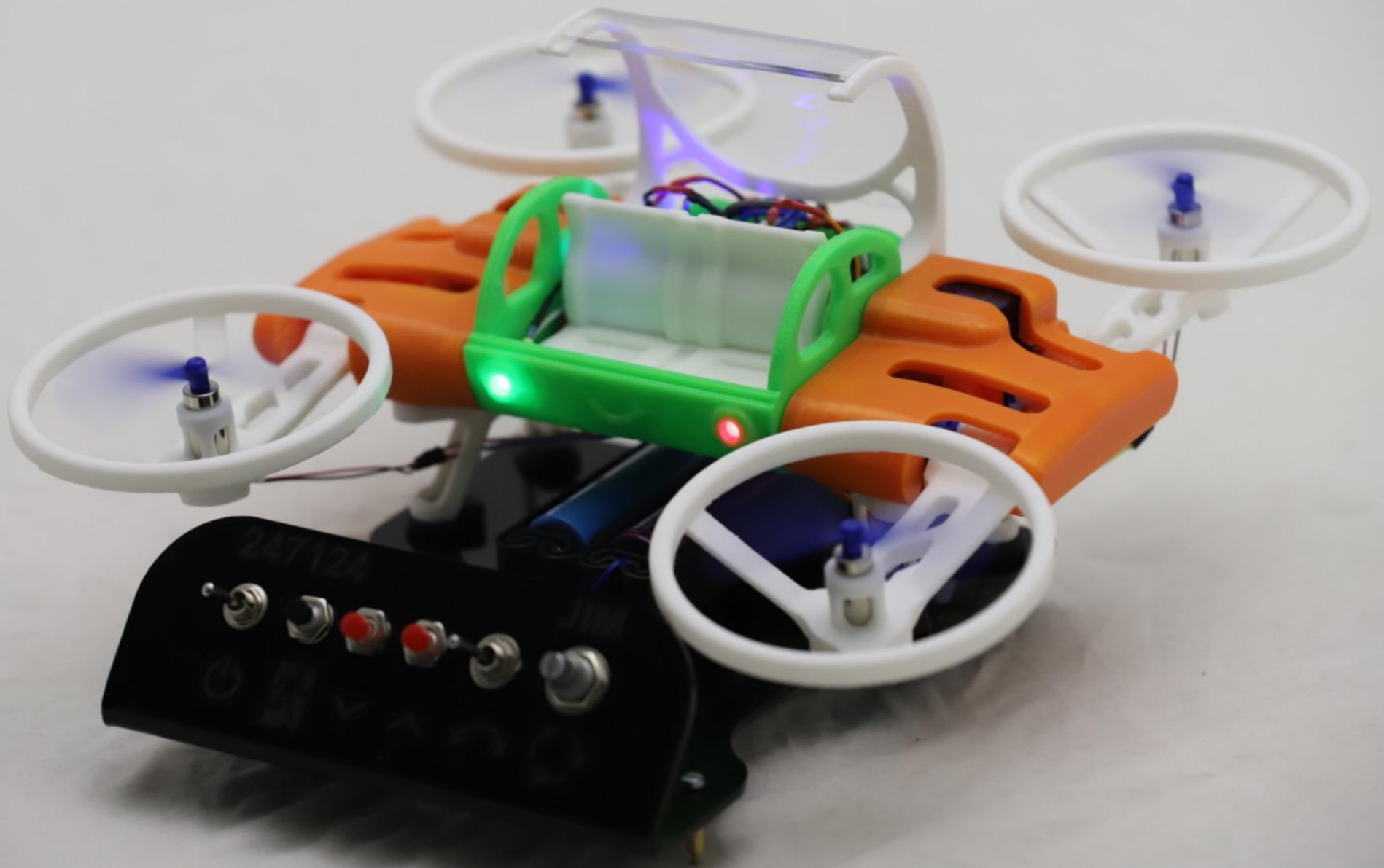




Engineering Assessment

LC 2025 - 247124

Analysis of Brief

a) Fuselage Compartment

The design must include a fuselage or main body compartment. This compartment typically houses key components (e.g., motors, batteries, wiring).

c) ≥ 4 Electronically Operated Motors

The design must incorporate 4 or more electronically operated motors that are powered by batteries.

e) All Main Operating Features Clearly Visible Without Dismantling

My design must have all wiring and operating features be clearly visible without the need for disassembly

g) Voltage Does Not Exceed 9 Volts

All electrical systems must operate at or below 9 volts. This is typically for safety and standard battery compliance.

b) Seating for Pilot and Passenger

The model should feature seating arrangements for both a pilot and at least one passenger, reflecting the requirement for occupant space.

d) Include an Automated Door

The design must include an automated door for access. This door should be able to open or close mechanically (e.g., via a motor or simple mechanism).

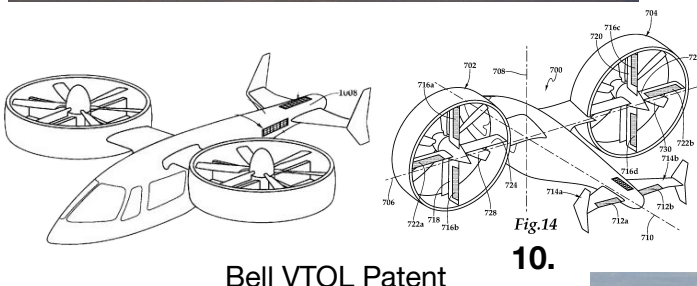
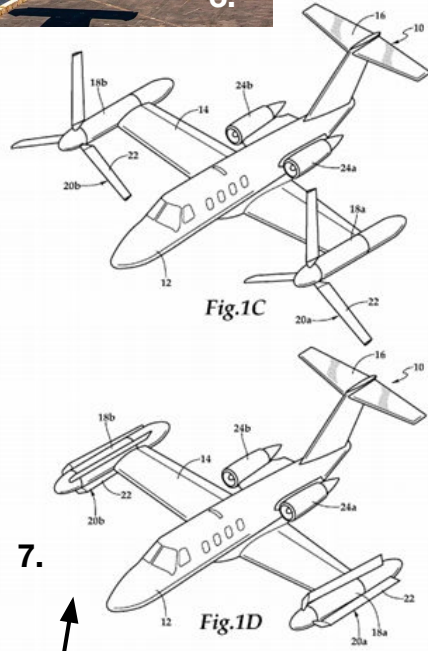
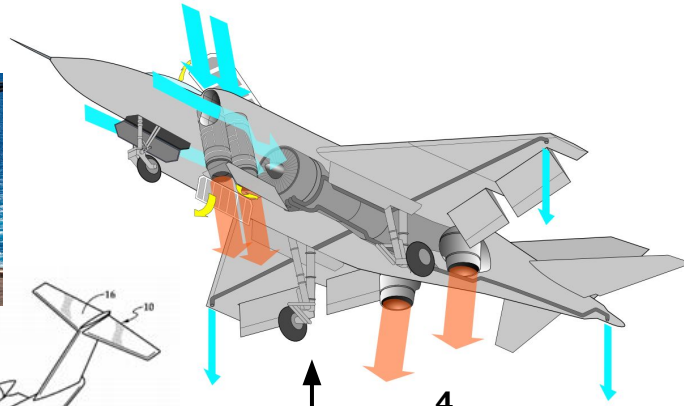
f) Longest Dimension $\leq 400\text{mm}$

The maximum overall dimension of the model (length, width, or height) must be less than 400 millimeters to satisfy size constraints.

Investigation of solutions VTOL Jet Research

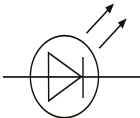


A vertical take-off and landing (VTOL) aircraft is **one that can take off and land vertically** without relying on a runway.

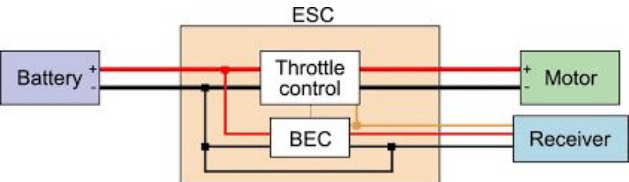


Investigation of solutions

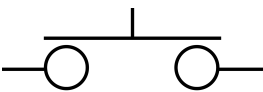
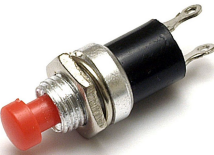
Electronics Research



Output: **Light Emitting Diode (LED)**



Control: **Electronic Speed Controller**



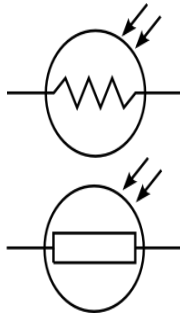
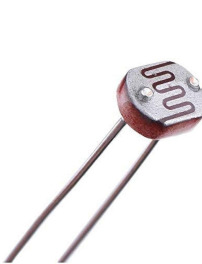
Input: **Push-to-make Switch**



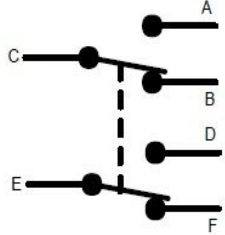
Output: **Piezoelectric Buzzer**



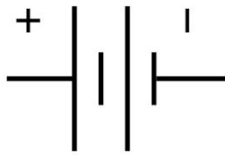
5/3.3v Microcontroller: **ESP32 Devkit1**



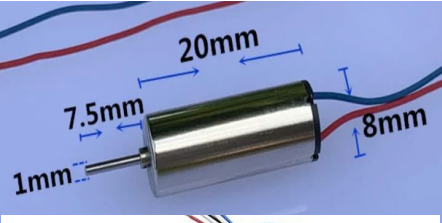
Sensor: **Light Dependent Resistor LDR**



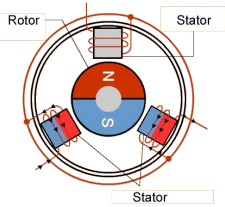
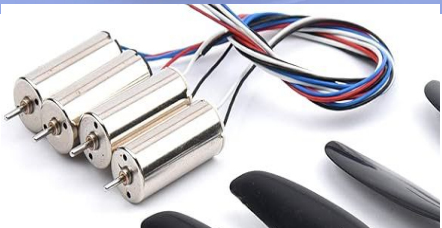
Input: **DPDT Switch**



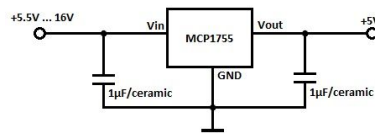
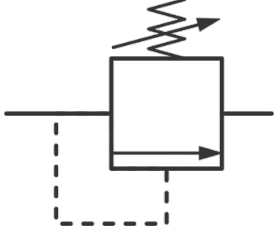
Power: **9v 1200mah Lithium Battery**



Output: **Brushed 8520 DC Motor**
3.7V, 1.6A, 30500–39000 RPM



Output: **5v Positional Servo Motor**



Voltage Regulation: **5v LDO Voltage Regulator**



Investigation of solutions

Potential door mechanisms

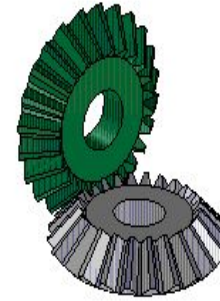
[Chooser charts](https://www.stem.org.uk)

[stem.org.uk](https://www.stem.org.uk)

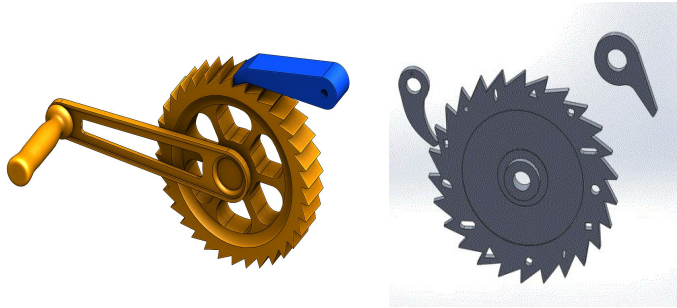
←--More
information



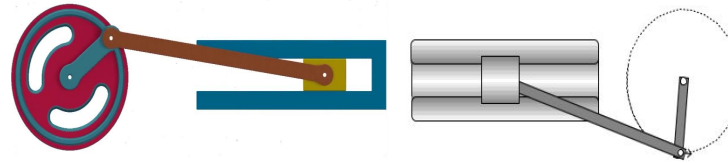
Bevel gears



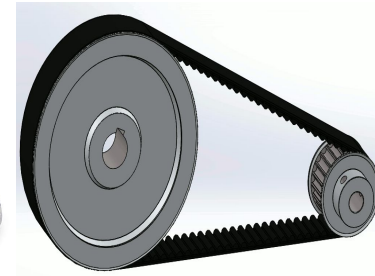
Pulley wheel and belt



Ratchet and pawl



Crank and slider



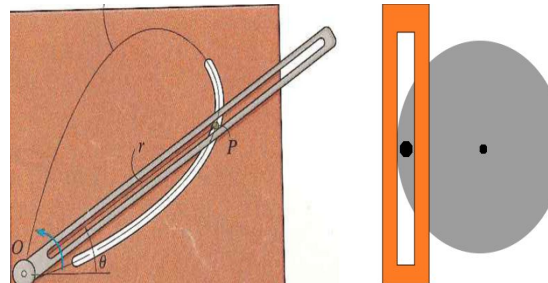
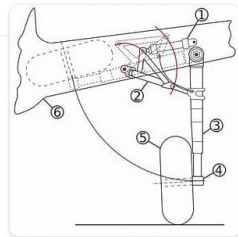
Toothed belt and pulleys

Mechanism

Device that transforms forces

In engineering, a mechanism is a device that transforms input forces and movement into a desired set of output forces and movement.

Mechanisms generally consist of moving components which may include:...

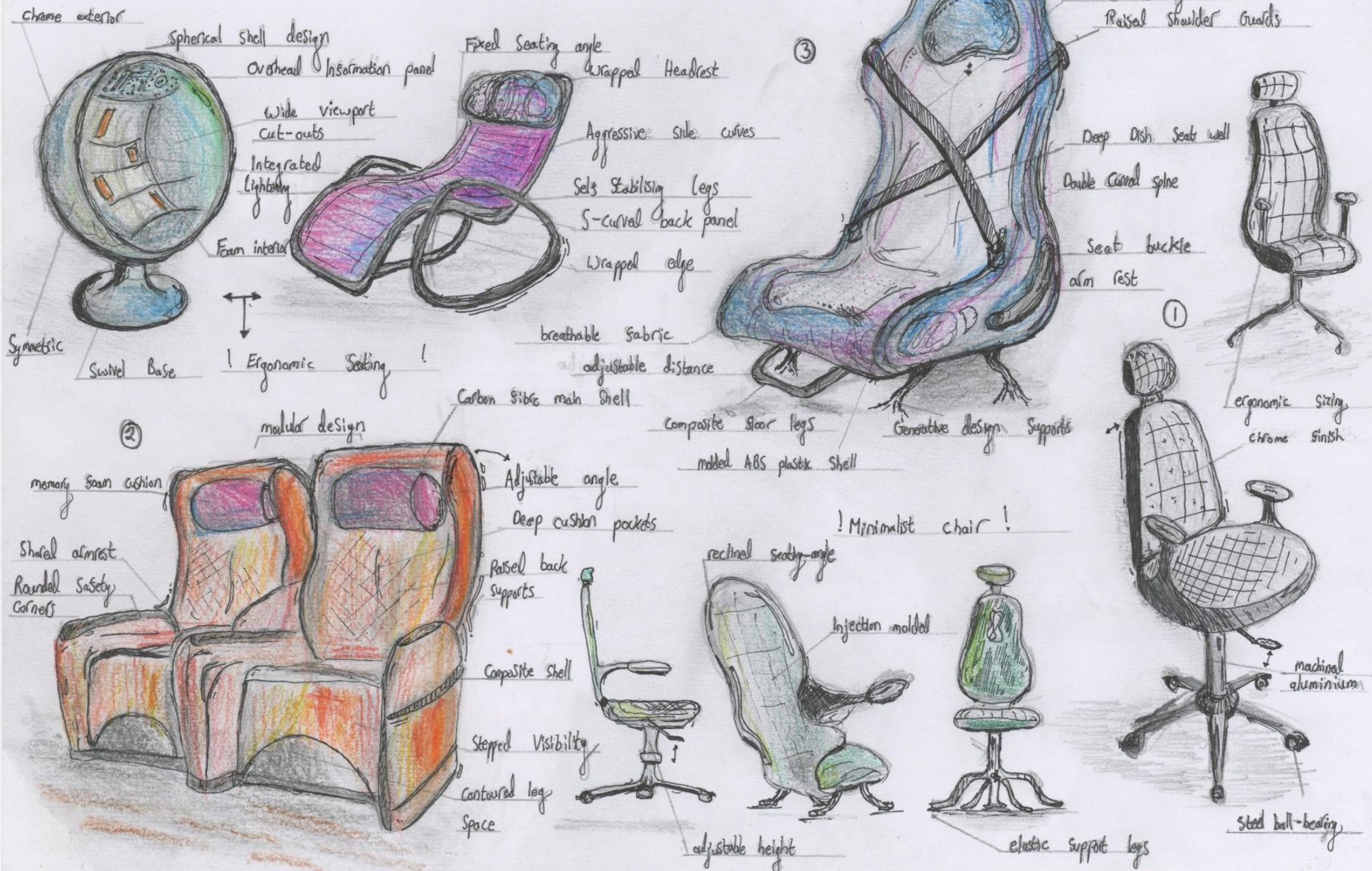


Peg and slot



Chain and sprocket

3 Initial Concepts - Seating



3 Initial Concepts - Door

Edge trim: TPO

wheelchair accessible
Emergency exit lever

Double hinge mounting points

Safety Lock Position

①

Gull Wing Door

Impact-resistant reinforced
Carbon-fibre

Carbon-fibre composite

Large entry-space
maximum clearance angle

Weather Seal
EPDM rubber

Cold-rolled Steel

Gas strut mounting
points

Fighterjet concept
Door

Polarised Screen Bullet-proof ballistic glass

Sand-blasted & Polished
Pearlescent finish

③

Fighter Jet Door

Hull Door

⑤

②

hinge mounting
points
horizontally
oriented

Cost-
effective
material

Ergonomic
Door
Handle

Pine frame
Standard
Pivot hinge

The simple door

Chrome plating

Sleek, aerodynamic
form

Wide viewing
angle

Tight seams
/ tolerances

Airflow

Panel
construction

Frame reinforcement

Pop-Riveted
Anti-glare film coating

Weather Shielding

double hinged assembly
Sealing system: Multi-
chlorometer rubber compounds

Turbulent
wake
drag-reduction
geometry

Large opening-area volume

Pin-locking mechanism
acoustic - foam-padding (core)

