CanSat 2025
Critical Design Review (CDR)

3168
Gemini Supernova

Presentation Outline

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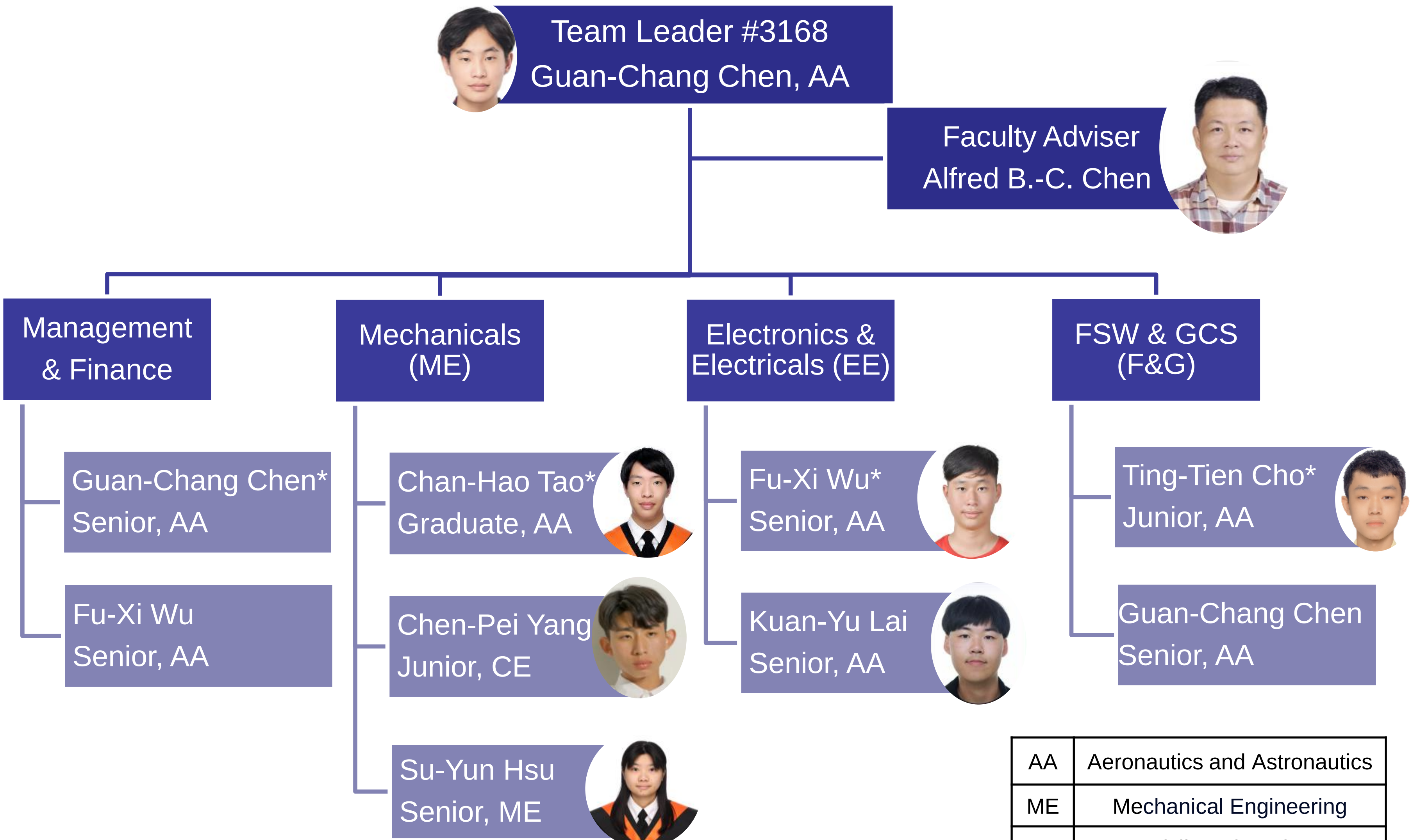
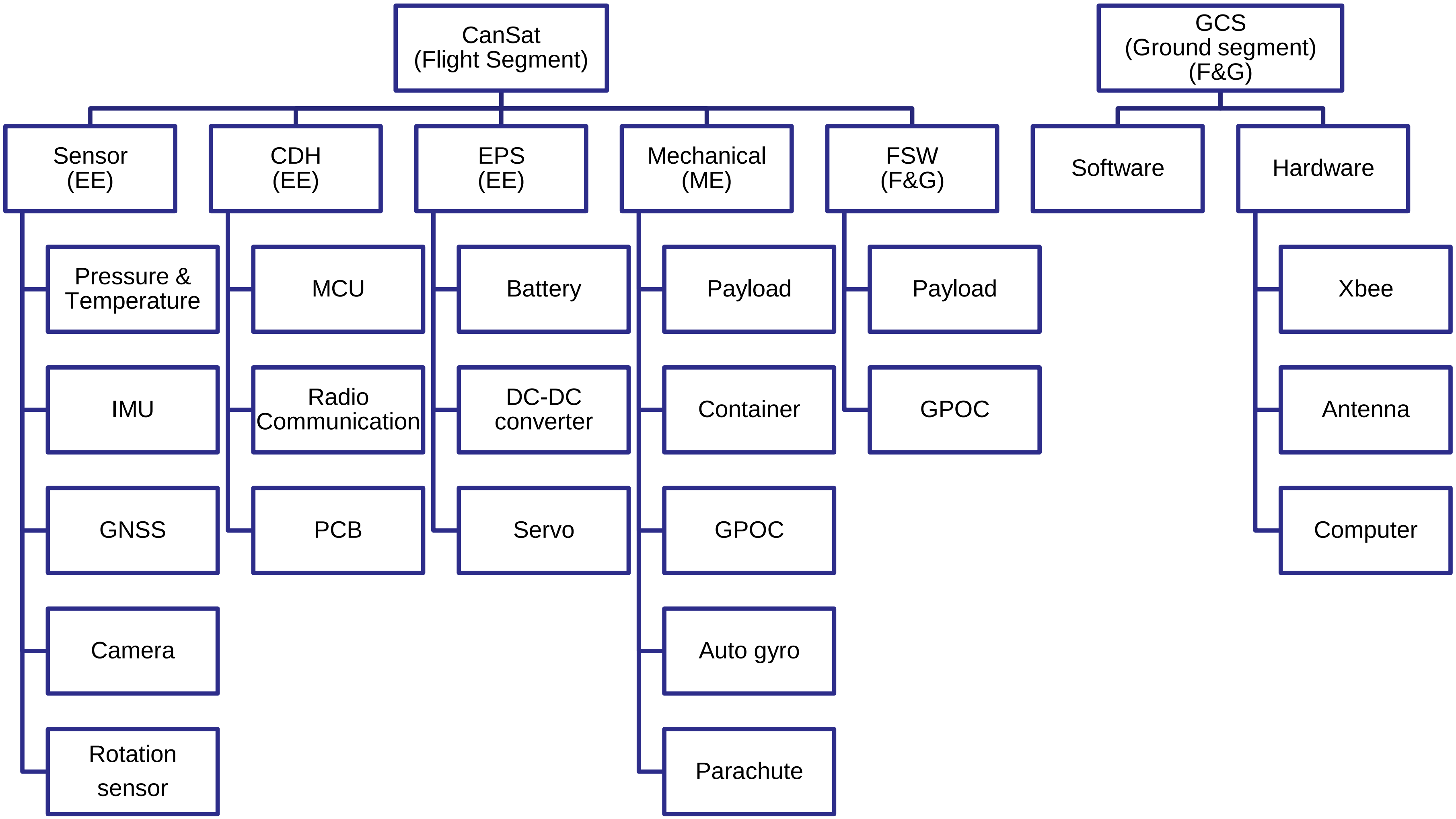
Team Organization



AA	Aeronautics and Astronautics
ME	Mechanical Engineering
CE	Civil Engineering

*note: the leader of the subgroup

System Diagram



Acronyms (1/2)

Acronym	Definition
ADC	Analog to Digital Converter
CONOP	Concept of Operations
CCW	CounterClockWise
CW	ClockWise
CDR	Critical Design Review
EE	(Group of) Electronics and Electricals
EEPROM	Electrically-Erasable Programmable Read-Only Memory
EQM	Engineering Qualification Model
FSW	Flight Software
F&G	(Group of) FSW and GCS

Acronym	Definition
FRR	Flight Readiness Review
GCS	Ground Control Station
GNSS	Global Navigation Satellite System
GPOC	Ground Pointing and Orientation Camera
GUI	Graphic User Interface
hh	Hours
HW	Hardware
H/L	High or Low
I^2C	Inter-Integrated Circuit
IMU	Inertial measurement unit
LCO	Launch Control Officer
MCU	Microcontroller Unit
ME	(Group of) Mechanicals

Acronyms (2/2)

Acronym	Definition
MET	Mission Elapse Time
MOM	Mission Operations Manual
mn	Minutes
P&T	Pressure and Temperature
PCB	Printed circuit board
PFB	Pre Flight Briefing
PFR	Post Flight Review
PL	Payload
PLA	Polylactic Acid
PETG	Polyethylene Terephthalate Glycol
PWM	Pulse Width Modulation

Acronym	Definition
RAM	Random-access memory
RPM	Revolutions Per Minute
RSO	Range Safety Officer
RTC	Real-Time Clock
RF	Radio Frequency
RQMT	Requirement
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.

Summary of Changes Since PDR (1/3)

Subsystem	Component	PDR	CDR	Rationale
ME	Nose Cone	Length is 168.4mm (L/D = 1.2)	Length is 115.5mm (L/D = 0.8)	• To reduce mass
	GPOC	3-axis GPOC 1 SER0053 & 2 MS08MAII	2-axis GPOC 1 SER0053 & 1 MS08MAII	• Reduce mass • Simplify the control system
	Parachute	Dome-shape Parachute	Hexagonal-shape Parachute	• To distribute stress more evenly • Easy to process
	Auto-gyro	ABS blades 8mm main shaft NSK 608ZZ CCW hub	Carbon fiber blades 6mm main shaft NSK 696ZZ CW hub	• Lighter weight • In accordance with the aerodynamics of the blade.

Summary of Changes Since PDR (2/3)

Subsystem	Component	PDR	CDR	Rationale
GCS	Ground Station Antenna	OA-8996M08-NF	OLT-G1-915-05	To fit luggage size for transportation
Sensor	Payload Tilt Sensor	ICM-20948	MPU9250	• Heritage • Better stability • ICM failed frequently during test
Sensor	GPOC Orientation Sensor	ICM-20948	MPU9250	• Heritage • Better stability • ICM failed frequently during test
Sensor	Payload GNSS Sensor	LS2003E-G	LS20031	• Heritage • 0.1” pitch, easier for soldering

Summary of Changes Since PDR (3/3)

Subsystem	Component	PDR	CDR	Rationale
FSW	Software State diagram	Frist **setup** system state and then read the **recover** data file.	Frist read the **recover** data file and then **setup** system state.	To correct a flow logic.
	GPOC State Diagram	Without **PID** control	Include **PID** control	Using PID control improves the operation and adjustment.
	Pressure sampling frequency	100 Hz	20 Hz	To reduce MCU load.
	Save data frequency	4 Hz	5 Hz	To synchronize data rate with all sensors' sampling frequencies.

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	ME		V		
2.	The CanSat container shall be mounted on top of the rocket with the shoulder section inserted into the airframe.	High	ME				V
3.	The CanSat payload and container shall be deployed from the rocket when the rocket motor ejection charge fires.	High	ME				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	ME			V	
5.	At 75% flight peak altitude, the payload shall be released from the container and deploy an auto-gyro descent control system.	High	ME, FSW, GCS				V
6.	The payload shall descend at 5 meters/second with the auto-gyro descent control system.	High	ME			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	ME, 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	ME, 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	ME, FSW, GCS, EE	V			
11.	The CanSat and container mass shall be 1400 grams +/- 10 grams.	High	ME		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	ME		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	ME		V		
14.	CanSat structure must survive 15 Gs vibration and 30 G shock	High	ME			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	ME		V		
16.	Above the shoulder, the container diameter shall be 144.4 mm ,the length above the shoulder shall be 250 mm +/- 5%	High	ME		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	ME, 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	ME, EE			V	
19.	The CanSat container shall meet all dimensions and container materials in section F.	High	ME		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	ME, 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	ME			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	ME		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). The units shall be indicated on the displays. In addition, Plot each telemetry data field in real-time during the 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	

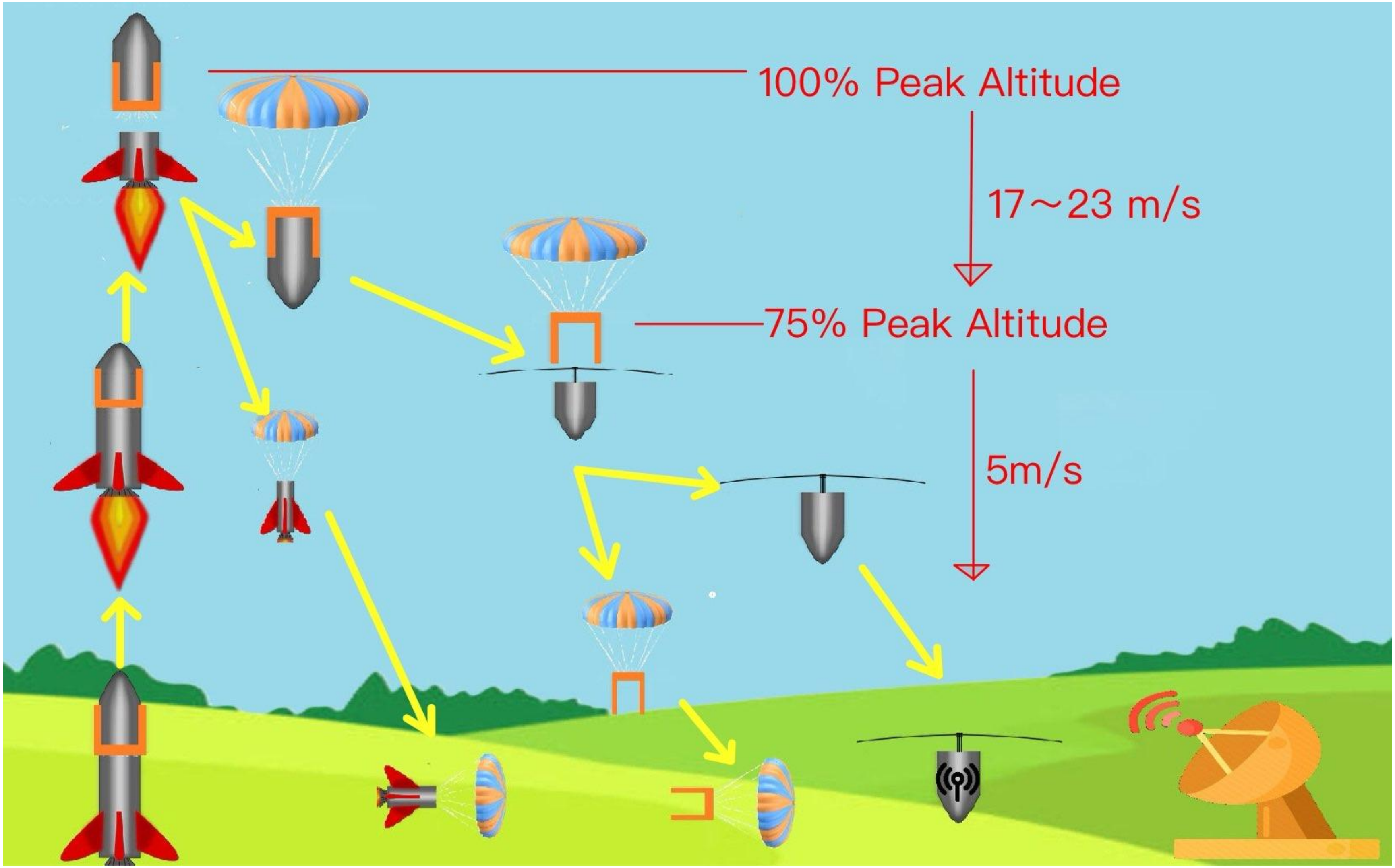
System Requirement Summary (8/9)

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 displays shall be designed using larger fonts (14 point minimum), bold plot traces and axes, and dark text on a 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

System Concept of Operations (CONOPS) (1/3)



System Concept of Operations (CONOPS) (2/3)

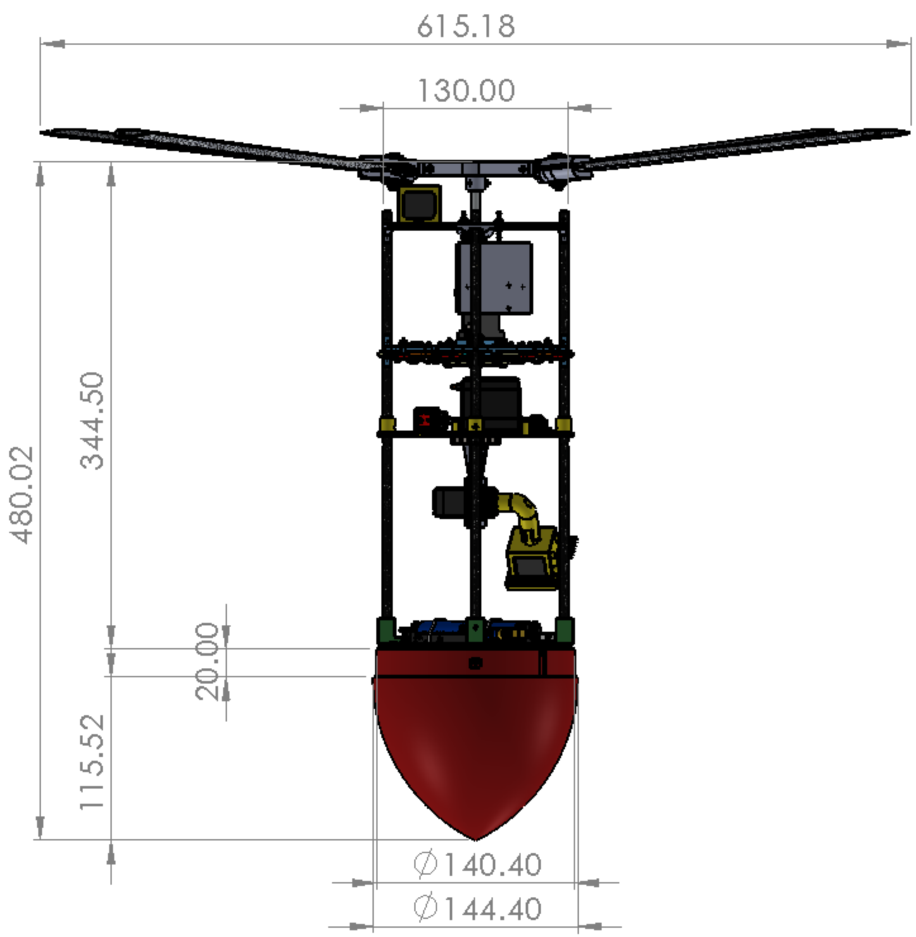
- **Phase 1 Initial:**
  - The CanSat is powered on and loaded to the launch vehicle.
  - The CanSat starts sensor calibration and data transmission.
  - The CanSat starts two cameras recording.
- **Phase 2 Ascent:**
  - The CanSat is launched and ascends to apogee.
- **Phase 3 Separation and release 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 (CONOPS) (3/3)

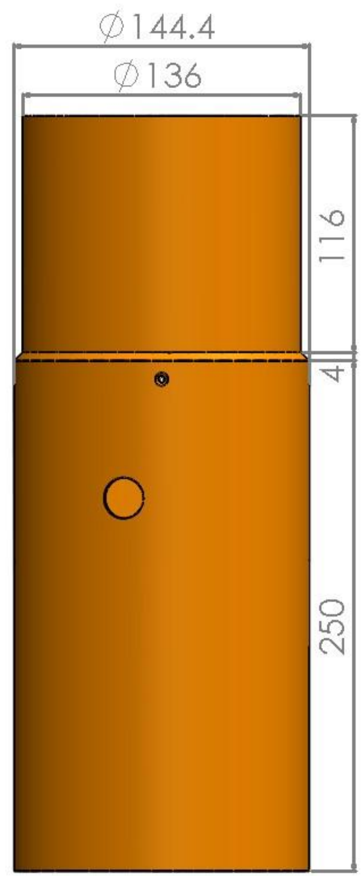
- **Phase 4 Payload Release:**
  - The Payload is released from the container at 75% of apogee height.
  - The Payload deploys the auto-gyro system and descends at a rate of 2~8 m/s.
  - The first camera records the deployment of the auto-gyro.
  - The second camera records the ground at 45 degrees from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

Physical Layout (1/9)

PL dimensions



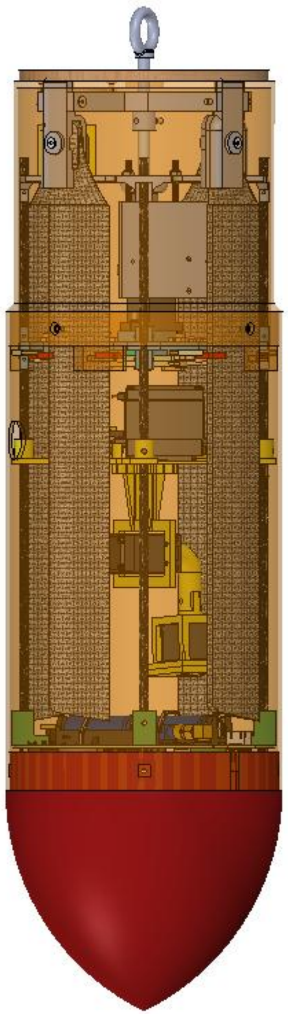
Container dimensions



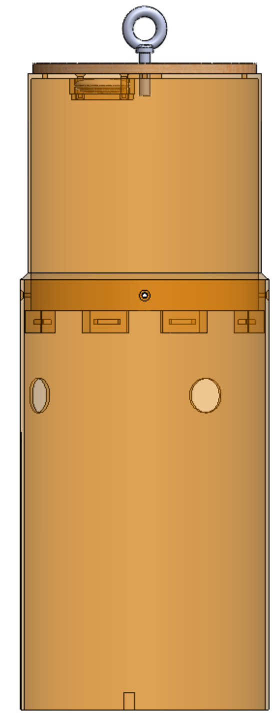
unit : mm

Physical Layout (2/9)

