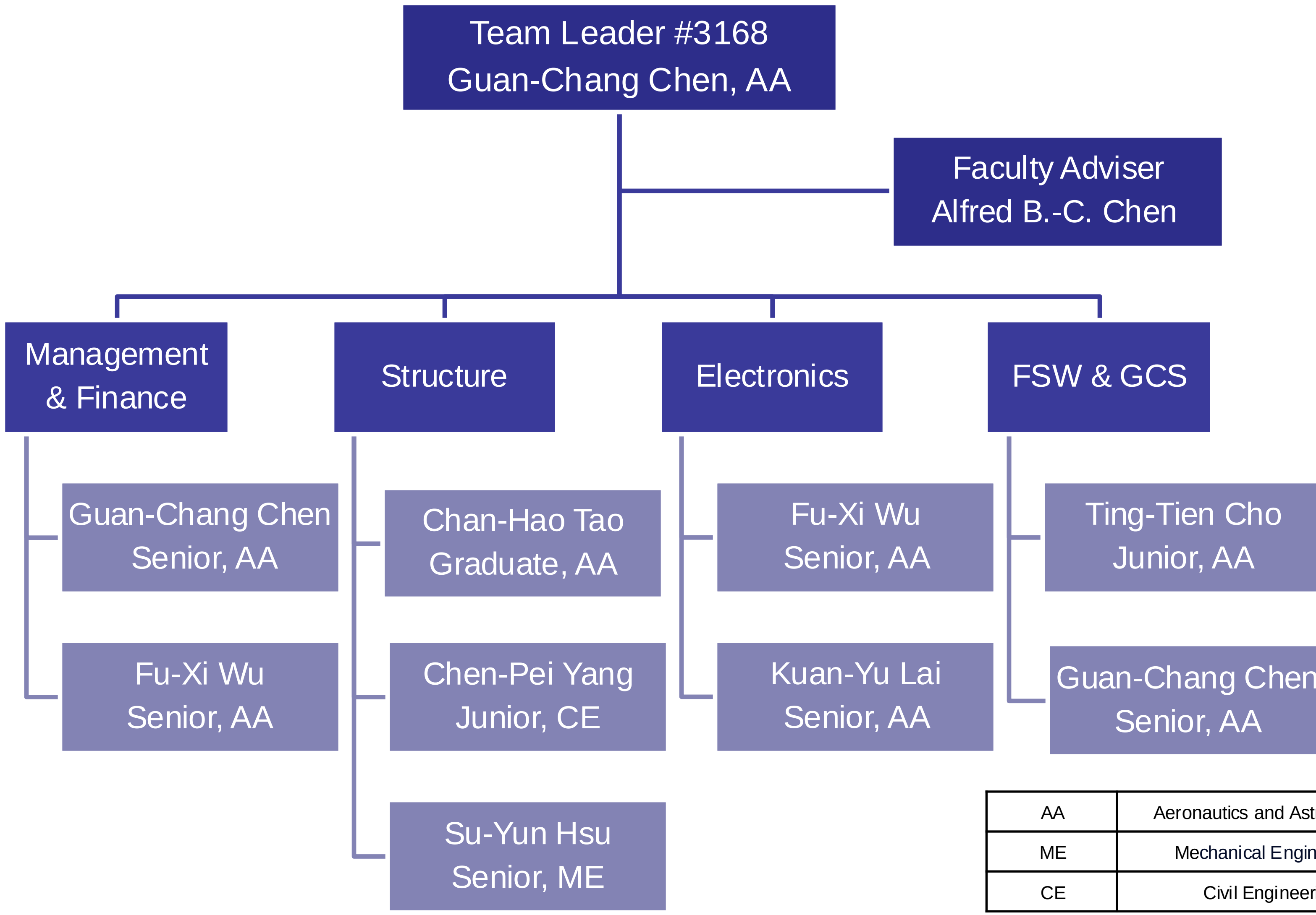
CanSat 2025
Preliminary Design Review (PDR)

3168
Gemini Supernova

Presentation Outline

Team Organization



AA	Aeronautics and Astronautics
ME	Mechanical Engineering
CE	Civil Engineering

Acronyms (1/2)

Acronym	Definition
ADC	Analog to Digital Converter
CONOP	Concept of Operations
DCS	Descent Control System
EE	Electronics
EEPROM	Electrically-Erasable Programmable Read-Only Memory
EQM	Engineering Qualification Model
FSW	Flight Software
FRR	Flight Readiness Review
GCS	Ground Control Station
GNSS	Global Navigation Satellite System

Acronym	Definition
GPOC	Ground Pointing and Orientation Camera
GUI	Graphic User Interface
hh	Hours
HW	Hardware
HWR	Hardware Review
H/L	High or Low
I^2C	Inter-Integrated Circuit
IMU	Inertial measurement unit
LCO	Launch Control Officer
MCU	Microcontroller Unit
MET	Mission elapse time
mn	Minutes
P&T	Pressure and Temperature

Acronyms (2/2)

Acronym	Definition
PCB	Printed circuit board
PDR	Preliminary Design Review
PFB	Pre Flight Briefing
PFR	Post Flight Review
PL	Payload
PLA	Polylactic Acid
PWM	Pulse Width Modulation
RAM	Random-access memory
RPM	Revolutions Per Minute
RSO	Range Safety Officer
RTC	Real-Time Clock
RF	Radio Frequency

Acronym	Definition
RQMT	Requirement
SOE	Sequence of Events
ST	Structure
ss	seconds
TBD	To Be Determined
TBR	To Be Resolved
UART	Universal Asynchronous Receiver/Transmitter

Systems Overview

Chan-Hao Tao

Mission Summary

Main Objective
Design a CanSat that consists of a payload and a container that mounts on top of the rocket. The payload rests inside the container at launch and includes the nose cone as part of the payload.
The CanSat deploys from the rocket when the rocket reaches the peak altitude, and the rocket motor forces a separation. The CanSat shall descend at a rate of no more than 20 meters/second by a parachute.
At 75% peak altitude, the payload shall separate from the container and use an auto-gyro descent control system until landing. The descent rate shall be 5 meters/second.
A video camera shall show the separation of the payload from the container and the auto-gyro functioning. A second video camera shall be pointing downward at 45 degrees from the nadir and oriented north during descent and be spin stabilized so that the view of the earth is not rotating.
The CanSat shall collect sensor data during ascent and descent, and transmit the data to a ground station at a 1 Hz rate. The sensor data shall include interior temperature, battery voltage, altitude, auto-gyro rotation rate, acceleration, rate, magnetic field, and GPS position.

System Requirement Summary (1/9)

No.	Requirement	Priority	Subsystem	A	I	T	D
1.	The CanSat payload shall function as a nose cone during the rocket ascent portion of the flight.	High	ST		V		
2.	The CanSat container shall be mounted on top of the rocket with the shoulder section inserted into the airframe.	High	ST				V
3.	The CanSat payload and container shall be deployed from the rocket when the rocket motor ejection charge fires.	High	ST				V
4.	After deployment, the CanSat payload and container shall descend at 20 meters/second using a parachute that automatically deploys. Error is +/- 3 m/s.	High	ST	V			
5.	At 75% flight peak altitude, the payload shall be released from the container and deploy an auto-gyro descent control system.	High	ST,FSW, GCS				V
6.	The payload shall descend at 5 meters/second with the auto-gyro descent control system.	High	ST	V			
7.	The payload shall record video of the release of the payload from the container and the operation of the auto-gyro descent control system.	High	ST,FSW				V

System Requirement Summary (2/9)

No.	Requirement	Priority	Subsystem	A	I	T	D
8.	A second video camera shall point in the north direction during descent, be pointed 45 degrees from the CanSat nadir direction during descent and shall be spin stabilized so the ground view is not rotating in the video.	High	ST,FSW				V
9.	The CanSat payload shall include an audible beacon that is turned on separately and is independent of the CanSat electronics.	High	FSW,GCS		V		
10.	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost of the CanSat. Equipment from previous years shall be included in this cost, based on current market value.	High	ST,FSW, GCS,EE	V			
11.	The CanSat and container mass shall be 1400 grams +/- 10 grams.	High	ST		V		
12.	Nose cone shall be symmetrical along the thrust axis, and radius shall be exactly 72.2 mm and shoulder length shall be a minimum of 50 mm and height shall be a minimum of 76 mm	High	ST		V		

System Requirement Summary (3/9)

No.	Requirement	Priority	Subsystem	A	I	T	D
13.	The nose cone be made as a single piece and shall not have any openings allowing air flow to enter. Segments are not allowed.	High	ST		V		
14.	CanSat structure must survive 15 Gs vibration and 30 G shock	High	ST			V	
15.	The container shoulder length shall be 90 to 120 mm, diameter shall be 136 mm, and wall thickness shall be at least 2 mm.	High	ST		V		
16.	Above the shoulder, the container diameter shall be 144.4 mm ,the length above the shoulder shall be 250 mm +/- 5%	High	ST		V		
17.	The CanSat shall perform the function of the nose cone during rocket ascent. The CanSat container also can be used to restrain any deployable parts of the CanSat payload but shall allow the CanSat to slide out of the payload section freely.	High	ST,FSW				V

System Requirement Summary (4/9)

No.	Requirement	Priority	Subsystem	A	I	T	D
18.	All electronics and mechanical components shall be hard mounted using proper mounts such as standoffs, screws, or high-performance adhesives.	High	ST,EE		V		
19.	The CanSat container shall meet all dimensions and container materials in section F.	High	ST		V		
20.	If the nose cone is to separate from the payload after payload deployment, the nose cone shall descend at no more than 5 meters/sec.	High	ST,FSW				V
21.	If the nose cone is to separate from the payload after payload deployment, the nose cone shall be secured to the payload until payload deployment with a pull force to survive at least 15 Gs acceleration.	High	ST			V	
22.	Mechanisms that use heat (e.g., nichrome wire) shall not be exposed to the outside environment and all mechanisms shall be capable of maintaining their configuration or states under all forces. No pyrotechnical or chemical actuators are allowed.	High	ST		V		

System Requirement Summary (5/9)

No.	Requirement	Priority	Subsystem	A	I	T	D
23.	Spring contacts shall not be used for making electrical connections to batteries.	High	EE		V		
24.	Battery source may be alkaline, Ni-Cad, Ni-MH or Lithium. Lithium polymer batteries are not allowed. Lithium cells must be manufactured with a metal package similar to 18650 cells. Coin cells are allowed. Lithium polymer batteries are not allowed.	High	EE		V		
25.	Easily accessible power switch and power indicator is required.	High	EE		V		
26.	The CanSat shall operate for a minimum of two hours when integrated into the rocket.	High	EE	V			
27.	The audio beacon shall operate on a separate battery with an easily accessible power switch	High	EE		V		
28.	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE radios are also allowed. XBEE radios shall have their NETID /PANID set to their team number. broadcast mode is NOT allowed.	High	EE,FSW, GCS		V		

System Requirement Summary (6/9)

No.	Requirement	Priority	Subsystem	A	I	T	D
29.	The CanSat shall transmit telemetry once per second, including altitude, air pressure, temperature, battery voltage, command echo, and GPS coordinates that include latitude, longitude, altitude and number of satellites tracked.	High	EE				V
30.	CanSat payload shall measure its altitude using air pressure, internal temperature, battery voltage, position using GPS, acceleration and rotation rates, auto-gyro rotation rate, magnetic field.	High	EE			V	
31.	The camera video, in color and with a minimum resolution of 640x480, shall be spin stabilized and oriented in the north direction so the view of the ground is not rotating more than 10 degrees in either direction .	High	EE,FSW			V	
32.	Developed own ground station. The ground station shall command the CanSat to calibrate the altitude to zero when the CanSat is on the launch pad prior to launch and generate csv files of all sensor data as specified in the Telemetry Requirements section, including mission time with 1 second resolution.	High	FSW,GCS				V

System Requirement Summary (7/9)

No.	Requirement	Priority	Subsystem	A	I	T	D
33.	Configuration states such as zero altitude calibration software state shall be maintained in the event of a processor reset during launch and mission.	High	FSW,GCS				V
34.	All telemetry shall be displayed in real time during ascent and descent on the ground station in the International System of Units (SI) and the units shall be indicated on the displays. In addition, Plot each telemetry data field in real time during flight.	High	FSW,GCS				V
35.	The ground station shall be portable and include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a tabletop or handheld antenna.	High	FSW,GCS				V
36.	The ground station software shall be able to command the payload to operate in simulation mode by sending two commands, SIMULATION ENABLE and SIMULATION ACTIVATE.	High	FSW,GCS			V	

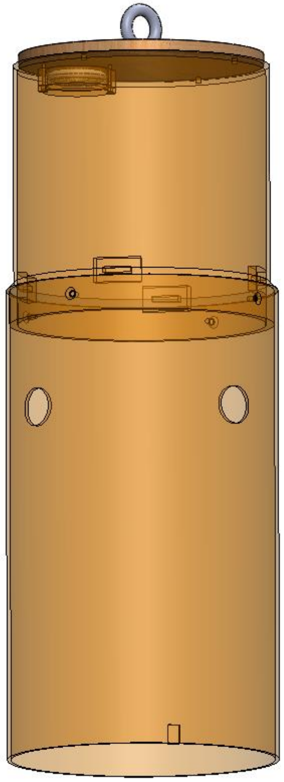
System Requirement Summary (8/9)

No.	Requirement	Priority	Subsystem	A	I	T	D
37.	In simulation mode, the ground station shall transmit pressure data from a csv file provided by the competition at a 1 Hz interval to the CanSat.	High	FSW,GCS			V	
38.	Ground station's displays shall be designed using larger fonts (14 point minimum), bold plot traces and axes, and a dark text on light background theme.	High	FSW,GCS				V
39.	Ground system shall count the number of received packets that it successfully received and be able to activate all mechanisms on command.	High	FSW,GCS				V
40.	The flight software shall maintain a count of packets transmitted which shall increment with each packet transmission throughout the mission. The value shall be maintained through processor resets.	High	FSW,GCS			V	
41.	The CanSat shall maintain mission time throughout the whole mission even with processor resets or momentary power loss and have its time set to within one second UTC time prior to launch.	High	FSW,GCS				V

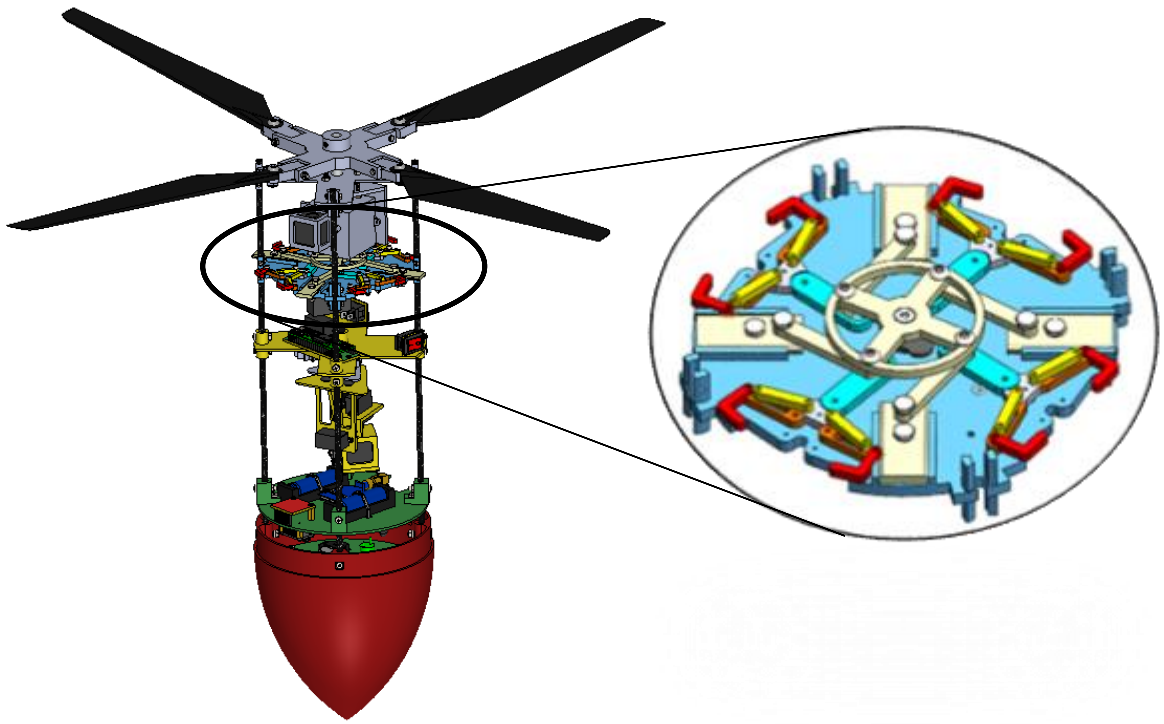
System Requirement Summary (9/9)

No.	Requirement	Priority	Subsystem	A	I	T	D
42.	The flight software shall support simulated flight mode where the ground station sends air pressure values at a one second interval using a provided flight profile csv file.	High	FSW,GCS			V	
43.	In simulation mode, the flight software shall use the radio uplink pressure values in place of the pressure sensor for determining the payload altitude.	High	FSW,GCS			V	
44.	The payload flight software shall only enter simulation mode after it receives the SIMULATION ENABLE and SIMULATION ACTIVATE commands.	High	FSW,GCS			V	
45.	The flight shall include commands to activate all mechanisms. These commands shall be documented in the mission manual.	High	FSW,GCS				V

Design A – Motor-Driving Release Design

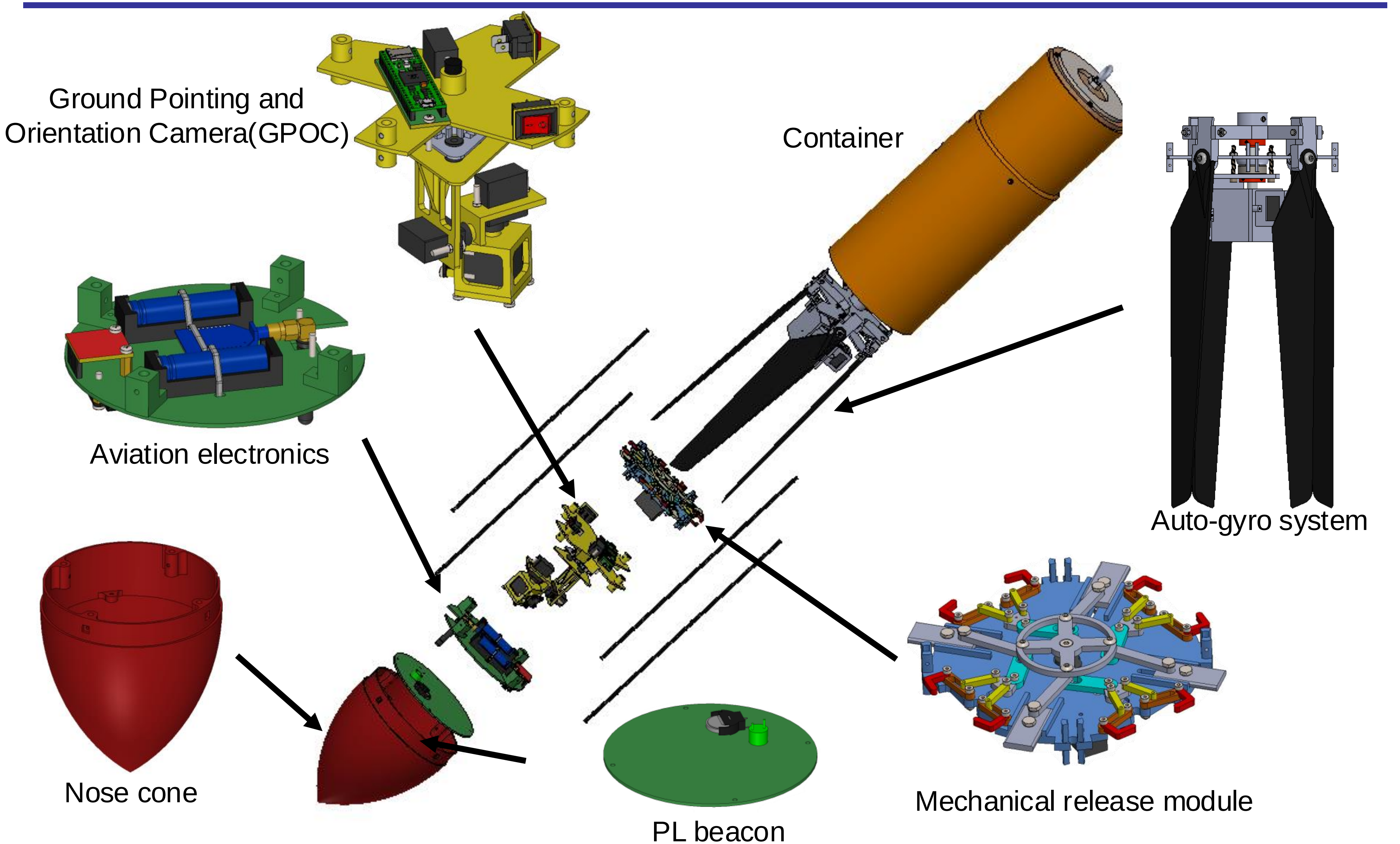


Container

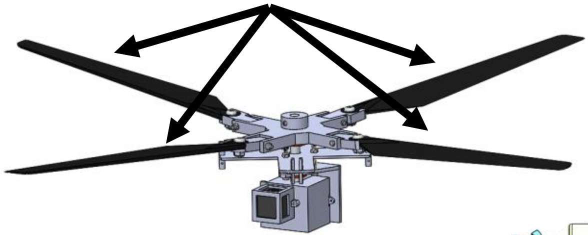


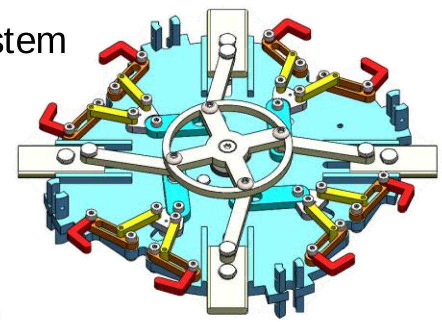
Payload

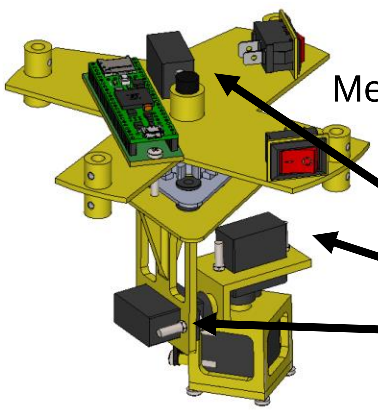
System Level CanSat Configuration Trade & Selection (2/7)



Design A – Motor Driving Release Design







Main Feature

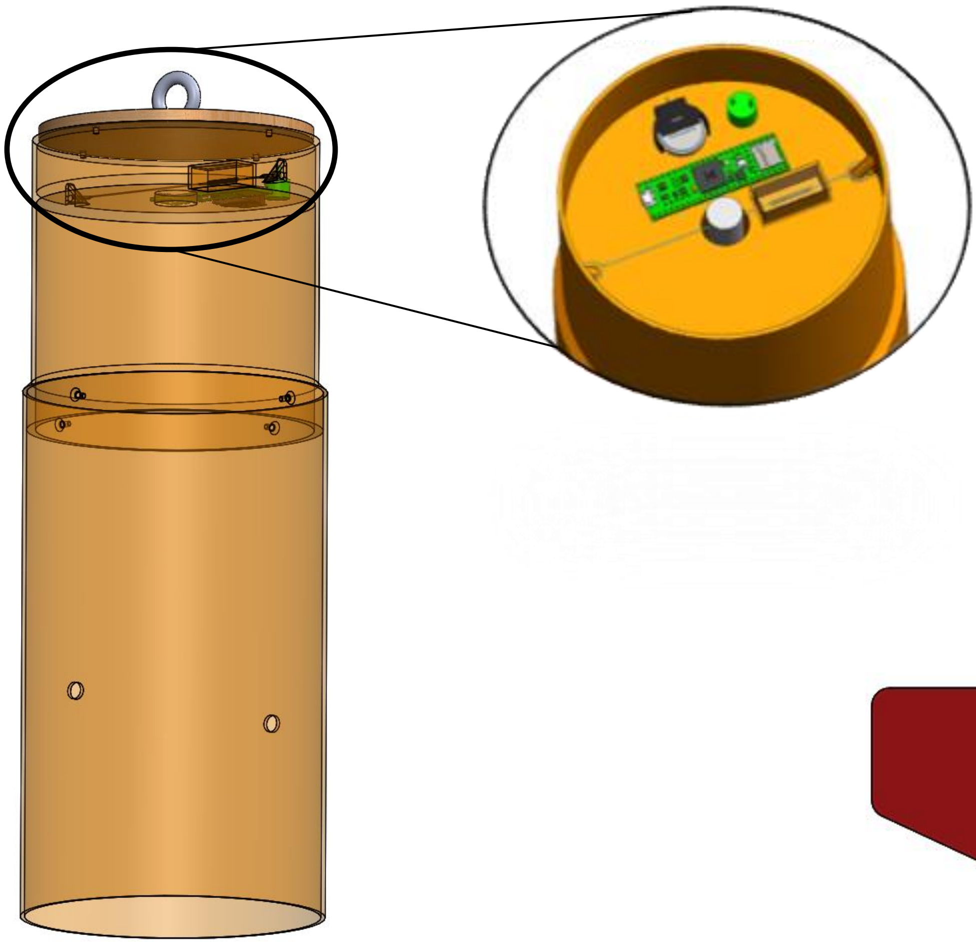
- Auto-gyro uses a 4-blade configuration.
- Use mechanical release configuration.
- The Ground Pointing and Orientation Camera is controlled by three independent servos to stabilize it.

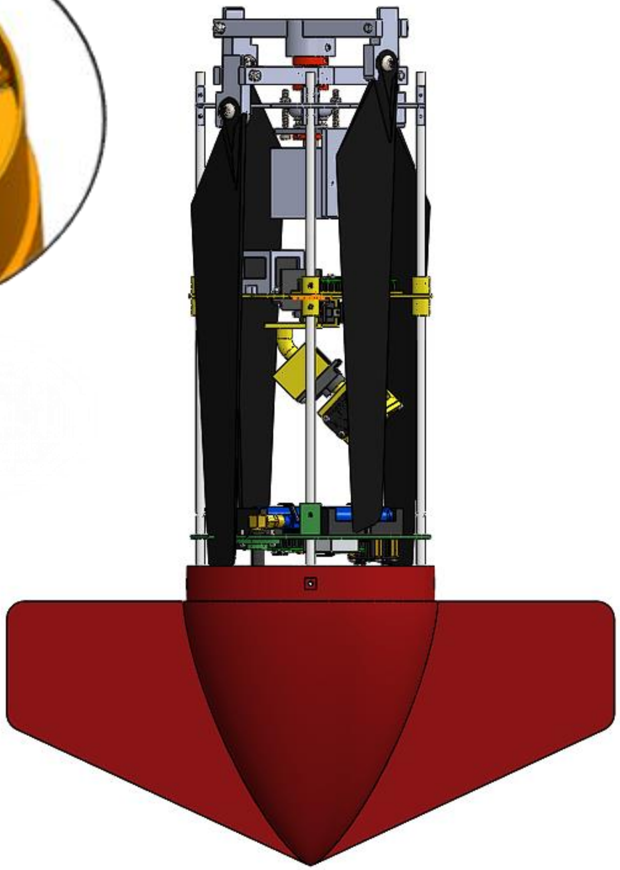
CONOPS Variation

- The payload is released from the container using a mechanical mechanism.

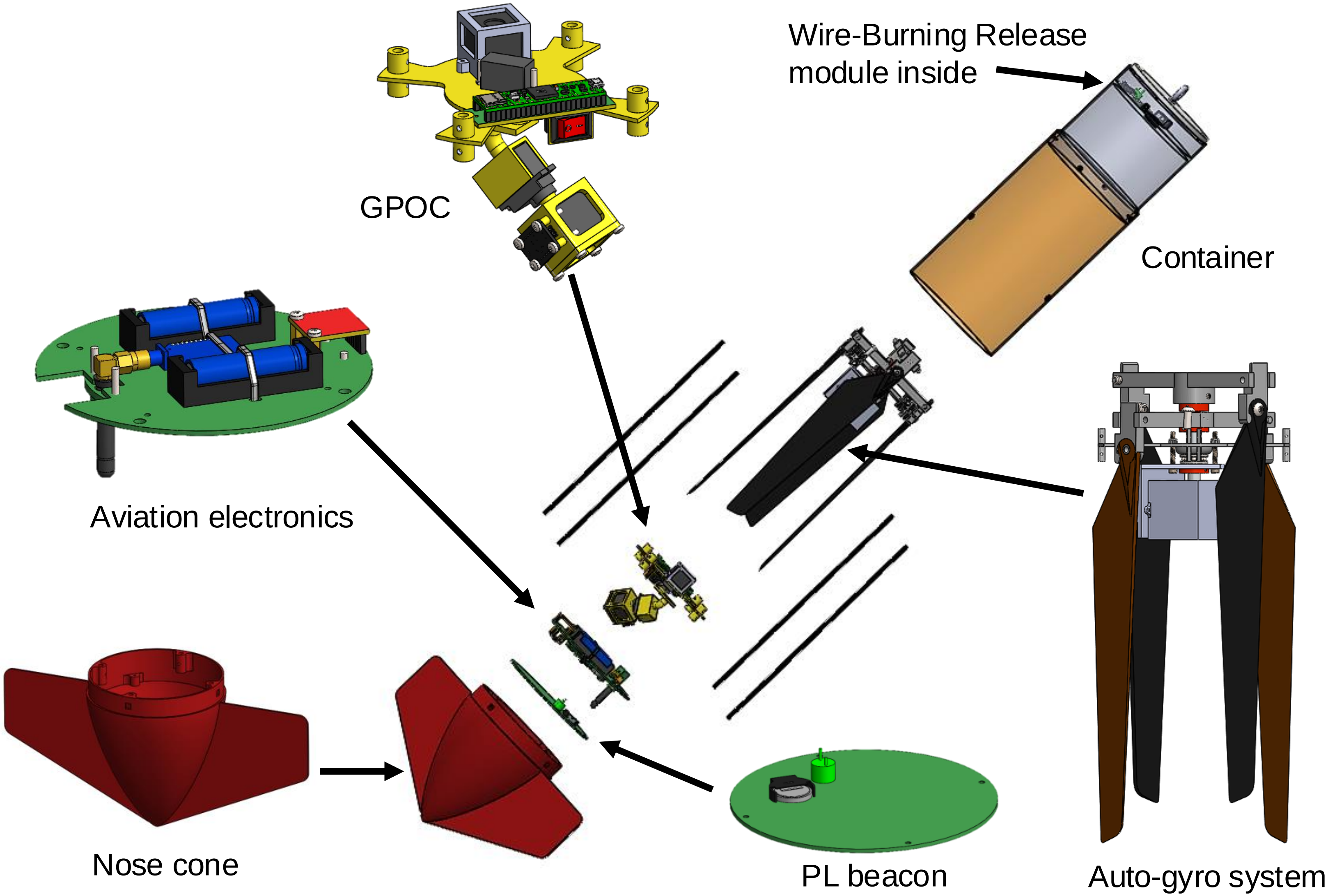
System Level CanSat Configuration Trade & Selection (4/7)

Design B – Wire-Burning Release Design





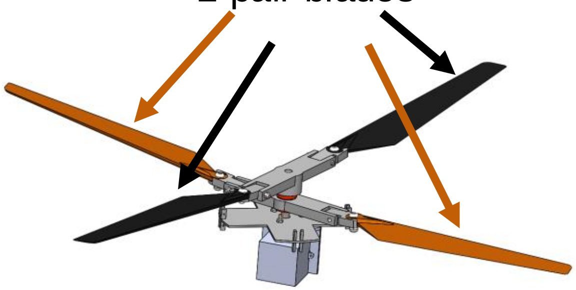
System Level CanSat Configuration Trade & Selection (5/7)



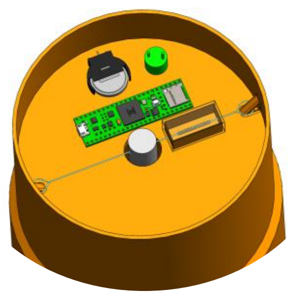
System Level CanSat Configuration Trade & Selection (6/7)

Design B – Wire-Burning Release Design

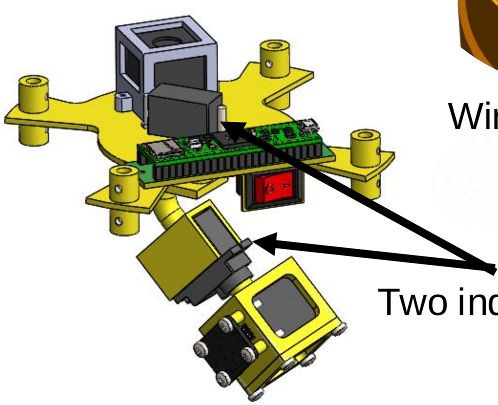
2-pair-blades



Auto-gyro system



Wire-Burning release system



Two independent servos

GPOC

Main Feature

- Auto-gyro uses a 2-pair-blades configuration.
- Use wire-burning release configuration.
- Ground Pointing and Orientation Camera use two independent servos to stabilize.

CONOPS Variation

- The payload is released from the container using a burn wire mechanism
- The nose cone features a spring mechanism for actively separating the payload and container.

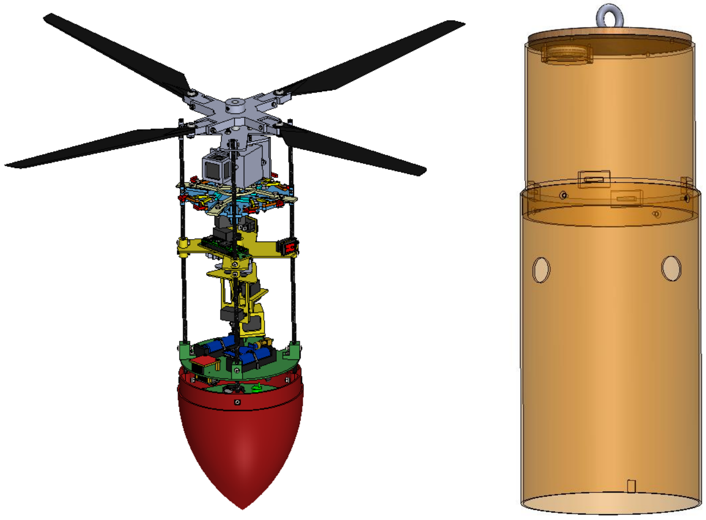
System Level CanSat Configuration Trade & Selection (7/7)

- **System Level CanSat**

Criteria	Trade Study
Auto-gyro system	• **Design A** uses a 4-blade configuration. • **Design B** uses a 2-pair-blade configuration.
Release system	• **Design A** uses a Motor-Driving Release Design. • **Design B** uses a Wire-Burning Release Design.
GPOC	• **Design A** employs three-axis independent control. • **Design B** controls only two degrees of freedom, but simpler structure.
Nose cone	• **Design B**'s mechanism is more complicated than **Design A**'s.

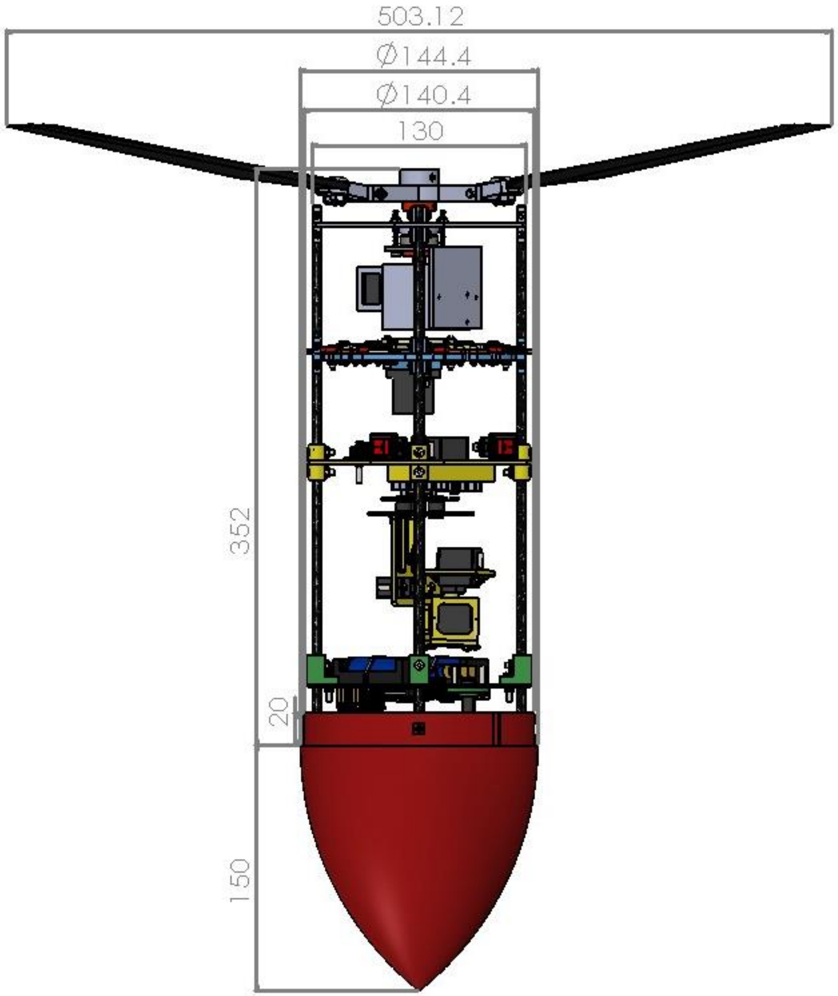
System Level Configuration Selection

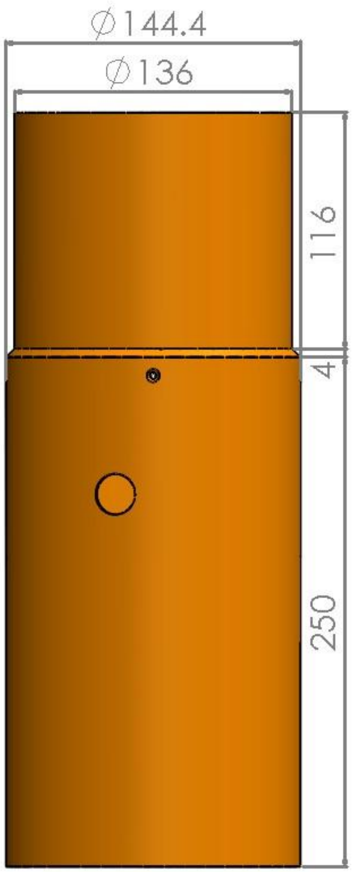
Selection: Motor Driving Release Design
Rationale: • GPOC is capable of handling more complex scenarios. • The release system is more reliable. • The auto-gyro system accommodates less space.
Drawbacks: • The payload and container undergo passive separation. • A more complex structure.