locking mechanism detail

Interior panel: ABS plastic

3 Initial Concepts - Rotary Propulsion System

Status LEDs / bulbs

Cross-balanced frame

Quadcopter Concept

ESC Housing
"X" Configuration

rotor variations

historical diesel engine
fixed-pitch composite propeller

blade geometry
analysis

316 grade Stainless
steel

lubricated brass inserts

hub connection
point

Tip Vortex Reduction

Titanium alloy fasteners

Single rotor enclosed

impact resistant shroud
prop guards

bearing mount

balanced hub assembly

airflow director

air guide shroud

hub core

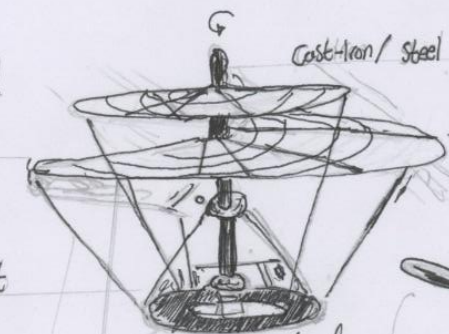
hardened-steel core

balanced hub assembly

vibration dampening
mount

wire channels

root fittings



main motor head

central stay-wires
head assembly

Da Vinci Concept Helicopter
impact-resistant
polycarbonate

rotation direction

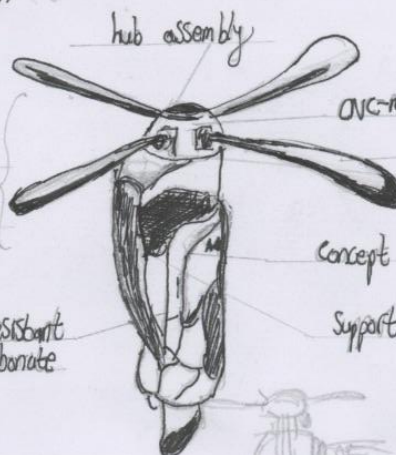


BLDC motor

blade attachment bolt

topology optimised legs

generative-design
supporting arm.



hub assembly

aerodynamic profile

arc-milled aluminium

bearing housing

concept design

support structure

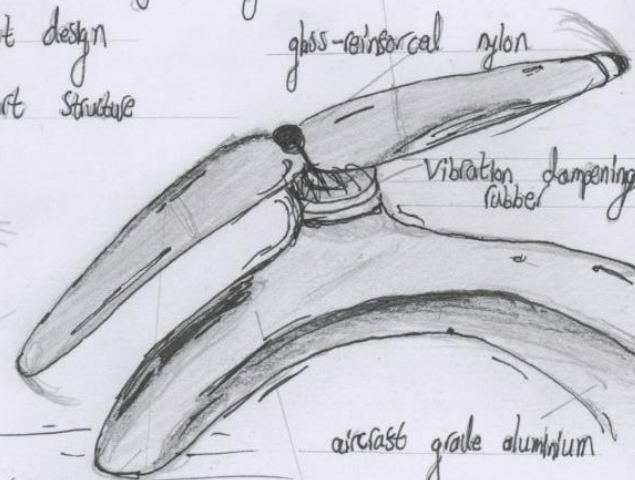
pop-rivet assembly

air intake / ventilation grating

adjustable angle of attack

glass-reinforced nylon

vibration dampening
rubber



aircraft grade aluminium

epoxy-coated composite
storable blades / foldable

action shot
futuristic, minimalist leg

Investigation of solutions: Fuselage Shape

When considering the fuselage of the drone we cannot just restrict it to the seating alone. We must consider the actual shape of the central body of the VTOL drone, and whether the pilot and passenger should sit alongside one another or one behind the other.



Bike Style

- Good all-around visibility
- Easy to jump-off the vehicle in case of emergency
- No protection to the human body



Up-Right Position

- Robust: accommodates all ages and body sizes
- Most ergonomic position
- Poor aerodynamics as large cross section exposed to drag



Formula-1 Style

- Highly Aerodynamic
- Low Center-of-gravity
- Difficult to get in and out of vehicle

Seating Positions
Ergonomics of Single-Person VTOL Aircraft

I believe that up-right position would best suit this application

1. Tandem Seating, Oblong:

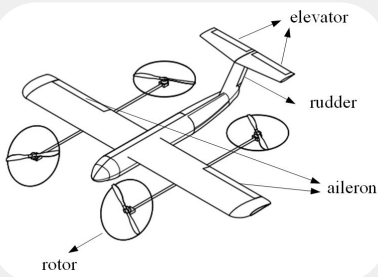
- a. Oblong, like a fighter-jet?
 - i. Reduced leg-space
 - ii. Increased aerodynamics
 - iii. Quite space efficient, but this equally does not allow much space for storing electronics.



More space efficient seating



Highly aerodynamic shape



Does not allow as much space for storage

2. Parallel Seating, Wide:

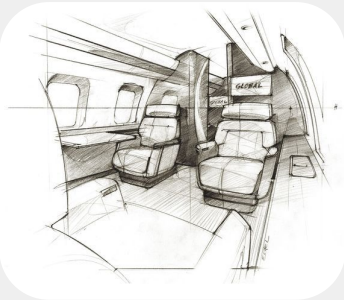
- a. Wider, like a commercial aircraft?
 - i. Increased leg-space & comfort
 - ii. Increased head-on aerodynamic load
 - iii. This allows considerable extra space for electronics behind the pilots

Decision:

I believe that creating a wider fuselage with the two seats alongside one another would allow the most additional space for electronics to be stored safely and easily visible to an examiner. This would also provide the most comfort for hypothetical users. I have chosen to continue with option (2).



Increased user comfort, more space



Less aerodynamic shape, wider attacking face



Space for storing electronics, behind

Criteria for selection of solution

Design Concept Evaluation - deciding upon what concepts I will implement

Summary:

To determine the most suitable design for the JIM VTOL Drone, I systematically analyzed three initial concepts for each major component: propulsion, doors, and seating. Each concept was evaluated against six key criteria: structural integrity, aerodynamics, weight, ease of manufacturing, user experience, and overall feasibility. By comparing these metrics, I identified the most effective combination that aligns with performance, safety, and user experience.

For propulsion, the **Quadcopter Concept** was selected due to its symmetrical thrust distribution, predictable handling, and efficient aerodynamics. The **Gull Wing Door** emerged as the best choice for its fast and reliable access, critical for usability and safety. Lastly, the **Reclined Seat** was chosen for its ergonomic support and stability, ensuring a comfortable and secure user experience.

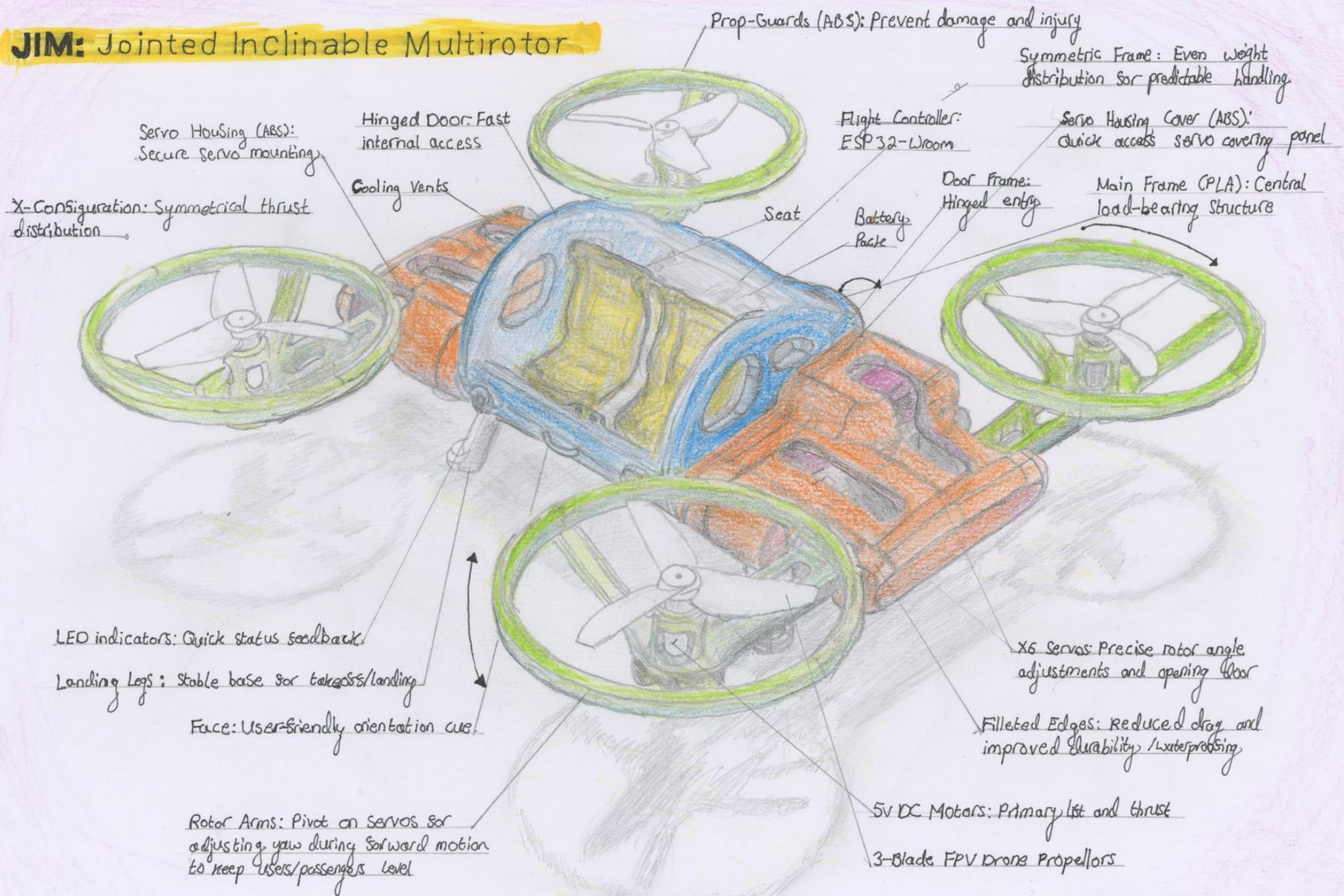
My Final Design Requirements

My design must incorporate a **Jointed Inclined Multirotor (JIM) system** featuring a **quadcopter propulsion system**, **gull-wing door access**, and a **reclined ergonomic seat**. This combination ensures **optimal stability, aerodynamic efficiency, and user-centered functionality**, making JIM the most viable and effective solution.

Analysis Table

Concept	Category	Structural Integrity	Aerodynamics	Weight	Ease of Manufacturing	User Experience	Overall Feasibility	Selected
Quadcopter Concept	<i>Propulsion</i>	8	9	7	6	8	9	✓
Single Rotor Enclosed	Propulsion	9	8	9	7	9	8	-
Da Vinci Concept	Propulsion	7	7	6	5	7	7	-
Gull Wing Door	<i>Doors</i>	7	8	8	7	9	8	✓
Fighter Jet Door	Doors	8	9	7	6	8	9	-
Hull Door	Doors	9	6	6	8	6	7	-
Spherical Shell	Seating	7	7	6	7	9	7	-
Reclined Seat	<i>Seating</i>	8	9	9	8	8	9	✓
Modular Seat	Seating	9	8	8	9	9	8	-

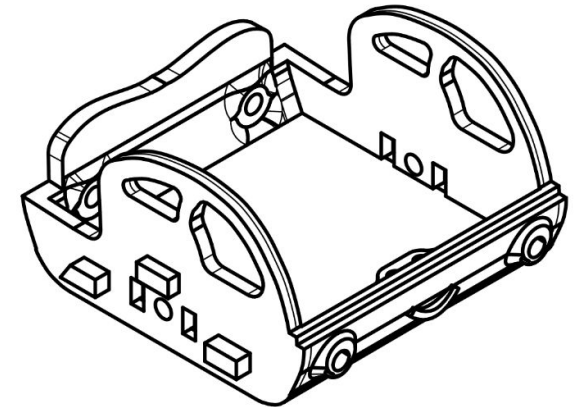
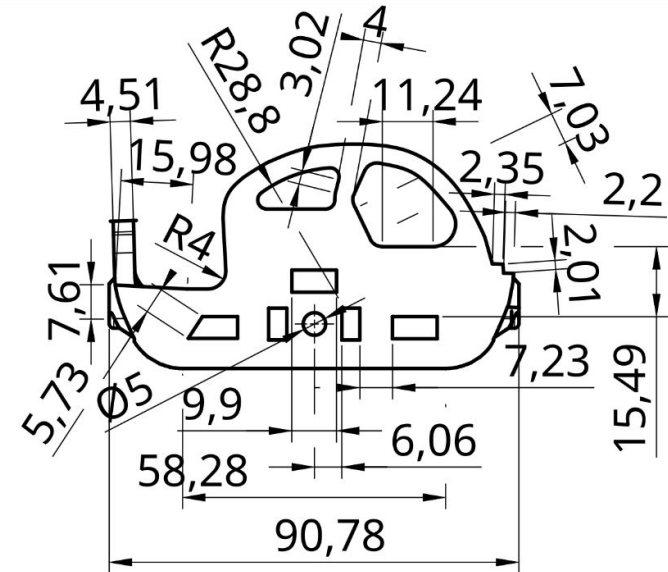
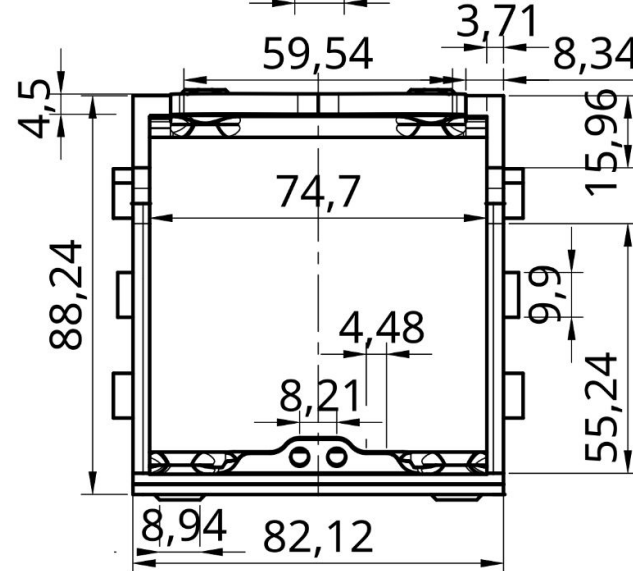
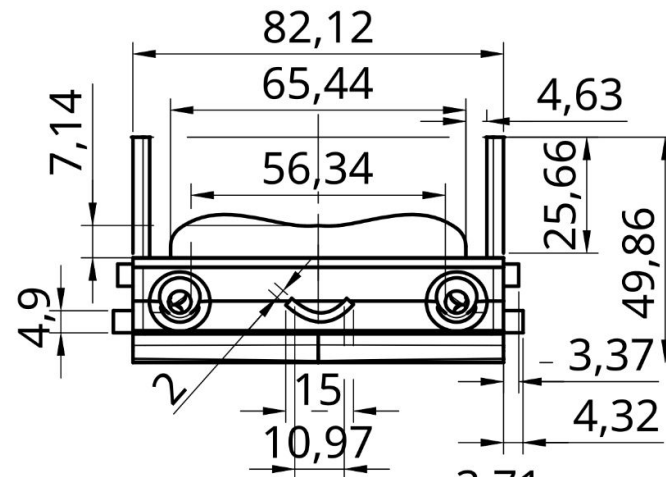
JIM: Jointed Inclinable Multirotor





