JUNE 2025

NORTHBOARD - TRAIN

ABOUT OUR ROCKET MIRACLE

I, the teacher, and 12 other incredible students

LEAD-IN

We're a team of students from Taipei First Girls High School who share a love for engineering and aerospace. Despite the heavy academic workload, we committed ourselves to this competition. At the beginning, we knew nothing about rockets, there was no related club or course at school, and even our advisor wasn't from this field.

But step by step, we figured things out on our own. We stayed up countless nights designing, running simulations, building structures, tearing them apart, and building them again.

Eventually, we made it to the finals. And from there came a whole new set of stories though the ones from the build phase alone could already fill a book.

This was a group of girls who went all in together, crazy and passionate, in the best way youth can be.

ABOUT OUR TEAM NAME

Our team name, Northboard – Train, is a playful wordplay in Chinese. It sounds like "北上火車" — "northbound train" — which we reimagined as Beiyi Upper Rocket Express, symbolizing our drive to move full speed ahead, carrying our school and rocket to new heights.

03

ABOUT TAIWAN ROCKET CUP

The Taiwan Rocket Cup, organized by the Taiwan Space Agency (TASA), is the first rocketry competition in Asia requiring secondary and university teams to design, build, and launch rockets capable of exceeding 1 kilometer in altitude. In 2025, the event gathered 638 students across 56 teams nationwide. After a preliminary design review and a hands-on rocketry training camp, only 10 high school teams and 5 university teams advanced to the finals. The final launches took place at the Syuhai Launch Site in Pingtung County, where rockets were evaluated for flight performance, system integration, and mission completion.

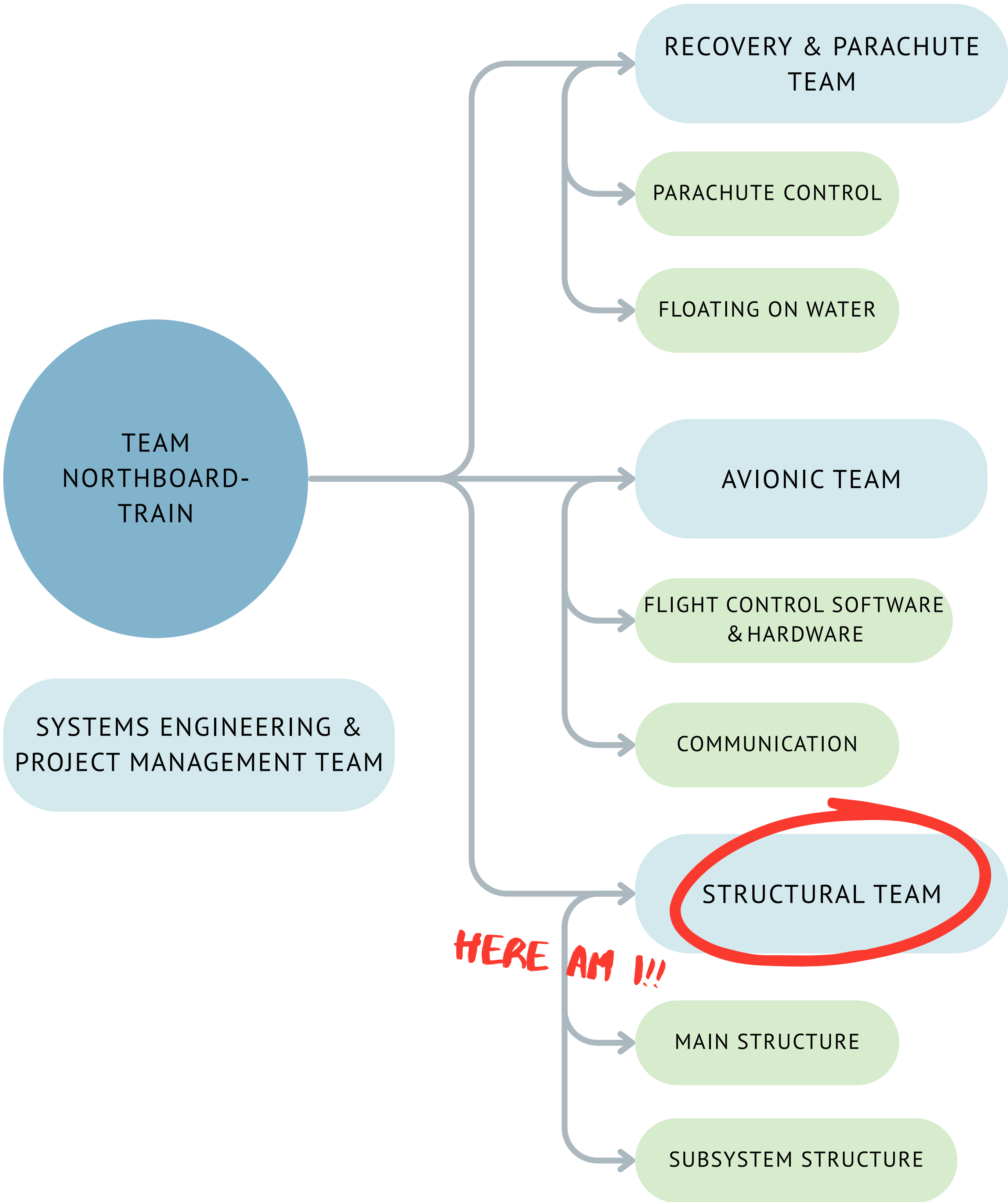
We design it. We build it. We tell its story.

OUR MISSION

Our mission was to design, build, and launch a high-power rocket capable of exceeding an altitude of 1 kilometer, while successfully deploying a recovery system to ensure the safe landing of all components. The design included structural optimization, aerodynamic simulations, and the integration of control and recovery subsystems. Although a malfunction in the avionics system prevented the parachute from deploying during the final launch, the project provided invaluable hands-on experience in aerospace engineering and system integration.

05

TEAM ORGANIZATIONAL CHART

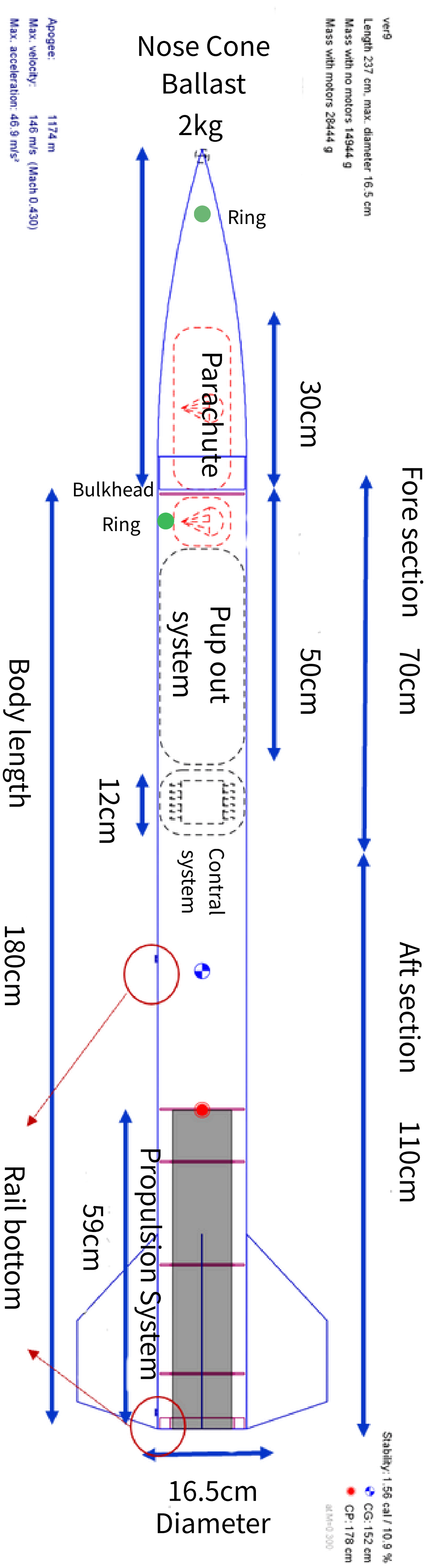


06

MY ROLE AND CONTRIBUTION

I’m the vice captain and structural lead of our team, responsible for the overall rocket frame and nose cone design: from CAD modeling and parts of the aerodynamic simulations to material selection. I led multiple redesign cycles to improve the strength-to-weight ratio, enabling a stable launch during final testing. I also coordinated subsystems like control and recovery, managed logistics (yes, including transportation, meals, and accommodation), handled communication with our advisor, and occasionally supplied the team with brilliant flashes of inspiration !

07



ROCKET DESIGN

Rocket Body Material	Rocket Total Weight
4 mm thick PVC	28.444kg

Airframe length	Rocket body dimensions
237cm	OD: 16.5, ID: 15.7

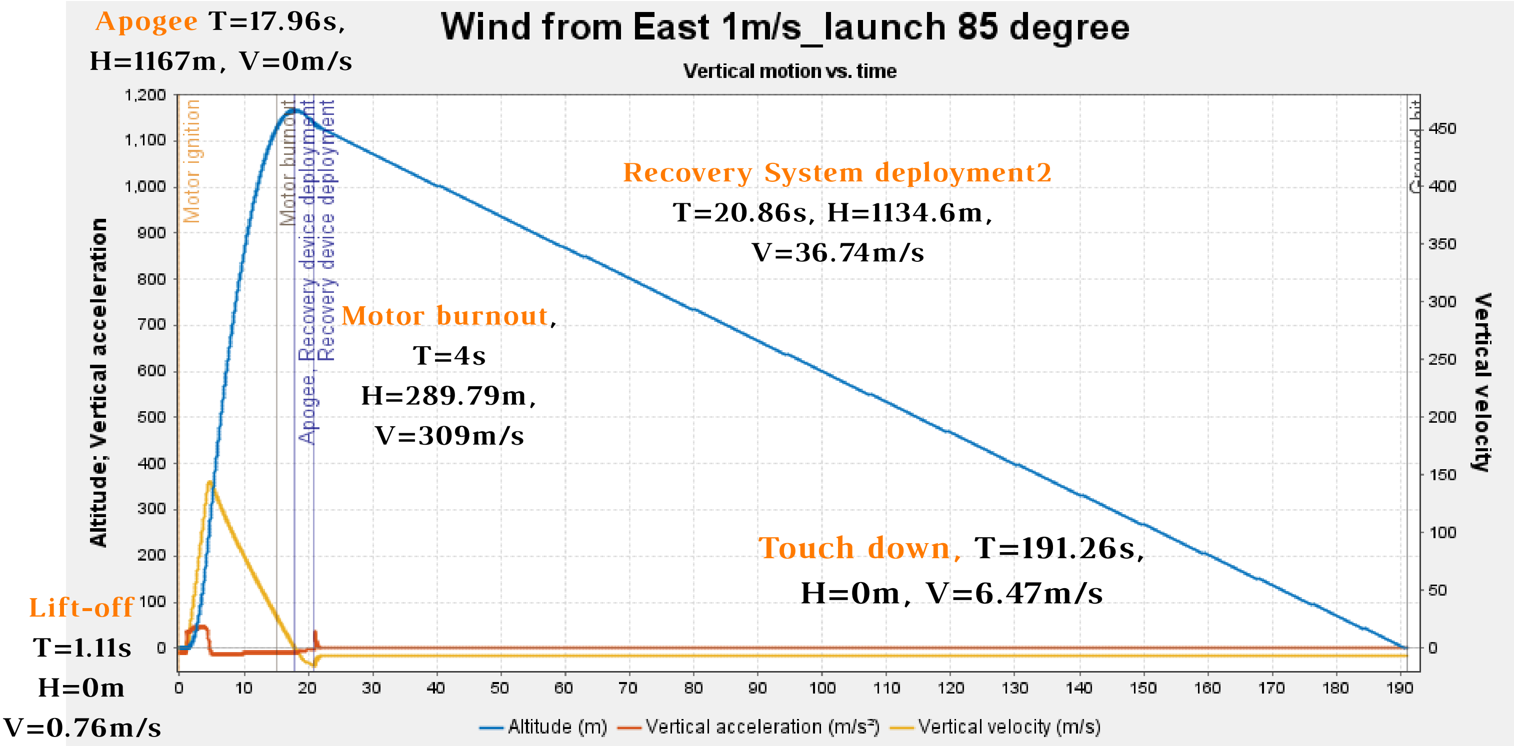
CG/CP	Power Supply Duration
CG: 152cm/ CP: 178cm/ CP-CG>1.5 Diameter	1.5hours