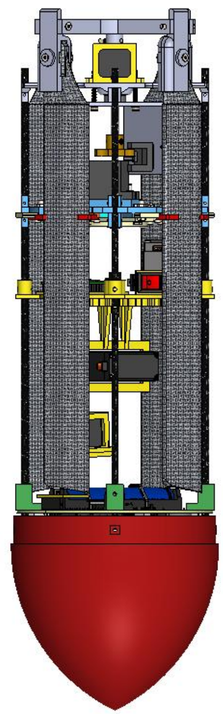
Launch Configuration



Container

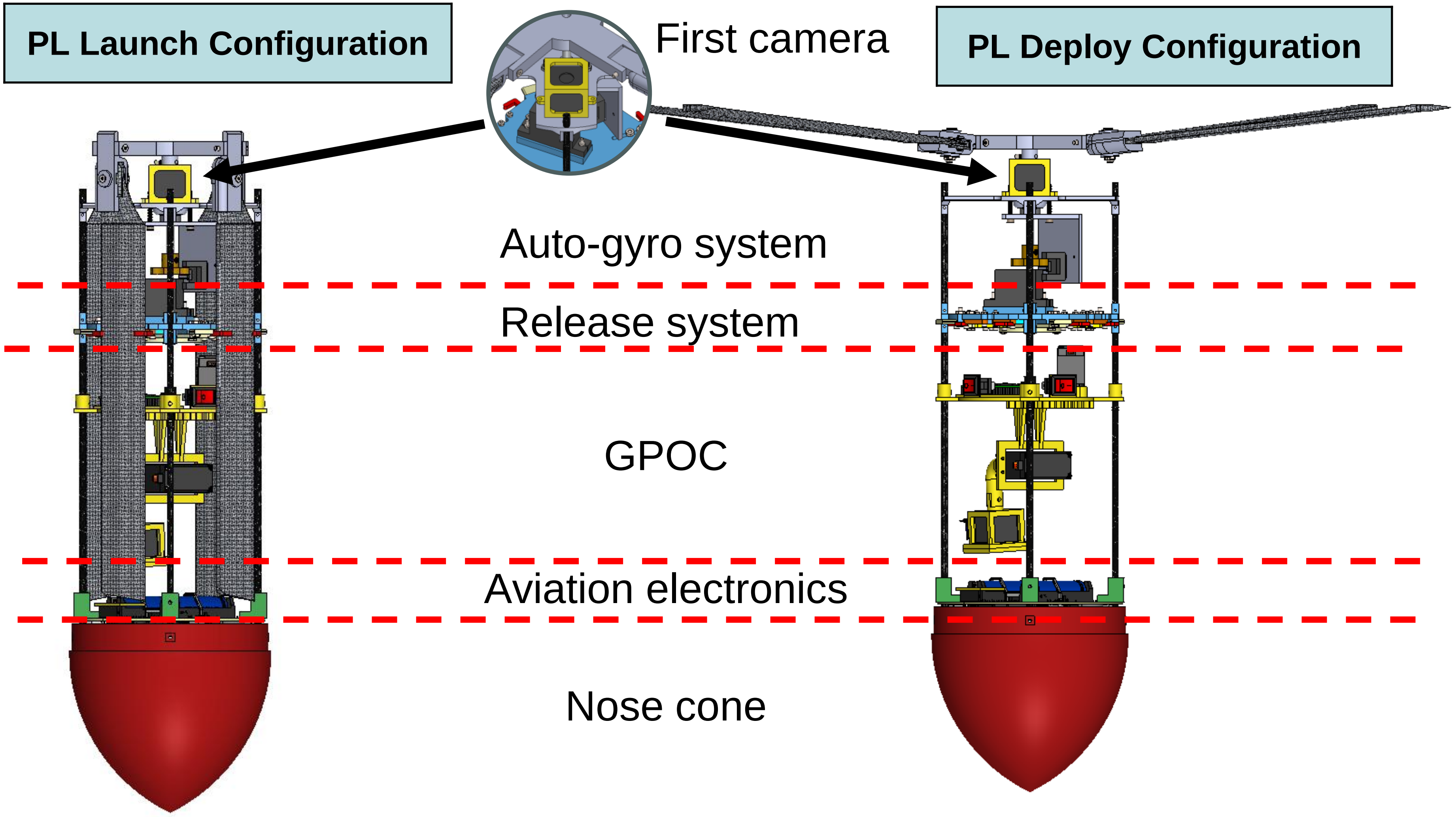


Payload

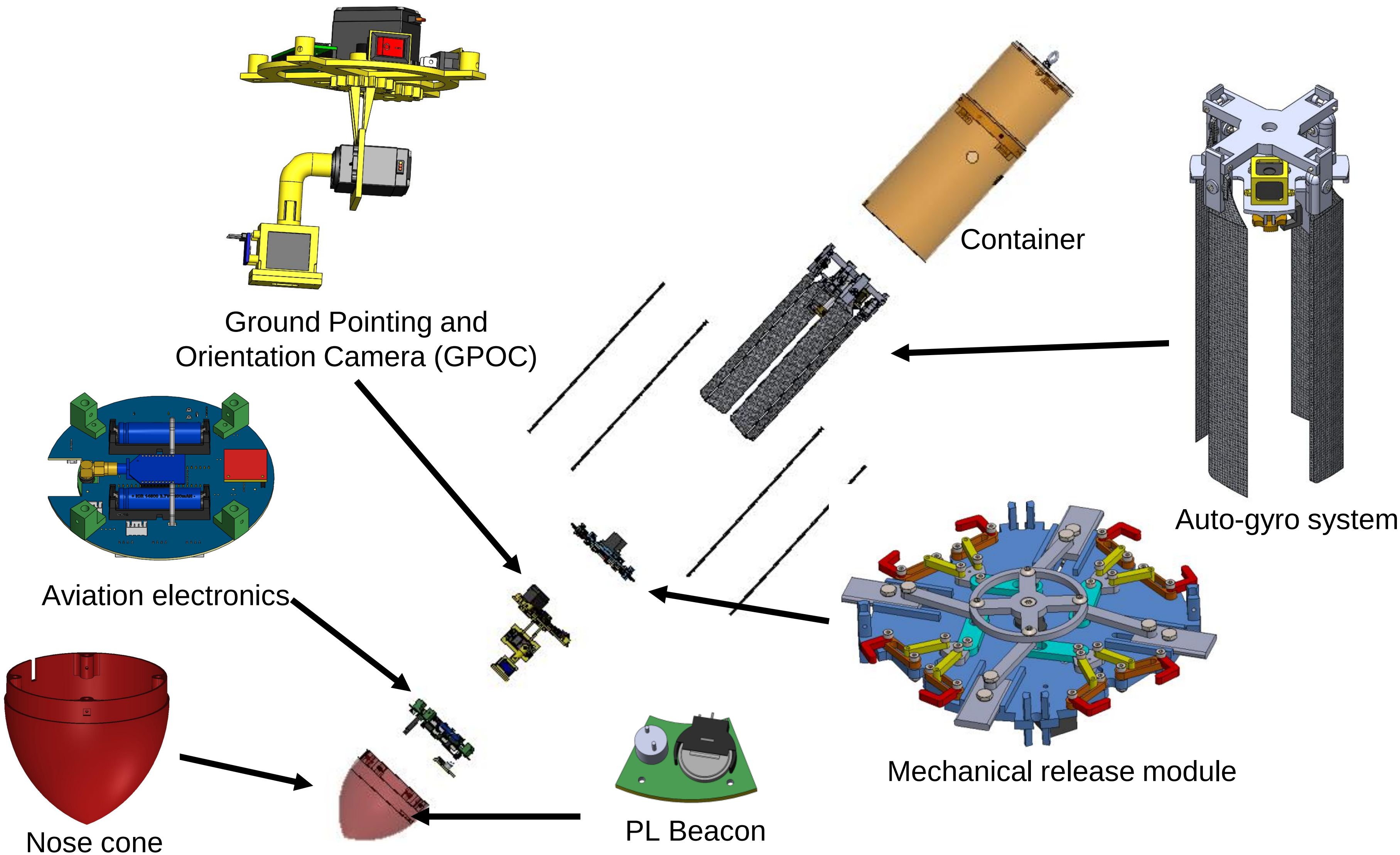


unit : mm

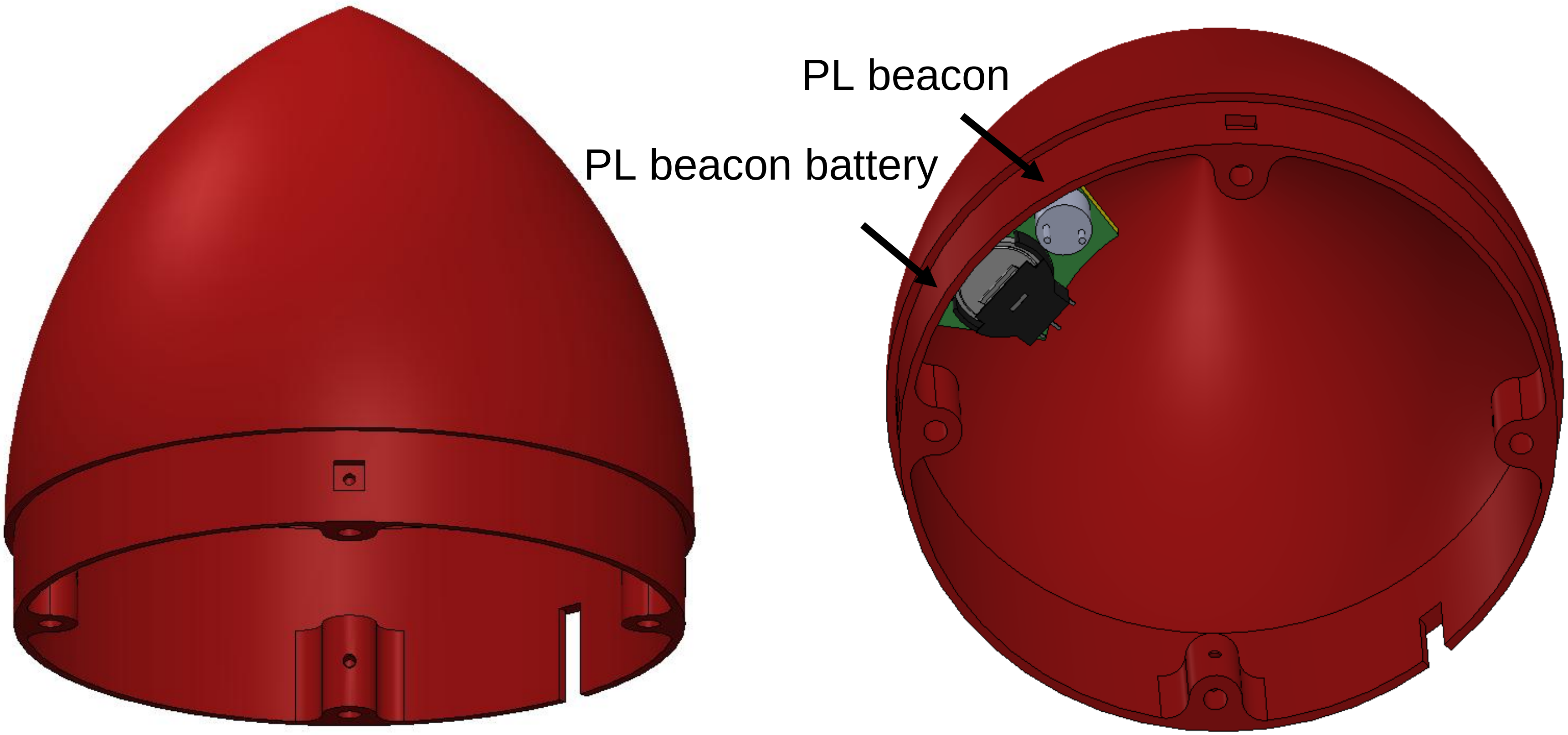
Physical Layout (3/9)



Physical Layout (4/9)

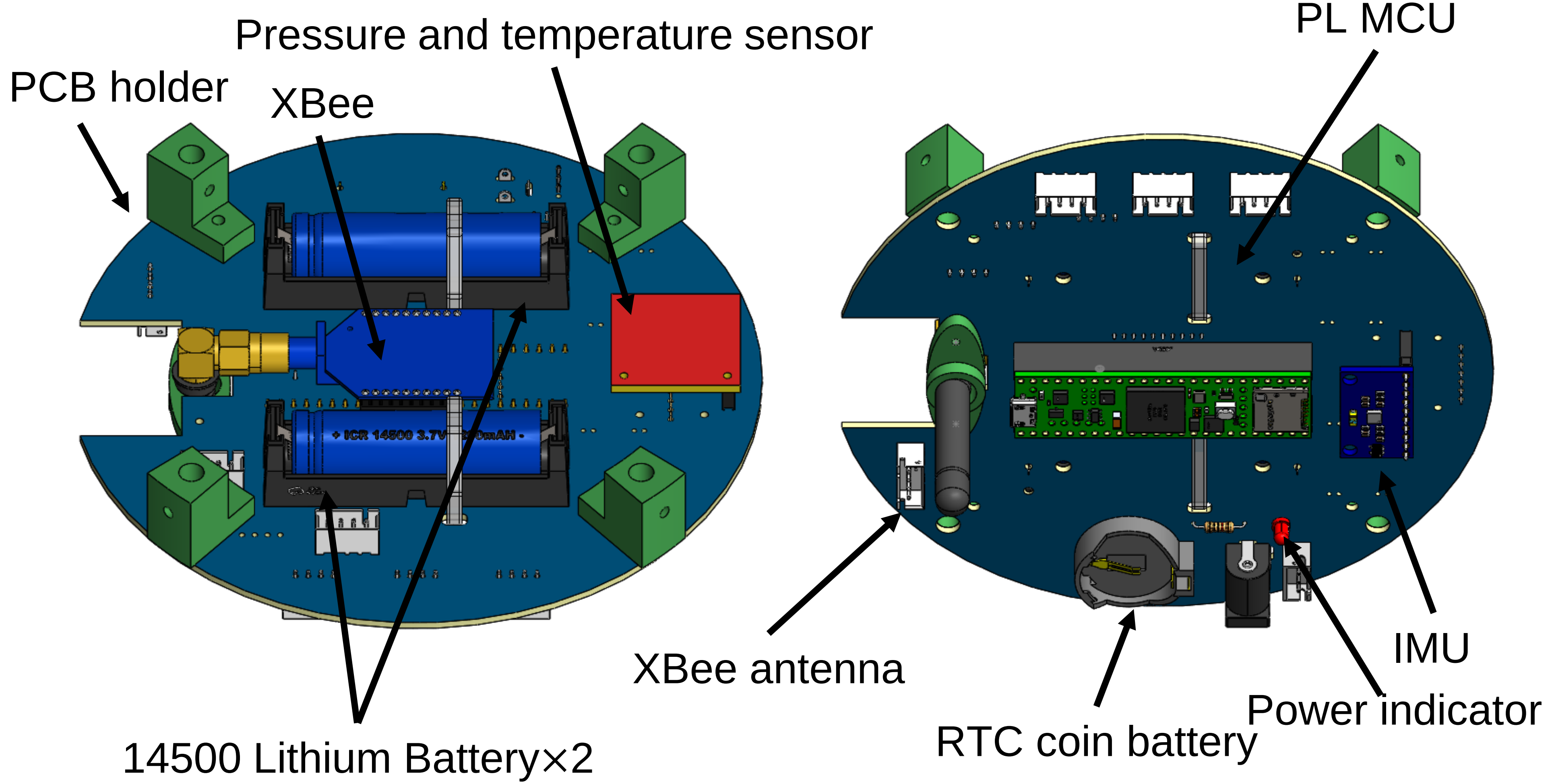


Nose Cone



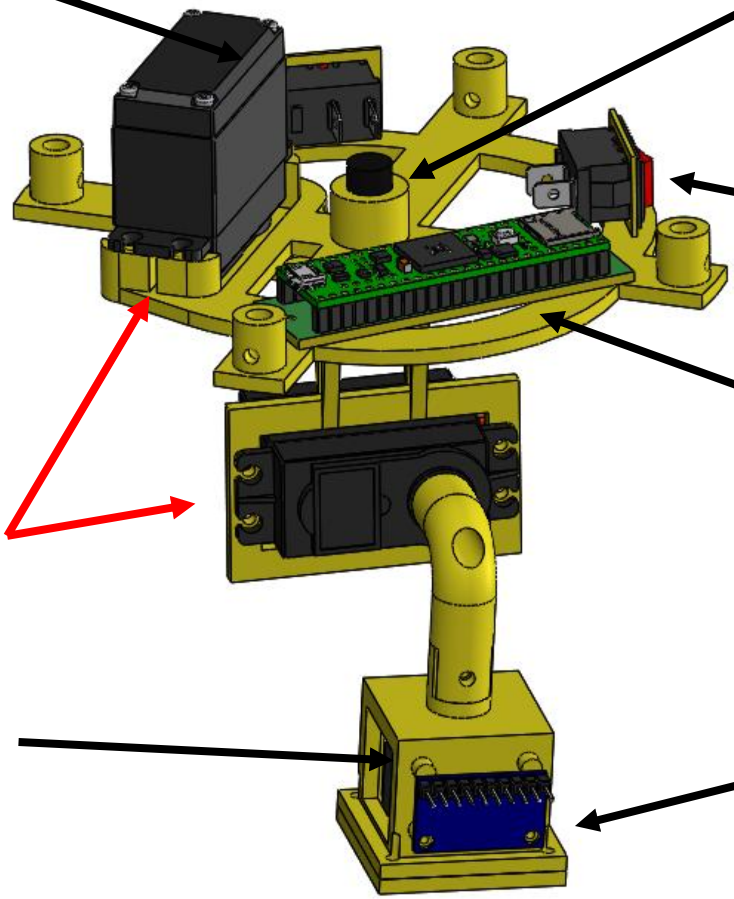
Physical Layout (6/9)

Aviation Electronics



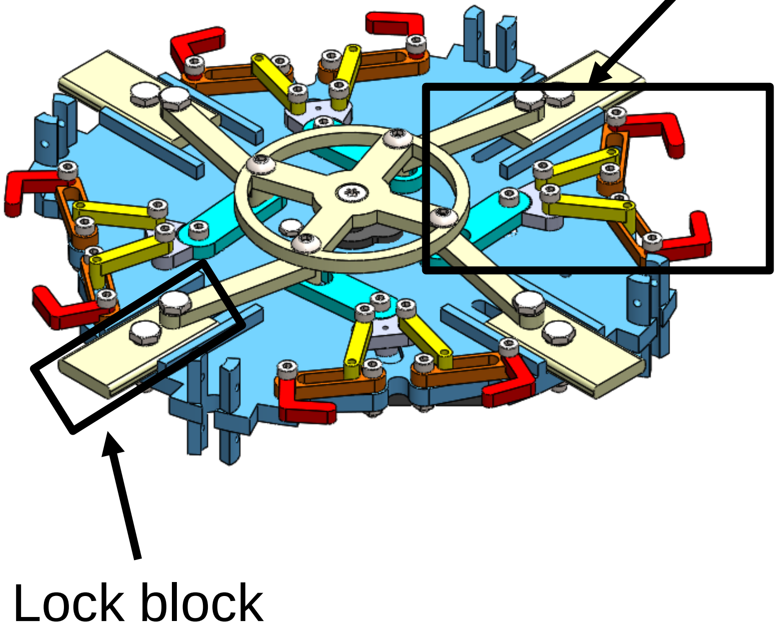
Physical Layout (7/9)

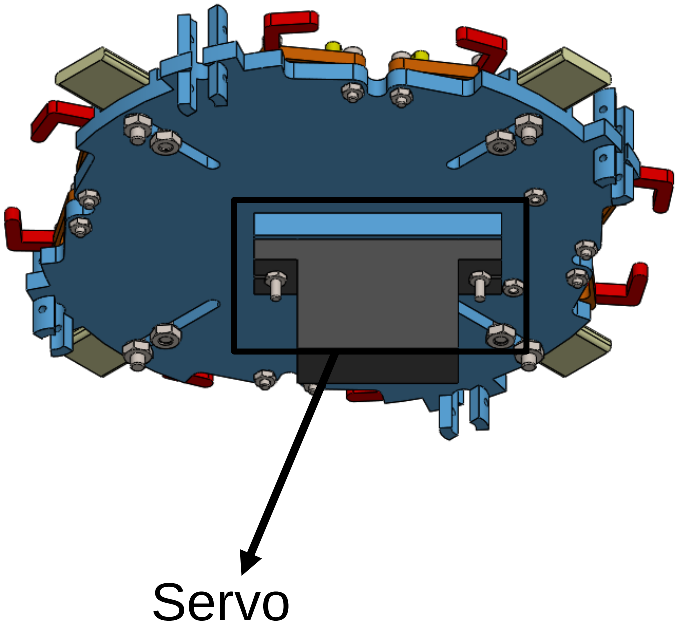
GPOC (Second camera)



* The red arrows indicate the changes since PDR.

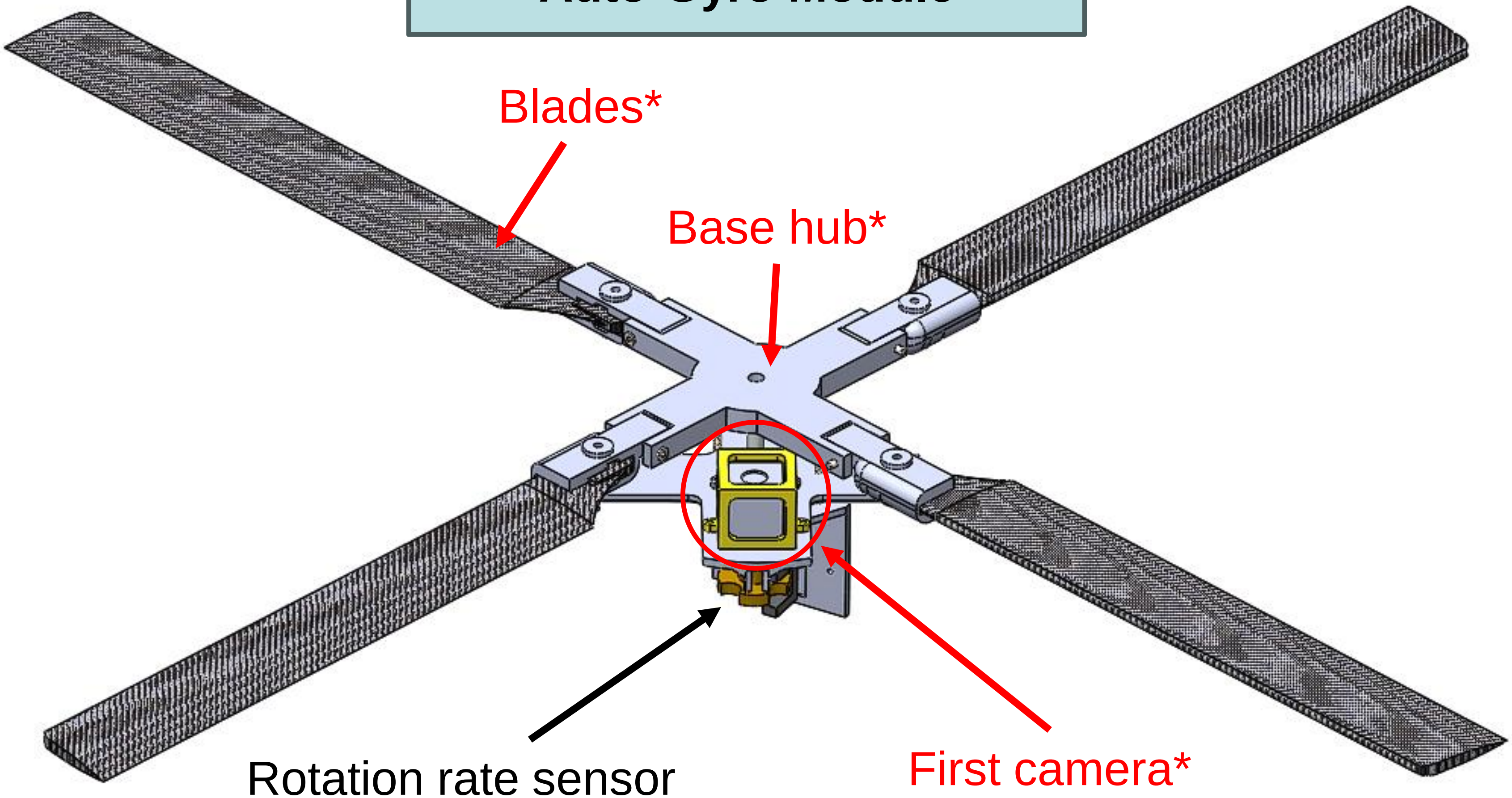
Mechanical Release Module





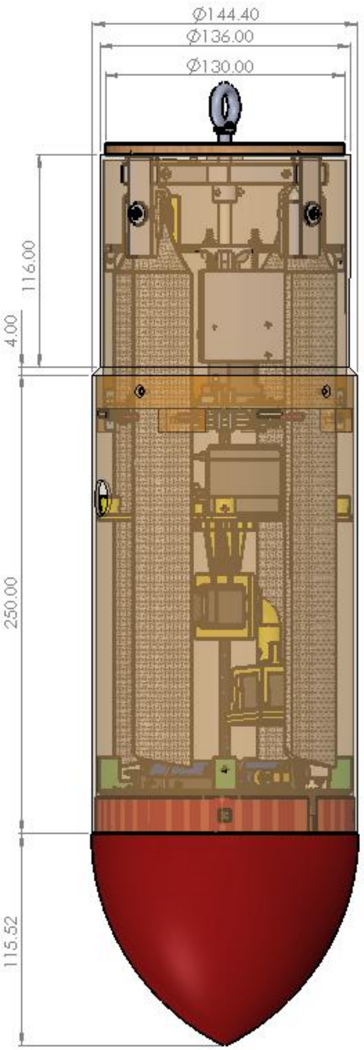
Physical Layout (9/9)

Auto-Gyro Module



* The red arrows indicate the changes since PDR.

Launch Vehicle Compatibility



Launch Configuration

unit: mm

No sharp protrusions on the blades

Clearance Table (Unit: mm)			
Dimensions	**CanSat**	**Rocket**	**Margin**
Container Shoulder Diameter	136	137	1
Container Shoulder Length	120	90~120	0

Sensor Subsystem Design

Kuan-Yu Lai

Sensor Subsystem Overview

Component	Model	Function
Air Pressure Sensor	BMP581	To determine atmospheric pressure.
Air Temperature Sensor	BMP581	To measure the internal temperature of the CanSat.
Battery Voltage Sensor	ADC of MCU	To monitor the voltage of the batteries
GNSS Sensor	LS20031	To provide the precise location and altitude data for the CanSat.
Auto-Gyro Rotation Rate Sensor	FC-33	To measure the rotation rate of the auto-gyro.
Tilt Sensor	MPU9250	To determine payload tilt during descent.
Ground Camera Orientation Sensor	MPU9250	To measure the payload rotation.
Parachute Release Camera	SQ11	To capture the video of the CanSat release and descent.
Ground Camera	SQ11	To capture ground video during the CanSat flight.