Main body

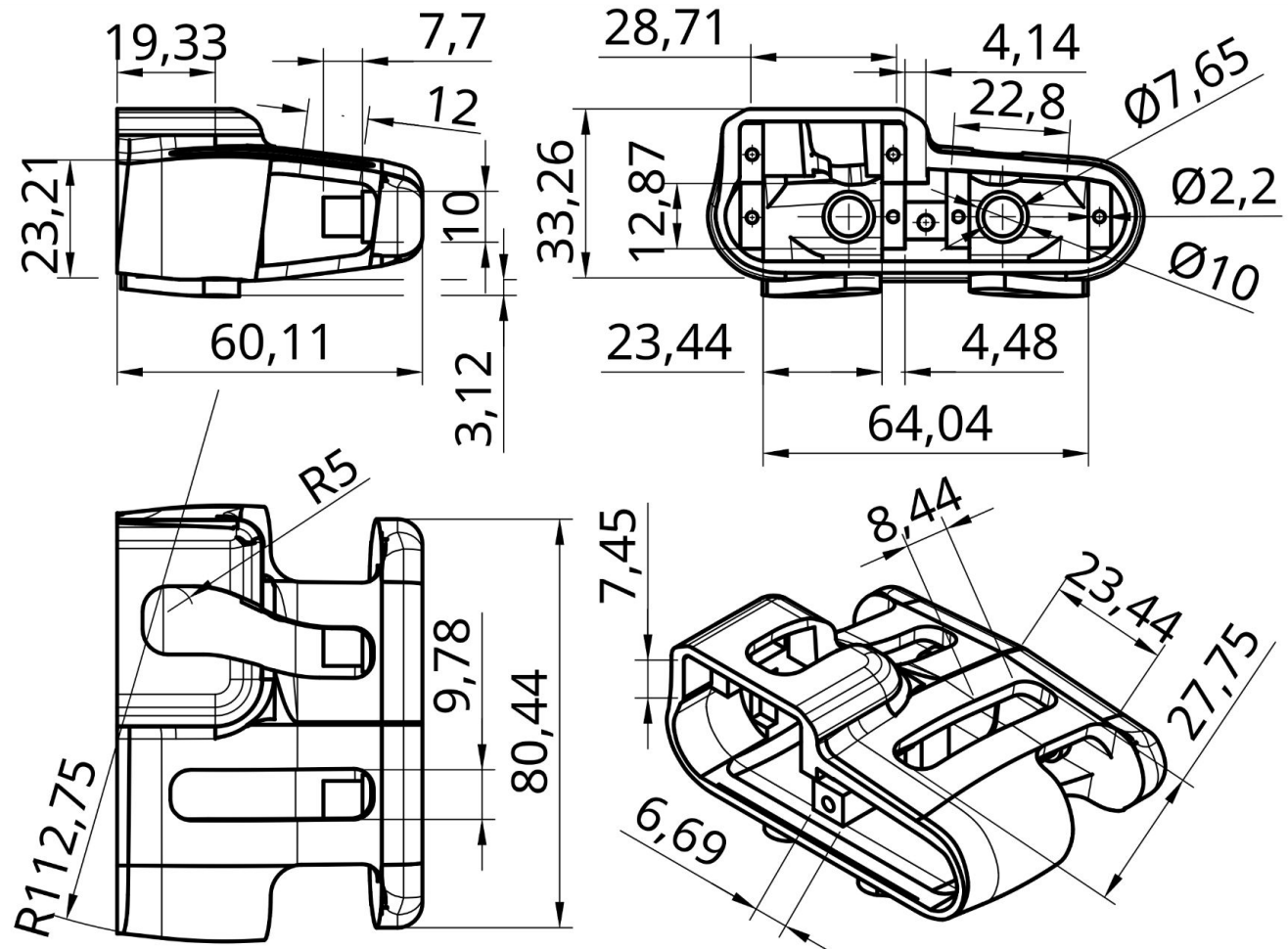
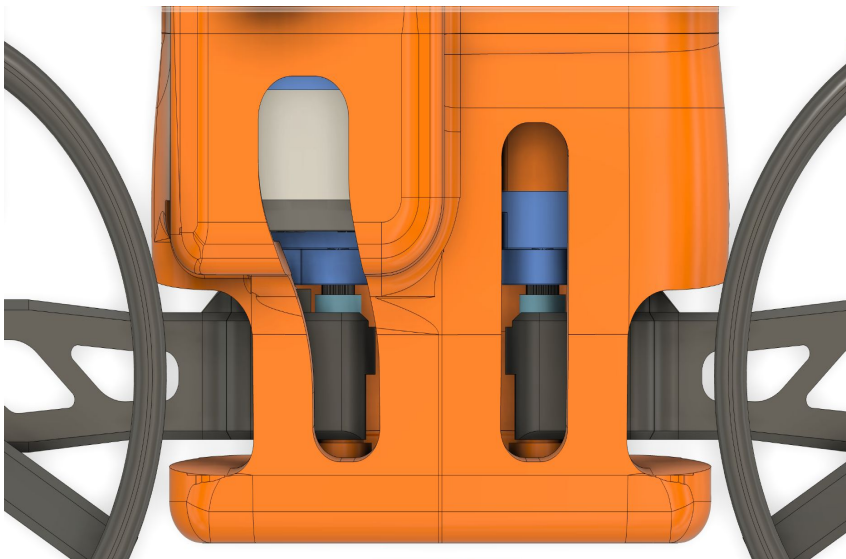
x1



Production Drawings/Plans

Servo Housing Unit

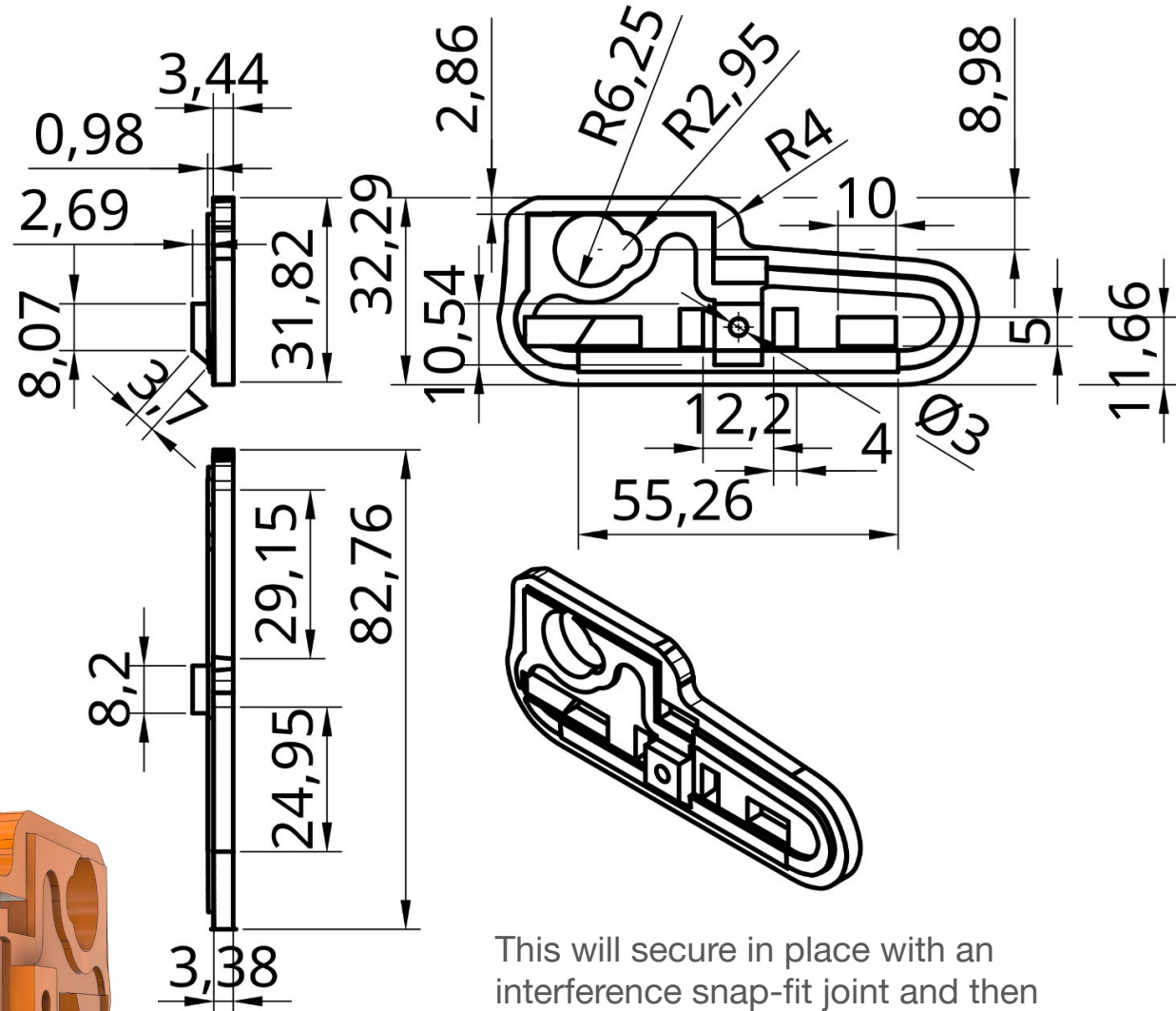
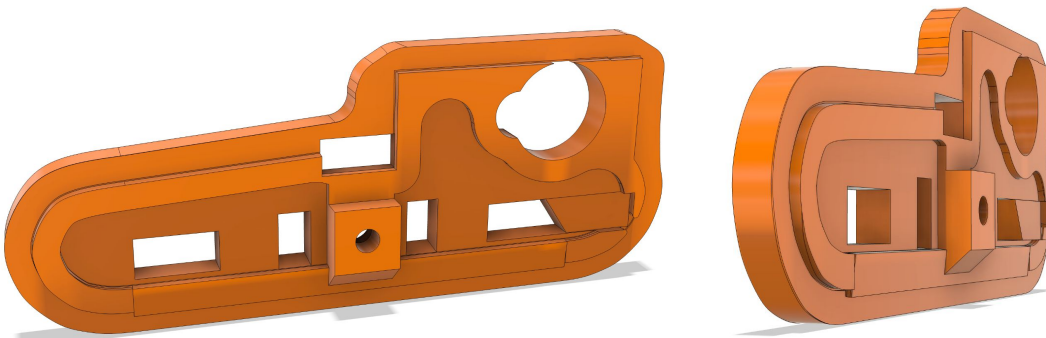
x2 (mirrored)



Production Drawings/Plans

Servo Housing Cover

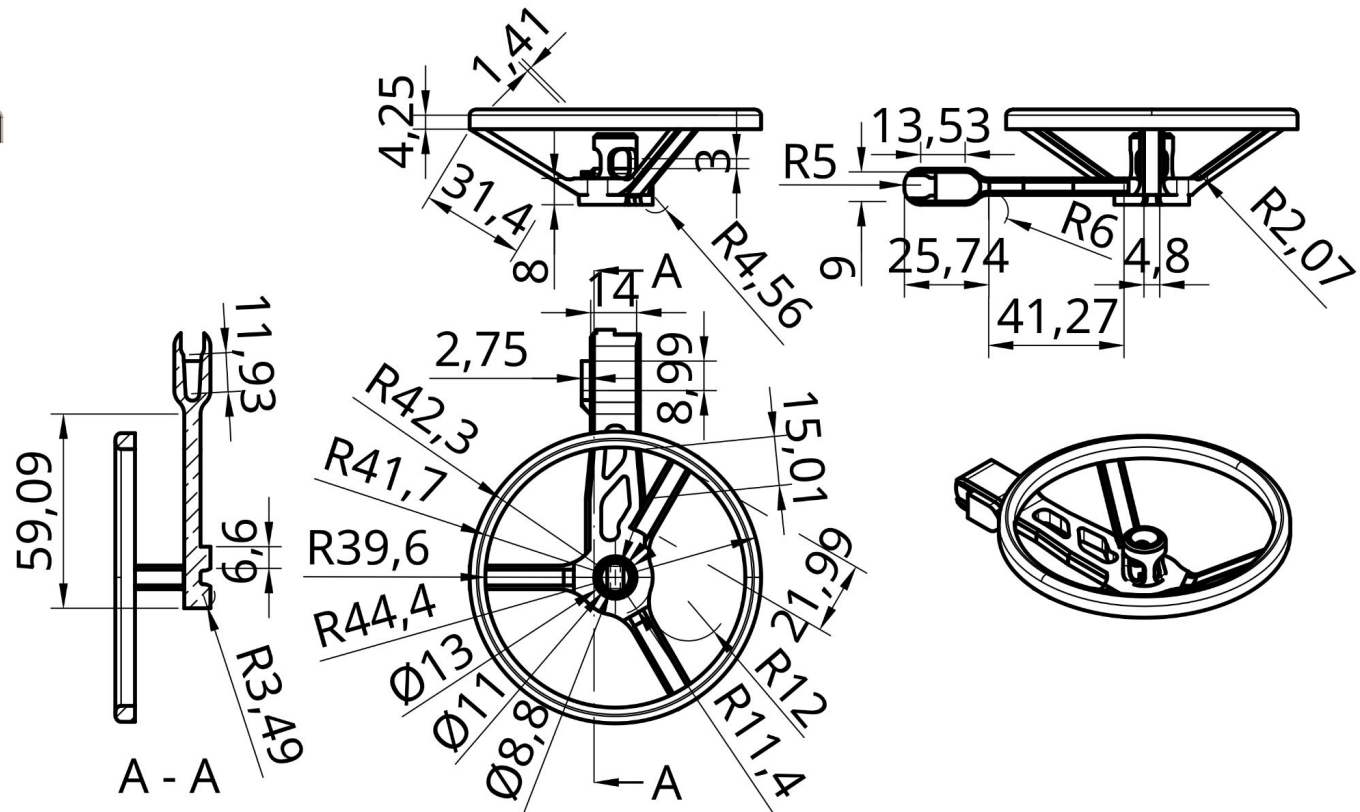
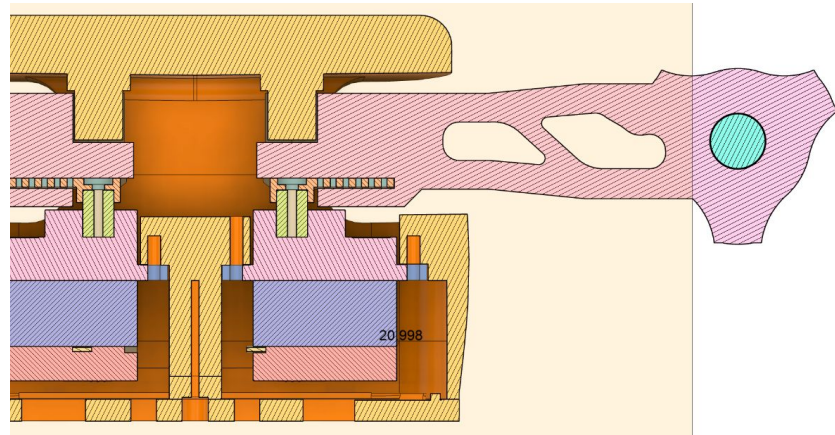
x2 (mirrored)