RF Bands for Uplink and Downlink
915Mhz

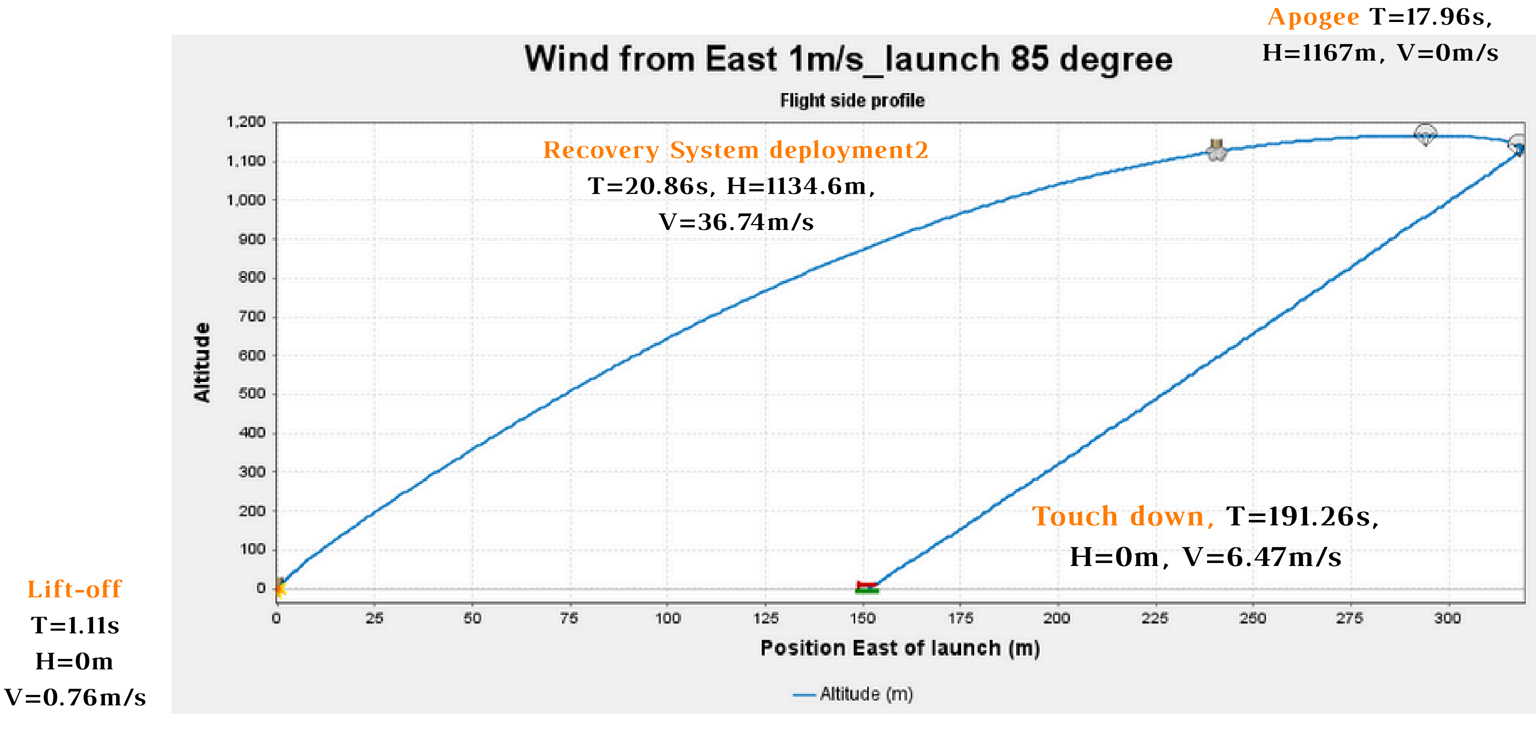
08

ROCKET FLIGHT SIMULATION AND ANALYSIS

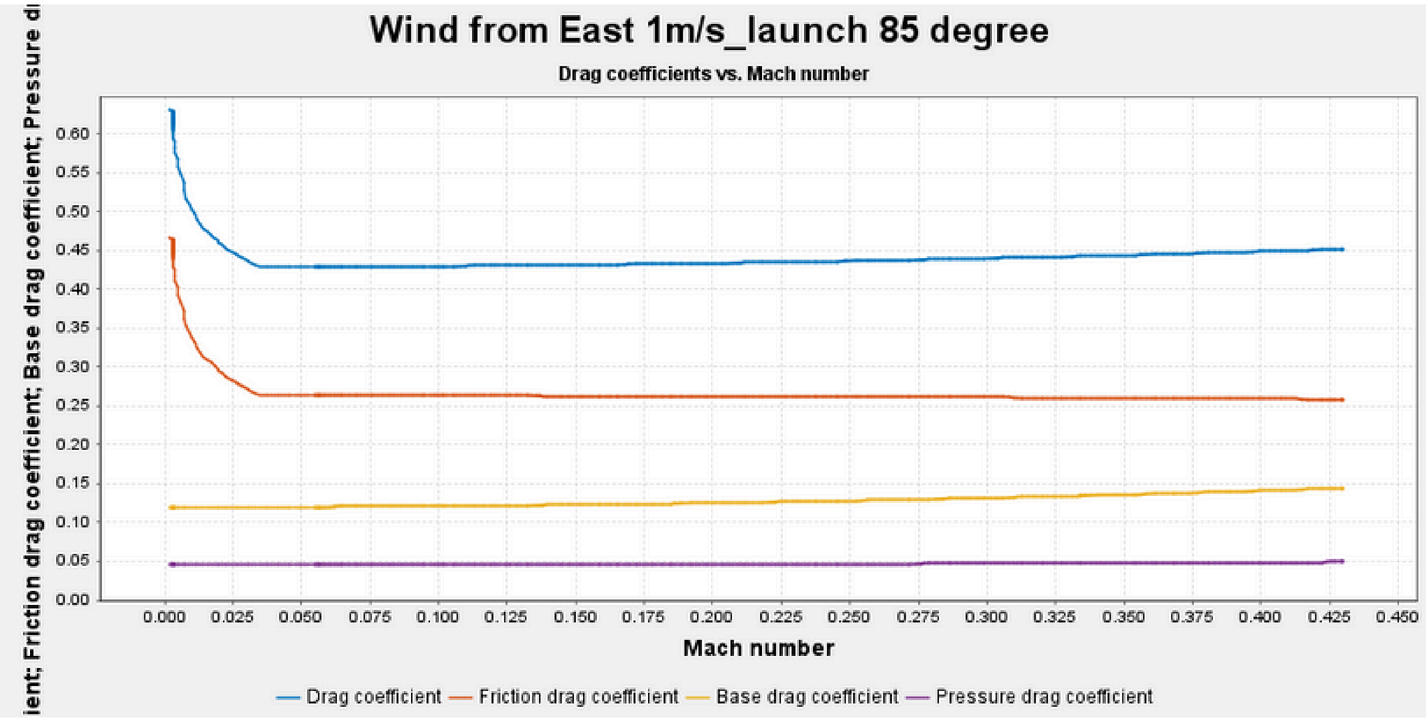
1D SIMULATION



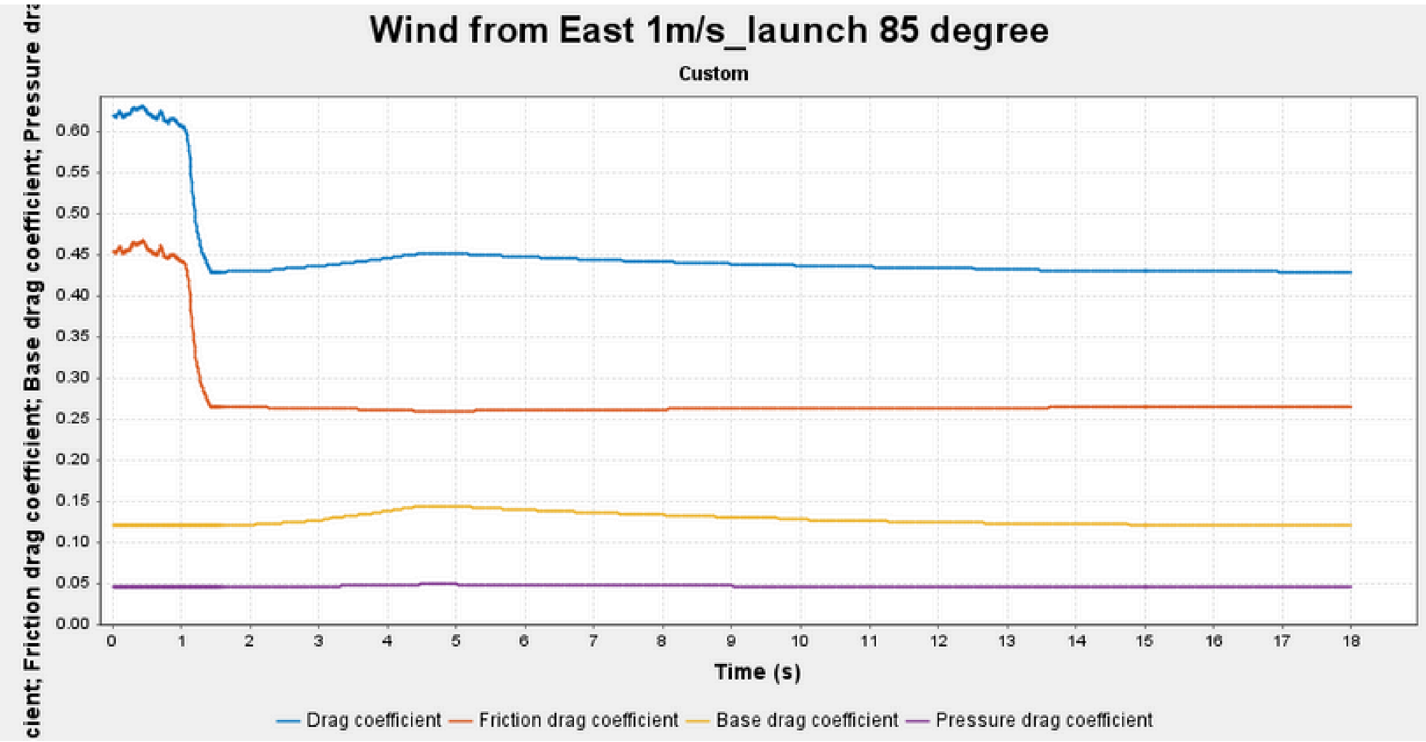
2D/3D SIMULATION



ROCKET FLIGHT SIMULATION AND ANALYSIS



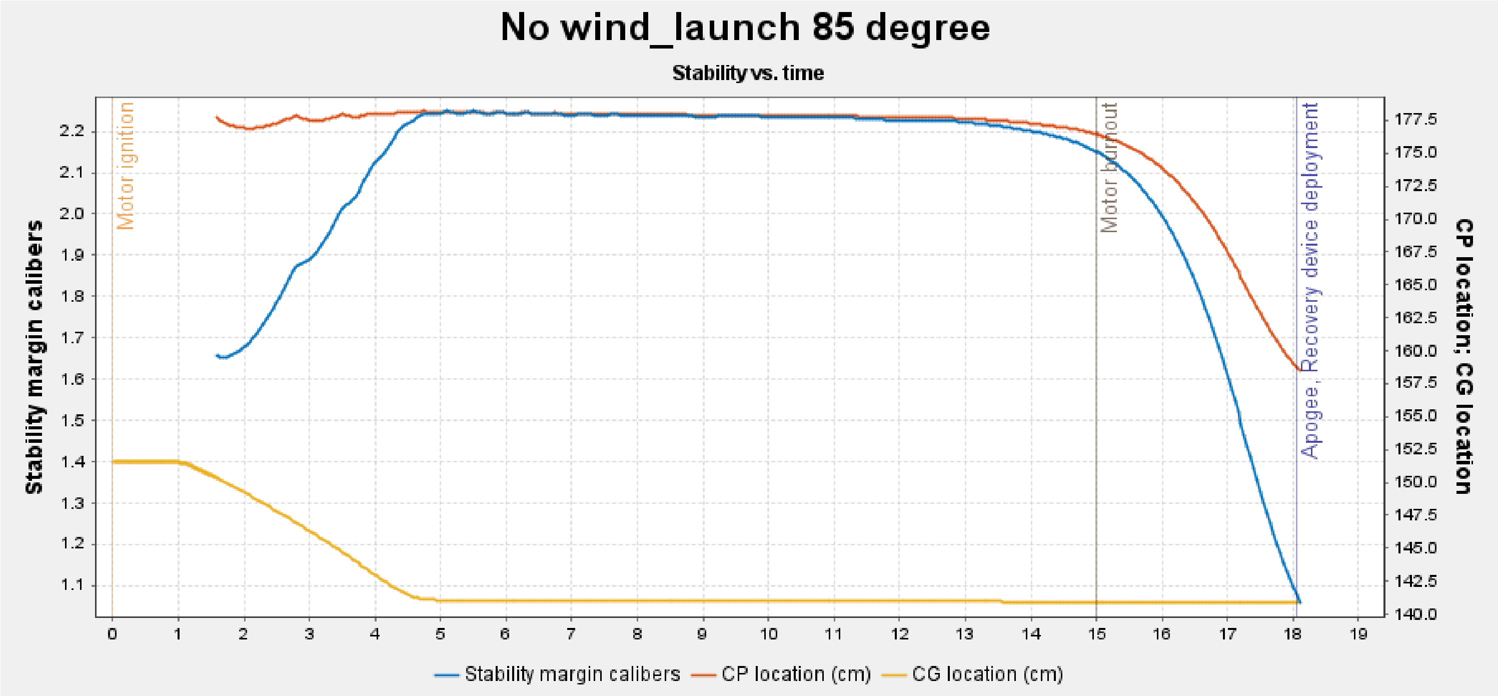
RELATIONSHIP BETWEEN DRAG COEFFICIENT AND MACH NUMBER



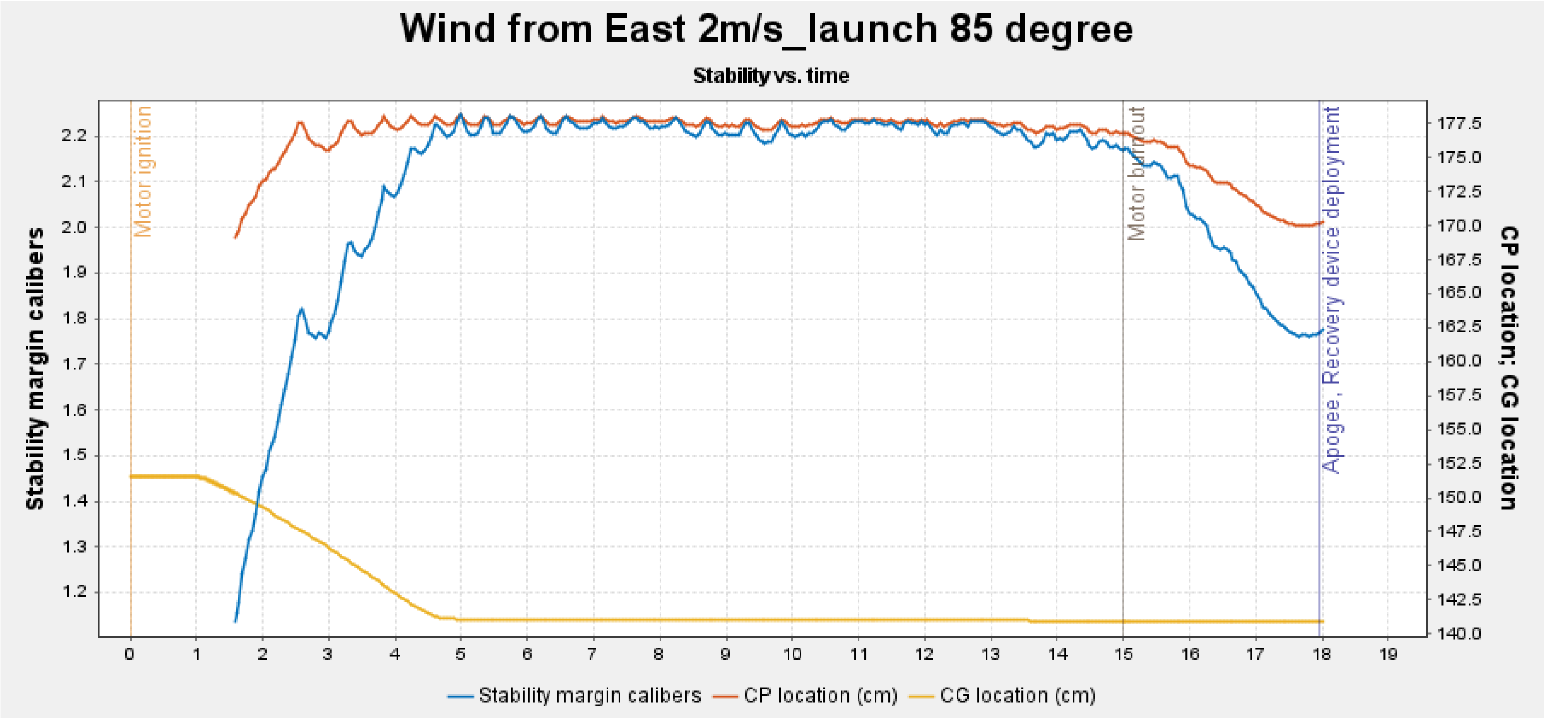
RELATIONSHIP BETWEEN DRAG COEFFICIENT AND TIME (SECONDS)

10

ROCKET FLIGHT SIMULATION AND ANALYSIS



STABILITY (NO CROSSWIND)



STABILITY (WITH 2 M/S CROSSWIND FROM THE EAST)

ROCKET FLIGHT SIMULATION AND ANALYSIS

	Position North of launch	Position East of launch
no crosswind	0.15	273.41

Wind Direction during Flight (1 m/s)	Position North of launch	Position East of launch