Sensor Changes Since PDR

Component	PDR	CDR	Rationale
Payload Tilt Sensor	ICM-20948	MPU9250	• Heritage • Better stability • ICM failed frequently during test
Payload Ground Camera Orientation Sensor			
Payload GNSS Sensor	LS2003E-G	LS20031	• Heritage • 0.1” pitch, easier for soldering

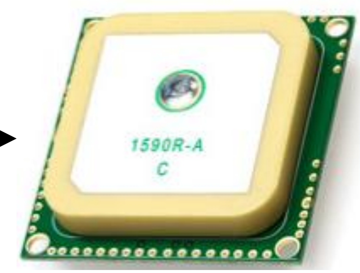
ICM-20948

→

MPU9250

LS2003E-G

→

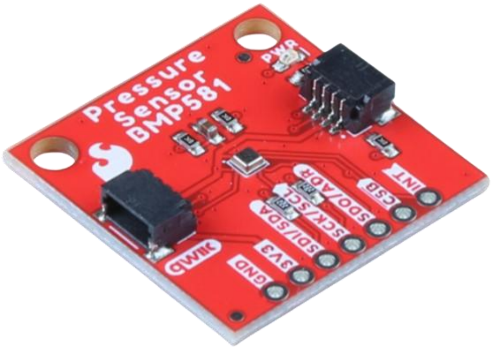


LS20031

Payload Air Pressure Sensor Summary

Module	Interface	Resolution (Pa)	Operating voltage (V)	Operating Current (μA)	Range (hPa)	Dimension (mm)	Weight (g)
BMP581	I²C/SPI	0.016	3.3	1.3	300 ~ 1250	25.4×25.4	18

Data Processing
Using "SparkFun_BMP581_Arduino_Library.h" Library Uses I²C communication Using the following formula to transfer pressure to altitude $Altitude = 44330 \times (1 - \left(\frac{P}{P_0}\right)^{\frac{1}{5.225}})$ P: Atmospheric pressure at current altitude (Pa) P_0: Atmospheric pressure at sea level (Pa) Telemetry data rate is 1Hz.

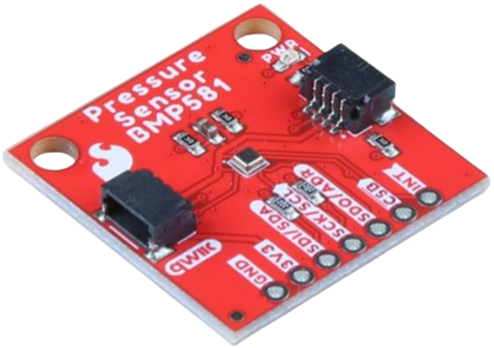


Data Format	Accuracy
Altitude = XX.X m Pressure = XX.X kPa	± 6 Pa

Payload Air Temperature Sensor Summary

Module	Interface	Resolution (°C)	Operating voltage (V)	Operating Current (μA)	Range (°C)	Dimension (mm)	Weight (g)
BMP581	I²C/SPI	0.01	3.3	1.3	-40 ~ 85	25.4×25.4	18

Data Processing
Using "SparkFun_BMP581_Arduino_Library.h" Library Uses I²C communication In order to obtain more accurate values, we round to the nearest tenth decimal place $\text{Temperature} = \text{round}(\text{data.temperature} \times 10)/10.0;$ Telemetry data rate is 1Hz.

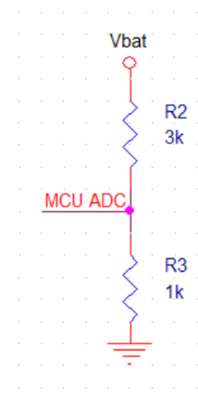


Data Format	Accuracy
Temperature = XX.X °C	± 0.5°C

Payload Voltage Sensor Summary

Model	Interface	Resolution	Size (mm)	Weight	Cost (USD)
ADC of MCU	Analog	12 bit within 3.6V	Negligible*	Negligible*	29.60

*NOTE: Part of MCU (Teensy 4.1)



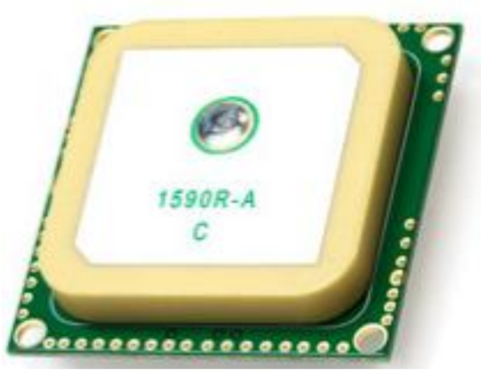
Data Processing
adcVal = analogRead(39); Vread = adcVal*3.3/1023; Vin = Vread/1*(3+1); Telemetry data rate is 1Hz.

Data Format	Accuracy
Voltage = X.X V	± 0.1V

Payload GNSS Sensor Summary

Module	Interface	Update Rate (Hz)	Operating Voltage (V)	Operating Current (mA)	Sensitivity (dBm)	Weight (g)
LS20031	UART	10	3.3	16	-160	14

Data Processing
Using "TinyGPSPlus.h" Library Uses UART communication Time = (t.hour() : t.minute() : t.second()); Altitude = gps.altitude.meters(); Latitude = gps.location.lat(); Longitude = gps.location.lng(); Satellite = gps.satellites.value(); Telemetry data rate is 1Hz.



Data Format	Accuracy
Time = hh:mm:ss Altitude = X.X m Latitude = X.XXXX° Longitude = X.XXXX° Satellite = X	±2.5 m

Auto-gyro Rotation Rate Sensor Summary

Module	Interface	Measurement Technique	Operating Voltage (V)	Operating Current (mA)	Weight (g)	Timing Accuracy (ms)	Range (RPM)
FC-33	Digital	Infrared Radiation	3.3	10	3.2	<1	0~20,000

Data Processing

When the light is interrupted and generate a pulse signal. We record the time interval of a revolution, and calculate the rotation rate

R(rpm) = 1000 / $\Delta t(ms)$* 60;
Δt:time interval of a revolution

Telemetry data rate is 1Hz.

Data Format	Accuracy
rpm = XX RPM	<0.1%(@1000RPM)

Payload Tilt Sensor Summary

Module	Interface	Operating Current (mA)	Maximum Gyroscope Range (°/sec)	Resolution (bit)	Size (mm)	Weight (g)
MPU9250	I²C, SPI	3.2	± 2000	16	15x25x3.3	2

Data Processing
Using "MPU9250.h" Library Uses I2C communication Yaw = imu.getYaw(); Pitch = imu.getPitch(); Roll = imu.getRoll(); Telemetry data rate is 1Hz.

Data Format	Accuracy
Yaw = X.XX° Pitch = X.XX° Roll = X.XX°	±3°~5°

Payload Ground Camera Orientation Sensor

Module	Interface	Operating Current (mA)	Maximum Gyroscope Range (°/sec)	Resolution (bit)	Size (mm)	Weight (g)
MPU9250	I²C, SPI	3.2	± 2000	16	15x25x3.3	2

Data Processing
Using “MPU9250.h” Library Uses I2C communication gyro[0] = mpu.getGyroX(); gyro[1] = mpu.getGyroY(); gyro[2] = mpu.getGyroZ(); accel[0] = mpu.getAccX(); accel[1] = mpu.getAccY(); accel[2] = mpu.getAccZ(); Telemetry data rate is 1Hz.

Data Format	Accuracy
GYRO_R = X.XX °/s GYRO_P = X.XX °/s GYRO_Y = X.XX °/s ACCEL_R = X.XX $°/s^2$ ACCEL_P = X.XX $°/s^2$ ACCEL_Y = X.XX $°/s^2$	0.061°/s 0.061 $°/s^2$

Ground Camera Sensor Summary

Module	Resolution (pixel)	Frame Rate (fps)	Built-in battery	Operatin Current (mA)	Viewing Angle (°)	Dimension (mm)	Weight (g)
SQ11	1920 x 1080	30	YES	300	140	23x23x23	10

Data format
Video file type: AVI Video Resolution: 1920 x 1080 • Video in color Integrated MicroSD Card • Maximum MicroSD size: 64 GBytes

Auto-Gyro Deploy Camera Summary

Module	Resolution (pixel)	Frame Rate (fps)	Built-in battery	Operation Current (mA)	Viewing Angle (°)	Dimension (mm)	Weight (g)
SQ11	1920 x 1080	30	YES	300	140	23x23x23	10

Data format
Video file type: AVI Video Resolution: 1920 x 1080 • Video in color Integrated MicroSD Card • Maximum MicroSD size: 64 GBytes

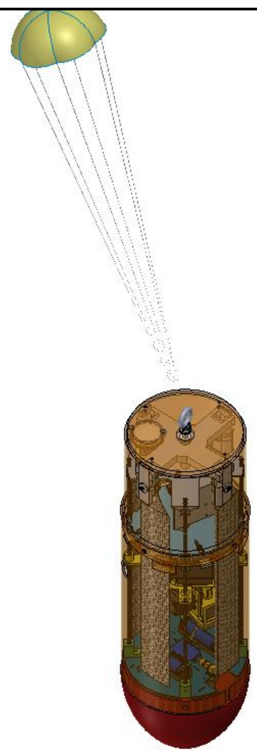
Descent Control Design

Chen-Pei Yang

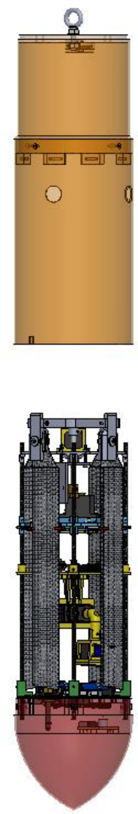
Su-Yun Hsu

Descent Control Overview

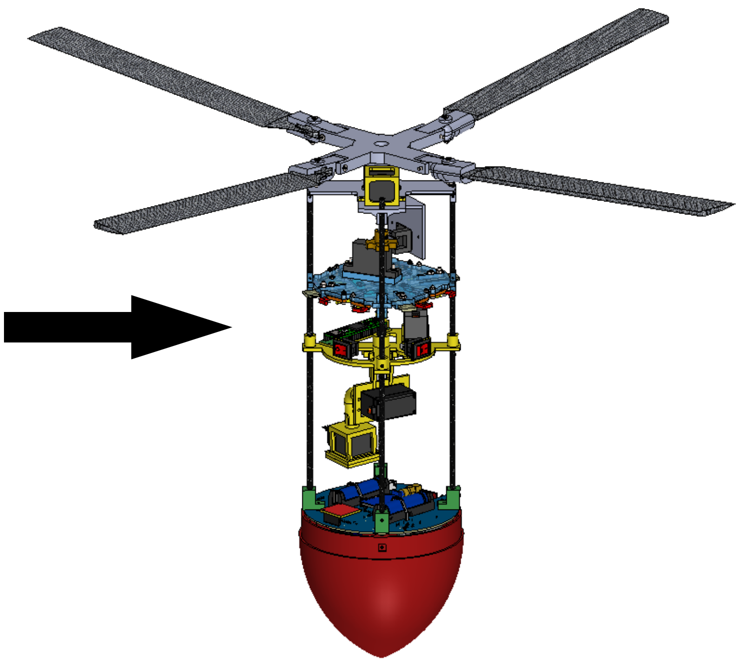
Parachute (for Cansat & container)



Release



Auto-Gyro Module (for PL)



(Descent rate of 17~23 m/s)

(Descent rate of 2~8 m/s)

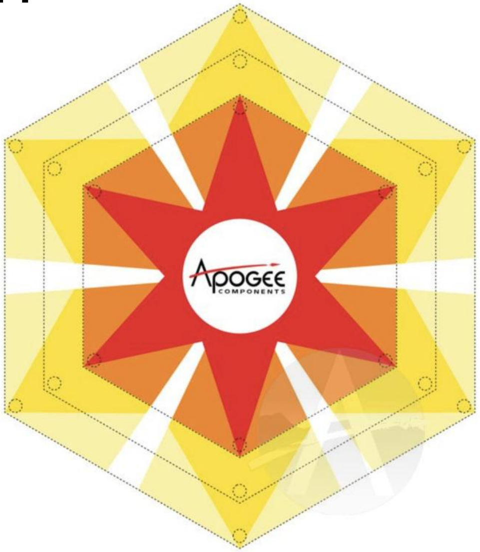
Apogee to 75% peak altitude	Reach 75% peak altitude	75% peak altitude to landing

Descent Control Changes Since PDR (1/2)

PDR	CDR	Rationales
Dome-shape Parachute	Hexagonal-shape parachute	• To distribute stress more evenly • Easy to process

PDR design :

CDR design :

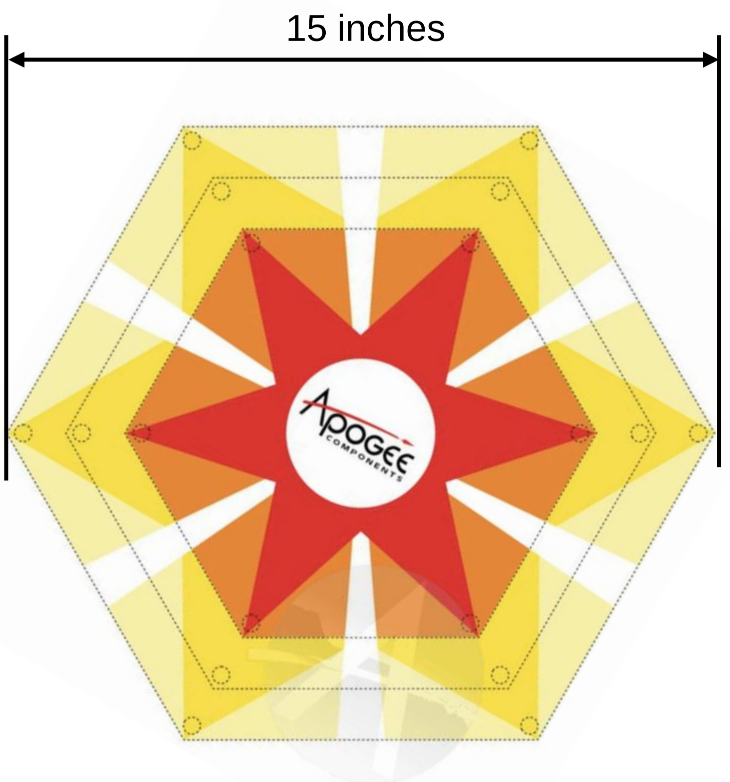


Descent Control Changes Since PDR (2/2)

Prototype testing :

The parachute and auto-gyro are tested to verify their functionality and compliance with the requirements. In the prototype testing, a 1.4 kg cardboard container with essential electronic components inside is designed as a substitute for the CanSat. The parachute and auto-gyro were separately attached to this container. Test drops were conducted from a 12-story building, ensuring a safe landing area. The results showed that the parachute effectively slowed the descent speed while keeping the ropes intact. Additionally, a stable descent of the auto-gyro is also demonstrated.

Container Parachute Descent Control Summary



- Shape: hexagonal
- Size: diameter of 15 inches
- Color: bright orange and bright yellow

A hexagonal parachute design was chosen for its high stability and even stress distribution. With a 15-inch diameter, it can achieve a descent rate of about 20 m/s. The bright orange and yellow colors enhance visibility for easy recovery, especially in grassy environments.

Auto-gyro selection summary (1/2)

- **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°C
L = Lift force(N)
r = blade long(m)

Case : $V_t = 5\ m/s$

C_d	1.16	1.1
A=	0.20	0.20
r=	0.25	0.25

Case : $V_t = 2\ m/s$

C_d	1.16	1.1
A=	1.23	1.25
r=	0.63	0.63

Case : $V_t = 8\ m/s$

C_d	1.16	1.1
A=	0.08	0.08
r=	0.16	0.16

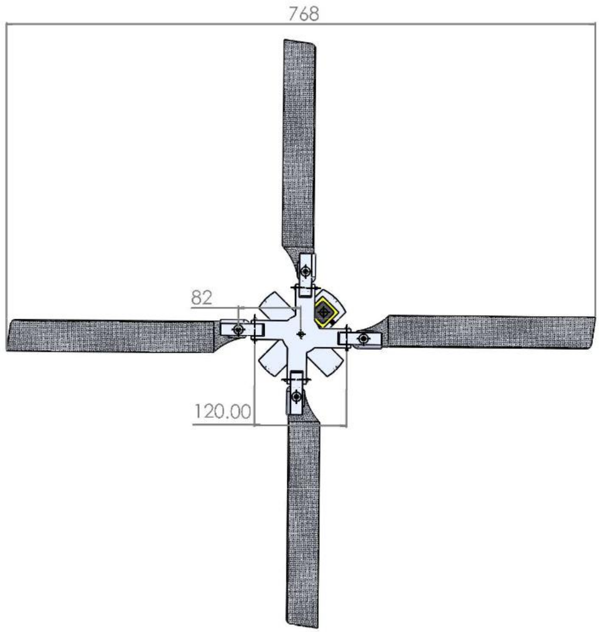
Conclusion:

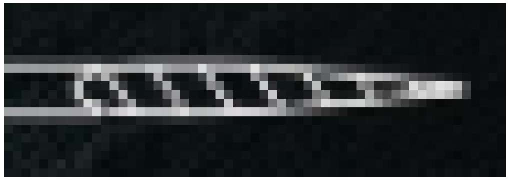
- **The Descent rate limit: 2~8m/s**
- **The longest blade that can fit in the container is choosen.**

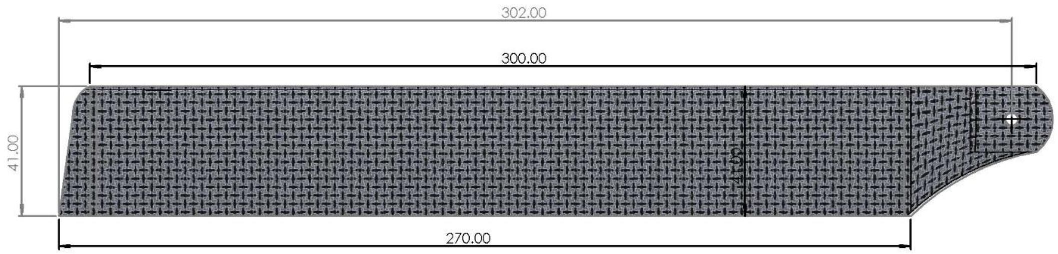
$\Rightarrow$ **r=0.3m**

- **Auto-gyro blade**

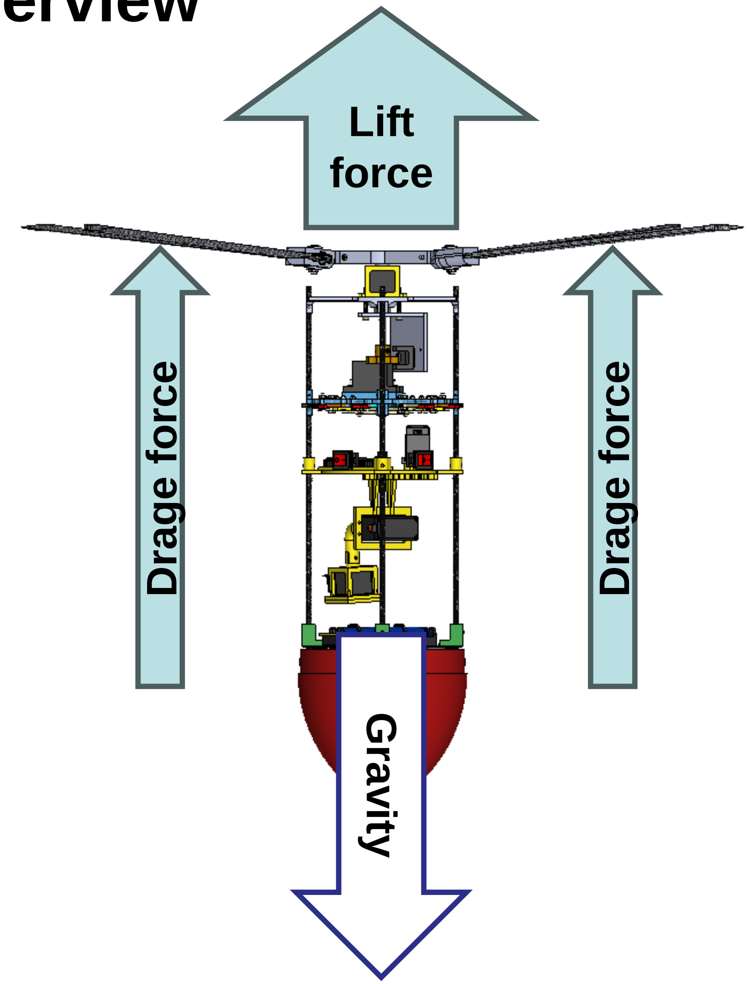
Rotor disk	Carbon fiber Blade
768mm	• Long:300mm • blade-width:41mm • Blade thickness:4.1mm • Shape : naca0012







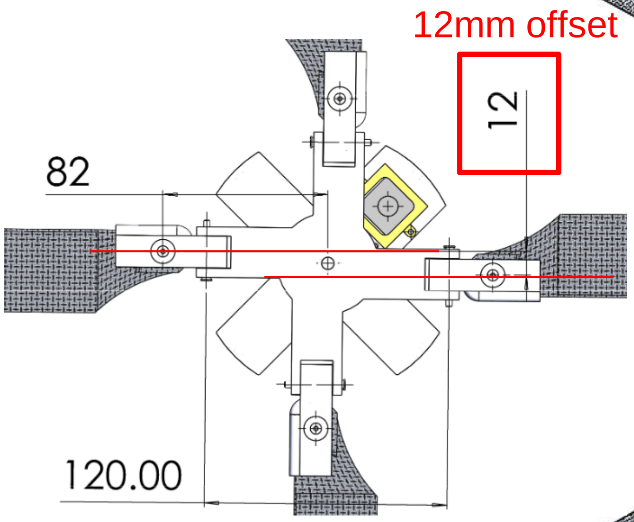
- **Auto-gyro descent control overview**

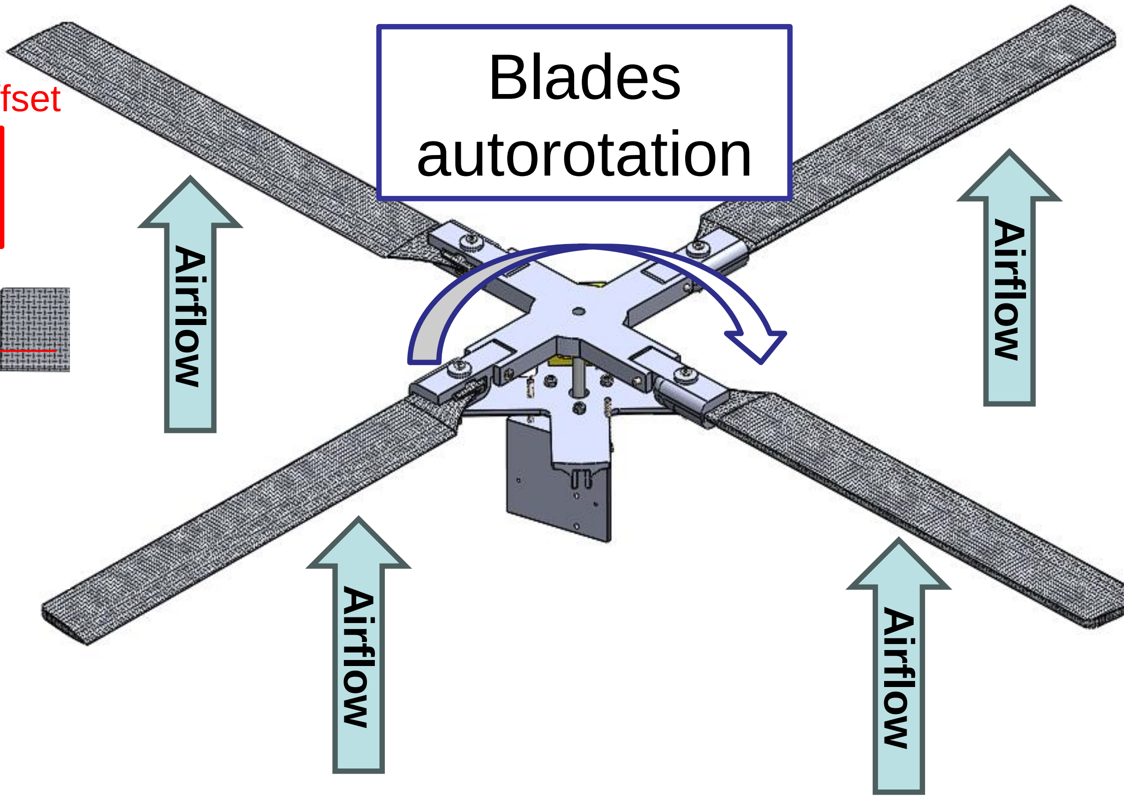


- The auto-gyro blades generate drag force, and upon entering autorotation, the blades produce upward lift.
- These two forces work together to generate a counteracting force opposite to the direction of descent during the payload's descent phase.

