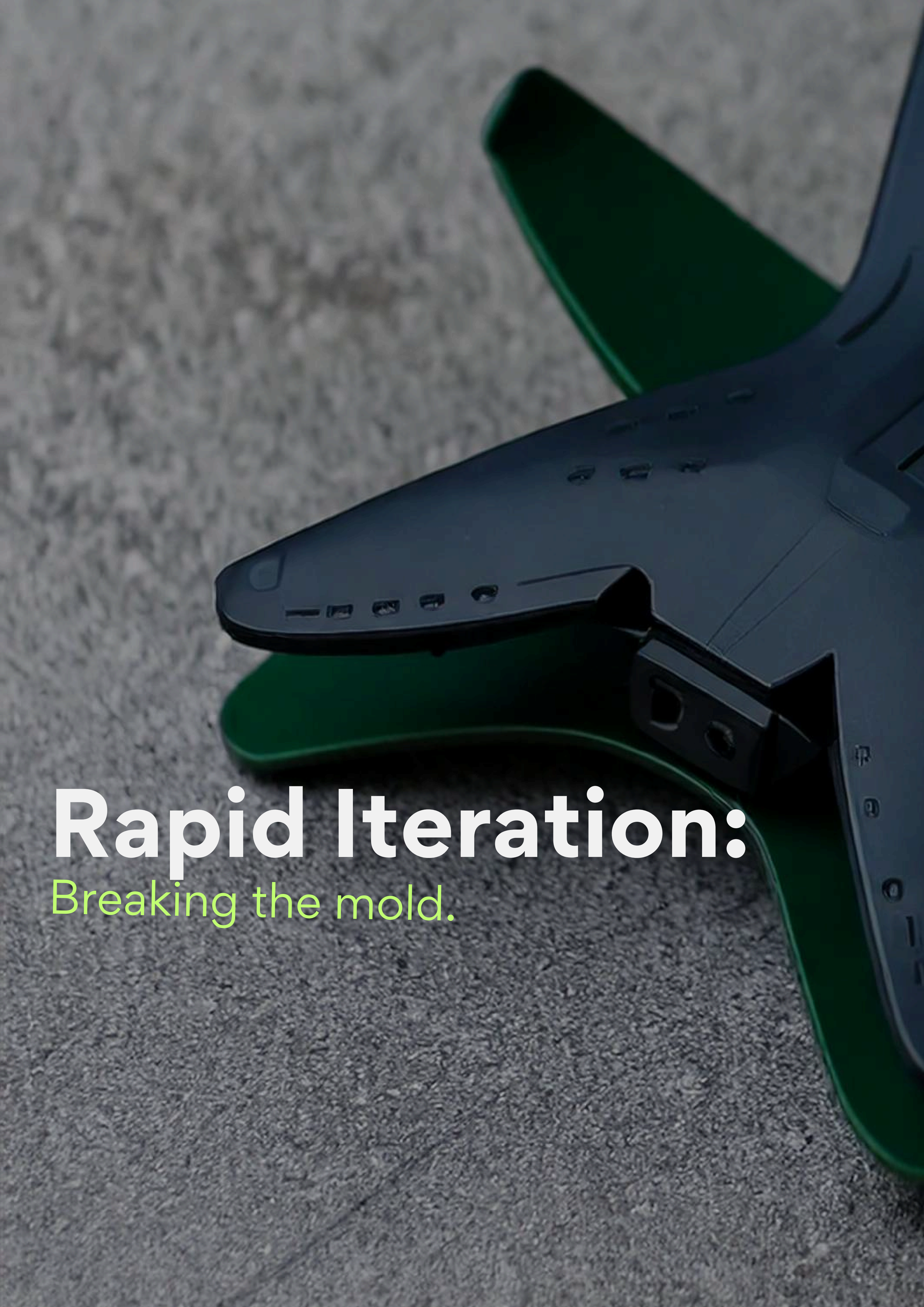
Max Takeoff Weight
4069g

Max Flight Time
41 min

Max Angular Velocity
Pitch: 150°/sec
Yaw: 100°/sec

Max Pitch Angle
35°

Hovering Accuracy
Vertical: ±0.1m
Horizontal: ±0.3m

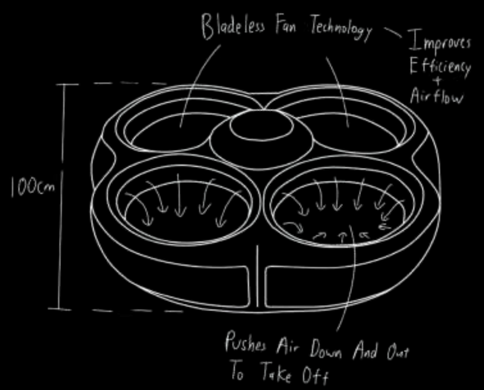


Rapid Iteration:

Breaking the mold.

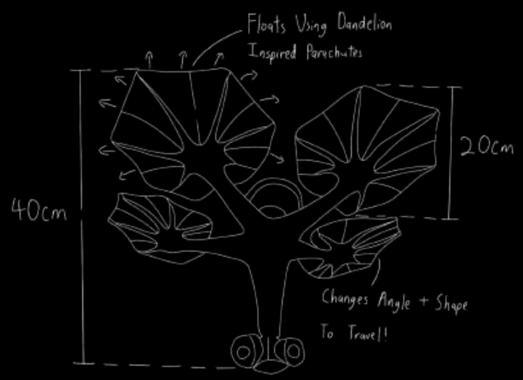
Rapid Iteration Phase

To thoroughly interrogate the design space and break free from default engineering assumptions, we engaged in a process of rapid iteration, producing a suite of speculative mobility concepts that each explored distinct strategies for autonomous locomotion, deployment, and environmental adaptability. This phase prioritised breadth over fidelity, embracing imaginative leaps and provocative configurations in order to surface novel ideas unconstrained by premature optimisation. The resulting sketches include everything from flapping-wing drones inspired by avian morphology to vertical takeoff systems propelled by miniature rockets to amphibious vehicles capable of hydrographic survey missions. These concepts were intentionally diverse in both form and scale, allowing us to stretch the boundaries of what was technologically plausible while remaining grounded in potential field applications.



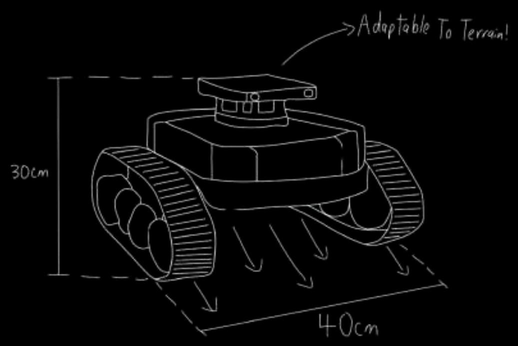
Dyson Drifter

A bladeless VTOL aircraft utilising circular fan technology to enhance lift efficiency and airflow. Its 100 cm footprint ensures stable hovering without exposed rotors.



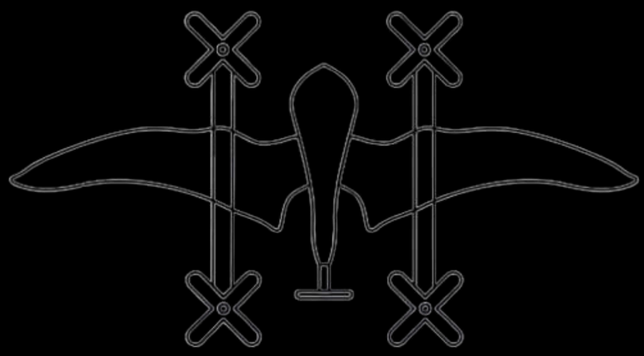
Aeroseed

Modeled after dandelion seeds, this ultra-lightweight craft floats and drifts using passive wind forces. It adapts its shape mid-air to control direction and descent.



Pathfinder Mini

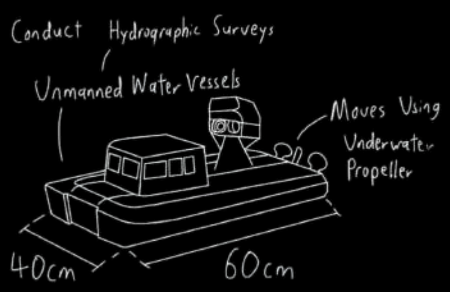
A terrain-adaptive crawler with high mobility and a low-profile design. Built for ground-level exploration with an elevated sensor suite for navigation and mapping.



Aeroscreech

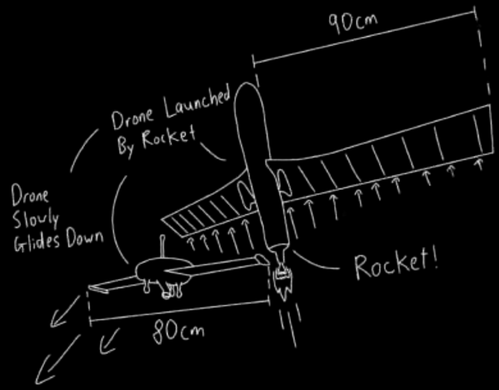
This fixed-wing VTOL aircraft features dual vertical propeller arrays and a bat-like design. Its hybrid lift and thrust system enables stable hovering and efficient forward flight.

Rapid Iteration Phase



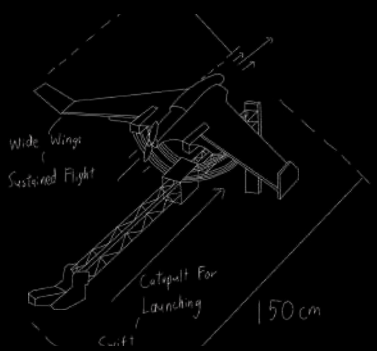
Auto Lander

An unmanned water vessel designed for hydrographic surveys, powered by an underwater propeller system. Its compact 60x40 cm frame allows for autonomous riverine or coastal deployment.



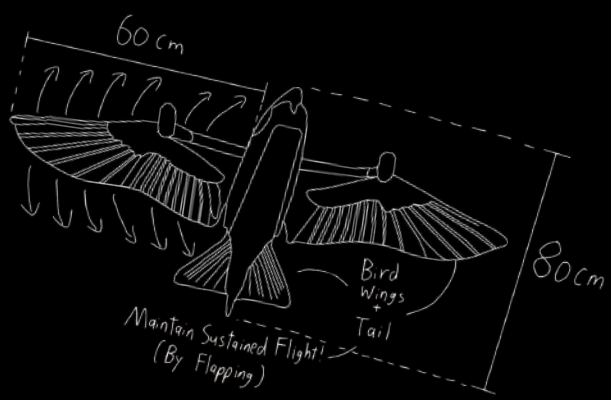
Rocket V-TOL

A hybrid launch platform where drones are propelled by rocket boosters and glide down for aerial mapping. This enables vertical takeoff in space-constrained environments.



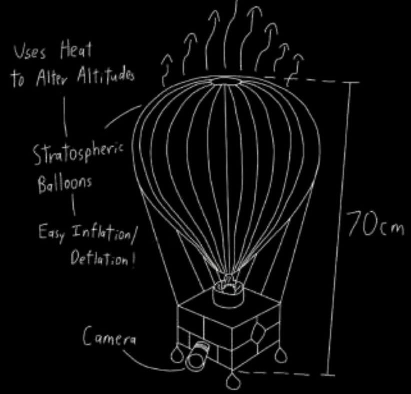
Fixed-Wing Catapulter

This 150 cm launch rail system uses a mechanical catapult to accelerate fixed-wing UAVs into flight. Ideal for achieving rapid deployment and long-range missions.



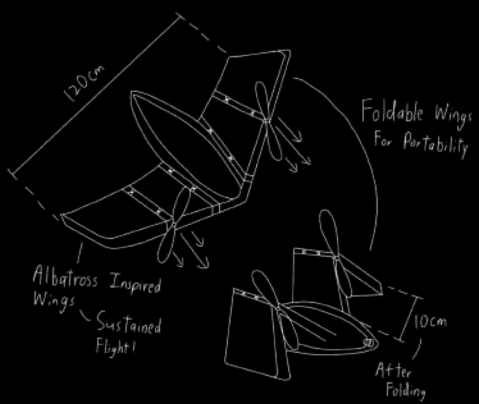
Fixed-Wing Adapter

Inspired by avian biology, this modular system uses bird-like flapping wings and a tail to maintain flight. It blends natural aerodynamics with robotic precision.



Hot Drifter

A stratospheric balloon concept that uses thermal control to change altitude dynamically.