crosswind from the east	0.1543	155.08
crosswind from the west	0.13	394.06
crosswind from the south	118.47	273.37
crosswind from the north	-118.75	272.602

Wind Direction during Flight (2 m/s)	Position North of launch	Position East of launch
crosswind from the east	0.15	28.39
crosswind from the west	0.11	522.45
crosswind from the south	243.65	270.99
crosswind from the north	-242.35	271.42

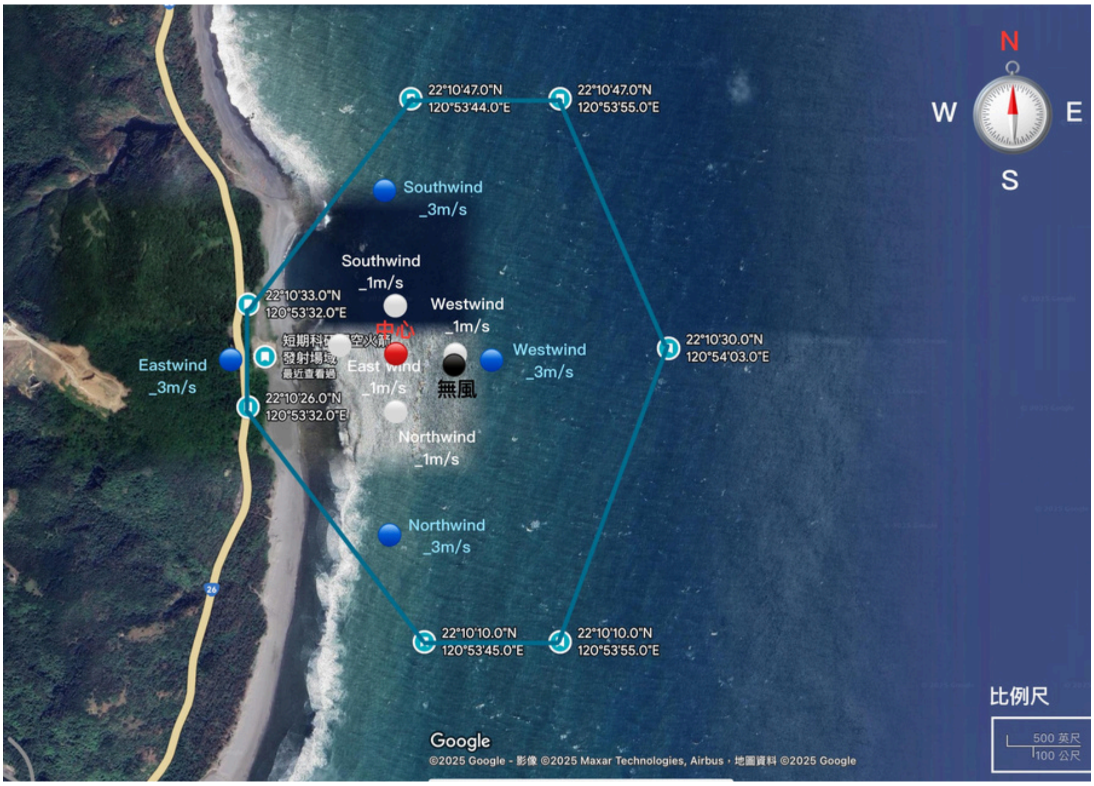
ROCKET FLIGHT SIMULATION AND ANALYSIS

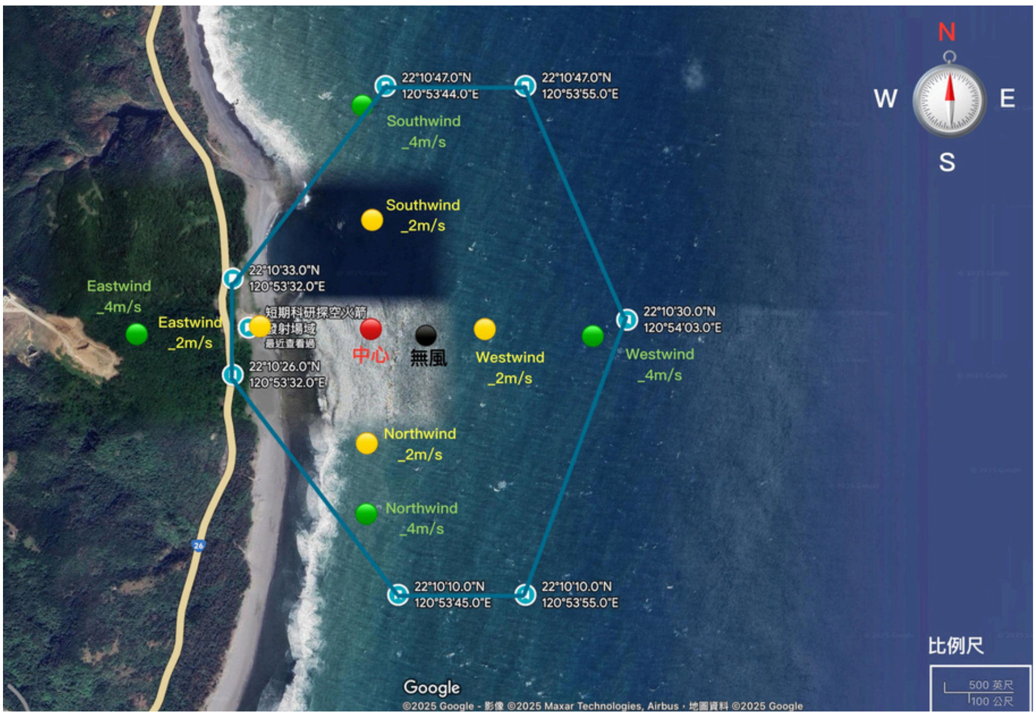
Wind Direction during Flight (3 m/s)	Position North of launch	Position East of launch
crosswind from the east	0.18	-98.6
crosswind from the west	0.08	648.86
crosswind from the south	353.5	268.46
crosswind from the north	-366	268.67