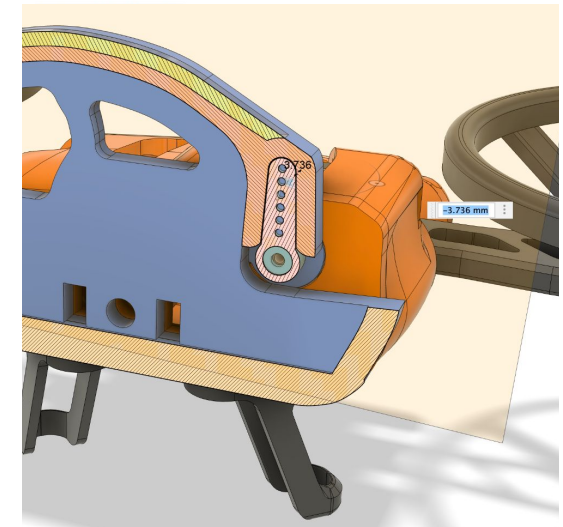
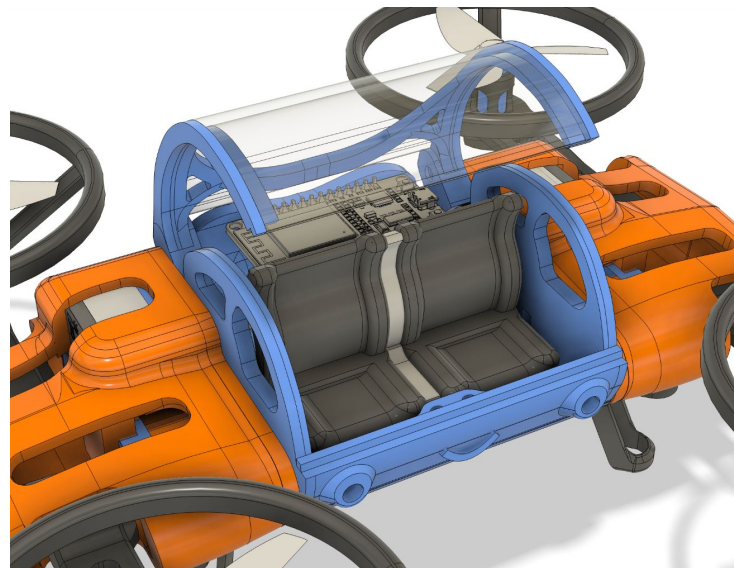
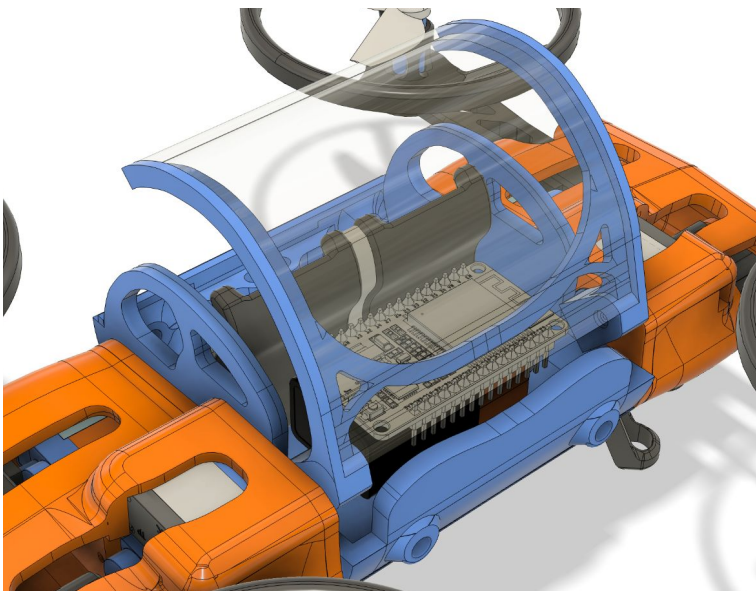
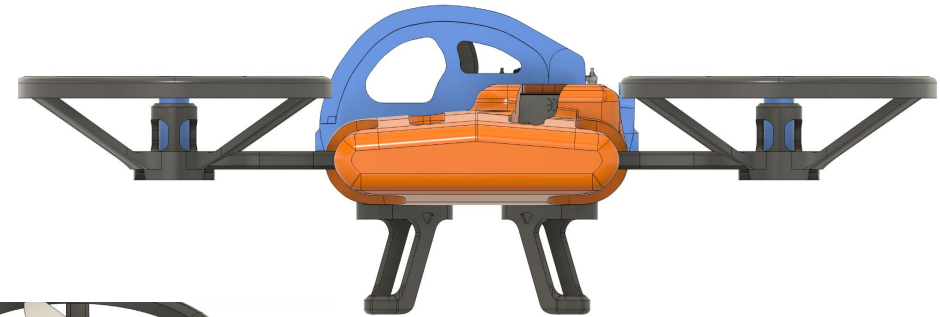
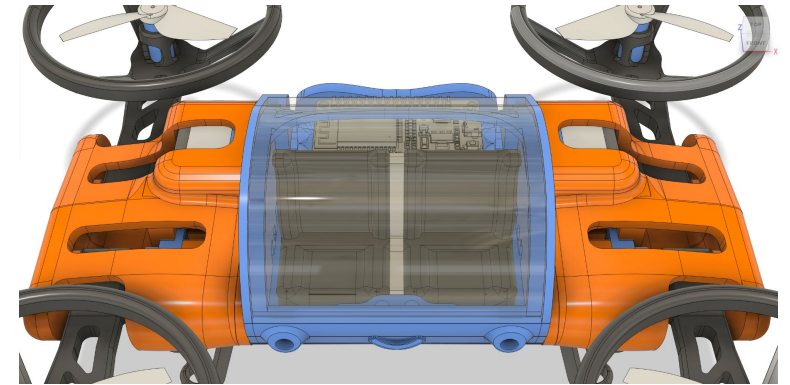
This will secure in place with an interference snap-fit joint and then will be later secured by an M3 screw running through

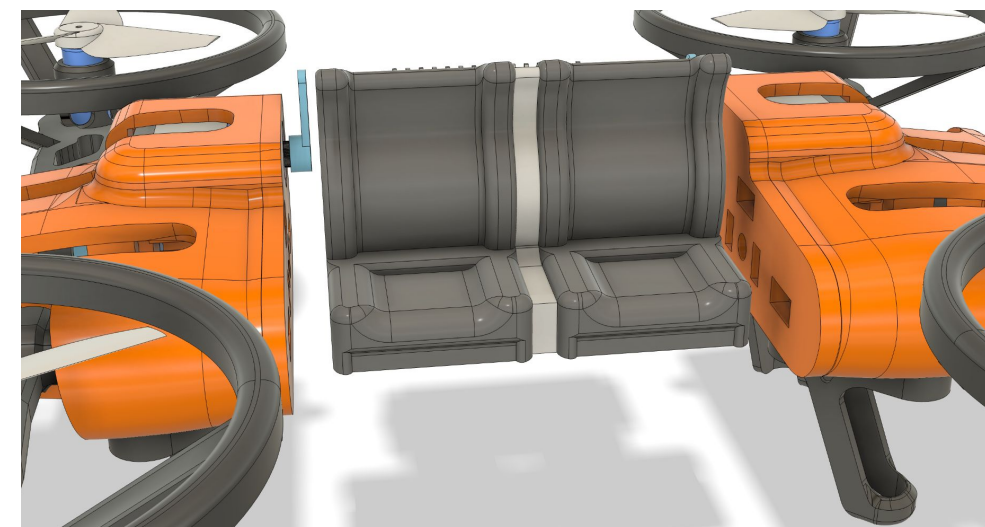
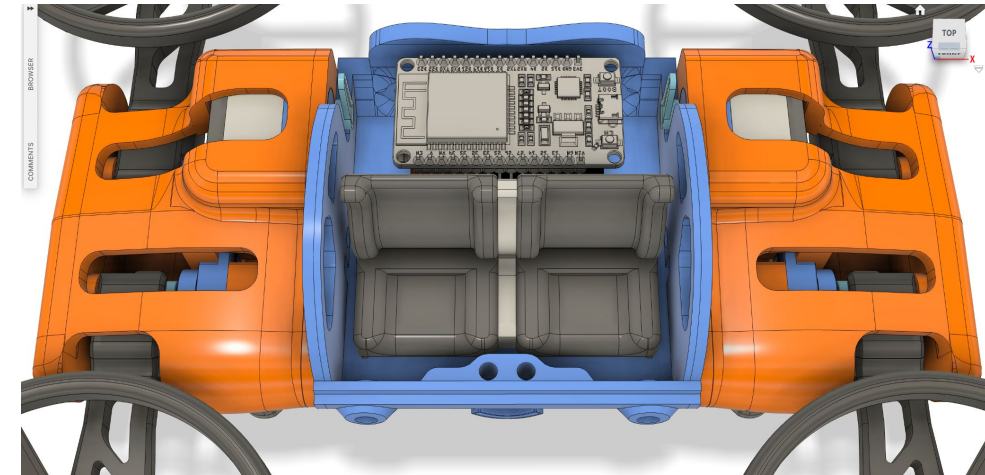
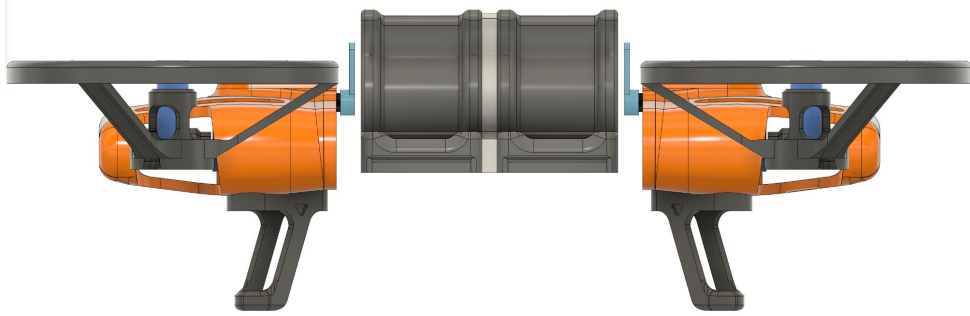
LC 2025 - 247124

Technical drawing showing a cross-section of a mechanical assembly. The assembly consists of a brown base with a yellow hatched section, a blue motorized arm, and a pink hatched arm. The pink hatched arm is labeled with the number 36.967. The drawing is a cross-section, indicated by the hatching patterns.