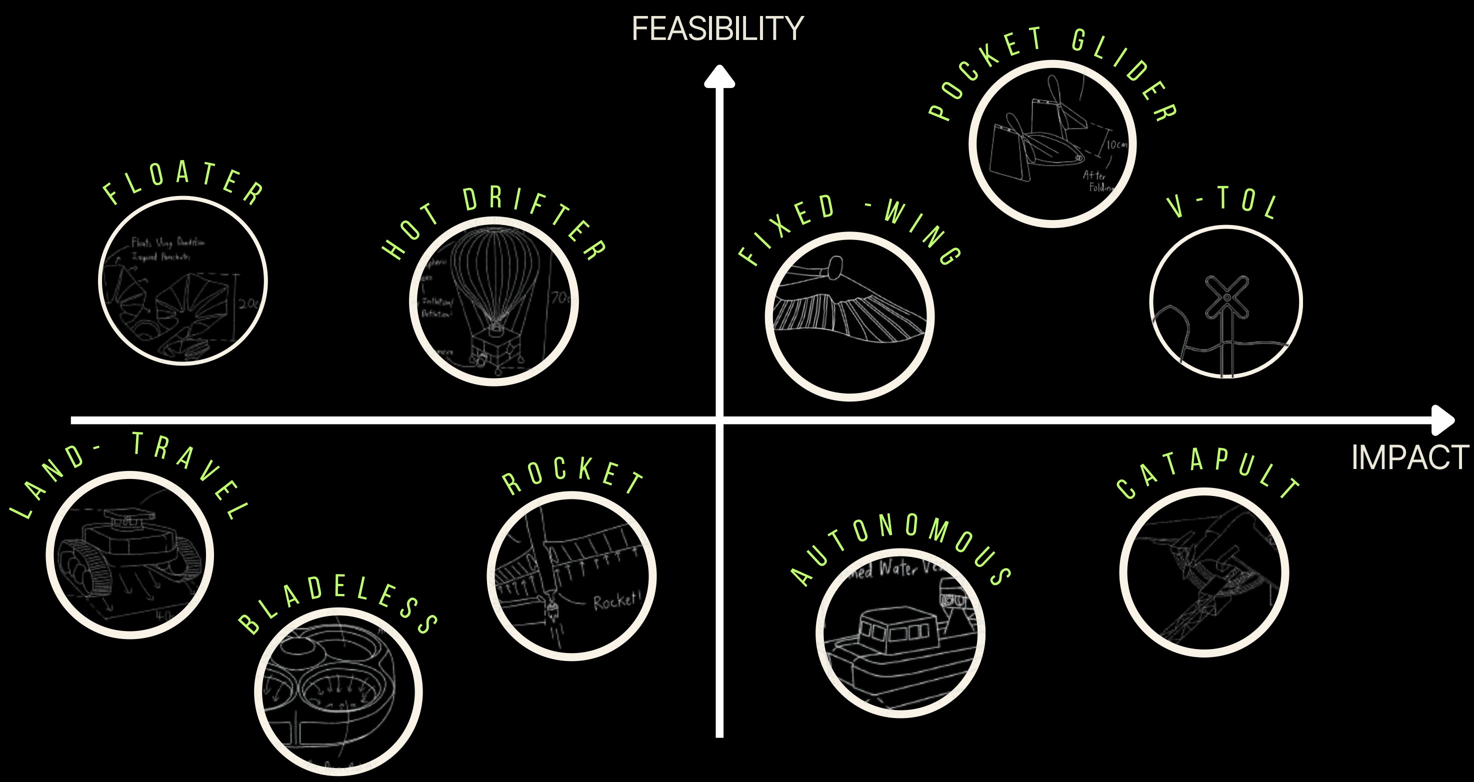


Pocket Glider

An albatross-inspired glider with foldable wings for compact storage and portability. Once deployed, it achieves sustained flight with minimal thrust requirements.

Evaluating Iterations

Each concept was assessed based on feasibility and potential impact. While some ideas pushed creative boundaries, only those that balanced technical viability with meaningful geospatial utility advanced. The Pocket Glider and VTOL emerged as top candidates, blending endurance, deployability, and range.

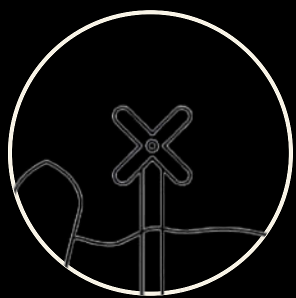


Winning features

The final design combines the extended range of fixed-wing flight, the versatility of VTOL, and the portability of compact formats—maximizing performance across diverse terrain and mission needs.

FIXED WING FLIGHT

Enables long-range travel with minimal energy consumption.



VTOL

Offers agile vertical take-off and landing in constrained spaces.

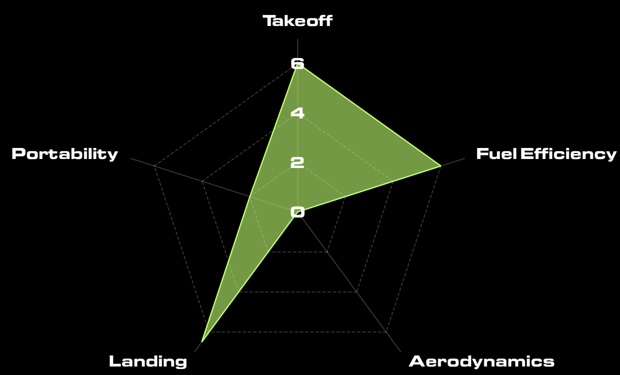
COMPACT TRAVEL

Foldable form ensures easy transport and rapid deployment.

The First Iteration

AetherPlate

Being inspired by the sugar glider, our team ideated an open plate “sandwich” drone, which has less weight compared to a traditional enclosed drone and allows for easy access to internal components for interchangeability. The plates themselves could also be changed to adapt to suit the different terrain requirements.



Adaptive plate materials

Our team explored different materials for the plates, which ultimately helped us in deciding the most suitable material for our final prototype. Each different material was meant for a different “mode” of the AetherPlate. For example, the ABS Matte finish plates were meant for stealth mode.


ABS Matte finish


ABS spray finish


Lightweight PLA


Balsa wood


Stainless steel


Carbon Fibre

While our first iteration delivered on the takeoff and landing aspects, it ultimately traded the aerodynamics needed for long-range flight for customisability. Moving forward, we aimed to develop a single optimised build that covered more ground.

Form Finding

Sketch first, Simulate later

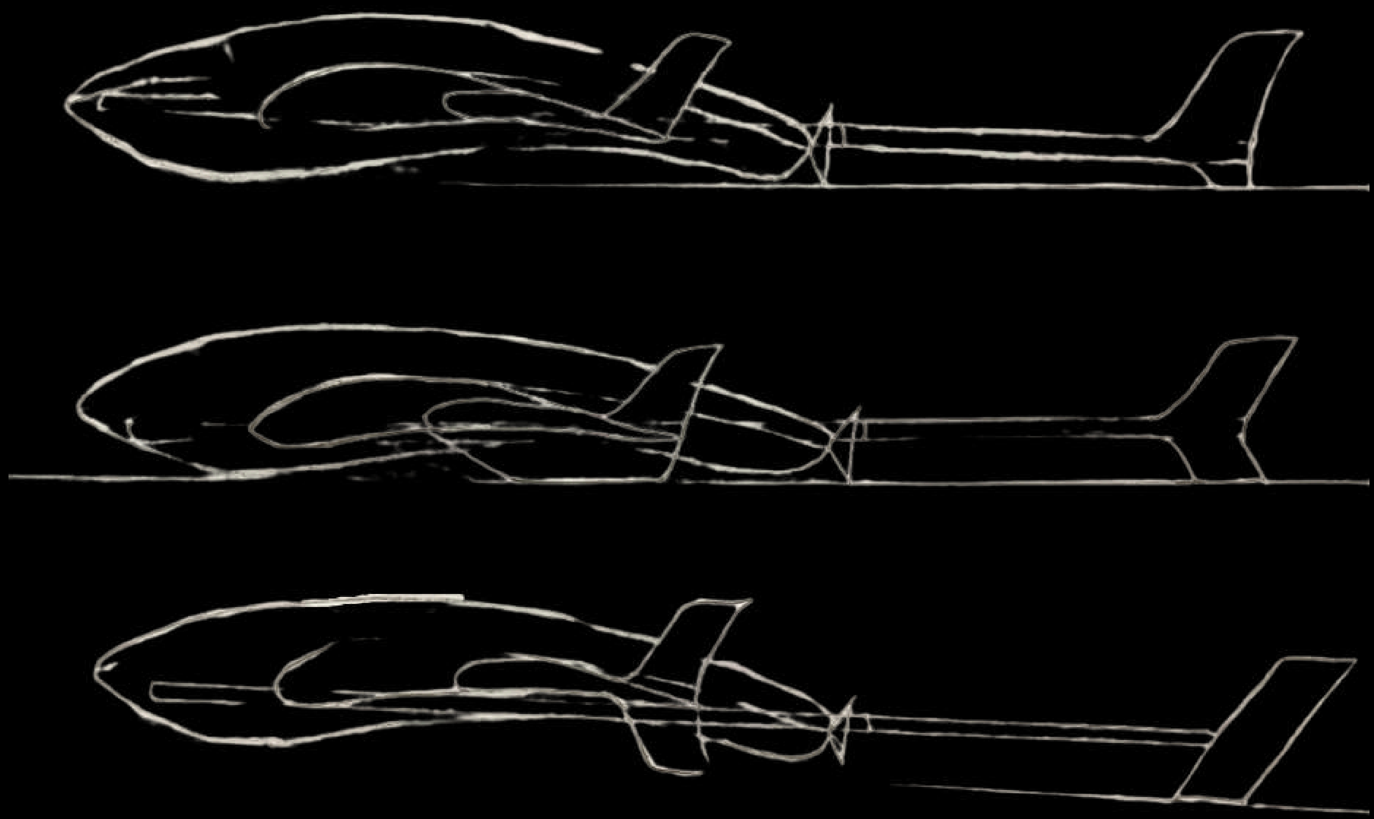
Form Finding

With aerodynamics in mind, our team set out to develop a streamlined speed form that we could sculpt according to our needs.

The form-finding process was fundamentally an iterative one. To find the right shape, our team studied different aerodynamic forms to gain inspiration. Chief among them was the flying fish. Our team was deeply inspired by its ability to seamlessly transition between mediums - gliding through air and water with natural efficiency and grace. This translated well to our narrative, with the Nika Atlas being launched from ships at sea.

As such, our fuselage followed the natural streamline curvature with a break at the sides to form a clean profile. We also chose to have the tail of the fuselage curve down, forming two natural touch points with the ground. Then we experimented with different thickness and roundness at different points to communicate bulk or speed.

Landing Flat



With the fuselage defined, it was time to design the corresponding landing mechanisms.

The two touchpoints alone were insufficient for a proper landing. Given the wingspan of any fixed-wing drone, wing support was definitely needed. Additionally, the tail itself provided two touch points that extended from the structure supporting the spoiler-like form. Our first iterations, as seen above, were derived from whale tails and shark fins, creating a highly stylised shape. We then narrowed down the shapes to those that could be constructed from airfoil profiles. This originally presented us with the rather primitive table-like shape in the sketches below. To minimise drag, we scaled down the same airfoils and lofted them to form a more defined asymmetric V-shape.

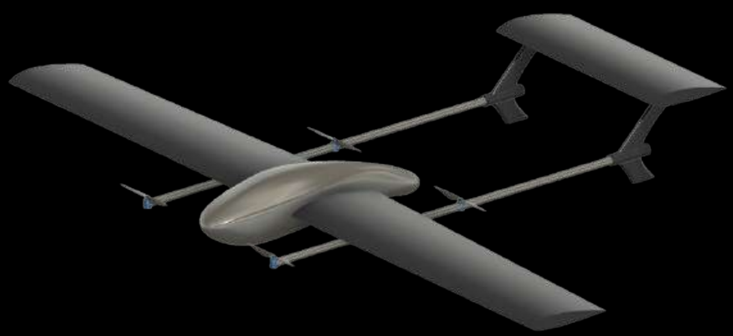
Developed Form

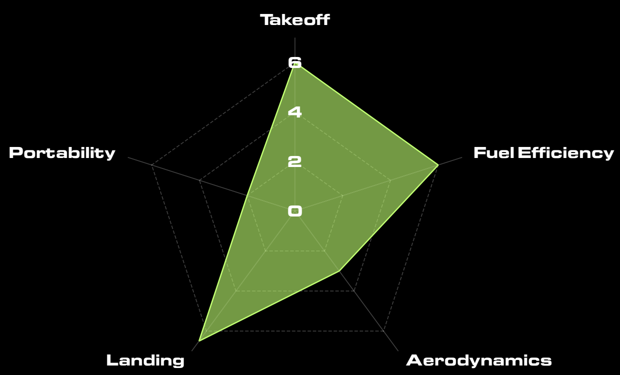
The power of sketch

Through sketching, our team was able to express our ideas about how the physical prototype should look. Through this iteration, our team gained the confidence to sketch out our ideas to visually communicate the form and mechanisms we wanted in future iterations.