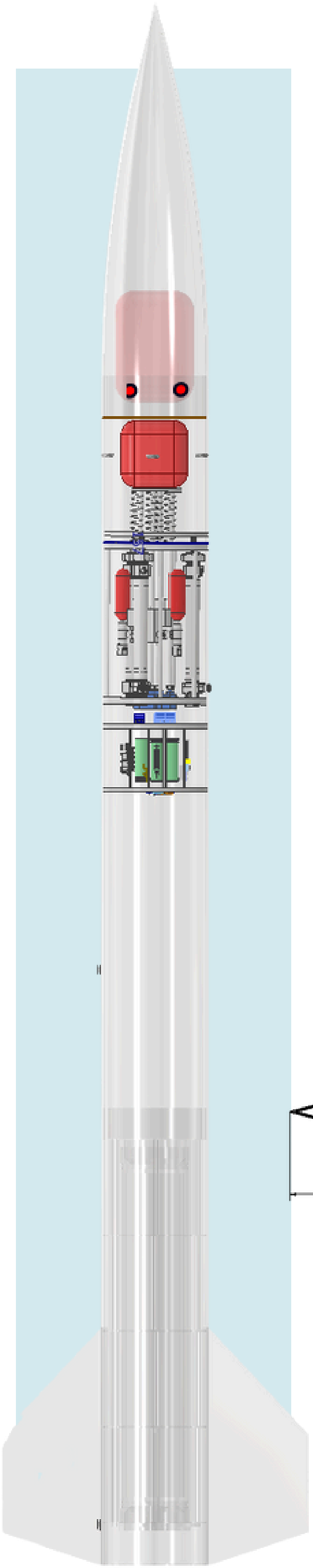
Wind Direction during Flight (4 m/s)	Position North of launch	Position East of launch
crosswind from the east	0.17	-241.58
crosswind from the west	0.07	770.07
crosswind from the south	508.5	267.6
crosswind from the north	-514.05	287.81

ROCKET FLIGHT SIMULATION AND ANALYSIS

IMPACT POINT ANALYSIS

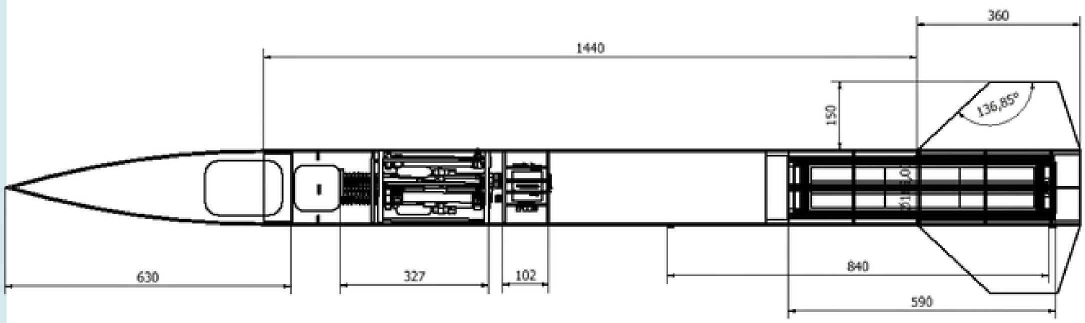




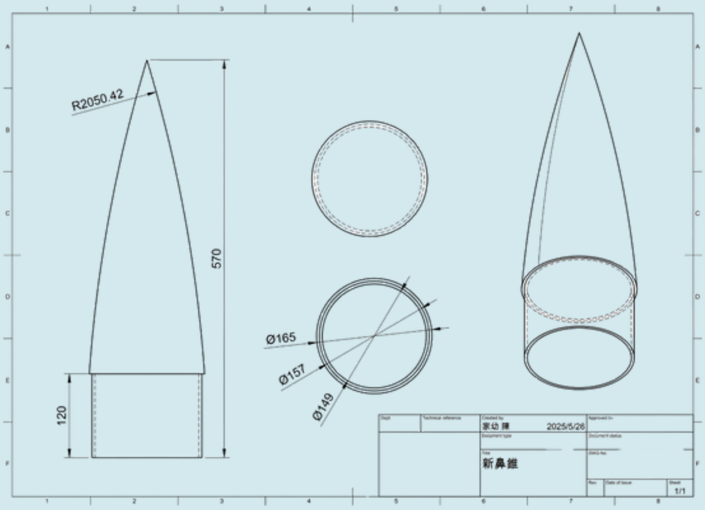


STRUCTURAL SUBSYSTEM

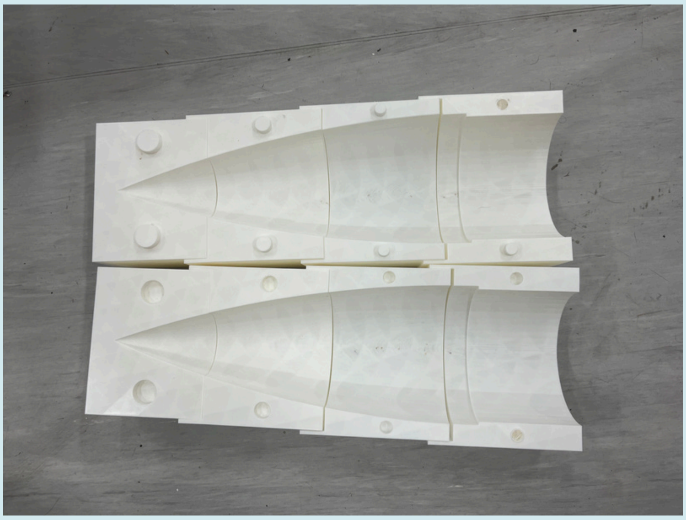
The structural subsystem provides the rocket's primary load-bearing framework, ensuring aerodynamic stability and mechanical strength during flight. The body is constructed from 4 mm thick PVC with an outer diameter of 16.5 cm and inner diameter of 15.7 cm, reinforced by M5 screws at each joint. A bulkhead separates the drogue chute and main parachute bays, with dedicated holes to prevent cord entanglement. The recovery sequence is supported by shear pins (M2, ~500 N) and multiple vent holes (M4) for pressure equalization near the barometer and pneumatic cylinder. A 2 kg ballast in the nose cone shifts the center of gravity forward, while the modular design allows reliable integration of propulsion, avionics, and recovery systems.



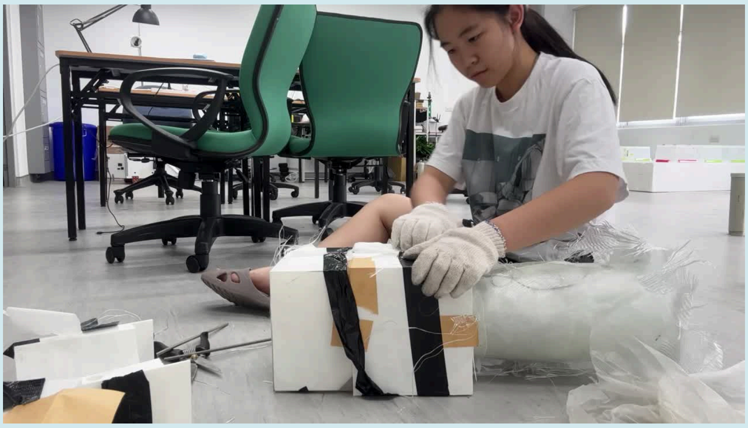
NOSE CONE MANUFACTURING PROCESS



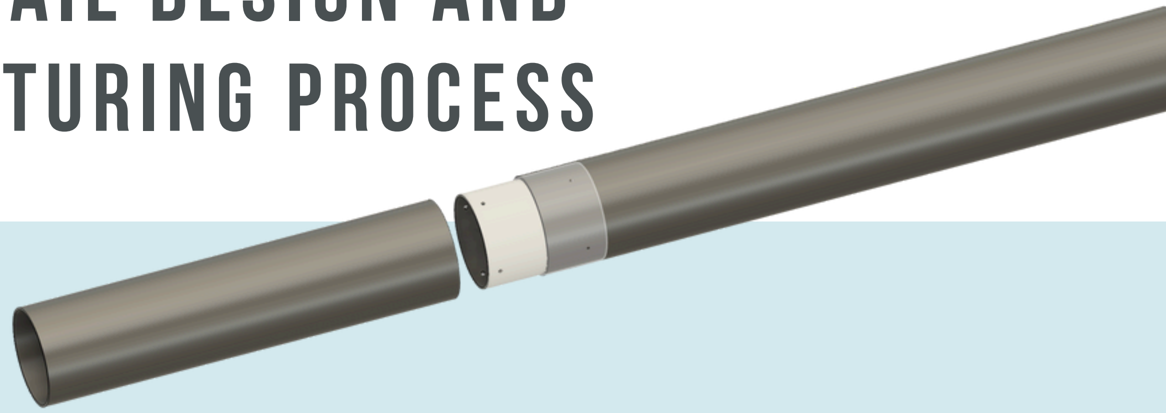
The fabrication process began by placing a release layer (baking paper) to prevent adhesion. Fiberglass cloth was then stacked layer by layer, with epoxy resin applied between each layer to ensure bonding and structural integrity.



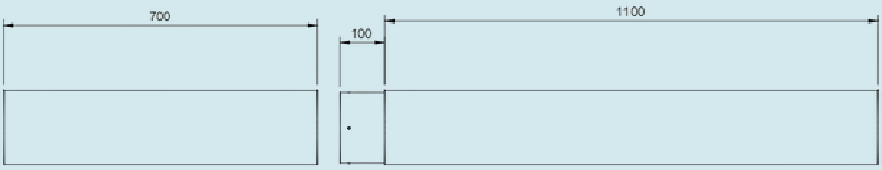
HARDEST PART...



BODY DETAIL DESIGN AND MANUFACTURING PROCESS



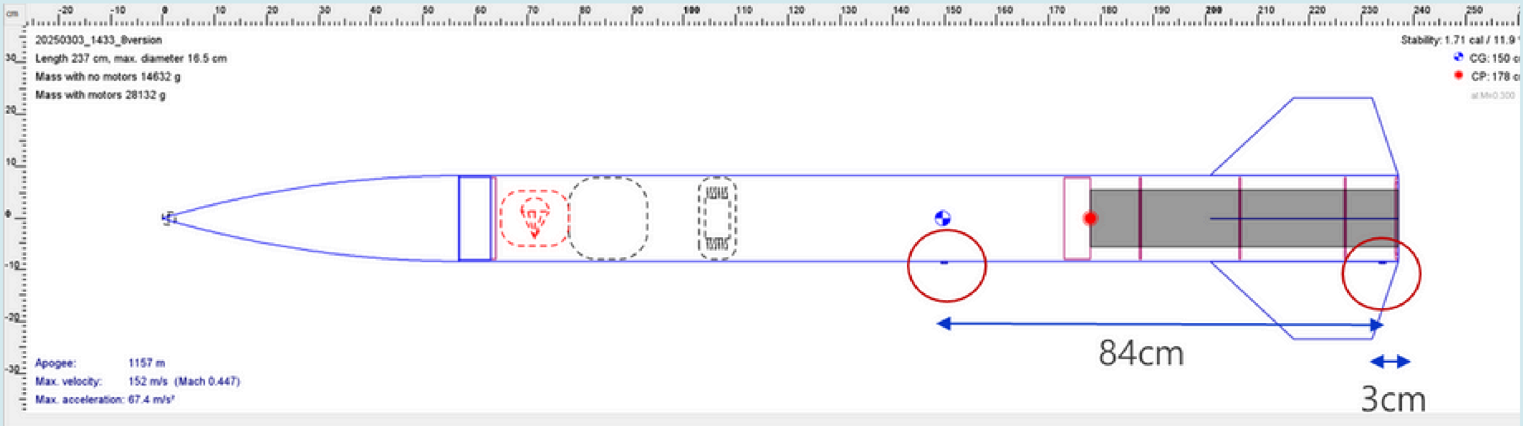
The PVC airframe was cut into 70 cm and 110 cm sections using a pipe cutter. A reinforced inner tube made of cardboard, fiberglass cloth, and epoxy resin was used to connect the segments. Two sets of 6-mm pressure-relief holes (4 near the avionics bay and 4 near the air-pressure system) were added. An eye-bolt nut served as the parachute attachment point. The forward bulkhead includes two slots: one for the main parachute's shroud line and another for the line connecting the drogue and main parachutes.