Physical Layout (1/9)

PL dimensions	Container dimensions

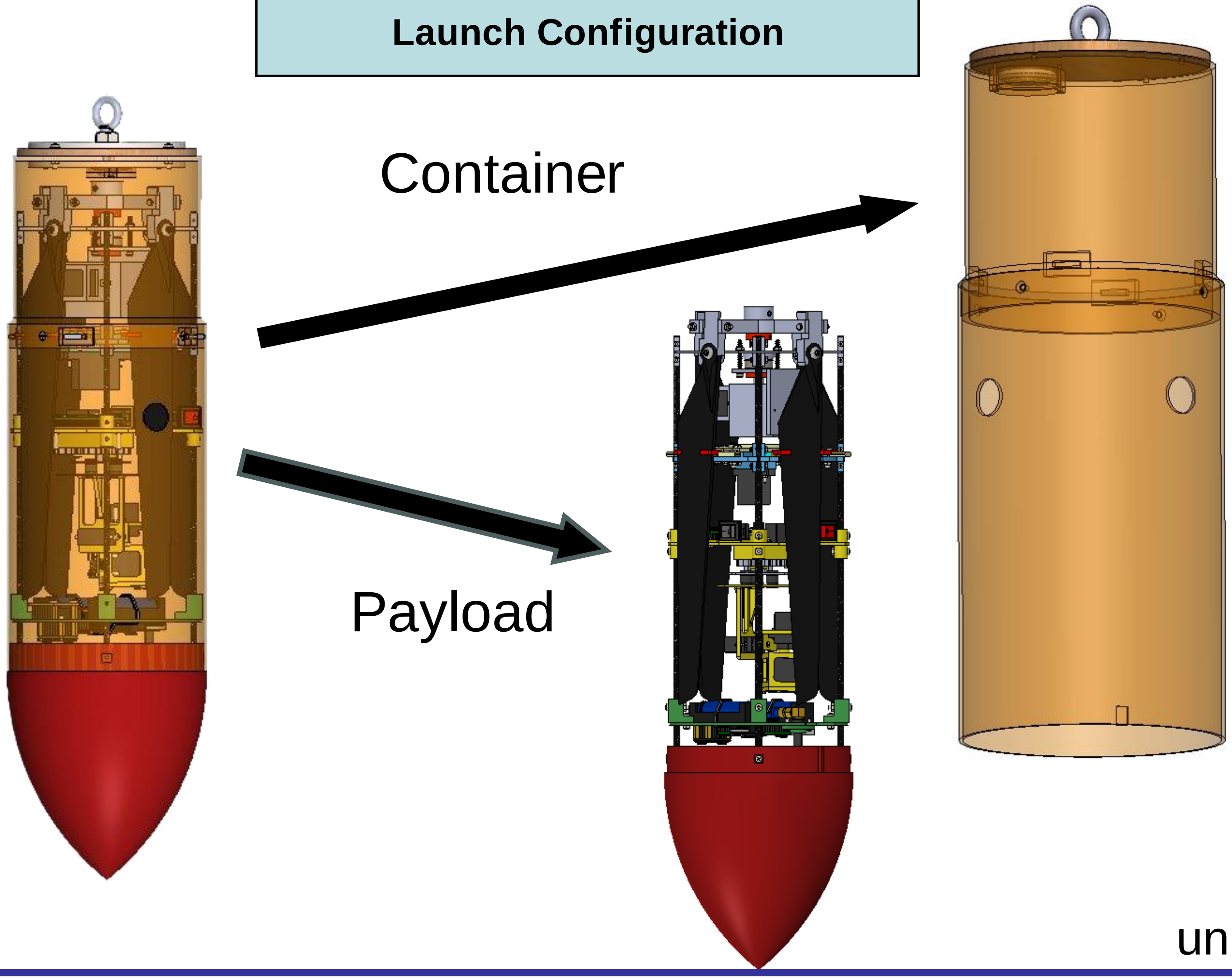




unit : mm

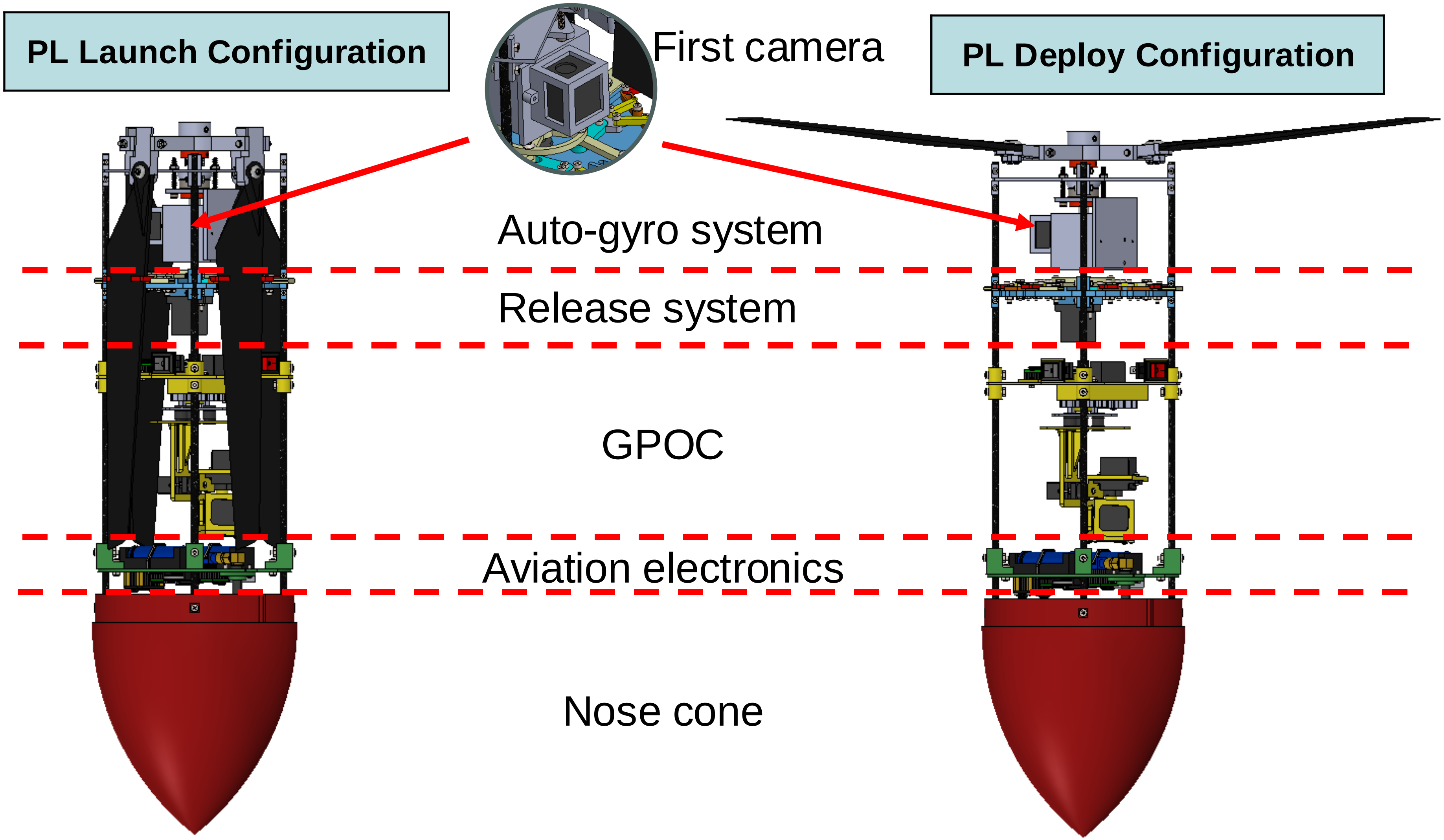
Physical Layout (2/9)

Launch Configuration

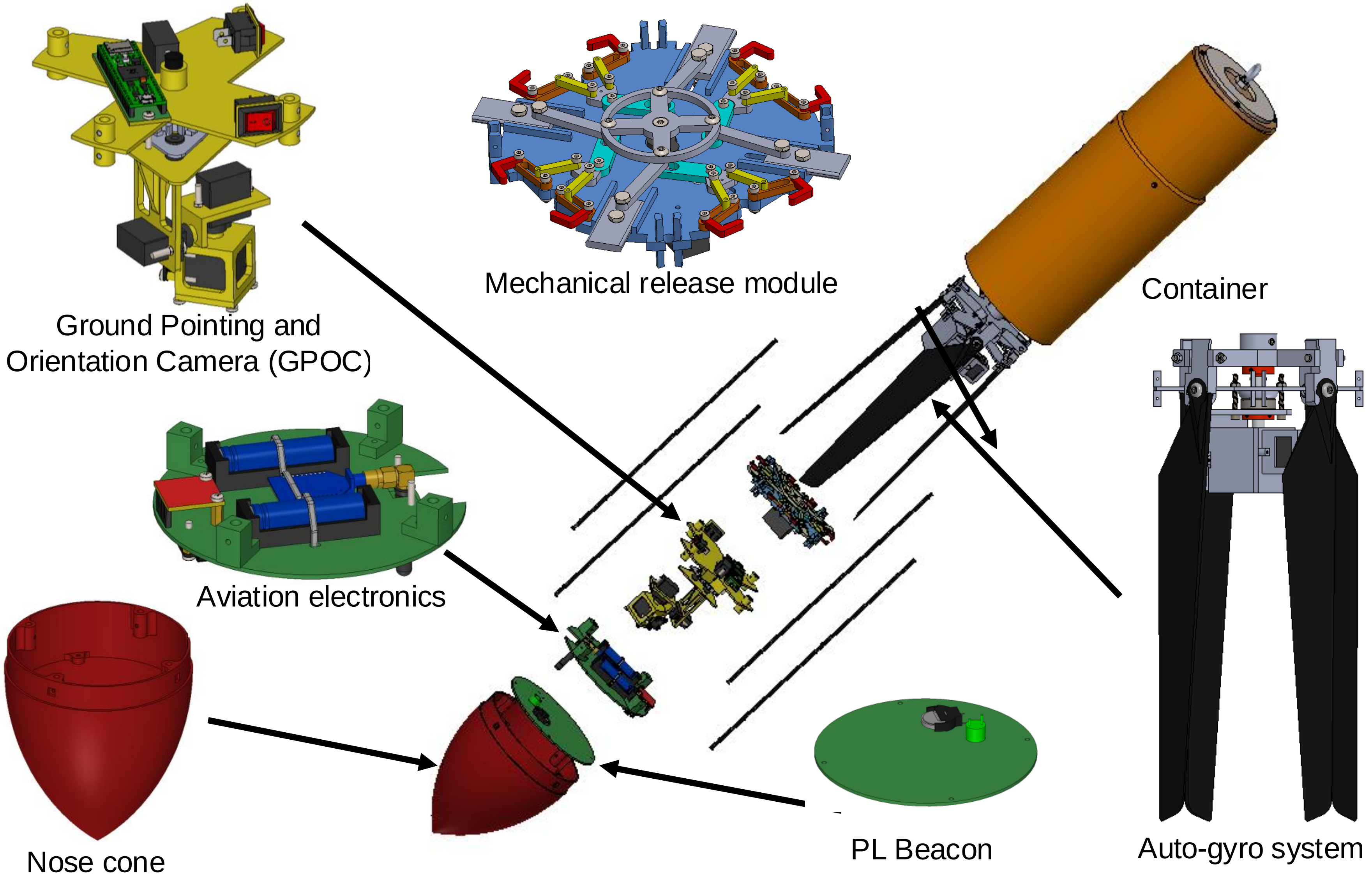


unit : mm

Physical Layout (3/9)

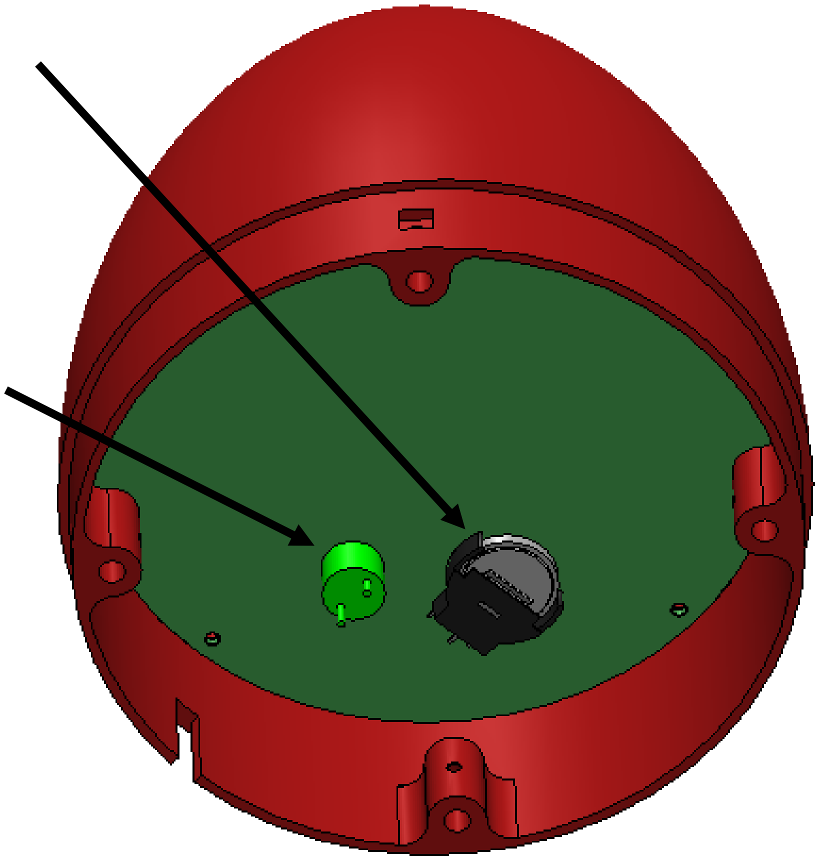


Physical Layout (4/9)

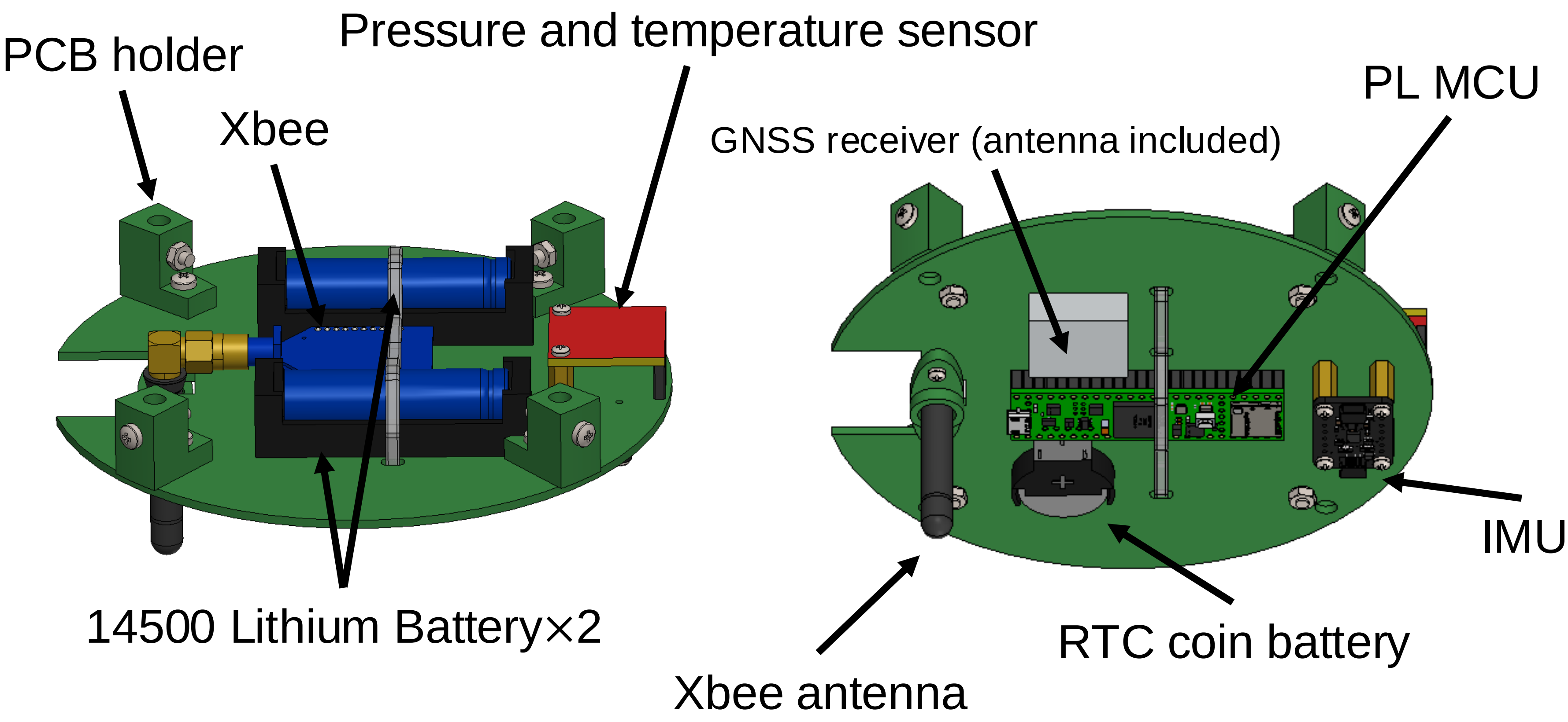


Physical Layout (5/9)

Nose Cone

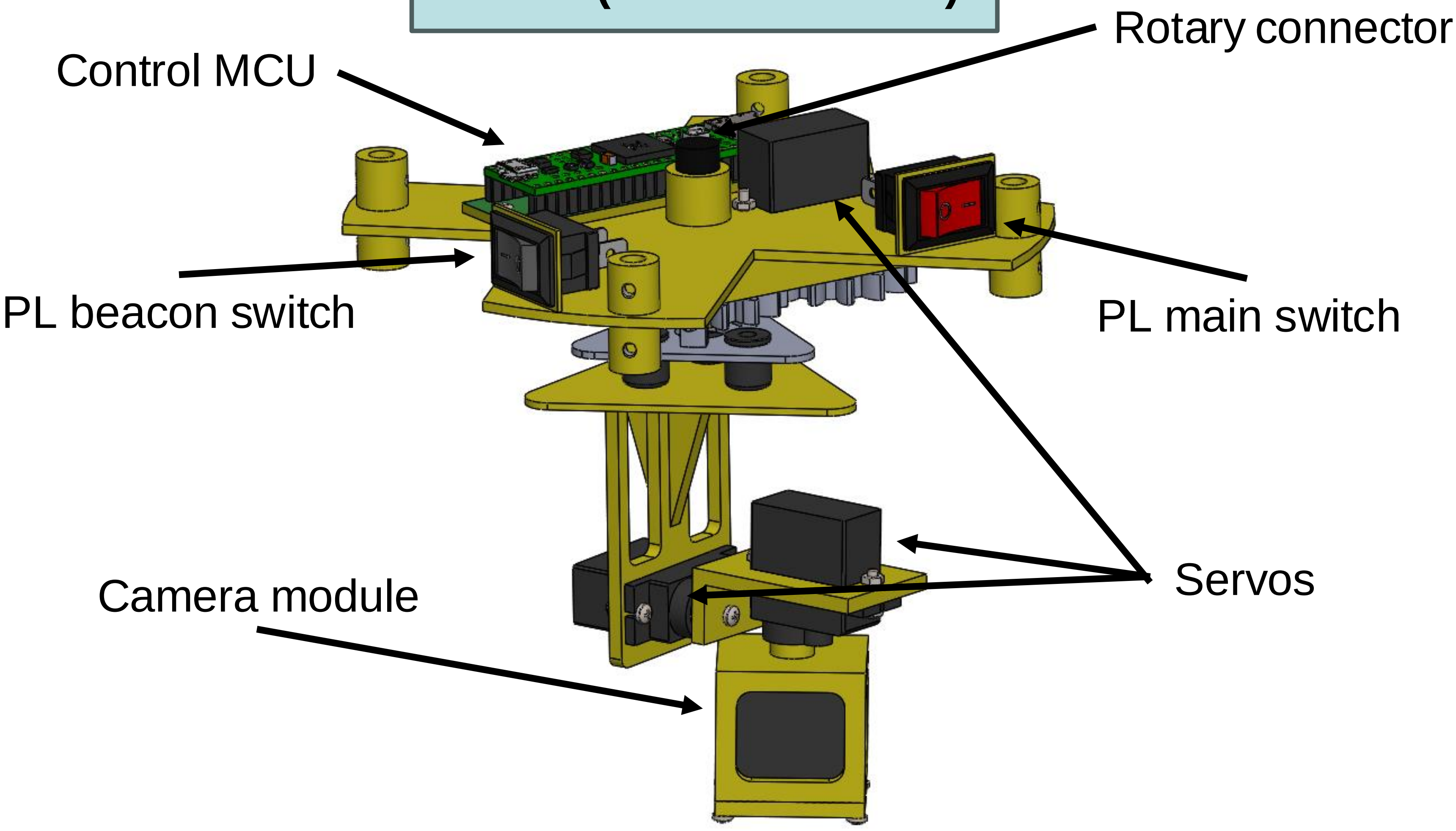


Aviation Electronics

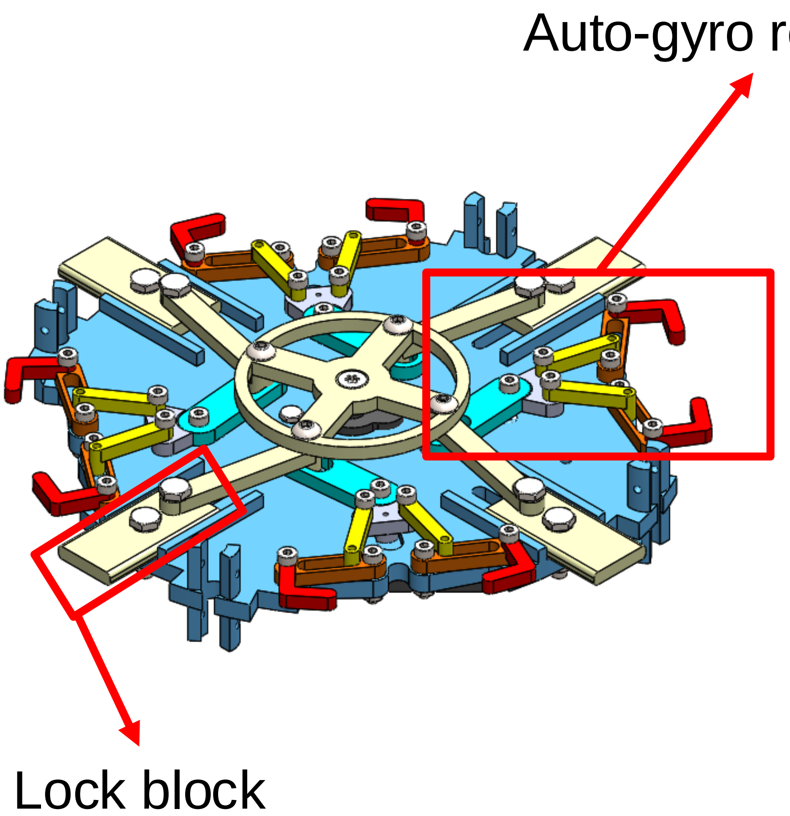


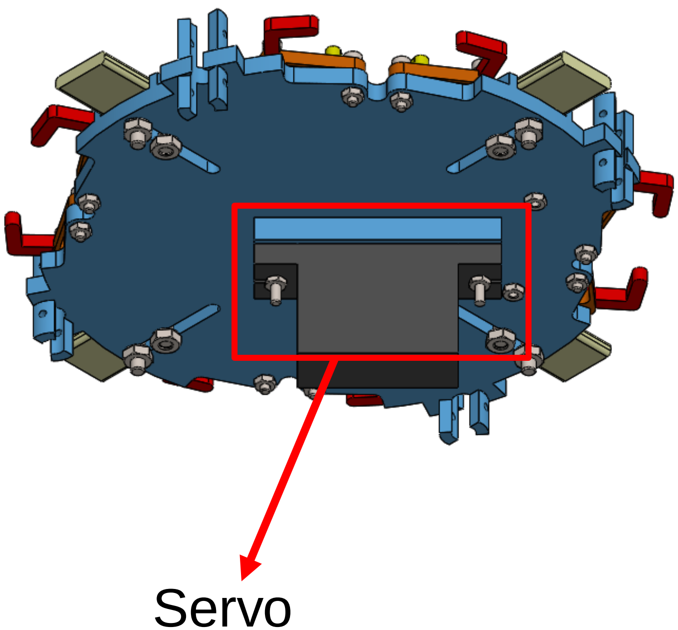
Physical Layout (7/9)

GPOC (Second camera)



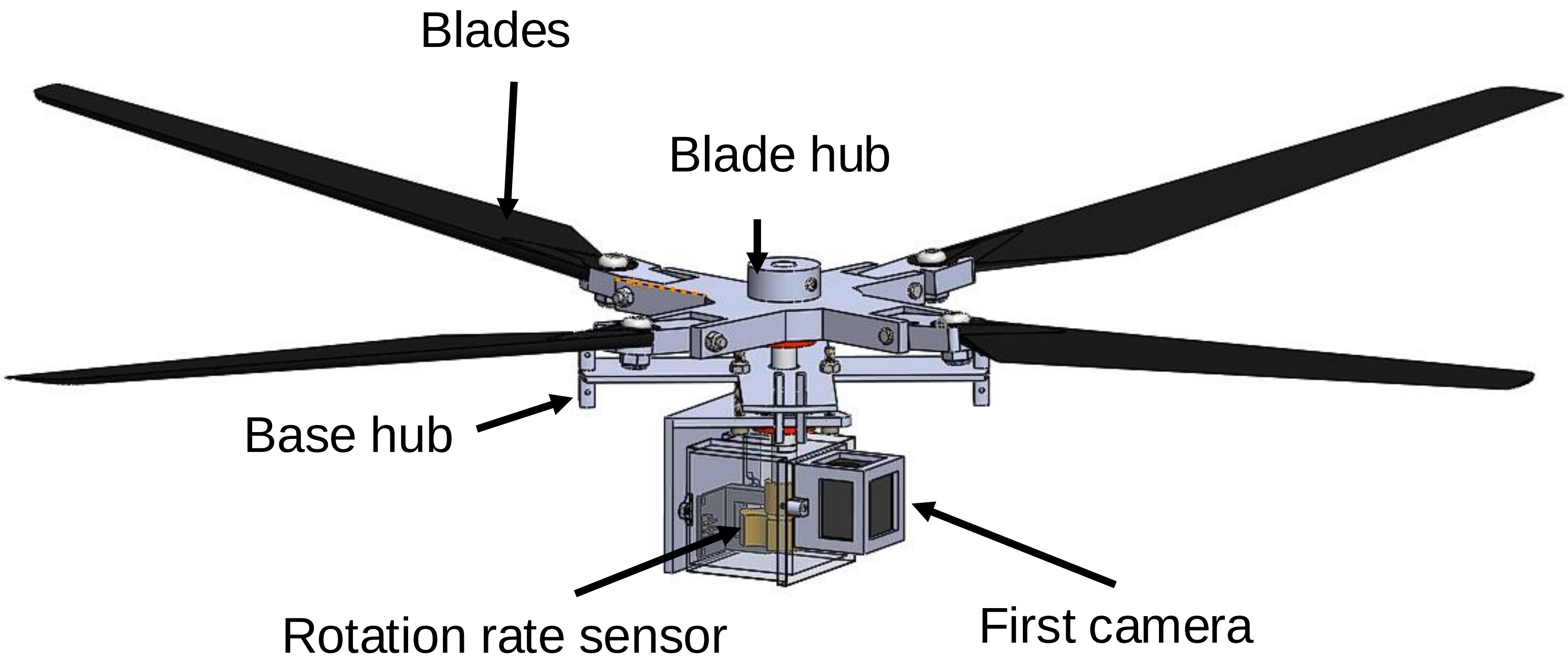
Mechanical Release Module



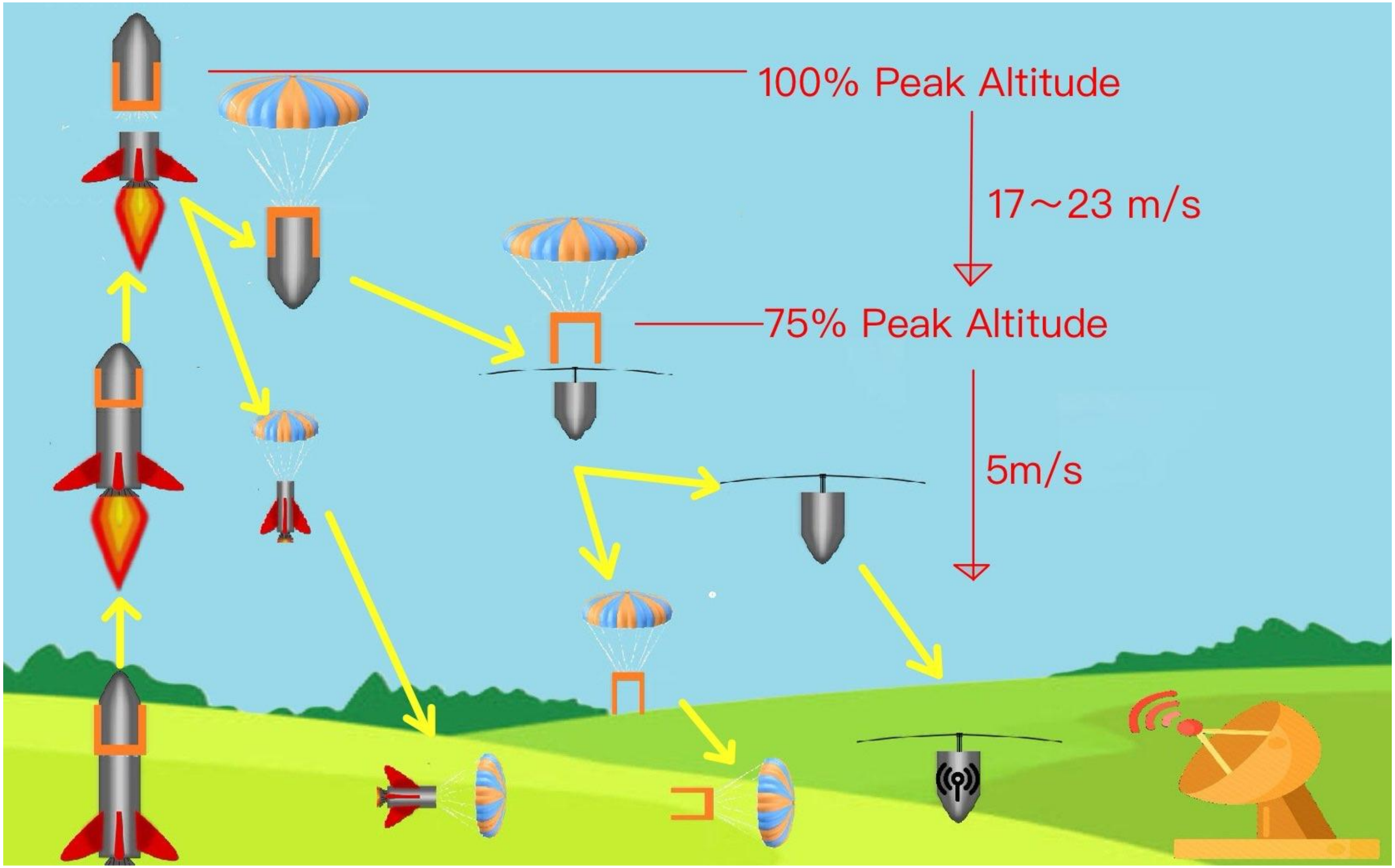


Physical Layout (9/9)

Auto-Gyro System



System Concept of Operations (1/3)



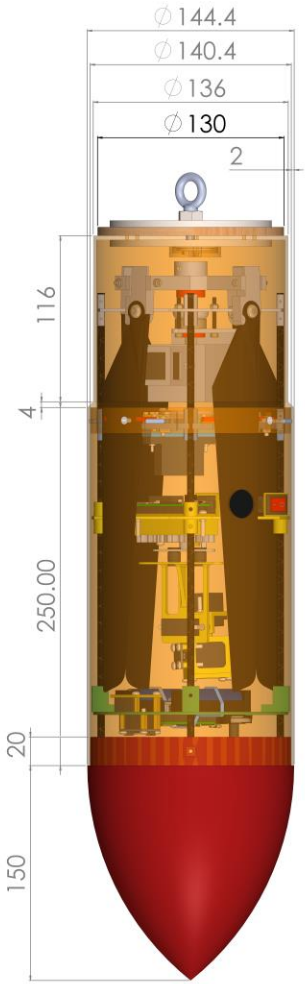
System Concept of Operations (2/3)

- **Phase 1 Initial:**
  - The CanSat is powered on and loaded to the launch vehicle.
  - The CanSat starts sensor calibration and data transmission.
  - The CanSat starts two cameras recording.
- **Phase 2 Ascent:**
  - The CanSat is launched and ascends to 670~725 m height. (TBD)
- **Phase 3 Separation and release of the parachute:**
  - The CanSat is separated from the rocket.
  - The CanSat deploys the parachute and descends at a rate of 17~23 m/s.

System Concept of Operations (3/3)

- **Phase 4 Payload Release:**
  - The Payload is released from the container at 75% of apogee height.
  - The Payload deploys the auto-gyro system and descends at a rate of 2~8 m/s.
  - The first camera records the deployment of the auto-gyro.
  - The second camera records the ground at 45 degrees from the nadir direction.
- **Phase 5 Land:**
  - The Payload stops data transmission and camera recording.
  - The data transmission and camera recording are stopped.
  - Recovered by team crews.

Launch Vehicle Compatibility



No sharp protrusions on the blades

Clearance Table (Unit: mm)			
Dimensions	**CanSat**	**Rocket**	**Margin**
Container Shoulder Diameter	136	137	1
Container Shoulder Length	118	90~120	2

Launch Configuration

unit : mm

Sensor Subsystem Design

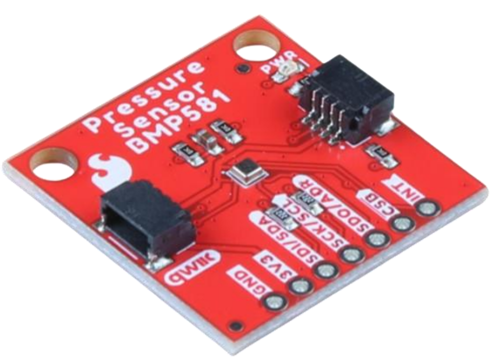
Kuan-Yu Lai

Sensor Subsystem Overview

Component	Model	Function
Air Pressure Sensor	BMP581	Determine atmospheric pressure to estimate the altitude of the CanSat.
Air Temperature Sensor	BMP581	Measure the internal temperature of the CanSat.
Battery Voltage Sensor	ADC of MCU	Monitor the voltage of the battery
GNSS Sensor	LS2003E-G	Provide the precise location and altitude data for the CanSat.
Auto-Gyro Rotation Rate Sensor	FC-33	Measure the rotation rate of the auto-gyro.
Tilt and Acceleration Sensor	ICM-20948	Detect the tilt and orientation of the CanSat.
Ground Camera Orientation Sensor	ICM-20948	To stabilize the camera for clear, north-oriented ground video.
Release Camera	SQ11	Capture the video of the CanSat release and descent.
Ground Camera	SQ11	Capture ground video during the CanSat flight.

Payload Air Pressure Sensor Trade & Selection

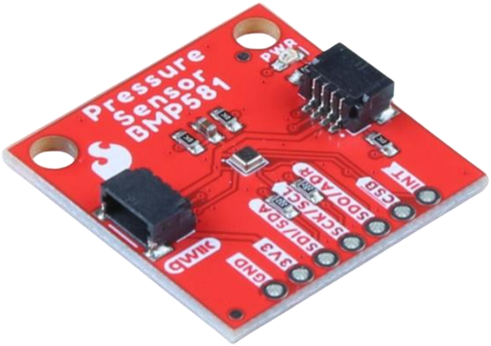
Air Pressure Sensor								
Module	Interface	Resolution (Pa)	Accuracy (hPa)	Operating Current (μA)	Range (hPa)	Dimension (mm)	Weight (g)	Cost (USD)
BMP384	I²C/SPI	0.016	±0.09	3.4	300 ~ 1250	25.4×25.4	18	15.95
BMP581	I²C/SPI	0.016	±0.06	1.3	300 ~ 1250	25.4×25.4	18	19.95
BME680	I²C/SPI	0.18	±0.6	3.1	300 ~ 1100	25.4×25.4	1.2	18.95
BMP280	I²C/SPI	0.01	±1	2.8	300 ~ 1100	15.2×15.2	4.5	15.95



Selected Air Pressure Sensor	Rationales
BMP581	• Better resolution • Better pressure range • **Less power consumption**

Payload Air Temperature Sensor Trade & Selection

Air Temperature Sensor								
Module	Interface	Resolution (˚C)	Accuracy (˚C)	Operating Current (μA)	Range (˚C)	Dimension (mm)	Weight (g)	Cost (USD)
BMP384	I²C/SPI	0.01	±0.5	3.4	-40 ~ 85	25.4×25.4	18	15.95
BMP581	I²C/SPI	0.01	±0.5	1.3	-40 ~ 85	25.4×25.4	18	19.95
BME680	I²C/SPI	0.01	±1	3.1	-40 ~ 85	25.4×25.4	1.2	18.95
BMP280	I²C/SPI	0.01	±1	2.8	-40 ~ 85	15.2×15.2	4.5	15.95



Selected Air Pressure Sensor	Rationales
BMP581	• **Integrated with pressure sensor** • Less power consumption

Payload Battery Voltage Sensor Trade & Selection

Battery Voltage Sensor					
Model	Interface	Resolution	Dimension (mm)	Weight	Cost (USD)
ADC of MCU	Analog	12 bit within 3.6V	Negligible*	Negligible	29.6
ADS1100	I²C	16 bit within 5.5V	3×3.05×1.1	Negligible	57.8
MCP3221	I²C	12 bit within 5V	3.05×3×1.45	Negligible	47.7

*NOTE: Part of MCU (Teensy 4.1)

Selected Voltage Sensor	Rationales
ADC of MCU	• **Easy to integrate** • Low cost • Appropriate resolution

Payload GNSS Sensor Trade & Selection

GNSS Sensor						
Module	Interface	Position Accuracy (m)	Update Rate (Hz)	Dimension (mm)	Weight (g)	Cost (USD)
LS2003E-G	UART	2.5	10	22×22×7.5	10	53
SAM M8Q	UART/ I²C	2.5	18	26×16×7.5	7	34
NEO M8N	SPI/UART /USB/ I²C	2.5	10	12.2×16×2.4	1.6	34
PA1616S -MTK3339	UART/ I²C	3	10	16×16×5.2	4	25.2

Selected Module	Rationales
LS2003E-G	• Performance and Accuracy • Anti-interference Capability • **Less Power Consumption**

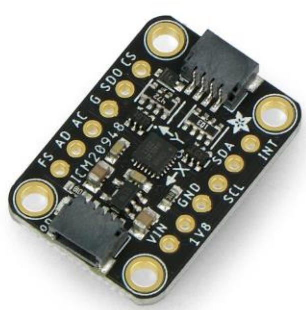
Payload Auto-Gyro Rotation Rate Sensor Trade & Selection

Auto-Gyro Rotation Rate Sensor								
Module	Interface	Measurement Technique	Supply Voltage (V)	Current (mA)	Dimension (mm)	Weight (g)	Resolution (RPM)	Cost (USD)
FC-33	Digital	Infrared Radiation	3.3	10	20×27×18	3.2	1	1.4
Sharp GP2Y0D810Z0F	Digital	Infrared Radiation	2.7	5	21×9×10	1.8	1	7.5
KY-003	Digital	Magnetic Field	3.3	8	18×15×3	3.5	1	2.8

Selected Module	Rationales
FC-33	• Low cost • **Easy to program** • Infrared radiation enables more accurate measurement than magnetic fields

Payload Tilt Sensor Trade & Selection

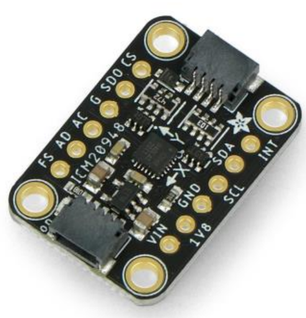
Tilt Sensor							
Module	Interface	Operating Current (mA)	Maximum Gyroscope Range (°/sec)	Resolution (bit)	Dimension (mm)	Weight (g)	Cost (USD)
MPU6050	I²C	3.6	± 2000	16	21.2×16.4×3.3	2.1	1.2
MPU9250	I²C, SPI	3.2	± 2000	16	15×25×3.3	2	11.3
BNO055	I²C, UART	12.3	± 2000	16	20×27×4	3	28.1
ICM-20948	I²C, SPI	3.11	± 2000	16	25.7×17.7×4.6	5	15.6



Selected Module	Rationales
ICM-20948	• **Magnetometer included** • Low cost • **Easy to program** • Less power consumption • High accuracy

Payload Tilt Sensor Trade & Selection

Ground Camera Orientation Sensor							
Module	Interface	Operating Current (mA)	Maximum Gyroscope Range (°/sec)	Resolution (bit)	Dimension (mm)	Weight (g)	Cost (USD)
MPU6050	I²C	3.6	± 2000	16	21.2×16.4×3.3	2.1	1.2
MPU9250	I²C, SPI	3.2	± 2000	16	15×25×3.3	2	11.3
BNO055	I²C, UART	12.3	± 2000	16	20×27×4	3	28.1
ICM-20948	I²C, SPI	3.11	± 2000	16	25.7×17.7×4.6	5	15.6



Selected Module	Rationales
ICM-20948	• **Magnetometer included** • Low cost • Same as tilt sensor • Easy to program • Less power consumption • High accuracy

Parachute Release Camera Trade & Selection

Parachute Release Camera							
Module	Interface	Max Operating Current (mA)	Resolution (pixel)	Frame Rate (fps)	Dimension (mm)	Weight (g)	Price (USD)
OV7670	I²C	10	640 x 480	30	35×35×30	20	4.2
TTL Serial Camera	Serial	75	640 x 480	30	32×32×10	3	41.3
5MP Plus OV5642	I²C/SPI	390	1920 x 1080	30	34×24×10	20	46.2
SQ11	MINI USB	300	1920 x 1080	30	23×23×23	10	12

Selected Module	Rationales
SQ11	• Low cost • Small size • Onboard SD card for recording • Independent operation

Ground Camera Trade and Selection

Ground Camera							
Module	Interface	Max Operating Current (mA)	Resolution (pixel)	Frame Rate (fps)	Dimension (mm)	Weight (g)	Price (USD)
OV7670	I²C	10	640 x 480	30	35×35×30	20	4.2
TTL Serial Camera	Serial	75	640 x 480	30	32×32×10	3	41.3
5MP Plus OV5642	I²C/SPI	390	1920 x 1080	30	34×24×10	20	46.2
SQ11	MINI USB	300	1920 x 1080	30	23×23×23	10	12

Selected Module	Rationales
SQ11	• **Same as parachute release camera** • Low cost • Small size • On board SD card for recording • Independent operation

Descent Control Design

Chen-Pei Yang

Su-Yun Hsu

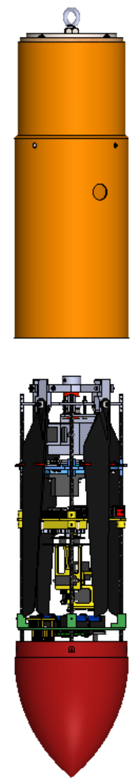
Descent Control Overview

Parachute

(Descent rate of 17~23 m/s)

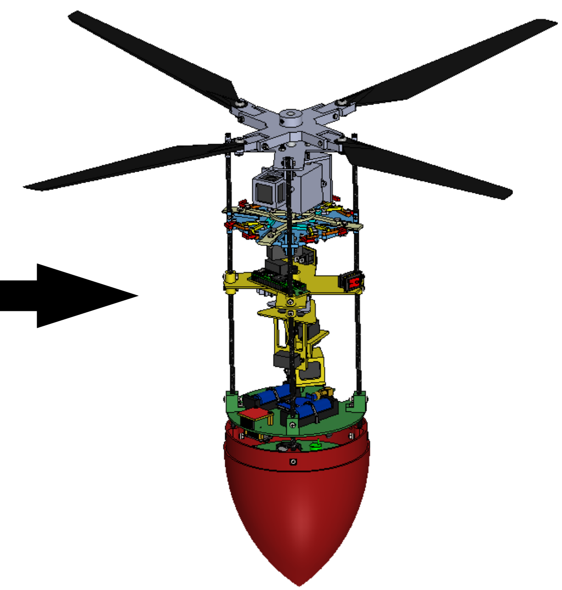
Apogee to 75% peak altitude

Release



Reach 75% peak altitude

Auto-Gyro System



(Descent rate of 2~8 m/s)

75% peak altitude to landing

Parachute Descent Control Strategy Selection and Trade

Parachute Design Trade		
Design Feature	**Advantages**	**Disadvantages**
Dome	• Common in design • High drag coefficient ($C_{D,Dome} = 0.75$)	• Difficult to stack
Cross	• Lightweight	• Low drag coefficient ($C_{D,Cross} = 0.6$) • Limited accessibility

Dome

Cross

Selected Design	Rationales
Dome	• High drag coefficient • Commonly used

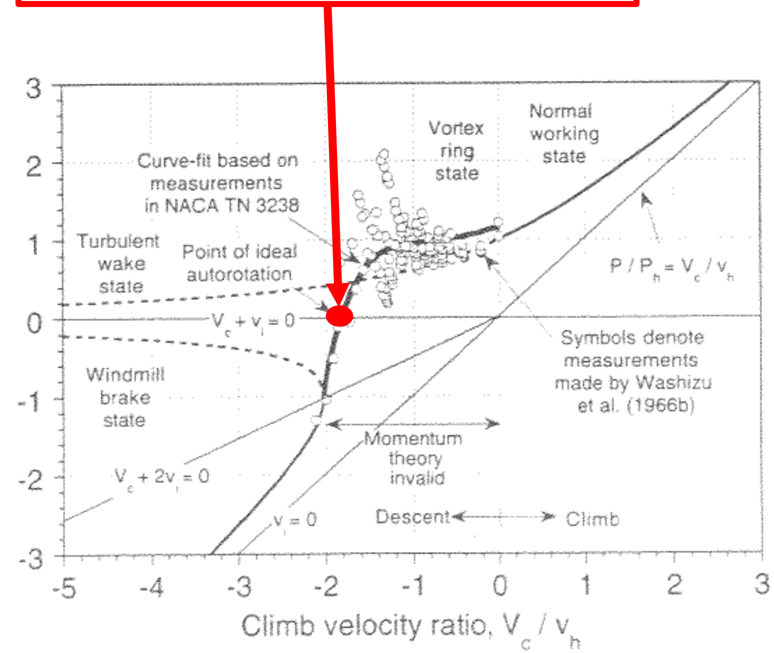
- In auto-rotation, no power is required. For ideal auto-rotation, the $\frac{V_c}{V_h}$ should range between -1.85 and -1.9, as determined from the graph. (V_c : climb velocity, V_h : induced velocity at hover)

- The drag coefficient(C_d), calculated using the following equation, falls between 1.10 and 1.16.

$$c_d = \frac{4}{\left(\frac{v_c}{v_h}\right)^2}$$

V_c : climb velocity
V_h : induced velocity at hover.