SkyFin VX

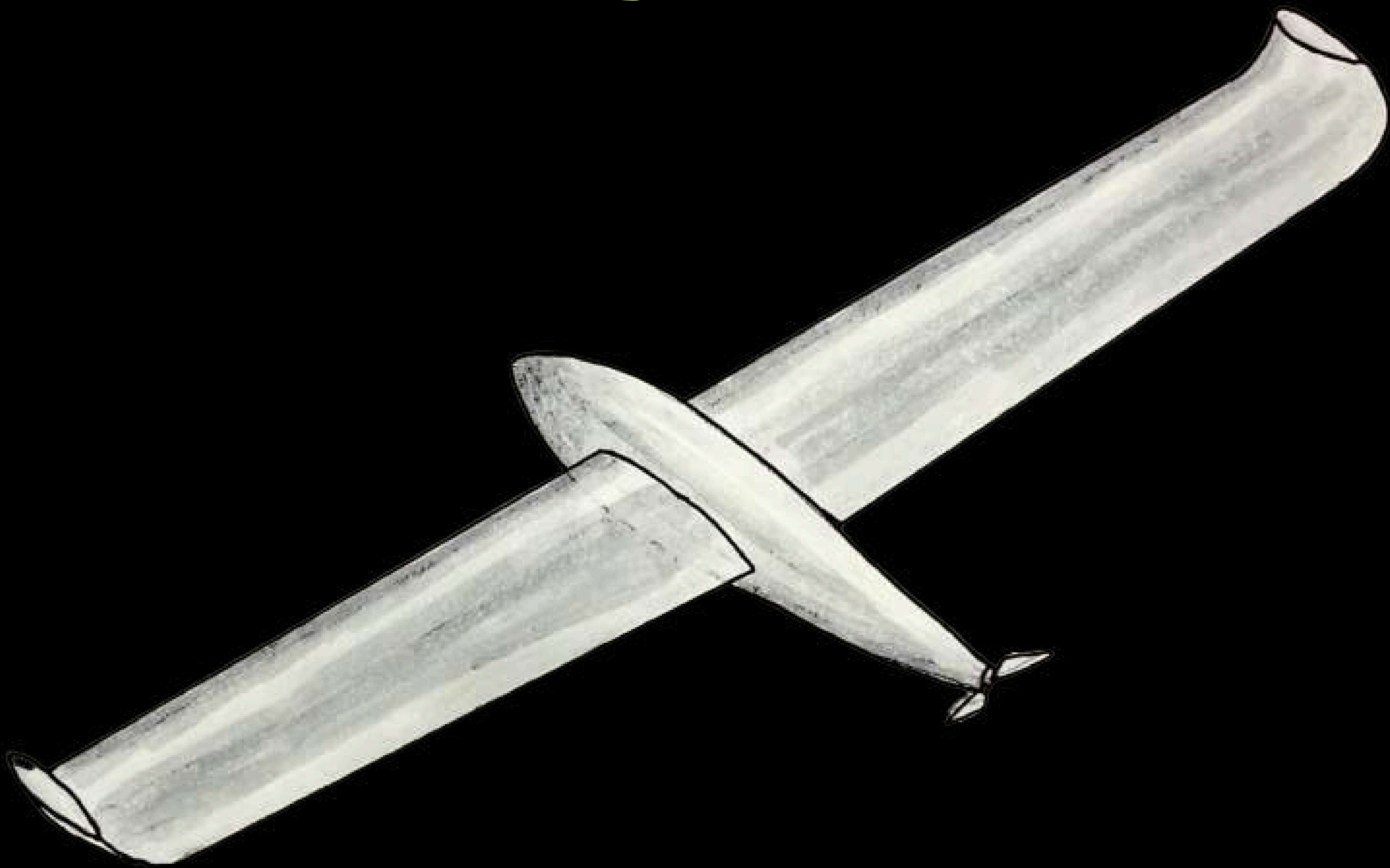
The Skyfin served as an important milestone in our drone development as it served as the basis for our final iteration. In this drone, we used a proper airfoil and wing twist to ensure sufficient lift and stability. More importantly, its form was a step in the right direction, as it had much better aerodynamics than the Aetherplate.



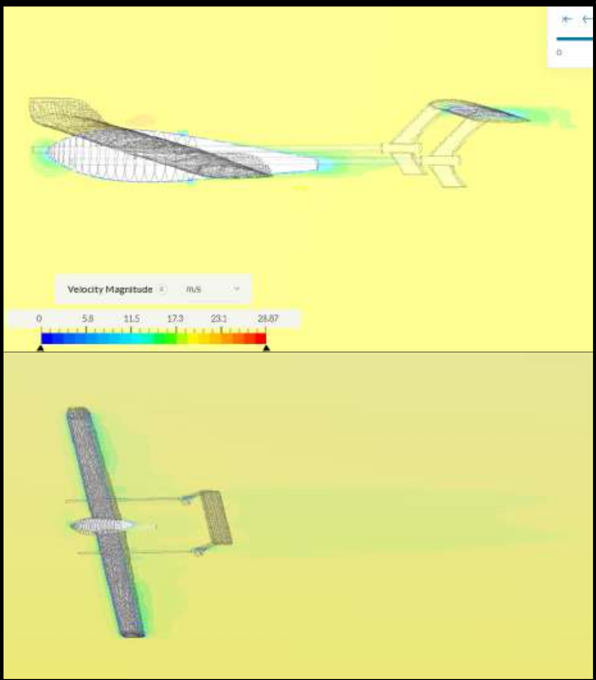


While the SkyFin has successfully incorporated the VTOL to fixed-wing transition, delivering on the launching, landing, and fuel efficiency, there is still much to be desired in terms of its portability and aerodynamics. Thus, we pressed on to make quantifiable improvements in these aspects.

New Fuselage



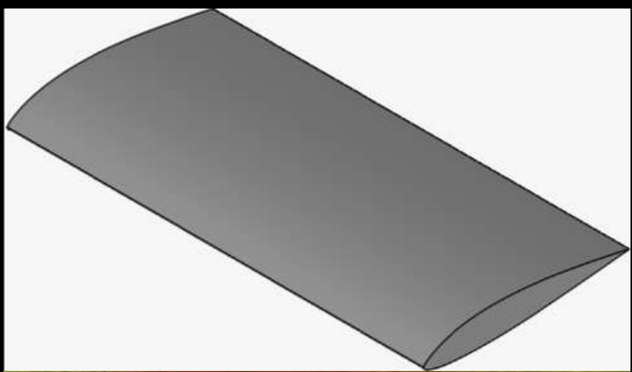
With the fuselage defined, it was time to design the corresponding landing mechanisms.

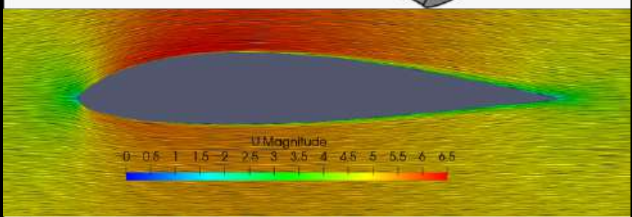


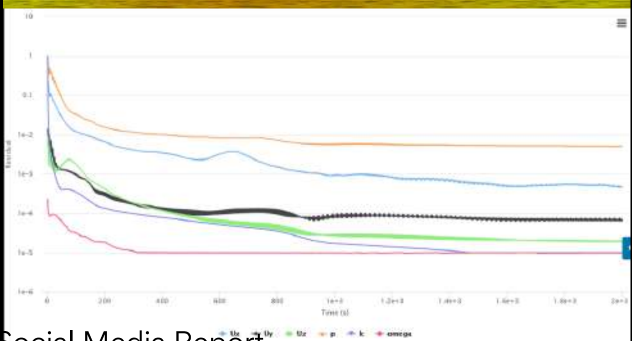
After consulting industry experts, we quickly realised that simple airfoil-inspired forms would beat out the bulky stylised fuselage of the SkyFin. With this, we quickly sketched out a teardrop-shaped fuselage which would generate less drag according to Bernoulli's principle. To quantify the improvements of our changes, we carried out a Computational Fluid Dynamics (CFD) analysis of our current form. The results on the left indicate a smoother airflow with the velocity magnitude trailing more narrowly behind the fuselage. This is a huge improvement over the large wake produced by the previous SkyFin model. The glaring issue now is that the spoiler-shaped tail generates a more than proportionate wake.

Gemini II Airfoil

The most crucial component of a fixed-wing drone is its wings. Using an established airfoil ensures our wings have the right metrics for our drone to fly.





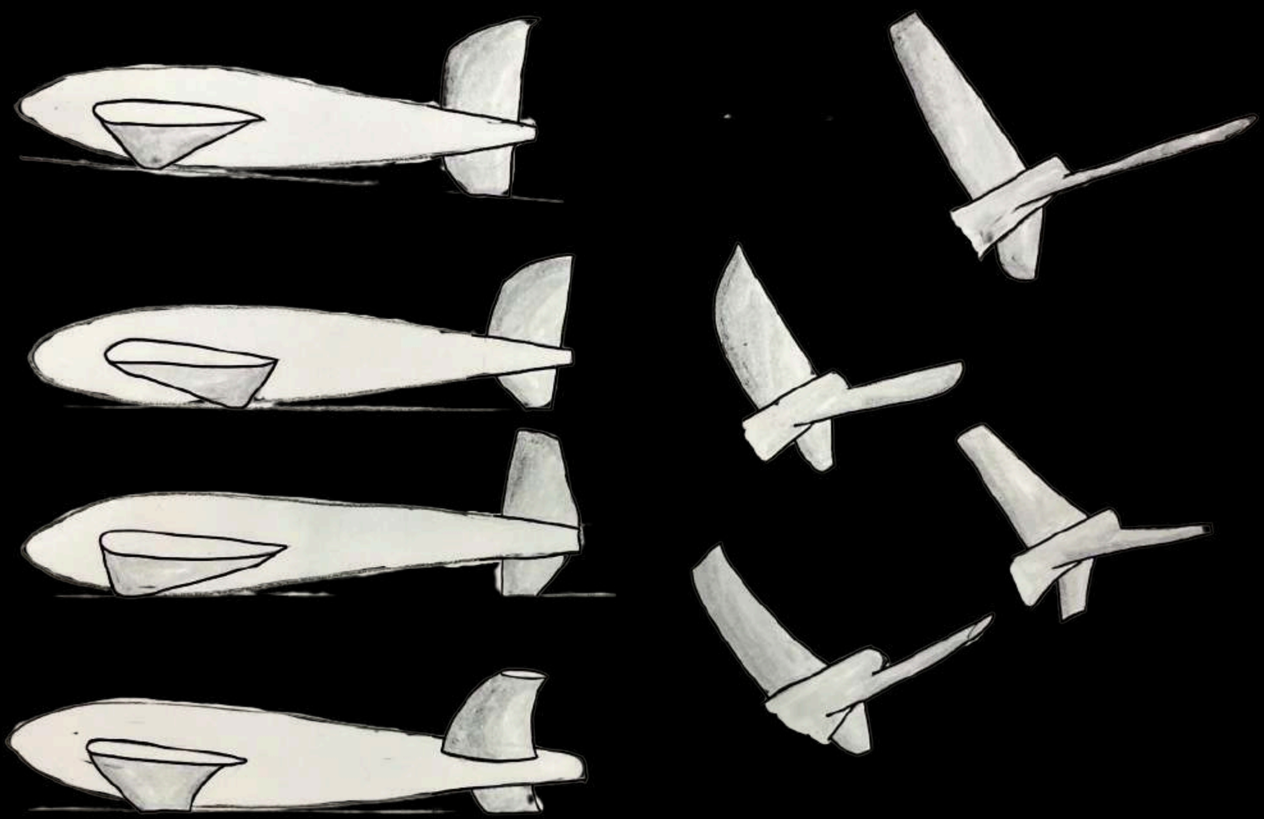


The Gemini II Airfoil has a high lift-to-drag ratio of 75.98 according to the CFD analysis, which indicates excellent aerodynamic efficiency. The velocity contour as seen on the left shows a clean flow with minimal wake, reducing drag and improving energy efficiency. The research simulation was carried out at 5 m/s and validated at a Reynolds number of 1,000,000. Thus, it performs well in conditions typical of small to mid-sized drones.

We then added wing twist, which is when the airfoil at the wing tip is rotated from the airfoil at the wing root. Doing so reduces wingtip vortex and drag, improving lateral stability.

A blended winglet with a generous arc was added to reduce wingtip vortices. Having a generous arc at the intersection reduces pressure peaks and local airspeeds. Together, airflow is kept smooth, reducing turbulence.

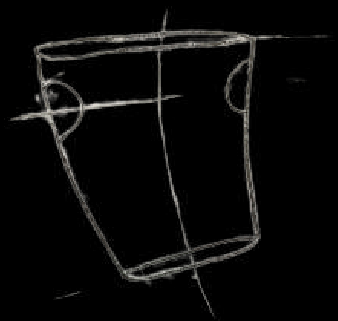
The Y-tail

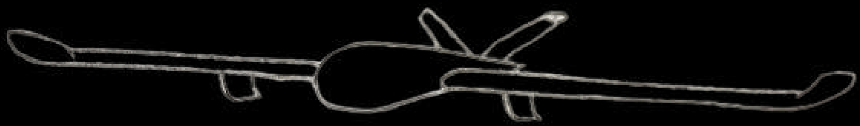


Since the tail was identified as the problem in the SimScale simulation, it was time to rethink its form and function.

The function of the tail was to provide a lift-generating surface while generating stabilising moments for the drone. After much research, we found that Y-tails for drones not only weigh less but also provide less drag interference. Compared to traditional V-tails, Y-tails offer improved control authority by separating the vertical and horizontal stabilising components, which can simplify control surface actuation and improve stability in both pitch and yaw axes. Similar to the original tail, the bottom rudder also provides a landing surface for a safe and stable landing. As seen above, we initially went for shape profiles that resembled propellers on ships before deciding that it clashed with the streamlined shape of our fuselage. As such, we returned to our initial inspiration and chose a more fin-like structure.