Auto-gyro Descent Control Summary (2/4)

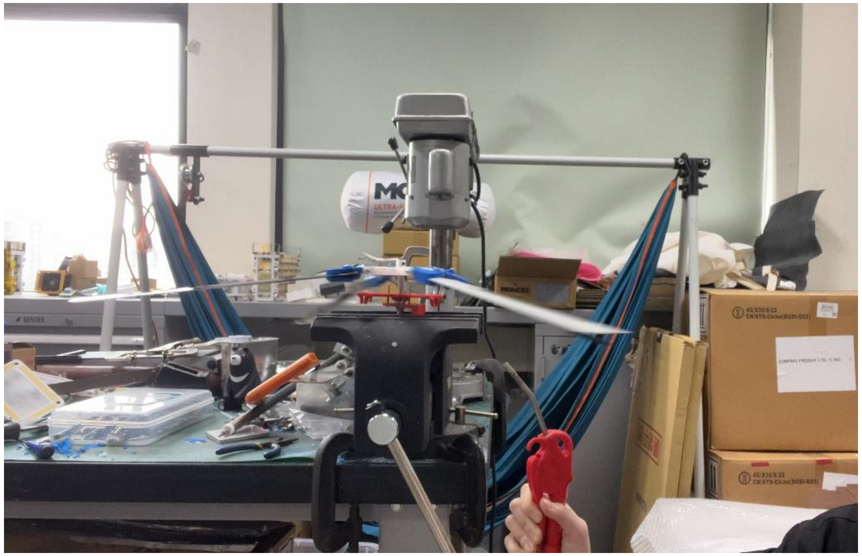
- **The fixed axis of the blade is offset, causing the blades to start rotating clockwise when the auto-gyro module is deployed during the decent phase.**





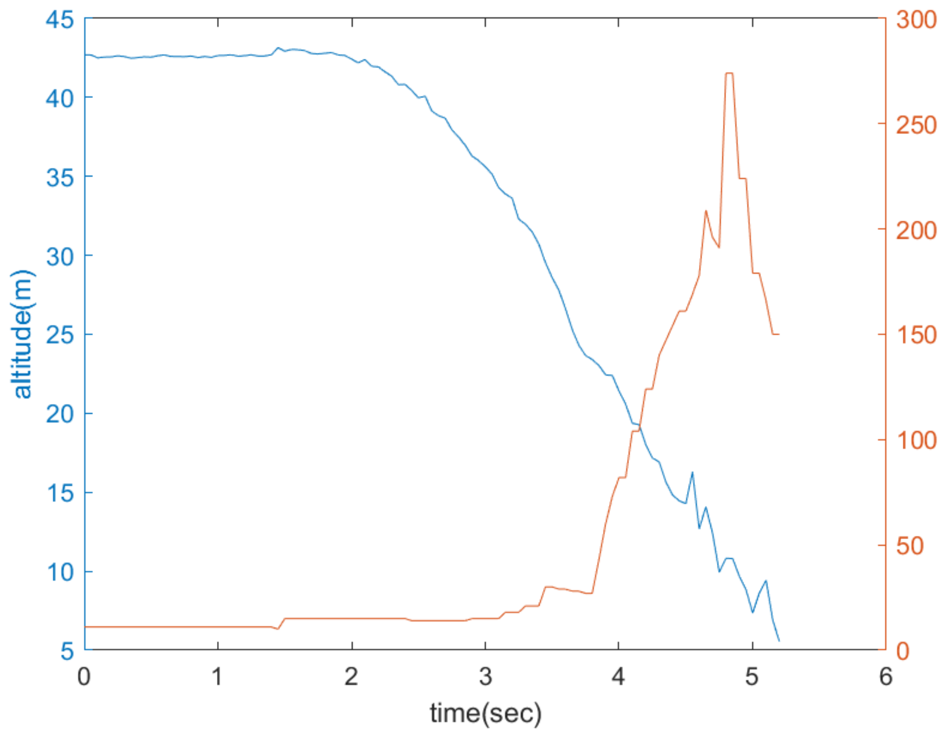
Auto-gyro Descent Control Summary (3/4)

- **Auto-gyro autorotation test**
  - Blowing by compressed air. https://youtu.be/HOP8VPchZoQ
  - Blowing by nature wind. https://youtu.be/5SyogglDOZA



Auto-gyro Descent Control Summary (4/4)

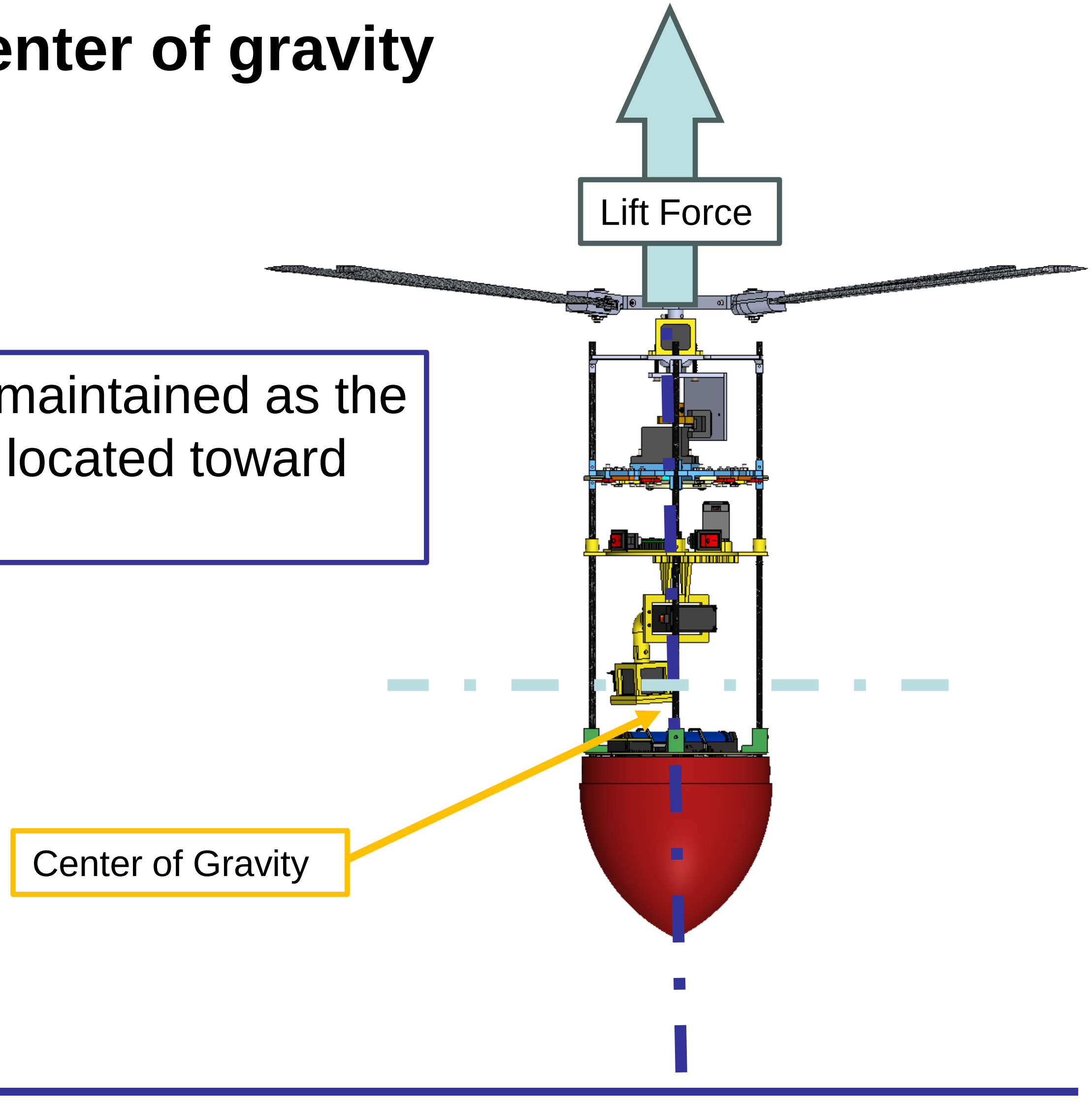
- **The result of the freefall test by the prototype:**



- Freefall test:
  - Hight: 42.5m
  - Max. rotation rate: 270rpm

Passive control: low center of gravity

The nadir direction is stably maintained as the CanSat's center of gravity is located toward the nose cone.



Parachute

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

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

$$\Rightarrow A_p = 0.084\ m^2$$

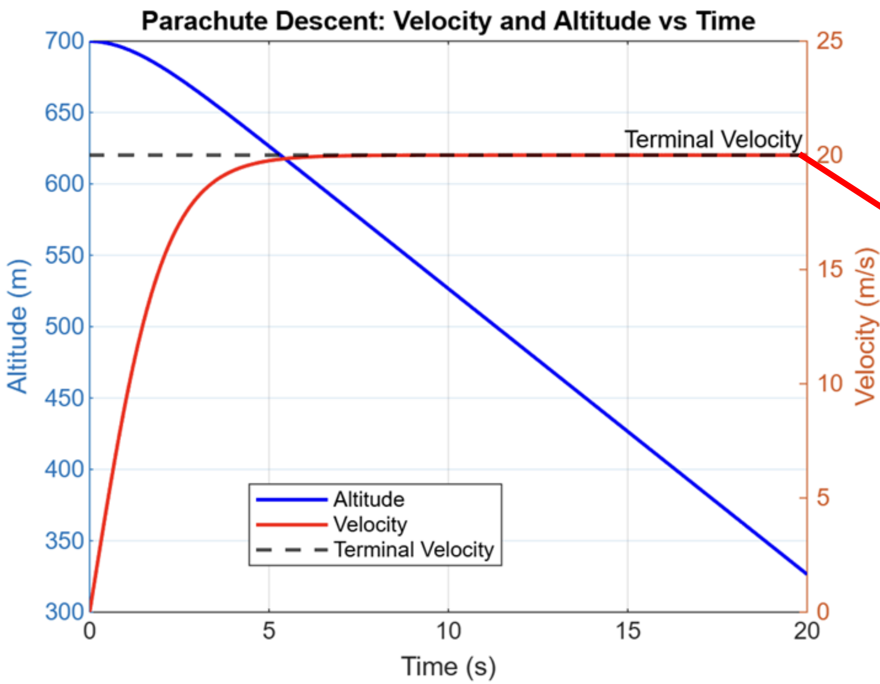
$$\Rightarrow D_p = 163.5\ mm\ \text{(parachute diameter)}$$

Descent Rate Estimates (2/4)

Parachute

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

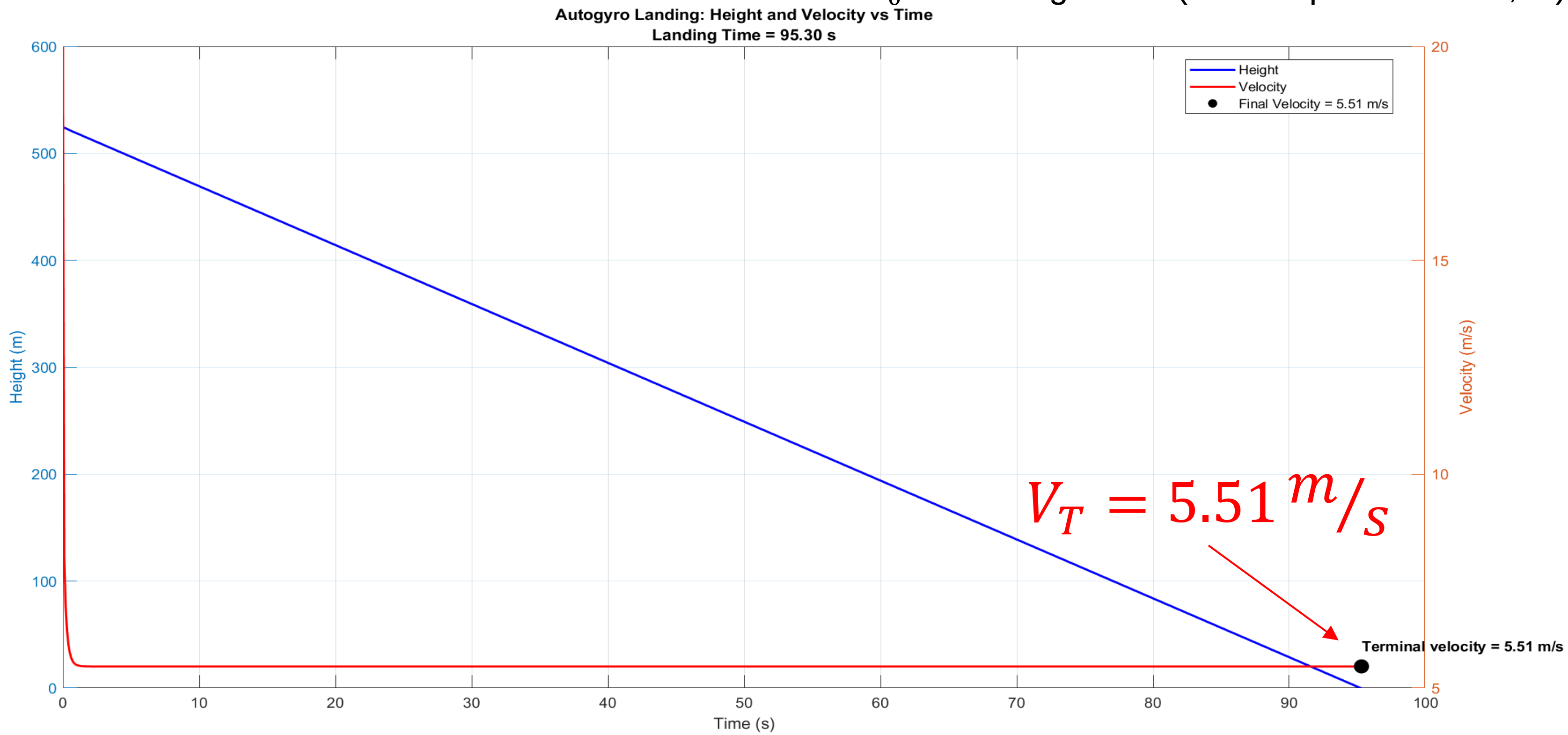
A_p: Area of the Parachute (m^2)
$\mathrm{C_D}$: Drag Coefficient (Assumed $\mathrm{C}_{\mathrm{D},Dome} = 0{,}75$)
ρ: Air Density at 31˚C ($1.089\ kg/m^3$)
V_T: Terminal velocity ($20\ m/s$ by requirements)
$\mathrm{F_D}$: Drag Force (Equal to the weight= $1.4\ kgw$)



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

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)



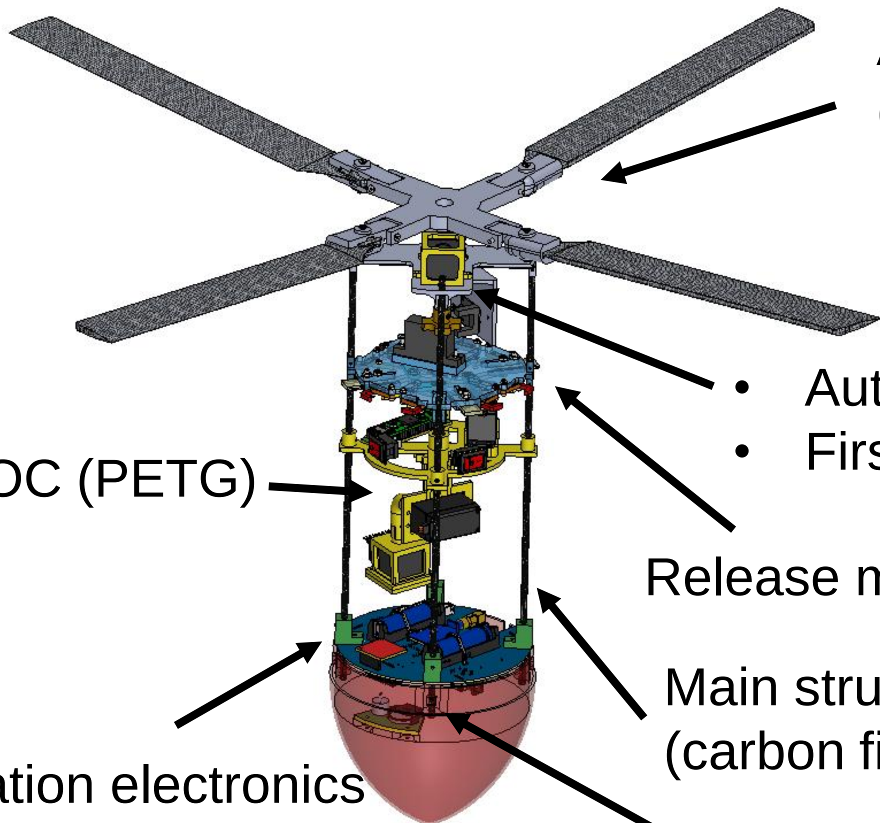
Descent Rate Estimates (4/4)

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

Mechanical Subsystem Overview



Auto-gyro system
(PETG, metal, carbon fiber)

- Auto-gyro rotation sensor
- First camera

GPOC (PETG)

Release module (PETG)

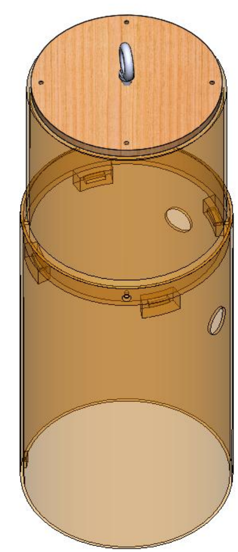
Main structural tube
(carbon fiber)

Aviation electronics

PL beacon

Nose cone (PETG)

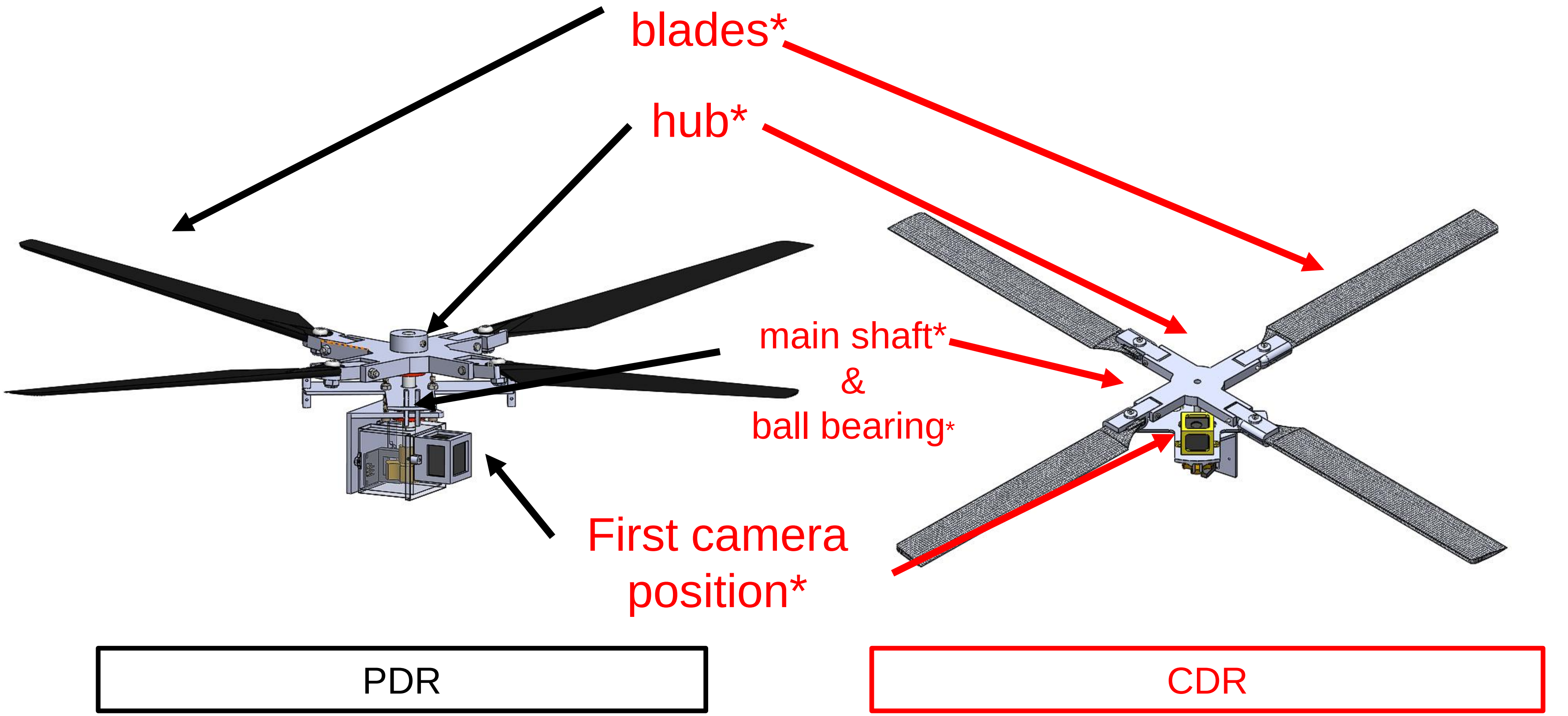
Nose Cone does not separate from the payload



Container (PLA+)

Mechanical Subsystem Changes Since PDR (1/5)

- **Auto-gyro module mechanical changes overview in CDR**



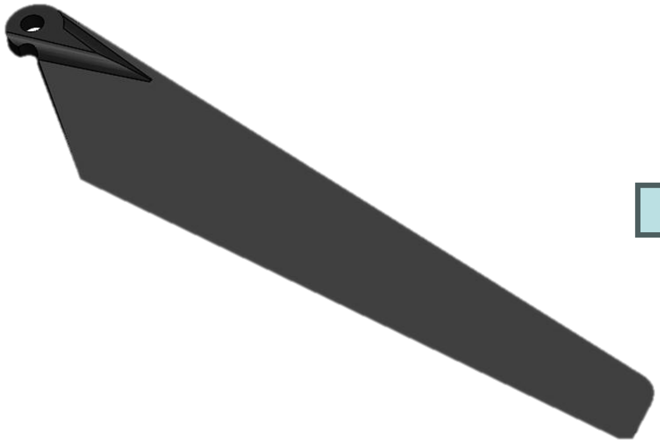
* The red arrows indicate the changes since PDR.

Mechanical Subsystem Changes Since PDR (2/5)

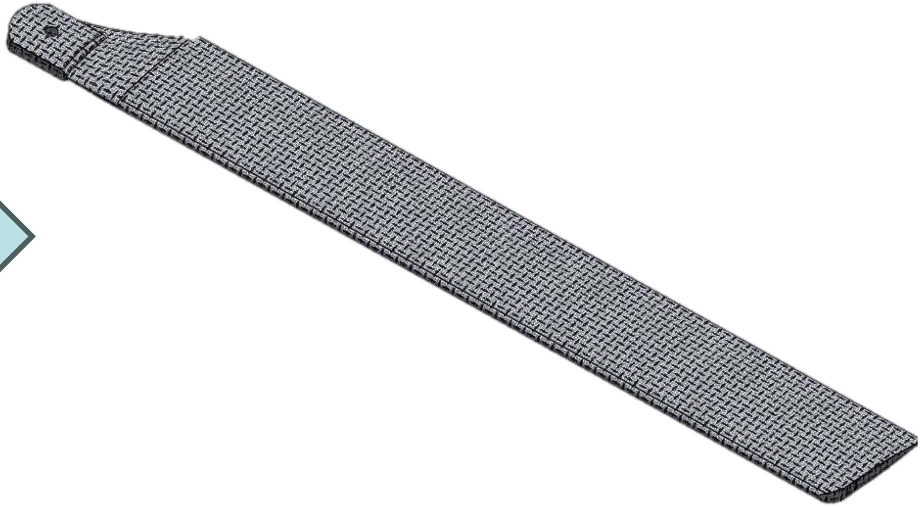
- **Auto-gyro blade**

PDR	CDR	Rationales
ABS blades	carbon fiber blades	• Lighter weight • Better specific strength.