x1

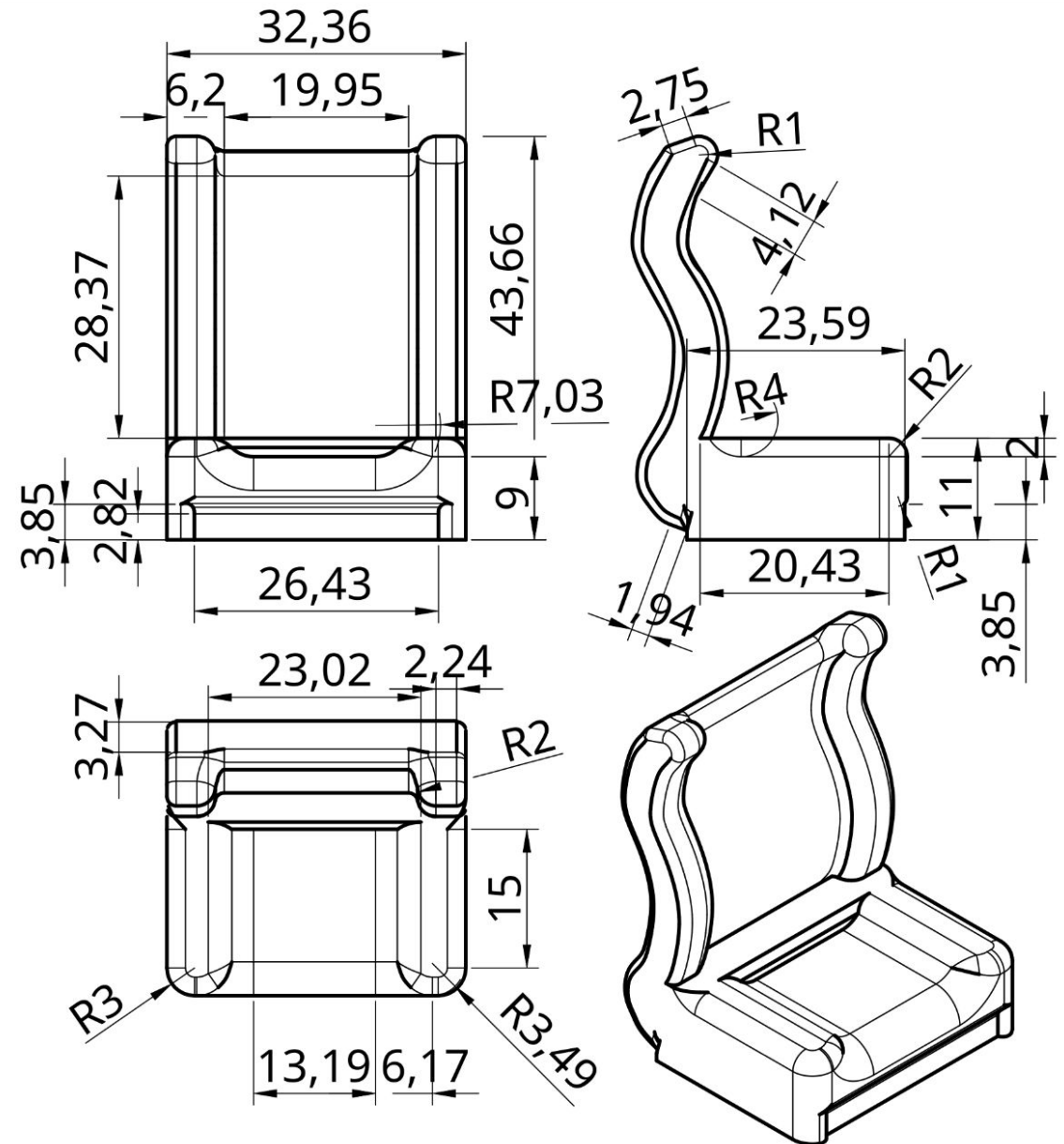




Production Drawings/Plans

Seat

x2



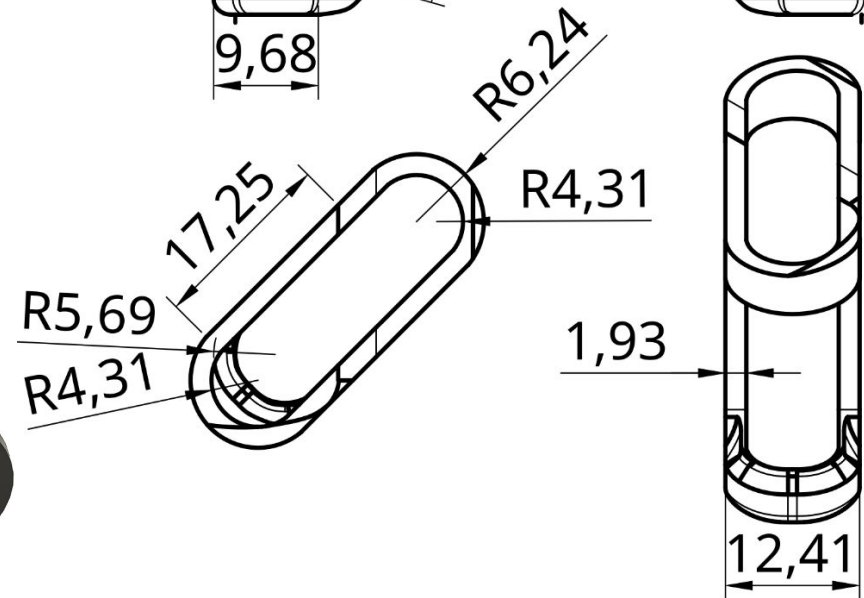
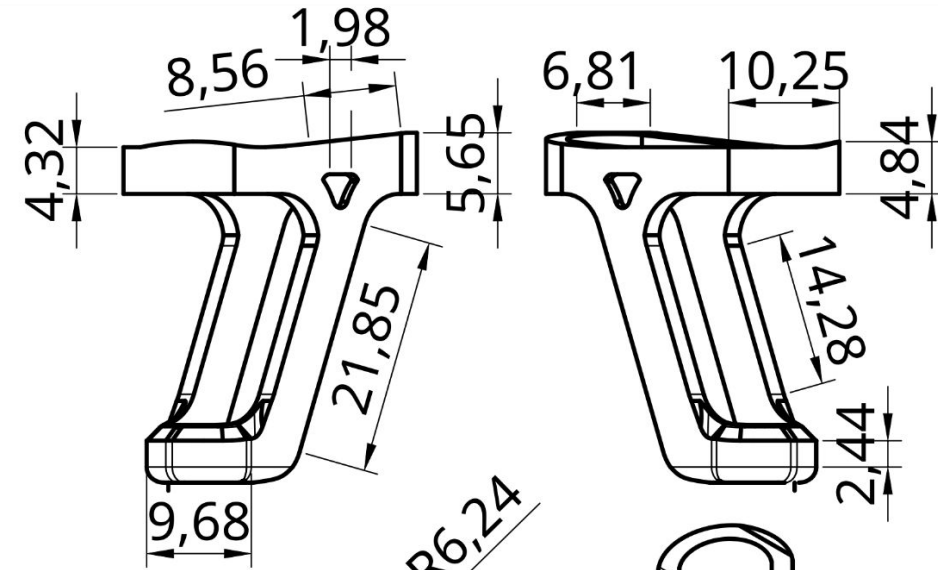
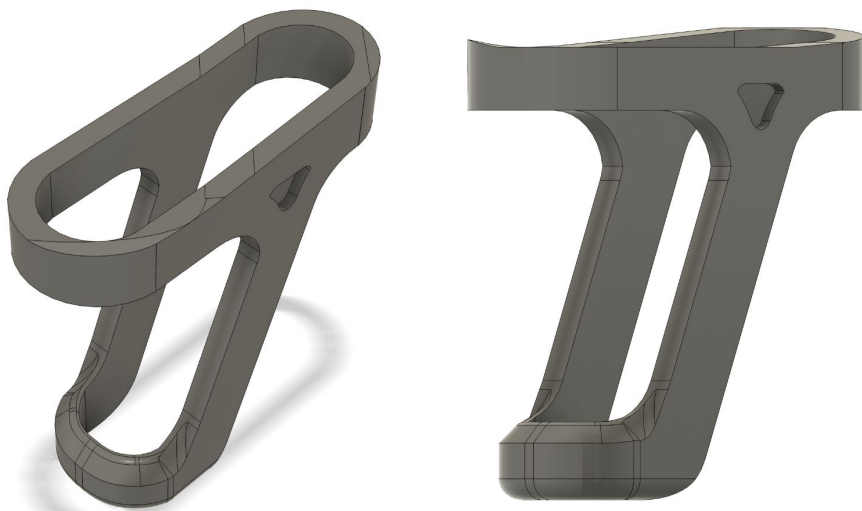
Seats to be attached to the base with two M3 threaded inserts and bolts

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Production Drawings/Plans

Leg

x4 (mirrored)

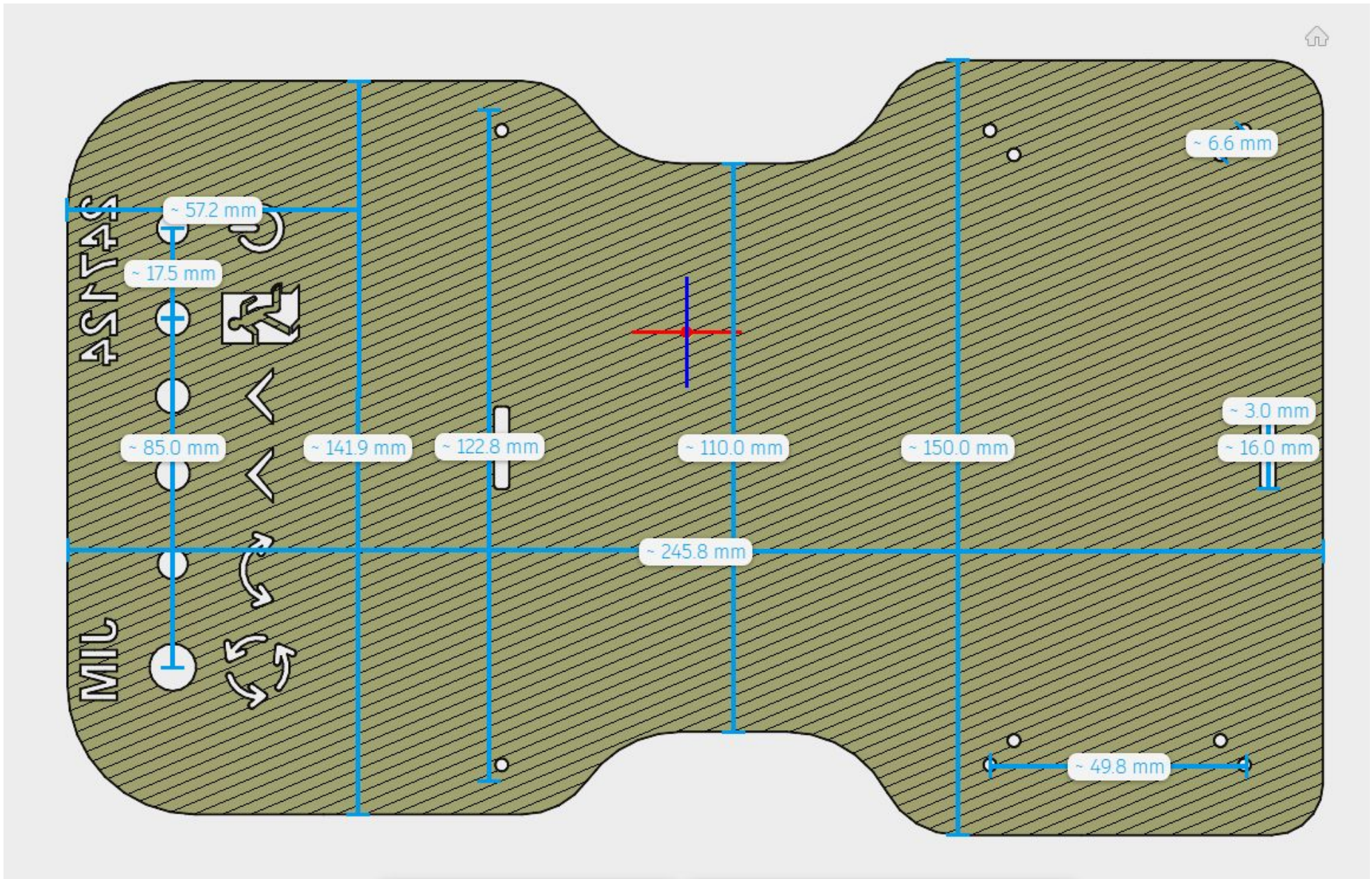


Press-fit assembly



Production Drawings/Plans

User Interface Acrylic Base



Production Drawings/Plans

Cutting List & Materials

Windscreen and base were laser cut from clear polycarbonate and black acrylic sheets respectively.

Brass stand-off legs were manufactured by me from 15mm X Ø10mm brass lengths.

All 3D Printed parts were made with white and orange PLA using our Engineering room's Creality K1 Max (except for the central body which was printed using green PETG).



Printer Image source:

<https://www.matterhackers.com/store/l/creality3d-k1-max-large-high-speed-3d-printer/sk/MPVPDE6C>

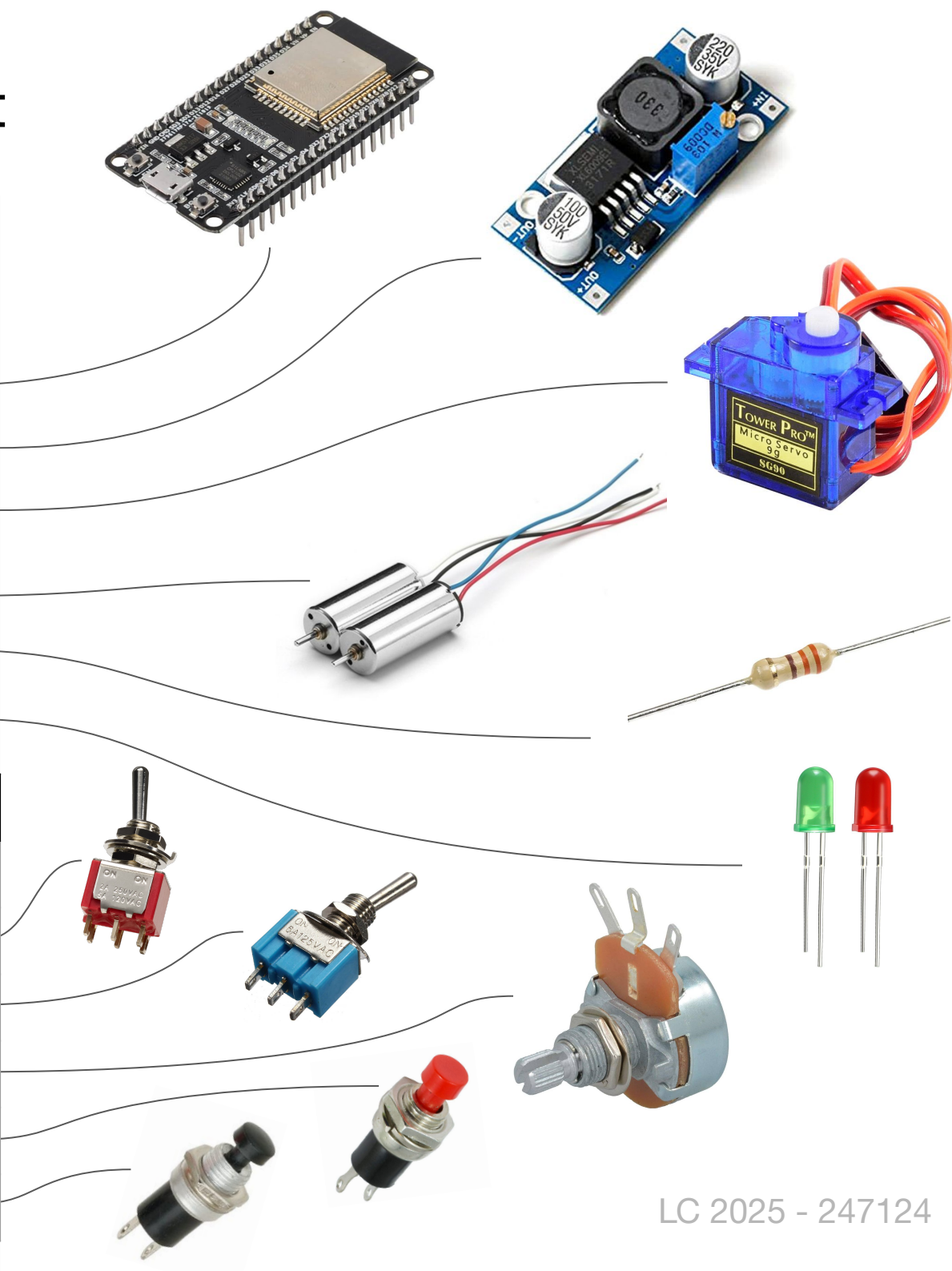
Production Drawings/Plans

Electronic Component List

I sourced all components from our school's Engineering room.

VTOL Assembly	
QTY	Component Name
1	ESP32-WROOM 32 DevKit
1	XL6009 DC-DC Buck Boost Converter
6	SG90 Micro Servo
4	8520 Magnetic Micro Coreless Motor
2	330Ω Resistor
4	LEDs (2 Red, 2 Green. FAA Compliant)

User Interface	
QTY	Component Name
1	DPDT 2-position Switch
1	On/Off Toggle Switch
1	Potentiometer B50Ω
2	Push-to-make Button (red)
1	Push-to-break Button (black)



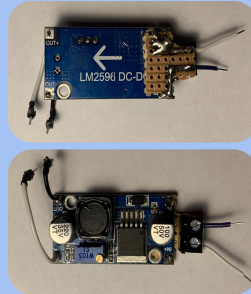
Production Drawings/Plans - Electronics

Complete Wiring Diagram

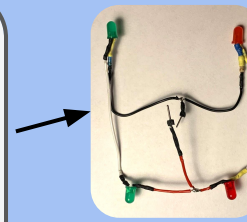
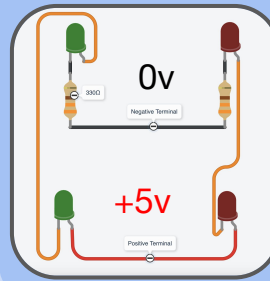
Code Execution Flowchart

Smaller sub-circuits

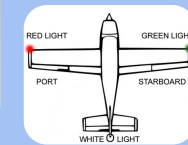
9v→5v Converter



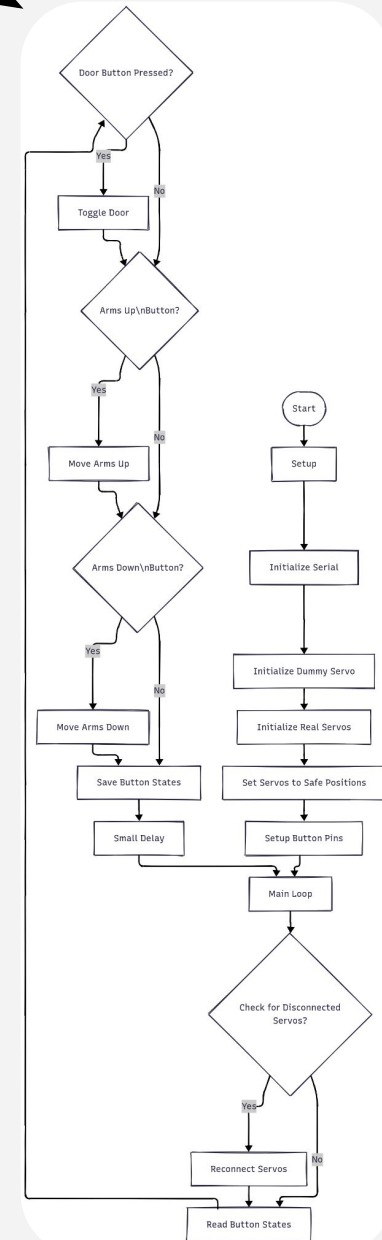
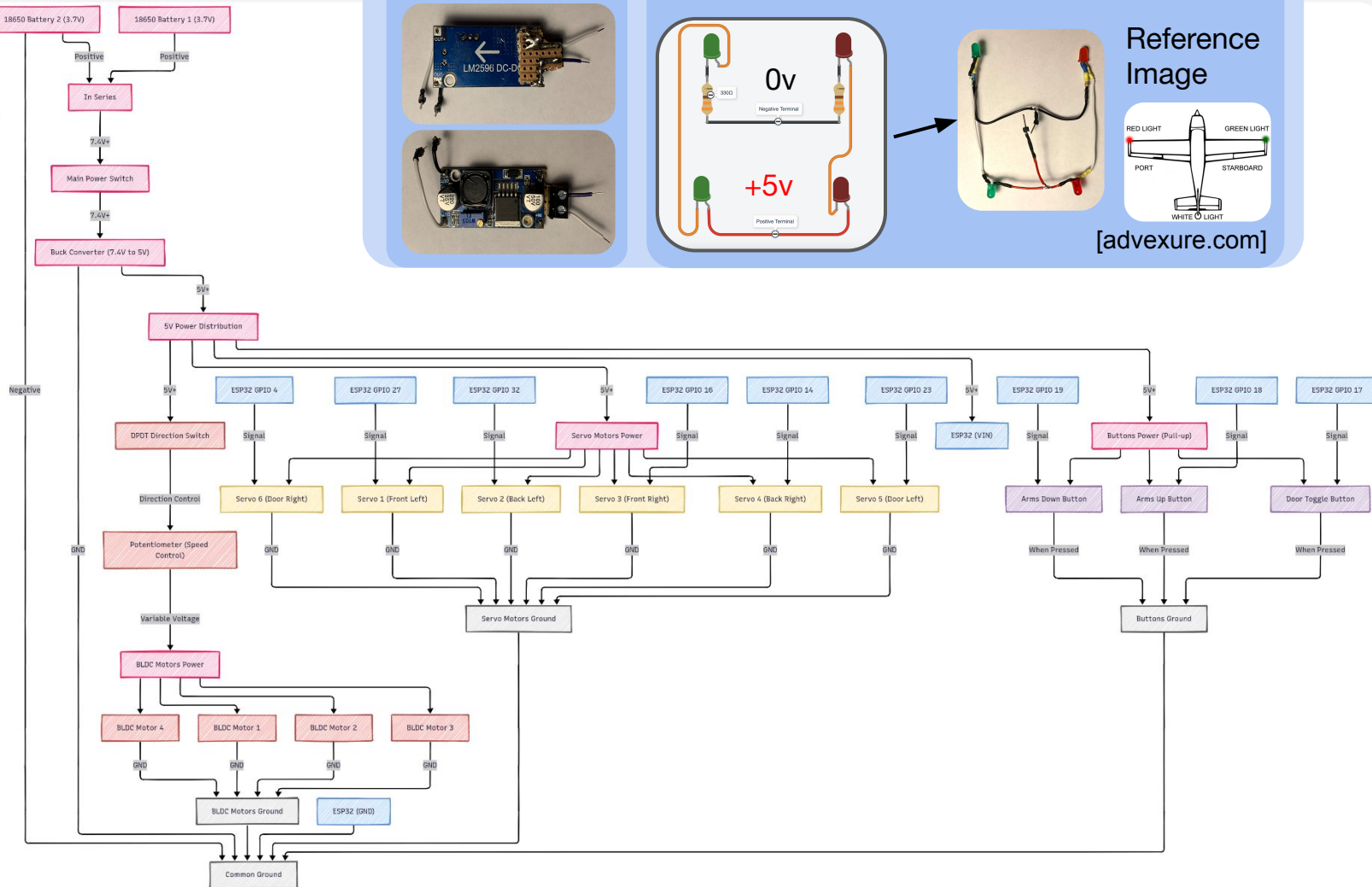
LED Circuit