70-cm front tube

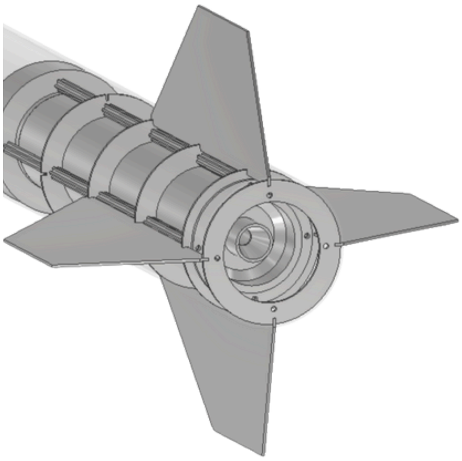
110-cm rear tube

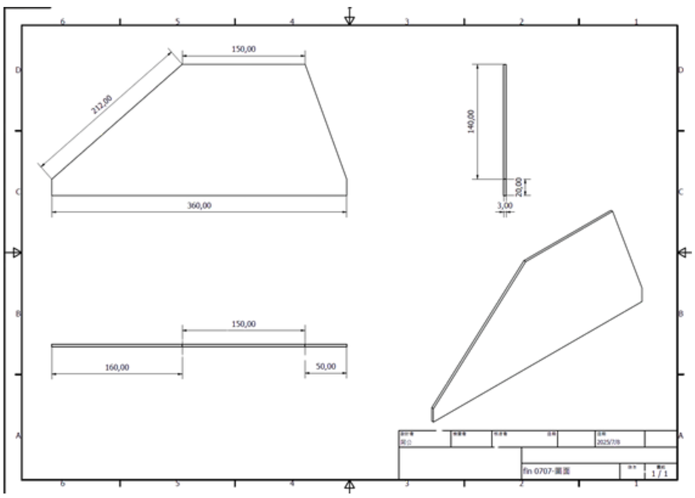
RAIL BUTTON



The rail buttons are secured to the PVC airframe using M8 screws and nuts, with the contact surface against the launch rail being smooth and unthreaded. Two rail buttons are installed to ensure proper alignment and guidance along the aluminum extrusion launch rail.

FINS DESIGN AND FIXED PROCESS





The fins are aligned with the slots on the centering ring and fixed onto the airframe. After positioning, epoxy resin is applied to secure the fins, followed by additional reinforcement using masking tape.

FIN FLUTTER SPEED

root chord length(in/mm)	tip chord length(in/mm)	semi-span(in/mm)	fin thickness(in/mm)	shear modulus G(pst)	maximum rocket acceleration(m/s)
5.91/320	6.30/150	12.60/160	0.12/3	942,745	148

taper ratio(λ)	fin area S(in^2/mm^2)	aspect ratio	altitude(ft/m)	temperature(°F)	atmospheric pressure(lbs/ft^2)
0.469	0.248/160	1.362	3753.26/1144	45.64	1844.21

speed of sound(ft/s)
1102.95

$$T(°F) = 59 - .00356h$$

$$P(lbs/ft^2) = 2116 \times \left(\frac{T + 459.7}{518.6}\right)^{5.256}$$

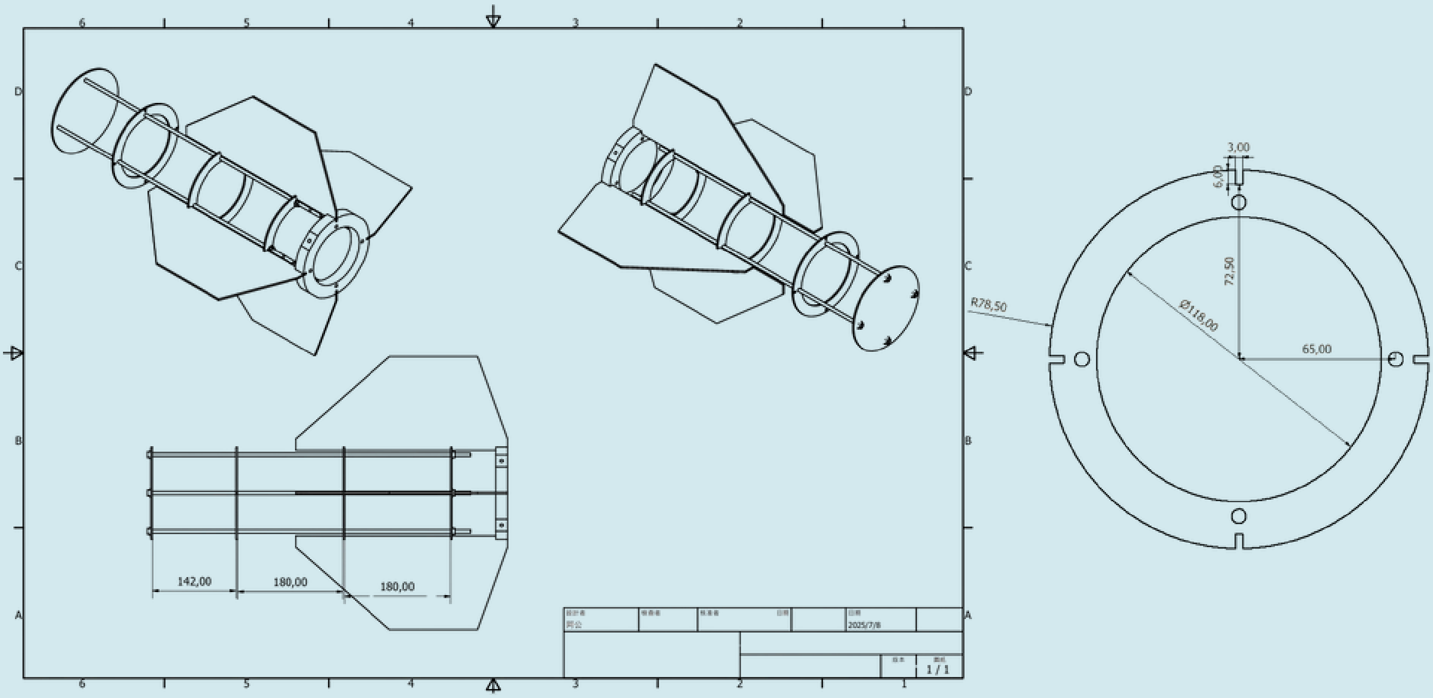
$$V_f = a\sqrt{\frac{G}{\frac{1.337AR^3P(\lambda+1)}{2(AR+2)(\frac{t}{c})^3}}}$$

$$a = \sqrt{1.4 \times 1716.59 \times (\mathrm{T}(°\mathrm{F}) + 460)}$$

Fin flutter speed: 982.75 ft/s = 299.542 m/s

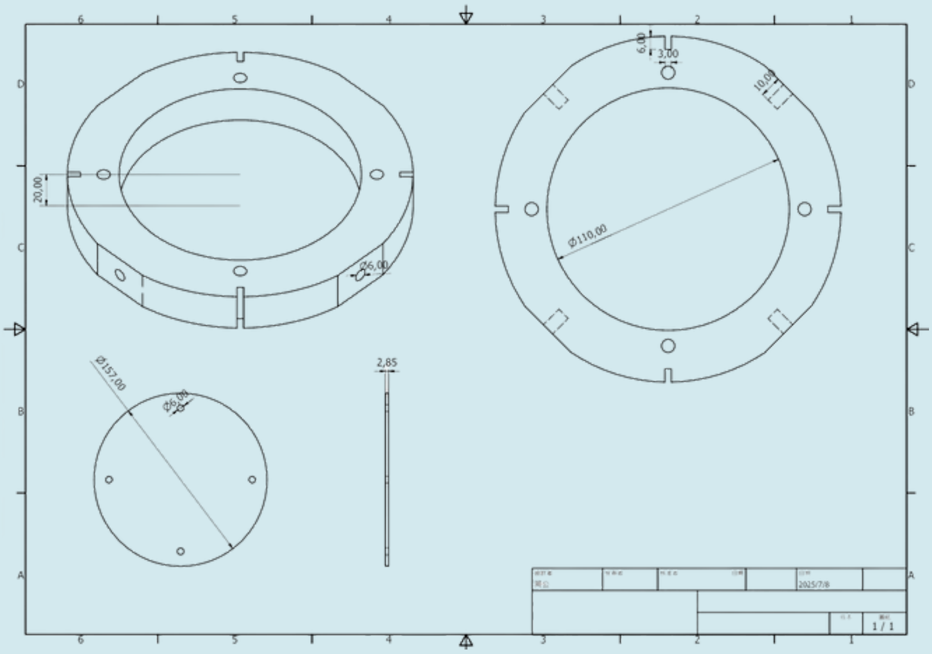
Factor of safety $SF = \frac{V_f}{V_{Rocket,MAX}}$ = 2.02 = 202%

CENTERING RING DESIGN AND MANUFACTARING PROCESS



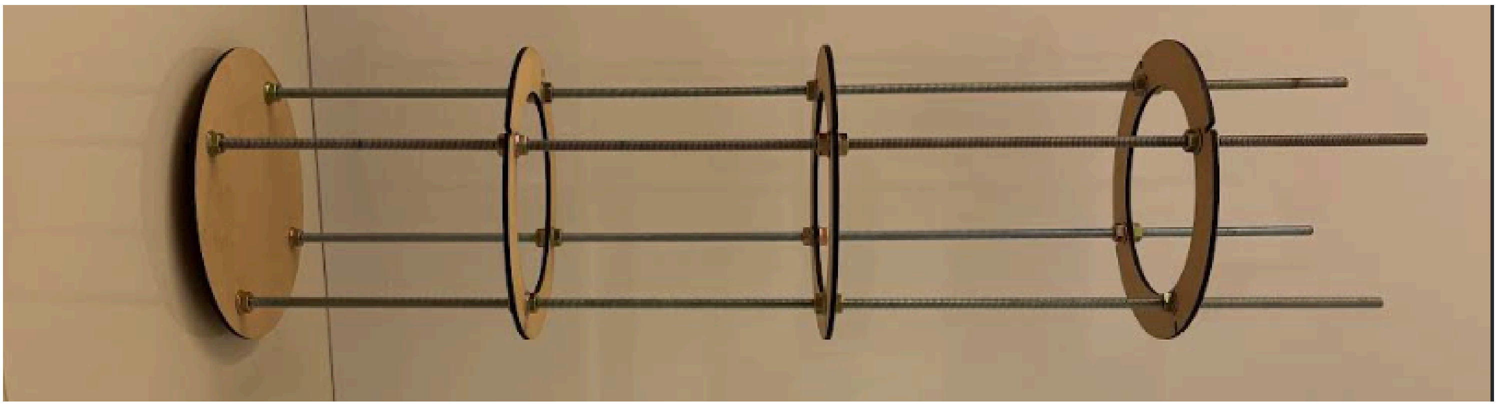
Three centering rings are used to stabilize the motor, and one motor-retaining ring is installed to secure it in place. A 500-mm threaded rod connects the centering rings, while M6 screws fasten the motor-retaining ring to the airframe. The centering rings are made of plywood and are covered with an additional layer of fiberglass for reinforcement.