New Legs

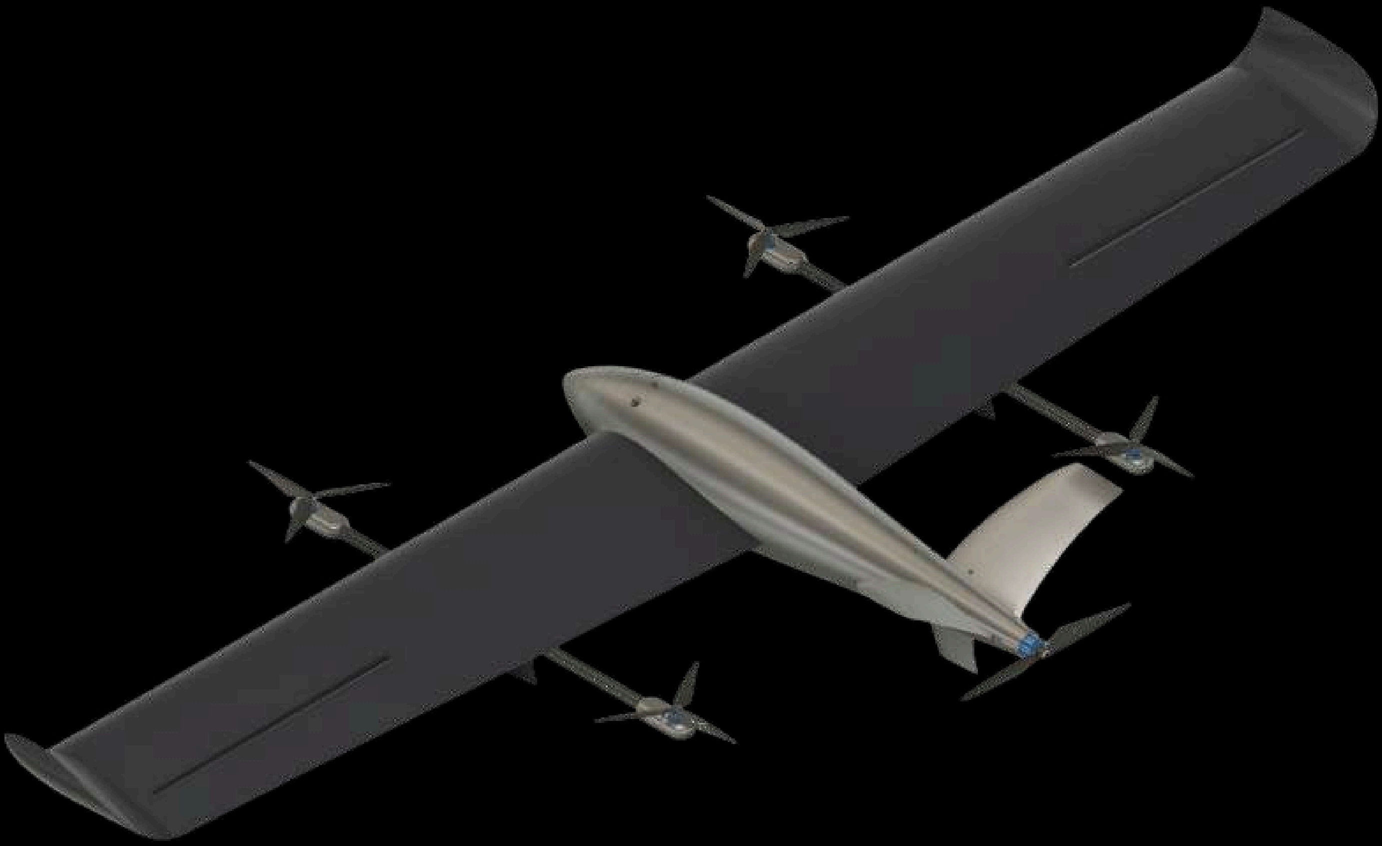


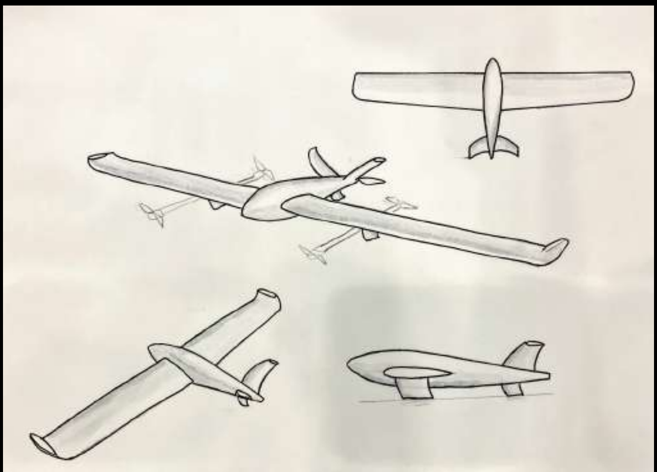


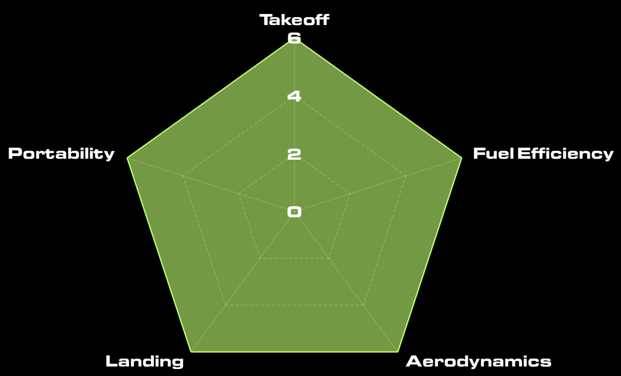
With the general shape of the main body and wings determined, it was time to make it stand.

As shown on the left, the original boom mount we referenced from the Super Stingray was not aerodynamic and could not provide landing support. To change this, we used the symmetric airfoil NACA 0012, which is a proven airfoil shape which provided minimal drag interference. We initially went for a symmetrical converging shape before deciding that it was too stubby to match the sleek form of the rest of the craft. To modify this, we sampled the fin-like curvature of the tail to achieve a sharp and coherent structure. We then added the rod and screw holes, which enabled the VTOL structure to be mounted and secured.

Final Form







Nika Atlas

After all of the research and prototyping, we finally arrived at the final iteration of the drone. With both VTOL and fixed-wing capabilities, this drone excels in fuel efficiency and takeoff and landing. Its aerodynamics builds upon established research on airfoils and leverages its form to reduce turbulence. All in all, its performance reflects a careful balance between innovation and proven aerodynamic principles.

Because it is assembled from distinct, individual components, it creates the capacity for it to be modular. Being modular is a crucial aspect of its viability, given that its 1.8m long wingspan would prove difficult in transport. Thus, being modular would enable it to be disassembled and fitted into a check-in luggage, which can be easily transported.

The Atlas, Delivered

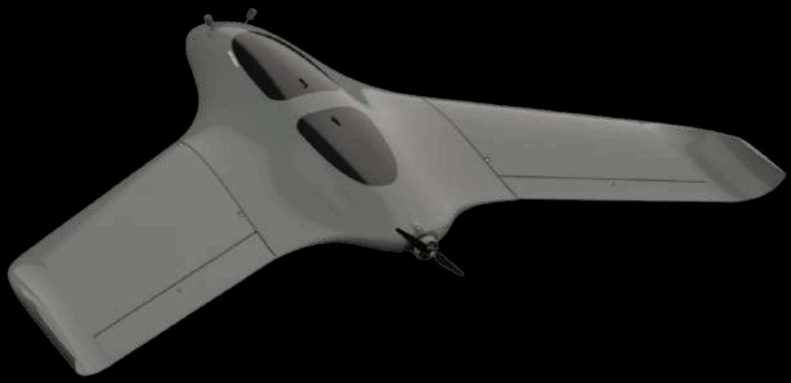
The final build. All or nothing.

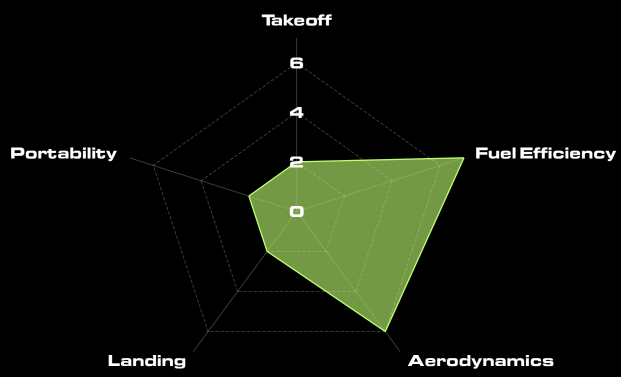
Key reference

Here's a successful commercial model that paralleled our requirements

Super Stingray

The Super Stingray, developed by Flightory, is our ideal reference since it was designed for long-range flight, with a flight time of ~3 hrs. Being similar in scale and function, its equipment list also proved to be a useful reference. Lastly, its body was entirely 3D printed, making it modular and manufacturable.





Our take aways

As explained subsequently, we adapted the Super Stingray and improved upon it to better suit the Nika Atlas.

Circuitry & components

Modularity & Manufacturability

Assembly Mechanisms

Circuitry & Components

Components Used

The components can be categorised into 6 groups: controllers, transmitters, sensors, cameras, motors and the power supply.

Controllers

The drone's flight control system is built around two key components: the flight controller and the electronic speed controller (ESC). The primary flight controller used is the Mateksys F405 VTOL (Fig. 1), which serves as the central hub for processing flight data and managing communication between onboard components. It directly interfaces with most subsystems, such as sensors, cameras, and telemetry modules, except for the propulsion system, which is handled separately.

The propulsion system is managed by a TBS Lucid Gorilla 4-in-1 Electronic Speed Controller (ESC) (Fig. 2). This unit is responsible for regulating and distributing power to the four VTOL motors, while also handling real-time signal transmission to ensure synchronized motor operation during both vertical take-off / landing and horizontal flight modes.

The Mateksys F405 VTOL flight controller consists of two stacked circuit boards, both of which are utilized to manage the complex wiring and connectivity demands of a hybrid VTOL-fixed wing platform (Fig. 3 & 4).

Fig. 1 Mateksys F405 VTOL Flight Controller

Fig. 2 TBS Lucid 60A 3-6S AM32 4-in-1 ESC - Gorilla 39x16

Fig. 3 Flight Controller Top Circuit

Fig. 4 Flight Controller Bottom Circuit

Motors

The propulsion system of the hybrid VTOL-fixed wing drone comprises multiple types of motors, each serving a specific function across different flight phases. For vertical take-off and landing (VTOL) operations, the drone is equipped with four brushless DC motors (Fig. 5) arranged in a quadcopter configuration, providing stable and responsive vertical thrust.

Fixed-wing flight is enabled by a single rear-mounted brushless motor (Fig. 6), which propels the drone forward during horizontal flight. Additionally, two servo motors (Fig. 7) are used to actuate the ailerons, allowing for roll control and enhanced maneuverability during fixed-wing mode.

Fig. 5 T-Motor Velox 2808 Brushless (VTOL) Motor

Fig. 6 T-Motor AT2317 Fixed Wing Brushless Motor

Fig. 7 EMax ES08MA II Servo Motor

Circuitry & Components

Sensors

To support stable autonomous flight while maintaining a lightweight design, the drone integrates only two essential sensors, carefully selected to align with its geospatial mapping focus.

The first is an Airspeed Sensor (Fig. 8), which measures the dynamic pressure of air flowing over the aircraft. This data allows the flight controller to estimate indicated and true airspeed, which is critical for stall detection, precise altitude control, and optimized automatic landing sequences.

The second is a combined Global Navigation Satellite System (GNSS) module and compass (Fig. 9). This sensor provides accurate positional data, enabling reliable navigation, waypoint tracking, and autonomous launch and recovery operations.

By minimizing the number of onboard sensors, the design prioritizes payload efficiency while retaining the core functionality needed for precise and stable flight in mapping missions.

Fig. 8 Mateksys AS-DVLR-I2C

Fig. 9 Mateksys GNSS & Compass M10Q-5883

Cameras

The prototype drone is equipped with two onboard cameras, each serving a distinct function in support of its geospatial mapping role and operational safety.

The primary camera is a GoPro Hero 3 (Fig. 10), used as a stand-in for the intended Livox Mid-360 oblique LiDAR sensor, which is specialized for spatial data acquisition. To reduce overall weight and integrate it into the drone's power system, the GoPro has been modified by removing its external casing and internal battery. It is powered directly via the flight controller to maintain a compact, lightweight form factor suitable for flight testing.

Complementing this is the Caddx Ratel 2 FPV (First Person View) camera (Fig. 11), which provides a real-time video feed for the drone operator. This camera enhances situational awareness and enables manual intervention if required, allowing the pilot to momentarily assume control to avoid hazards or respond to unexpected conditions during autonomous missions.

Fig. 10 GoPro Hero 3

Fig. 11 Caddx Ratel 2

Circuitry & Components

Transmitters

The drone utilizes multiple transmission systems to enable real-time communication with external devices and ensure operational control during flight.

The primary communication link is established through a telemetry radio module (Fig. 12), equipped with a screw-in antenna. This module communicates with its paired counterpart connected to a ground-based computer, transmitting real-time flight data and system diagnostics. This telemetry link allows for live monitoring, mission planning, and in-flight parameter adjustments.

For visual feedback, a dedicated video transmitter (Fig. 13), also featuring a screw-in antenna, relays a live feed from the onboard First Person View (FPV) camera to an external display. This provides situational awareness during manual or assisted flight operations.

In addition, the drone is equipped with an ExpressLRS (ELRS) receiver module (Fig. 14), which interfaces with a handheld radio transmitter used by the pilot. This serves as a manual override system for direct control in case of emergencies or system failures, ensuring an added layer of safety and reliability.

Fig. 12 Holybro SiK Telemetry Radio V3

Fig. 13 5.8GHz 40CH Digital Display FPV Video Transmitter

Fig. 14 BetaFPV ELRS Lite Receiver

Power supply

The drone's power system is centered around a 4-cell (4S) lithium polymer (LiPo) battery (Fig. 16), which serves as the primary energy source for all onboard electronics. This battery is directly connected to the flight controller, supplying power not only to the controller itself but also to all peripheral components, including sensors, transmitters, and cameras.