Point of the ideal auto-rotation



re 2.15 Total power required as a function of climb and descent velocity (u
er curve).

Taken from "Principles of Helicopter Aerodynamics" – J.GORDON LEISHMAN

Auto-Gyro Descent Control Strategy Selection and Trade (2/3)

- **Terminal velocity (V_t)=** $\sqrt{\frac{2(mg-L)}{\rho \cdot C_d \cdot A}}$
- **The rotor disk area** $A = \frac{2mg}{(C_d+4)\rho v_t^2} = \pi r^2$

m = CanSat maximum mass (kg)
ρ = Air Density at 31℃
L = Lift force(N)
r = blade long(m)

Case : $\mathbf{V_t} = 5\ m/s$

C_d	1.16	1.1
A=	0.20	0.20
r=	0.25	0.25

Case : $\mathbf{V_t} = 2\ m/s$

C_d	1.16	1.1
A=	1.23	1.25
r=	0.63	0.63

Case : $\mathbf{V_t} = 8\ m/s$

C_d	1.16	1.1
A=	0.08	0.08
r=	0.16	0.16

Conclusion:

- **The Descent rate limit: 2~8m/s**
- **We chose the longest blade that can fit in the container.**

⇒ **r=0.29m**

Auto-Gyro Descent Control Strategy Selection and Trade (3/3)

Auto-Gyro Design Trade		
Design Feature	**Advantages**	**Disadvantages**
3D-print Blade	• Processing-friendly	• In-house manufacturing • Stability has raised potential concerns
Commercial Blade	• Lightweight(30g/pic) • An aerodynamic design angle	• The product selection is limited

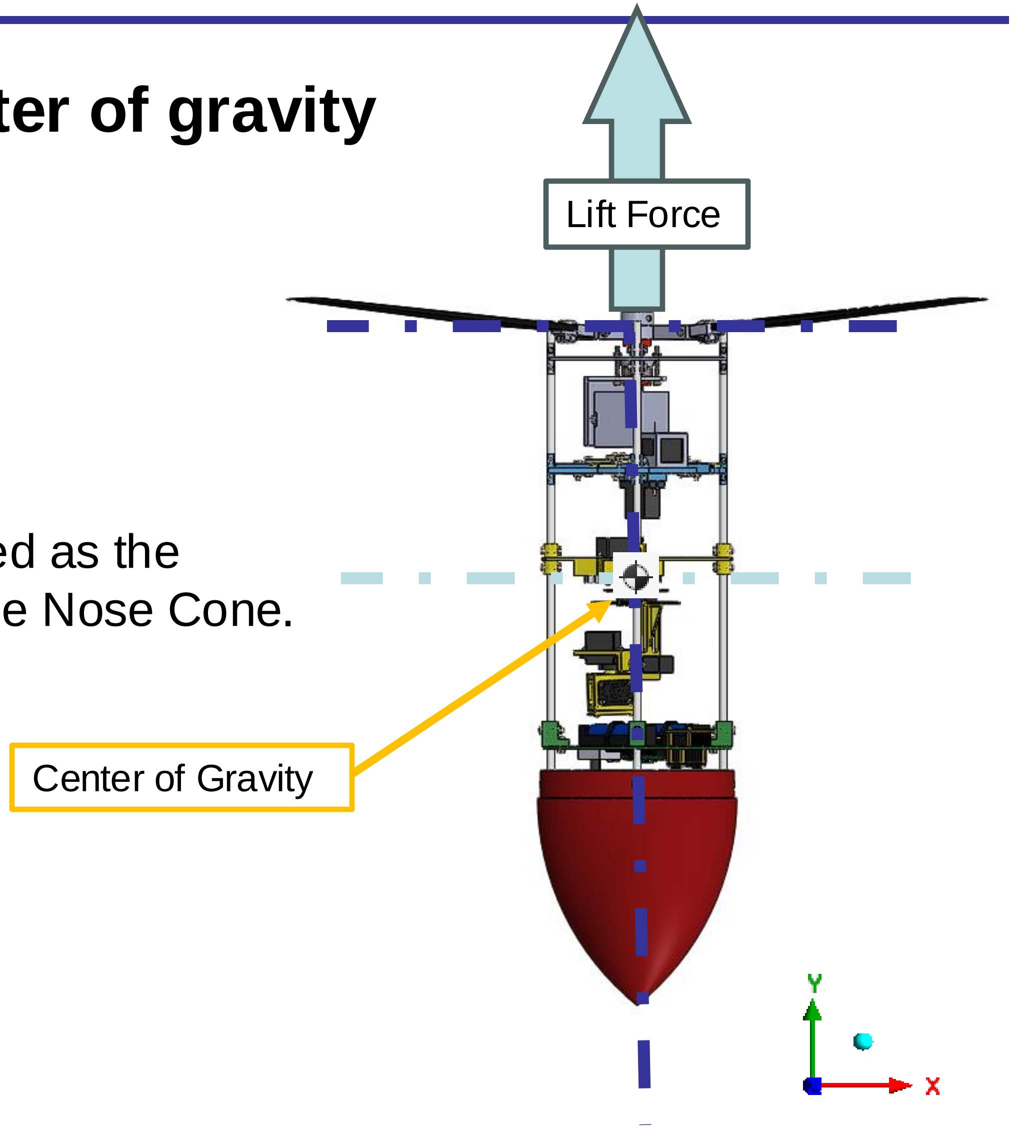
3D-print Blade

Commercial Blade

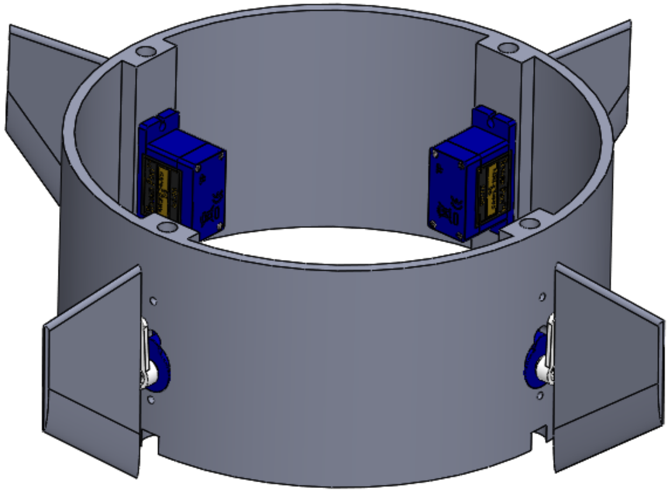
Selected Design	Rationales
Commercial Blade	• Lightweight(30g/pic) • An aerodynamic design angle

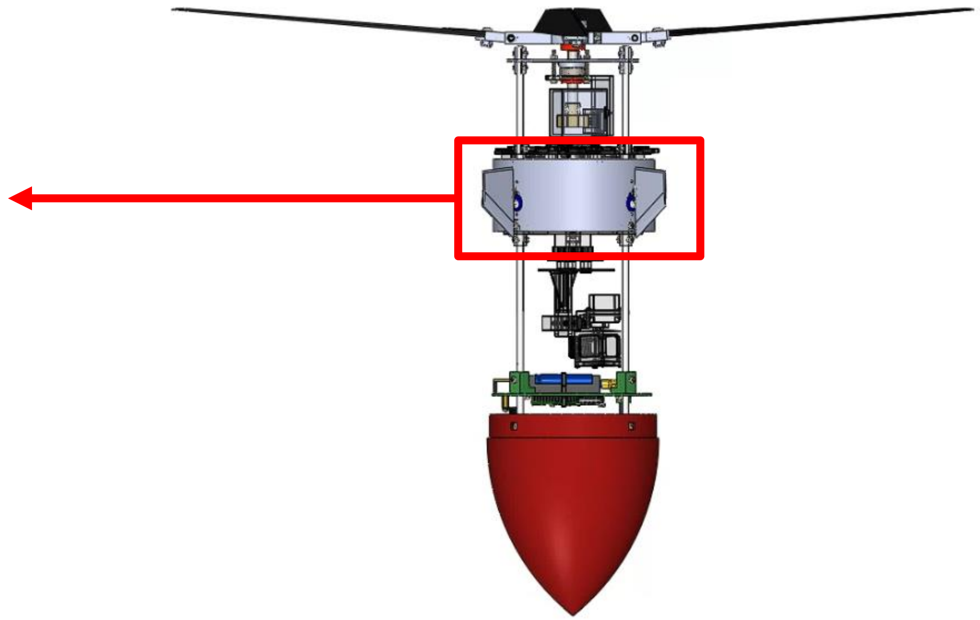
Passive control: Low center of gravity

The nadir direction will be maintained as the CanSat's center of gravity is near the Nose Cone.



Active stability control : Moveable Fins





Stabilizing force from fins:

- Fins generate a **normal force** when the payload deviates from a straight flight path (non-zero angle-of-attack).
- This **force creates a corrective moment** around the Center of Gravity.
- The corrective moment helps to restore the stability of the payload.

Descent stability control strategy trade studies and selection

Auto-Gyro Design Trade			
Design Feature	**Advantages**	**Disadvantage**	**Types of control**
Low center of gravity	• Better horizontal stability • Use minimal space	• Owe axial stability	• Passive control
Moveable Fins	• Higher axial stability	• Requires more components • Requires more space	• Active stability control

Selected Design	Types of control	Rationales
Low center of gravity	Passive control	• Use minimal space • Passive control • Better horizontal stability

Parachute

$$A_p = \frac{2 \cdot \mathrm{F_D}}{\mathrm{C_D} \cdot \rho \cdot V_T^2}$$

A_p: Area of the Parachute (m^2)
$\mathrm{C_D}$: Drag Coefficient (Assumed $\mathrm{C}_{\mathrm{D},Dome} = 0{,}75$)
ρ: Air Density at 31˚C ($1.089\ kg/m^3$)
V_T: Terminal velocity ($20\ m/s$ by requirements)
$\mathrm{F_D}$: Drag Force (Equal to the weight= $1.4\ kgw$)

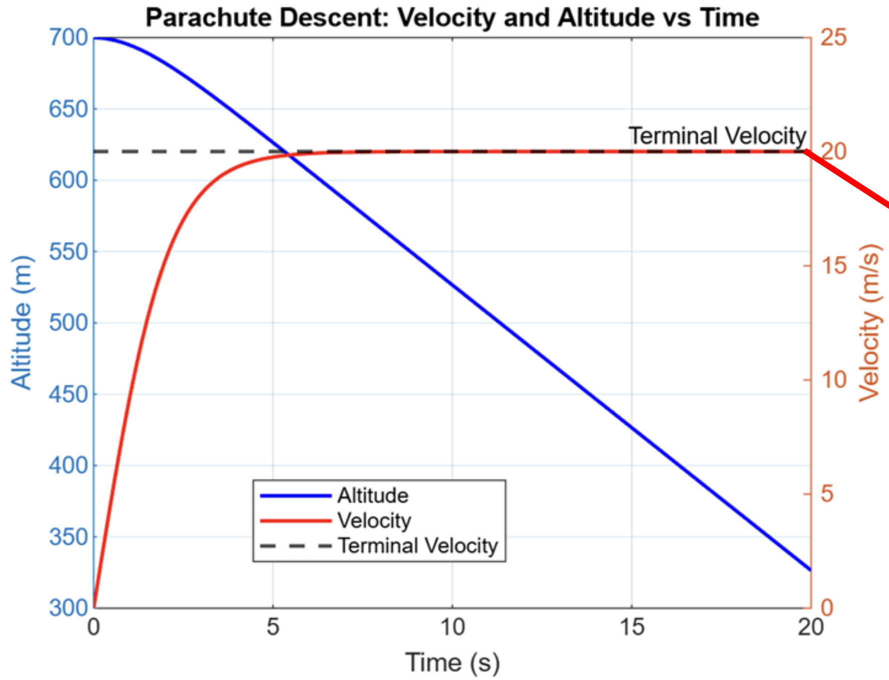
$$\Rightarrow A_p = 0.084\ \mathrm{m}^2$$

$$\Rightarrow D_p = 163.5\ \mathrm{mm\ (parachute\ diameter)}$$

Parachute

$$A_p = \frac{2 \cdot \mathrm{F_D}}{\mathrm{C_D} \cdot \rho \cdot V_T^2}$$

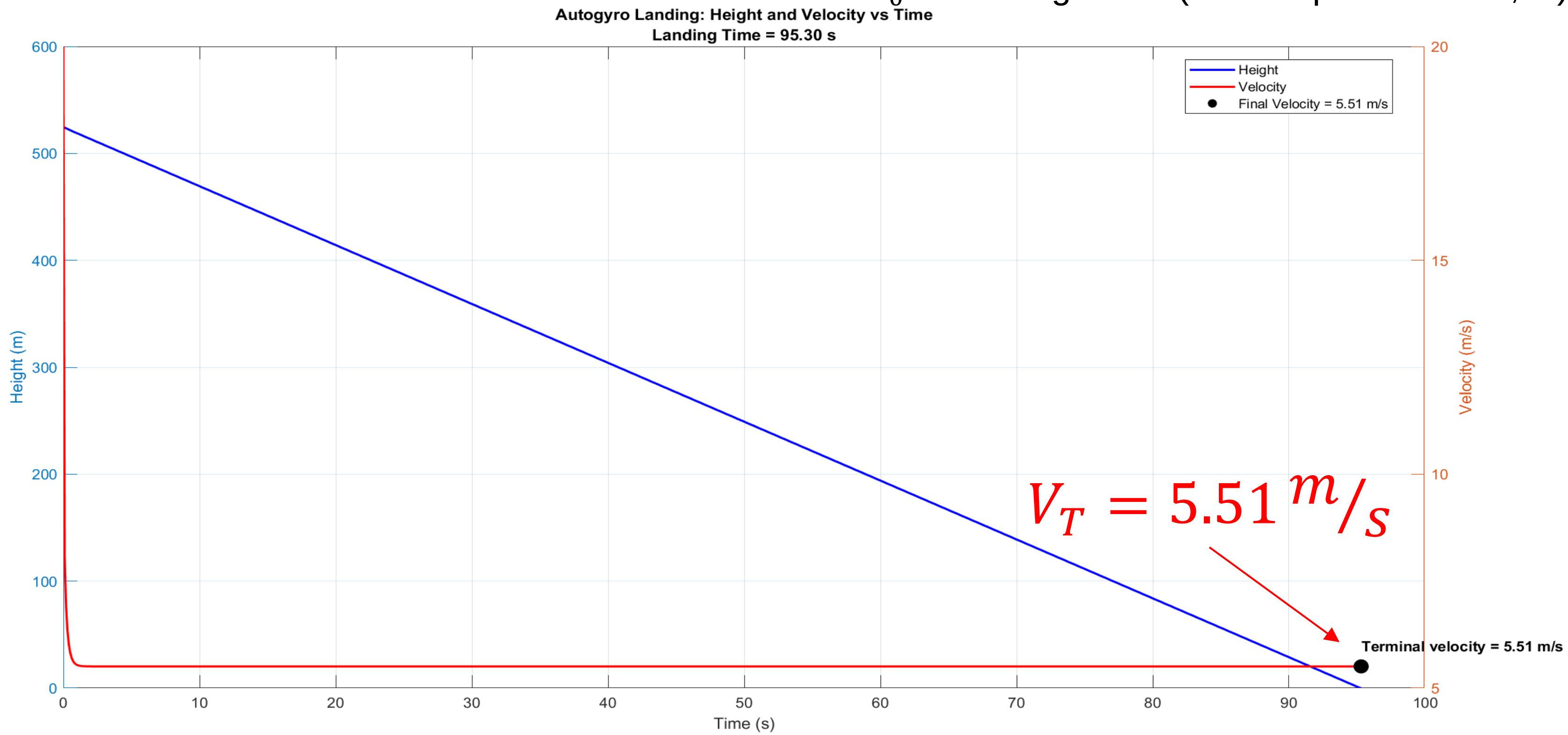
A_p: Area of the Parachute (m^2)
$\mathrm{C_D}$: Drag Coefficient (Assumed $\mathrm{C}_{\mathrm{D},Dome} = 0{,}75$)
ρ: Air Density at 31˚C ($1.089\ kg/m^3$)
V_T: Terminal velocity ($20\ m/s$ by requirements)
$\mathrm{F_D}$: Drag Force (Equal to the weight= $1.4\ kgw$)



$V_T = 20.01\,{}^{m}/_{s}$

Auto-gyro

- M=4; mass(kg)
- g=9.8;gravitational acceleration($\frac{m}{s^2}$)
- ρ;Air Density at 31˚C ($1.089\ \frac{kg}{m^3}$)
- C_D= 1.16 ; Drag Coefficient
- C_L=1.10 ; Lift Coefficient
- A=0.264 ; Rotor area($A = \pi r^2$,m^2)
- H_0 initial height=525(At 75% peak altitude, m)

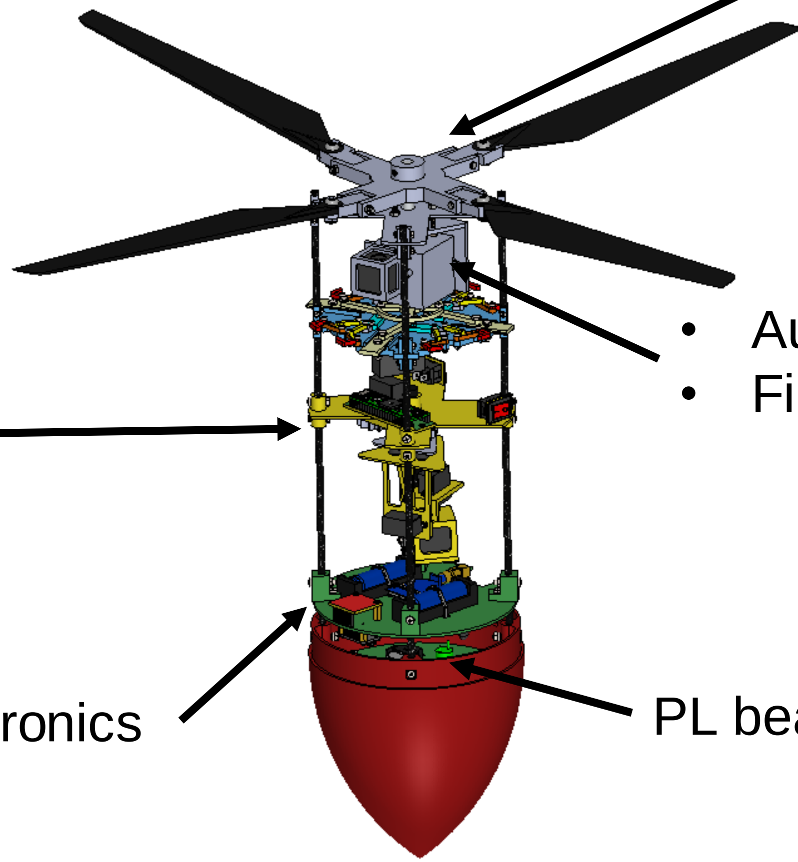


Descent Rate Estimates (4/4)

Summary	
Components	**Estimated Terminal Velocity**
Parachute	20.01 m/s
Payload auto-gyro	5.51m/s

Mechanical Subsystem Design

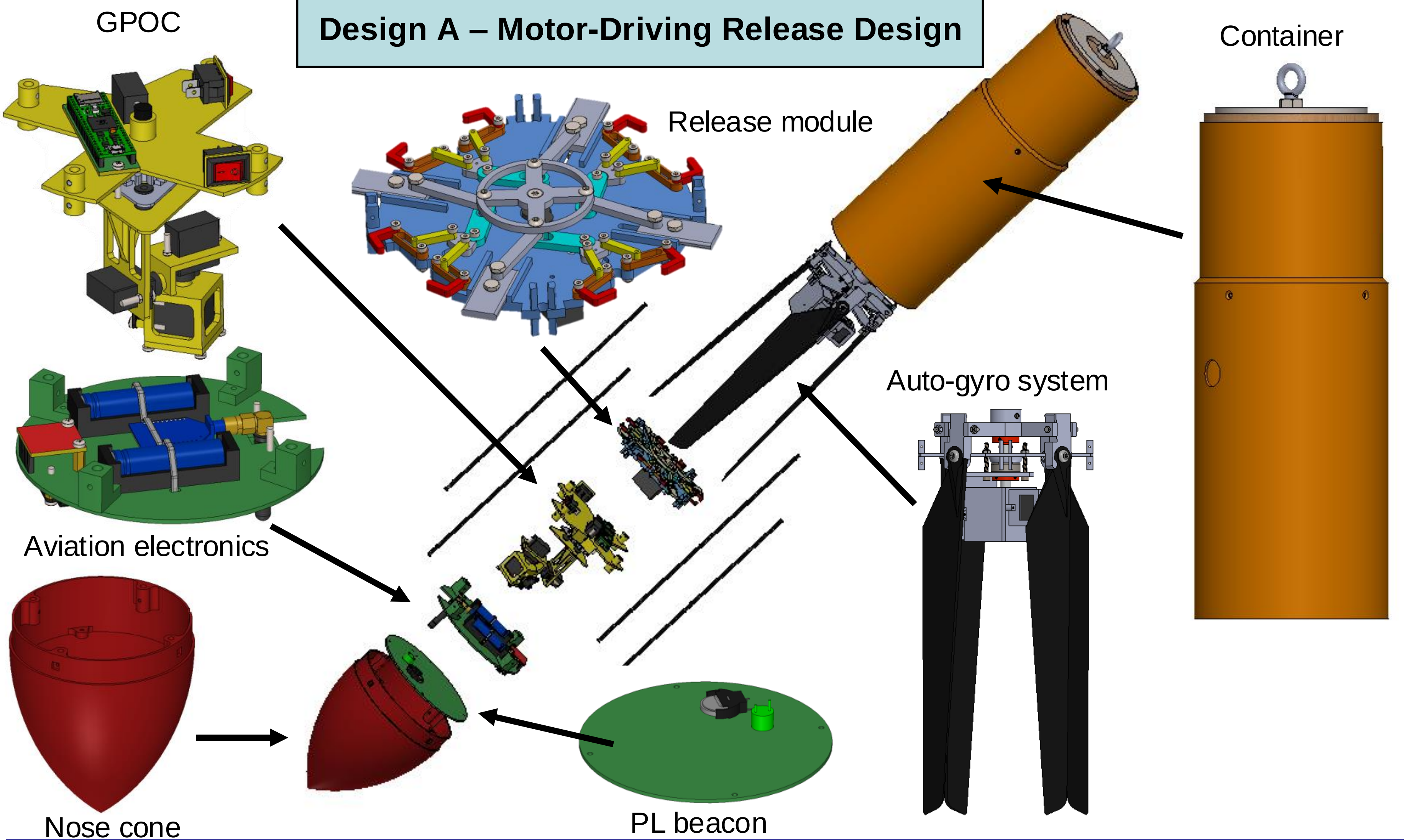
Chen-Pei Yang
Chan-Hao Tao
Su-Yun Hsu



Nose Cone does not separate from the payload

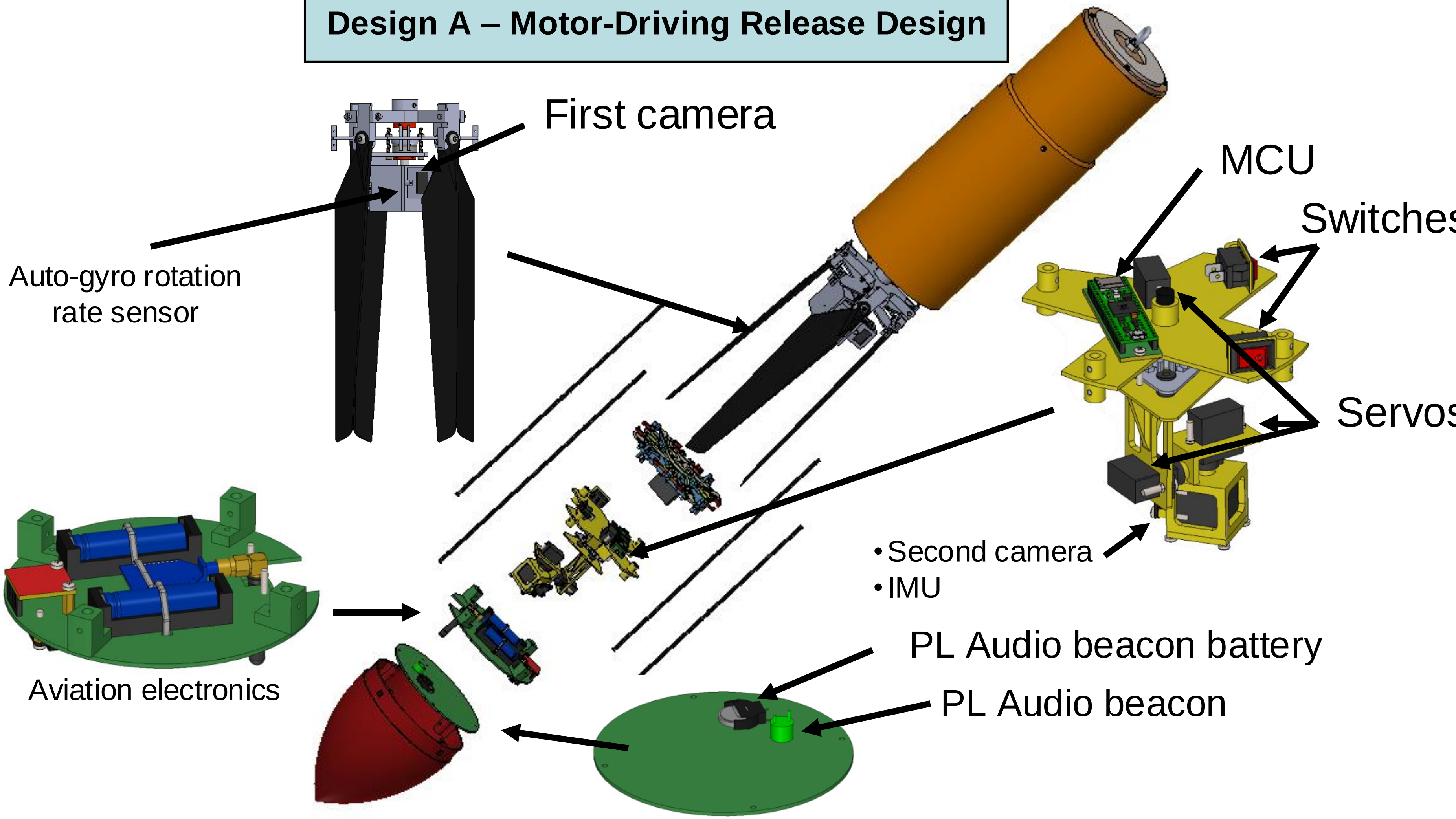
CanSat Mechanical Layout of Components Trade & Selection (1/10)

Design A – Motor-Driving Release Design

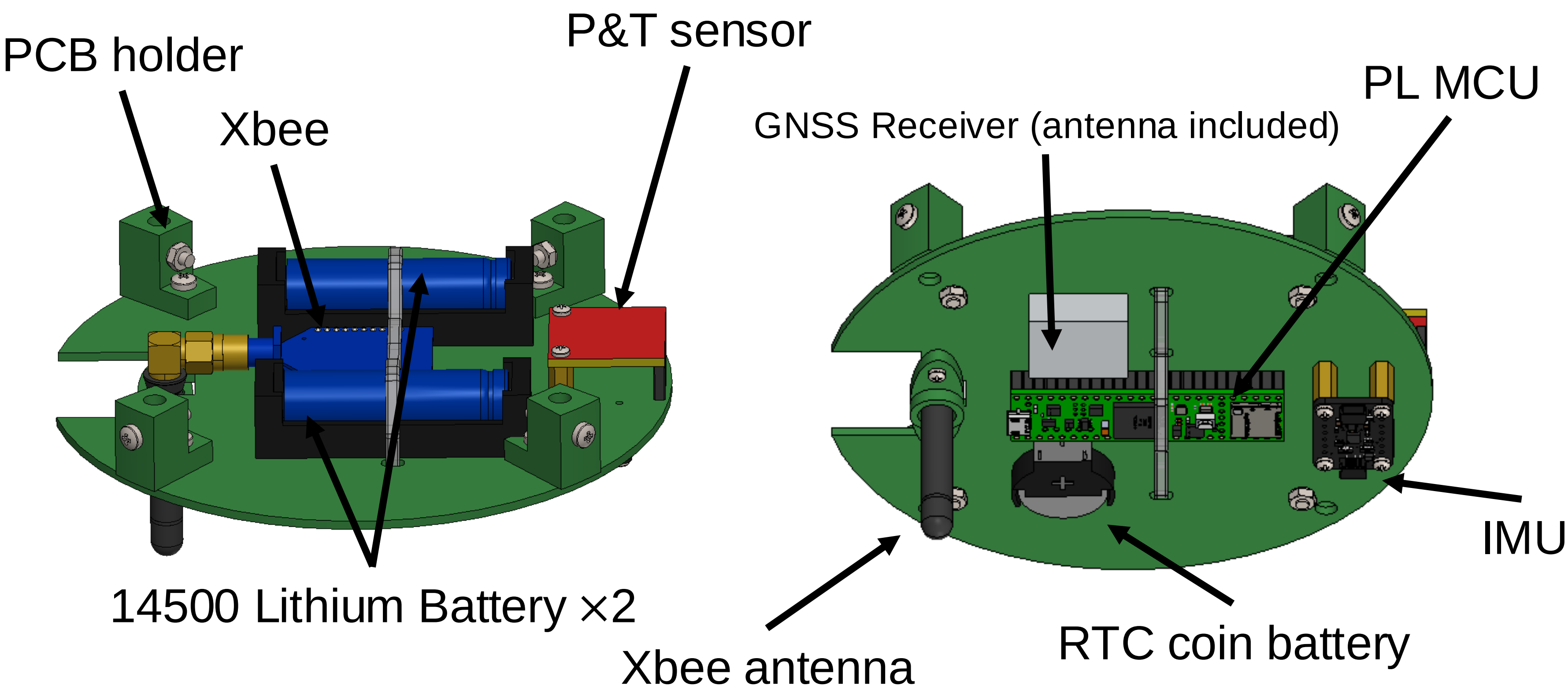


CanSat Mechanical Layout of Components Trade & Selection (2/10)

Design A – Motor-Driving Release Design

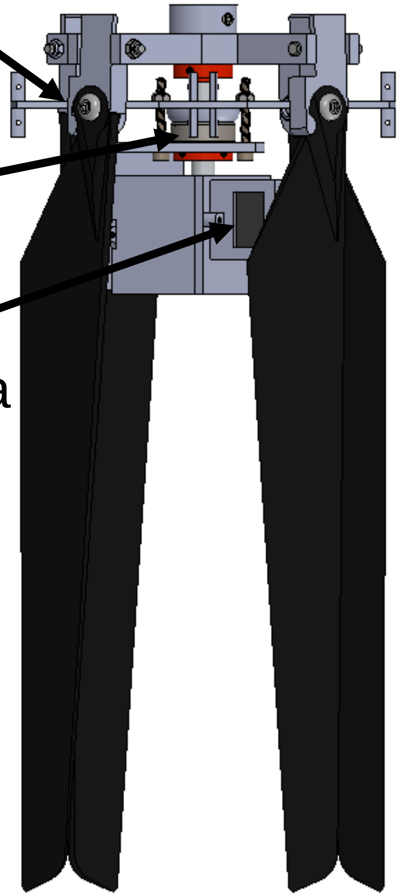


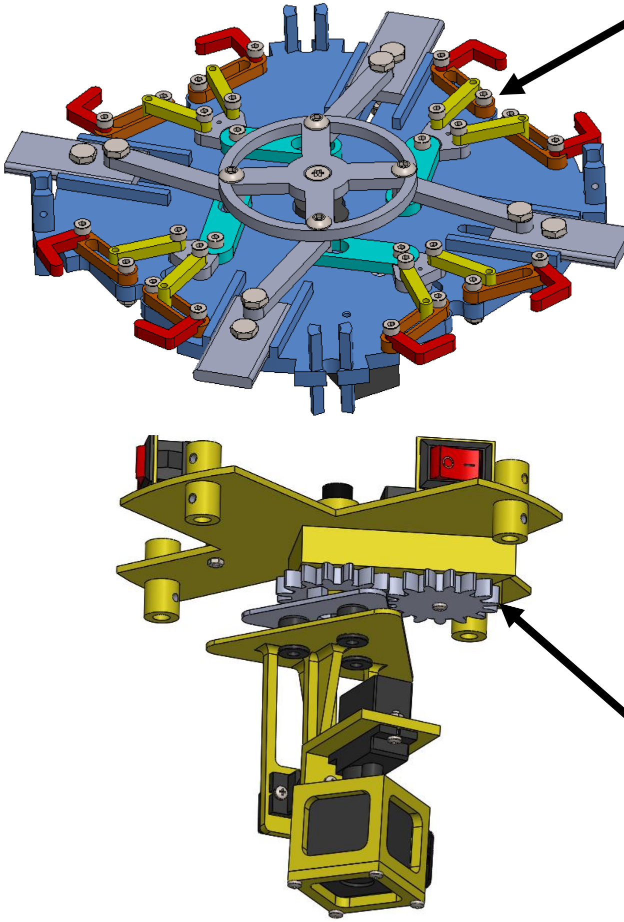
Design A – Aviation electronics



CanSat Mechanical Layout of Components Trade & Selection (4/10)

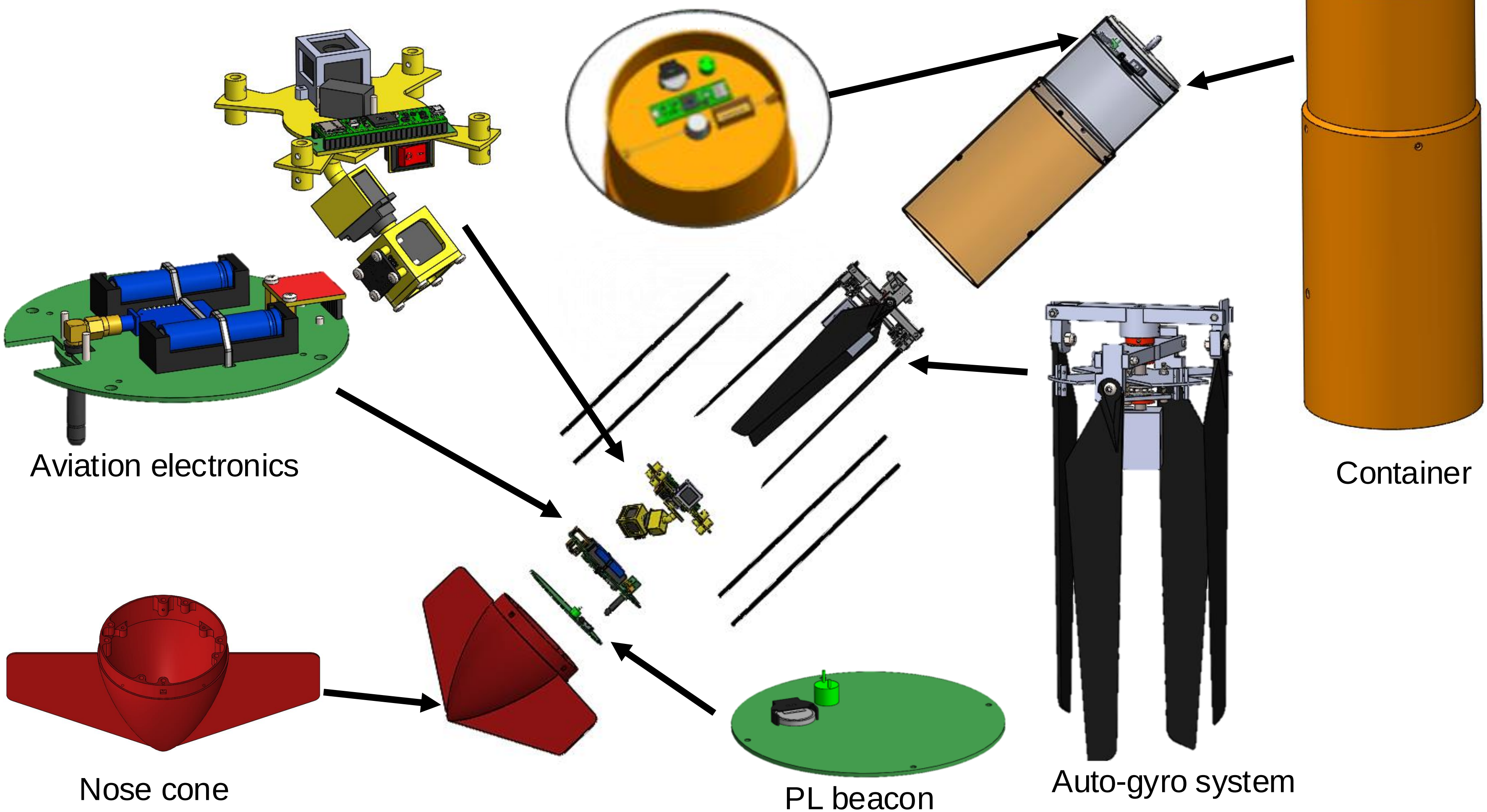
Design A – Motor-Driving Release Design





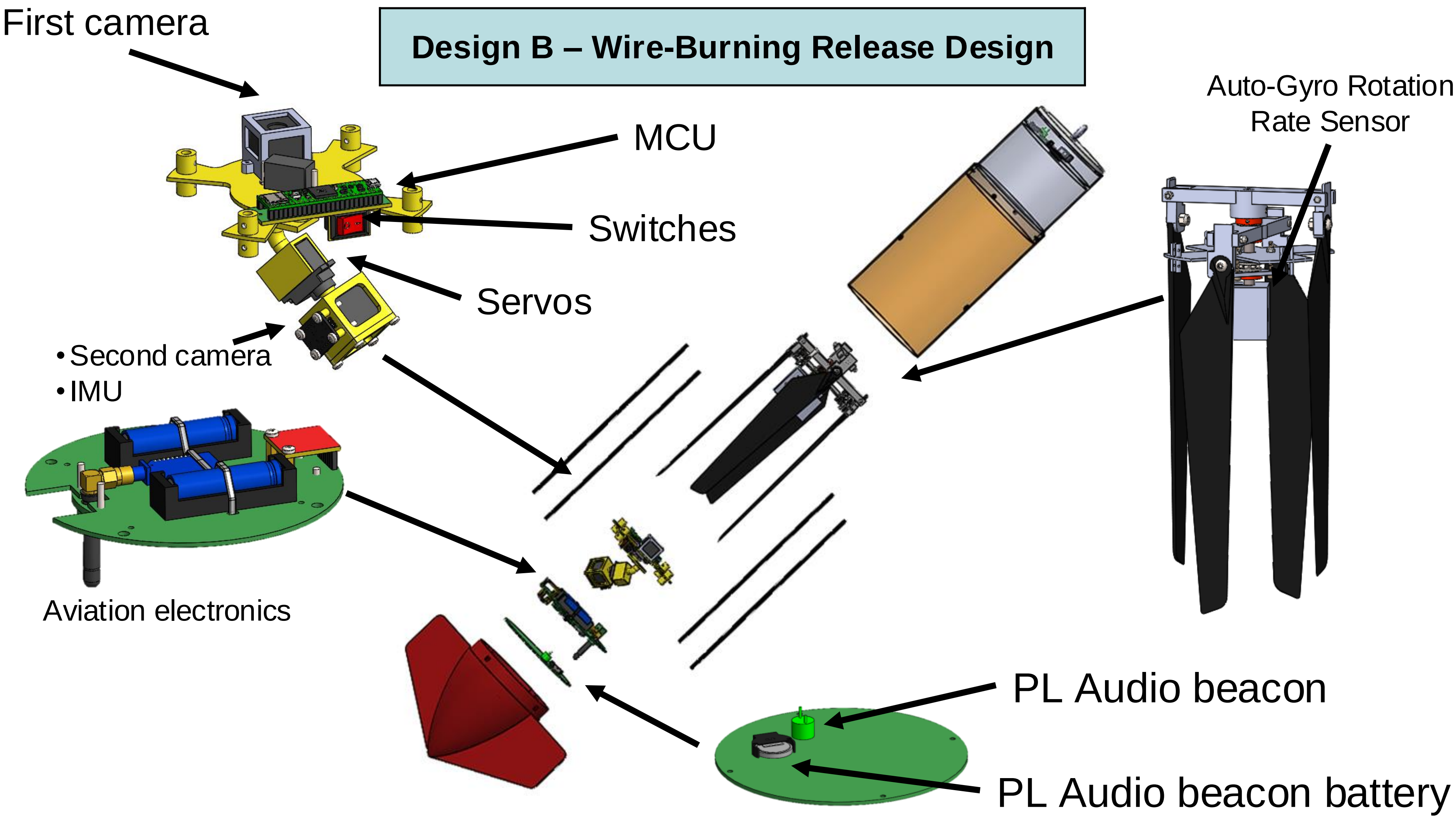
CanSat Mechanical Layout of Components Trade & Selection (5/10)