MOTOR MOUNT BASE PLATE & MOTOR MOUNT RETAINING RING



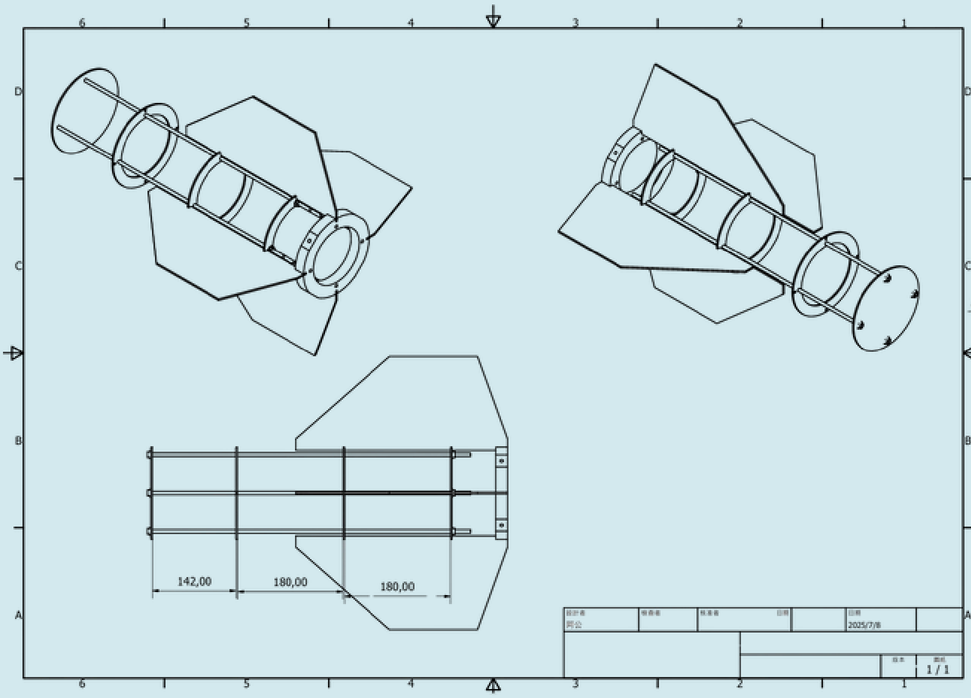
The motor-retaining ring is made from a 20-mm aluminum plate. The motor mount base plate is constructed from 2.85-mm plywood and reinforced with an additional layer of fiberglass.

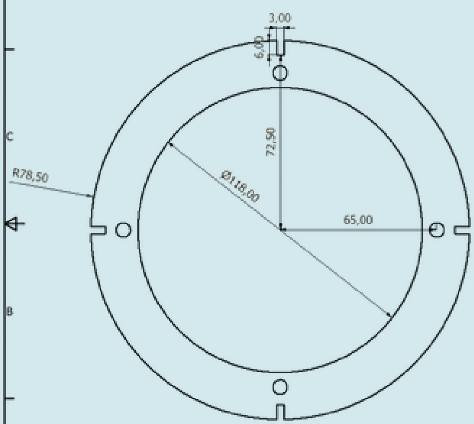
WHOLE MOTOR MOUNT



The plywood components were laser-cut according to the CAD designs shown on the previous two slides. The centering rings were fabricated using plywood reinforced with fiberglass cloth and epoxy resin.

CENTERING RING DESIGN AND MANUFACTARING PROCESS





Three centering rings are used to stabilize the motor, and one motor-retaining ring is installed to secure it in place. A 500-mm threaded rod connects the centering rings, while M6 screws fasten the motor-retaining ring to the airframe. The centering rings are made of plywood and are covered with an additional layer of fiberglass for reinforcement.

PARACHUTE ATTEACHMENT DESCRIPTION

An eye-bolt nut is used as the attachment ring for the parachute cords.

The forward bulkhead of the airframe contains two slots: one allows the main parachute's shroud line to pass through and connect to the eye-bolt, and the other provides a passage for the line linking the drogue parachute and the main parachute.

The main parachute is stored inside the nose cone, with two of its shroud lines attached to the nose cone and six attached to the airframe.
Inside the nose cone (connection of the two shroud lines):

Six shroud lines are attached to the airframe.

PARACHUTE DEPLOYMENT PROCESS

1.A pneumatic or spring mechanism pushes the drogue parachute forward.

2.The drogue parachute pushes the connecting plate.

3.The connecting plate drives the inner tube of the nose cone.

4.The nose cone separates from the airframe.

5.The drogue parachute falls out of the nose cone.

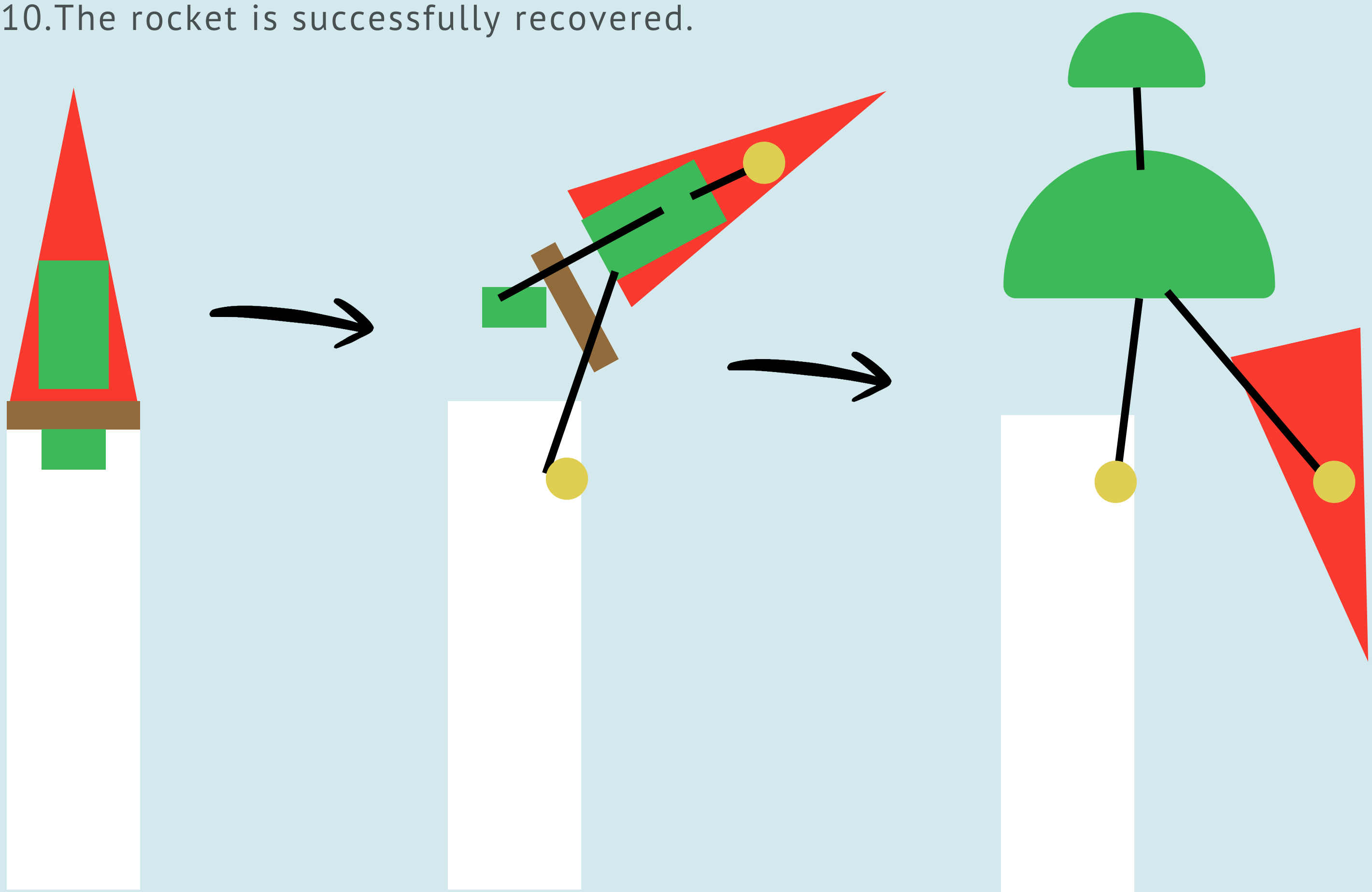
6.The drogue parachute deploys.

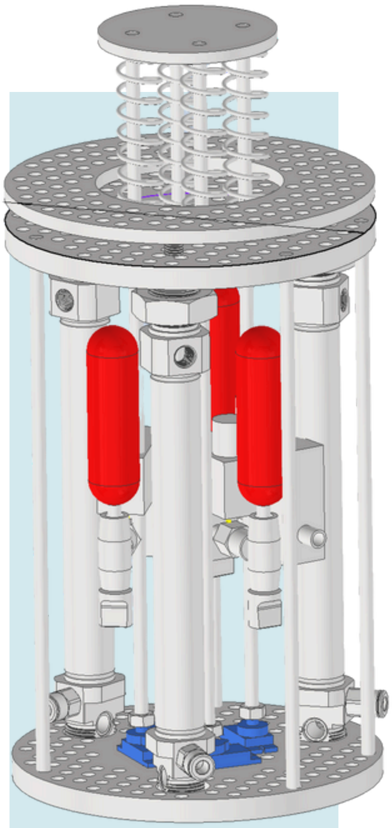
7.The drogue parachute pulls out the main parachute.

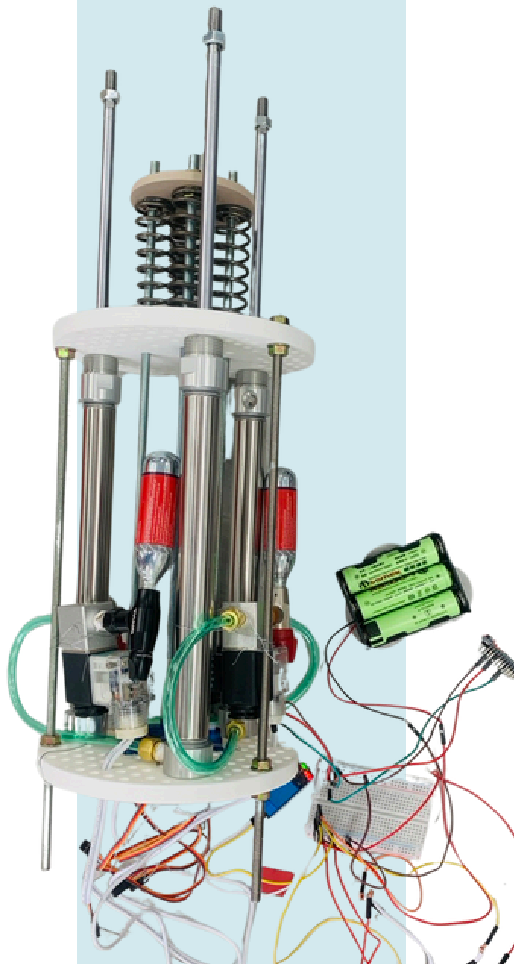
8.The main parachute fully opens.

9.The main parachute holds both the nose cone and the airframe together.

10.The rocket is successfully recovered.





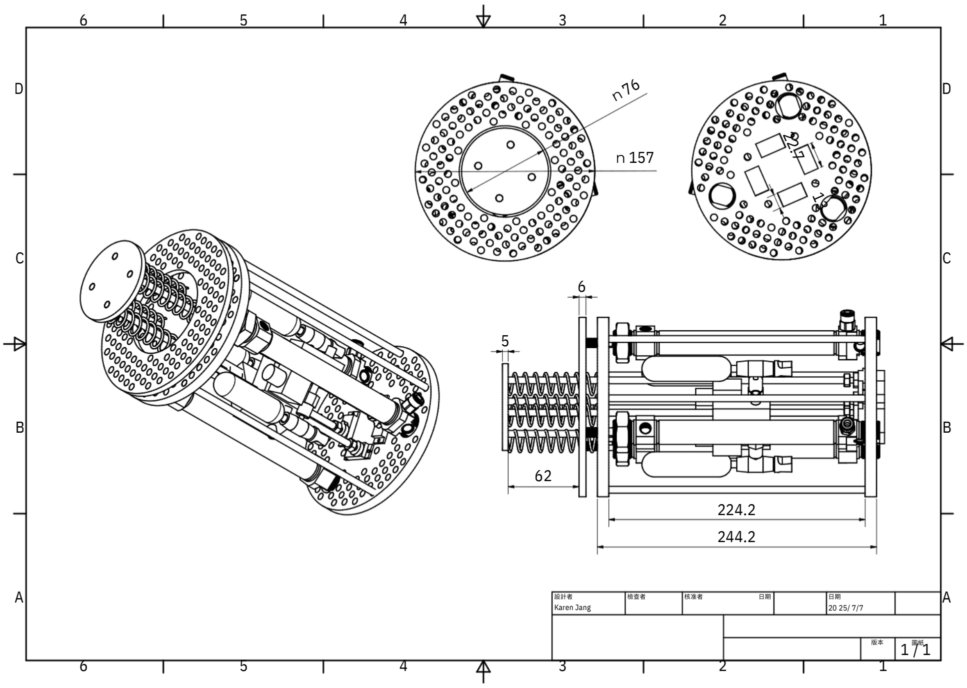


RECOVERY & PARACHUTE SUBSYSTEM

The perforated boards are secured using threaded rods and nuts, with threadlocker applied to ensure sufficient structural stability.