To ensure stable and noise-free power delivery to the propulsion system, a capacitor (Fig. 15) is soldered onto the 4-in-1 Electronic Speed Controller (ESC). This capacitor helps suppress voltage spikes and electrical noise generated during motor operation, protecting sensitive electronic components and contributing to the overall reliability and longevity of the drone's circuitry.

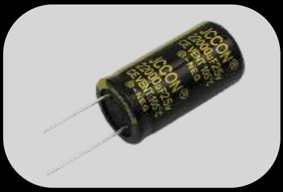
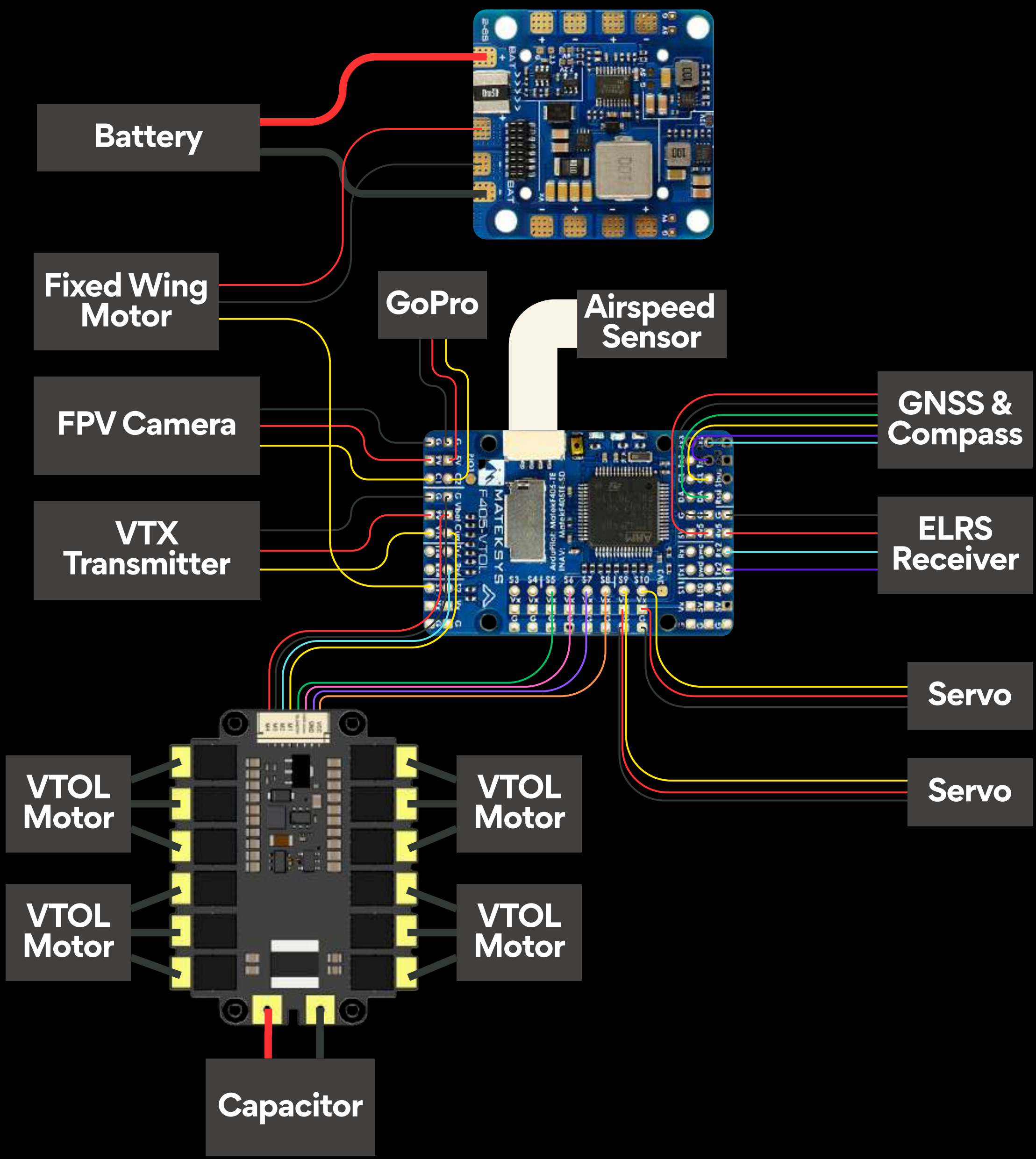


FIg. 15 Capacitor

Fig. 16 4s Battery

Circuitry & Components

Circuit for the internals of the drone



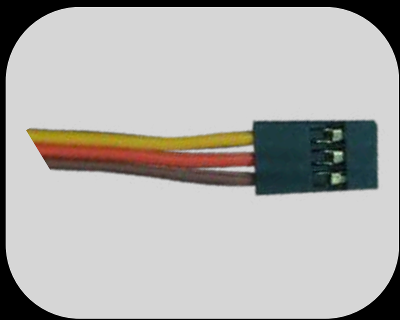
Circuitry & Components

Connectors

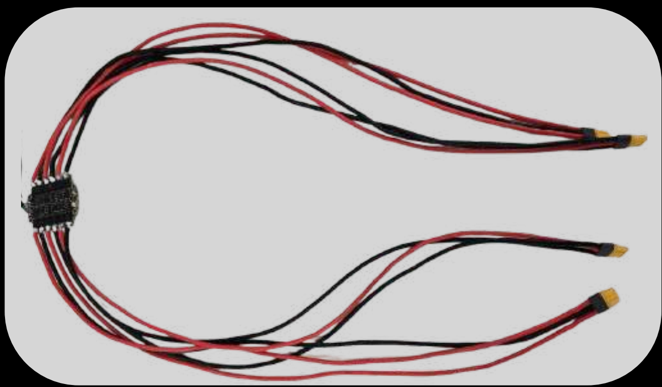
Given the drone's modular and disassemblable design, it was essential to implement detachable wiring to allow for the removal of motor mounts and wings during transport or maintenance. To facilitate this, connectors were strategically placed along key sections of the wiring harness, providing both reliable electrical connections and ease of disconnection. Sufficient wire slack was included to ensure that assembly and disassembly remain straightforward and do not strain the connectors.

Specifically, AMASS MR60 connectors were used for the battery and all brushless motors (both VTOL and fixed-wing) due to their high current rating and secure locking mechanism. For the servo motors, JR connectors were employed to interface with the standard three-pin servo terminals, ensuring compatibility and ease of use.

AMASS MR60 Connector (Male and Female)



JR Male Connector



Example of using MR60 connectors for the VTOL motor circuit

Mechanisms

Holding it together.

Overview

Since our drone has to be assembled from its modular components, it needs strong and convenient locking mechanisms that can both be assembled in five minutes and withstand the stress of flight.

VTOL Motor Mount

The reference VTOL motor mount on the far left (black) is from the Super Stingray. The Super Stingray used a 500mm carbon tube and attached the motor mount on both ends. Our initial plan was to attach another carbon tube at the end to secure our original tail design. Referencing the black model, we then iterated 2 versions of the mount for the front and the rear VTOL motors to ensure that the carbon tubes can be secured.

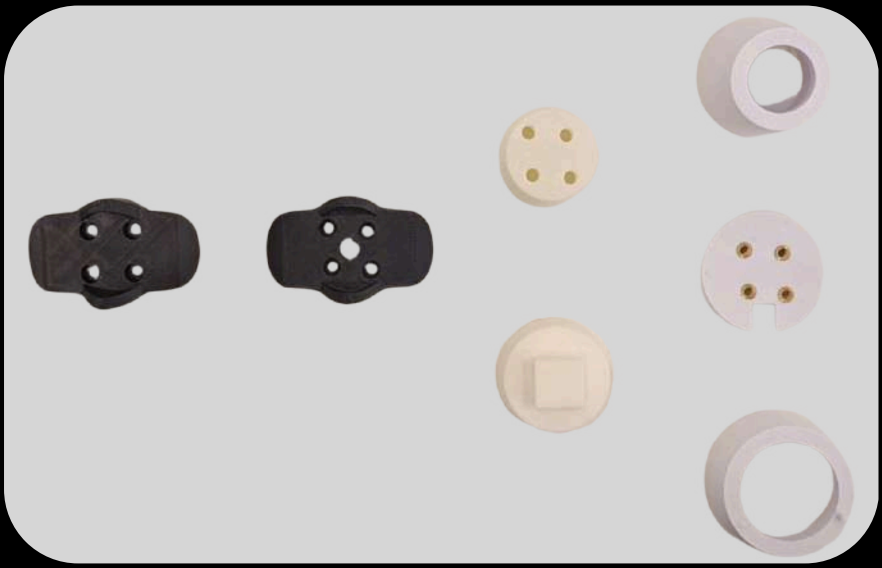
After several iterations of the tail, we have decided against adding the extra length of carbon tube as we arrive at the Y-tail design. After running several analyses on SimScale, we have come up with a more aerodynamic form factor for the motor mount *(2nd from right)*.

For this iteration, we have decided to cut a slit to secure the carbon tube *(left)*. However, due to the inflexibility of the PLA, cracks began to appear when the mount was fastened. We then iterated again using the same form factor and followed the 2-piece design from the Super Stingray Motor Mount *(middle)*. We strategically placed 3 screws to secure the 2 pieces together to reduce the weight of the motor mount in contrast to 6 screws used for the Super Stingray motor mount *(right)*.

Mechanisms

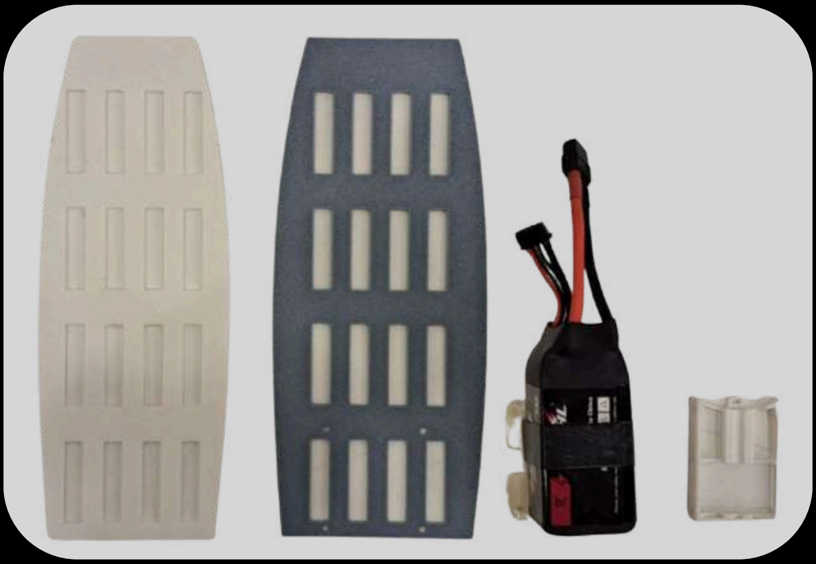
Holding it together.

Rear Motor Mount



Initially, we followed a similar attachment style to the Super Stingray rear motor mount *(far left)*, where the rear fixed-wing motor was fully exposed. However, to give the tail a more streamlined and coherent design, we decided to cover the majority of the rear motor to conceal it and only expose the shaft to attach the rear 7” propeller. This can be seen from the white models on the far right.

Battery mount



The first iteration *(on the far left)* was made from our initial hollowed-out fuselage. After trying to place the physical electronics onto this frame, we realised that firstly, there was not enough space, and secondly, the walls of the fuselage are too thick. Hence, we reduced the wall thickness from 10mm to 5mm and obtained the second iteration of the electronics frame. We also added holes to screw in the battery mount *(on the far right)* at the bottom to secure the battery firmly. This electronics frame will then be glued into the bottom of the fuselage once all the electronics have been secured.

Mechanisms

Holding it together.

Hatch latching mechanism

Referencing the Super Stingray's hatch mechanism on the left, we have adapted the latching mechanism for our eventual drone *(parts in white)*. We used a spring-lock mechanism to ensure that the hatch can be removed easily while being secure during flight.

Wing Latching mechanism

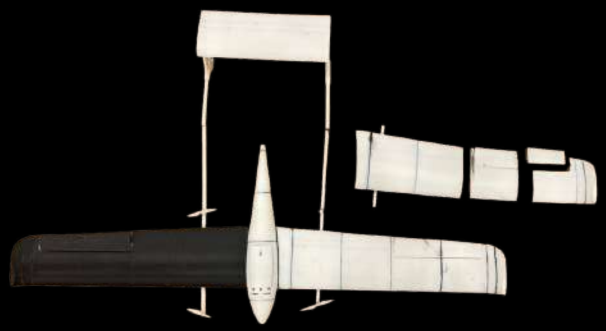
Our initial idea for easy disassembly of the wings came from a clothes peg. We modelled the wing latching mechanism after it and arrived at a snap-fit, spring-loaded mechanism to secure the wings in place while ensuring ease of assembly and disassembly. The images show several iterations through modelling the clothes peg to test fitting the parts together onto isolated portions of the wing *(on the far right)*.

Modularity and manufacturability

Bit by bit.