PDR design :



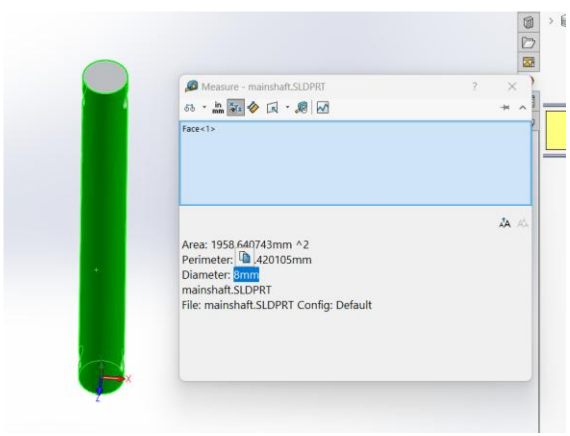
CDR design :



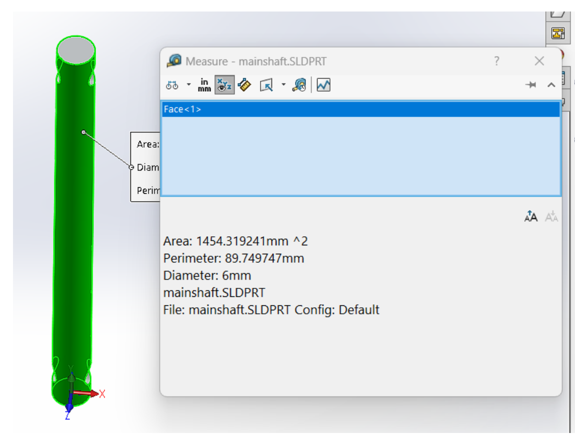
- **Auto-gyro main shaft :**

PDR	CDR	Rationales
Diameter **8mm** steel shaft	Diameter **6mm** steel shaft	• Lighter weight • The same stability

PDR design :



CDR design :

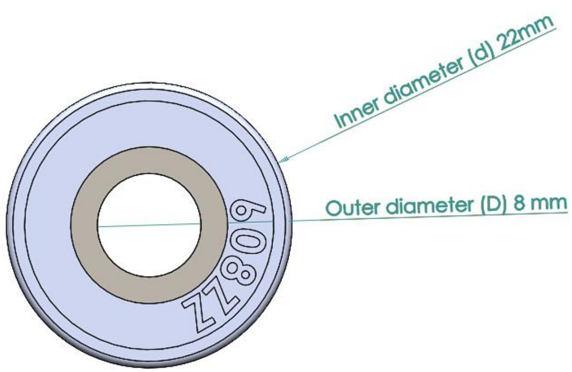


Mechanical Subsystem Changes Since PDR (4/5)

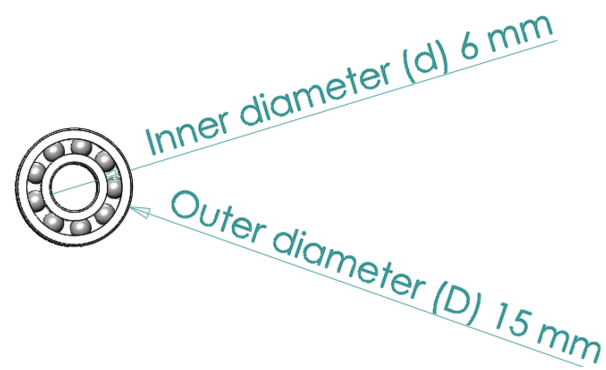
- **Auto-gyro ball bearing :**

PDR	CDR	Rationales
NSK 608ZZ	NSK 696ZZ	• Lighter weight • Smaller inner diameter

PDR design :



CDR design :

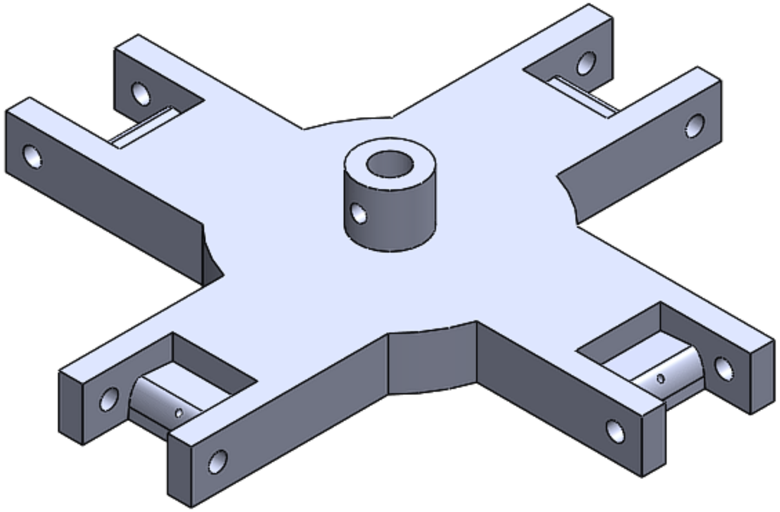


Mechanical Subsystem Changes Since PDR (5/5)

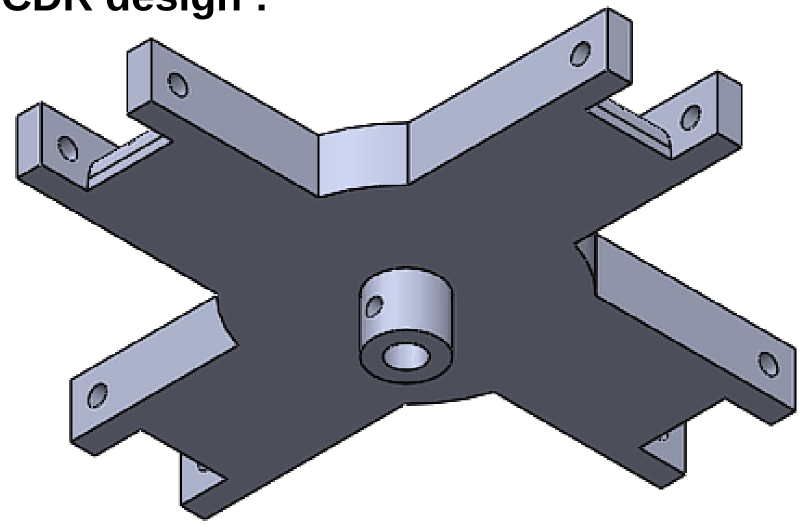
- **Blade Hub :**

PDR	CDR	Rationales
Counterclockwise (CCW) hub design	Clockwise (CW) hub design , the blades arranged in a counterclockwise direction.	• In accordance with the aerodynamics of the blade.

PDR design :

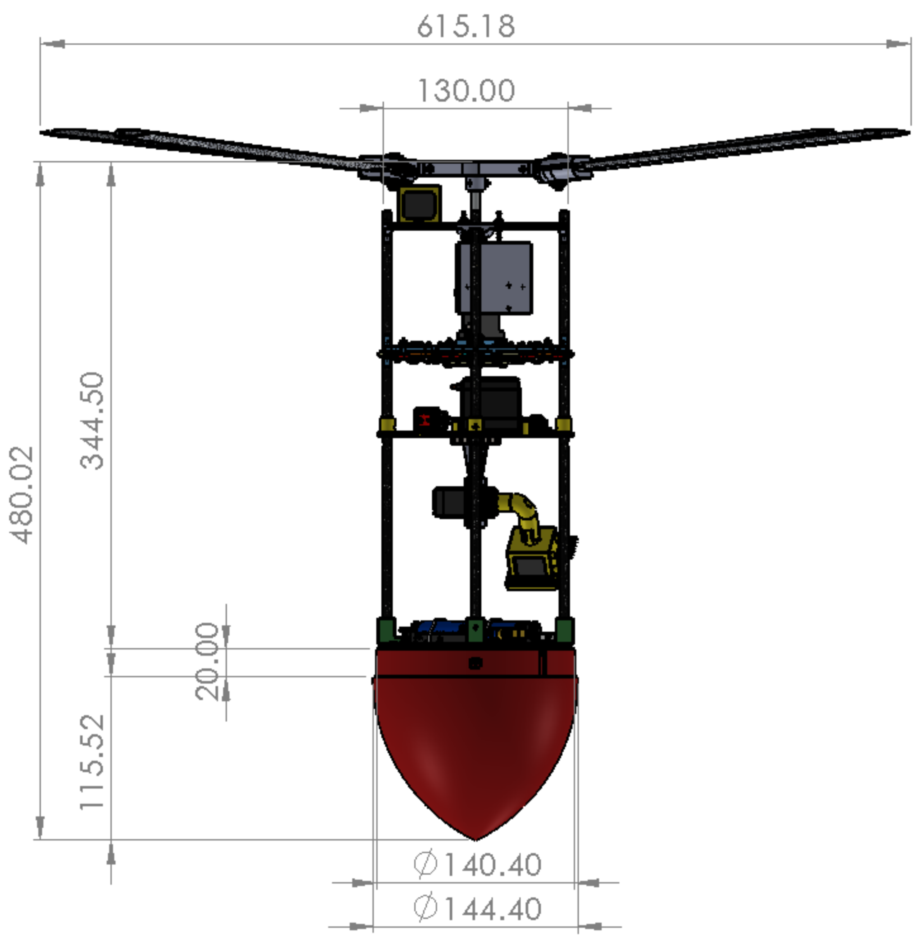


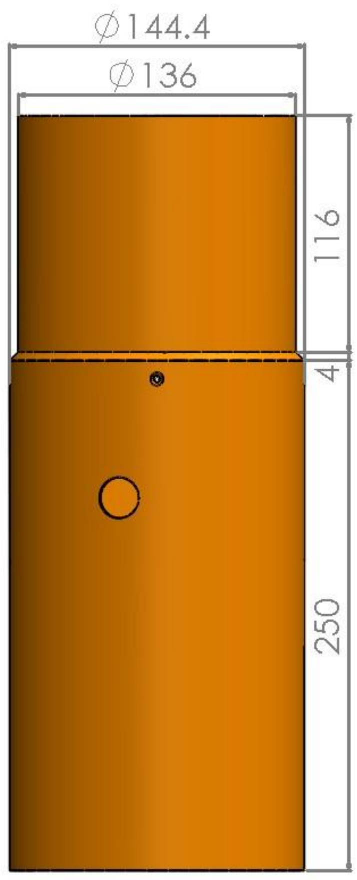
CDR design :



CanSat Mechanical Layout of Components (1/11)

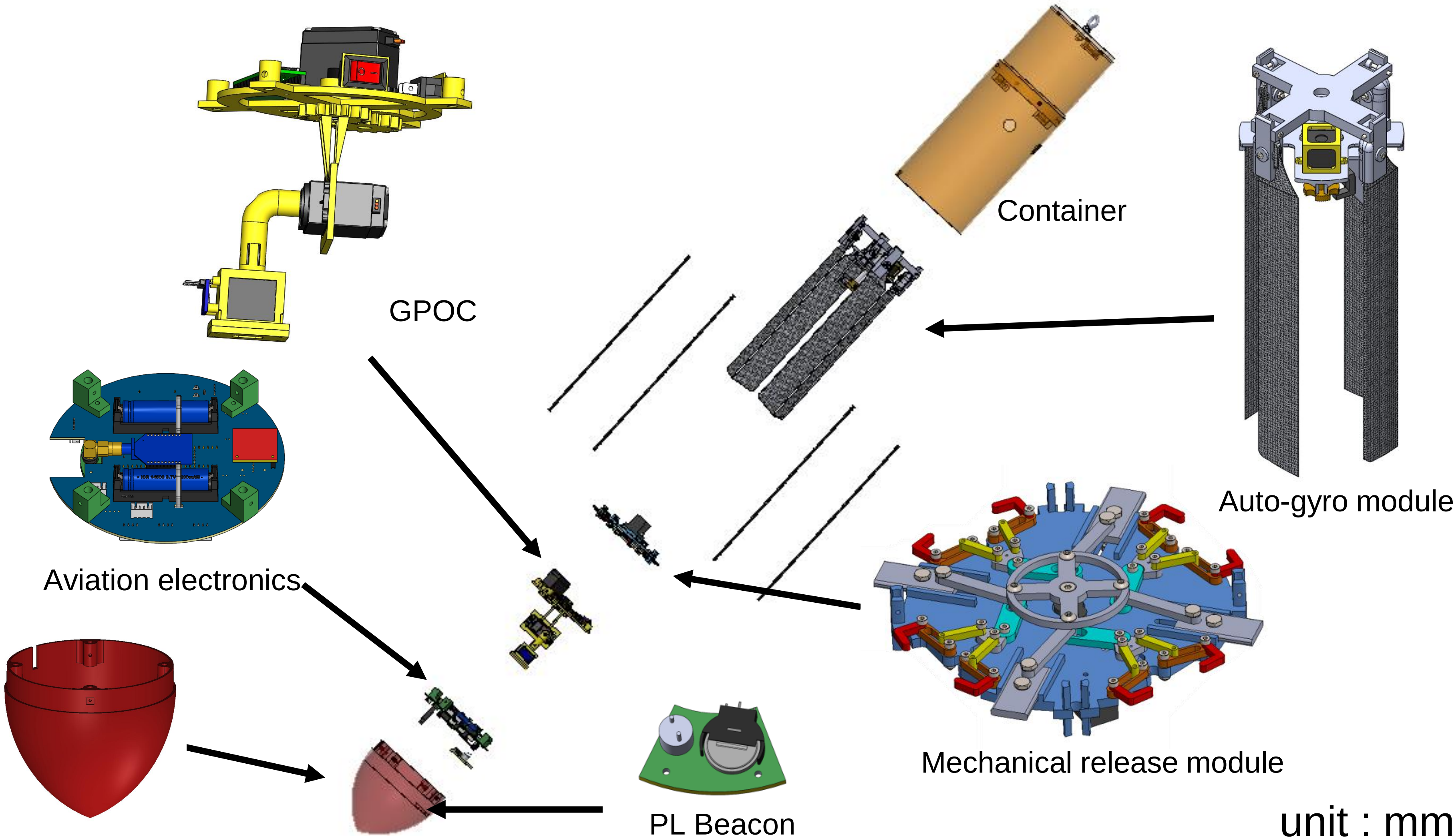
PL dimensions	Container dimensions





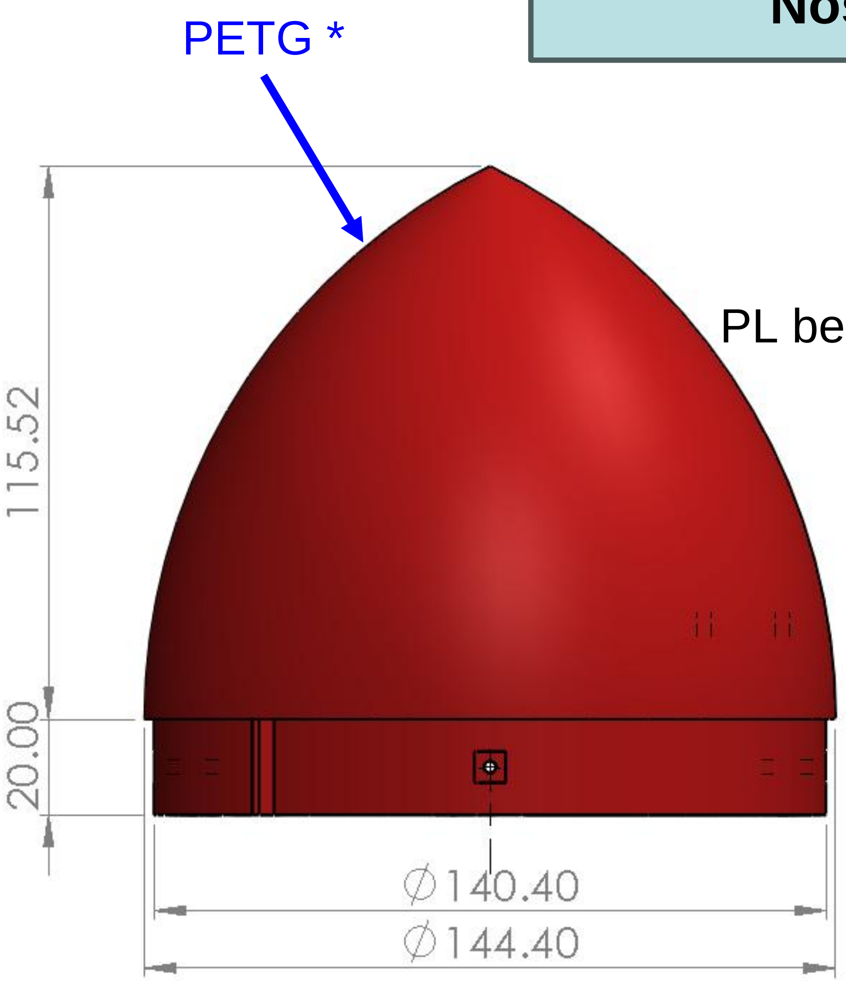
unit : mm

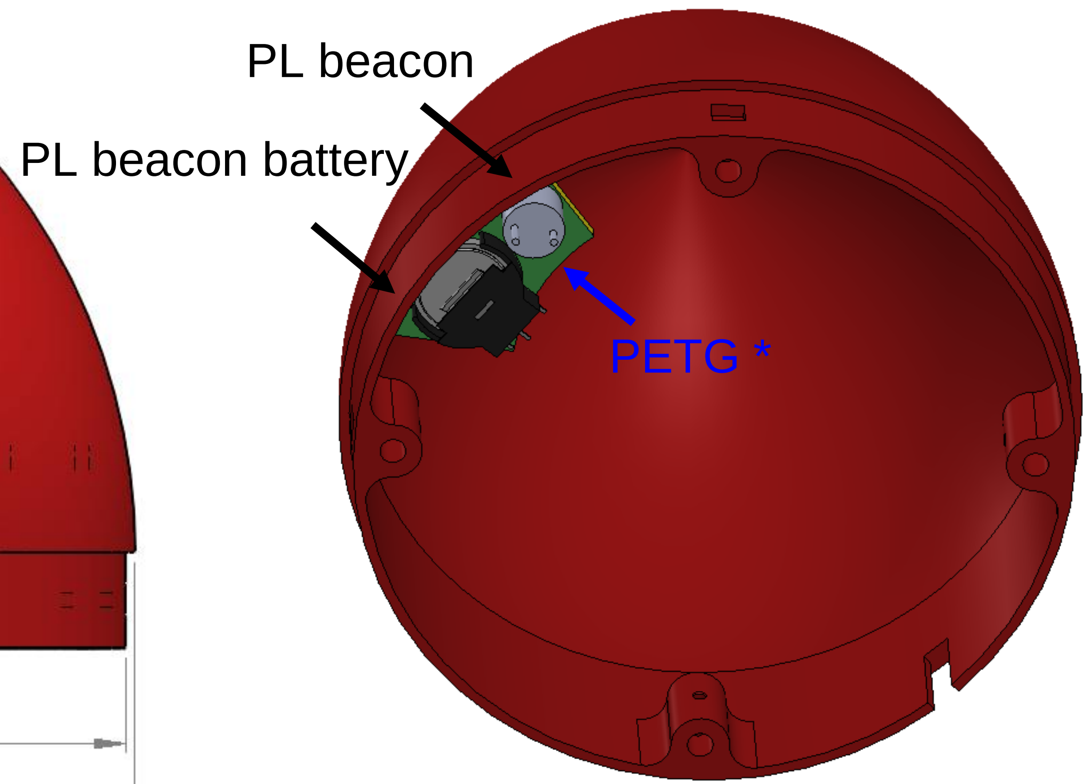
CanSat Mechanical Layout of Components (2/11)



CanSat Mechanical Layout of Components (3/11)

Nose Cone



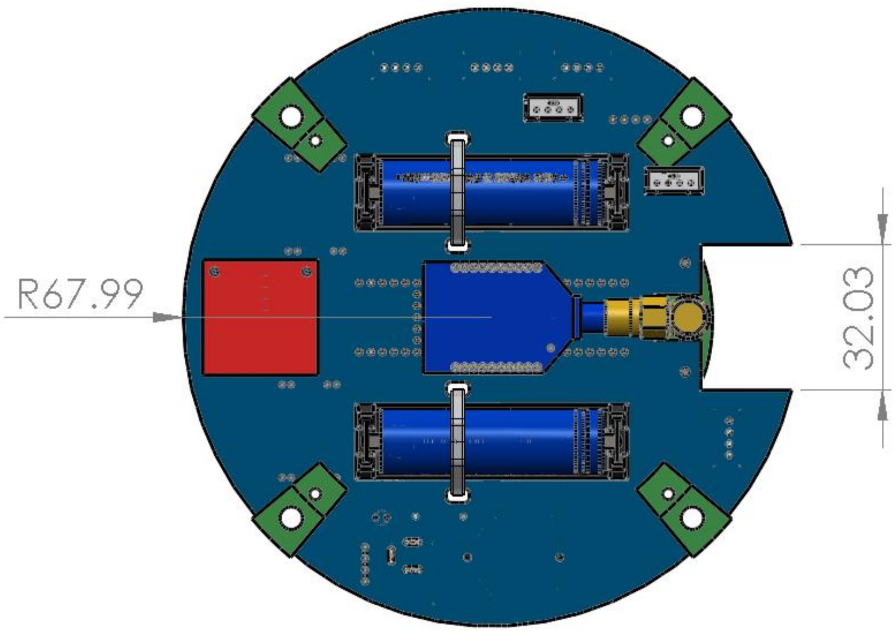


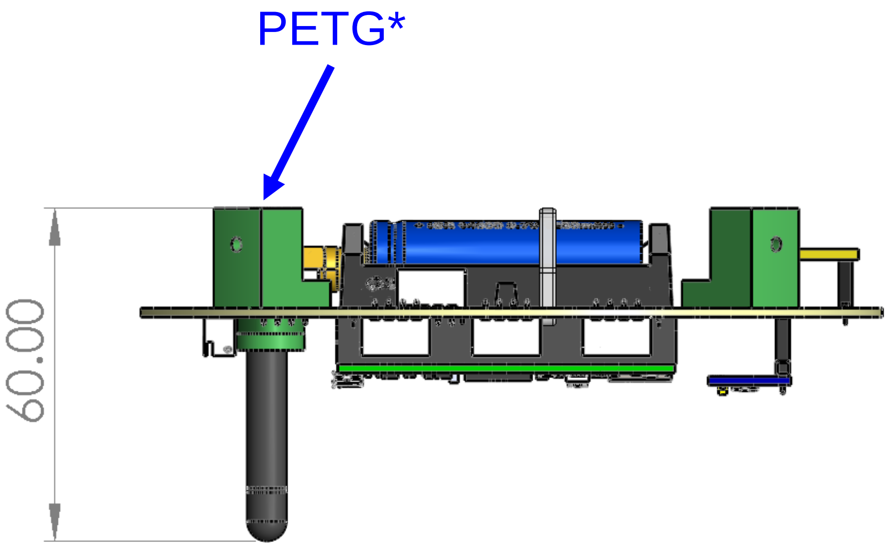
* The blue arrows indicate the material.

unit : mm

CanSat Mechanical Layout of Components (4/11)

Aviation Electronics



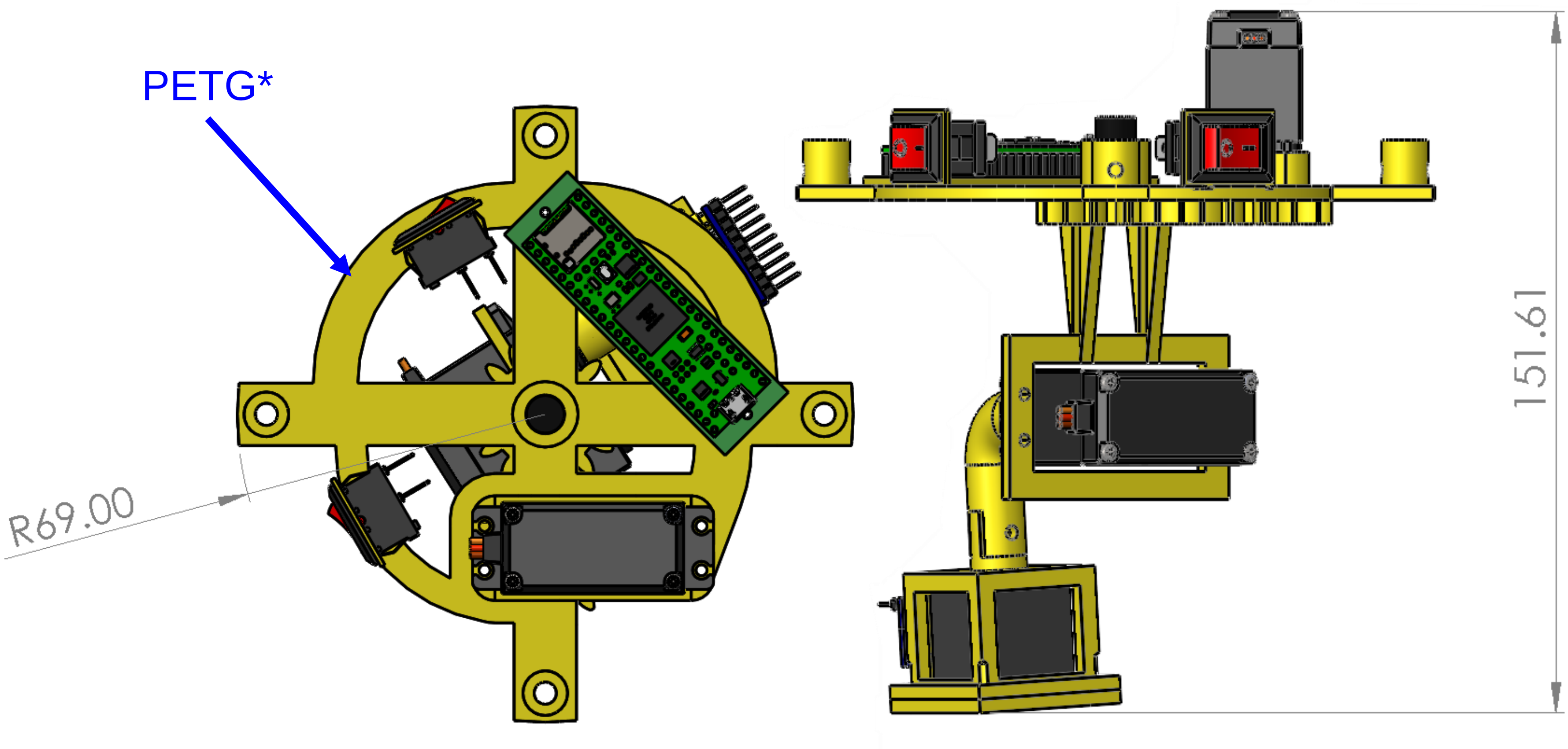


* The blue arrows indicate the material.