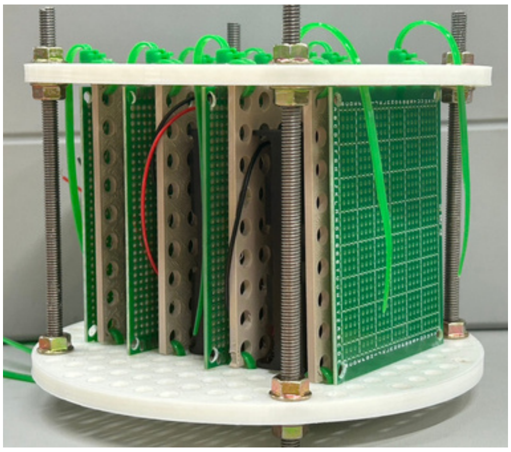
Subsystem Operation Sequence

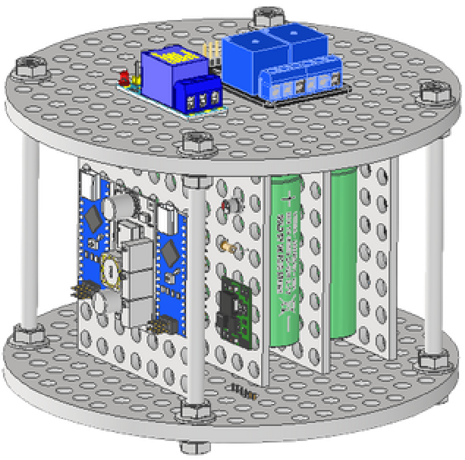
1. A pneumatic or spring mechanism pushes the drogue parachute forward.
2. The drogue parachute then pushes the connecting plate.
3. The connecting plate moves the inner tube of the nose cone.
4. The shear pins reach their maximum load limit.
5. The shear pins break.
6. The nose cone separates from the airframe.
7. The drogue parachute deploys and pulls out the main parachute.
8. The main parachute fully opens.
9. The rocket is successfully recovered.

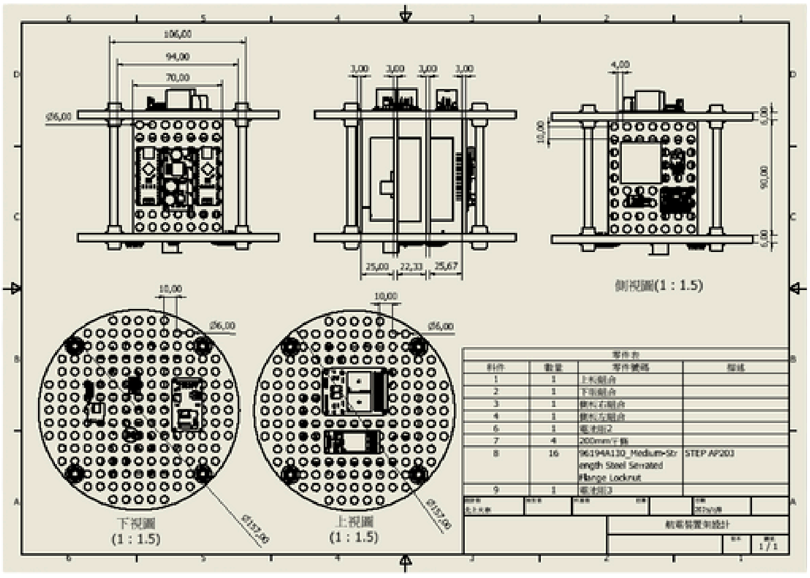


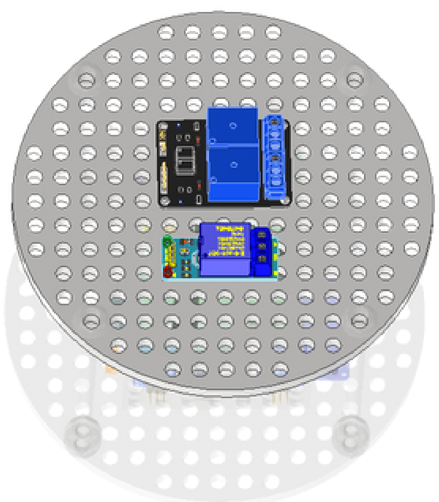
AVIONIC SYSTEM

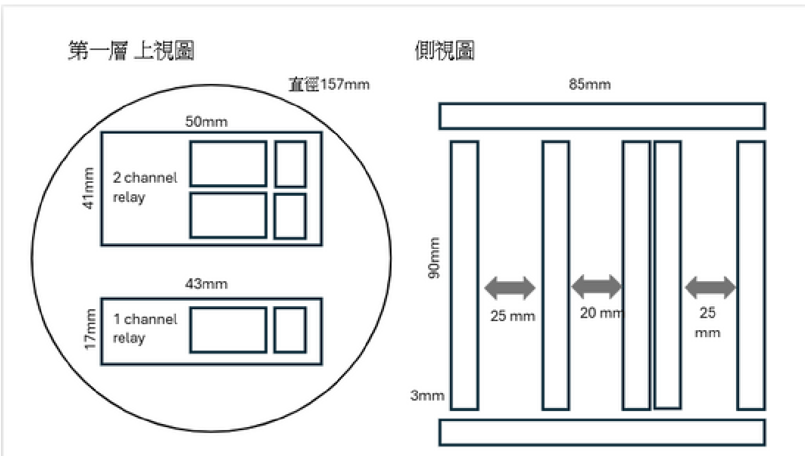
The two perforated boards are connected by side panels that were 3D-printed. Five side panels create three compartments for battery placement. The Arduino and other sensors are mounted on the outer sides of the lateral panels.