3D printing

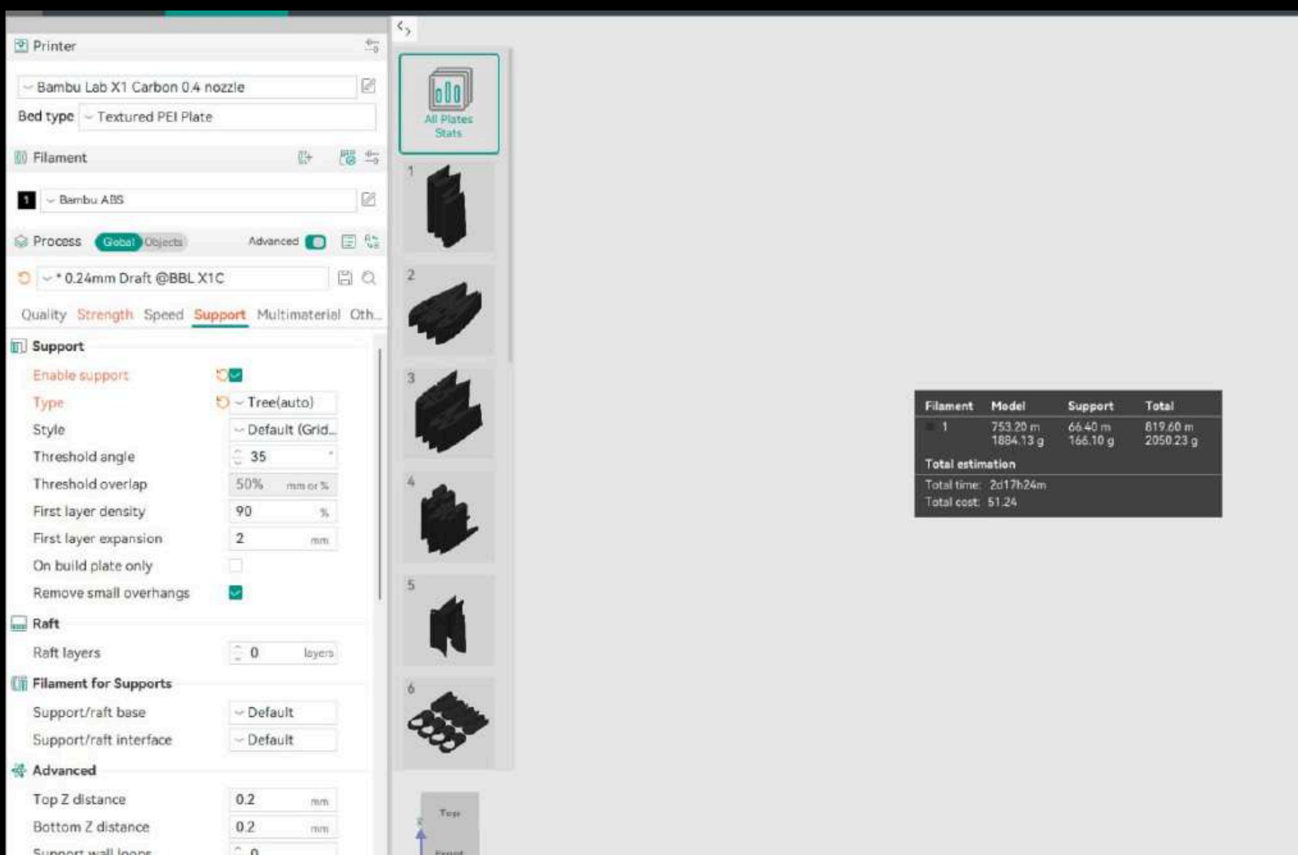
We chose 3D printing as our primary means of manufacturing the Nika Atlas as it not only allowed for a high degree of precision but also facilitated our robust iterative process of parts and mechanisms. As seen below, 3D printed parts often helped us visualise how a part would be broken down before we built it to scale.



Print settings

We adapted several mechanisms from the referenced Super Stingray model.
Slicer Settings: with orca slicer, 1884.13g (without supports)

- 3% gyroid
- 20% gyroid for servo motor cover, rear motor mount parts, VTOL motor mounts, battery mount, electronics frame, and wing latches



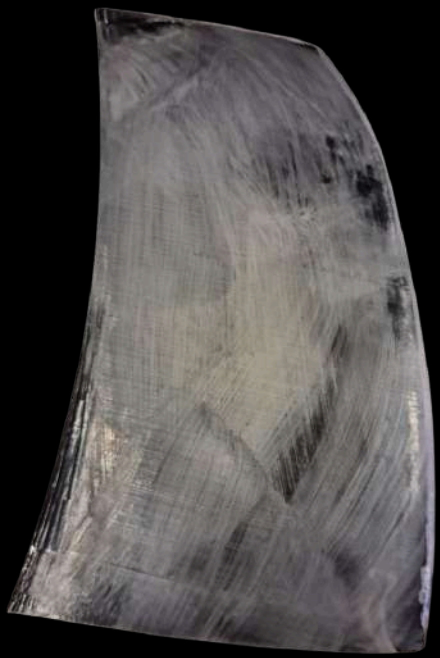
Processing & Finishing

Sand, Prime, Paint!

Step 1: Create an Acetone Slurry

Acetone melts ABS materials. Hence, it was chosen as one of the steps to speed up the post-processing of the 3d-printed parts to ensure a smooth surface finish. To ensure that the acetone does not melt through the whole ABS print, an acetone slurry is made by melting ABS support material in a glass jar containing acetone. A runny mixture is achieved through trial and error by testing the slurry on spare ABS prints.

Step 2: Melt Layer Lines



An even coat of the acetone slurry is applied on all surfaces to be spray painted using a brush. We decided to use a bristle brush instead of a foam brush to scrub the surface of the parts to aid in melting the layer lines. As a safety precaution, a respirator mask and non-nitrile gloves were used whenever acetone is in use.

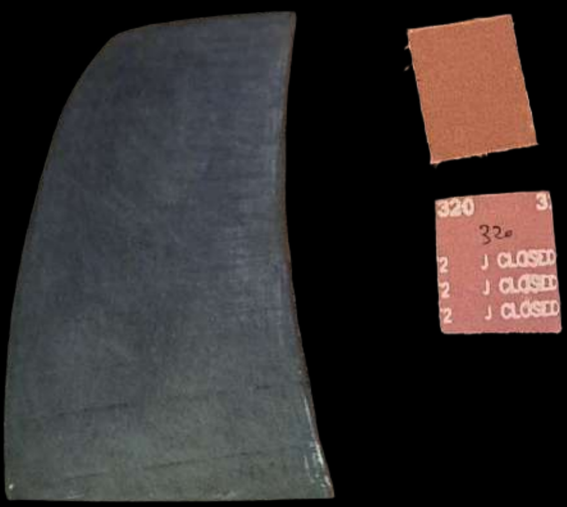
Processing & Finishing

Sand, Prime, Paint!

Step 3: Sand with Increasing Grit Sandpaper

After 80 Grit Sandpaper

After 120 Grit Sandpaper



After 320 Grit Sandpaper

After 400 Grit Sandpaper

To ease the process of sanding, a handheld sanding machine was used for 80-grit sanding. The nooks and crannies, as well as the smaller fragile parts, were hand-sanded. To ensure a smooth surface for priming, 80-grit sanding was done until the melted layers from applying acetone were removed and the colour changed to a shade closer to the original filament's colour. Thereafter, 120, 320 and 400 grit sandpaper were used to hand-sand the parts.

Processing & Finishing

Sand, Prime, Paint!

Step 4: Wash and Dry Sanded Parts

After sanding, all parts are thoroughly rinsed with tap water to ensure that no dust particles remain on the surface of the pieces. This is to ensure that the primer would have a nice, even coating on the sanded parts.

Step 5: Prime the Dried Parts

2 layers of primer were used for all parts to ensure that all gaps were filled. After the first layer of primer is applied, further sanding is done using 120, 320, followed by 400 grit sandpapers to ensure that all surfaces are smooth and there are no visible layer lines. We also cured UV-resin on parts with obvious blemishes. A 2nd layer of primer is then applied and allowed to dry before applying the final top coat of black gloss spray paint.

Luggage prototyping

Transporting the Atlas

Portability

To accommodate the far-ranging nature of geospatial mapping, the Atlas has to be portable. To do so, we fitted a travel luggage with foam to perfectly fit the disassembled parts of the drone. This allows for:

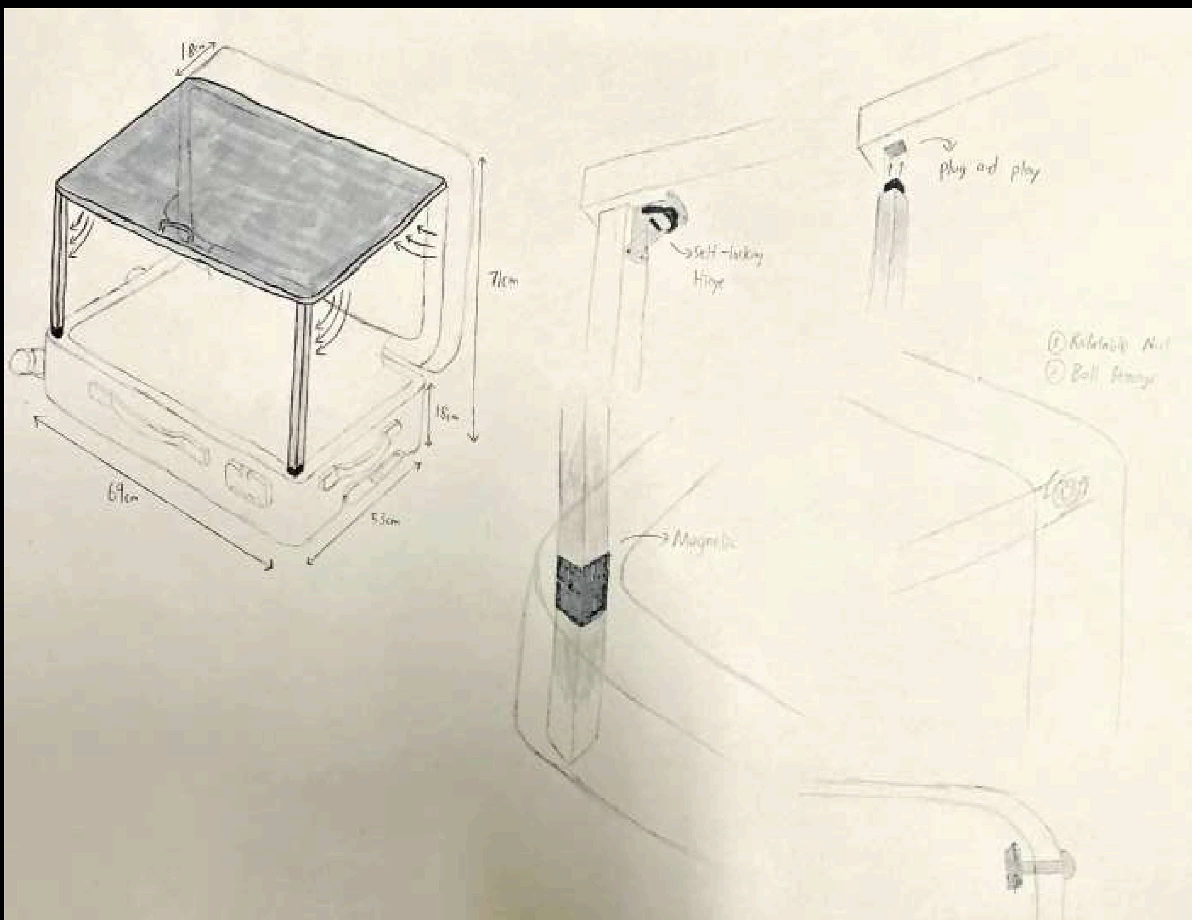
1. Easy storage of the drone
2. Increased portability and ease of carry
3. Easy transport across countries

Baseline constraints

The luggage's dimensions are 69cm x 36cm x 53cm, which are the most generic dimensions for a huge check-in luggage (max dimensions of a check in luggage: 158cm, length + width + height)

Our first iteration

Taking into account the 3 main functions of our luggage, we decided to take inspiration from the current ways of storing items cleanly and deliberately. The 1st iteration was inspired by a foldable table, which opens up using a hinge. We played with how the mechanism works, and after the table is pulled outwards, the legs of the table could be attached, or there could be self-locking hinges and strong magnets that lock the legs, and hence, the table in place. This mechanism allows all the parts of the drone to be exposed, and creates ease of assembly of the drone for the user.

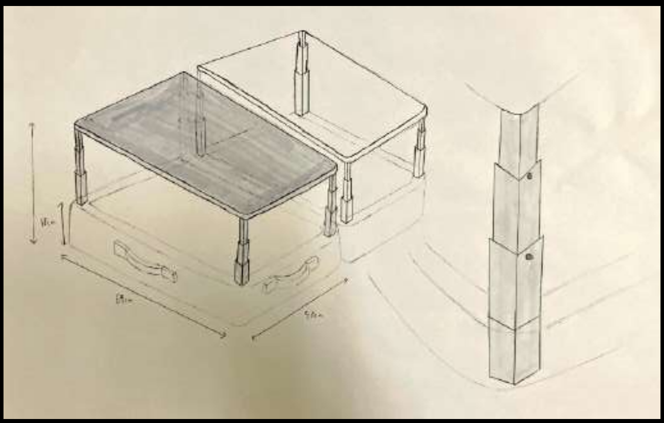


Luggage prototyping

Transporting the Atlas

Our second iteration

However, we found out that it would be better if the luggage is able to fully open, so that both halves of the luggage could lie flat on the floor. Hence, our 2nd iteration is a pull-up table design, inspired by the opening mechanism of a foldable umbrella. The tables can be pulled upwards after the luggage is opened, exposing the drone parts kept beneath. The user can use the table to assemble the drone with ease at a more comfortable height, without having to sit or kneel down to assemble it. The legs of the tables can be collapsed into each other, similar to keeping the shaft and shortening its length into one that can fit into the luggage, and will be locked using a metal bob that pops out when the hole aligns with it, stabilising the table.