Design B – Wire-Burning Release Design

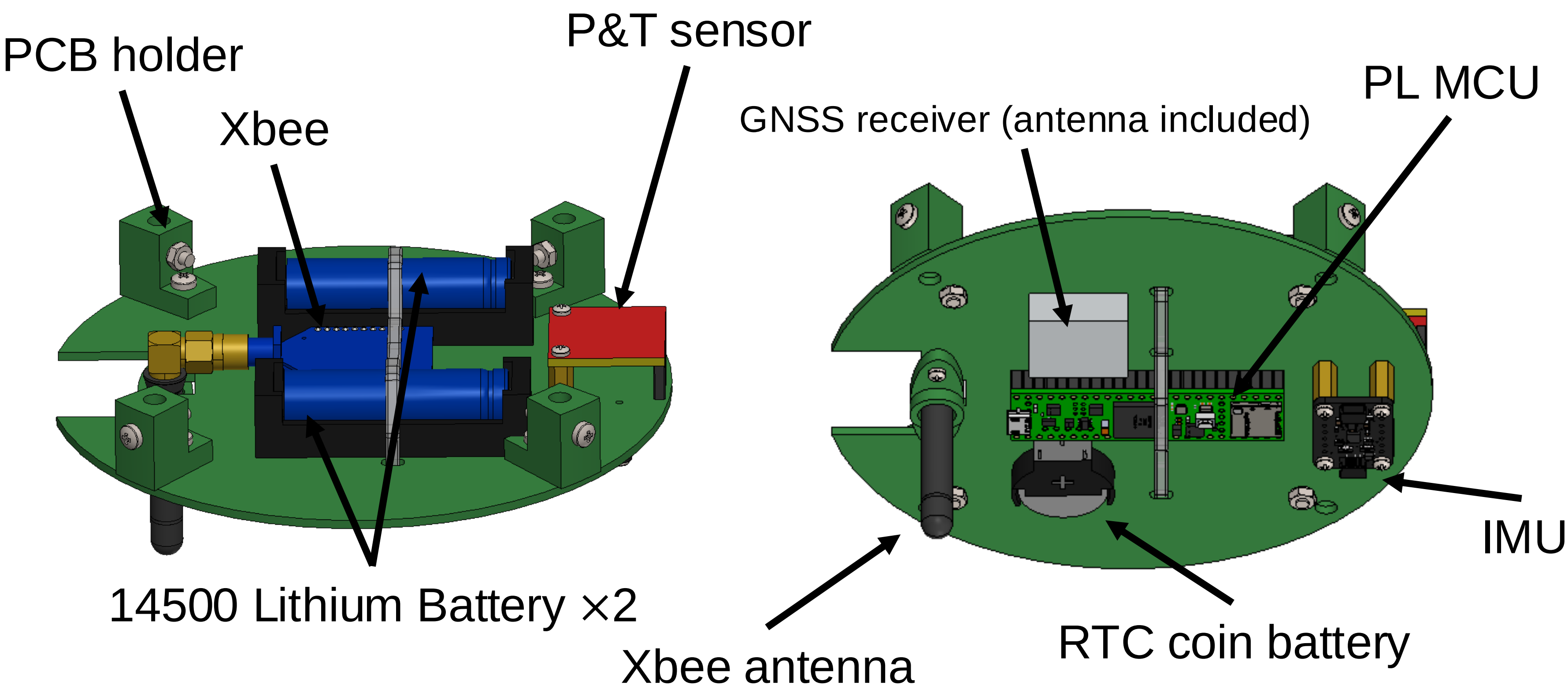


CanSat Mechanical Layout of Components Trade & Selection (6/10)

Design B – Wire-Burning Release Design

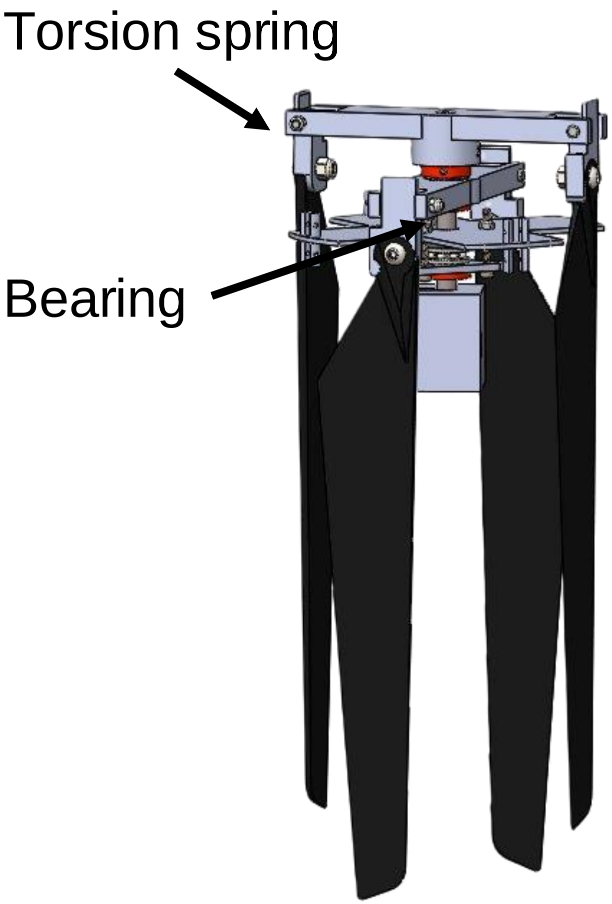


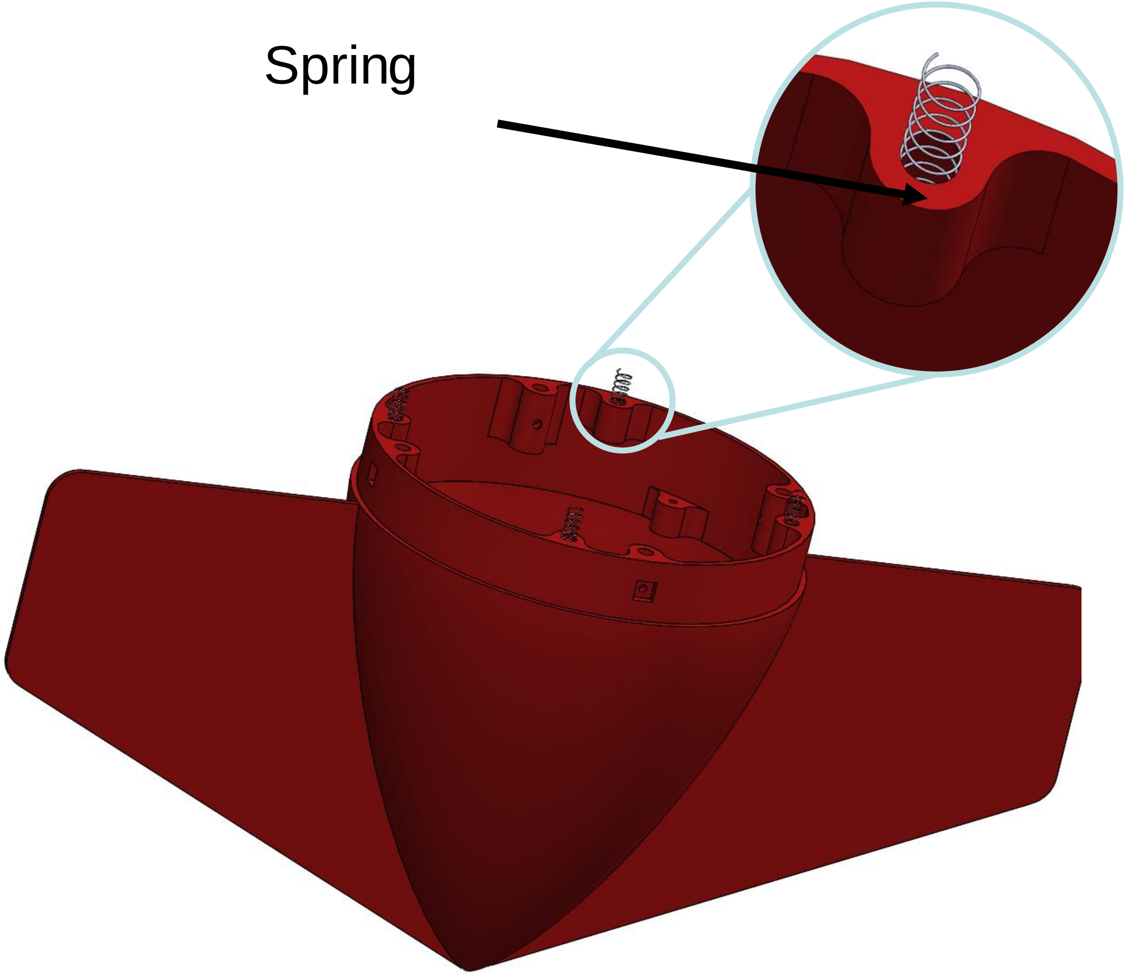
Design B - Aviation electronics



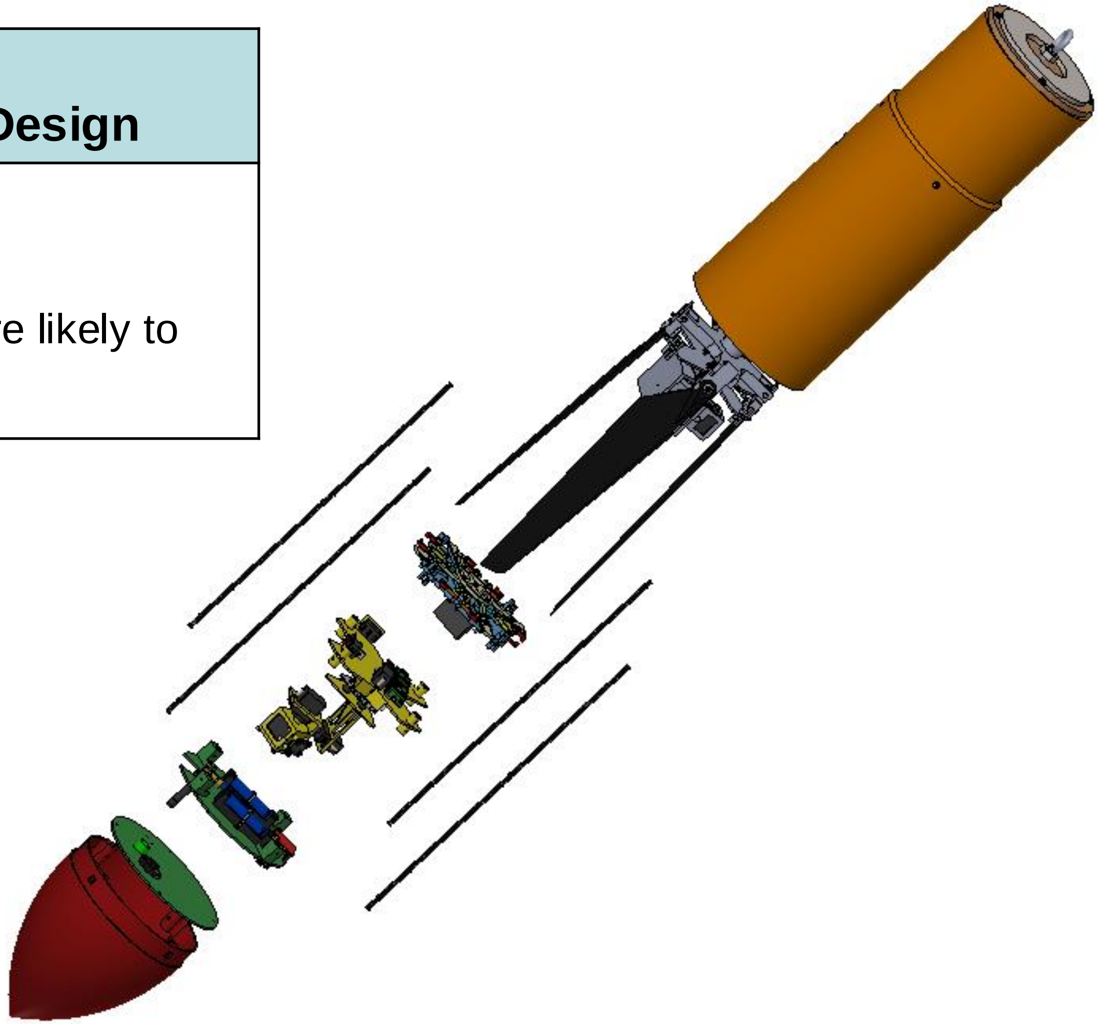
CanSat Mechanical Layout of Components Trade & Selection (8/10)

Design B – Wire-Burning Release Design





Selection: Motor-Driving Release Design
Reasons : • Mechanics is more reliable • The mechanical structure is more likely to achieve the mission objectives



CanSat Mechanical Layout of Components Trade & Selection (10/10)

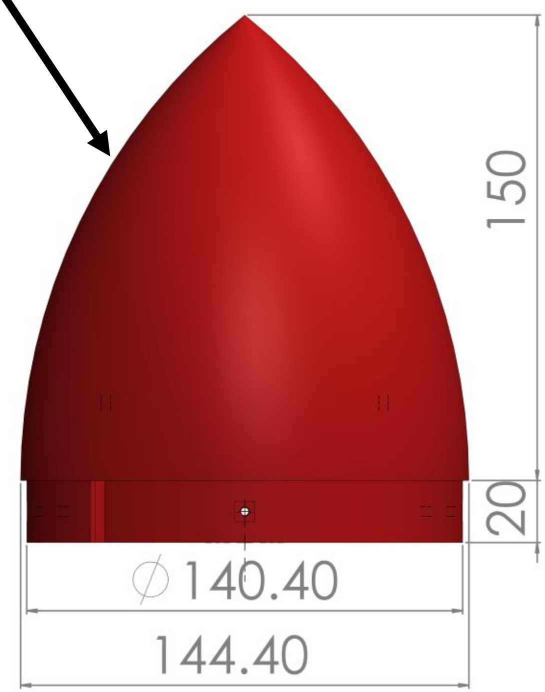
Material Trade & Selection		
Materials	**Advantages**	**Disadvantages**
Carbon fiber	• High structural strength • Lighter in weight • Directly available for purchase	• More challenging to manufacture
Aluminum	• Greater structural strength • Easy to process	• Heavier in weight • Higher processing costs
PLA (3D print)	• Customizable 3D-printed shapes	• Inferior material strength

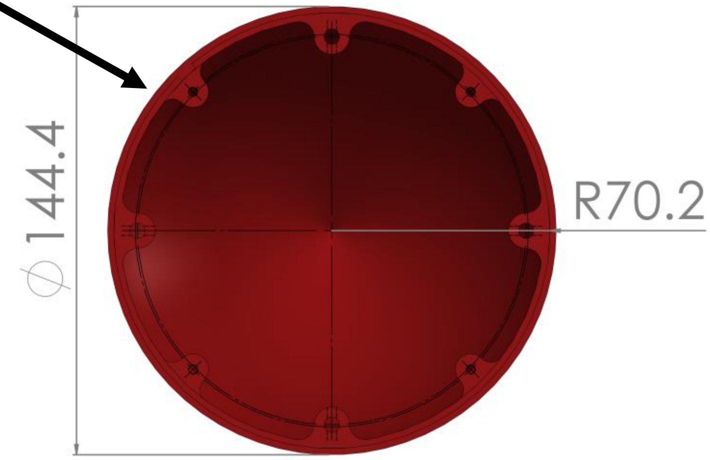
Selected Design	Rationales
Carbon fiber (for main structure)	• Higher structural strength can meet design requirements with a lighter mass
PLA (3D print)	• Freely definable structural shapes allow more flexible utilization of limited space in design

Design A – Nose Cone without Fin

Tangent ogive design

The groove is used for easier integration with the container.



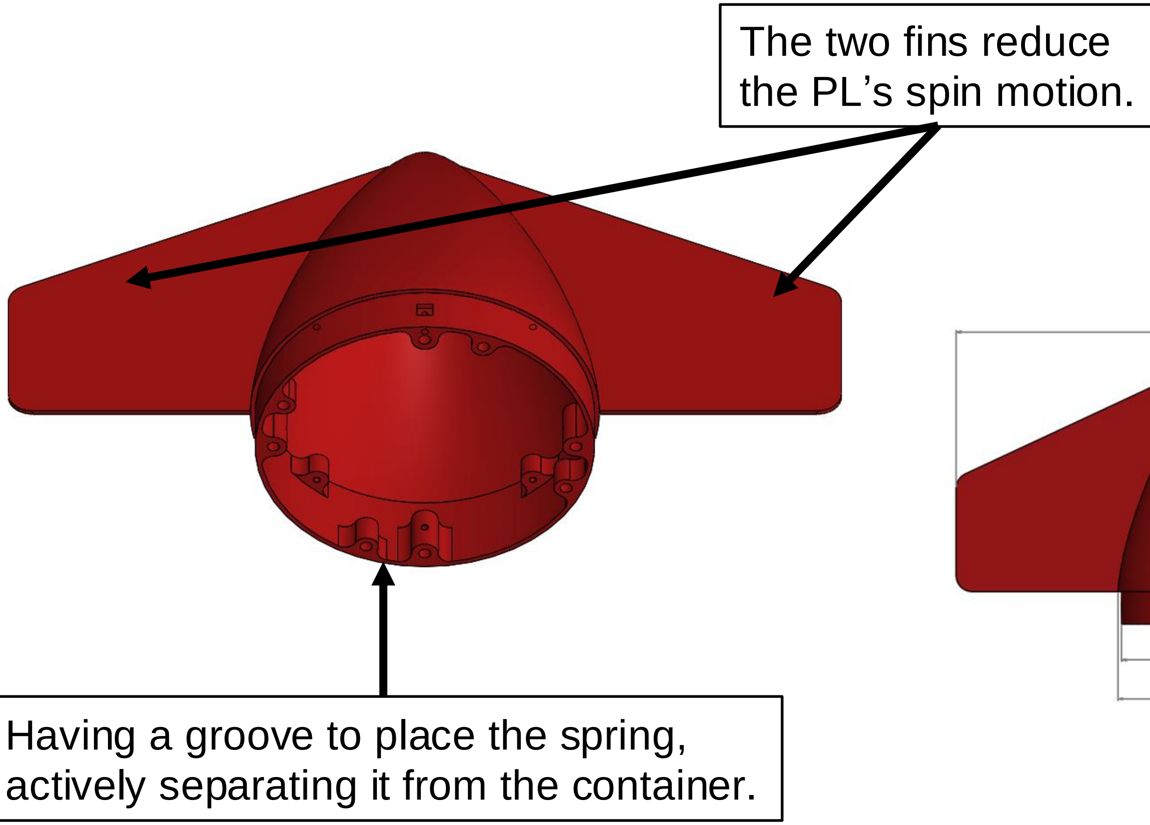


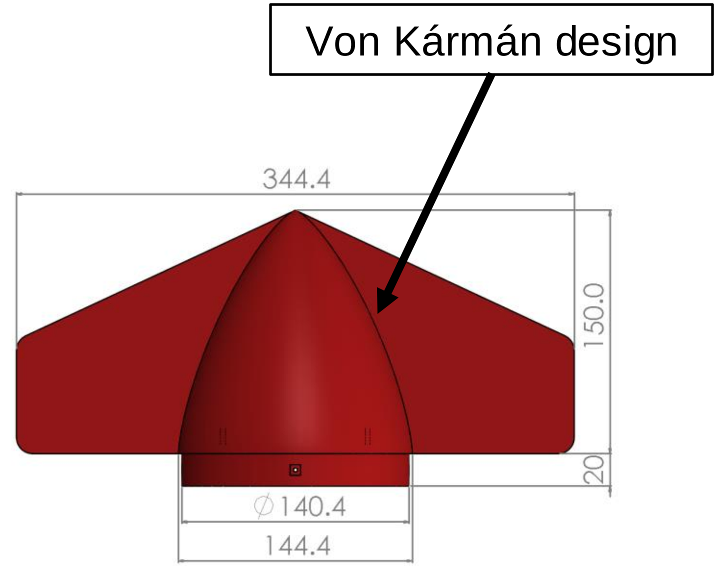
Drag Coefficient : 0.163 (Simulated by ANSYS)

Unit : mm

Nose Cone Design Trade & Selection(2/3)

Design B – Nose Cone with Fin



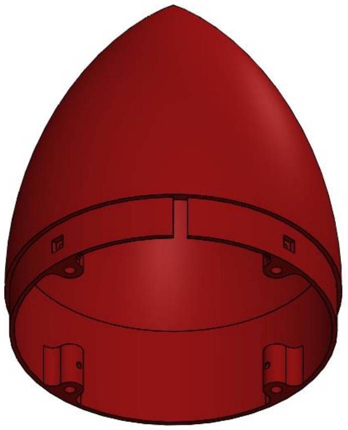


Drag Coefficient : 0.169 (Simulated by ANSYS)

Unit : mm

Nose Cone Design Trade & Selection(3/3)

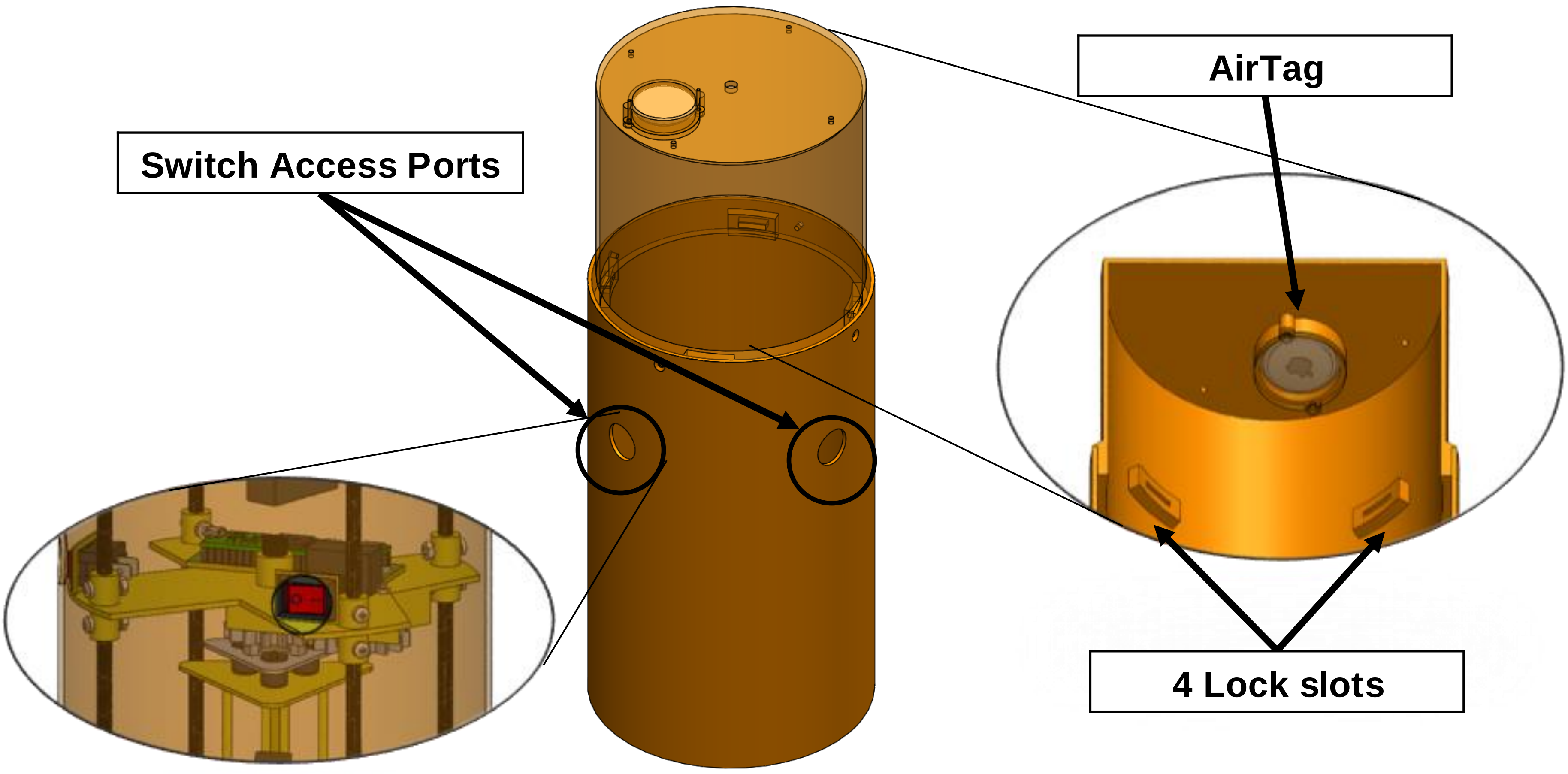
Aerobraking Deployment Trade		
Design	**Advantages**	**Disadvantages**
A	• The lighter weight(148.02g) • As simple a structure as possible	• Higher rotation speed • The PL and container undergo passive separation.
B	• Reduce the PL's spin motion • The PL and container undergo initiative separation.	• Higher weight(193.2g) • It may result in irregular rolling motions.



Selected Design	Rationales
Design A	• Based on the experience of previous teams, two fins have no significant effect on roll reduction. • Design B is more complex and may cause irregular rolling motions when the payload separates.

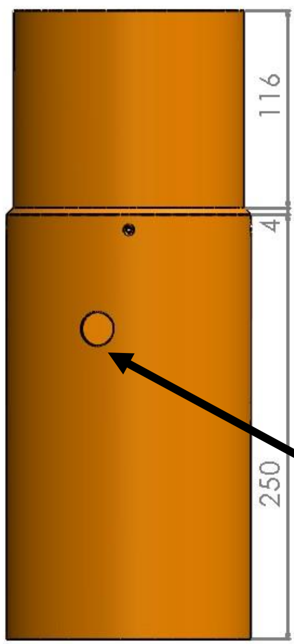
Container Design and Configuration Trade & Selection (1/5)

Design A – Grooved for Motor Design

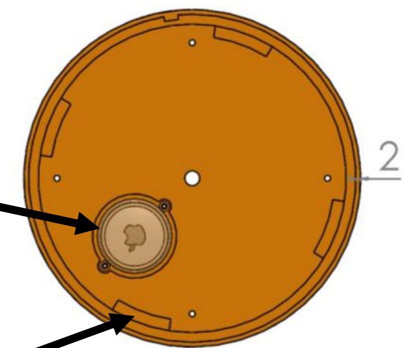


Container Design and Configuration Trade & Selection (2/5)

Design A – Groovedfor Motor Design

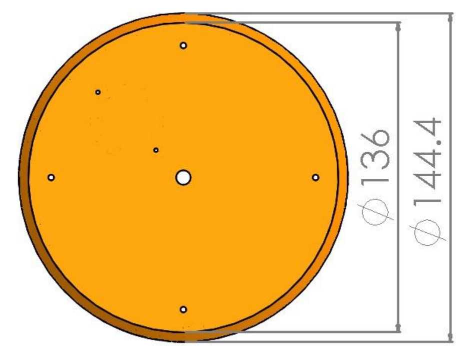


AirTag for container retrieval



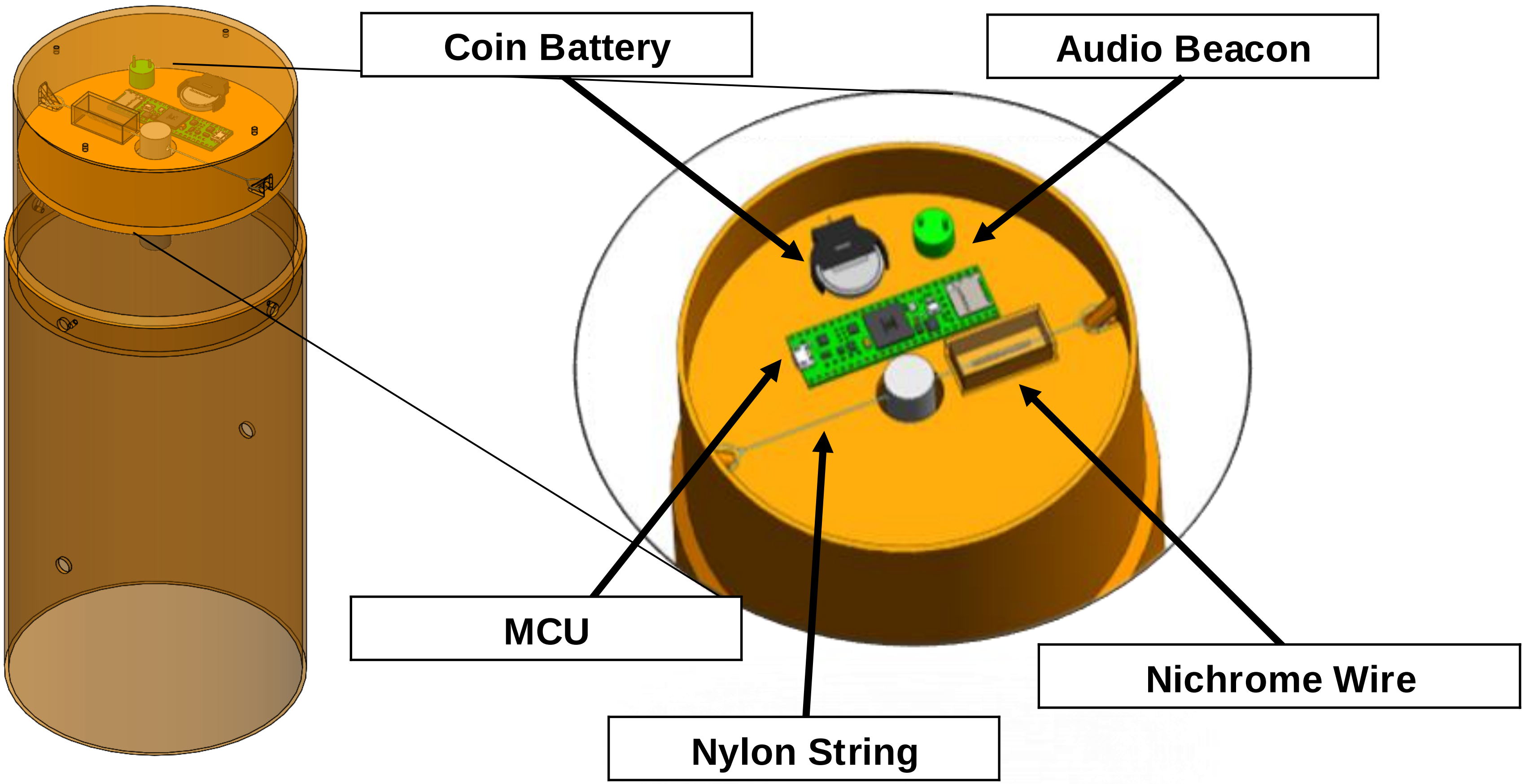
The 4 lock slots on the container are designed to accommodate the servo motor release mechanism.

By using the vent holes as two switch access ports on the container, the operator can reach the switch to turn on the PL.



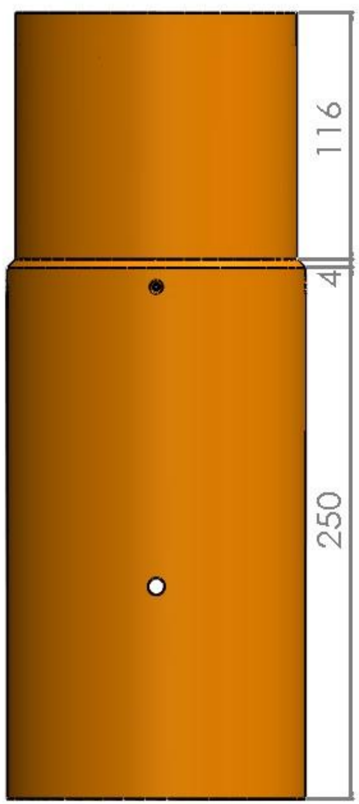
Unit : mm

Design B – Wire-Burning Design



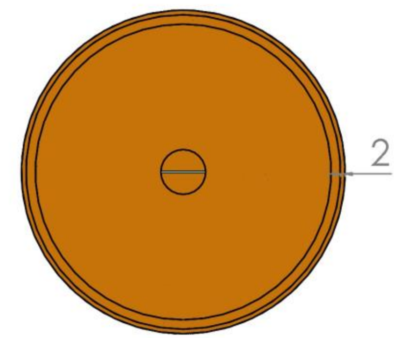
Container Design and Configuration Trade & Selection (4/5)

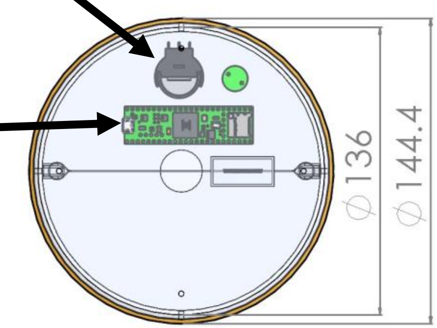
Design B – Wire-Burning Design



The coin battery supplies the power to the audio beacon.

The MCU on the container heats the nichrome wire to melt the nichrome line. It also operates the audio beacon switch automatically

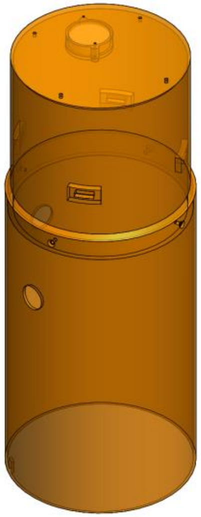




Unit : mm

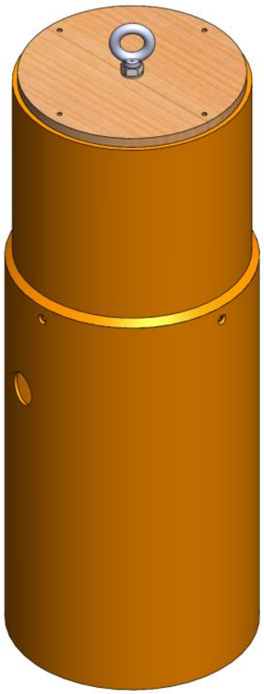
Container Design and Configuration Trade & Selection (5/5)

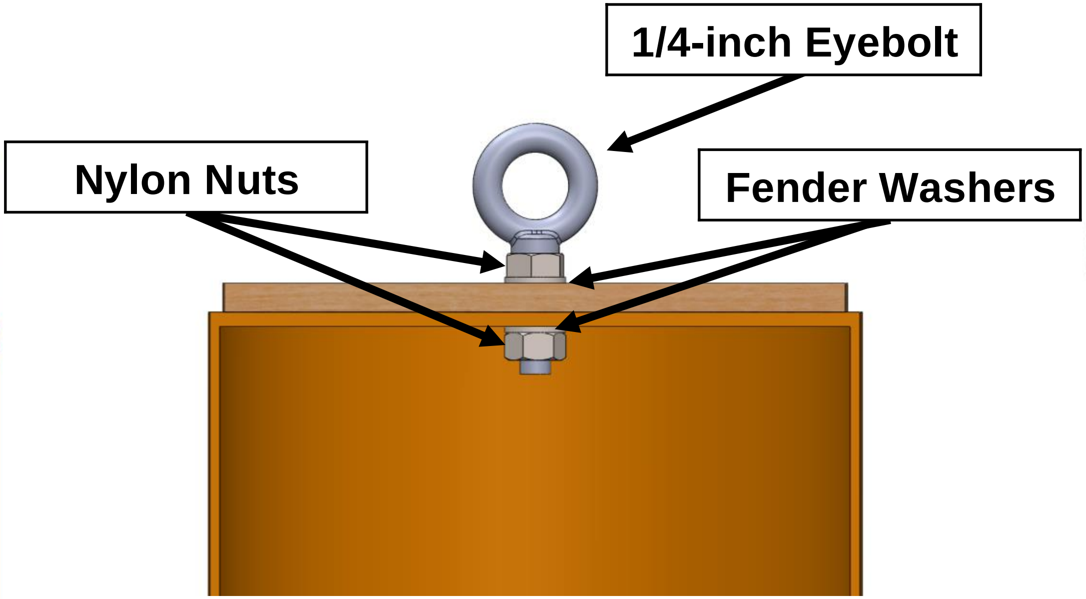
Container Design Trade		
Design	**Advantages**	**Disadvantages**
A	• More reliability • Reusable	• Manual switch • Higher weight
B	• The lighter weight	• It is hard to tie the nylon string and connect it to the release mechanism • Slow response and low reliability



Selected Design	Rationale
Design A	• Reliability is important to the mission's success

Parachute Attachment



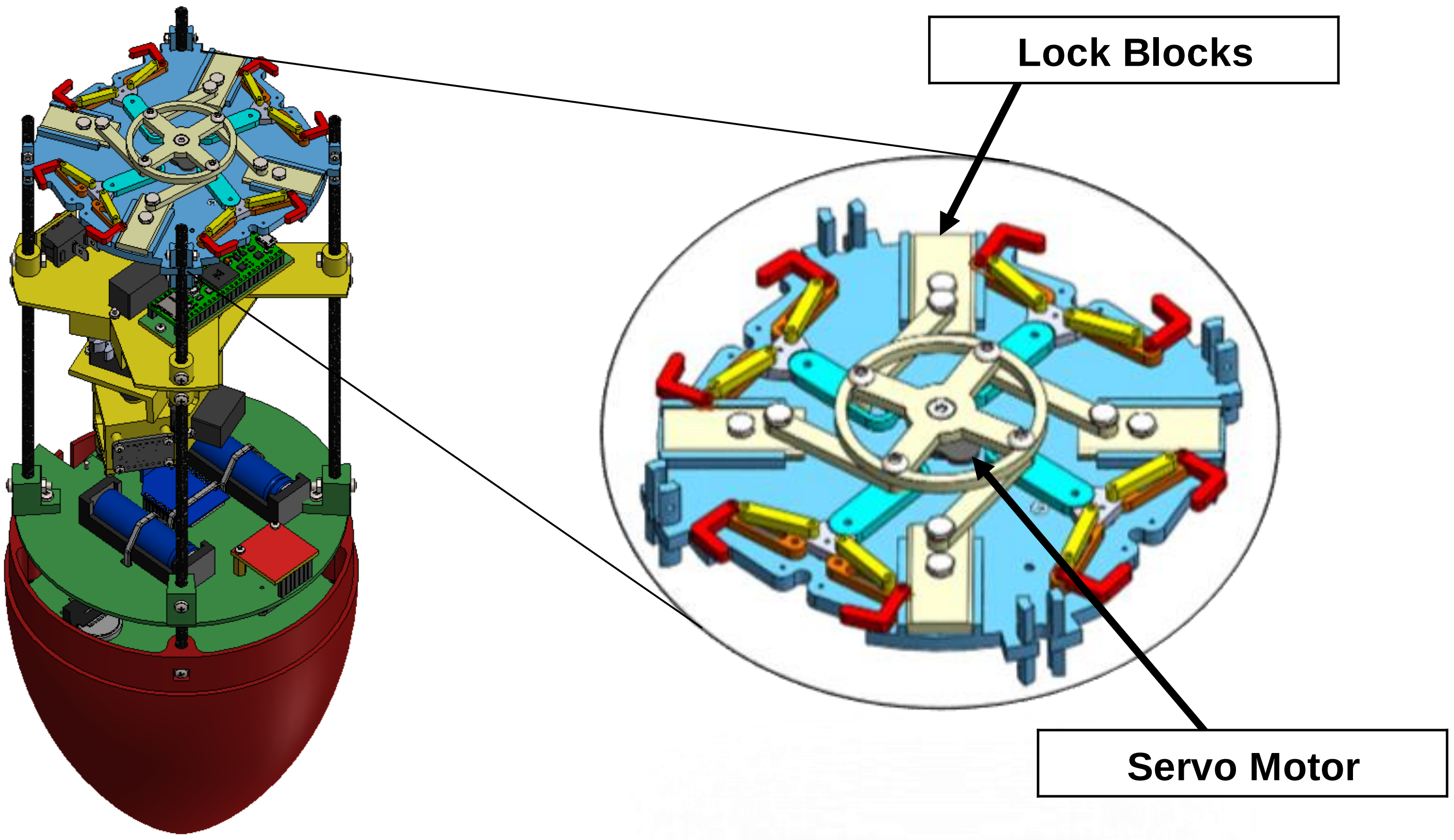


Unit : inch

Insert a 1/4-inch eyebolt through the plywood and the 3D-printed container, then use fender washers and nylon nuts to firmly secure the eyebolt to a wooden disc at the base of the container.