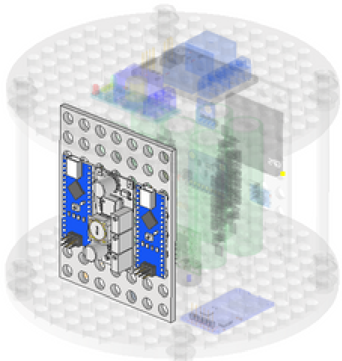


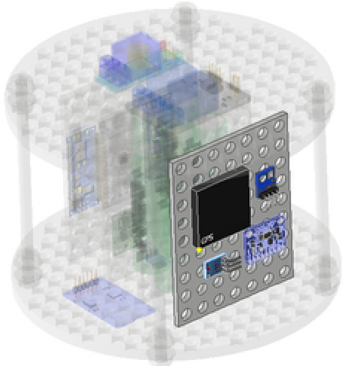


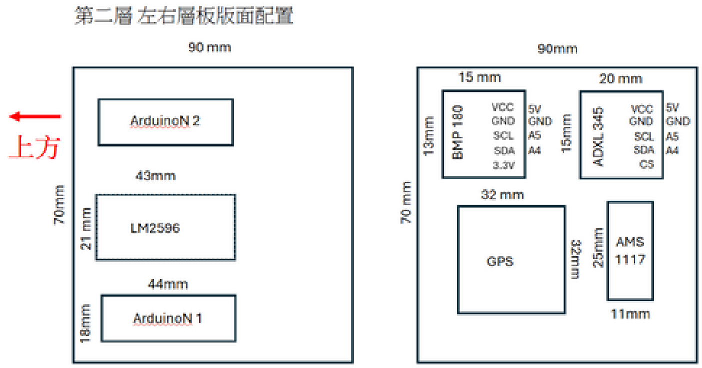


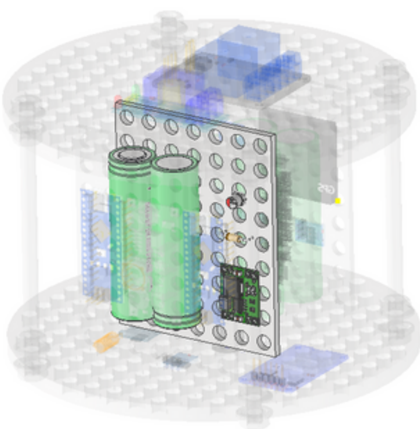


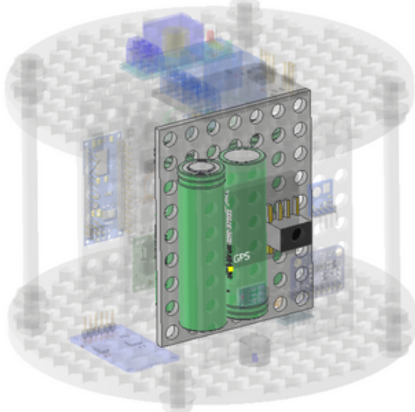
26
AVIONIC SYSTEM

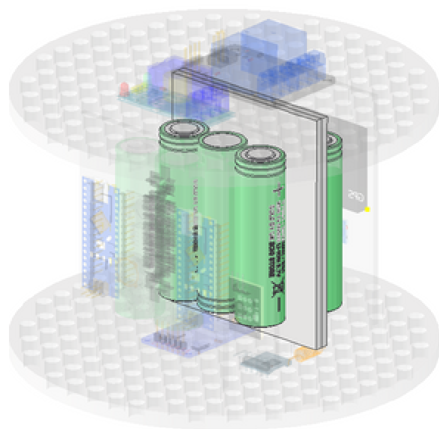




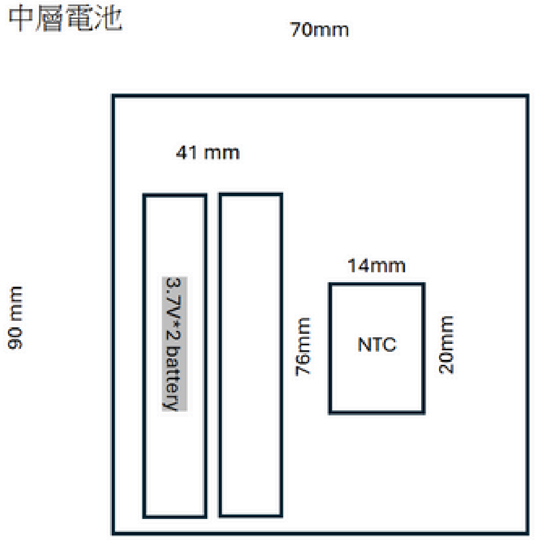




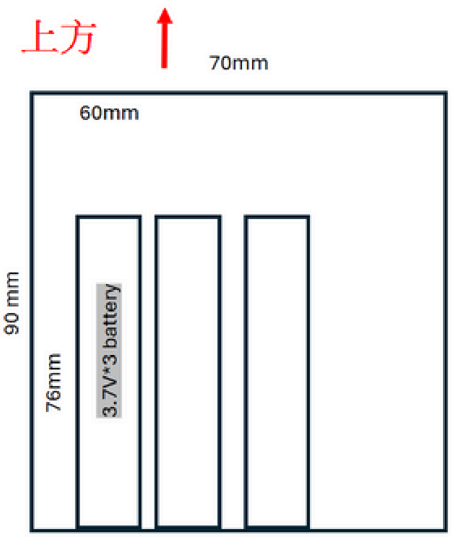




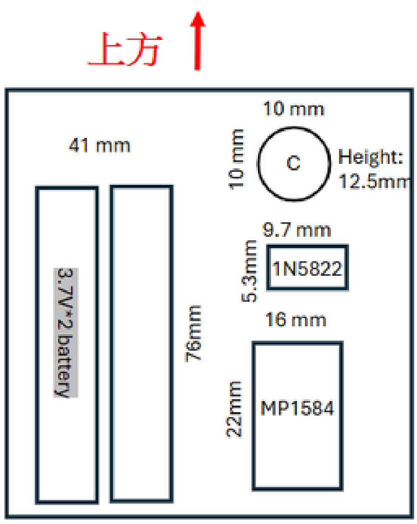
中層電池



Flight Control System Backup Battery



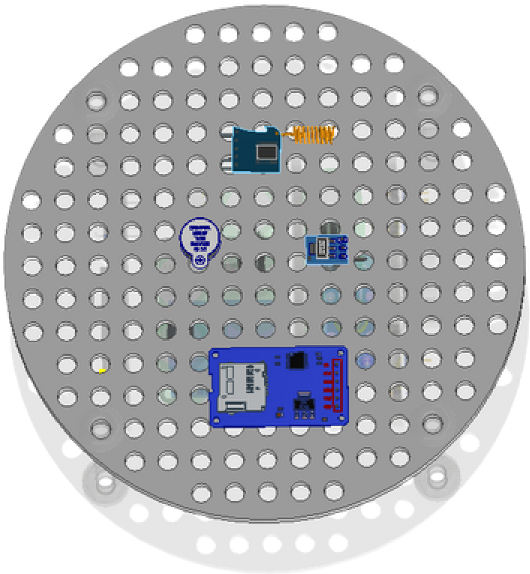
Recovery and Descent Control System Battery



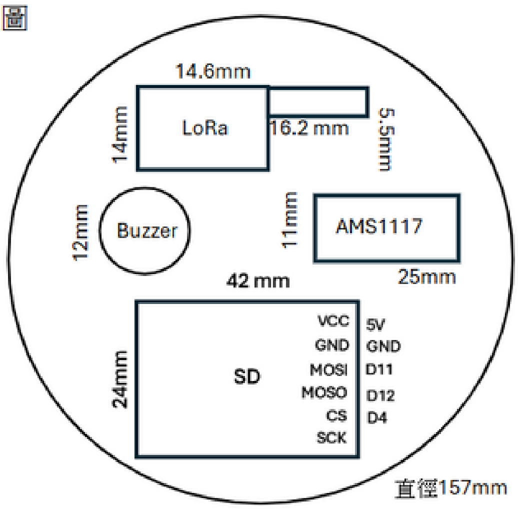
Flight Control System Battery

27

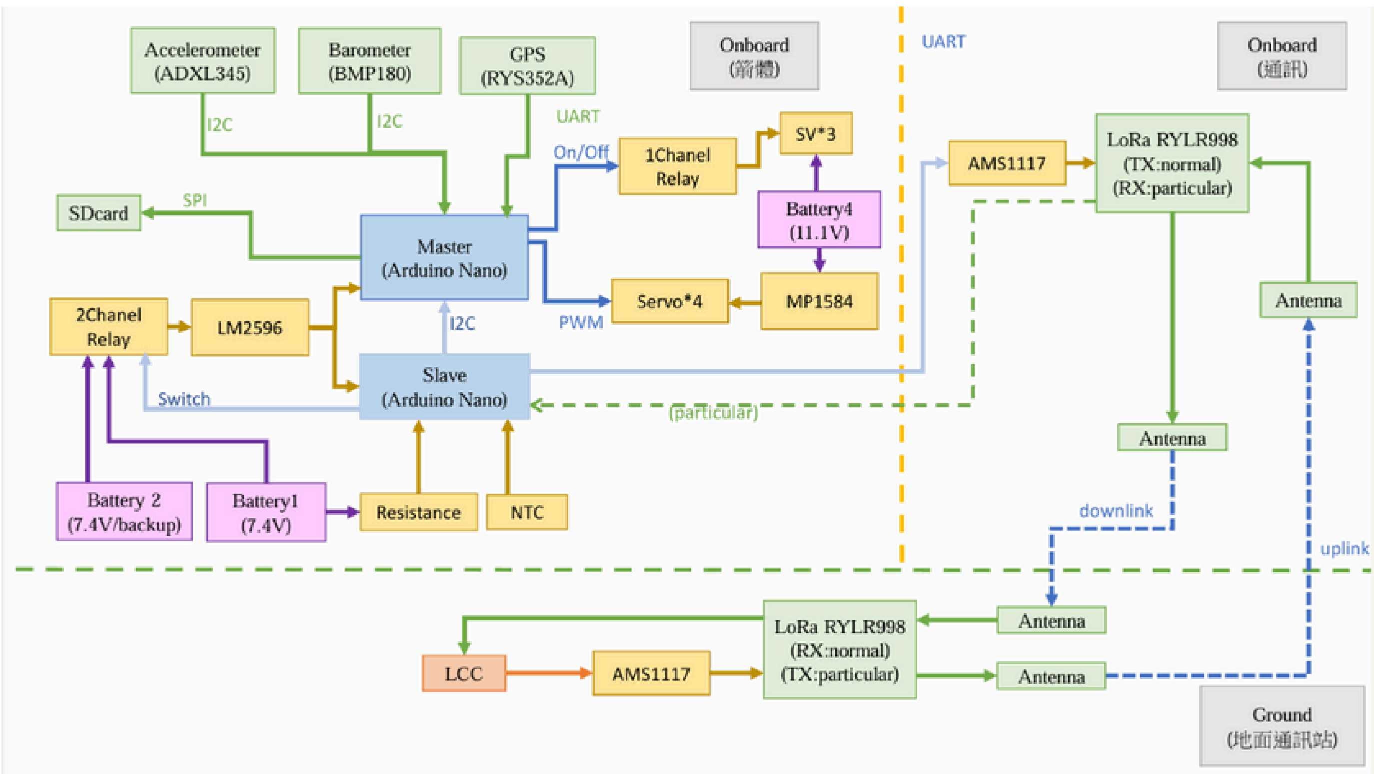
AVIONIC SYSTEM



第三層上視圖



p.s. avionic diagram



POST-COMPETITION RVIEW AND IMPROVEMENTS

- Nose cone

Original:
The nose cone was fully constructed using fiberglass and epoxy resin, with additional weight added using an epoxy-sand mixture combined with steel beads.

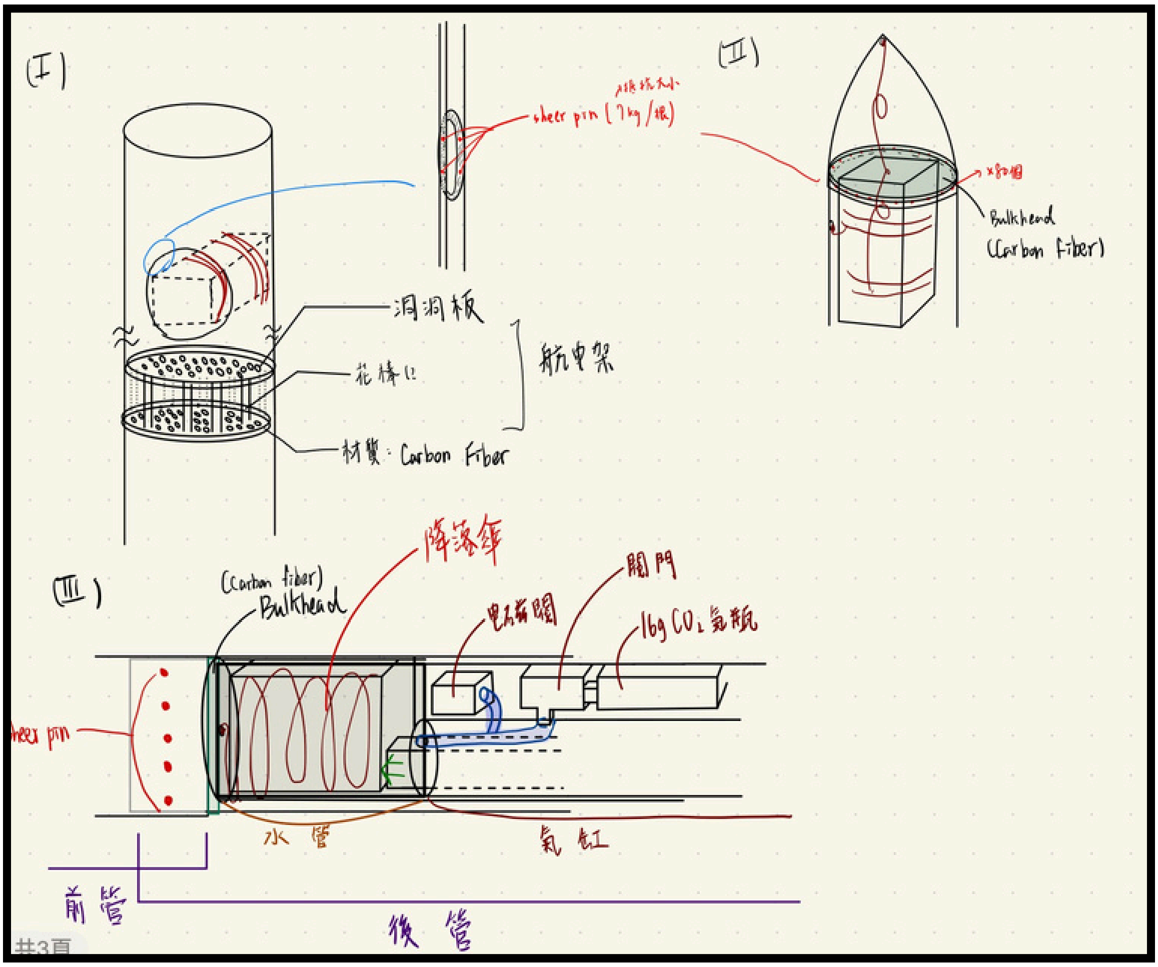
A 3D-printed mold was used, within which layers of fiberglass were laid by hand. This process was difficult to execute and prone to deformation, resulting in a nose cone that was slightly uneven and not perfectly aligned with the airframe.

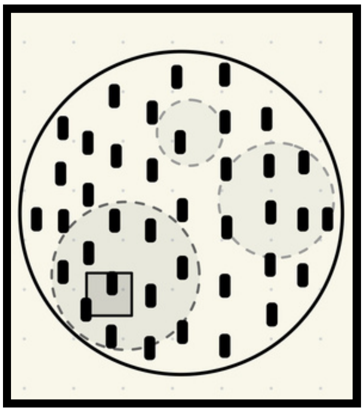
Improvement direction:
We originally avoided using 3D printing as the primary material for the nose cone because we assumed it might melt during flight and could be structurally weak. However, after the competition and several subsequent exhibitions, many teams in the professional division noted that they have not encountered melting issues with 3D-printed nose cones. Strength concerns can also be addressed by applying layers of fiberglass over the printed surface.
This approach not only solves the problem of shape control and difficult manual fabrication but also prevents inconsistent thickness caused by repeatedly laying fiberglass by hand.

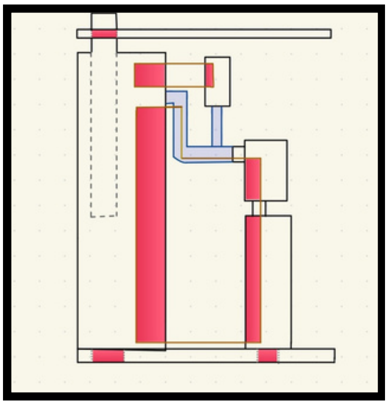
FUN PICTURES

We carried this 20-kg, 3-meter-long rocket for nearly 2 km...That's how we became muscle girls.

DESIGN SCRATCH







CAD FILE

WHOLE SYSTEM DETAIL DESIGN(CHINESE)