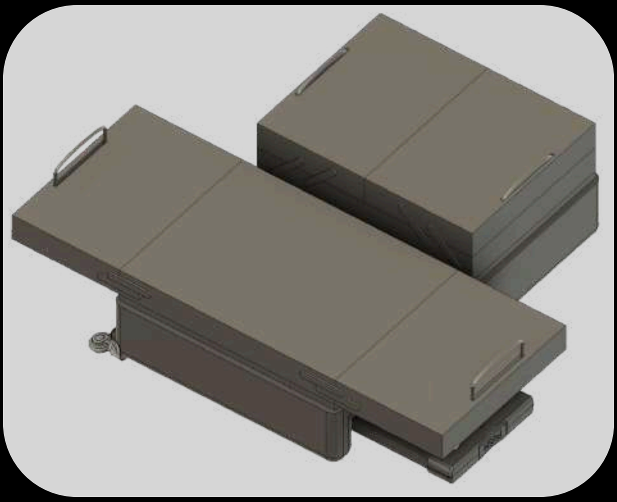
After the initial sketches, we decided to model out the table design, as it seems to provide more substance and aid to the user. From there, we realised there were some flaws in the design. The table's height was not ideal, as even though it added height to the assembly, it was only to the height of an average person's knee. This means that the person is unable to comfortably assemble it and would have to hunch their back.

Luggage prototyping

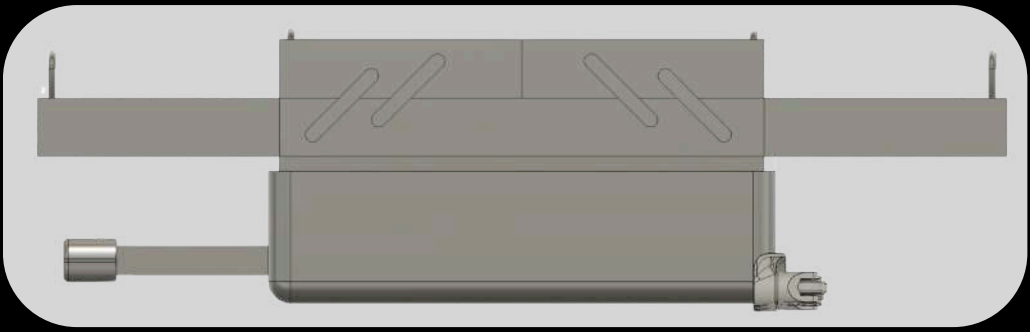
Transporting the Atlas

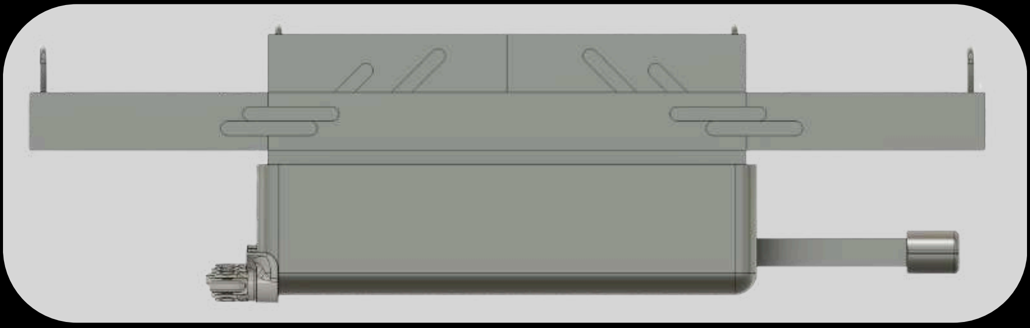
Our third iteration

Taking our learning points from the previous 2 iterations, we crafted our 3rd iteration. Removing the tables, we dove fully into making the luggage open as intuitively as possible. We integrated the 'table' portion of the luggage into the storage as well. Now, inspired by a mechanical toolbox, which swings open and opens neatly, we added handlebars to the side to allow the user to pull the whole foam containing the foam out, adding a little leverage of height that allows the user to kneel and easily assemble the drone.



Looking at the side views, it is clear to see how the mechanism works. There are 4 metal rods attached to the side of the respective foams, and when it is pulled open, the rods rotate, turning the top 2 quarters of the foam outwards, and aligning with the bottom half of the foam. This creates a good base for the parts to be taken out and assembled. However, a flaw in this system is that it would be hard to hold the foam aligned well due to the weight of the parts and the foam itself, and it is neither aesthetic nor clean.



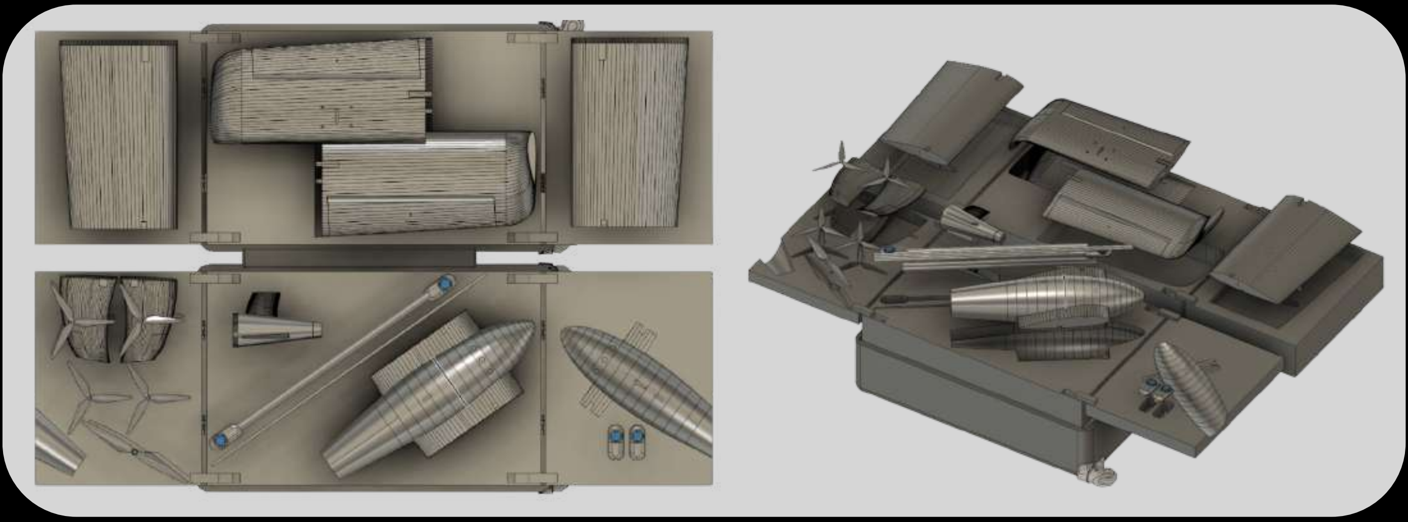


Luggage prototyping

Transporting the Atlas

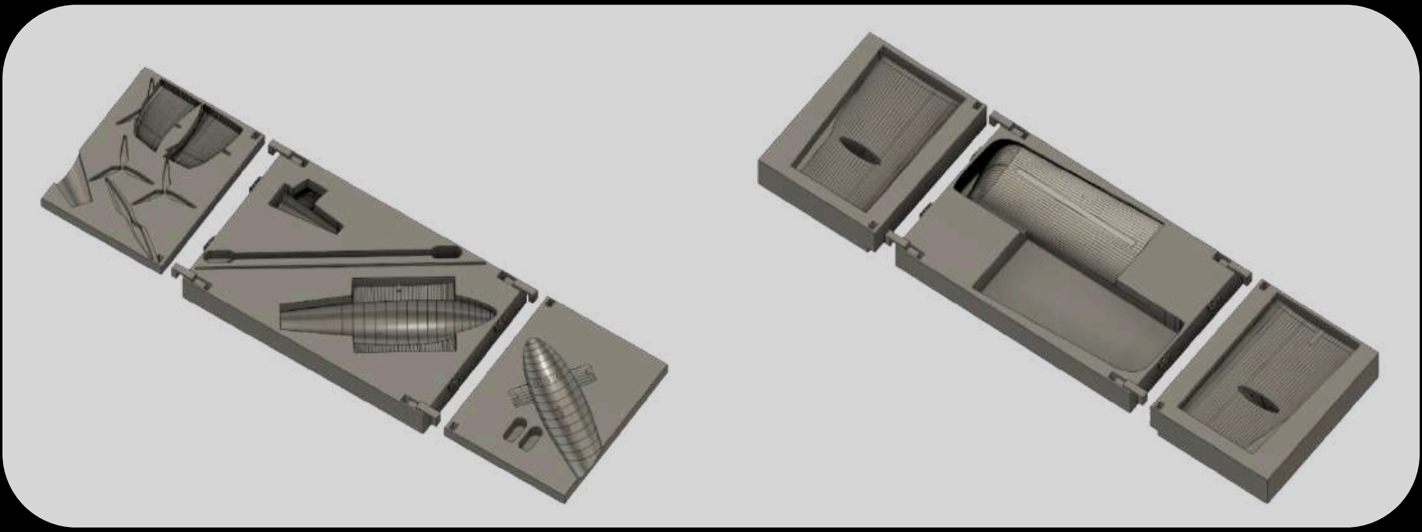
Our final iteration

Finally, after much deliberation and experimentation, we came up with our final design, using hinges and a special U-lock mechanism that holds the foam tightly in place. To ensure all the disassembled parts can be organised into the luggage, we tested it out using our virtual model, ensuring the dimensions of the luggage can encompass every part of the drone. After playing around with the various ways to arrange, we concluded this final structure to be the optimal as it aligns everything well. The wings are slotted into the top half of the luggage, while the rest of the parts, like the fuselage and the propellers, are fitted into the bottom half.



Locking mechanism of hinges & U-lock

The hinges are attached between the larger half of the foam and the two quarters, allowing the quarters to fold outwards easily and intuitively. After they are opened, the four U-locks, hidden within the larger halves, can be taken out and slot into the holes carved in the foam, locking the quarters to the big half, preventing any excessive movement. Overall, this creates not only a strong foundation, but also a minimalistic and sleek design for the luggage to all fit together.



Autonomous Precision Landing

AprilTag Visual Servoing

In this proof-of-concept (PoC) implementation, we develop and demonstrate a lightweight, vision-based autonomous landing system for drones, using AprilTag detection and MAVLink telemetry. The aim is to simulate the end-to-end functioning of a precision landing system in preparation for integration with a downward-facing Livox LiDAR camera on a UAV platform. In the current setup, a HuskyLens vision module serves as the stand-in for the Livox sensor, interfaced with a Raspberry Pi 3B to handle computation and communication with the flight controller (FC).

System Overview and Hardware Configuration

The core of the system comprises three interconnected components: the HuskyLens vision sensor, the Raspberry Pi 3B single-board computer, and the flight controller. As shown in *Fig. 1*, the HuskyLens is connected to the Raspberry Pi via UART communication using four jump wires (TX, RX, GND, VCC). The HuskyLens module performs onboard AprilTag detection and transmits key data to the Raspberry Pi in real time. The Raspberry Pi processes this data and relays it to the FC using MAVLink, the standard micro air vehicle communication protocol.

AprilTag Target and Visual Input

To simulate a landing pad, a high-contrast AprilTag (specifically tag36h11 family, ID 0) was printed and affixed onto a rigid cardboard base to ensure visibility and physical stability during detection tests. The visual target, seen in *Fig. 2*, was sized at approximately 15 cm x 15 cm with a consistent black border to enhance edge contrast under varying lighting conditions. This setup mirrors typical drone landing scenarios where a visual fiducial marker is positioned on the ground to aid autonomous descent.

MAVLink Telemetry Generation and Processing Logic

The Raspberry Pi 3B in this setup functions as the telemetry generator, emulating MAVLink messages that simulate input from a vision-based landing system. The HuskyLens camera continuously scans for AprilTags and transmits the detected tag ID and its corresponding x/y offset values over UART. These values are parsed by the Raspberry Pi and used to construct two key MAVLink message types: HEARTBEAT and LANDING_TARGET.

As shown in *Fig. 3*, a HEARTBEAT message is sent at regular intervals to establish a persistent telemetry link with the flight controller. In parallel, the LANDING_TARGET message is populated with the tag ID and positional offset data obtained from the HuskyLens. This message includes slight randomised noise in the coordinates to simulate natural jitter in real-world detections.

The console output shown in *Fig. 4* confirms that the system correctly picks up and logs the AprilTag ID alongside the calculated offsets, verifying that the telemetry data pipeline is functioning end-to-end. These messages are streamed via serial over /dev/ttyACM0 to the flight controller, representing the intended downstream communication logic that will be finalised with the integration of the Livox camera.

Autonomous Precision Landing

System Functionality and Validation

While the direct verification of MAVLink command reception on the FC via Mission Planner has been excluded from this PoC due to system constraints, the upstream pipeline - from tag detection to MAVLink message formation and transmission - has been validated in isolation. The modularity of the architecture ensures that once telemetry integration is resolved at the FC layer, the system can be fully extended to onboard control logic for descent and touchdown.