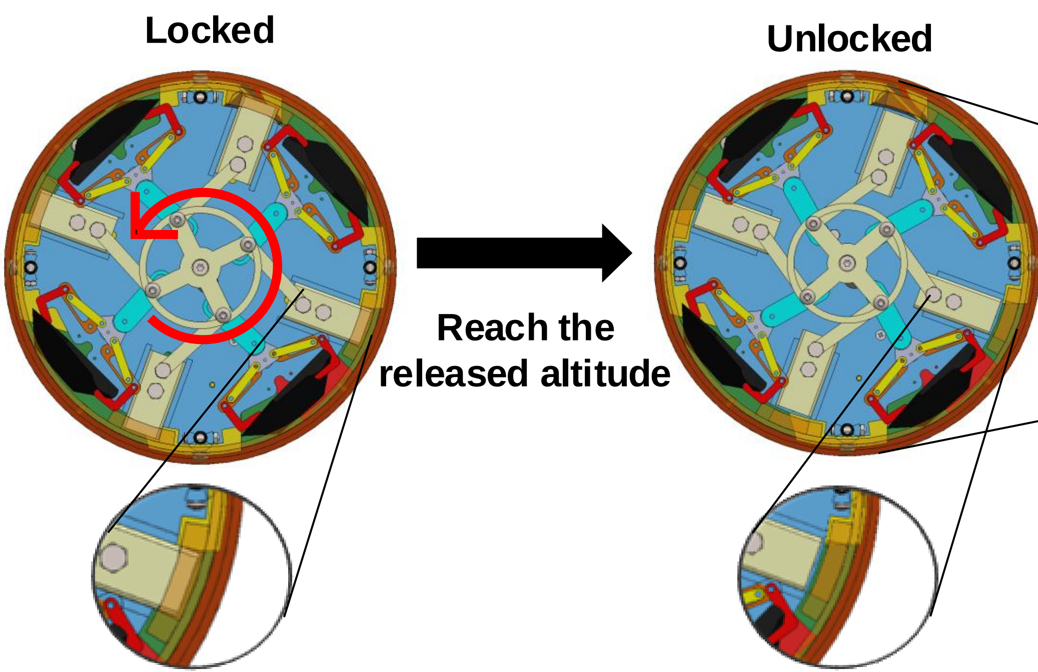
Payload Release Trade & Selection (1/5)

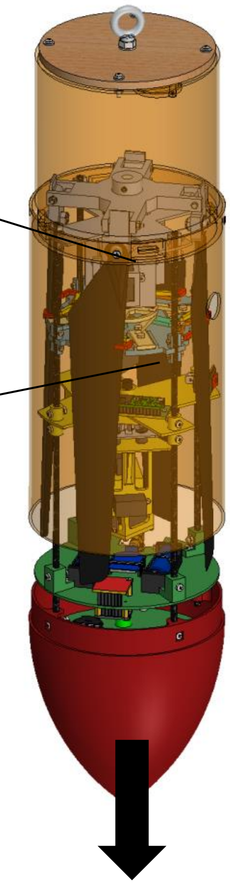
Design A – Motor-Driving Release Design



Payload Release Trade & Selection (2/5)

Design A – Motor-Driving Release Design

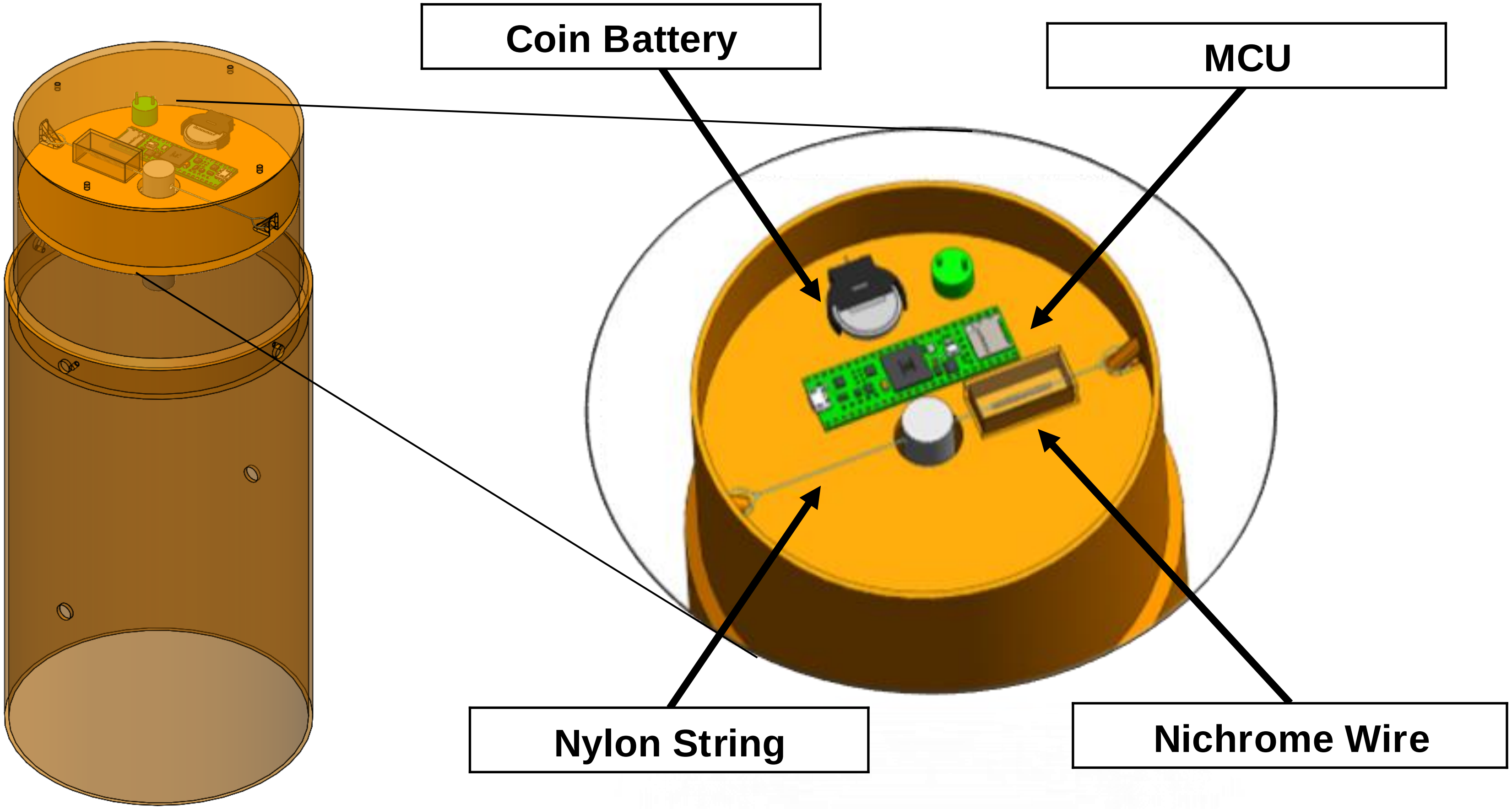




- When the CanSat reaches the released altitude, the release motor is activated.
- The servo turns clockwise, and the PL is released.
- After unlocking, The PL is pulled out of the container by gravity.

Payload Release Trade & Selection (3/5)

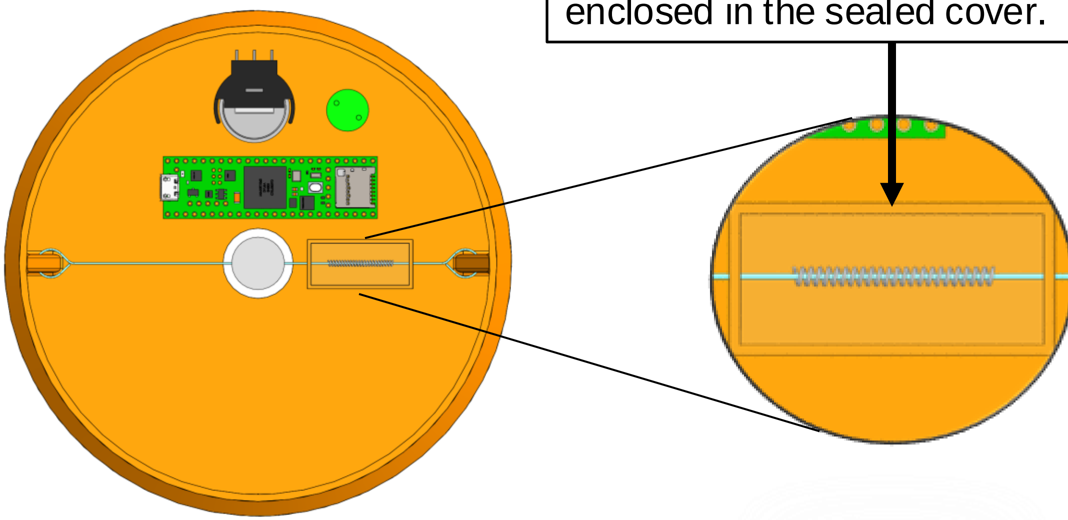
Design B – Nichrome Wire Design



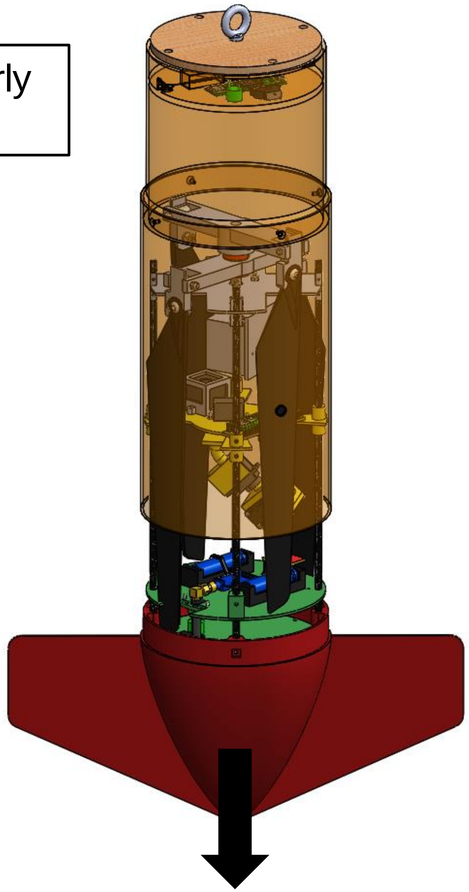
Payload Release Trade & Selection (4/5)

Design B – Nichrome Wire Design

Ensure that the nichrome wire is properly enclosed in the sealed cover.

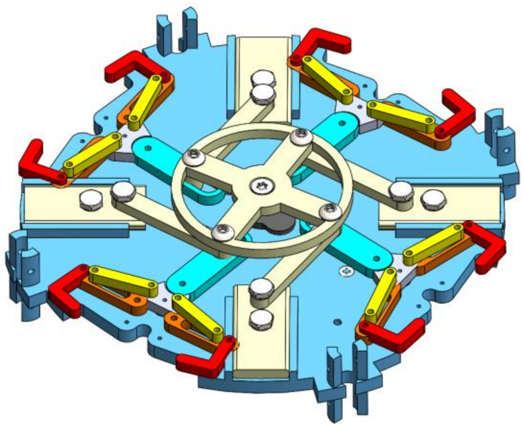


- When the CanSat reaches the released altitude, the nichrome wire is heated up and it causes the nylon string to melt and break.
- After melting, The PL is pulled out of the container by gravity.



Pulled out by gravity.

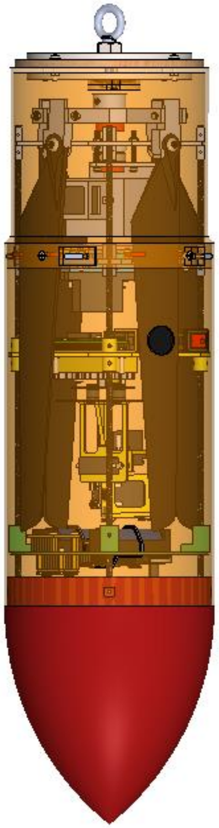
Payload Release Design Trade		
Design	**Advantages**	**Disadvantages**
A	• Reusable • More reliability	• Higher weight
B	• The lighter weight • Simplified mechanism	• It is hard to tie the nylon string and connect it to the release mechanism • Slow response and low reliability



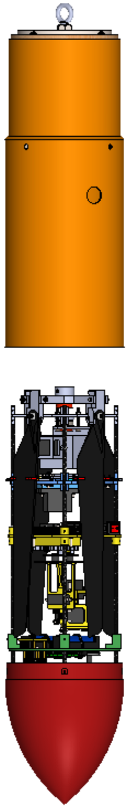
Selected Design	Rationales
Design A	• For a mission to succeed, reliability is essential. • Reusability is also helpful for testing.

Auto-gyro Stow Configuration Trade & Selection (1/5)

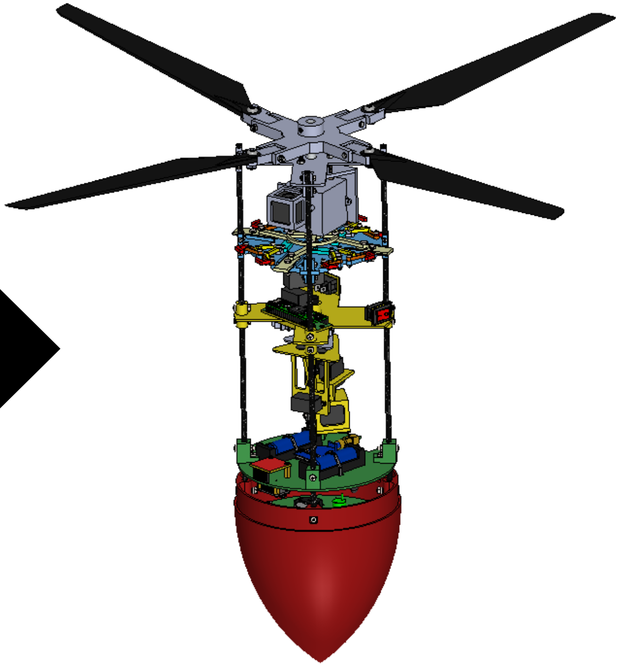
Stowed during flight



Being released from container

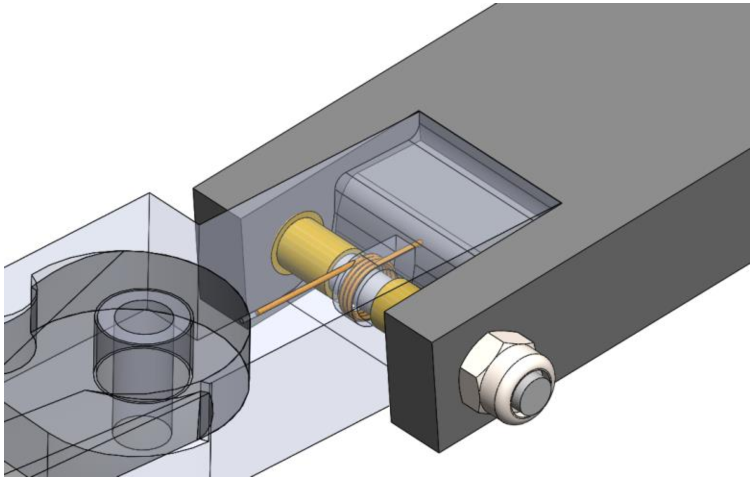


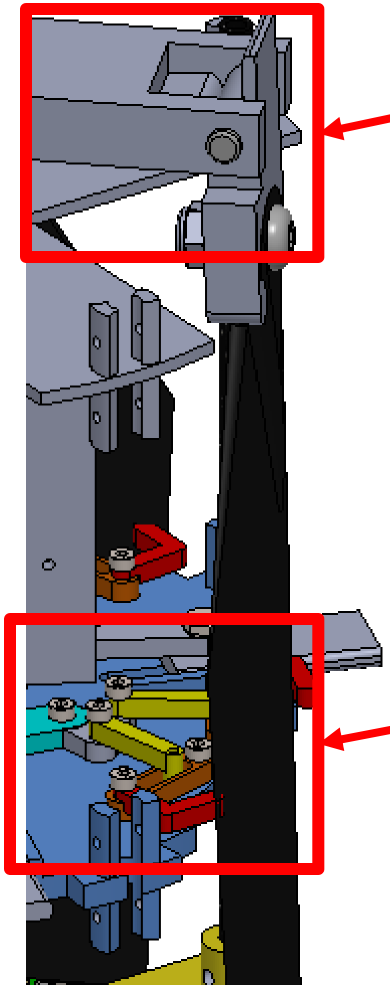
Auto-gyro released



Nose cone does not separate from the payload

Design A: Hinge and Gripper

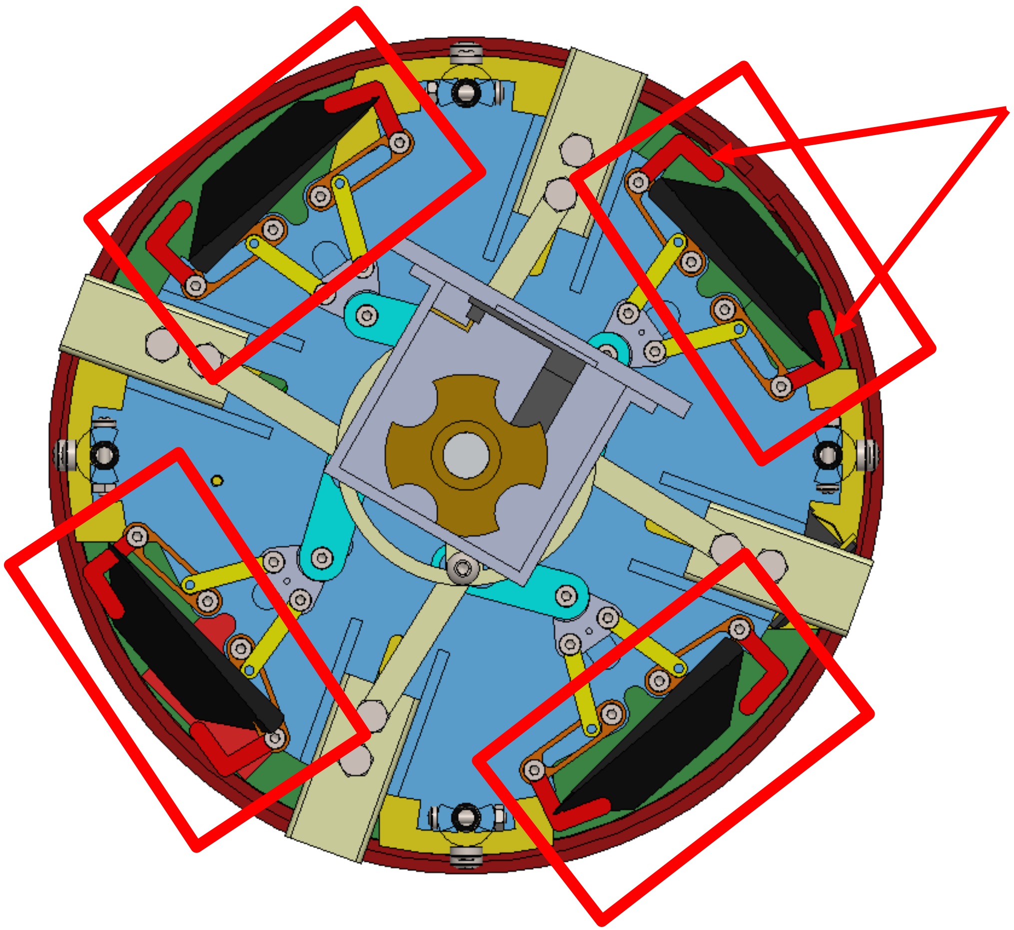




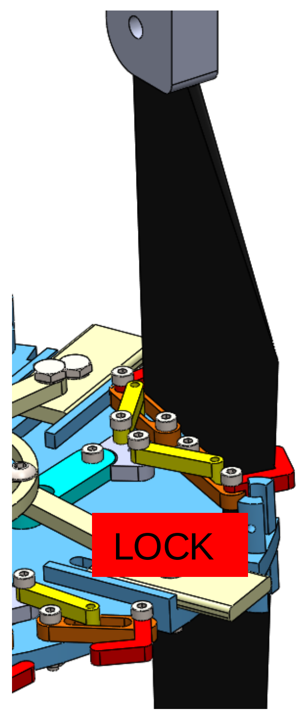
A hinge is used in this configuration.

A gripper is used to stow blades.

Design A: Hinge and Gripper

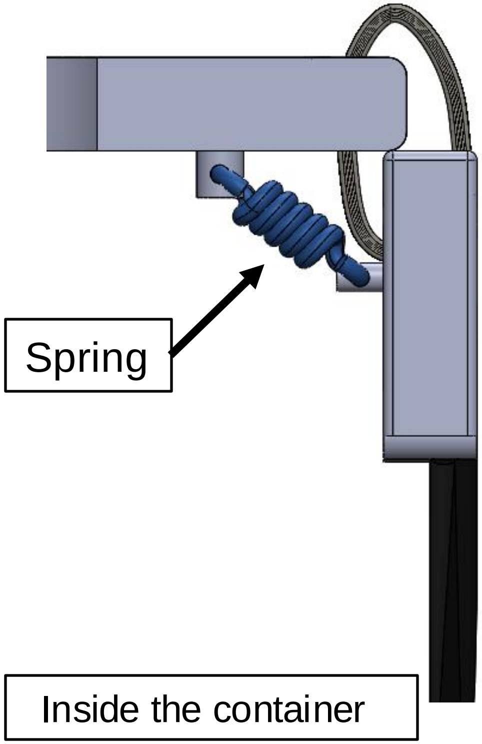


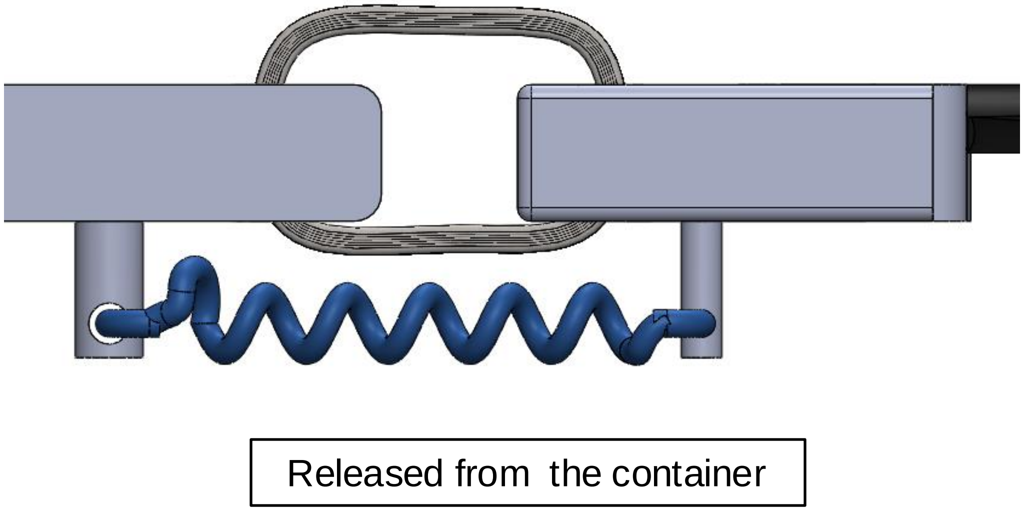
Since the torsion spring has a self-recovery capability, we need a **gripper** to secure the blades inside the container.



Design B: Spring

Use a spring and make sure it can secure the blades inside the container.

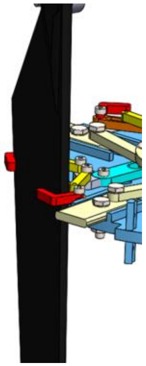




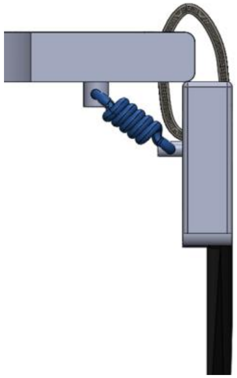
Auto-gyro Stow Configuration Trade & Selection (5/5)

Auto-Gyro Stow Configuration Trade		
Design Feature	**Advantages**	**Disadvantages**
Design A	• Torsion spring force to open • Securely stowed	• Requires more components
Design B	• Requires least components	• Wing push • Unable to be securely stowed in the container.

Design A



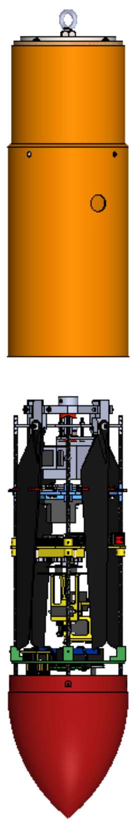
Design B



Selected Design	Rationales
Design A	• Torsion spring force to open • **Securely stowed**

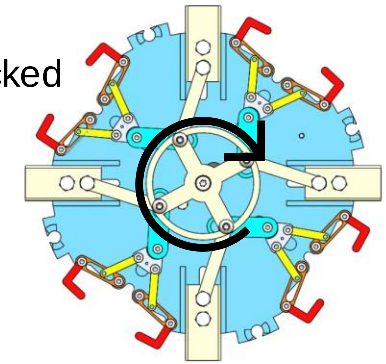
Auto-gyro Deployment Configuration Trade & Selection (1/6)

Released from container

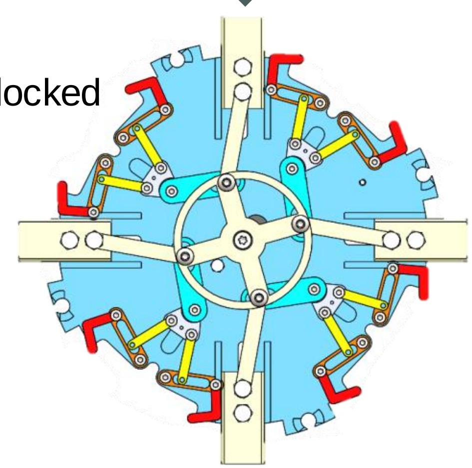


Release four blades

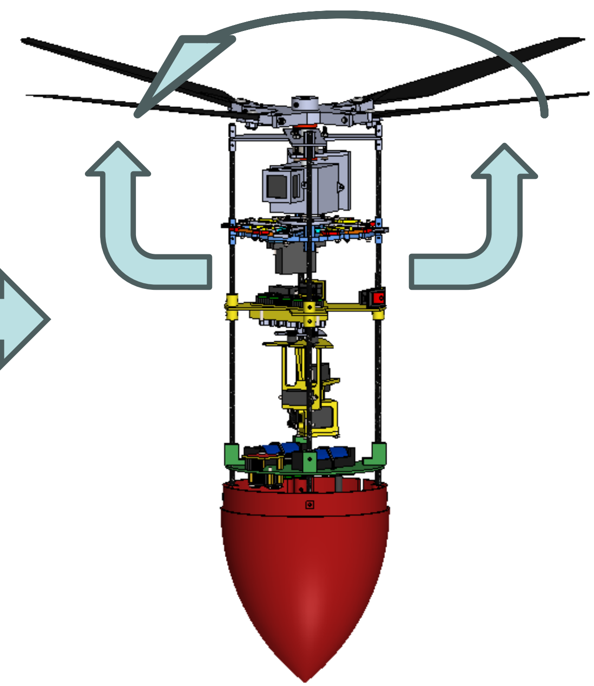
Locked



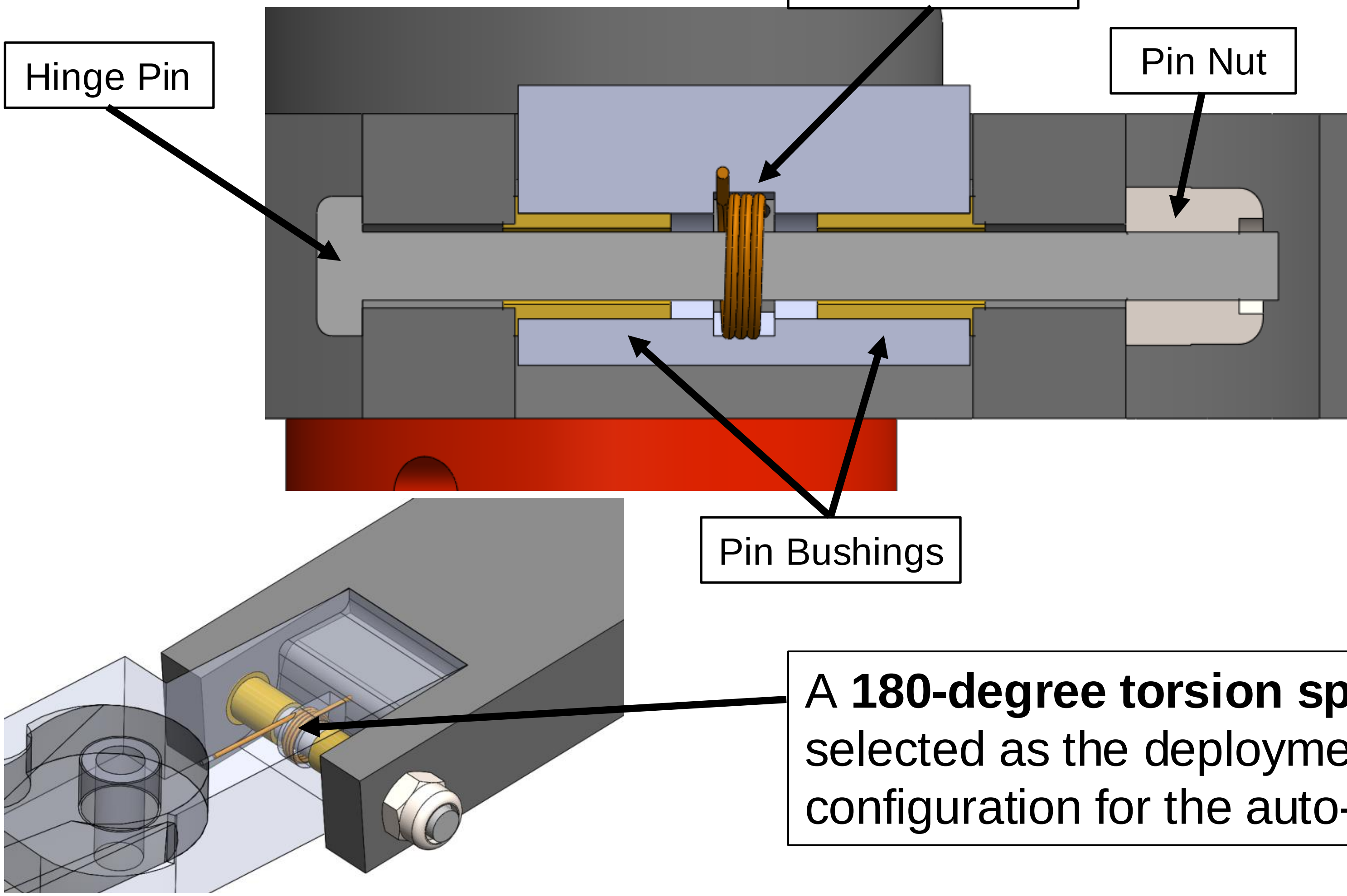
Unlocked



Deploying auto-gyro for deceleration



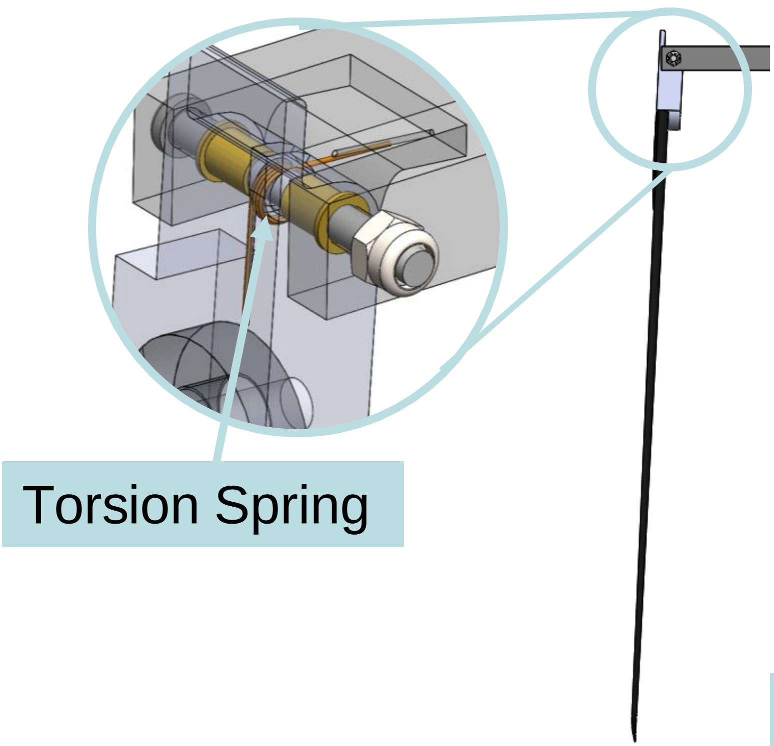
Design A : Torsion spring



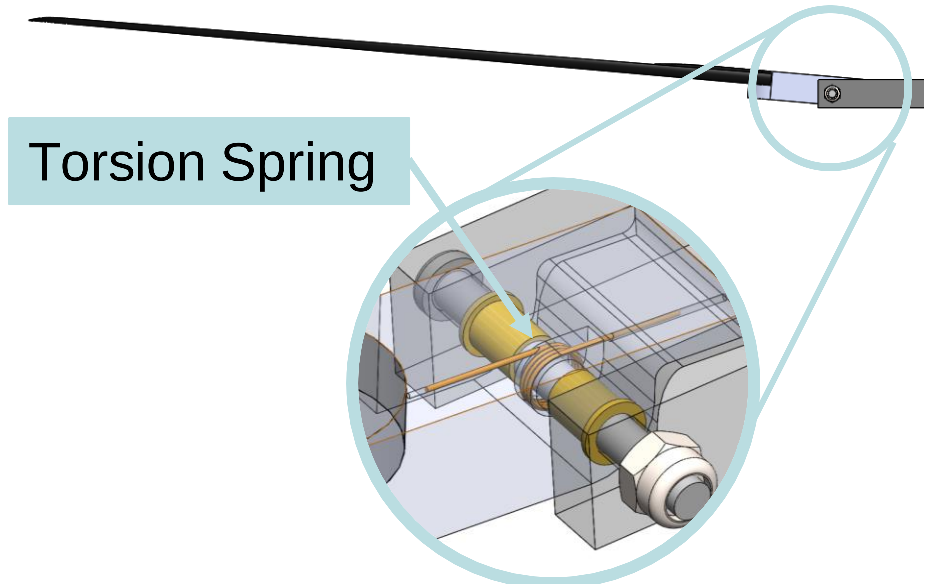
A **180-degree torsion spring** is selected as the deployment configuration for the auto-gyro.

Design A : Torsion spring

Stage1: Stowed in the container



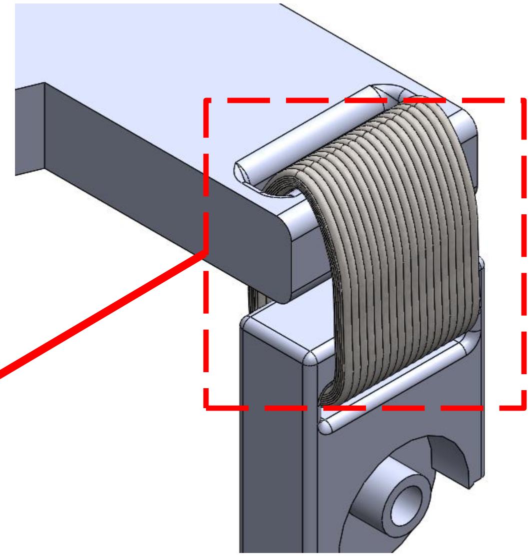
Stage2: During the deceleration



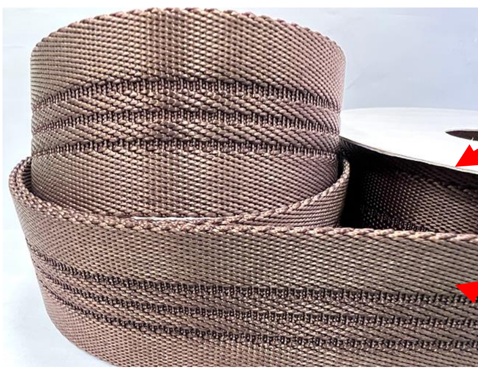
Automatic deployment utilizes the rebound force of the torsion spring

Auto-gyro Deployment Configuration Trade & Selection (4/6)

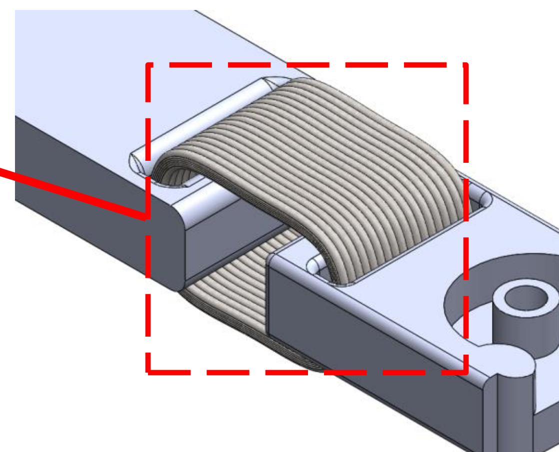
Design B : Lanyard



Stage1 : Stowed in the container

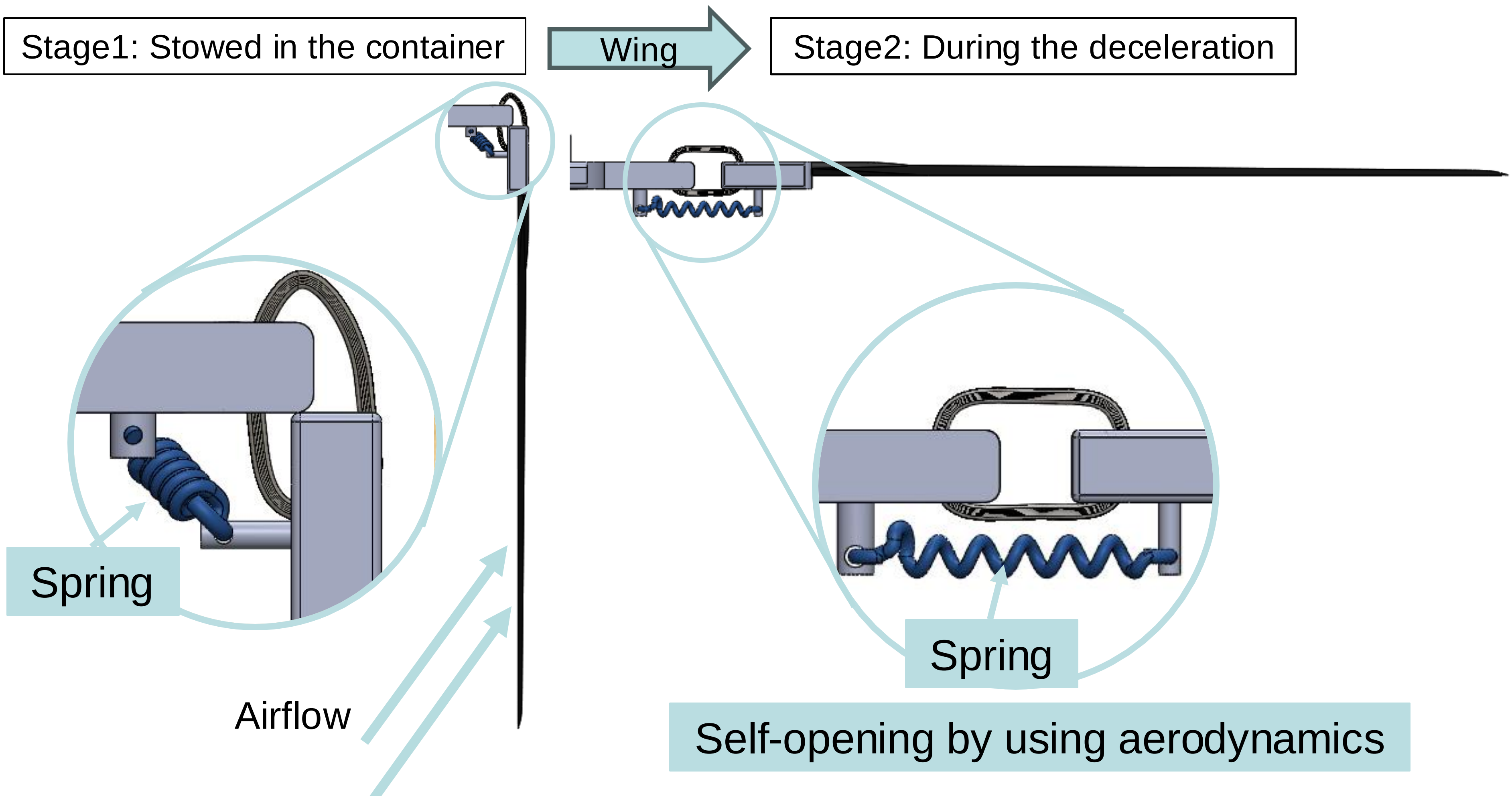


Lanyard



Stage2 : Deployed

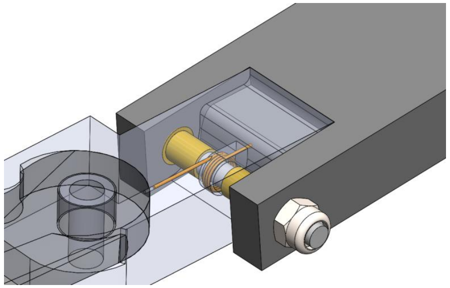
Design B : Lanyard



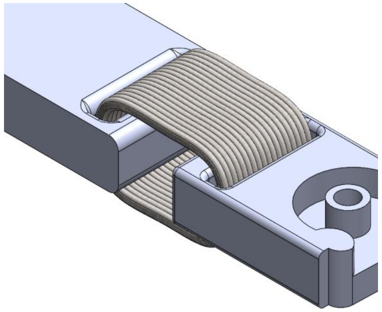
Auto-gyro Deployment Configuration Trade & Selection (6/6)