unit : mm

CanSat Mechanical Layout of Components (5/11)

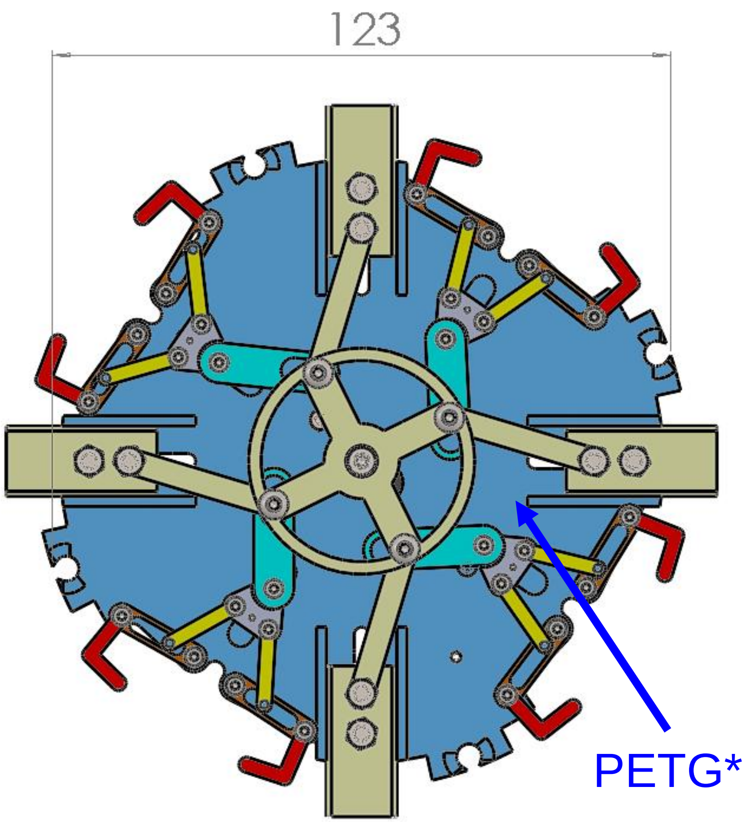
GPOC

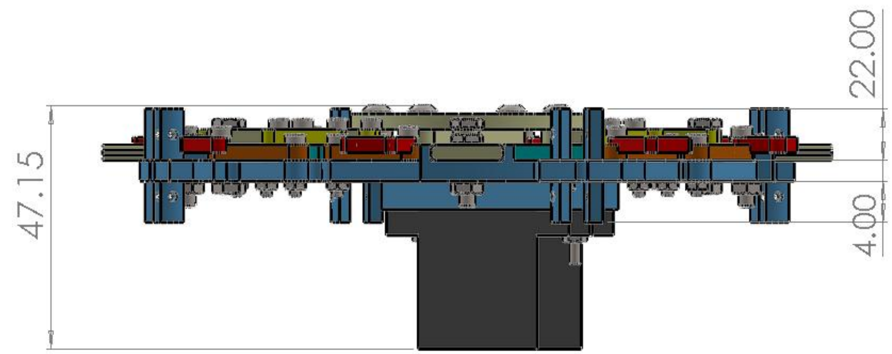


* The blue arrows indicate the material.

unit : mm

Mechanical Release Module



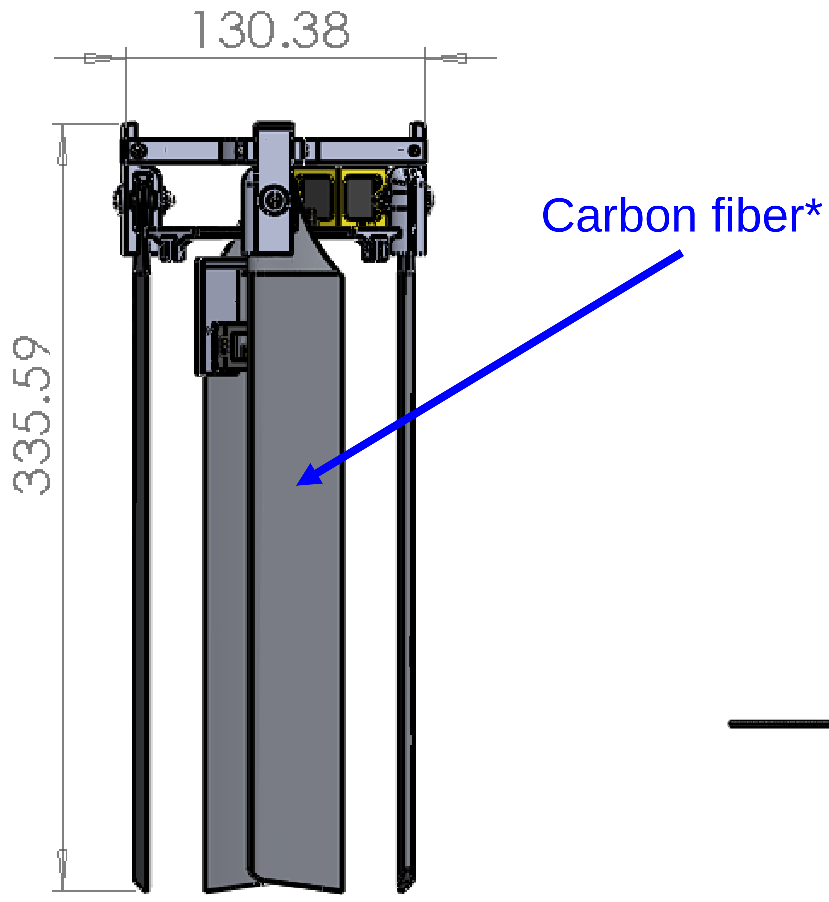


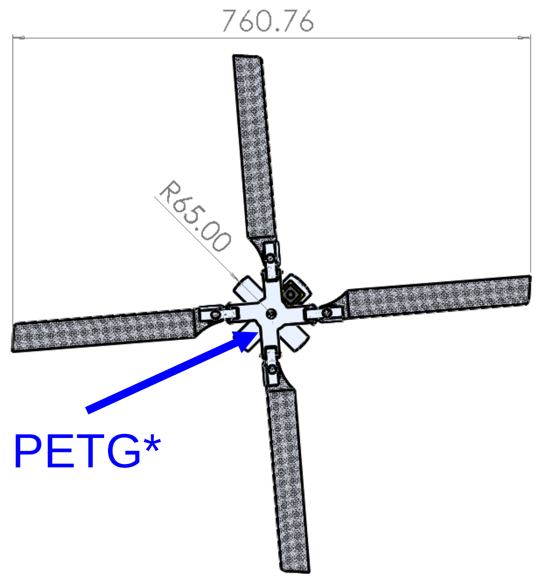
Unit : mm

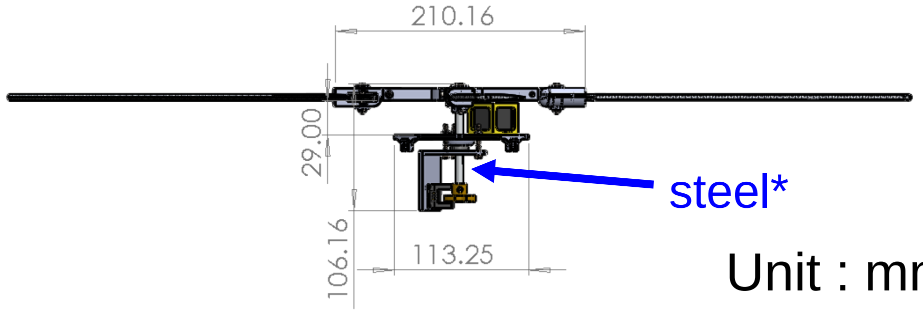
* The blue arrows indicate the material.

CanSat Mechanical Layout of Components (7/11)

Auto-Gyro Module





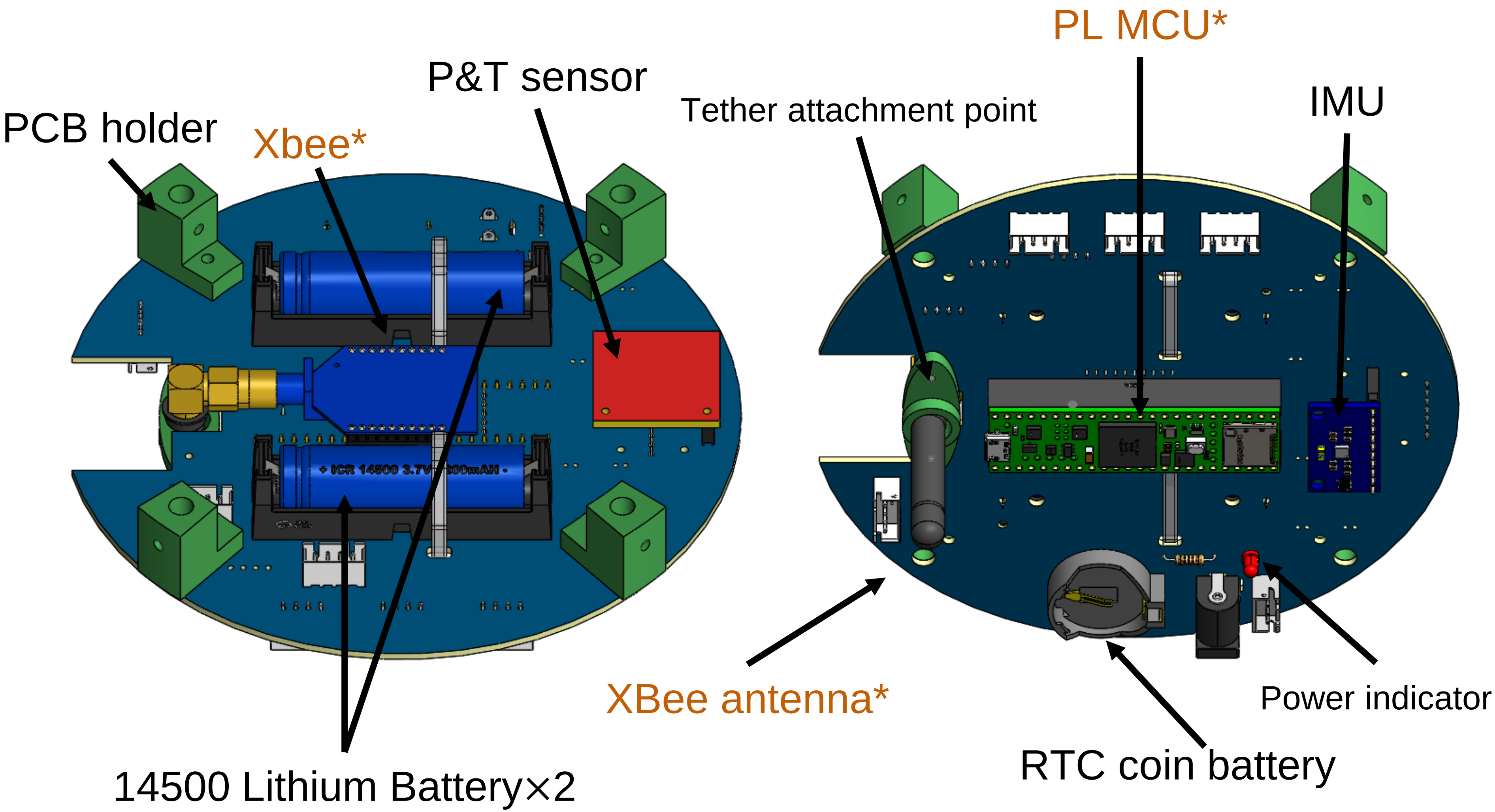


Unit : mm

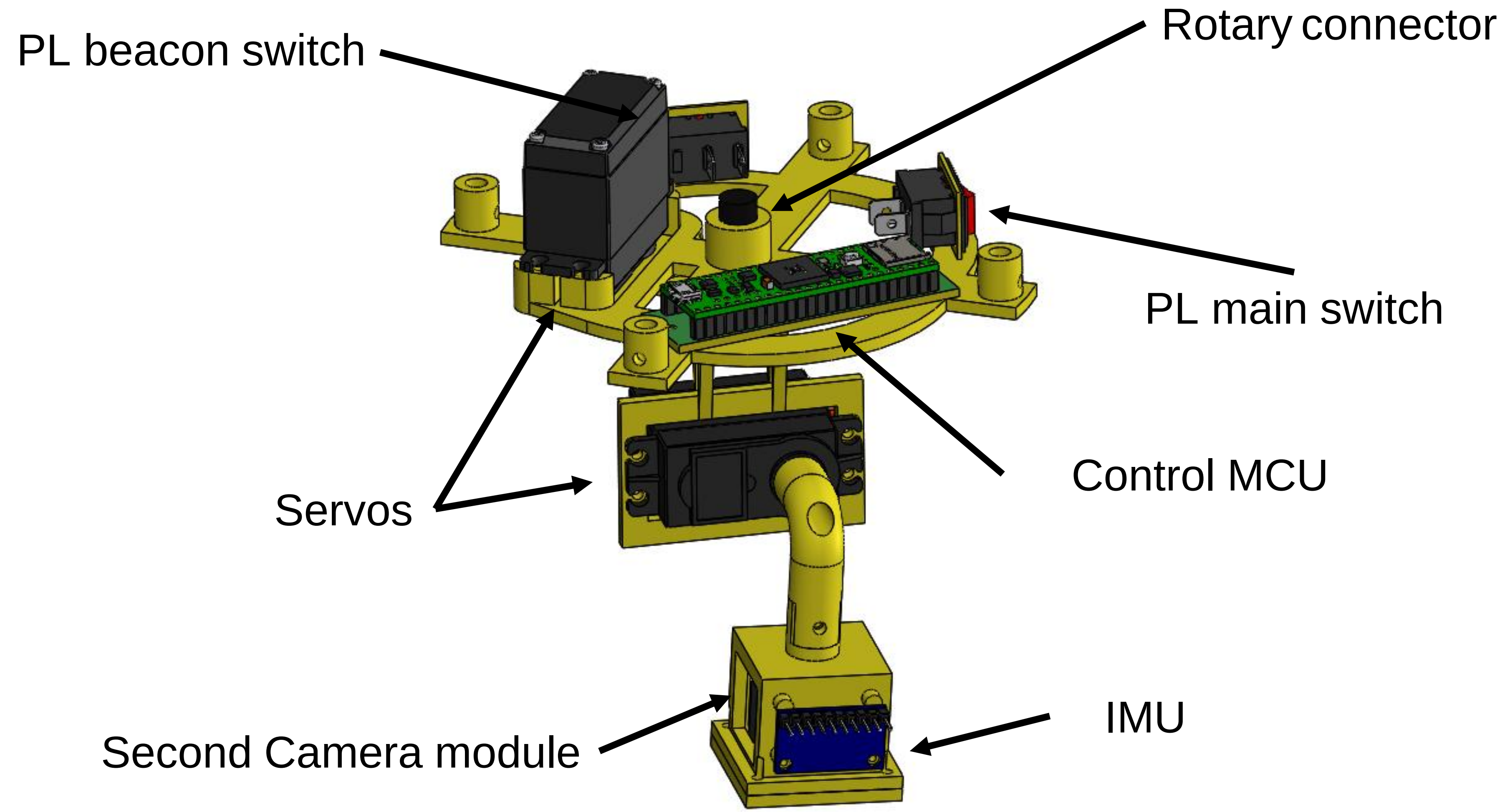
* The blue arrows indicate the material.

CanSat Mechanical Layout of Components (8/11)

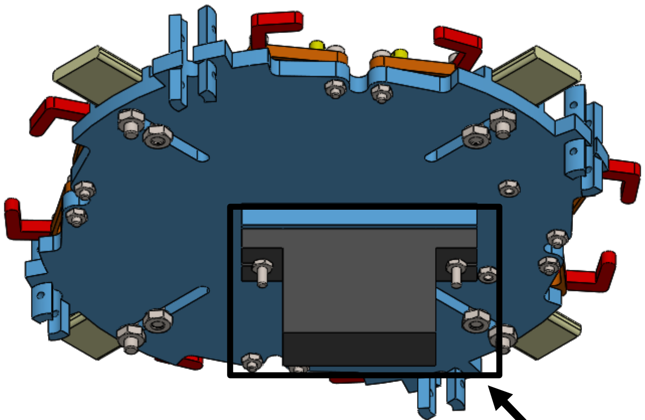
*:The brown Color stands for the CDH components

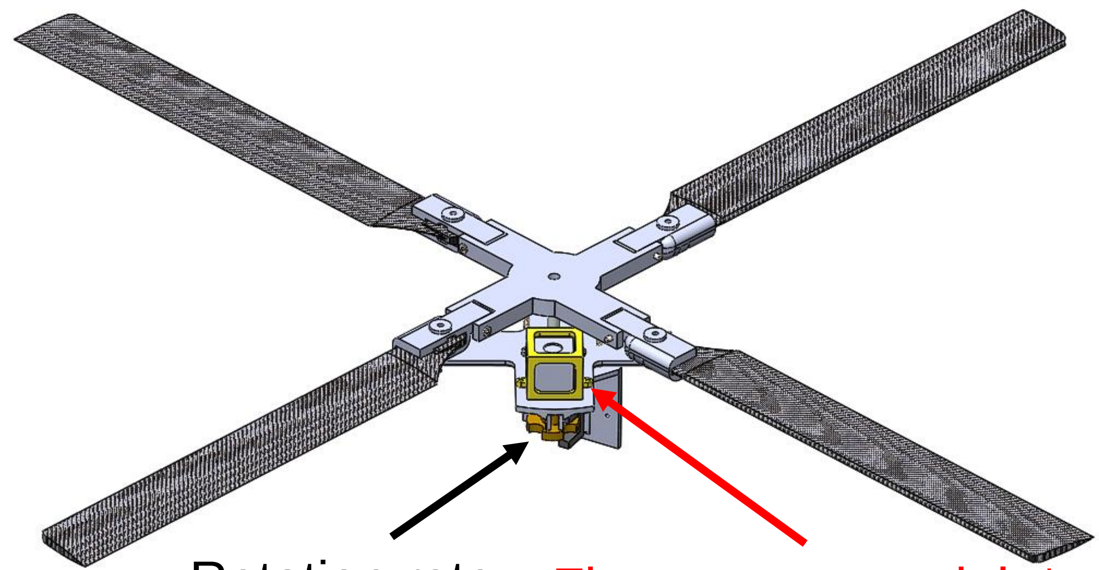


CanSat Mechanical Layout of Components (9/11)



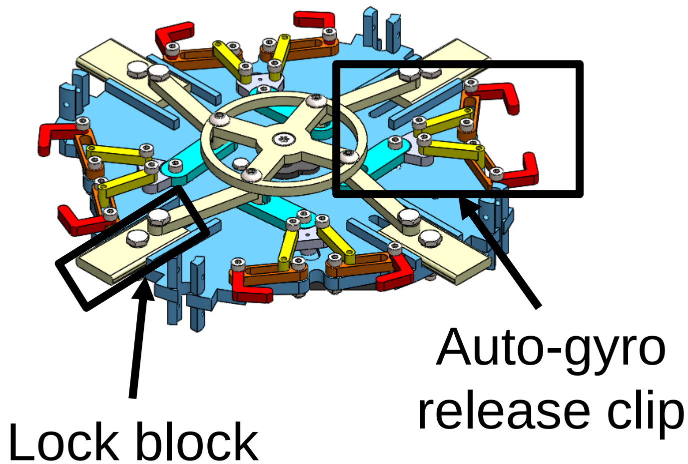
CanSat Mechanical Layout of Components (10/11)

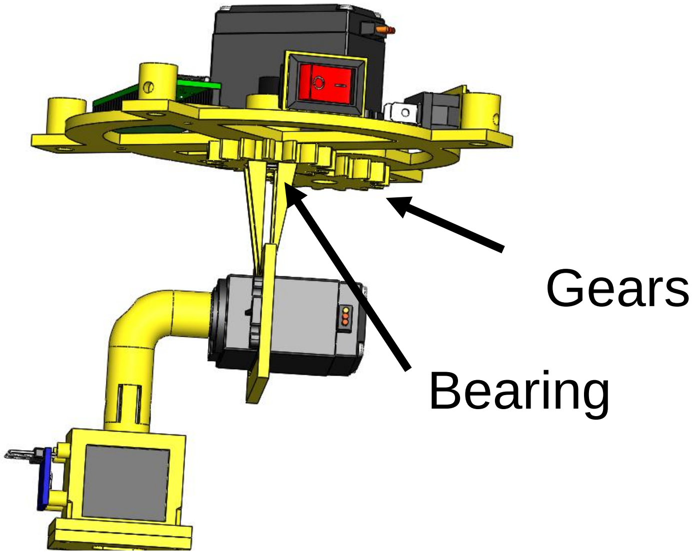


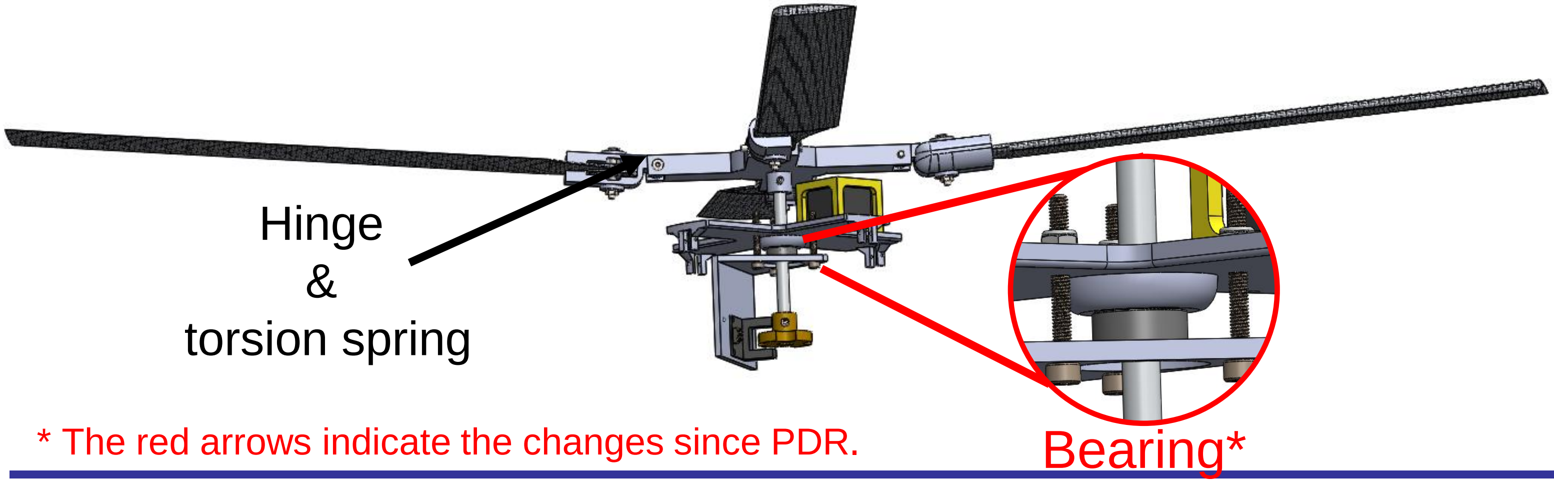


* The red arrows indicate the changes since PDR.