Despite the limited onboard compute power of the Raspberry Pi 3B and the basic UART interface, the pipeline operates with low latency and sufficient consistency for real-world scenarios. The use of HuskyLens offloads image processing, allowing the Pi to remain dedicated to message handling and communication.

Conclusion and Forward Path

This prototype successfully demonstrates the viability of AprilTag-guided landing using a modular visual input-processing-communication stack. By replacing the HuskyLens with the intended Livox sensor and resolving end-to-end integration with the FC following full calibration of the drone, the system will evolve into a fully functional autonomous landing mechanism suitable for hybrid UAV deployment. Future developments will include noise reduction in pose estimation, adaptive descent modulation, and hardware refinement for robust deployment in varied environments.

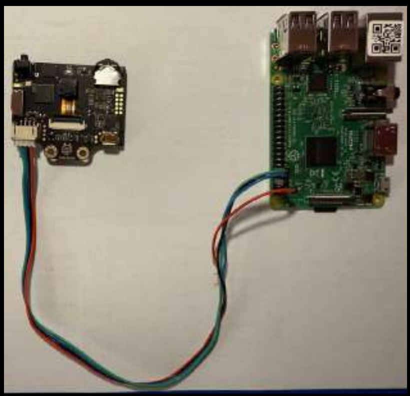


Fig. 1. UART connection between HuskyLens and Raspberry Pi 3B using four jumper wires.

Fig. 2. AprilTag (ID 0, tag36h11 family) mounted on cardboard landing pad.

```
nikadrone@raspberrypi:~ $  source ~/mav_env/bin/activate
(mav_env) nikadrone@raspberrypi:~ $ python3 ~/f_mavlink_sender.py
Sent HEARTBEAT + LANDING_TARGET
Sent HEARTBEAT + LANDING_TARGET
Sent HEARTBEAT + LANDING_TARGET
Sent HEARTBEAT + LANDING_TARGET
Sent HEARTBEAT + LANDING_TARGET
Sent HEARTBEAT + LANDING_TARGET
```

Fig. 3. Terminal output of f_mavlink_sender.py, sending MAVLink HEARTBEAT and LANDING_TARGET messages.

```
nikadrone@raspberrypi:~ $ source ~/mav_env/bin/activate
(mav_env) nikadrone@raspberrypi:~ $ python3 ~/send_apriltag_to_fc.py
Sent tag36h11, Tag ID: 0, x=0.00, y=-0.00, dist=0.30
Sent tag36h11, Tag ID: 0, x=-0.00, y=-0.01, dist=0.30
Sent tag36h11, Tag ID: 0, x=-0.00, y=-0.01, dist=0.30
Sent tag36h11, Tag ID: 0, x=-0.01, y=-0.01, dist=0.30
Sent tag36h11, Tag ID: 0, x=-0.01, y=0.00, dist=0.30
Sent tag36h11, Tag ID: 0, x=0.00, y=0.01, dist=0.30
```

Fig. 4. Parsed AprilTag data from send_apriltag_to_fc.py with real-time x, y offsets and estimated distance.

Unleashed. Sleeker than ever.

NIKA: ATLAS

Final Technology

After researching readily available drones on the market and going through several iterations, we arrived at our final design. Although flight testing has yet to be accomplished due to time constraints, our drone boasts the following statistics based on theoretical calculations.

Drone Specifications

Hybrid Module
Fixed-wing to VTOL

Apriltag detection
68.4 km/h

Height Flight
120 m

Captures 235 hectares
39.6 km/h

34.5km travelled per flight
4kg

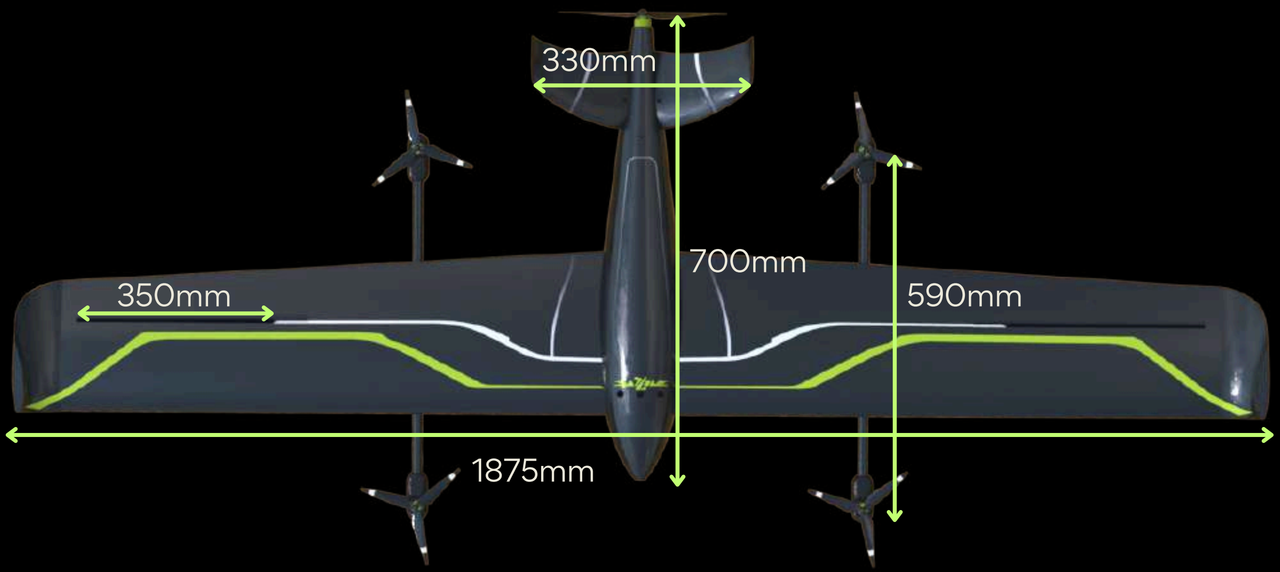
Flight Time
1 hour

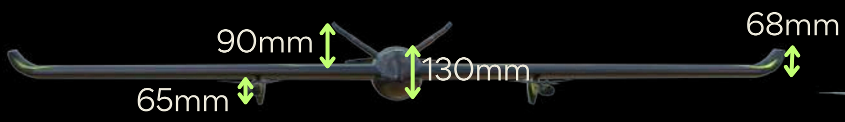
Speed
68.4km/h Max Speed
39.6km/h Stall Speed

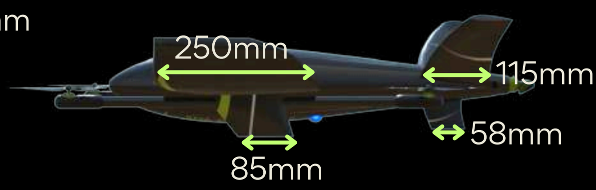
Load
Carries up to 4kg of load

Final Technology

Dimensions







Oblique Camera

The current image-capturing tool used by Nika for geospatial data collection is a gimbal camera. This has the limitation of having to rotate to be able to capture images in all directions. To resolve this limitation, we intend to include an oblique which has a wider field of view. This increases the efficiency of image capturing over long-duration flights.

The model that we have chosen is the Livox mid-360. The Livox Mid-360 is a compact, hybrid solid-state LiDAR sensor designed for low-speed robotics and autonomous vehicles. It features a 360° horizontal and 59° vertical field of view, detecting objects as close as 0.1 meters and up to 70 meters away at 80% reflectivity. With a point rate of 200,000 points per second and a frame rate of 10 Hz, it offers high-resolution 3D perception. The sensor is lightweight at 265 grams, has an IP67 rating for dust and water resistance, and operates within a temperature range of -20°C to 55°C.

Key renders

Takeoff using VTOL propellors

Hover mode to reach transition speed

Key renders


Back propellor kicks in while VTOL propellors ease out


Successfully transitioned to fixed wing flight mode

Key renders

Key renders


Atlas detects QR to land

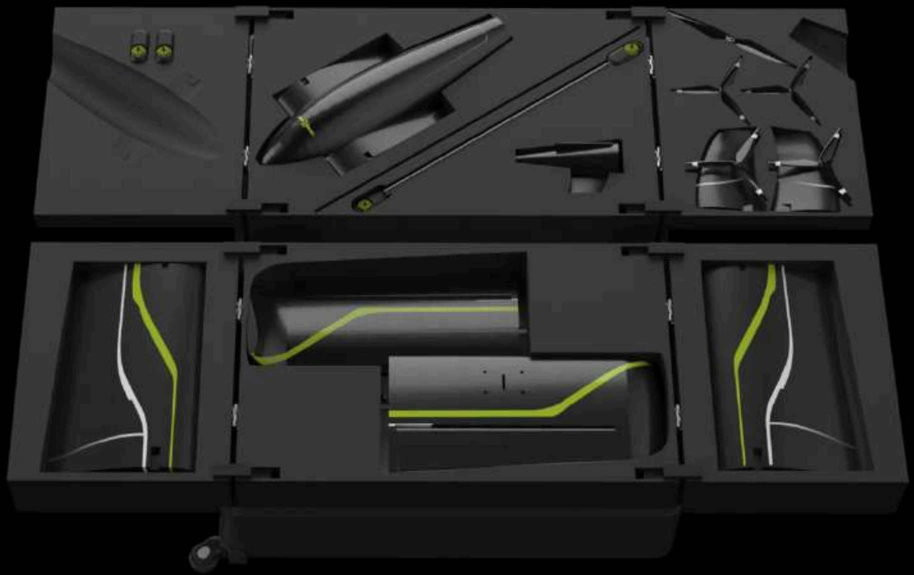

It corrects and aligns itself with the QR


Precision landing is especially crucial on moving surfaces like ships

Key renders

Key renders

Once the drone is disassembled, the work area is collapsed.



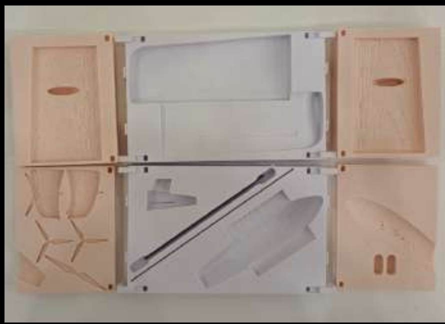
Drone Prototype

The PoC was printed in ABS because it offers high impact resistance, good strength-to-weight ratio, and durability under stress. Its heat resistance makes it suitable for components near motors or exposed to sunlight. ABS can also be easily post-processed for a better fit and finish. While it requires controlled printing conditions due to warping, its toughness and resilience make it a strong choice for prototyping and functional drone components. The PoC also has carbon tubes inserted within the wings, through the fuselage, to reinforce the build.

Luggage Prototype

1:5 Scaled Models

To fully test out the hinges and U-lock mechanism, we 3D printed out the drone, luggage, and foam parts on a 1:5 scale, and tried to fit everything in together. After some minor adjustments and changes, we were able to slot the drone parts all into the printed 'foam' cutouts. This ensures that our organisation of the drone into the foam parts fully works, and the mechanism for locking the foam parts together all integrate with each other well.



Full Scale Model

To create the full scale model, we used expandable foam to cover the full scale disassembled parts of the drone, which creates the overall cut-out of the drone parts, and after removing the drone parts, proceeded to cut the outer shape into rectangles using a foam cutter, and any blemishes within by carving with a knife. Next, we covered the foam with felt to give it a nice finish, and also to allow the parts to be laid on a softer material, while still being form fitting into their grooves. As shown below, this is how the final arrangement of the disassembled drone will be like.

PDS recap


2025/03/06 13:29:42
2025/03/07 14:53:00
2025/03/19 11:51:39
2025/03/05 15:59:59
2025/04/01 16:01:41

PDS recap

WE BUILT MORE THAN A DRONE — WE BUILT A DREAM.
Through sleepless nights, last-minute fixes and countless coffee-fuelled debates, we learned to trust, adapt and overcome. Atlas was the goal, but the real success was becoming a team that never backed down. Here's to the grit, the laughs, and the flight we took — together.

— Ritu

Being relatively new to having a design thinking mindset, it has been quite a journey both in SUTD & this studio module. Before I entered SUTD, design was something for the 'pros' and only those with innate talent. However, I soon realised that this 'talent' can be learnt. This product design studio has allowed me to be surrounded by many talented individuals, peers & mentors alike, bringing a new perspective to my mindset towards design. Through many iterations and research to back up our ideas, I have learnt that design journeys are never linear. More often than not, we end up back at square 1 even after weeks of blood, sweat and tears.

Jallyson Ang

My heart is so full seeing the project come to fruition. I am endlessly grateful to my wonderful team who supported me through it all. I think we have all grown much as designers and as people. I could never have guessed what our final product ended up as, just as I would never have guessed what a ride this PDS was.

-Aderiz Choo

When I joined DAI, I was worried. What if I didn't enjoy it? What if I couldn't handle everything together? What if I regret? Looking back at these questions now, I realised: these were unnecessary, worthless questions. I have no regrets joining DAI, in fact, I LOVE it. Studio has opened my eyes to everything I did not have much experience in, be it IOT, sketching cubes, 3D modelling, or building a drone. Through the many discussions and group work, we have become much more bonded to each other, and I felt that I have grown so much as a person. If I had the chance, I would do it all. Over. Again. ♡

~ Isaac Oh

I think making a drone for this project was a very fun and rewarding experience. I learnt a lot of technical and design skills that would be applicable in the future but I must say that the most important thing I learnt is that anything can be done if you set your mind to it. I mean come on, we made a drone! Let's goooo!

— Amit

PDS recap

Amit

thank you

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