Reference Image



[advexure.com]



Electronics Assembly Sequence Plan

1. Assemble DC→DC converter, test

2. Assemble the LED array, test

Due to different resistance between the LEDs
I had to make 2 different parallel circuits

3. Create +5v, GND power rail

4. Install pin connectors for servos

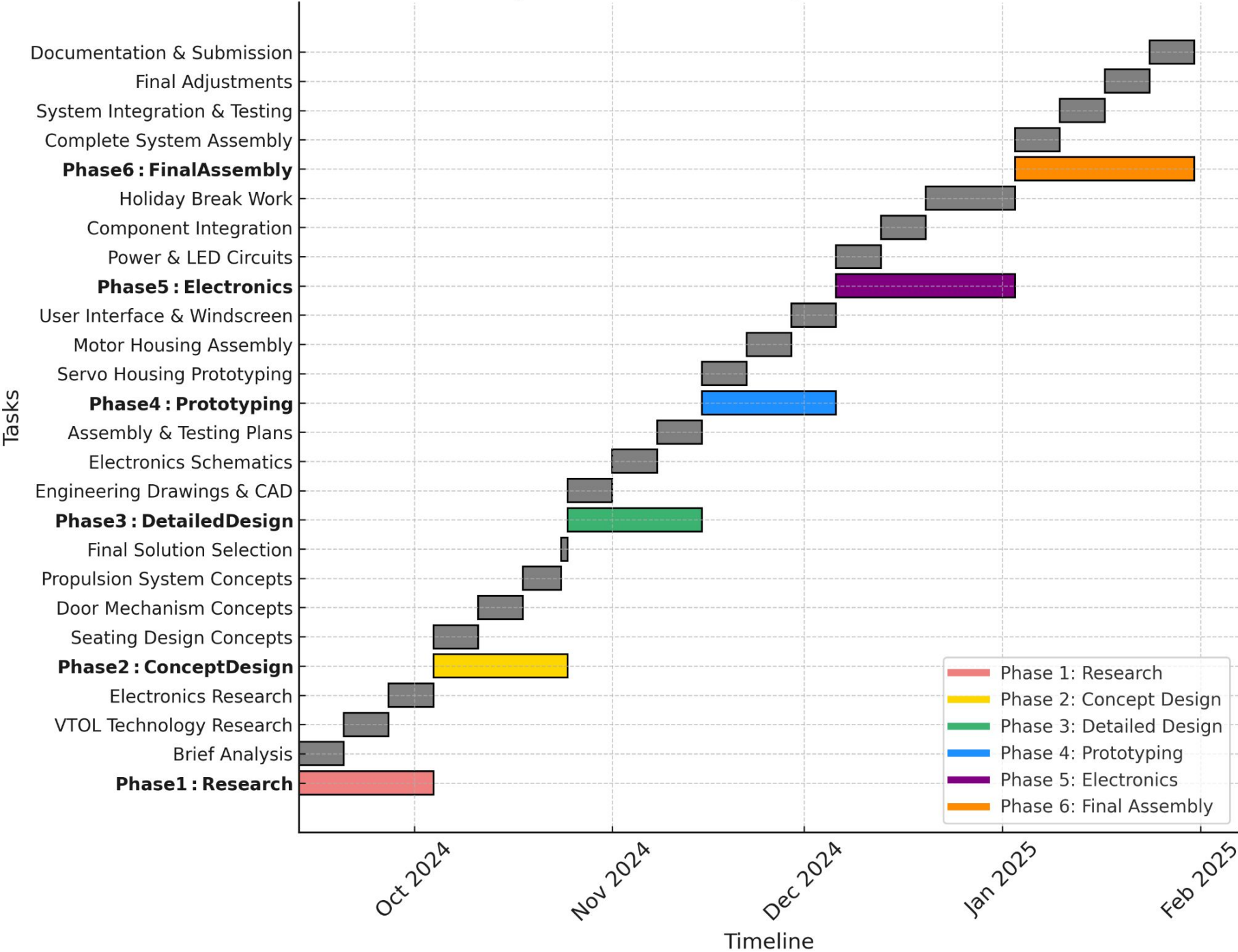
5. Mount servos in enclosure, program

6. Install user interface and test

Time Management

Production Drawings/Plans

JIM VTOL Drone Project Gantt Chart

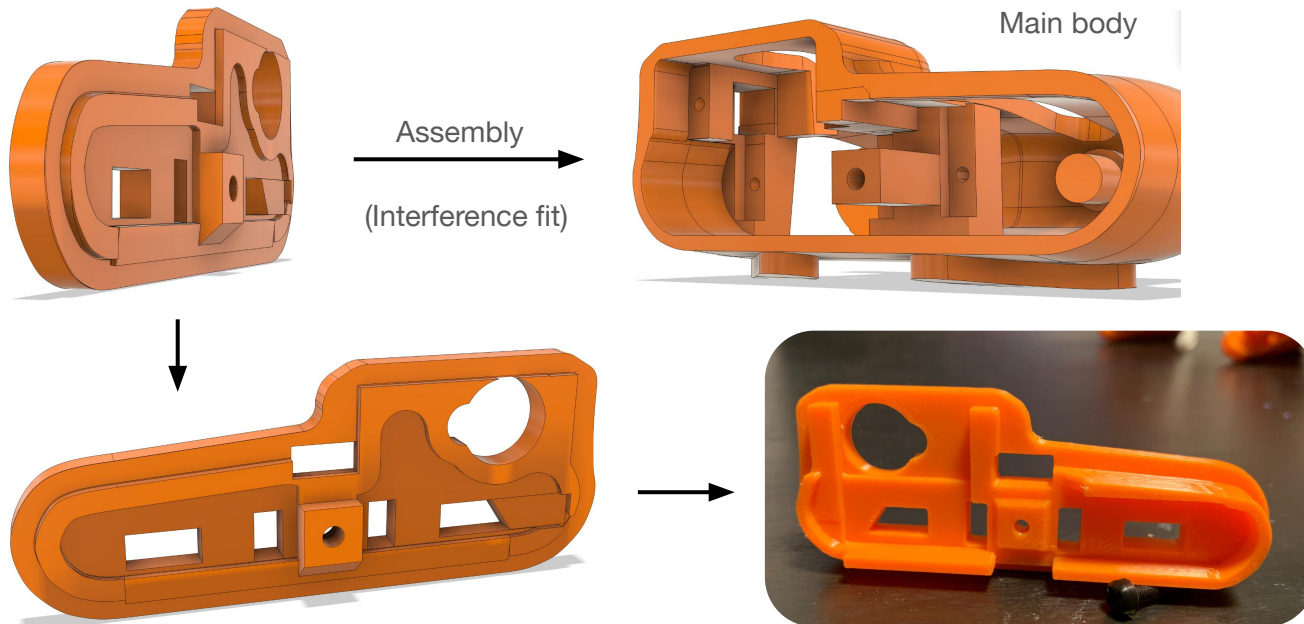


Testing & Evaluation - Servo Motor Housing Cover (Press-fit)

Problem: *The press fit cover was too loose and kept sliding out of place when I assembled the first version of the servo assembly.*

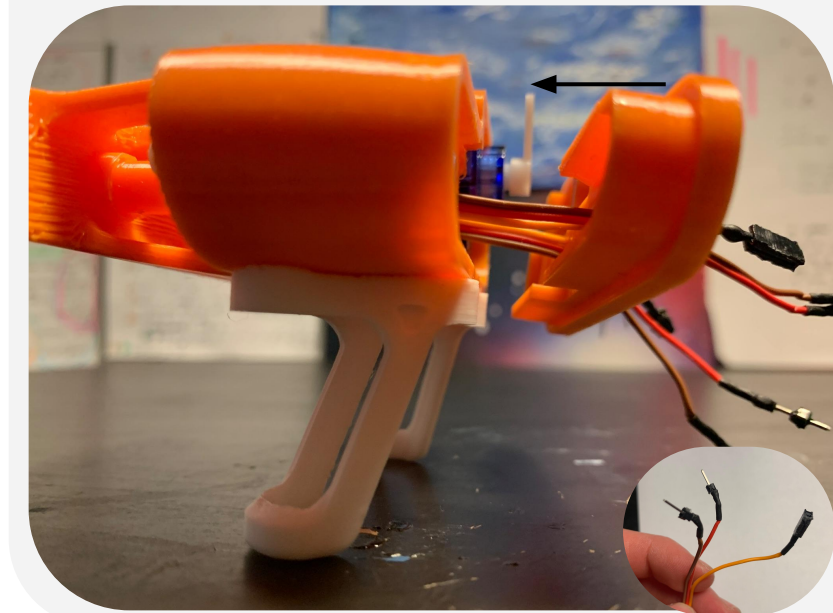
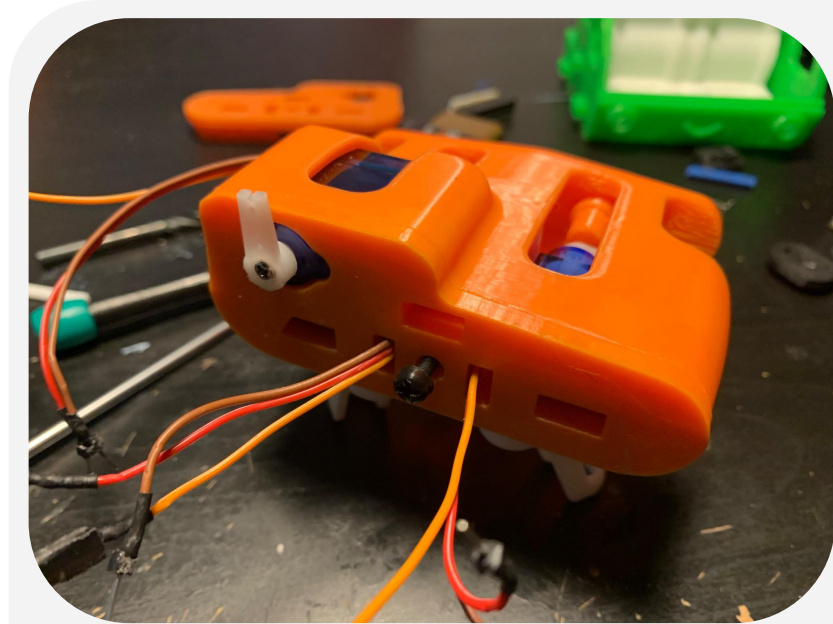
Description: After printing the cover for the servo housing, I quickly realised that I needed to extend the press-fit interface further into the main body. When assembled, the first iterations fell out with very little effort and the tolerance was too large. I extended the edges by $\approx 12\text{mm}$, and reduced the tolerance from 0.2mm to 0.15mm . I learned that accurate tolerances for press-fit joints is crucial.

Evaluation: After three of prototypes, *I reduced the tolerance and extend the interface between the cover and housing for a tighter fit.*



v1 - loose fit, easily fell out

v2 - tighter tolerances, secure fit

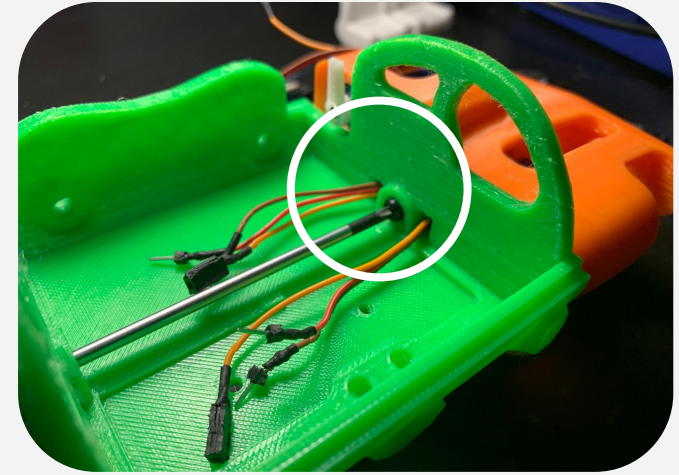


Testing & Evaluation - Motor Housing Assembly

Problem: I had initially planned on using nylon screws for securing the motor housing assemblies to the central (green) body, as they were readily available. However, these screws ended up shearing and didn't connect the halves securely enough to the central body.

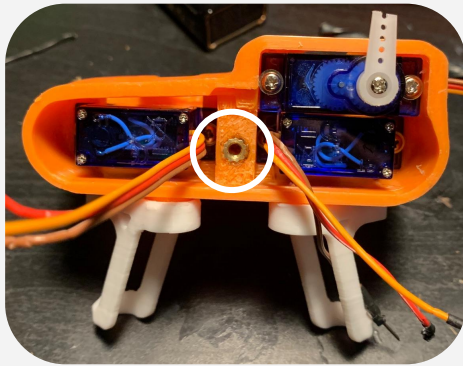
Description: To address this problem, I had to disassemble the drone and swap nylon fixing-screws for aluminium. It proved far more secure

Evaluation: The motor housing assemblies fitted securely to the central body and the heads of the bolts no longer sheared off their threads.