CanSat Mechanical Layout of Components (11/11)



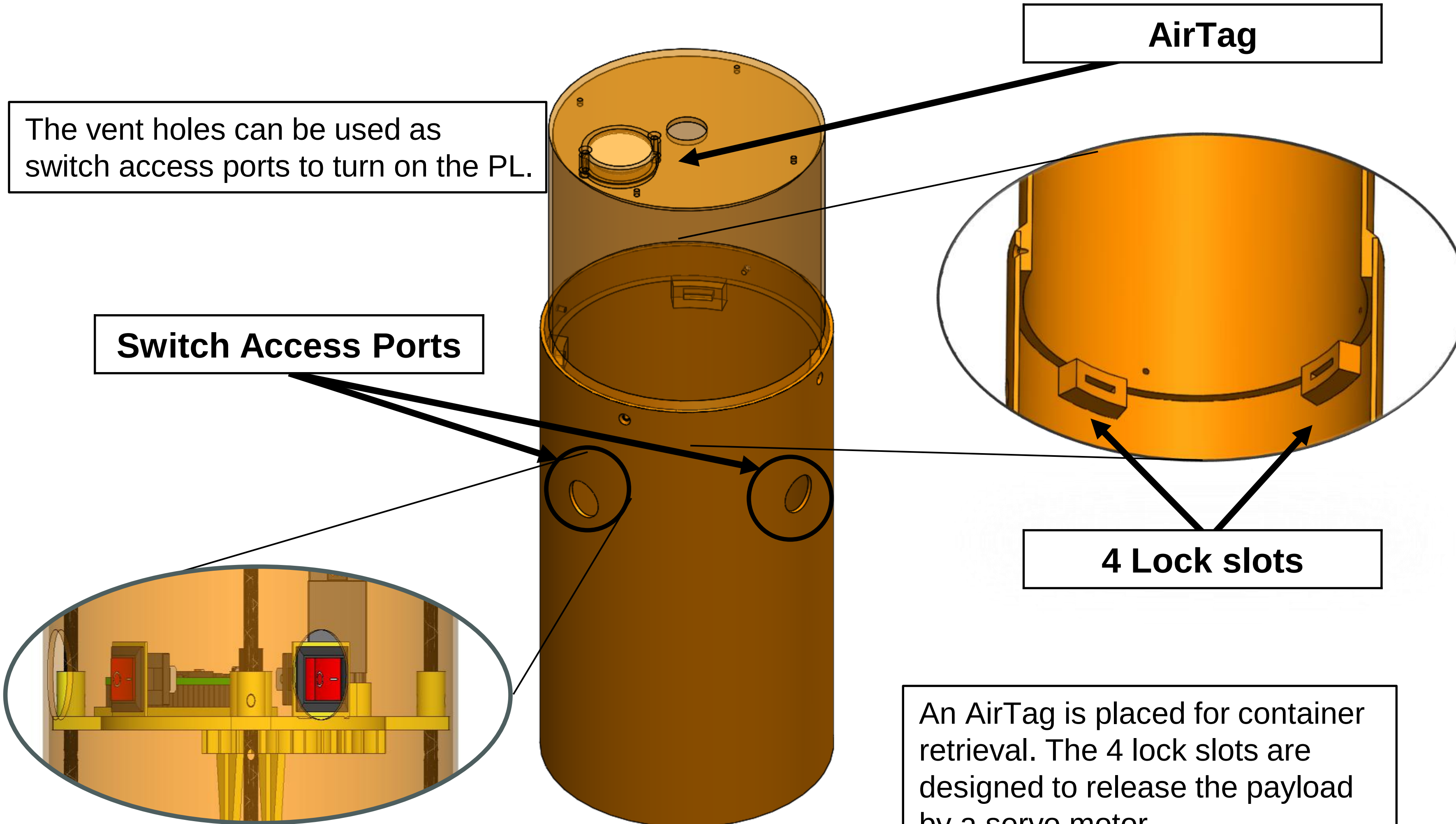




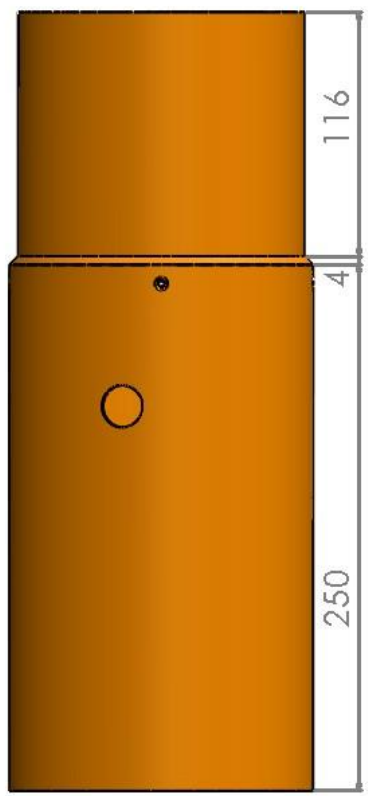
* The red arrows indicate the changes since PDR.

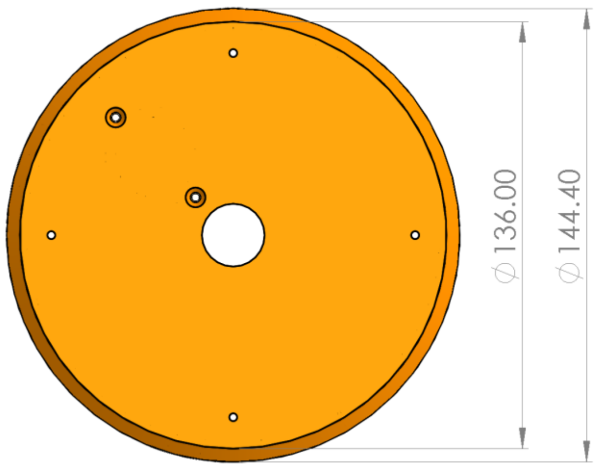
Container Design (1/2)

The vent holes can be used as switch access ports to turn on the PL.



An AirTag is placed for container retrieval. The 4 lock slots are designed to release the payload by a servo motor.

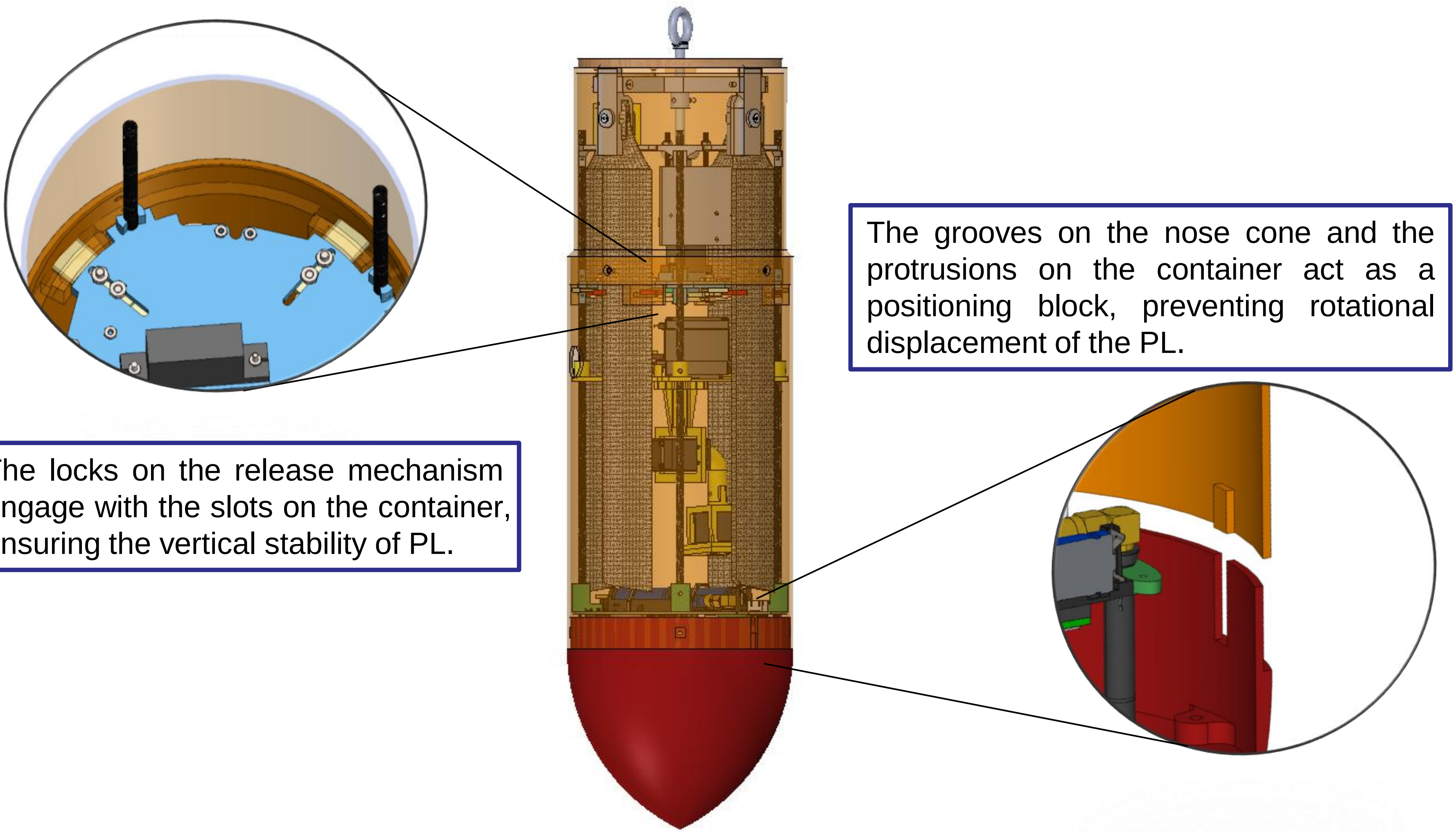




Unit: mm

The container shoulder has a diameter of 136mm to ensure that it can fit into the rocket appropriately. Container is made of PLA+.

Payload Pre-Deployment Configuration (1/2)

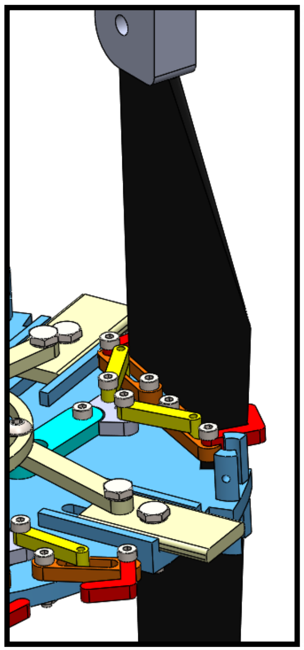


The locks on the release mechanism engage with the slots on the container, ensuring the vertical stability of PL.

The grooves on the nose cone and the protrusions on the container act as a positioning block, preventing rotational displacement of the PL.

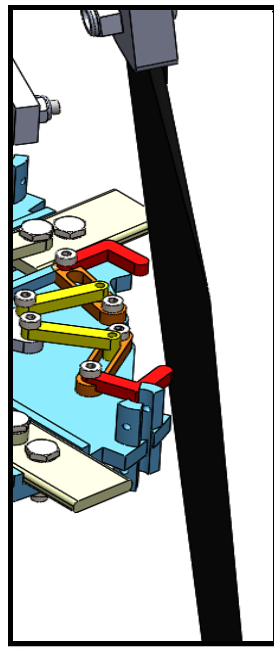
Payload Pre-Deployment Configuration (2/2)

- **Stowed position explanation:**

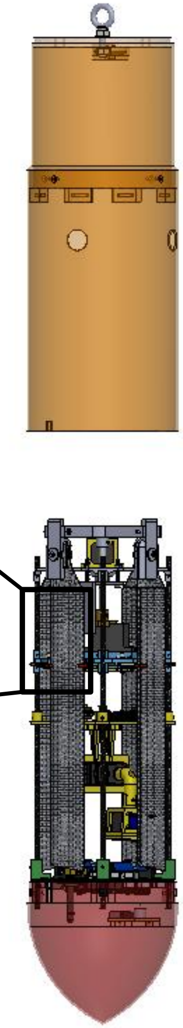


Locked

After separate from container

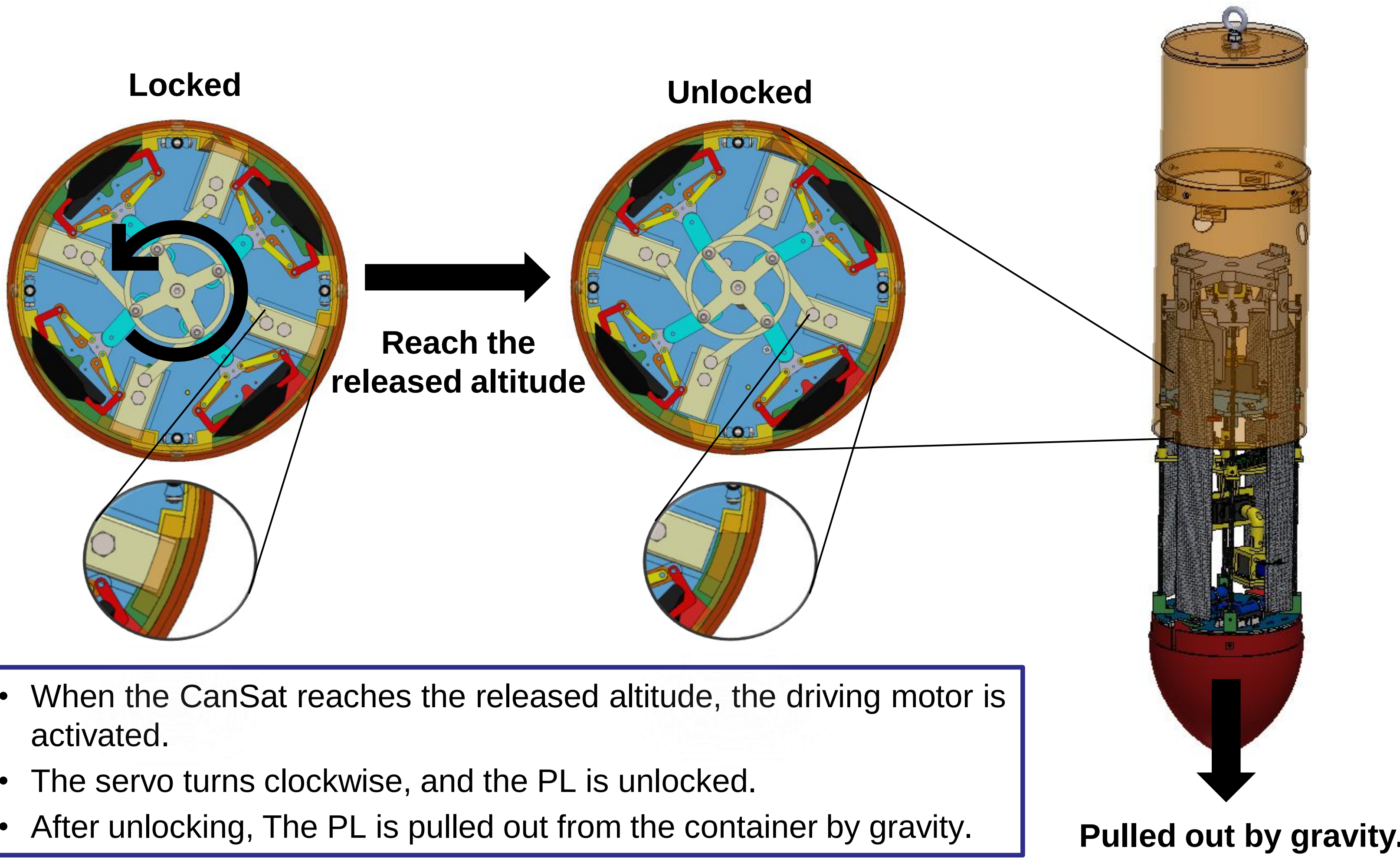


Unlocked



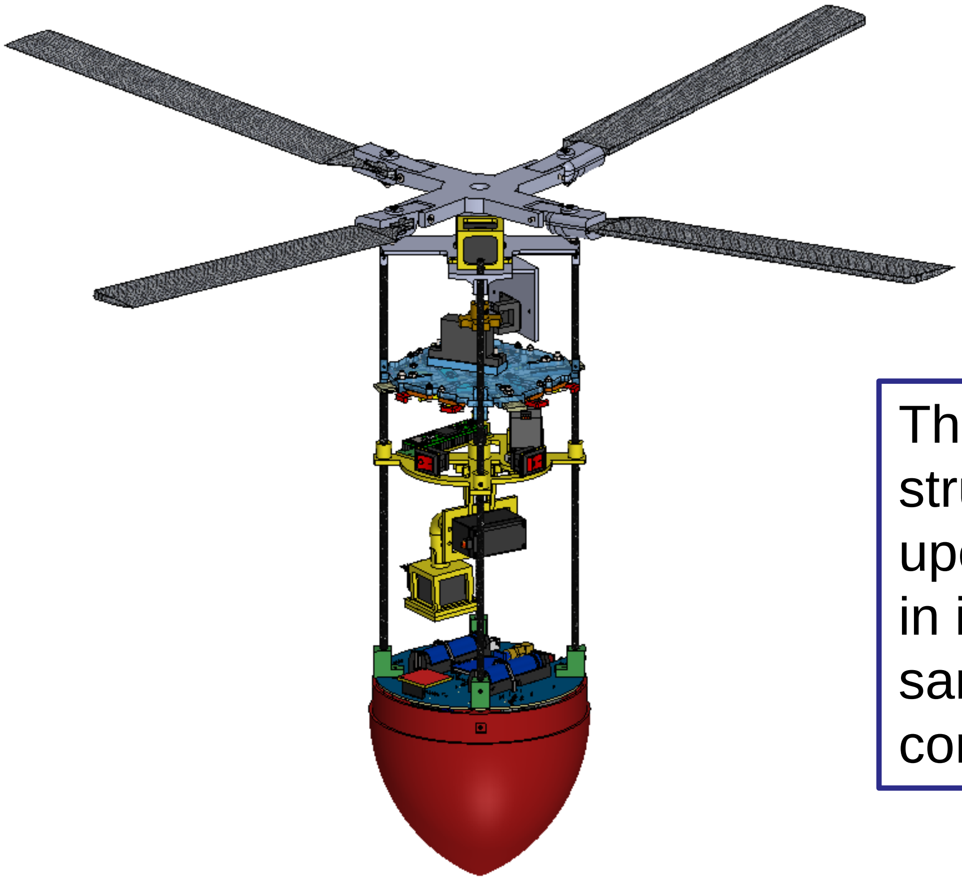
Since the torsion spring has a self-recovery capability, a gripper is placed to hold the PL in the stowed position.

Payload Release



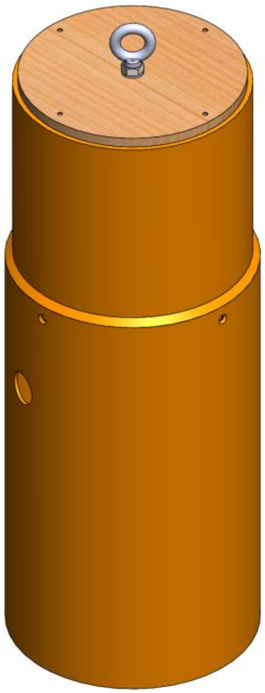
- When the CanSat reaches the released altitude, the driving motor is activated.
- The servo turns clockwise, and the PL is unlocked.
- After unlocking, The PL is pulled out from the container by gravity.

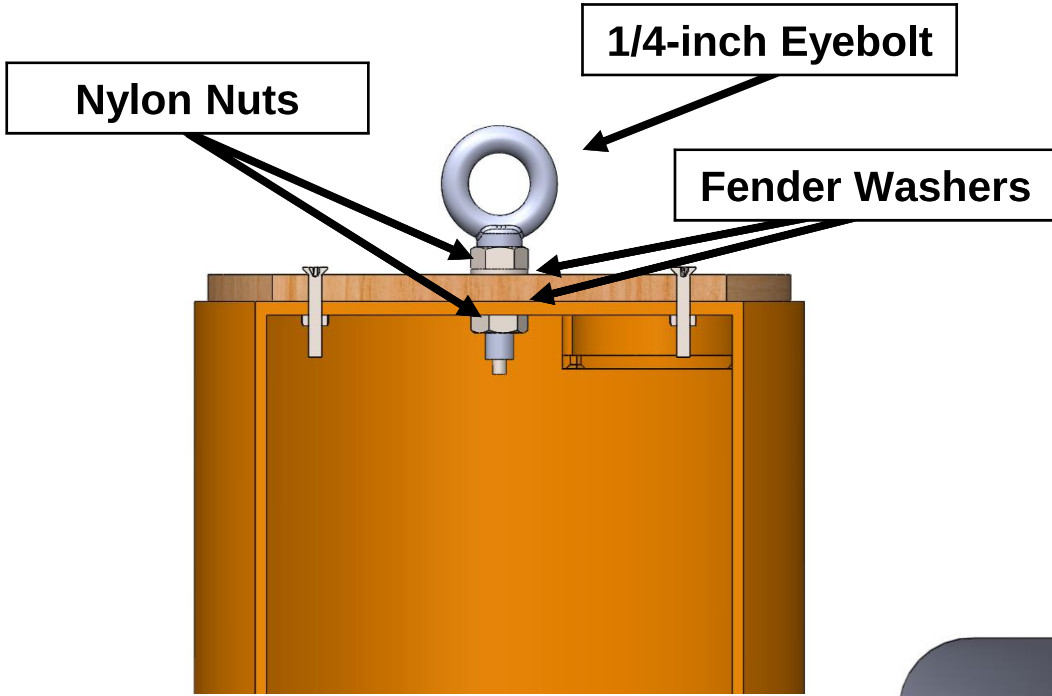
Payload Deployment Configuration



There are no mechanisms or structural changes in the payload upon release. The payload remains in its original configuration, the same as when it is inside the container.

Parachute Attachment to Container

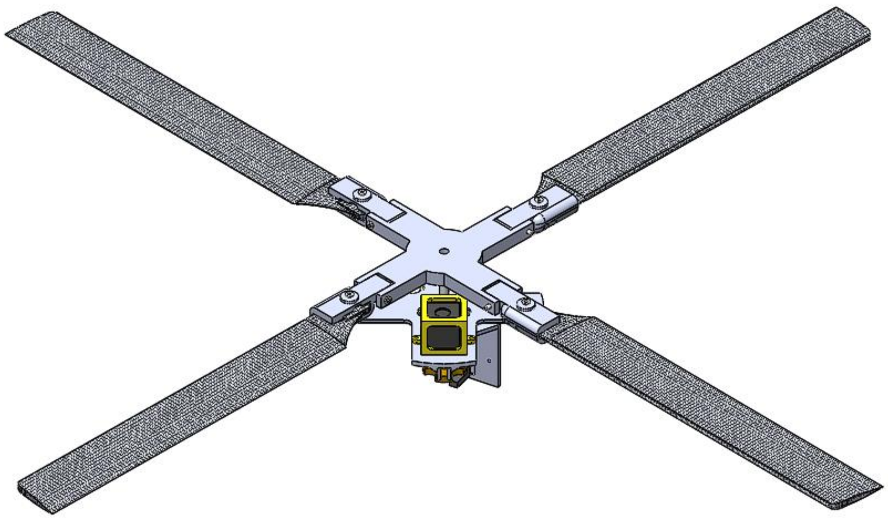




Insert a 1/4-inch eyebolt through the plywood, then use fender washers and nylon nuts to firmly secure the eyebolt to a wooden disc at the base of the container.