Auto-Gyro Deployment Configuration Trade		
Design Feature	**Advantages**	**Disadvantages**
Design A	• Torsion spring force to open • Simpler blades deployment	• Requires more components
Design B	• Requires least components	• Requires resisting the force of the spring • Risk of contact

Design A



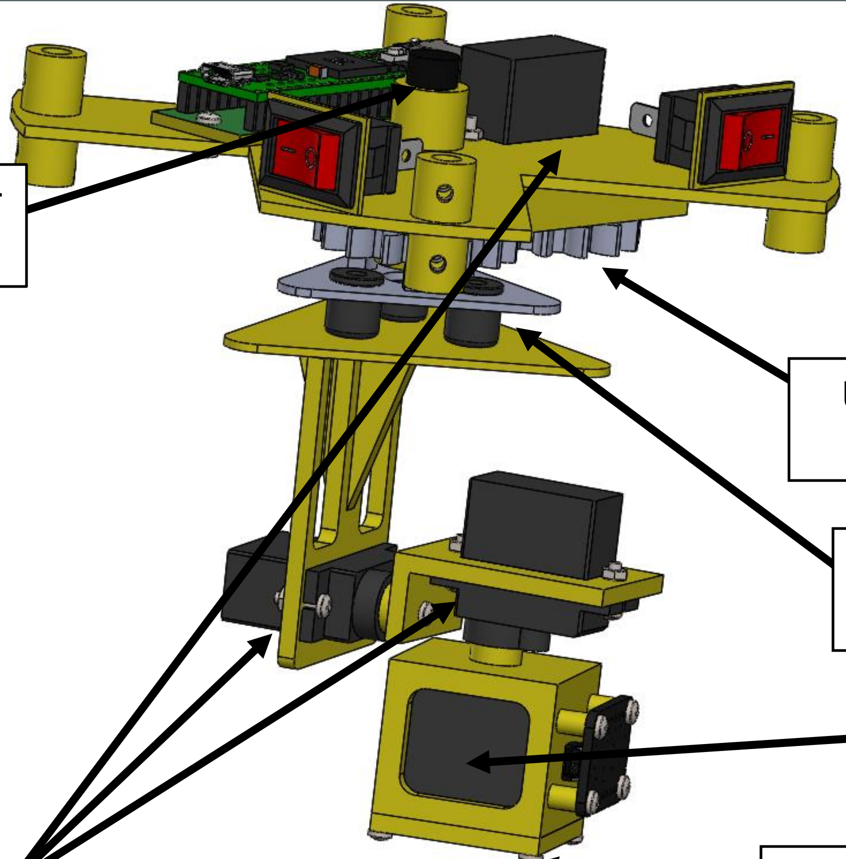
Design B



Selected Design	**Rationales**
Design A	• **Torsion spring force to open** • Simpler blades deployment

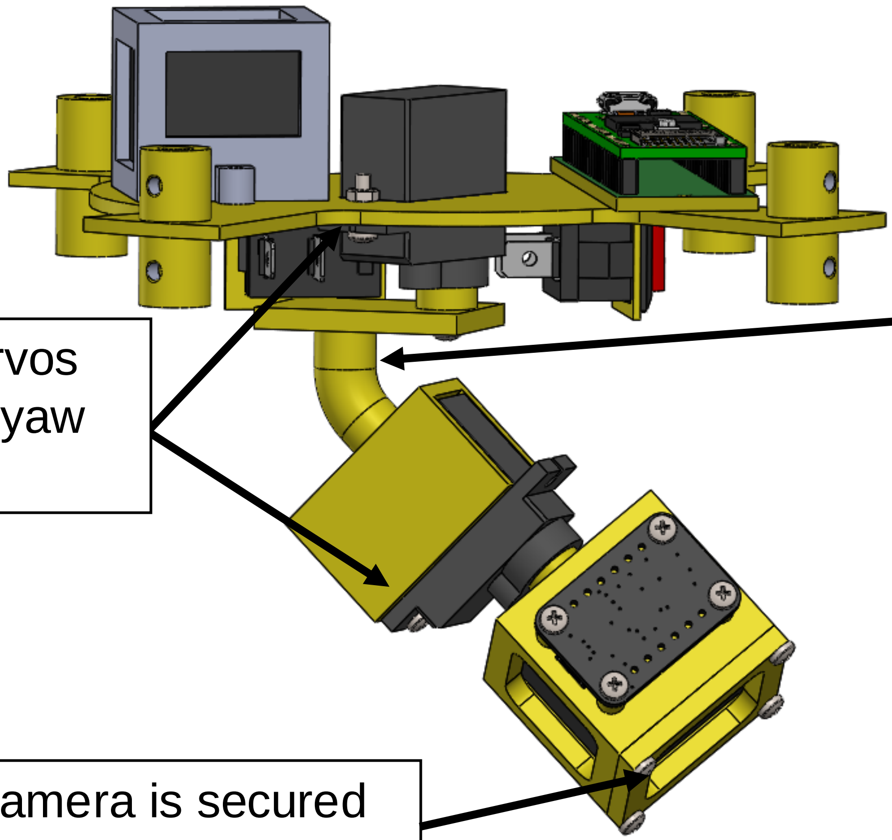
Ground Pointing and Orientation Trade & Selection (1/3)

Design A – 3-axis stabilization with shock absorption



Ground Pointing and Orientation Trade & Selection (2/3)

Design B - Two-axis stabilization with a fixed downward angle



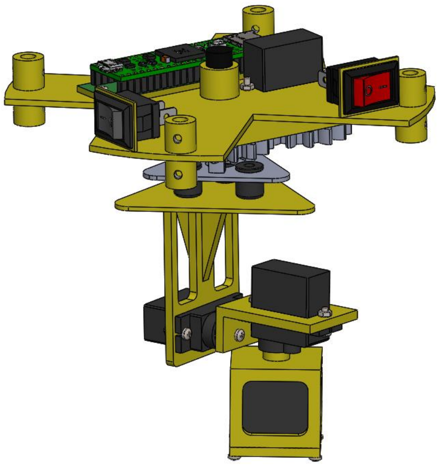
Two independent servos control the camera's yaw and roll

The camera is fixed at a 45-degree angle

Second camera is secured using four M2 screws

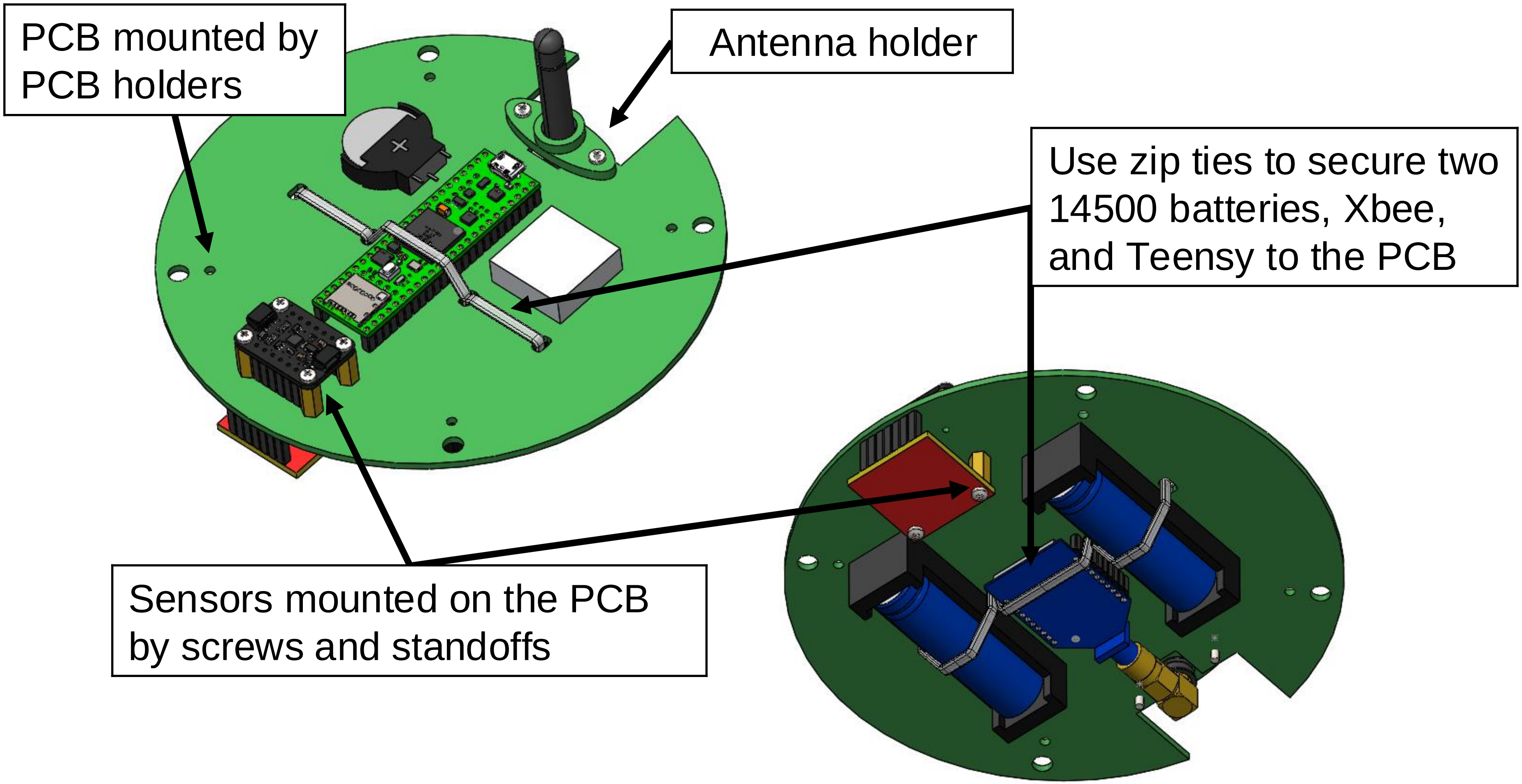
Ground Pointing and Orientation Trade & Selection (3/3)

Aerobraking Deployment Trade		
Design	**Advantages**	**Disadvantage**
A	• A greater range of rotational angles • Effectively minimizes payload vibration.	• More complex control program • Higher weight • Higher structural requirements
B	• Simpler control program • The lighter weight • As simple a structure as possible	• Unable to effectively reduce payload vibration • Unable to control the camera's pitch



Selected Design	Rationale
Design A	• Effectively adapting to various situations is more crucial

Electronics Structural Integrity



Mass Budget (1/10)

Electronics Mass Budget (1/2)					
Component	**Model**	**Mass (g)**	**Quantity**	**Summary**	**Source**
MCU	Teensy 4.1	10	2	20	Datasheet
P&T Sensor	BMP581	18	1	18	Measured
Tilt & Camera orientation Sensor	ICM20948	5	2	10	Datasheet
GNSS Receiver	LS2003E-G	10	1	10	Datasheet
Camera	SQ11	10	2	20	Datasheet
Micro SD card	SanDisk Ultra Micro SDHC UHS-I C10 32GB	0.2	1	0.2	Measured
RF Module	Xbee S3B PRO	11.5	1	11.5	Measured
Antenna	ANT-916-CW-RCS	9	1	9	Datasheet

Mass Budget (2/10)

Electronics Mass Budget (2/2)					
Component	**Model**	**Mass (g)**	**Quantity**	**Summary**	**Source**
Battery	Vapcell L10 ICR14500	22	2	44	Datasheet
Rotation rate sensor	FC-33	2.4	1	2.4	Measured
Battery Holder	Keystone Electronics 1049	2.5	2	5	Estimated
Voltage Indicator	BL-B5141	5	1	5	Datasheet
Audio Beacon	CMI-1210-5-95T	2	2	4	Datasheet
Servo	ES08MAII	20	3	60	Datasheet
Servo	SER0053	13.9	1	13.9	Datasheet
Tracker	AirTag	11	1	11	Datasheet
Switch	E44145	1	2	2	Datasheet

Electronics Total Mass	**246 g**

Mass Budget (3/10)

Mechanical Mass Budget (1/7)						
Subsystem	**Component**	**Material**	**Mass (g)**	**Quantity**	**Summary**	**Source**
Nose cone	Nose cone	PLA	140.3	1	140.3	Estimated
	Carbon fiber bar	Carbon fiber	7.72	4	30.88	Estimated
Container	Container main part	PLA	237.3	1	237.3	Estimated
	Container shoulder	PLA	174.4	1	174.4	Estimated
	Plywood disk	Plywood	63.42	1	63.42	Estimated
	Eyebolt	SS400	2.1	1	2.1	Estimated
Electronics structure	PCB holder	PLA	2.1	4	8.4	Estimated

Mass Budget (4/10)

Mechanical Mass Budget (2/7)						
Subsystem	**Component**	**Material**	**Mass (g)**	**Quantity**	**Summary**	**Source**
GPOC	Main Gear	PLA	4.7	1	4.7	Estimated
	Second Camera box	PLA	7.1	1	7.1	Estimated
	Second Camera cover	PLA	2	1	2	Estimated
	First plate of vibration-absorbing platform	PLA	7.8	1	7.8	Estimated
	Second plate of vibration-absorbing platform	PLA	3.2	1	3.2	Estimated
	Bearing Fix unit	PLA	0.4	1	0.4	Estimated
	Stabilizer base	PLA	29.47	1	29.47	Estimated
	Transmission Gear	PLA	3	1	3	Estimated
	Rubber dampers	Silicone	0.5	3	1.5	Datasheet

Mass Budget (5/10)

Mechanical Mass Budget (3/7)						
Subsystem	**Component**	**Material**	**Mass (g)**	**Quantity**	**Summary**	**Source**
Release module	First Camera cover	PLA	4.1	1	4.1	Estimated
	Base plate	PLA	28	1	28	Estimated
	Lock block	PLA	1.3	4	5.2	Estimated
	Link rod	PLA	0.6	4	2.4	Estimated
	Spin disc	PLA	2.8	1	2.8	Estimated
	Gripper_link1	PLA	0.6	4	2.4	Estimated
	Gripper_link2	PLA	0.2	8	1.6	Estimated
	Gripper_link3	PLA	0.3	8	2.4	Estimated
	Gripper_link4	PLA	0.3	8	2.4	Estimated
	Gripper_slide	PLA	0.6	4	2.4	Estimated

Mass Budget (6/10)

Mechanical Mass Budget (4/7)						
Subsystem	**Component**	**Material**	**Mass (g)**	**Quantity**	**Summary**	**Source**
Auto-gyro	Base hub	PLA	16.78	1	16.78	Estimated
	Blade shaft	PLA	2.94	4	11.76	Estimated
	Hub4	PLA	19	1	19	Estimated
	Speed disk	PLA	3.6	1	3.6	Estimated
	Top hub	PLA	11.98	1	11.98	Estimated
	Fixmainshaft	aluminum	6.5	2	13	Datasheet
	Mainshaft	Steel	10.3	1	10.3	Datasheet
	Ball bearing	Sheet metal	9.27	1	9.27	Datasheet
	Blade	ABS	30	4	120	Datasheet
	Hinge pin	Steel	8	4	32	Datasheet
	Torsion spring	Stainless Steel	0.2	4	0.8	Datasheet

Mass Budget (7/10)

Mechanical Mass Budget (5/7)						
Subsystem	Component	Material	Mass (g)	Quantity	Summary	Source
Fastener	M1.6 × 8 Flat Head Screw	Aluminum	0.2	4	0.8	Estimated
	M2 × 4 Flat Head Screw	Aluminum	0.16	12	1.92	Estimated
	M2 × 5 Flat Head Screw	Aluminum	0.16	8	1.28	Estimated
	M2 × 10 Flat Head Screw	Aluminum	0.2	8	1.6	Estimated
	M2 × 12 Flat Head Screw	Aluminum	0.2	23	4.6	Estimated
	M2 × 20 Flat Head Screw	Aluminum	0.26	3	0.78	Estimated
	M3 × 6 Flat Head Screw	Aluminum	0.22	8	1.76	Estimated
	M3 × 8 Flat Head Screw	Aluminum	0.24	1	0.24	Estimated

Mass Budget (8/10)

Mechanical Mass Budget (6/7)						
Subsystem	**Component**	**Material**	**Mass (g)**	**Quantity**	**Summary**	**Source**
Fastener	M3 × 12 Flat Head Screw	Aluminum	0.24	8	1.92	Estimated
	M3 × 16 Flat Head Screw	Aluminum	0.3	50	15	Estimated
	M3 × 25 Flat Head Screw	Aluminum	0.3	3	0.9	Estimated
	M2.5 × 5 Flat Head Screw	Aluminum	0.2	4	0.8	Estimated
	M4 × 6 Flat Head Screw	Aluminum	0.2	2	0.4	Estimated
	M4 × 12 Flat Head Screw	Aluminum	0.3	2	0.6	Estimated
	¼-inch Nylon Nut	Aluminum	0.8	2	1.6	Estimated
	¼-inch Fender Washer	Aluminum	0.2	2	0.4	Estimated

Mass Budget (9/10)

Mechanical Mass Budget (7/7)						
Subsystem	**Component**	**Material**	**Mass (g)**	**Quantity**	**Summary**	**Source**
Fastener	M2 Lock Nut	Copper	0.27	44	11.88	Estimated
	M3 Lock Nut	Copper	0.58	30	17.4	Estimated
	M3 Washer	Copper	0.04	4	0.16	Estimated

Mechanical Total mass	**1082.20 g**

Mass Budget (10/10)

CanSat Mass Budget (1/1)			
Subsystem	**Component**	**Mass (g)**	**Source**
Electronics	All components	246	Estimated
Mechanical	Electronics structural	8.4	Estimated
	Nose cone	171.18	Estimated
	Container	477.22	Estimated
	Ground Pointing and Orientation Camera	59.17	Estimated
	Release module	53.7	Estimated
	Auto-gyro	248.49	Estimated
	fastener	64.04	Estimated

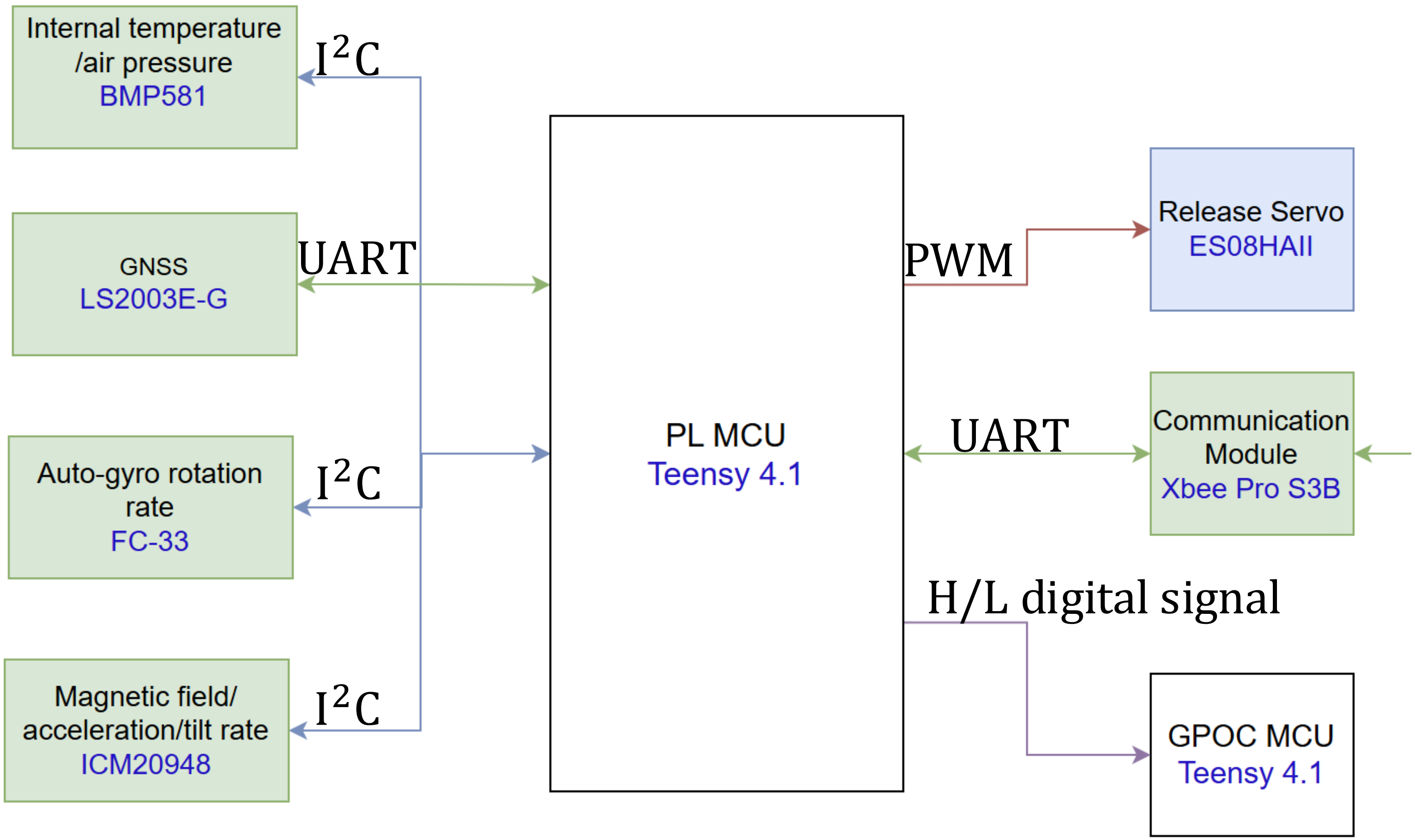
Total mass	1328.2 g
+5% margin	**1394.61g**

(Satisfy the requirements)

Communication and Data Handling (CDH) Subsystem Design

Guan-Chang Chen

Payload Command Data Handler (CDH) Overview



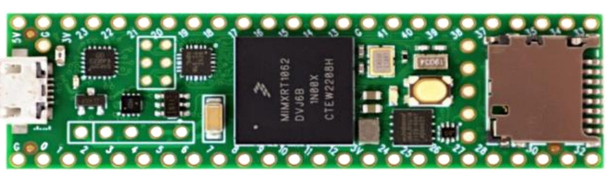
Payload Processor & Memory Trade & Selection

Processor & Memory Trade								
Module	Boot Time (ms)	Clock Frequency (MHz)	Data Interfaces	I/O PINS	Nonvolatile Memory	Volatile Memory (RAM)	Dimension (mm)	Cost (USD)
STM32F407G-DISC1	1	164	3*SPI pin, 3*I²C, 6*UART, 2*CAN, 1*SDIO	140	1MB Flash	256 kB	80×50	22.34
NUCLEO-F412ZG	3	100	5*SPI, 4*I²C, 4*USART, 2*CAN, 1*SDIO	114	1MB Flash	256 kB	67×35	66.20
Teensy 4.1	4	599	8*UART, 3*SPI, 3*I²C	54	7MB Flash	1023 kB	75×21	40.75

Selected Processor	Rationales
Teensy 4.1	• Embedded SD card writer • Most useable ports • Better size

Payload Real-Time Clock

Real-Time Clock Trade						
Model	**Interface**	**Reset Tolerance**	**Oscillator (kHz)**	**Weight (g)**	**Dimensions (mm)**	**Cost (USD)**
Teensy 4.1	I^2C	Unaffected due to external battery backup	32.768	Integrated in MCU	Integrated in MCU	0
PCF8523TS	I^2C	Unaffected due to external battery backup	32.8	1.2	6.6×5.1×1.1	1.68
Adafruit DS3231 Precision RTC	I^2C	Unaffected due to external battery backup	32	2.3	38×22×14	11.8

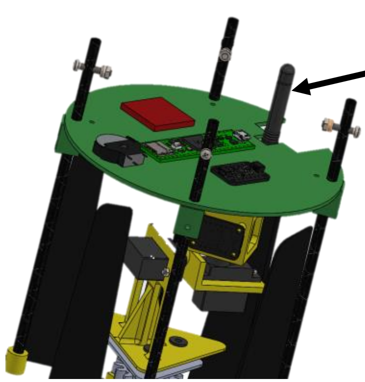


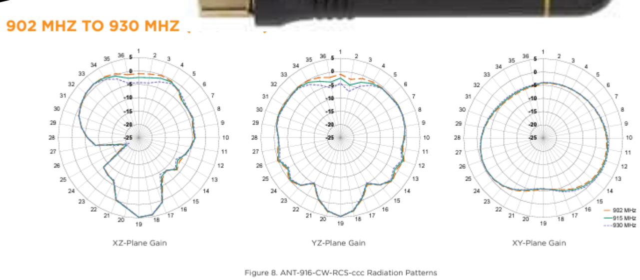
External CR2032 coin cell battery will be used to provide independent power for RTC

Selected Real-Time Clock	Rationale
Teensy 4.1	• Integrated with Teensy 4.1 • Only cost for CR2032 coin cell battery

Payload Antenna Trade & Selection

Antenna Trade						
Model	**Dimension (mm)**	**Gain (dBi)**	**Pattern**	**Frequency Range (MHZ)**	**Weight (g)**	**Cost (USD)**
ANT-916-CW-RAH	46.5 x 17 x 8	2.2	Omnidirectional	850 ~ 970	7.158	8.62
ANT-916-CW-RCL	97.7 x 18.7 x 10.5	4.2	Omnidirectional	902 ~ 930	13.256	8.25
ANT-916-CW-RCS	53.5 x 9.4 x 8	3.3	Omnidirectional	902~930	9	8.81





Selected Antenna	Rationales
ANT-916-CW-RCS	• Better Gain • Smaller size

Payload Radio Configuration

Radio Configuration							
Model	Range (km)	Operating Frequency (MHz)	Operating Voltage (V)	Operating Current (mA)	Sensitivity (dBm)	Transmit Power (mW/dBm)	Cost (USD)
XBEE Pro S3B	14	902~928	2.4~3.6	TX:215 RX:26	-107	250/24	91.25

XBEE Configuration

- XBEE Radio Selection: XBEE Pro S3B 900HP
- NETID: 3168
- Transmission Method: Unicast mode

Transmission Control

1. The CanSat starts sending data at 1Hz once receives a command “CMD, 3168, CX, ON” from GCS.
2. The data transmission rate is maintained at 1 Hz throughout the entire mission.
3. When the CanSat land, it will stop sending data to the Ground Station.

Payload Telemetry Format (1/5)

Competition Given Telemetry Format

<TEAM_ID>, <MISSION_TIME>, <PACKET_COUNT>, <MODE>, <STATE>, <ALTITUDE>, <TEMPERATURE>, <PRESSURE>, <VOLTAGE>, <GYRO_R>, <GYRO_P>, <GYRO_Y>, <ACCEL_R>, <ACCEL_P>, <ACCEL_Y>, <MAG_R>, <MAG_P>, <MAG_Y>, <AUTO_GYRO_ROTATION_RATE>, <GPS_TIME>, <GPS_ALTITUDE>, <GPS_LATITUDE>, <GPS_LONGITUDE>, <GPS_SATS>, <CMD_ECHO>

Example Telemetry Packet

3168, 07:38:10, 65, F, ASCENT, 342.2,
23.0, 101.3, 7.2, 4.1, 0.2, 0.6, 0.0,
0.3, 0.4, 0.2, 0.4, 0.1, 258,
07:38:04, 525.6, 36.2589, -56.2265, 5, CXON

The telemetry data file is named as “Flight_3168.csv”, which is displayed in the International System of Units (SI), and the presented format satisfies the Requirements!!

Payload Telemetry Format (2/5)

Data Field	Description	Units	Resolution
TEAM_ID	The assigned four digit team number		
MISSION_TIME	UTC time in format hh:mn:ss.		
PACKET_COUNT	Total count of transmitted packets since turn on		
MODE	‘F‘ for flight mode and 'S‘ for simulation mode		
STATE	The operating state of the software		
ALTITUDE	The altitude in meters relative to ground level at the launch site	m	0.1 m
TEMPERATURE	The internal temperature of CanSat	°C	0.1 °C
PRESSURE	The air pressure of the sensor used	kPa	0.1 kPa

Payload Telemetry Format (3/5)

Data Field	Description	Units	Resolution
VOLTAGE	The voltage of the CanSat power bus	Volt	0.1 volts
GYRO_R	The gyro readings in degrees per second for the roll	°/s	0.1°/s
GYRO_P	The gyro readings in degrees per second for the pitch	°/s	0.1°/s
GYRO_Y	The gyro readings in degrees per second for the yaw	°/s	0.1°/s
ACCEL_R	The accelerometer readings in degrees per second squared for the roll	$°/s^2$	$0.1°/s^2$
ACCEL_P	The accelerometer readings in degrees per second squared for the pitch	$°/s^2$	$0.1°/s^2$
ACCEL_Y	The accelerometer readings in degrees per second squared for the yaw	$°/s^2$	$0.1°/s^2$

Payload Telemetry Format (4/5)

Data Field	Description	Units	Resolution
MAG_R	Magnetometer readings in the roll	gauss	0.1gauss
MAG_P	Magnetometer readings in the pitch	gauss	0.1gauss
MAG_Y	Magnetometer readings in the yaw	gauss	0.1gauss
AUTO_GYRO_ROTATION_RATE	The rotation rate of the auto-gyro relative to the CanSat structure	°/s	1°/s
GPS_TIME	The time from the GPS receiver in UTC	s	1 s
GPS_ALTITUDE	Altitude from the GPS receiver in meters above mean sea level	m	0.1 m

Payload Telemetry Format (5/5)

Data Field	Description	Units	Resolution
GPS_LATITUDE	The latitude from the GPS receiver in decimal degrees	°	0.0001 ° N/S
GPS_LONGITUDE	The longitude from the GPS receiver in decimal degrees	°	0.0001 ° W/E
GPS_SATS	The number of GPS satellites being tracked by the GPS receiver		
CMD_ECHO	The text of the last command received and processed by the CanSat		

Payload Command Formats (1/2)

Declaration	Team ID	Command Name	Option	Example	Description
CMD	3168	CX	ON	CMD,3168,CX,ON	Activates payload telemetry transmission
		CX	OFF	CMD,3168,CX,OFF	Deactivates payload telemetry transmission
		ST	UTC_TIME	CMD,3168,ST,13:35:59	Sets the mission time to the value given
		ST	GPS	CMD,3168,ST,GPS	Sets the time to the current GPS time
		SIM	ENABLE	CMD,3168,SIM,ENABLE	To enable the simulation mode
		SIM	ACTIVATE	CMD,3168,SIM,ACTIVATE	To activate the simulation mode
		SIM	DISABLE	CMD,3168,SIM,DISABLE	Disables and deactivates the simulation mode

Payload Command Formats (2/2)

Declaration	Team ID	Command Name	Option	Example	Description
CMD	3168	SIMP	Custom	CMD,3168,SIMP, 101325	Provides a simulated pressure reading to the payload
		CAL		CMD,3168,CAL	Calibrate the telemetered altitude to 0 meters on the launch pad
		MEC	RELEASE, PL	CMD,3168,MEC, RELEASE,PL	Activate the servo to release payload
		MEC	RELEASE, OFF	CMD,3168,MEC, RELEASE,OFF	Activate the servo to hold payload and auto-gyro
		MEC	RELEASE, AU	CMD,3168,MEC, RELEASE,AU	Activate the servo to release auto-gyro

Electrical Power Subsystem (EPS) Design

Fu-Xi Wu

EPS Overview

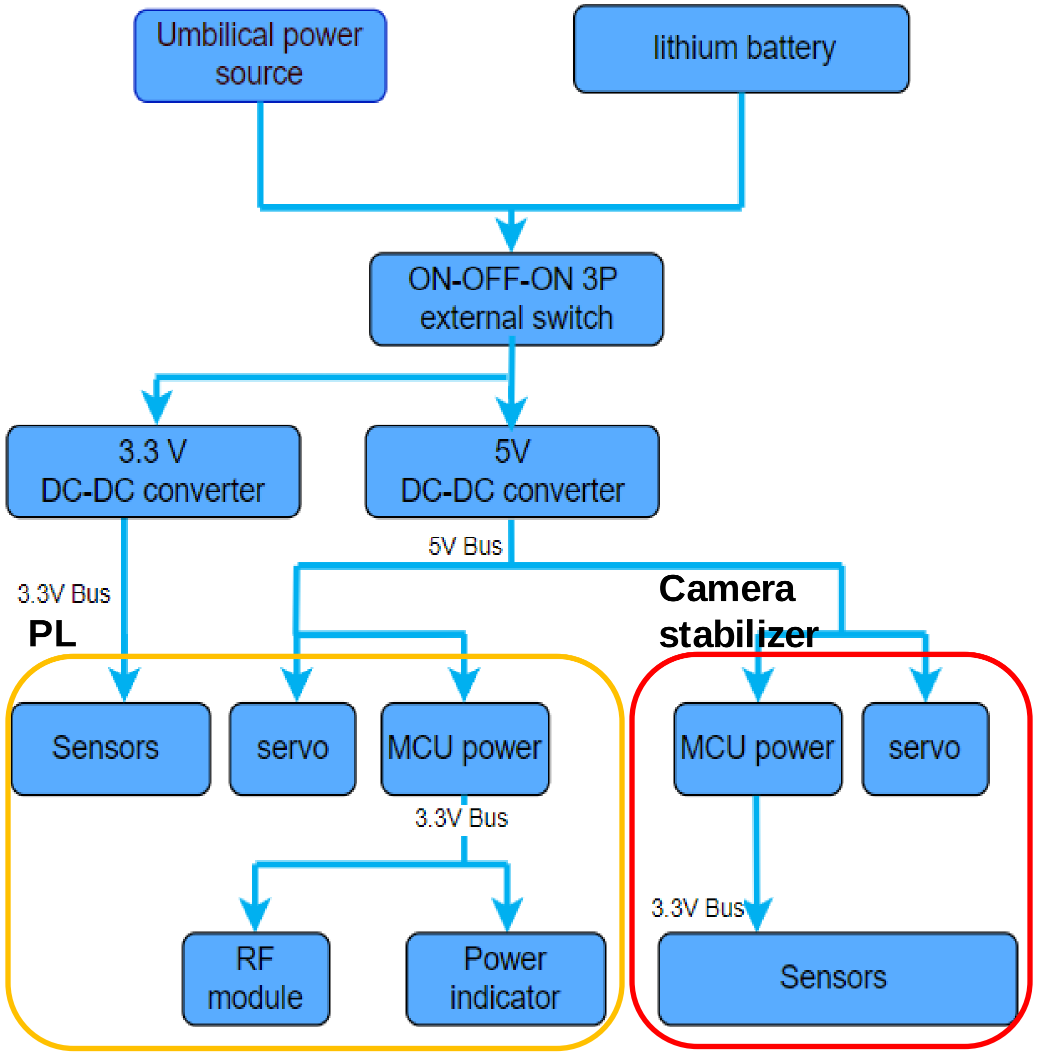
Umbilical power source:
A detachable connector from the batteries that allows the use of an external power source.

Battery:
14500 AA lithium batteries, 3.7V, 2S outputting 7.4V

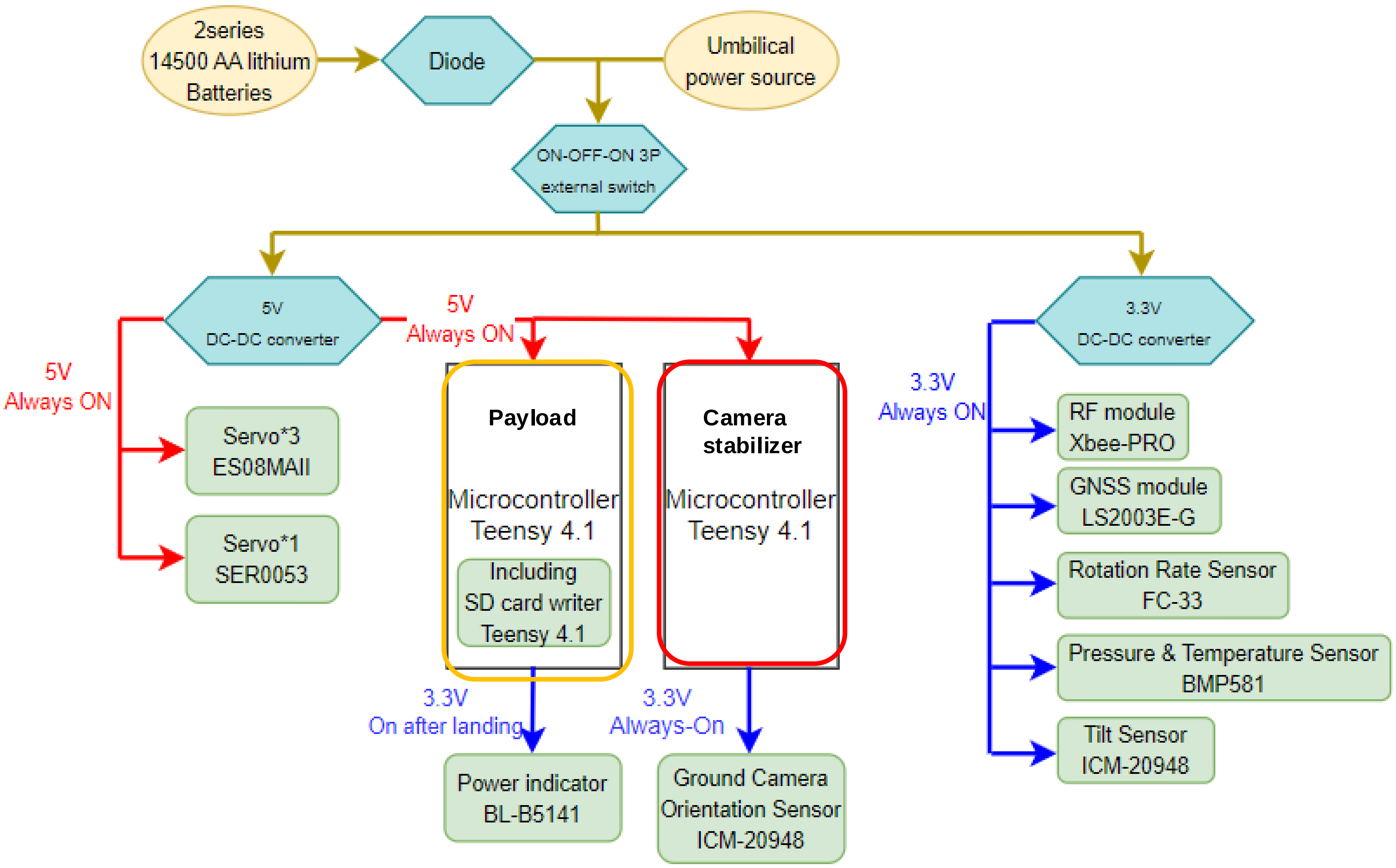
ON-OFF-ON 3P external switch:
A 3P ON-OFF-ON switch that can disable power or select between power sources, designed to prevent interference between them.

5V DC-DC converter:
It converts and stabilizes the voltage to 5V for the components use.

Power indicator:
The power-on indicator



Payload Electrical Block Diagram



Payload Power Trade & Selection

Payload Power Trade							
Module	Type	Voltage (V)	Capacity (mAh)	Unit Weight (g)	Max Current (A)	Capacity (Wh)	Cost (USD)
Panasonic NCR-18650GA	18650 Lithium Battery	3.7	3350	47.5	8	12.395	18.68
Vapcell L10 ICR14500	14500 Lithium Battery	3.7	1050	22	3	3.78	3.59
Sanyo UR14500AC	14500 Lithium Battery	3.7	800	20	1.52	2.96	3.55

Selected Battery	Rationales
Vapcell L10 ICR14500	• Capacity is sufficient for mission requirement • Less weight • Lower cost

Note:
1. 2 batteries are connected in series (2S1P)
2. The batteries is individually mounted in 14500 holders and secured with two zip ties.

Payload Power Budget(1/2)

Model	Voltage (V)	Total Active Power (mW)	Total Idle Power (mW)	Active Duration (hr)	Idle Duration (hr)	Quantity	Required Energy (Wh)
Teensy 4.1	5	500	0	2.00	0.00	2	2
FC-33	3.3	49.50	0	2.00	0.00	1	0.099
ICM-20948	3.3	10.26	0	2.00	0.00	2	0.041
LS2003E-G	3.3	66	1.65	2.00	0.00	1	0.132
BMP581	3.3	0.858	0.002	2.00	0.00	1	0.002
XBee®-PRO	3.3	396	102.3	2.00	0.00	1	0.792
ES08MAII	5	1000	32.5	0.005	1.995	1	0.07
	5	1000	32.5	0.03	1.97	2	0.188
SER0053	5	2750	250	0.03	1.97	1	0.575
BL-B5141	2.1	80	0	2.00	0.00	1	0.16
Power consumption estimated (Wh)				**4.122**			

- All data come from datasheet, except for ***ICM-20948*** which is estimated.
- ***SQ11*** uses a built-in battery, so it is not included in the power budget.