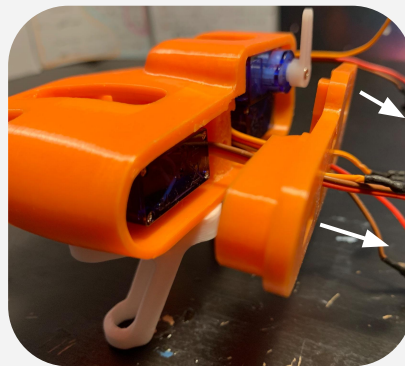


Nylon screws were problematic

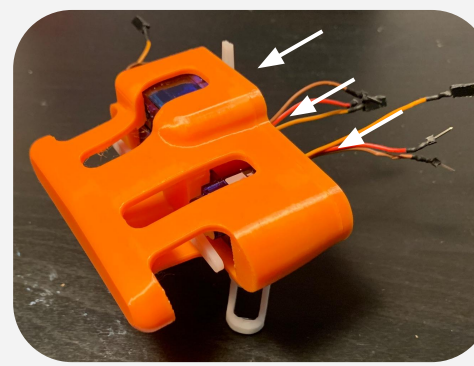
Assembly of Servo Housing Unit



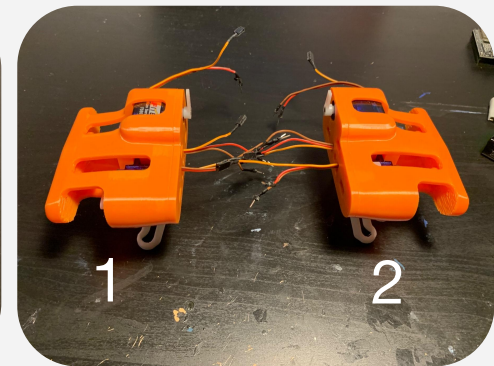
Threaded insert



Thread wires

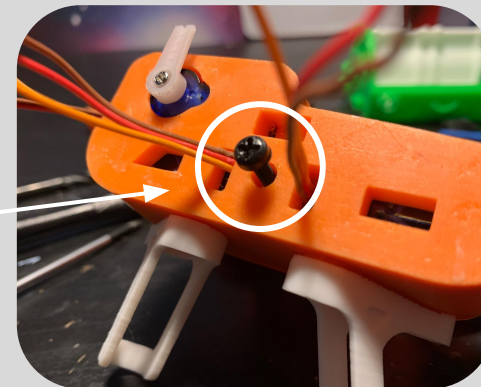
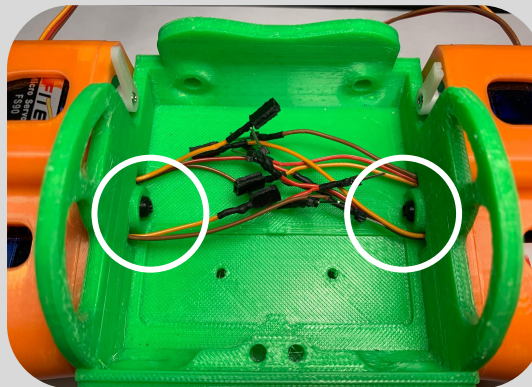
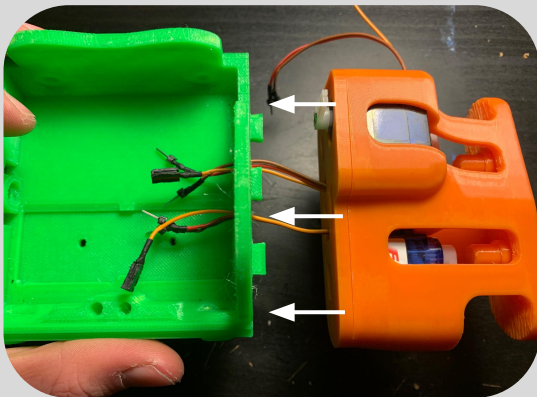


Press fit cover



2 symmetrical units

Assembly of Servo Housings and Body



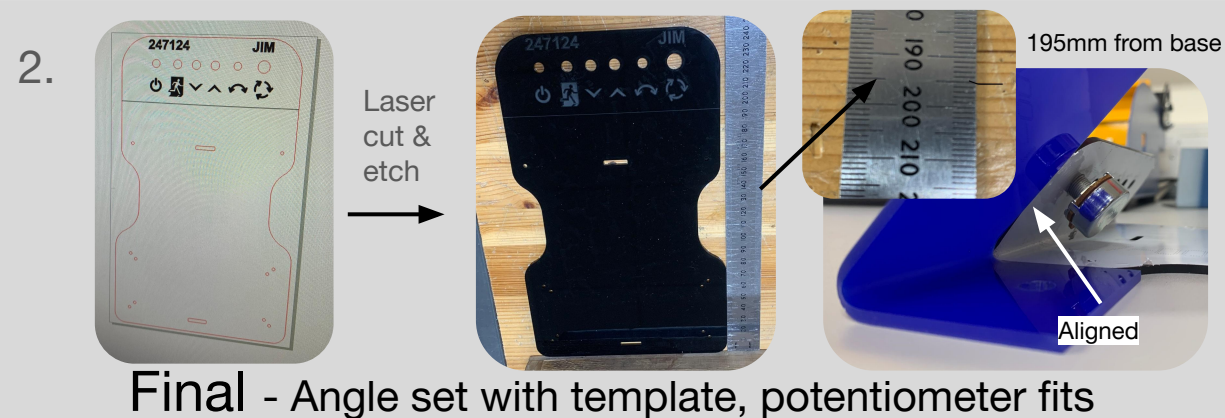
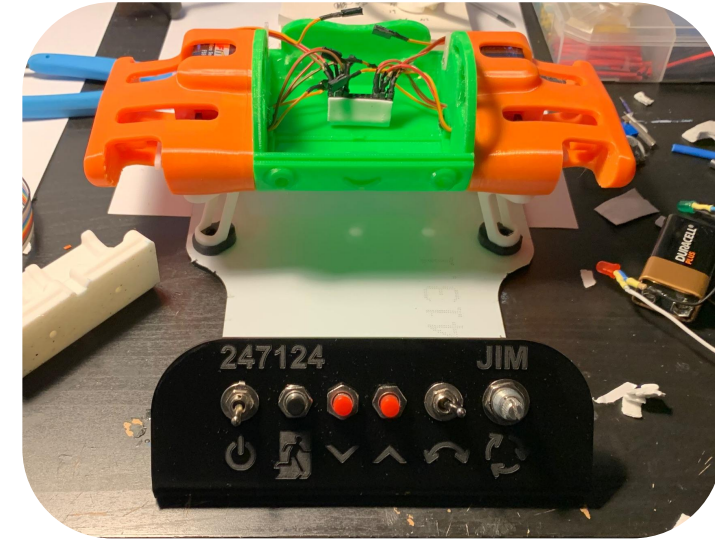
The fixing screw fits to the brass threaded insert inside the housing

Testing & Evaluation - User Interface Acrylic Base

Problem: In making this acrylic base, I had to make sure that the bended edge would leave enough space for the large potentiometer behind it.

Description: To address this problem, I made multiple prototypes with differing lengths of the rotated face and bend angles. I eventually found a set angle which both allowed enough space and maintained aesthetics.

Evaluation: I finally had a suitable template, whose dimensions I then copied and used in the final design of my acrylic user interface.



Testing & Evaluation

- Windscreen

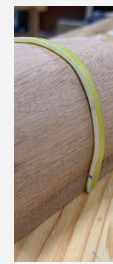
Problem: I wanted to make a windscreen through bending a laser cut clear polycarbonate sheet with a blowtorch but it kept forming bubbles.

Description: I first tried using a blowtorch, and after excessive bubbling I chose to use a crafts heat-gun, this fixed the issue of the wooden former starting to set on fire. I also used G-clamps to hold it in its correct position. I had tried holding the polycarbonate to the wood with an aluminium bar to prevent scratching but that heated up and caused some of the earlier versions to melt. I secured it to the main body with acrylic glue.

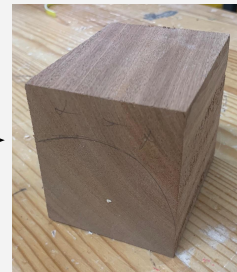
Evaluation: I now have a complete windscreen for the main door of my VTOL aircraft, after a number of prototypes and plenty learning.



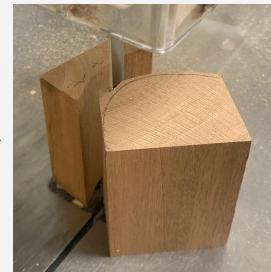
1
2
3
4



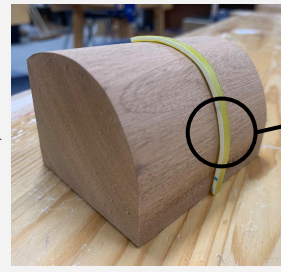
Laser-cut template



Mark outline using the laser cut guide



Cut with band saw



Sand final shape with belt sander

I laser cut this as a marking guide for the wood.

I then laser cut the polycarbonate sheets, for the windscreen itself



Butane blow torch



Test 1: too much heat



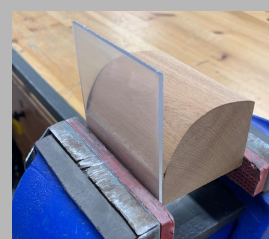
Test 2: former burnt



Test 3: ruler dented

Heat gun

Due to excessive bubbling and fires I chose to use a heat gun. This worked with the first test piece, and no excessive bubbling



I firstly bent it into shape using my hands, slowly



I then used G-clamps to hold it in position as I continued to heat and press it into its shape.



x2
→

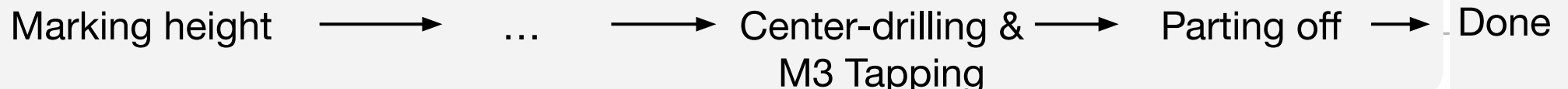
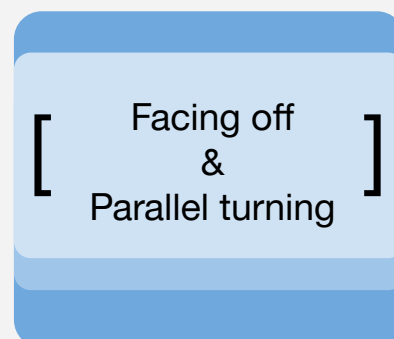
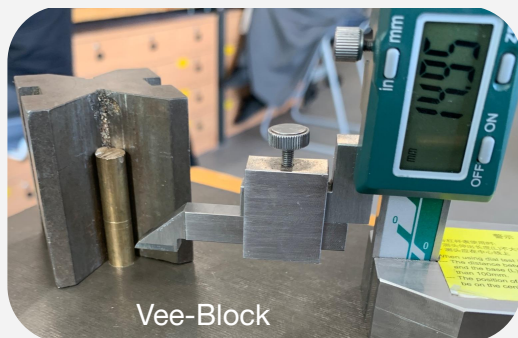
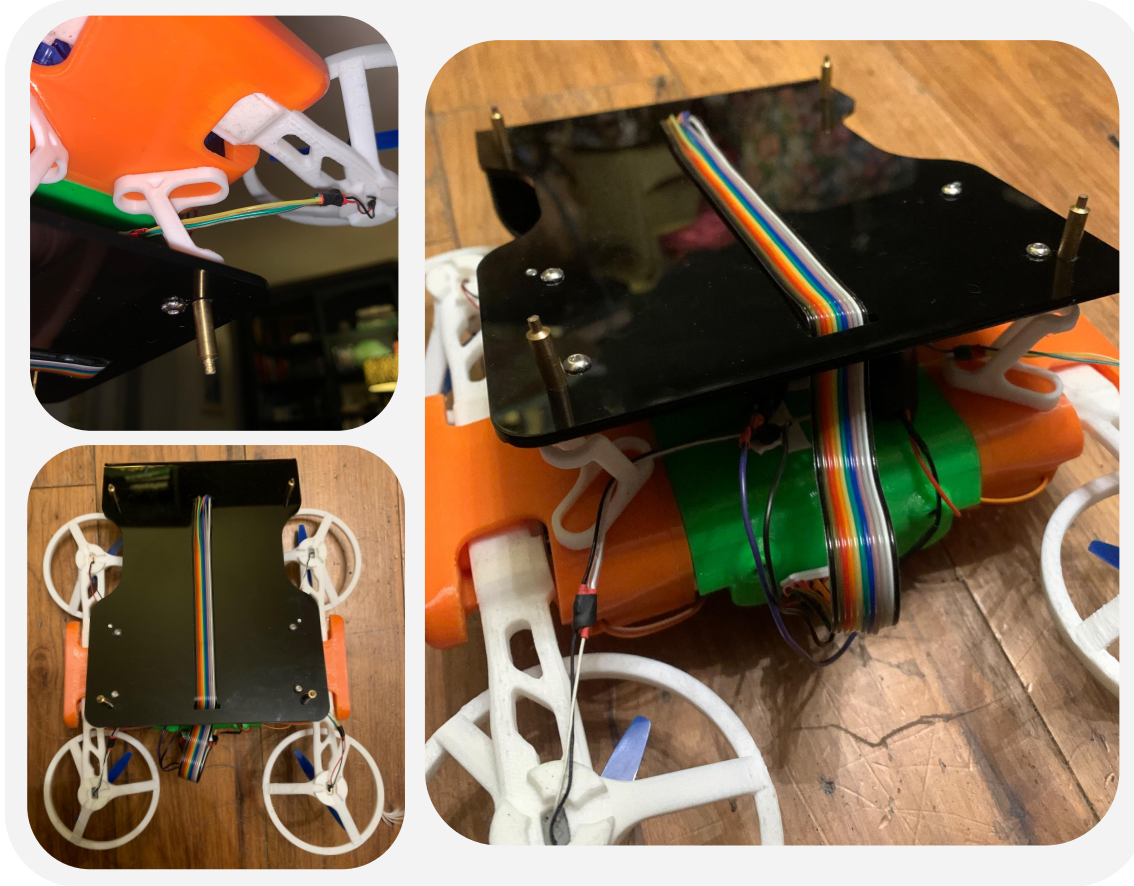


Testing & Evaluation - Standoff Legs

Problem: I needed short and stable mounting legs for my acrylic base.

Description: To address this problem, I turned 4 brass legs on the lathe. Each leg has an external diameter of 4.5mm. I center-drilled each with a diameter of 2.5mm and tapped each with an M3 die. The parting off tool created a slight tapered end which I chose to keep because it brought the legs a more aesthetically pleasing shape.

Evaluation: The legs screw into the base and onto the bolts which also hold the standing legs for the drone itself.



Testing & Evaluation - Power Supply

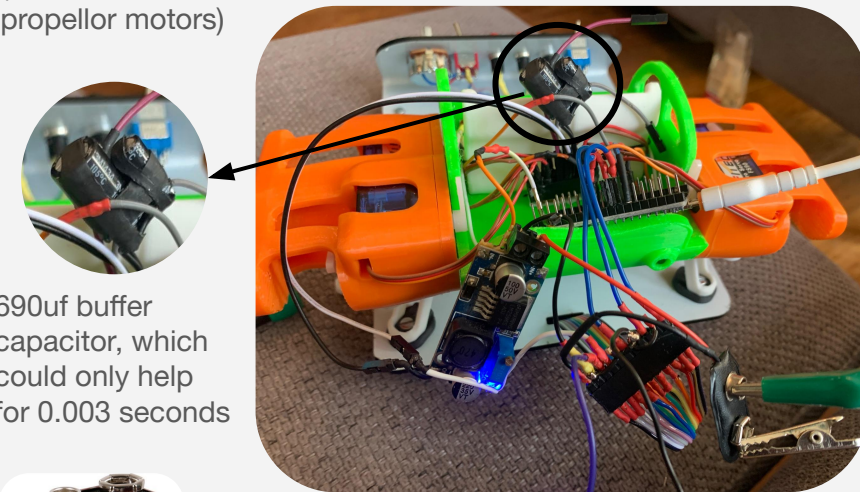
Problem: When powered from battery, either on power up, idle, or when all motors tried to move, the voltage would dip and then drop beneath the threshold for the esp32 and cause it to experience brownout and prevent undervoltage, and then when it stopped driving the servos it would then try drive them again and get caught in this endless loop. I needed a (far) higher current power supply.

Description: I had first planned on using a 9v battery to power my entire project, this did not work. 9v batteries have a maximum current of approximately 500ma. From my testing I realised that we would need approximately 7 continuous amps! I then tried powering it directly with my 20,000mah portable charger, which could provide about 2.4amps, it got further into the boot animation and then would start looping again. I had considered and explored using capacitors to smooth these dips, which I thought were momentary. However, I found that just having all servos turned on was drawing close on 7 amps when the arms were moving while the door opened. This is excluding the 8050 motors, each of which can draw $>1A$! I ultimately chose to power the project with two 18650 cells and step their combined total of 7.4V down to 5V. Each can provide 5-10A.

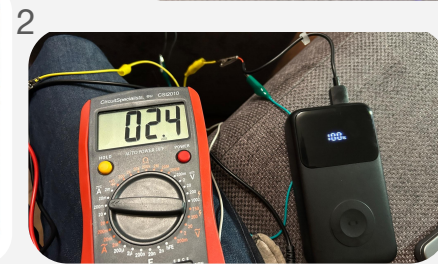
Evaluation: While initially I thought that I could have powered the entire project with just a 9v battery, I quickly realised that I would need about 18 in parallel for it to work. Instead the 18650 rechargeable cells work excellently. For powering the microcontroller, I connected the 7.4v of the cells to the usb input of the ESP32 devkit board, who's onboard voltage regulator is designed for between 7-12v.



Typical peak continuous current draw. (Excluding propellor motors)



690uf buffer capacitor, which could only help for 0.003 seconds



9V bat.: 0.5A Power bank: 2.5A

after which the voltage dropped below 4V and the ESP32 boot-loop cycle began.