Payload Power Budget(2/2)

Battery capacity (Wh) [A]	7.56
Depth of discharge (DoD) [B]	80%
Energy conversion efficiency [C]	80%
Total energy **Available** (Wh) [D=A*B*C]	4.84

Power **consumption** estimated (Wh) [E]	4.122

Margin (%) [(D-E)/D]	14.8%

Flight Software (FSW) Design

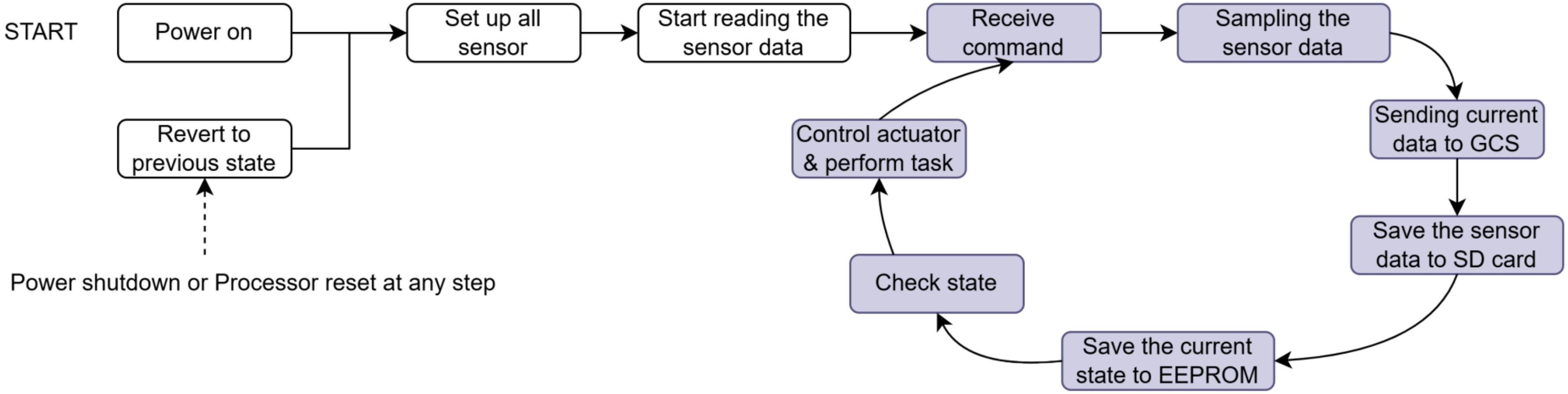
Ting-Tien Cho

FSW Overview(1/3)

- **Overview:**
  - Collect the sensor data
  - Transmit data to the ground station & save in the SD card (on payload)
  - Receive the command from GCS
  - Send signals to actuators according to the command from GCS or sensor data
  - Enable to save the current state to prevent MCU reset or power failure
- **An independent MCU controls the servo motors of the camera stabilizer.**

Programming languages	Development environments
C	Arduino IDE

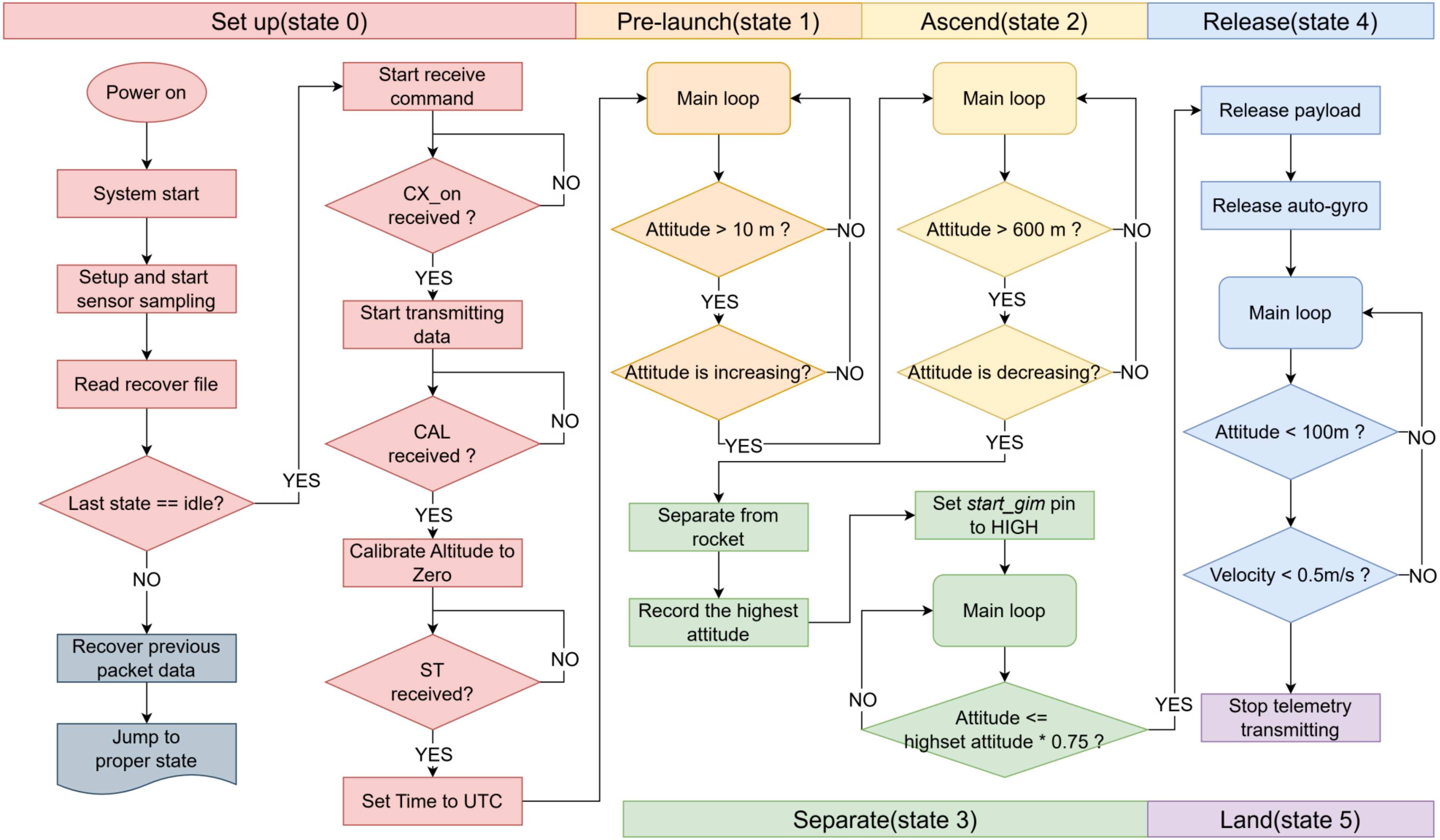
- **Basic FSW program execution flow:**



FSW Overview(3/3)

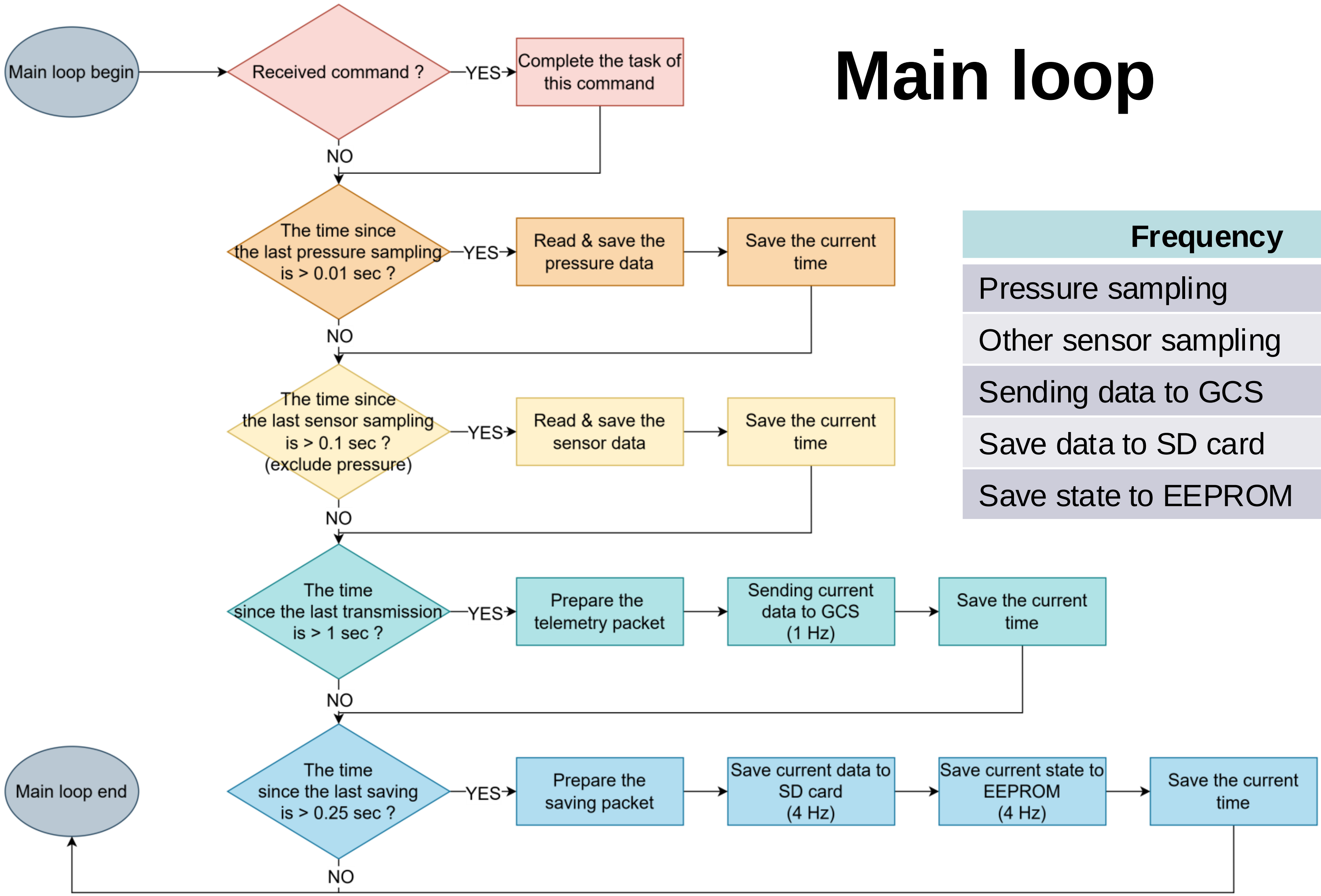
Flight Tasks	
Phase	**Tasks**
Initial	• Boot and setup all sensors • Read previous saved packet • Start transmitting data • Reset reference altitude • Initial MET • Start reading all sensor data
Separate	• Start the camera gimbal (camera stabilizer)
Release	• Open the servo to release PL from container • Release auto-gyro
Land	• Stop telemetry transmission
The whole flight	• Reading all sensor data • Sending data to GCS • Saving data to SD card

Payload FSW State Diagram(1/3)



Payload FSW State Diagram(2/3)

Main loop

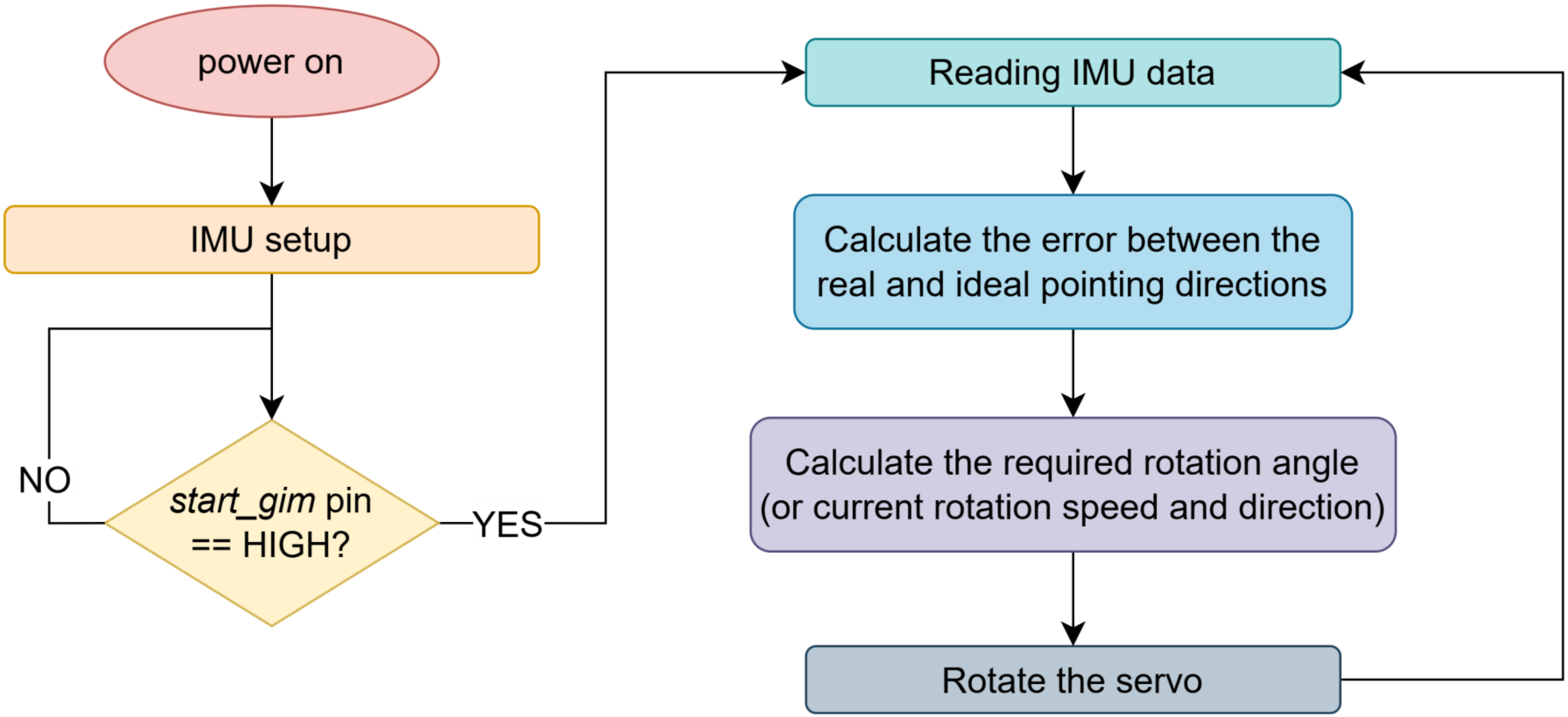


Frequency	
Pressure sampling	100Hz
Other sensor sampling	10Hz
Sending data to GCS	1Hz
Save data to SD card	4Hz
Save state to EEPROM	4Hz

Payload FSW State Diagram(3/3)

- **Reset Occurred**
  - Teensy 4.1 EEPROM stores time, packet counts, and state phase every loop.
  - Reset conditions:
    - Environment issues: shock, high acceleration
    - Power issues: voltage fluctuation
    - Reset command
  - When a reset occurs, the MCU reads previous state data from RAM as the initial values after restarting.

Payload FSW State Diagram - GPOC



Simulation Mode Software (1/2)

- In simulation mode, the execution is as in Flight mode, but pressure (altitude) data is ignored.
- The pressure data is replaced by the value received from GCS, using the same reception method as other commands, with a reception frequency of once per second.
- The GCS is able to read the .txt file, convert it into radio signals, and then send it to payload once per second automatically.

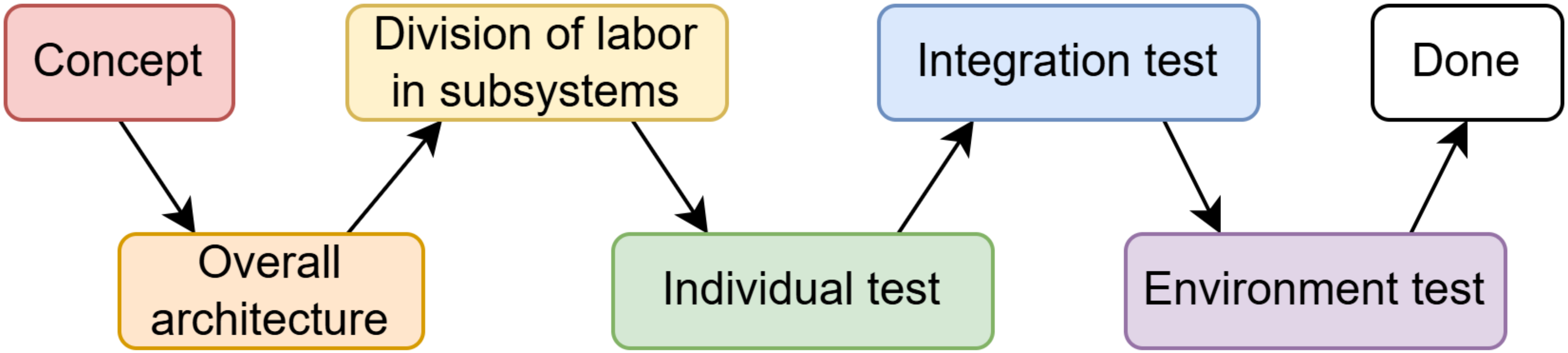
Simulation Mode Software (2/2)

- **Commands:**
  - SIM_ENABLE: Enable simulation mode
  - SIM_ACTIVATE: Activate simulation mode
  - SIM_DISABLE: Disable simulation mode
  - SIMP: Transmit simulation pressure

- To open the simulation, first enable it, then activate the simulation mode. Enabling the simulation is like unlocking a switch; it will close if it doesn't receive the activate command within 20 seconds.

Software Development Plan (1/3)

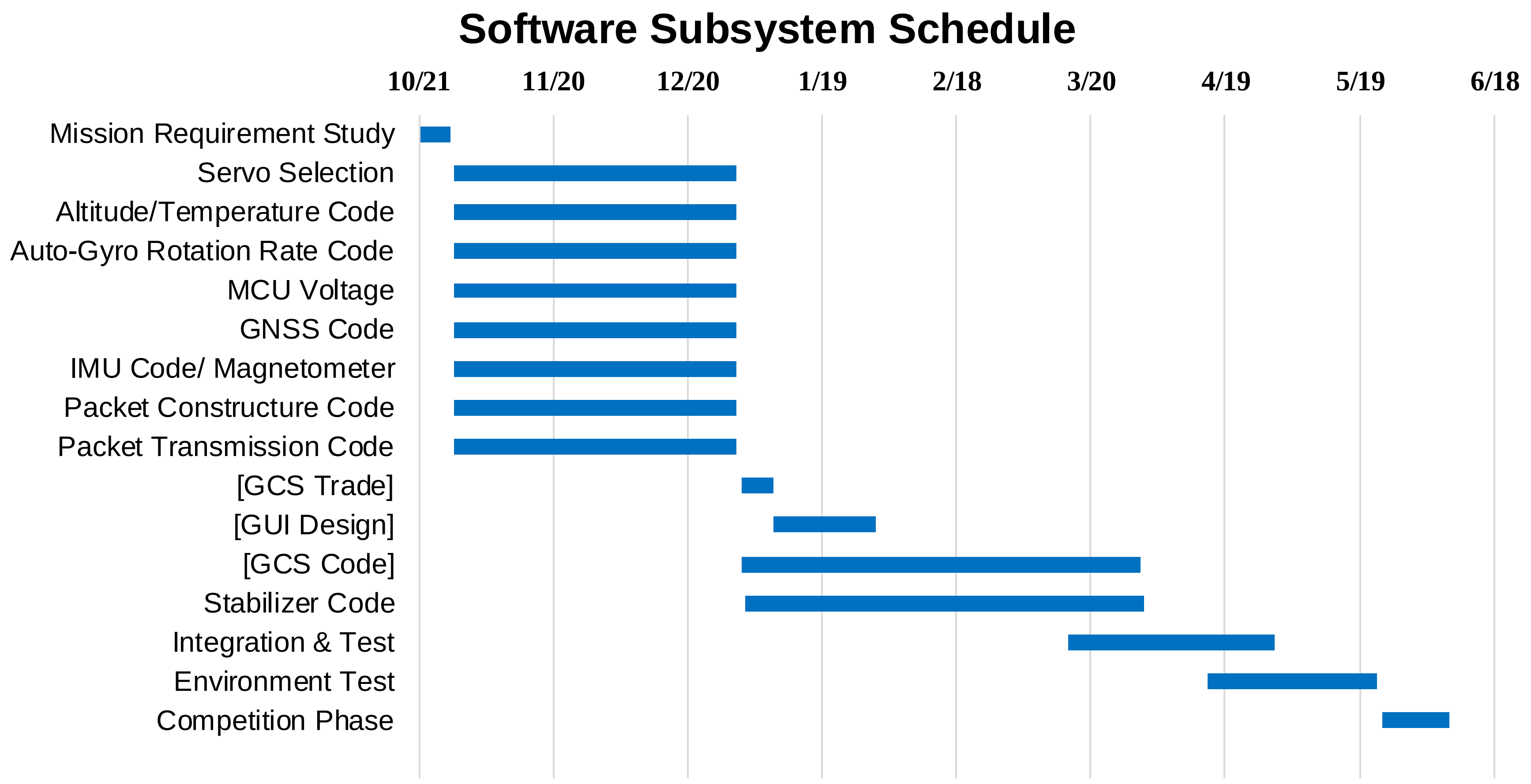
- Once part of the code is completed, it is tested to ensure it operates as expected. If an error is found, the issue will be discussed, analyzed, and resolved or improved. If it works correctly, we will proceed with writing and testing the next part of the code.



Software Development Team:

Item	Handling person
• Camera stabilizer • Sensor reading & storing • Simulation mode • State determination & saving • Actuator control • Overall test	Ting-Tien Cho
• Command receive • Data transfer	Guan-Chang Chen

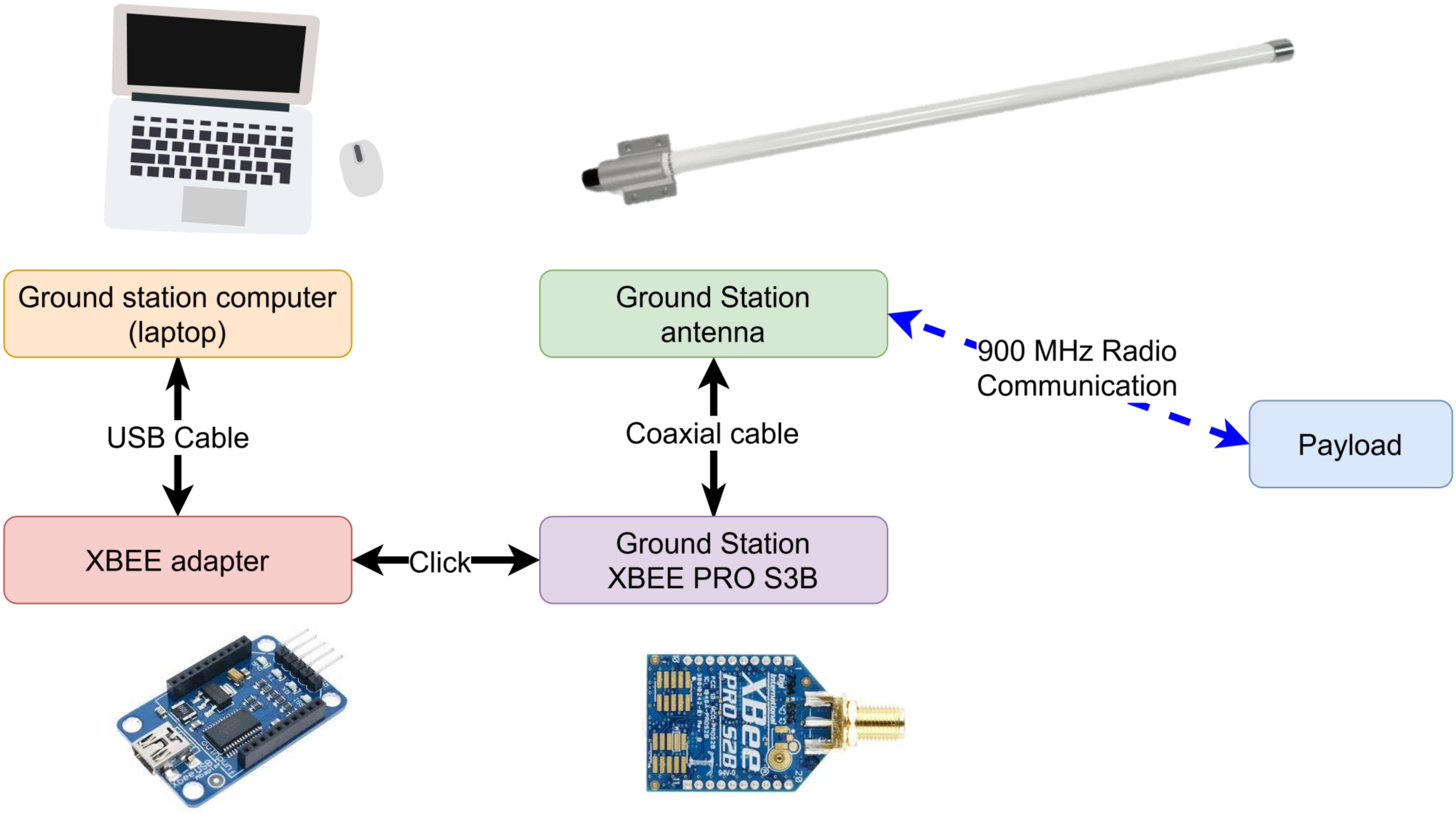
Software Development Plan (3/3)



Ground Control System (GCS) Design

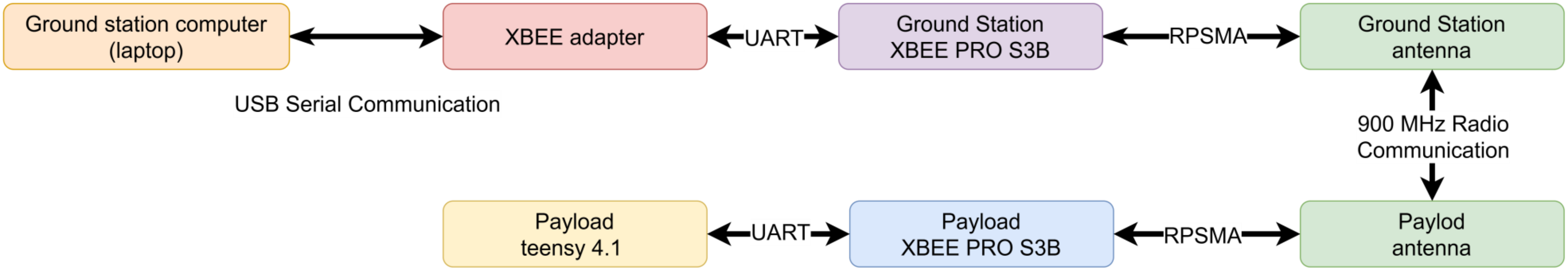
Guan-Chang Chen

GCS Overview



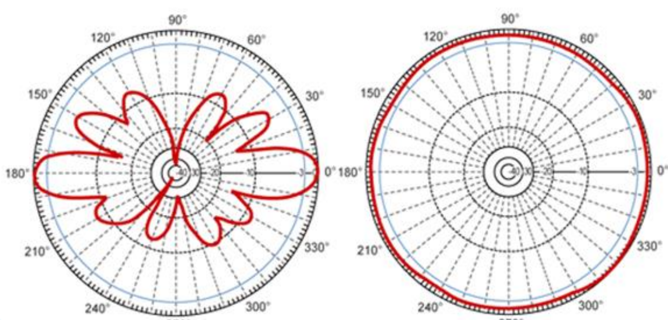
GCS Design

- **Operation time:** GCS can operate for a minimum of 2 hours.
- **Overheating mitigation:** Umbrellas or other shading tools are used to prevent the computer from being exposed to direct sunlight.
- **Auto update mitigation:** Windows automatic updates are paused during the launch activity.



GCS Antenna Trade & Selection

GCS Antenna Selection				
Model	Frequency Range	Gain(dBi)	Pattern	Mounting Type
OA-8996M08-NF	890MHz~ 960MHz	8	Omni	Handheld
OA-8996M02-NF	890MHz~960MHz	2	Omni	Handheld
OA-923M06-NF	917MHz-928MHz	6	Omni	Handheld



Vertical Horizontal

GCS Antenna	Rationales
OA-8996M08-NF	• Better Gain • Larger Frequency Range with Omni Direction • RoHS Compliant

GCS Software (1/3)

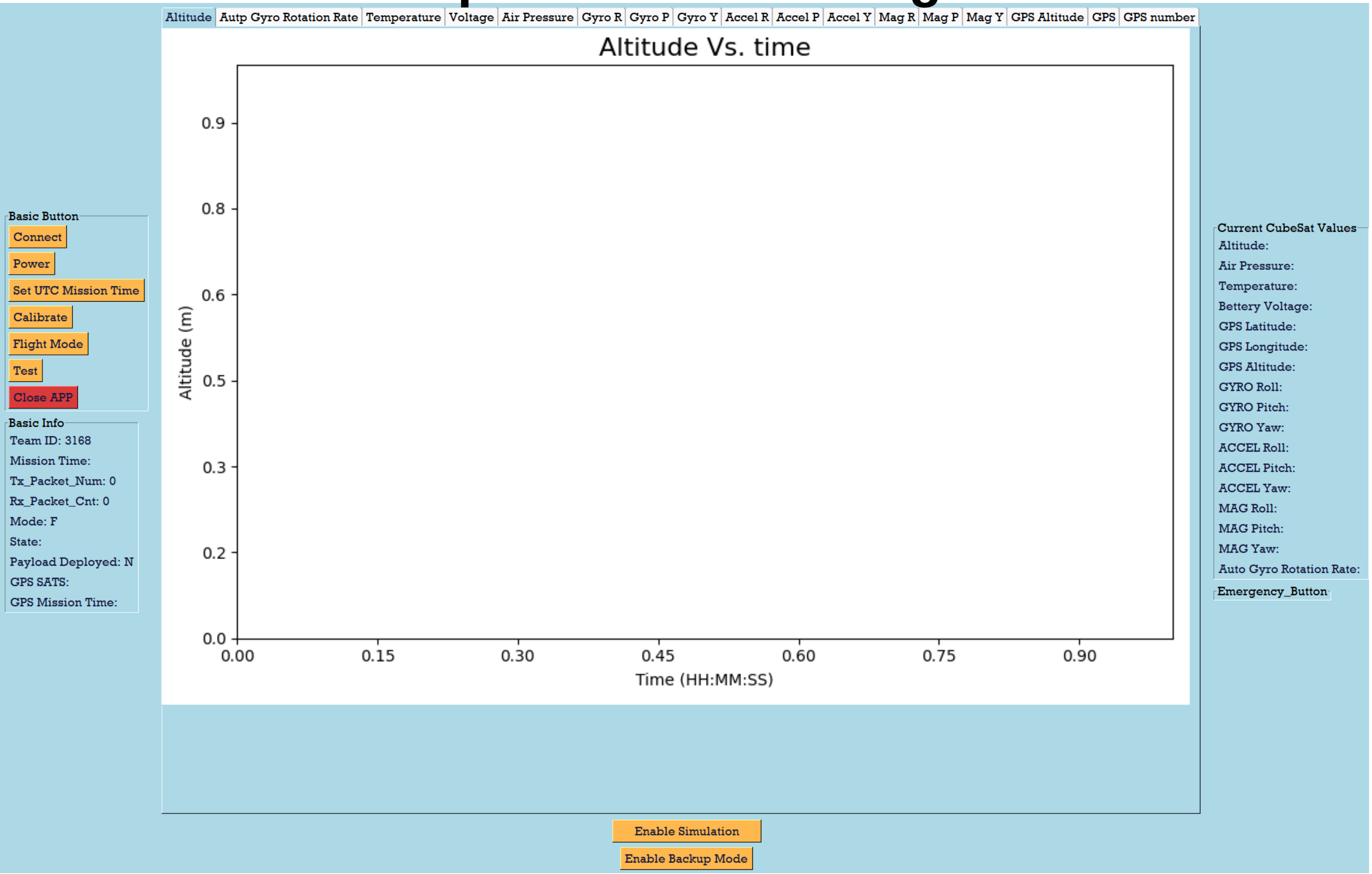
Telemetry display prototypes	The GCS computer displays telemetry data and payload status on the left, a line chart of sensor values from the beginning of the mission to the present in the middle, and real-time sensor values on the right.
Commercial off the shelf (COTS) software packages used	Using Spyder (program in Python) and XCTU(Xbee Program Software) We do not use commercial licensed software
Real-time plotting software design	Telemetry data is processed by Python using matplotlib.pyplot to display real-time data, with each sensor's numeric data shown on its own chart.
Command software and interface	A button is placed to automatically read and send air pressure data for simulation mode (SIMP command). All other commands can be sent instantly by pressing the button. Additionally, there's a backup text input window for sending commands directly.

GCS Software (2/3)

Telemetry data recording and media presentation to judges for inspection	CanSat telemetry data in the form of .csv file is handed over to the judge by USB drive. After recovering the payload, the video file from the payload camera is downloaded from the camera's SD card and shown in the PFR presentation.
Describe .csv telemetry file creation for judges	After the flight, all received telemetry data is saved as a .csv file named Flight_3168.csv. This file is handed over to the judges via a USB drive. The format can be found in the CDH section of the presentation.
Simulation mode description	The GCS initiates a simulation mode with SIM ENABLE and SIM ACTIVATE commands. It then reads the .csv file with barometric pressure data and sends it to the FSW at 1Hz as the SIMP command.
How the calibration will be transmitted and verified	The command is clicked manually, and the GCS sends the calibration command to the CanSat for calibration.

GCS Software (3/3)

- **GUI interface simple schematic diagram**



CanSat Integration and Test

Chan-Hao Tao

CanSat Integration and Test Overview

CanSat Integration and Test	Description	Subsystems
Subsystem Level Test	Each individual subsystem is tested respectively. Identify problems that need to be solved before integration.	Sensors CDH EPS Radio communications FSW Mechanical Descent Control
Integrated Level Function Test	Integrate each of the subsystems and individual components. To test and adjust any issue if necessary.	Parachute Auto-Gyro Communications Mechanisms Deployment
Environmental Test	After the full integration, the CanSat is tested using the suggested methods listed in the competition guide. Additionally, the CanSat is tested in our university's professional facilities.	Drop test Thermal test Vibration test Fit Check Vacuum test
Simulation Test	The CanSat is tested under simulation mode to receive simulated pressure data from the ground station to demonstrate functionality.	FSW logic

Subsystem Level Testing Plan(1/3)

Subsystem	Component	Test Plan	Pass Requirement
Sensor	ICM-20948	• Test sensors individually • Writing simple codes and run with Teensy 4.1 MCU • Sensor Calibration • Sensor accuracy test	• Sensor functions properly • Sensor outputs satisfy requirements
	BMP581		
	LS2003E-G		
	FC-33		
	SQ11		
EPS	Vapcell L10 ICR14500	• Battery endurance test by electric load • Test output voltages and current	• System remains powered on after designed duration • Switches can clearly indicate the power status
	DC-DC converter		

Subsystem Level Testing Plan(2/3)

Subsystem	Component	Test Plan	Pass Requirement
CDH	Teensy 4.1 CanSat Xbee	• Power-up and Initialization • Communication test • Sensor calibration and data acquisition • Data storage	• The CanSat and GCS can communicate and save data properly
Radio communication	Ground Station CanSat Xbee Teensy 4.1	• Xbee communication in three different distance • GCS's antenna best position • Two-way communication • Connection Stability	• The CanSat can receive commands from three different distances
FSW	Teensy 4.1 Ground station All Sensors and actuators	• Function testing. • Basic functions, such as data logging, sensor reading, and controls of actuators. • Flight protocol, such as deployment, descent, and landing • Transition between Flight mode and simulation mode • Senor calibration and integration • Survive under power cut and reset	• The FSW can properly logging, reading sensor's values and control different servos. • The FSW can switch between different flight modes.

Subsystem Level Testing Plan(3/3)

<table>
<tr><th>Subsystem</th><th colspan="2">Component</th><th>Test Plan</th><th>Pass Requirement</th></tr>
<tr><td rowspan="4">Mechanics</td><td colspan="2">Servo</td><td rowspan="2">• Once installed on the CanSat, the servo is responsible for operating the release system and the second camera.</td><td rowspan="2">• The servo can operate without impediments.</td></tr>
<tr><td colspan="2">FSW</td></tr>
<tr><td rowspan="2">Payload</td><td>Ground-Pointing and Orientation Camera</td><td>• Rotated by hand to confirm the camera direction ability.</td><td>• The camera can remain stably oriented toward the designated direction.</td></tr>
<tr><td>Release system</td><td>• The PL is released from the container at the specified time.</td><td>• The PL can be successfully released from the container.</td></tr>
<tr><td rowspan="2">Descent Control</td><td colspan="2">Parachute</td><td>• The CanSat will be released from high building to confirm the descent speed</td><td>• The parachute can effectively decelerate the CanSat to a speed of 17–23 m/s.</td></tr>
<tr><td colspan="2">Auto-gyro</td><td>• The PL be released from high building to confirm the descent speed</td><td>• The auto-gyro can effectively decelerate the payload to a speed of 2~8 m/s.</td></tr>
</table>

Integrated Level Functional Test Plan

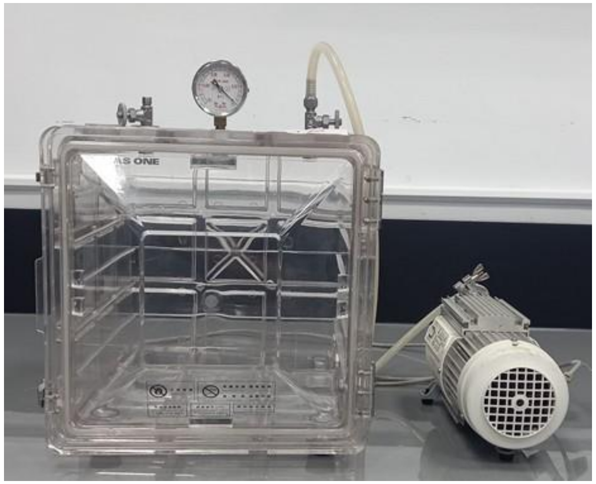
System	Test Plan	Pass Requirement
Descent	The CanSat be dropped from multiple different heights. • Ensure that the parachute is successfully deployed during the descent of the CanSat. • Ensure that the auto-gyro system is successfully released during the descent of the payload. • Ensure that the descent rate of the CanSat can be maintained between 17 to 23 m/s after the parachute is activated. • Ensure that the descent rate of the payload can be maintained between 2 to 8 m/s after the auto-gyro is activated.	• The CanSat is expected to descend at a rate of 17~23m/s with the parachute open and at a rate of 2~8 m/s with the auto-gyro deployed while maintaining stability.
Communications	• Test multiple antenna position • Test short, normal, and long-distance communication	• The telemetry should be transmitted and received effectively at various distances.
Mechanical	• The CanSat be suspended to inspect the functionality of the parachute and auto-gyro release mechanisms.	• The release mechanism of parachute and auto-gyro can be properly performed.
Deployment	• That each deployment subsystem works according to our expectations be tested.	• The CanSat should open the parachute and auto-gyro at predetermined attitude.

Environmental Test Plan (1/2)

Test	Test Plan	Pass Requirement
Drop Test	The drop test requires a 61 cm non-stretching cord, such as a 1/8-inch thick Kevlar cord. One end is attached to a fixed eyebolt on a rigid structure with sufficient clearance to prevent the CanSat from hitting the ground, while the other end is tied to the parachute. A mat or pillow may be placed beneath the CanSat for safety. The structure must remain rigid, and the cord must be secured to it—holding the cord or any part of the structure invalidates the test.	• CanSat does not lose power. • CanSat does not have any interior or exterior damage. • All functions still work perfectly, and telemetry is still being received.
Thermal Test	The CanSat be placed inside a thermal chamber at NCKU, where the air temperature be raised to 60°C. Each subsystem of the CanSat be observed for a duration of 2 hours to ensure proper functionality under elevated temperature conditions.	• The structural integrity of the CanSat, particularly the 3D printed components, must remain intact during the thermal testing. • All sensors should function normally, receiving and transmitting data as expected.
Vibration Test	The CanSat would be placed on an orbital sander, which vibrates at a frequency between 0 and 233 Hz for a minute.	• CanSat has no structural damage. • All functions still work perfectly and verify accelerometer data is still being collected.

Environmental Test Plan (2/2)

Test	Test Plan	Pass Requirement
Fit Check	The CanSat be inserted into a tube with dimensions matching those of the rocket's payload.	The CanSat can move in and out of the tube easily without impediment.
Vacuum test	The CanSat be tested in a vacuum desiccator at NCKU, simulating a pressure drop to 0.8 bar, equivalent to the air pressure at an altitude of 1 km. Telemetry data is collected and saved during the test.	The CanSat should transmit and record the telemetry throughout the test and the data is provided to the judges.



Simulation Test Plan

Component	Test Plan and Description
GCS	In this test, GCS should first successfully send the enable and activate simulation command then start reading a .txt file that include barometric pressure data provided by the competition and send the values to the CanSat at 1Hz via command (SIMP). GCS will receive simulated pressure data, altitude value converted from simulated pressure, and the rest actual sensor data from the FSW. • GCS successfully sends enable simulation command • GCS successfully sends activate simulation command • GCS successfully reads .txt file • GCS successfully sends SIMP command at 1HZ • GCS successfully receives simulation data from the CanSat
FSW (MCU)	In this test, FSW should successfully enter simulation mode after receiving enable and activate simulation command. When entering simulation mode, FSW should swap the data of the sensor with SIMP command's pressure value from GCS.

Mission Operations & Analysis

Chan-Hao Tao

Overview of Mission Sequence of Events (1/2)

1. Arrival (Whole team)

- Team arrival at the launch site
- Check any damages that may occur during transportation

2. Pre-Launch (CanSat and Ground Station Crew)

- Set up Ground station and antenna
- CanSat assembly and test
- Communication and sensor tests
- Mechanical check and test
- Battery check
- Final weight and dimension check

3. Rocket Integration (CanSat Crew)

- Final the CanSat inspection
- Power on CanSat, communication confirmation
- Integrate into the rocket
- Sensor calibration
- Safety check

4. Launch (Ground Station Crew)

- Execute launch procedure
- Flight Monitoring
- CanSat landing
- Save data to USB from GCS

5. Recovery (Recovery Crew)

- Payload and container recovery by audio beacon and visual
- Check payload and container damage situation
- Backup two cameras' micro-SD card and flight data

6. Data analysis (Ground Station Crew)

- Analyze data and video recording

Overview of Mission Sequence of Events (2/2)

Team	Main	Substitute
Mission Control Officer	Chan-Hao Tao	Guan-Chang Chen
Ground Station Crew	Ting-Tien Cho Guan-Chang Chen	Fu-Xi Wu
Recovery Crew	Kuan-Yu Lai Fu-Xi Wu	Ting-Tien Cho
CanSat Crew	Su-Yun Hsu Chen-Pei Yang	Chan-Hao Tao

Mission Operations Manual Development Plan

Section	Content
Team Rosters	Overview of the roles of each team and the responsibilities for each role.
Ground Station Configuration	Setting up Ground Station and start communication between CanSat and Ground Station.
CanSat preparation	CanSat assembly and inspection.
CanSat integration	Mount CanSat into the rocket and verify the CanSat functionality.
Launch preparation	Document is provided by CanSat competition.
Launch procedure	Document is provided by CanSat competition.
Removal procedure	Document is provided by CanSat competition.

CanSat Location and Recovery

Recovery Strategy	Description
Fluorescent color	The CanSat has a bright red outward and multiple-color parachute so it can be easily spotted.
Audio beacon	An audio buzzer is activated after the power is on.
GPS information	Latest GPS information provides the estimated location for the recovery crew.
Exterior label	Label affixed to the exterior of the CanSat.
Reflective strips	The reflective strips are attached to both the CanSat container and its payload to assit us to recover them.

Exterior label template →

CanSat competition 2025
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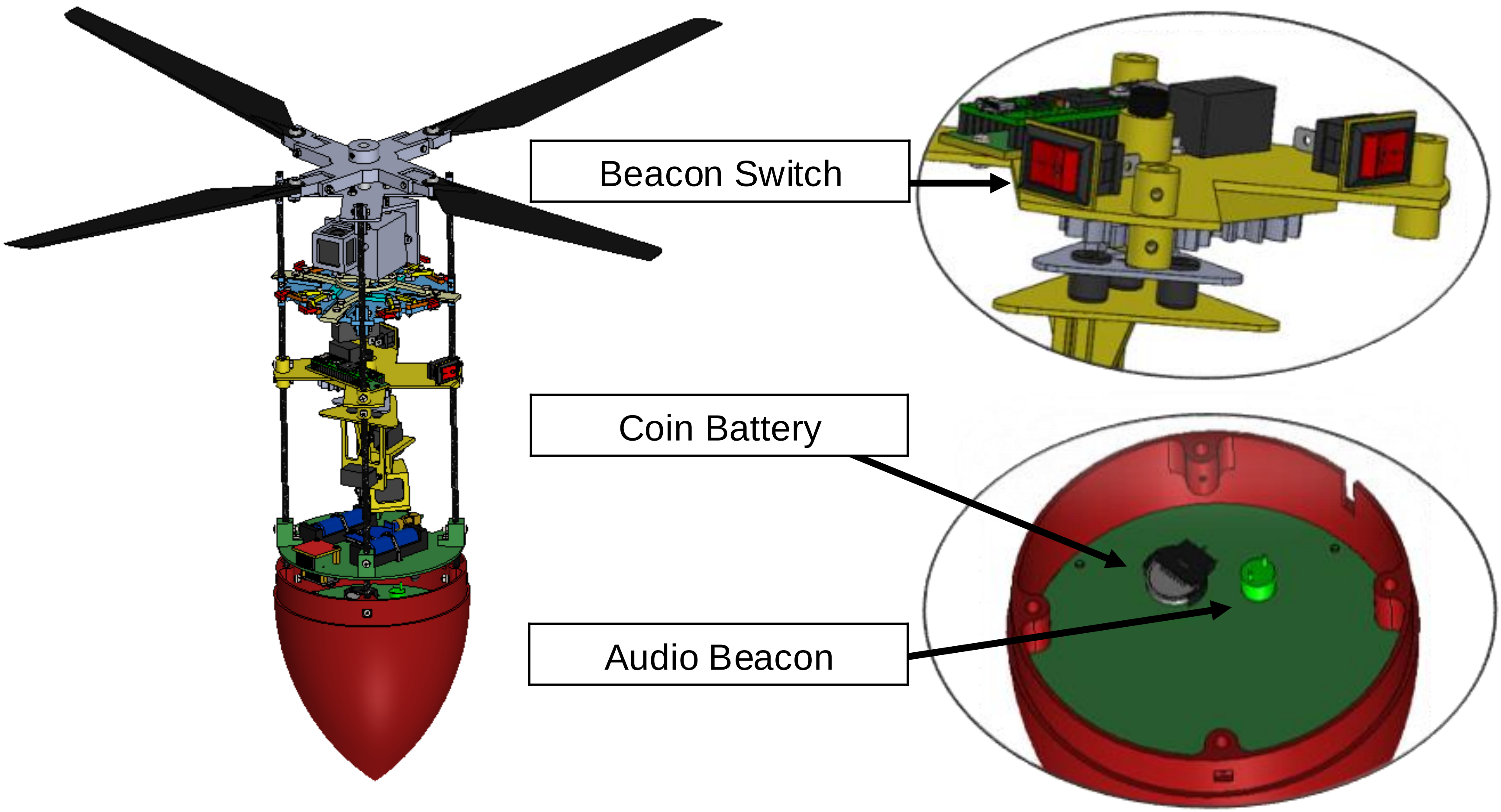
CanSat Beacon Design



Requirements Compliance

Guan-Chang Chen

Requirements Compliance Overview

A CanSat is designed by analyzing the 2025 CanSat Competition Mission Guide.

- 83 requirements are complied based on the mission guide.
- No requirement is partially complied with.
- There are 2 requirements that are not complied with in the current phase.
  - These requirements have to be validated by further analysis or environmental tests.

(green)	Comply
(yellow)	Partial Comply
(red)	NO Comply

Requirements Compliance (1/15)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
1	The CanSat payload shall function as a nose cone during the rocket ascent portion of the flight.	Comply	27~29, 74, 76	
2	The CanSat container shall be mounted on top of the rocket with the shoulder section inserted into the airframe.	Comply	37	
3	The CanSat payload and container shall be deployed from the rocket when the rocket motor ejection charge fires.	Comply	25, 37	
4	After deployment, the CanSat payload and container shall descend at 20 meters/second using a parachute that automatically deploys. Error is +/- 3 m/s.	Comply	51,56~59,61	
5	At 75% flight peak altitude, the payload shall be released from the container.	Comply	17,19,32, 84~87,136	
6	At 75% peak altitude, the payload shall deploy an auto-gyro descent control system.	Comply	88~98,136	

Requirements Compliance (2/15)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
7	The payload shall descend at 5 meters/second with the auto-gyro descent control system.	Comply	60	
8	The sensor telemetry shall be transmitted at a 1 Hz rate.	Comply	137	
9	The payload shall record video of the release of the payload from the container and the operation of the auto-gyro descent control system.	Comply	65, 67, 69, 72	
10	A second video camera shall point in the north direction during descent.	Comply	99~101, 139	
11	The second camera shall be pointed 45 degrees from the CanSat nadir direction during descent.	Comply	99~101, 139	
12	The second video camera shall be spin stabilize so the ground view is not rotating in the video.	Comply	99~101, 139	

Requirements Compliance (3/15)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
13	The CanSat payload shall include an audible beacon that is turned on separately and is independent of the CanSat electronics.	Comply	166	
14	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost of the CanSat. Equipment from previous years shall be included in this cost, based on current market value.	Comply	185~194	
15	The CanSat and container mass shall be 1400 grams +/- 10 grams.	Comply	103~112	
16	Nose cone shall be symmetrical along the thrust axis.	Comply	74,75	
17	Nose cone radius shall be exactly 72.2 mm	Comply	74,75	
18	Nose cone shoulder length shall be a minimum of 50 mm	Comply	74,75	

Requirements Compliance (4/15)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
19	The nose cone shall be made as a single piece. Segments are not allowed.	Comply	74,75,76	
20	The nose cone shall not have any openings allowing air flow to enter	Comply	74,75,76	
21	The nose cone height shall be a minimum of 76 mm.	Comply	74,75	
22	CanSat structure must survive 15 Gs vibration	No Comply	158	Confirmed by test
23	CanSat shall survive 30 G shock	No Comply	158	Confirmed by test
24	The container shoulder length shall be 90 to 120 mm.	Comply	25,37,78,80	
25	The container shoulder diameter shall be 136 mm.	Comply	25,37,78,80	
26	Above the shoulder, the container diameter shall be 144.4 mm	Comply	25,37,78,80	

Requirements Compliance (5/15)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
27	The container wall thickness shall be at least 2 mm.	Comply	78,80	
28	The container length above the shoulder shall be 250 mm +/- 5%.	Comply	78,80	
29	The CanSat shall perform the function of the nose cone during rocket ascent.	Comply	74,75,76	
30	The CanSat container can be used to restrain any deployable parts of the CanSat payload but shall allow the CanSat to slide out of the payload section freely.	Comply	26,77~87	
31	All electronics and mechanical components shall be hard mounted using proper mounts such as standoffs, screws, or high-performance adhesives.	Comply	30,32,64~71,83, 84,89~102	
32	The CanSat container shall meet all dimensions in section F	Comply	25,37,78,80	

Requirements Compliance (6/15)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
33	The CanSat container materials shall meet all requirements in section F.	Comply	77~80	
34	If the nose cone is to separate from the payload after payload deployment, the nose cone shall descend at no more than 5 meters/sec.	Comply	63,88	Nose cone does not separate.
35	If the nose cone is to separate from the payload after payload deployment, the nose cone shall be secured to the payload until payload deployment with a pull force to survive at least 15 Gs acceleration.	Comply	63,88	Nose cone does not separate.
36	No pyrotechnical or chemical actuators are allowed.	Comply	87,98	
37	Mechanisms that use heat (e.g., nichrome wire) shall not be exposed to the outside environment to reduce potential risk of setting the vegetation on fire.	Comply	86	

Requirements Compliance (7/15)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
38	All mechanisms shall be capable of maintaining their configuration or states under all forces.	Comply	153,158	
39	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Comply	129	
40	Lithium polymer batteries are not allowed.	Comply	129	
41	Battery source may be alkaline, Ni-Cad, Ni-MH or Lithium. Lithium polymer batteries are not allowed. Lithium cells must be manufactured with a metal package similar to 18650 cells. Coin cells are allowed.	Comply	129	
42	Easily accessible power switch is required.	Comply	127,128	
43	Power indicator is required.	Comply	127,128	

Requirements Compliance (8/15)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
45	The audio beacon shall operate on a separate battery.	Comply	166	
46	The audio beacon shall have an easily accessible power switch.	Comply	166	
47	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE radios are also allowed.	Comply	118	
48	XBEE radios shall have their NETID/PANID set to their team number.	Comply	118	
49	XBEE radios shall not use broadcast mode.	Comply	118	
50	The CanSat shall transmit telemetry once per second.	Comply	118	
51	The CanSat telemetry shall include altitude, air pressure, temperature, battery voltage, command echo, and GPS coordinates that include latitude, longitude, altitude and number of satellites tracked.	Comply	119~123	

Requirements Compliance (9/15)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
52	CanSat payload shall measure its altitude using air pressure.	Comply	40	
53	CanSat payload shall measure its internal temperature.	Comply	41	
54	CanSat payload shall measure its battery voltage.	Comply	42	
55	CanSat payload shall track its position using GPS.	Comply	43	
56	CanSat payload shall measure its acceleration and rotation rates.	Comply	45,46	
57	CanSat payload shall measure auto-gyro rotation rate.	Comply	44	
58	CanSat payload shall video record deployment of the auto-gyro at 75% peak altitude	Comply	47,65,69	

Requirements Compliance (10/15)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
59	CanSat payload shall video record the ground at 45 degrees from nadir direction during descent.	Comply	31,48, 99~101,139	
60	The camera video shall be spin stabilized and oriented in the north direction, so the view of the ground is not rotating more than 10 degrees in either direction. .	Comply	31,48, 99~101,139	
61	The video cameras shall record video in color and with a minimum resolution of 640x480.	Comply	48	
62	The CanSat shall measure the magnetic field.	Comply	45, 46	IMU includes magnetometer.
63	The ground station shall command the CanSat to calibrate the altitude to zero when the CanSat is on the launch pad prior to launch.	Comply	125, 135, 136, 150,151	
64	The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section.	Comply	150	

Requirements Compliance (11/15)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
65	Telemetry shall include mission time with 1 second resolution.	Comply	137	
66	Configuration states such as zero altitude calibration software state shall be maintained in the event of a processor reset during launch and mission.	Comply	136~138, 150	
67	Each team shall develop their own ground station.	Comply	145~151	
68	All telemetry shall be displayed in real time during ascent and descent on the ground station.	Comply	149~151	
69	All telemetry shall be displayed in the International System of Units (SI) and the units shall be indicated on the displays.	Comply	149~151	
70	Teams shall plot each telemetry data field in real time during flight.	Comply	149~151	

Requirements Compliance (12/15)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
71	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and an antenna.	Comply	146, 147	
72	The ground station must be portable so the team can be positioned at the ground station operation site along the flight line. AC power will not be available at the ground station operation site	Comply	146, 147	
73	The ground station software shall be able to command the payload to operate in simulation mode by sending two commands, SIMULATION ENABLE and SIMULATION ACTIVATE.	Comply	140, 141	
74	When in simulation mode, the ground station shall transmit pressure data from a csv file provided by the competition at a 1 Hz interval to the CanSat.	Comply	140, 141, 150	

Requirements Compliance (13/15)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
75	The ground station shall use a tabletop or handheld antenna.	Comply	148	
76	Because the ground station must be viewed in bright sunlight, the displays shall be designed with that in mind, including using larger fonts (14 point minimum), bold plot traces and axes, and a dark text on light background theme.	Comply	151	
77	The ground system shall count the number of received packets. Note that this number is not equivalent to the transmitted packet counter, but it is the count of packets successfully received at the ground station for the duration of the flight.	Comply	119, 120, 151	
78	The ground station shall be able to activate all mechanisms on command.	Comply	125, 151	

Requirements Compliance (14/15)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
79	The flight software shall maintain a count of packets transmitted which shall increment with each packet transmission throughout the mission. The value shall be maintained through processor resets.	Comply	135~138	
80	The CanSat shall maintain mission time throughout the entire mission even in the event of a processor resets or momentary power loss.	Comply	135~138	
81	The CanSat shall have its time set by ground command to within one second UTC time prior to launch.	Comply	124, 136, 150	
82	The flight software shall support simulated flight mode where the ground station sends air pressure values at a one second interval using a provided flight profile file.	Comply	140, 141, 150	

Requirements Compliance (15/15)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
83	In simulation mode, the flight software shall use the radio uplink pressure values in place of the pressure sensor for determining the payload altitude	Comply	140,141, 150,151	
84	The flight software shall only enter simulation mode after it receives the SIMULATION ENABLE and SIMULATION ACTIVATE commands.	Comply	140,141	
85	The flight shall include commands to activate all mechanisms. These commands shall be documented in the mission manual.	Comply	124,125	

Management

Kuan-Yu Lai

CanSat Budget – Electronics (1/3)

Component	Model	Quantity (pic)	Unit Price (USD/pic)	Total (USD)	Reusing	Actual/Estimated /Budgeted
MCU	Teensy 4.1	2	29.6	59.2	NO	Actual
Air pressure and temperature	BMP581	1	19.95	19.95	NO	Actual
IMU	ICM20948	2	15.6	31.2	NO	Actual
GNSS	LS2003E-G	1	53	53	NO	Actual
SD card	SanDisk Ultra Micro SDHC UHS-I C10 32GB	1	7	7	NO	Actual
SD card writer	Teensy 4.1	1	0	0	NO	Actual
Camera	SQ11	2	12	24	NO	Actual
Audio Beacon	CMI-1210-5-95T	2	0.15	0.3	NO	Actual

CanSat Budget – Electronics (2/3)

Component	Model	Quantity (pic)	Unit Price (USD/pic)	Total (USD)	Reusing	Actual/Estimated /Budgeted
Step motor	ES08MAII	3	6	18	NO	Actual
Servo motor	SER0053	1	10	10	NO	Actual
Voltmeter	Teensy 4.1 on board ADC	1	0	0	NO	Actual
Battery	Vapcell L10 ICR14500	2	3.59	7.18	NO	Actual
Battery basket	14500 battery box	2	0.3	0.6	NO	Actual
CanSat antenna	ANT-916-CW-RCS	1	8.81	8.81	NO	Actual
Xbee	XBEE Pro S3B	1	61.11	61.11	YES	Actual
Coin cell battery	CR2032	1	1.5	1.5	NO	Actual

CanSat Budget – Electronics (3/3)

Component	Model	Quantity (pic)	Unit Price (USD/pic)	Total (USD)	Reusing	Actual/Estimated /Budgeted
Auto-Gyro rotation rate	FC-33	1	1.4	1.4	NO	Actual
External power switch	KCD11-101	2	0.14	0.28	NO	Actual
PCB	Custom	2	20	40	NO	Actual
Tracker	AirTag	1	30.27	30.27	YES	Actual
Electronics Total : $373.8						

CanSat Budget – Hardware (1/7)

Component	Model	Quantity	Unit Price	Total (USD)	Reusing	Actual/Estimated /Budgeted
Nose cone	Nose cone	140.3 g	0.02 USD/g	2.81	NO	Estimated
	Carbon fiber bar	4 pic	2.5 USD	10	NO	Actual
Container	Container main part	237.3 g	0.02 USD/g	5.05	NO	Actual
	Container shoulder	174.4 g	0.02 USD/g	3.49	NO	Actual
	Plywood disk	1 pic	1 USD/pic	1	NO	Actual
	Eyebolt	1 pic	6.25 USD/pic	6.25	NO	Actual
Electronics Structural	PCB holder	8.4 g	0.02 USD/g	0.17	NO	Actual
GPOC	Main Gear	4.7 g	0.02 USD/g	0.1	NO	Actual
	Second Camera box	7.1 g	0.02 USD/g	0.15	NO	Actual

CanSat Budget – Hardware (2/7)

Component	Model	Quantity	Unit Price	Total (USD)	Reusing	Actual/Estimated /Budgeted
GPOC	Second Camera cover	2 g	0.02 USD/g	0.04	NO	Actual
	Second plate of vibration-absorbing platform	3.2 g	0.02 USD/g	0.07	NO	Actual
	First plate of vibration-absorbing platform	7.8 g	0.02 USD/g	0.16	NO	Actual
	Bearing Fix unit	0.4 g	0.02 USD/g	0.01	NO	Actual
	Stabilizer base	29.47 g	0.02 USD/g	0.63	NO	Actual
	Transmission Gear	3 g	0.02 USD/g	0.06	NO	Actual
	rubber dampers	3 pics	0.31 USD/pic	0.93	NO	Budgeted

CanSat Budget – Hardware (3/7)

Component	Model	Quantity	Unit Price	Total (USD)	Reusing	Actual/Estimated /Budgeted
Release mechanic	First Camera cover	4.1 g	0.02 USD/g	0.09	NO	Actual
	Base plate	28 g	0.02 USD/g	0.56	NO	Estimated
	Lock block	5.2 g	0.02 USD/g	0.11	NO	Estimated
	Link rod	2.4 g	0.02 USD/g	0.05	NO	Estimated
	Spin disc	2.8 g	0.02 USD/g	0.06	NO	Estimated
	Gripper_link1	2.4 g	0.02 USD/g	0.05	NO	Estimated
	Gripper_link2	1.6 g	0.02 USD/g	0.04	NO	Estimated
	Gripper_link3	2.4 g	0.02 USD/g	0.05	NO	Estimated
	Gripper_link4	2.4 g	0.02 USD/g	0.05	NO	Estimated
	Gripper_slide	2.4 g	0.02 USD/g	0.05	NO	Estimated

CanSat Budget – Hardware (4/7)

Component	Model	Quantity	Unit Price	Total (USD)	Reusing	Actual/Estimated /Budgeted
Auto-gyro	Base hub	24.9 g	0.02 USD/g	0.50	NO	Estimated
	Blade shaft	3 g	0.02 USD/g	0.24	NO	Estimated
	Hub4	25.5 g	0.02 USD/g	0.51	NO	Estimated
	Speed disk	3.6 g	0.02 USD/g	0.08	NO	Estimated
	Top hub	12.6 g	0.02 USD/g	0.26	NO	Estimated
	fixmainshaft	2 pic	2.99 USD/pic	5.98	NO	Budgeted
	mainshaft	1 pic	6.21 USD/pic	6.21	NO	Budgeted
	Ball bearing	1 pic	4.18 USD/pic	4.18	NO	Budgeted
	blade	4 pic	13.76 USD/pic	55.04	NO	Budgeted
	Hinge pin	4 pic	0.82 USD/pic	3.28	NO	Budgeted
	Torsion spring	4 pic	9.11 USD/pic	36.44	NO	Budgeted

CanSat Budget – Hardware (5/7)

Component	Model	Quantity (pic)	Unit Price (USD/pic)	Total (USD)	Reusing	Actual/Estimated /Budgeted
Screw	M1.6 × 8mm	4	0.051	0.2	NO	Actual
Screw	M2 × 4mm	12	0.051	0.61	NO	Actual
Screw	M2 × 5mm	8	0.051	0.41	NO	Actual
Screw	M2 × 10mm	8	0.051	0.41	NO	Actual
Screw	M2 × 12mm	23	0.051	1.17	NO	Actual
Screw	M2 × 20mm	3	0.051	0.15	NO	Actual
Screw	M3 × 6mm	8	0.020	0.16	NO	Actual
Screw	M3 × 8mm	1	0.020	0.02	NO	Actual

CanSat Budget – Hardware (6/7)

Component	Model	Quantity (pic)	Unit Price (USD/pic)	Total (USD)	Reusing	Actual/Estimated /Budgeted
Screw	M3 × 12mm	8	0.020	0.16	NO	Actual
Screw	M3 × 16mm	50	0.020	1	NO	Actual
Screw	M3 × 25mm	3	0.019	0.06	NO	Actual
Screw	M2.5 × 5mm	4	0.019	0.08	NO	Actual
Screw	M4 × 6mm	2	0.42	0.84	NO	Actual
Screw	M4 × 12mm	2	0.017	0.04	NO	Actual
Nylon nut	¼-inch	2	0.15	0.3	NO	Actual
Fender Washer	¼-inch	2	0.16	0.32	NO	Actual
Lock Nut	M2	44	0.45	19.8	NO	Actual
Lock Nut	M3	30	0.08	2.4	NO	Actual
Hinge Pin	4mm × 30mm	4	2.39	9.56	NO	Actual

CanSat Budget – Hardware (7/7)

Component	Model	Quantity	Unit Price (USD)	Total (USD)	Reusing	Actual/Estimated /Budgeted
Washer	M3	4	0.5	2	NO	Actual
Hardware Total : $220.67						

Electronics Total (USD)	Hardware Total (USD)	CanSat Overall Total (USD)
373.8	184.44	558.24

Ground Control System

Component	Model	Quantity	Unit Price (USD)	Total (USD)	Reusing	Actual/Estimated /Budgeted
XBee	XBEE Pro S3B	1	61.11	61.11	Yes	Actual
XBee adapter with USB cable	adapter	1	6.99	6.99	Yes	Actual
GCS antenna	OA-8996M08-NF	1	96	96	Yes	Actual
GCS laptop	ASUS Zenbook	1	400	400	Yes	Actual
Total : $565						

CanSat Budget – Other Costs

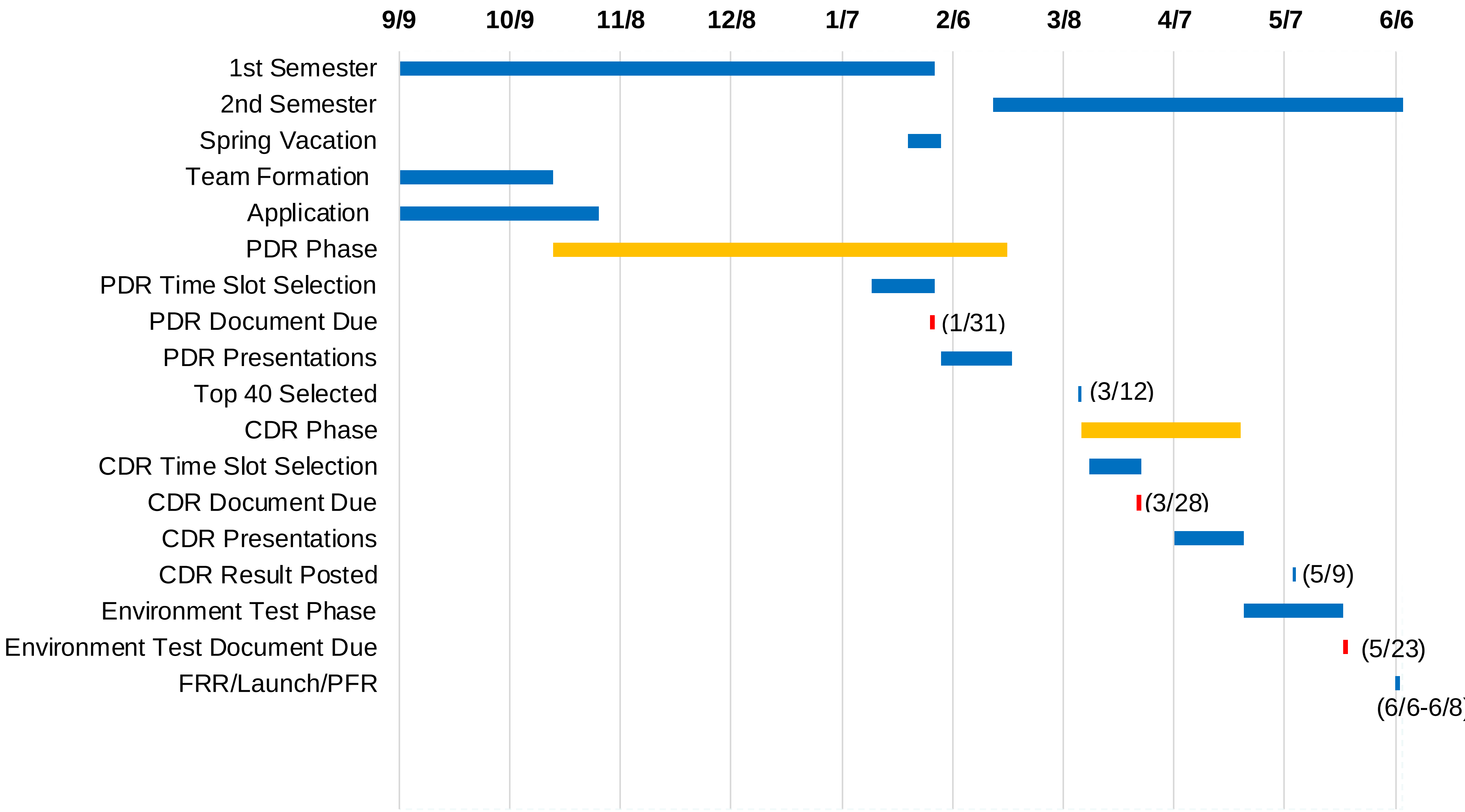
Travel

Component	Quantity	Unit Price	Total	Reusing	Actual/Estimated/Budgeted
Round Trip (TPE-IAD)	7	2,000	14,000	NO	Estimated
Car Rental + Fuel	2	600	1,200	NO	Estimated
Accommodation	7	300	2,100	NO	Estimated
Meals	7	250	1750	NO	Estimated
Domestic Transportation	7	100	700	NO	Estimated
Total : $29,750					

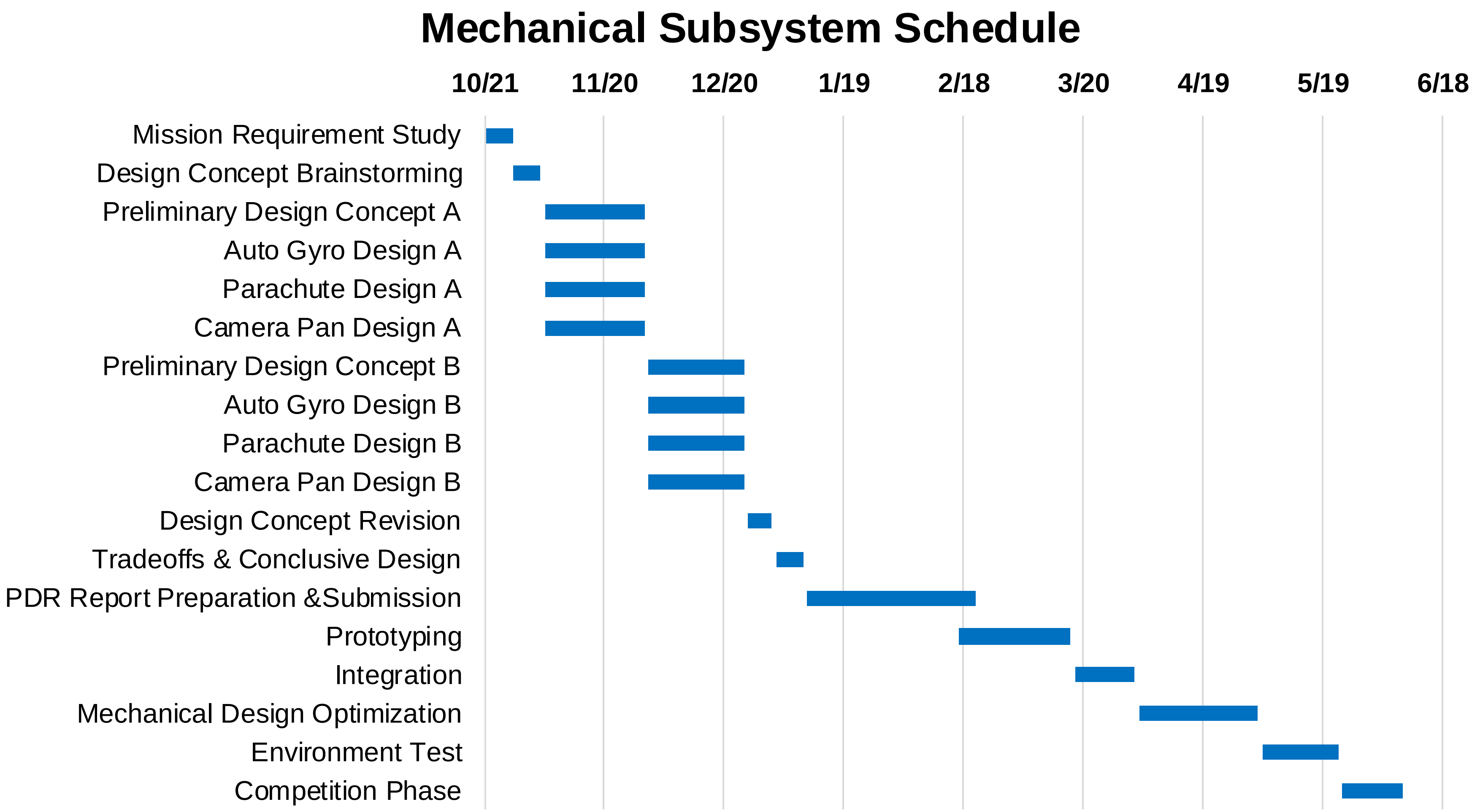
GCS & prototyping funding is sponsored by NCKU HMH Space Science & Technology Center.

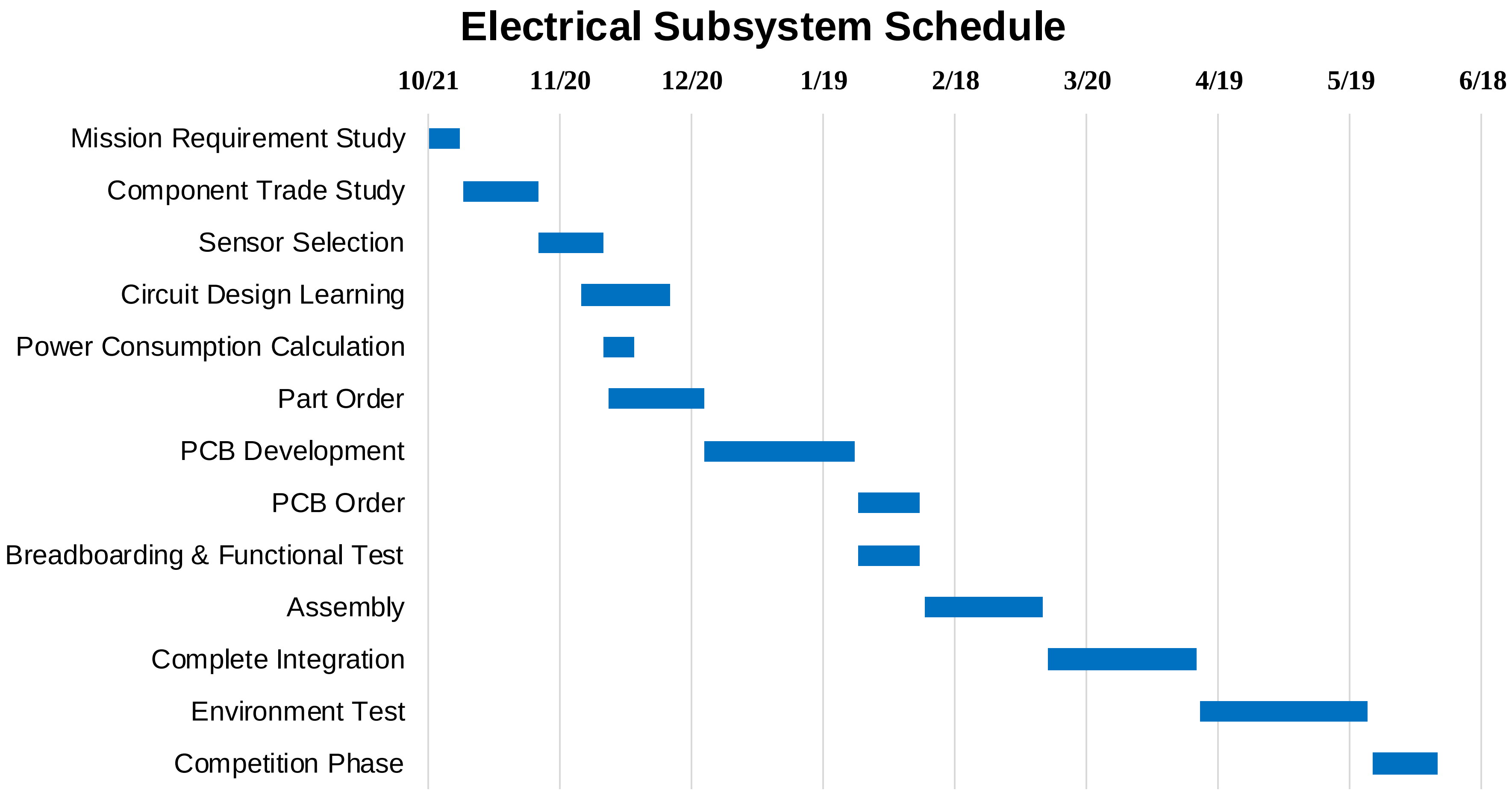
Travel funding is partially sponsored by the National Cheng Kung University, and the remaining funding is raised from external sponsorship including alumni, domestic industries, etc.

Program Schedule Overview



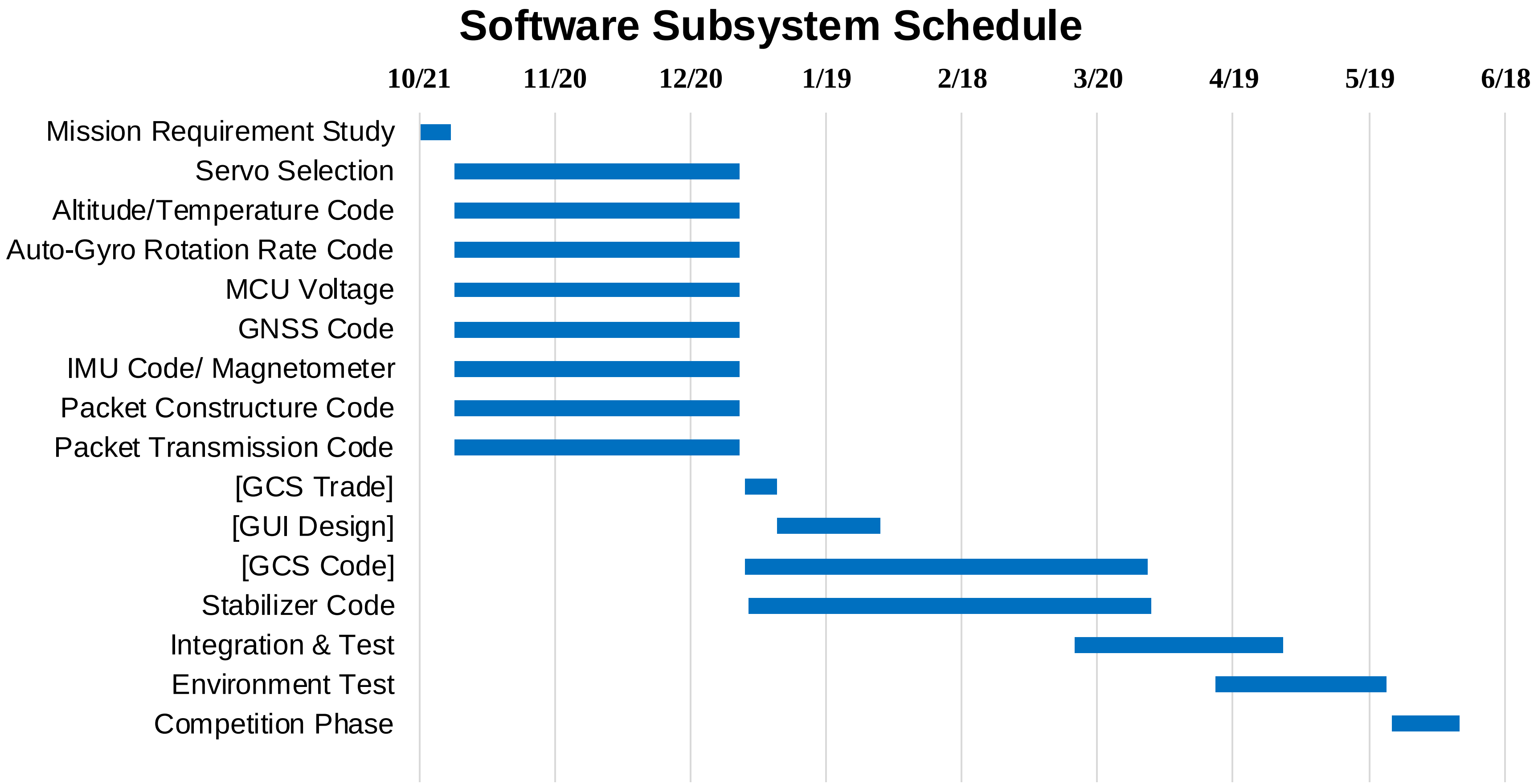
Detailed Program Schedule (1/3)





Electrical Subsystem Schedule
10/21
11/20
12/20
1/19
2/18
3/20
4/19
5/19
6/18
Mission Requirement Study
Component Trade Study
Sensor Selection
Circuit Design Learning
Power Consumption Calculation
Part Order
PCB Development
PCB Order
Breadboarding & Functional Test
Assembly
Complete Integration
Environment Test
Competition Phase

Detailed Program Schedule (3/3)



Conclusions (1/3)

Major accomplishment

- **Gemini Supernova Team**
  - Tasks have been assigned to each member based on the competition schedule.
  - The Preliminary Design Review (PDR) has been completed.
- **Mechanical**
  - Two different design concepts have been developed and selected.
  - Descent rate calculations have been completed.
  - Testing and prototype production are in progress.
- **Electronical**
  - The trade study and component selection have been completed.
  - The preliminary PCB design has been finalized.
- **Software**
  - GUI design has been completed.
  - Code libraries have been created, and some sensors have been tested.
  - Short-distance radio communication has been successfully tested.
- **Financial**
  - Hardware, ground control station, and prototyping funds are sponsored by the NCKU HMH Space Science & Technology Center.

Conclusions (2/3)

Major on-going work

- **Gemini Supernova Team**
  - Next milestone: CDR
  - Functional tests for all components
- **Mechanics**
  - Manufacture and prototype using 3D printing
  - Test all hardware and mechanism
  - Test parachute and auto-gyro
- **Electronics**
  - Final check and improvement of aviation electronics
  - Actuator testing
  - CDH testing
  - Integration with software
- **Software**
  - Complete the code
  - Finish testing all sensors
  - Conduct a long-distance communication test
  - Improve the ground station GUI
- **Finance**
  - The team is still soliciting more sponsorships

Why is Gemini Supernova ready to proceed to the next stage of development?

Gemini Supernova is poised to advance to the next stage of development, having successfully completed all essential preliminary designs. This encompasses the mechanics, software, and electronics systems for two CanSats. Our immediate goal is to commence the manufacturing of the EQM in the future. Furthermore, we intend to pursue potential financial support from the university and external sponsorship after passing the PDR.