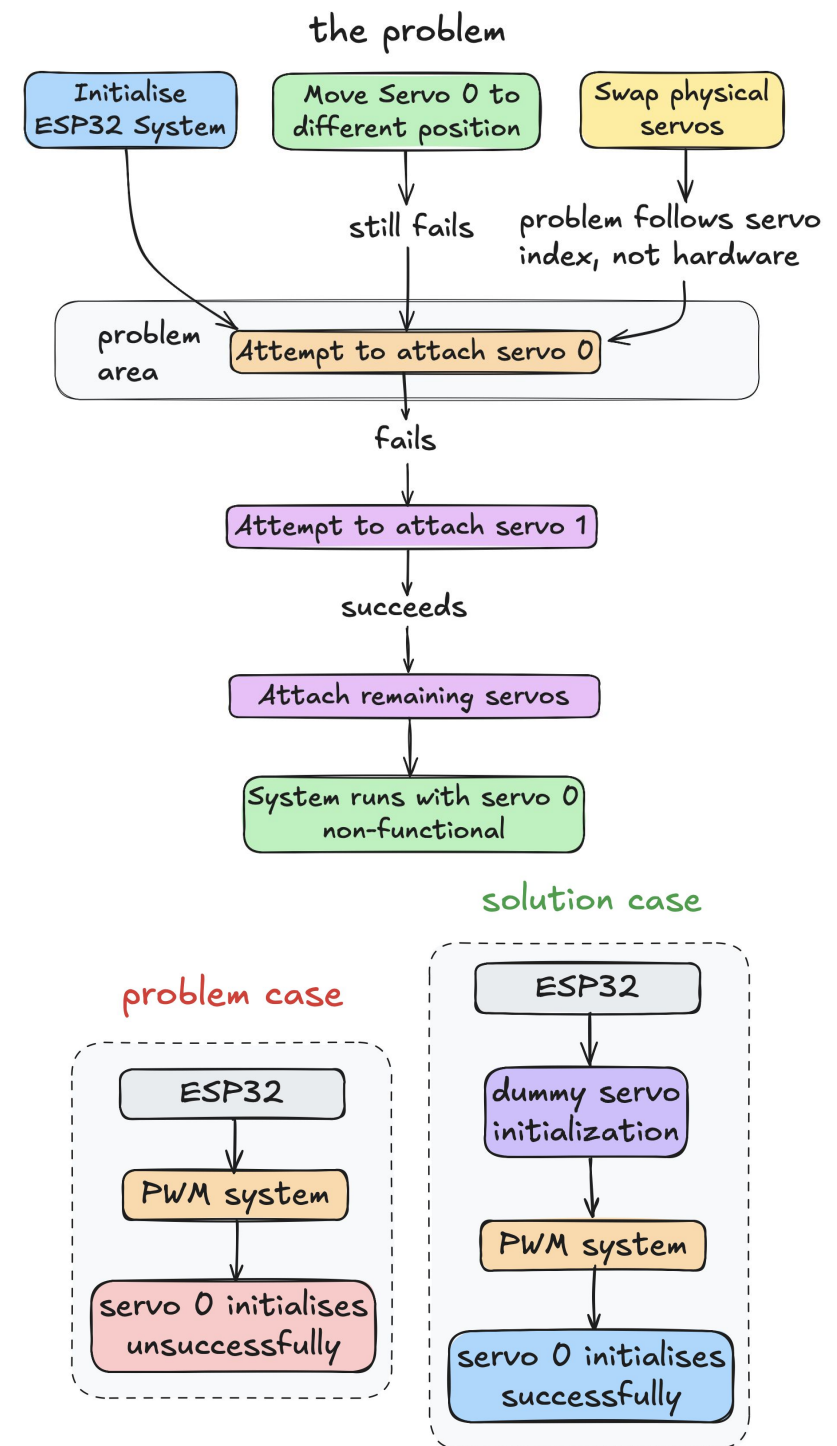
18650 cells:
 $<10-20A$!

Testing & Evaluation - The Case of the Missing First Servo (software issue)

Problem: When initializing multiple servos on the ESP32, the first servo in the array consistently failed to connect, regardless of which physical servo or pin it was connected to, while all other servos worked fine.

Description: Through systematic troubleshooting, I discovered the issue wasn't with specific hardware but with how the 'ESP32Servo' library initializes. I tried swapping servos, and allocated pins and the problem still persisted. The first servo to initialize triggers critical one-time setup of the PWM system. By creating a "dummy" servo that absorbs this problematic first-time initialization but isn't actually used in the system, I was able to bypass the issue entirely.

Evaluation: All servos now connect reliably, including the previously problematic first servo. This solution required minimal code changes while maintaining full functionality, proving that sometimes the elegant answer to a complex technical problem isn't replacing hardware or extensive redesign, but understanding and working with the initialization sequence of the system.



Testing & Evaluation

Does it meet the brief?

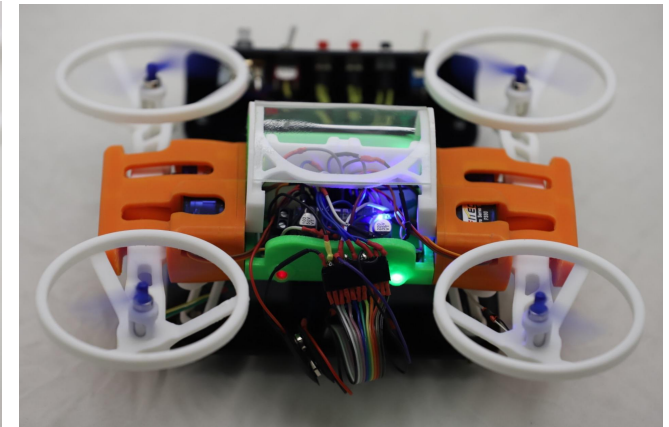
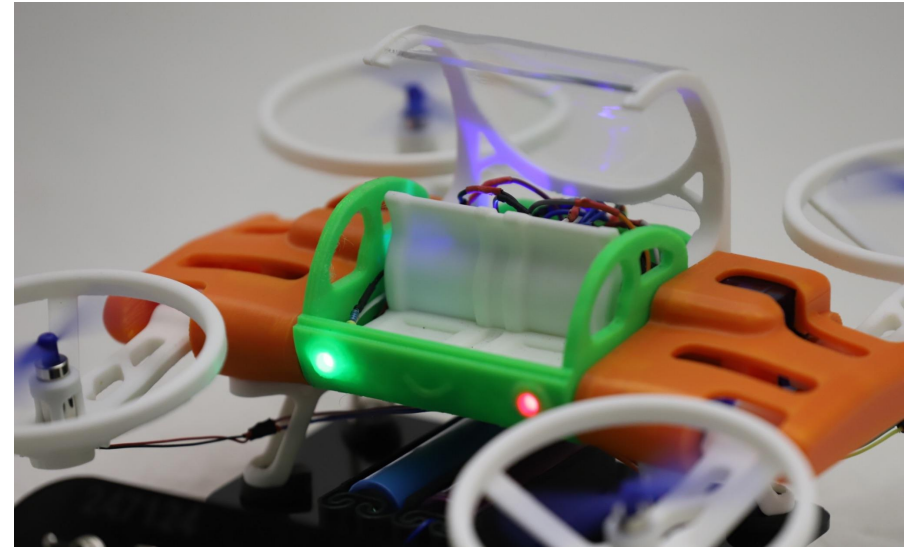
Requirement	Analysis	Verdict
a) Fuselage Compartment	J.I.M does indeed feature a fuselage component which houses both all of its electronics and seating arrangements.	✓
b) Seating for Pilot and Passenger	J.I.M includes two seats, for both a passenger and pilot.	✓
c) ≥ 4 Electronically Operated Motors	J.I.M features 4 8050 brushed DC motors for propulsion and 6 servo motors for controlling its door and arm positions.	✓
d) Include an Automated Door	The VTOL aircraft does include a prominent automated door attached to a sweeping polycarbonate windscreen which protects the pilot and passenger when flying.	✓
e) All Main Operating Features Clearly Visible Without Dismantling	I have included cut-outs where necessary and ensured that all elements of operating features and electronics are clearly visible.	✓
f) Longest Dimension $\leq 400\text{mm}$	Verified with a steel rule. The VTOL aircraft fits within a 400mm cube, as required.	✓
g) Voltage Does Not Exceed 9 Volts	The two 18650 batteries in series sum to a total maximum voltage of +7.4v, the buck converter steps this down to 5v. I have verified with my digital multimeter that the limit is not exceeded.	✓

Testing & Evaluation

Conclusion

In conclusion I believe that I have successfully created a fully operational VTOL aircraft which aligns with the brief's design requirements.

This involved a considerable amount of planning and prototyping but I'm satisfied with the final result.



All graphics, code and models throughout this project were made by me. :)

Bibliography and sources

VTOL Jet Research

VTOL Drone Images (all secondary sources)

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2. [Future-ready design of the Transwing eVTOL has a dihedral folding wing system](#)
3. [Everything You Need to Know About VTOL Aircraft - Orbitshub](#)
4. [What is the connection between the tragic Yak 141 fighter, also a vertical take-off and landing fighter, and the F-35? - iNEWS](#)
5. <https://www.gadgets360.com/transportation/news/air-taxi-startup-lilium-stages-test-hover-of-5-seater-prototype-2038517>
6. [Joby Aviation - Wikidata](#)
7. [Flight GlobalSOCOM looking for new high-speed vertical take-off and landing aircraft | News | Flight GlobalSee exact matches](#)
8. [RAF Families Federation](#)
9. [Moritz Gruber – Working Student - Materials & Processes – Lilium | LinkedIn](#)
10. [Bell patents novel VTOL aircraft concept | News | Flight Global](#)
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12. [United States Naval Academy](#)
13. [West Germany's Cold War-Era Hovering Jet Transport Just Couldn't Cut It](#)
14. [EEPower](#)
15. [Air & Space Forces Magazine](#)
16. [University of Maryland](#)

Key:

Colour	Image Source
	Primary Photographs
	Hand Sketched
	Secondary (Internet)

Electronics & Components List

Component Images

1. ESP32-WROOM 32 DevKit:
<https://www.google.com/url?sa=i&url=https%3A%2F%2Fshopdelta.eu%2Fdevelopment-kit-esp32-esp-wroom-32-esp8266-i2-p21391.html&psig=AOvVaw1Npi2o-aPhDpdWYxQ2aqFs&ust=1738586538762000&source=images&cd=vfe&opi=89978449&ved=0CBcQjhxqFwoTCLDcwtqBpYsDFQAAAAAdAAAAABAJ>
2. XL6009 DC-DC Buck Boost Converter:
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<https://www.google.com/url?sa=i&url=https%3A%2F%2Fjlawhersebai.com%2Ftutorials%2Fhow-to-use-the-sg90-servo-motor%2F&psig=AOvVaw1npliCwNWrMvOP5kxAXE09&ust=1738408669372000&source=images&cd=vfe&opi=89978449&ved=0CBcQjhxqFwoTCliJy7OoolsDFQAAAAAdAAAAABAE>
4. 8520 Magnetic Micro Coreless Motor:
https://www.google.com/url?sa=i&url=https%3A%2F%2Fhitechxyz.in%2Fproducts%2F8520-magnetic-micro-coreless-motor-for-micro-quadcopters-2xcw-2xcw&psig=AOvVaw39NfEVB_Rli_i59QsB7s5MS&ust=1738586647286000&source=images&cd=vfe&opi=89978449&ved=0CBcQjhxqFwoTCKif142CpYsDFQAAAAAdAAAAABAE
5. 330Ω Resistor:
<https://www.google.com/url?sa=i&url=https%3A%2F%2Fie.rs-online.com%2Fweb%2Fp%2Fthrough-hole-resistors%2F7077622&psig=AOvVaw3EwurZ7ZF3hHaHFAVOC1iX&ust=1738408918934000&source=images&cd=vfe&opi=89978449&ved=0CBcQjhxqFwoTCMjcxILsn4sDFQAAAAAdAAAAABAE>
6. LEDs (2 Red, 2 Green. FAA Compliant):
https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.ubuy.ie%2Fen%2Fproduct%2F1J19L10VC-uxcell-40pcs-2-colors-x-20pcs-5mm-red-green-led-diode-lights-colored-lens-diffused-round-20ma-lighting-bulb-lamp-electronic-components-light-emitting&psig=AOvVaw1LdtWvtw8yWuLX_et5tKwN&ust=1738409094205000&source=images&cd=vfe&opi=89978449&ved=0CBcQjhxqFwoTCQjW-9Xsn4sDFQAAAAAdAAAAABAE
7. DPDT 2-position Switch: <https://www.dimarzio.com/hardware/switches/dpdt-mini-switch-2-position>
8. On/Off Toggle Switch:
https://www.google.com/url?sa=i&url=https%3A%2F%2Fmostelectronic.com%2Fshop%2Fcomponents%2Fswitches%2Fmini-toggle-switch-3-pins-spdt-on-off-6a125vac%2F&psig=AOvVaw0D0wupfUB8J60pcB0v-P68&ust=1738410137873000&source=images&cd=vfe&opi=89978449&ved=0CBcQjhxqFwoTCPjijitw_n4sDFQAAAAAdAAAAABAJ
9. Potentiometer B50Ω:
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10. Push-to-make Button (red):
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11. Push-to-break Button (black):
<https://store.brightcomponents.co.uk/product/2x-momentary-push-button-switch-black-2-pieces/>

Bibliography and sources

Key:

Colour	Image Source
	Primary Photographs
	Hand Sketched
	Secondary (Internet)

Potential Door Mechanisms

Mechanism Images (all secondary sources)

1. Ratchet and Pawl Mechanism:
<https://www.engineersedge.com/mechanical/ratchet-pawl.htm>
2. Bevel Gears Mechanism:
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Fuselage Shape

(all secondary sources)

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<https://www.linkedin.com/pulse/seating-positions-fusionflight-hilre/>
2. Two fighter pilots sitting in tandem while smiling at the camera & The two fighter pilots sitting alongside one another while talking to another technician:
<https://aviation.stackexchange.com/questions/19157/why-do-some-2-seat-fighters-have-side-by-side-seating-while-others-have-the-pil>
3. Two pilots alongside one another, coloured sketch:
<https://www.dreamstime.com/illustration/pilot-plane-cockpit.html>
4. White VTOL on the grass: <https://www.t-drones.com/blog/VTOL-drone-guide.html>
5. Black VTOL with transparent background:
<https://ozrobotics.com/shop/t-drones-tilt-rotor-vtol-drone-with-va17-endurance-up-to-120min/>
6. Concept sketch of the parallel seating fuselage arrangement:
<https://www.pinterest.com/pin/702350504371884785/>

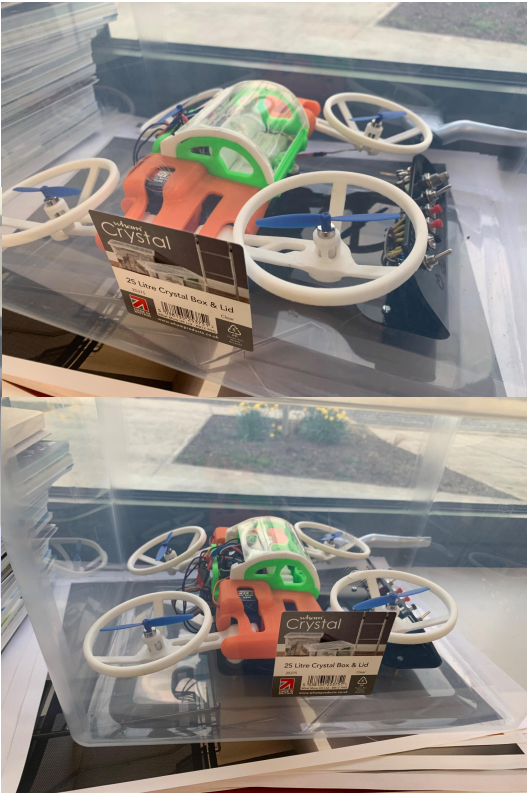
Fuselage Shape

(all secondary sources) [ctd]

7. Minimalist research-paper-sketch of oblong VTOL with the annotations:
https://www.google.com/imgres?q=s sketch%20of%20oblong%20vtol%20drone%20chairs&imgurl=https%3A%2F%2Fwww.researchgate.net%2Fpublication%2F373968243%2Ffigure%2Ffig1%2FAS%3A11431281189045948%401694871179219%2FOverview-of-the-tilt-rotor-VTOL-UAV.ppm&imgrefurl=https%3A%2F%2Fwww.researchgate.net%2Ffigure%2FOverview-of-the-tilt-rotor-VTOL-UAV_fig1_373968243&docid=ONFv5zh7JoJlzM&tbnid=DqjbBIKtuLMM&vet=12ahUKEwjttJaOrpKMAxVDXUEAHbERFjkQM3oECBIQAA..i&w=790&h=560&hcb=2&ved=2ahUKEwjttJaOrpKMAxVDXUEAHbERFjkQM3oECBIQAA

Bonus photos

Thank you to this box



JIM



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