Unit : inch

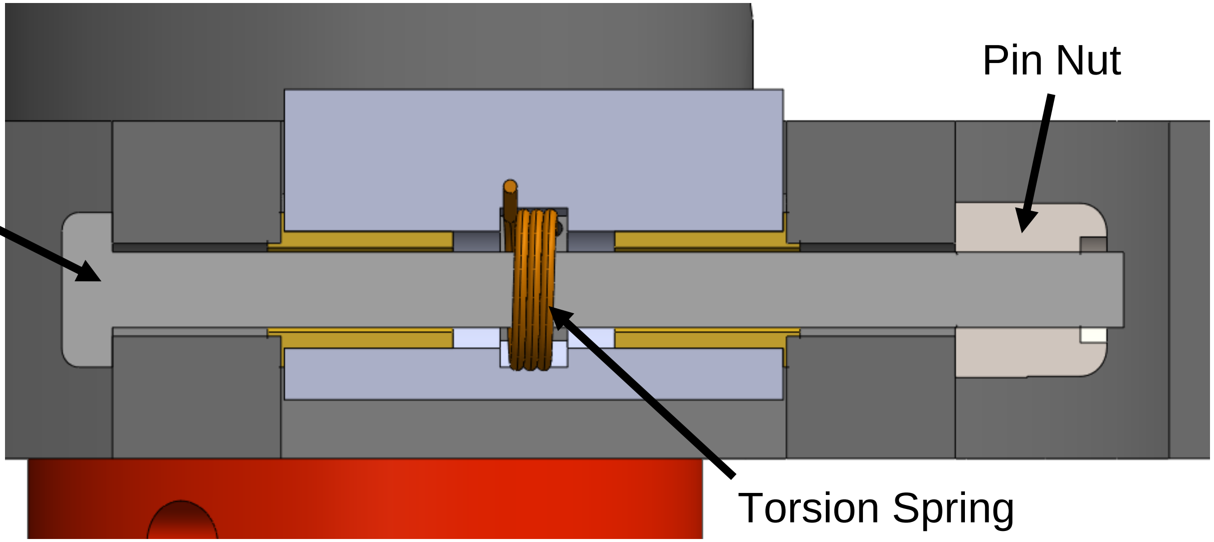
- **Auto-gyro module**

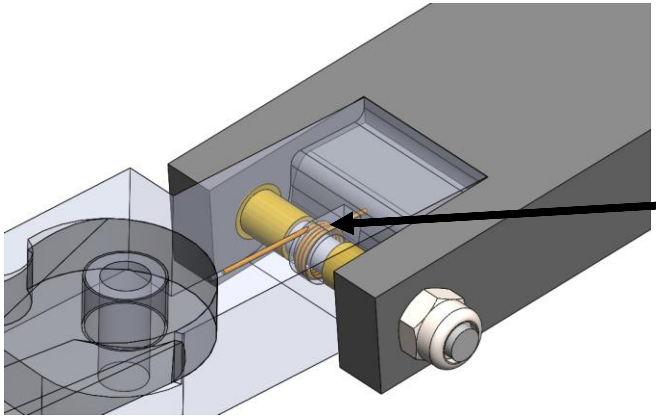


CAD

Prototype

- **Auto-gyro deployment configuration: Hinge& Torsion Spring**



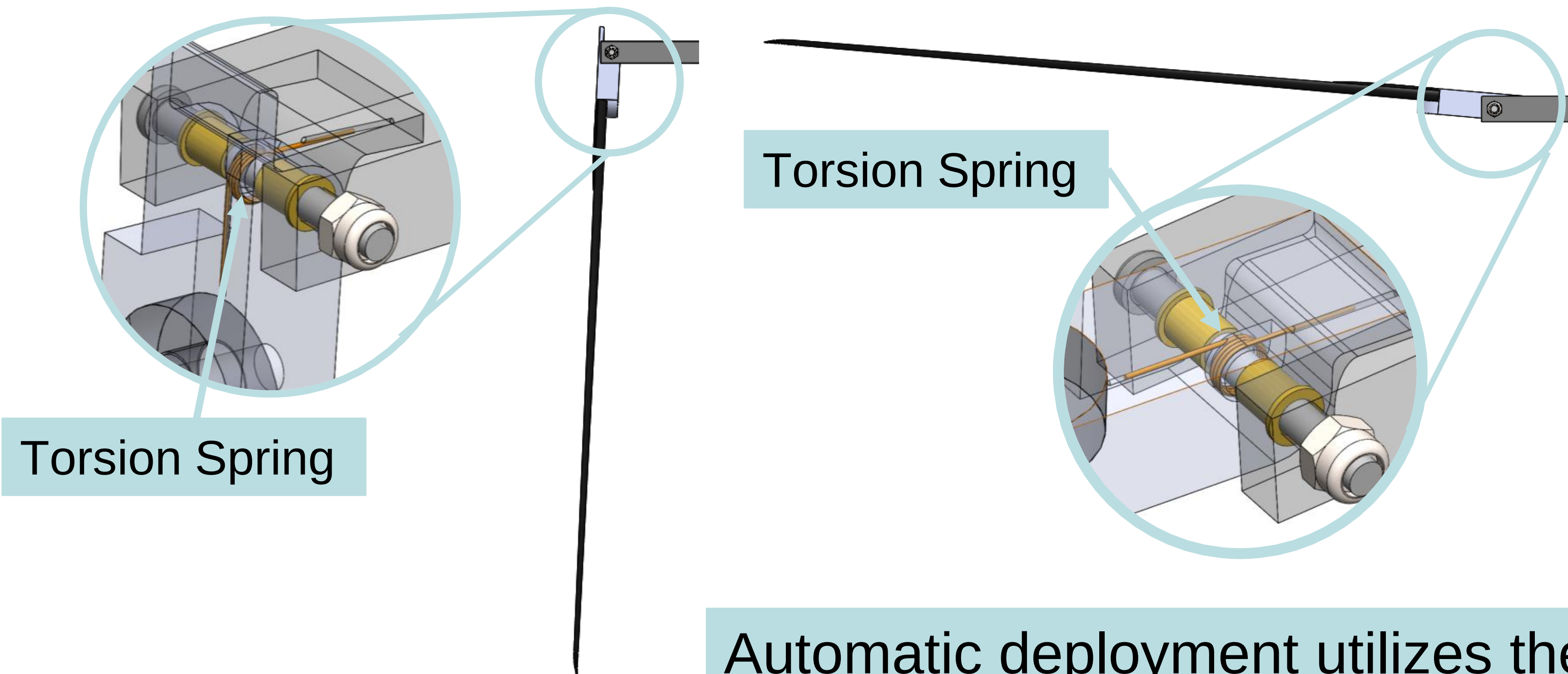


A **180-degree torsion spring** is selected as the deployment configuration for the auto-gyro.

- **Auto-gyro deployment configuration**

Stage1: Stowed in the container

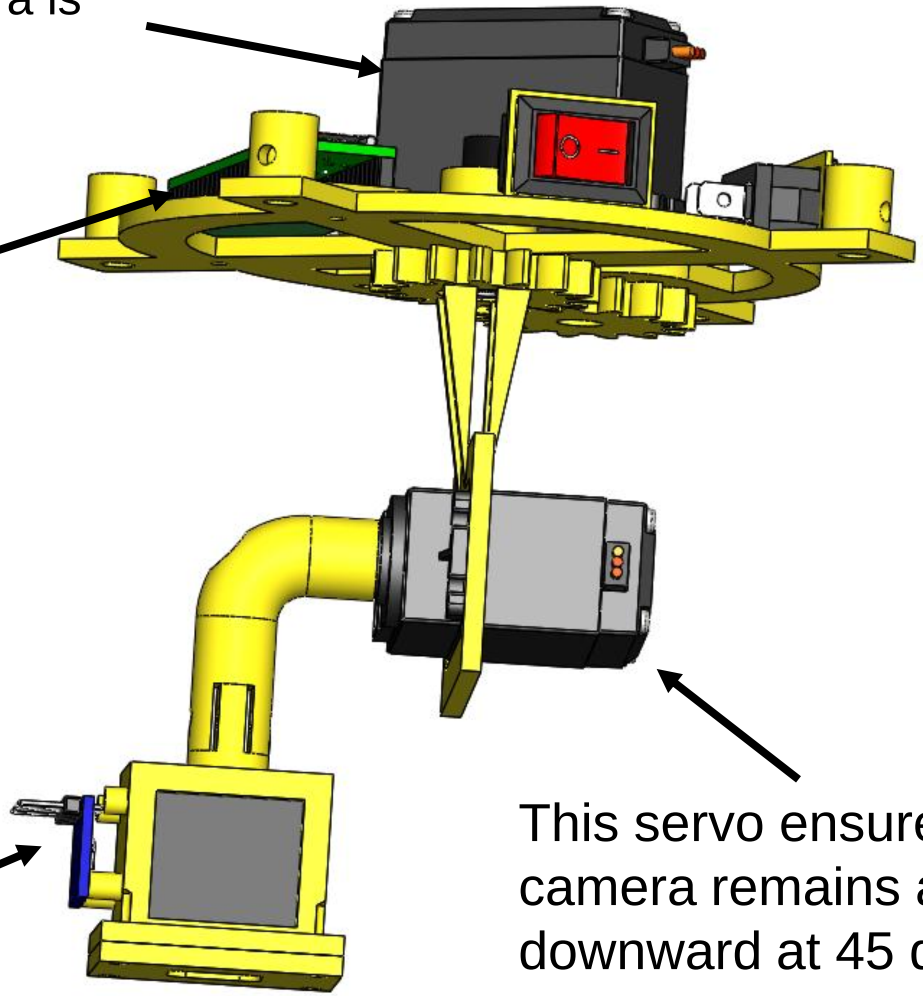
Stage2: During the deceleration



Automatic deployment utilizes the rebound force of the torsion spring

This servo ensures that the camera is controlled to point north.

GPOC MCU

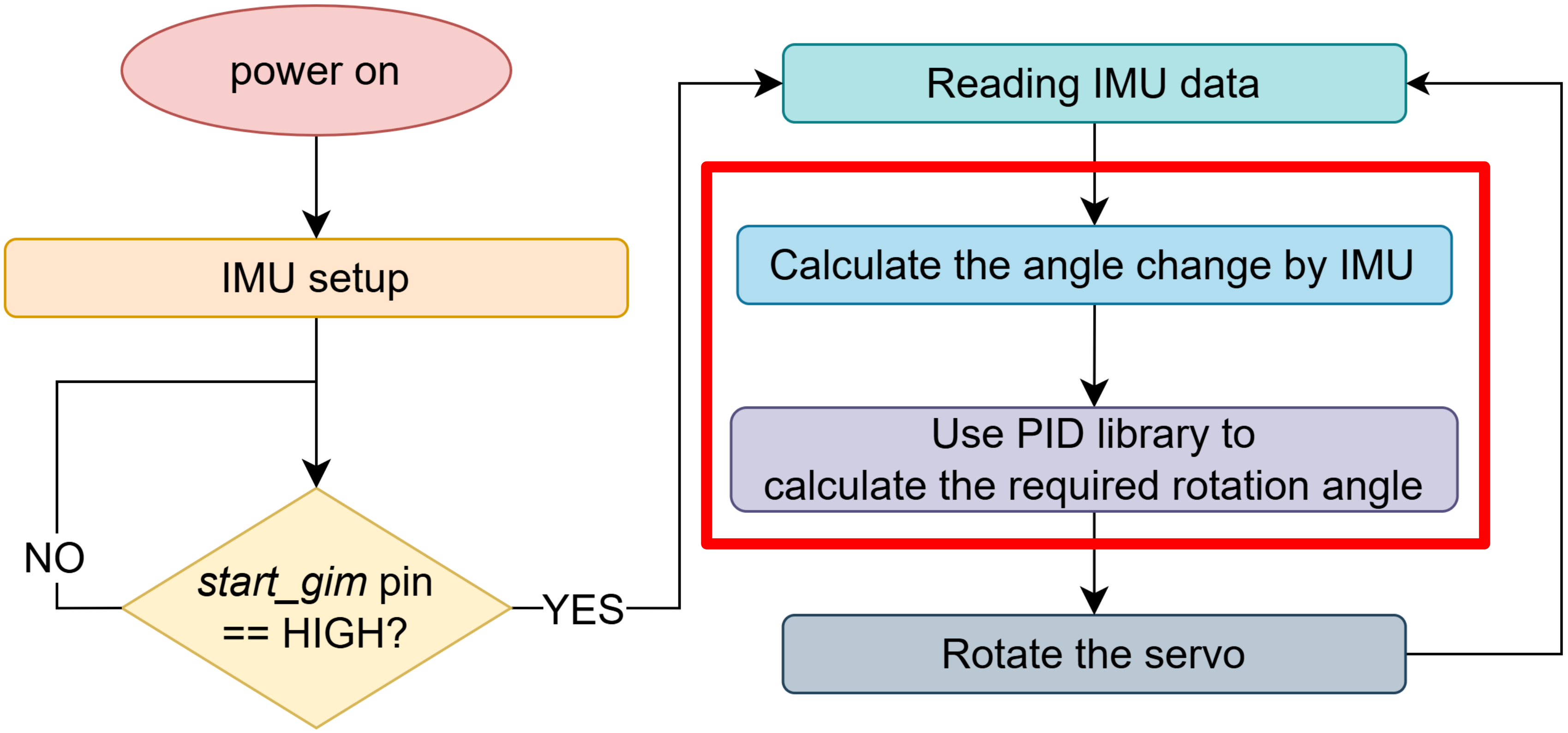


The orientation of the GPOC is determined by the onboard IMU.

This servo ensures the camera remains angled downward at 45 degrees.

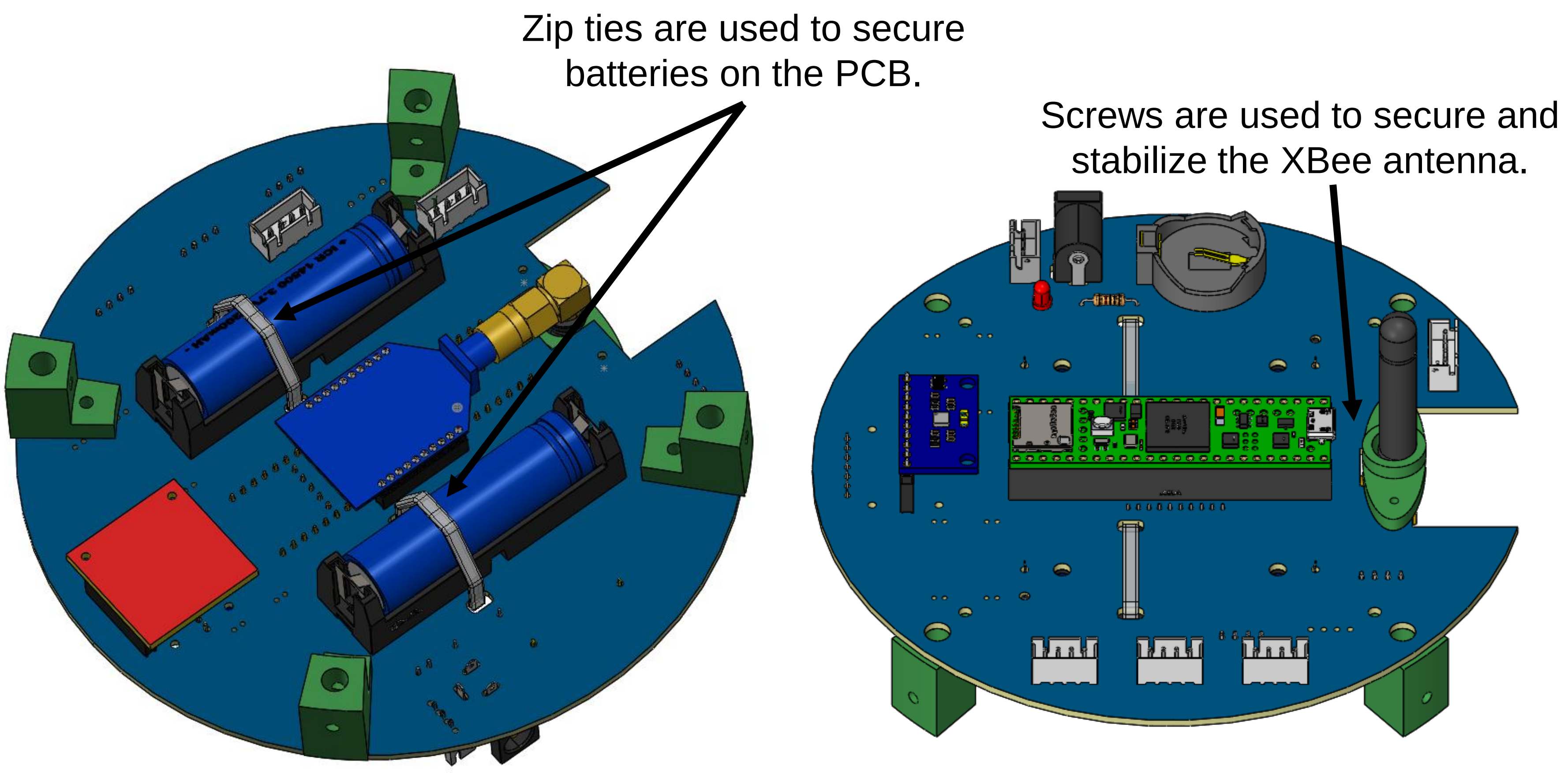
Ground Camera Pointing (2/2)

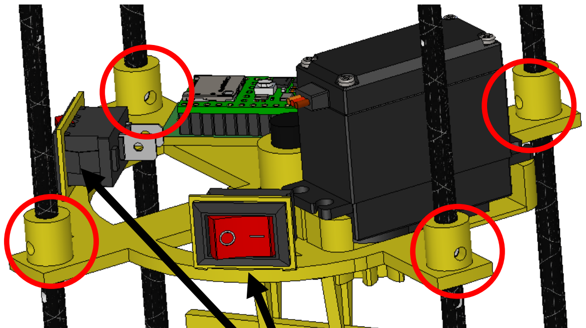
- **Algorithm:**



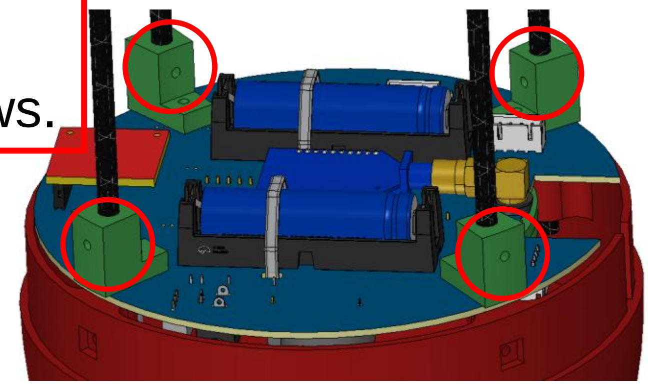
* The red frames indicate the changes since PDR.

Structure Survivability (1/2)

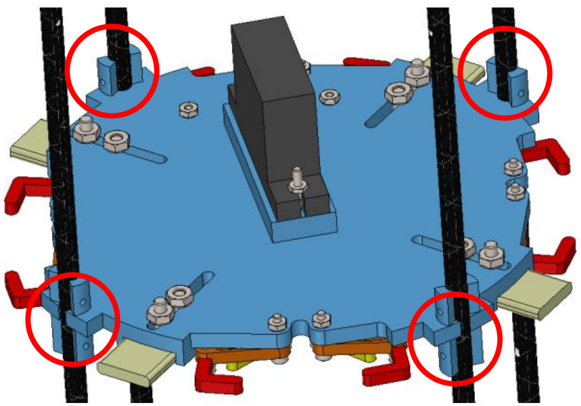


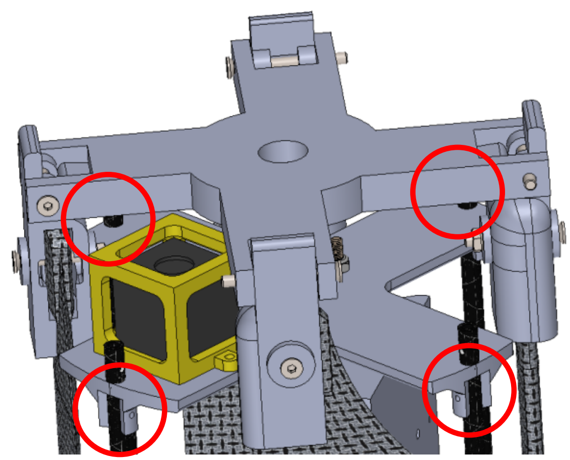


All components are fastened to the main structure by using screws.



High-pressing force switches are chosen to prevent accidental shutdown.





Mass Budget (1/12)

Electronics Mass Budget (1/2)					
Components	**Model**	**Mass (g)**	**Quantity**	**Summary (g)**	**Source**
MCU	Teensy 4.1	8.7	2	17.4 ± 0.2	Measurement
P&T Sensor	BMP581	2.9	1	2.9 ± 0.1	
Tilt & Camera orientation Sensor	MPU9250	2.3	2	4.6 ± 0.2	
GNSS Receiver	LS20031	13	1	13 ± 0.1	
Camera	SQ11	10.5	2	21 ± 0.2	
Micro SD card	SanDisk Ultra Micro SDHC UHS-I C10 32GB	0.2	2	0.4 ± 0.2	
RF Module	XBee S3B PRO	6.7	1	6.7 ± 0.1	
Antenna	ANT-916-CW-RCS	8.3	1	8.3 ± 0.1	

Mass Budget (2/12)

Electronics Mass Budget (2/2)					
Components	**Model**	**Mass (g)**	**Quantity**	**Summary (g)**	**Source**
Battery + Battery Holder	Vapcell L10 ICR14500	24	2	48 ± 0.2	Measurement
Coin Battery + Battery Holder	CR2032	3.9	2	7.8 ± 0.2	
Rotation rate sensor	FC-33	2.4	1	2.4 ± 0.1	
Audio Beacon	CMI-1210-5-95T	1.8	1	1.8 ± 0.1	
Servo	ES08MAII	20	2	40 ± 0.2	
Servo	SER0053	9.7	1	9.7 ± 0.1	
Tracker	AirTag	11.3	1	11.3 ± 0.1	
Switch	E44145	6.2	2	12.4 ± 0.2	
DC-DC converter	HW-133B	2.8	2	5.6 ± 0.2	

Electronics Total Mass	**213.3 ± 2.6 g**

Mass Budget (3/12)

Mechanical Mass Budget (1/7)						
Modules	**Component**	**Material**	**Mass (g)**	**Quantity**	**Summary (g)**	**Source**
Nose cone	Nose cone	PETG	135.0	1	135.0 ± 6.8	Analysis
	Carbon fiber bar	Carbon fiber	0.0183/mm	1340mm	24.5 ± 0.1	Measurement
Container	Container main part	PLA+	237.3	1	237.3 ± 11.9	Analysis (Uncertainty due to 3D printing)
	Container shoulder	PLA+	174.4	1	174.4 ± 8.7	
	Plywood disk	Plywood	62	1	62 ± 0.1	Measurement
	AirTag cover	PETG	2.7	1	2.7 ± 0.1	
	Eyebolt	SS400	2.1	1	2.1 ± 0.1	
	Parachute	Nylon	5.5	1	5.5 ± 0.1	
Electronics structure	PCB holder	PETG	2.1	4	8.4 ± 0.4	Analysis

Mass Budget (4/12)

Mechanical Mass Budget (2/7)						
Module	**Component**	**Material**	**Mass (g)**	**Quantity**	**Summar (g)**	**Source**
GPOC	Main Gear	PETG	6.9	1	6.9 ± 0.4	Analysis (Uncertainty due to 3D printing)
	Second Camera box		8.7	1	8.7 ± 0.4	
	Second Camera cover		2	1	2 ± 0.2	
	Rotary connector holder		0.4	1	0.4 ± 0.1	
	GPOC bearing		3.5	1	3.5 ± 0.1	
	Second axis		3.3	1	3.3 ± 0.2	
	Transmission Gear		2.9	1	2.9 ± 0.2	
	GPOC base		22.7	1	22.7 ± 1.1	

Mass Budget (5/12)

Mechanical Mass Budget (3/7)						
Modules	Component	Material	Mass (g)	Quantity	Summary (g)	Source
Release module	First Camera cover	PETG	4.1	1	4.1 ± 0.2	Analysis (Uncertainty due to 3D printing)
	Base plate		28	1	28 ± 1.4	
	Lock block		1.3	4	5.2 ± 0.3	
	Link rod		0.6	4	2.4 ± 0.1	
	Spin disc		2.8	1	2.8 ± 0.1	
	Gripper_link1		0.6	4	2.4 ± 0.1	
	Gripper_link2		0.2	8	1.6 ± 0.1	
	Gripper_link3		0.3	8	2.4 ± 0.1	
	Gripper_link4		0.3	8	2.4 ± 0.1	
	Gripper_slide		0.6	4	2.4 ± 0.1	

Mass Budget (6/12)

Mechanical Mass Budget (4/7)						
Modules	**Component**	**Material**	**Mass (g)**	**Quantity**	**Summary (g)**	**Source**
Auto-gyro	Base hub	PETG	16.8	1	16.8 ± 0.8	Analysis (Uncertainty due to 3D printing)
	Blade shaft		7.0	4	28.0 ± 1.4	
	Hub4		19	1	19 ± 1.0	
	Speed disk		3.6	1	3.6 ± 0.2	
	Top hub		12.0	1	12.0 ± 0.6	
	Fixmainshaft	aluminum	5.2	1	5.2 ± 0.1	Measurement
	Mainshaft	Steel	25.3	1	25.3 ± 0.1	
	Ball bearing	Sheet metal	3.5	1	3.5 ± 0.1	
	Blade	Carbon fiber	20	4	80 ± 0.4	
	Hinge pin	Steel	1.6	4	6.4 ± 0.4	
	Torsion spring	Stainless Steel	0.8	4	3.2 ± 0.4	

Mass Budget (7/12)

Mechanical Mass Budget (5/7)						
Modules	**Component**	**Material**	**Mass (g)**	**Quantity**	**Summary (g)**	**Source**
Fastener	M1.6 × 8 Flat Head Screw	Aluminum	0.2	4	0.8 ± 0.04	Measurement
	M2 × 4 Flat Head Screw		0.16	12	1.92 ± 0.12	
	M2 × 5 Flat Head Screw		0.16	8	1.28 ± 0.08	
	M2 × 10 Flat Head Screw		0.2	8	1.6 ± 0.08	
	M2 × 12 Flat Head Screw		0.2	23	4.6 ± 0.23	
	M2 × 20 Flat Head Screw		0.26	3	0.78 ± 0.03	
	M3 × 6 Flat Head Screw		0.22	8	1.76 ± 0.08	
	M3 × 8 Flat Head Screw		0.24	1	0.24 ± 0.01	

Mass Budget (8/12)

Mechanical Mass Budget (6/7)						
Modules	**Component**	**Material**	**Mass (g)**	**Quantity**	**Summary (g)**	**Source**
Fastener	M3 × 12 Flat Head Screw	Aluminum	0.24	8	1.92 ± 0.08	Measurement
	M3 × 16 Flat Head Screw		0.3	50	15 ± 0.5	
	M3 × 25 Flat Head Screw		0.3	3	0.9 ± 0.03	
	M2.5 × 5 Flat Head Screw		0.2	4	0.8 ± 0.04	
	M4 × 6 Flat Head Screw		0.2	2	0.4 ± 0.02	
	M4 × 12 Flat Head Screw		0.3	2	0.6 ± 0.02	
	¼-inch Nylon Nut		0.8	2	1.6 ± 0.02	
	¼-inch Fender Washer		0.2	2	0.4 ± 0.02	

Mass Budget (9/12)

Mechanical Mass Budget (7/7)						
Modules	**Component**	**Material**	**Mass (g)**	**Quantity**	**Summary (g)**	**Source**
Fastener	M2 Lock Nut	Aluminum	0.2	44	8.8 ± 4.4	Measurement
	M3 Lock Nut		0.5	30	15.0 ± 3	
	M3 Washer		0.04	4	0.16 ± 0.4	

Mechanical Total mass	**1017.56 ± 48.3 g**

Mass Budget (10/12)

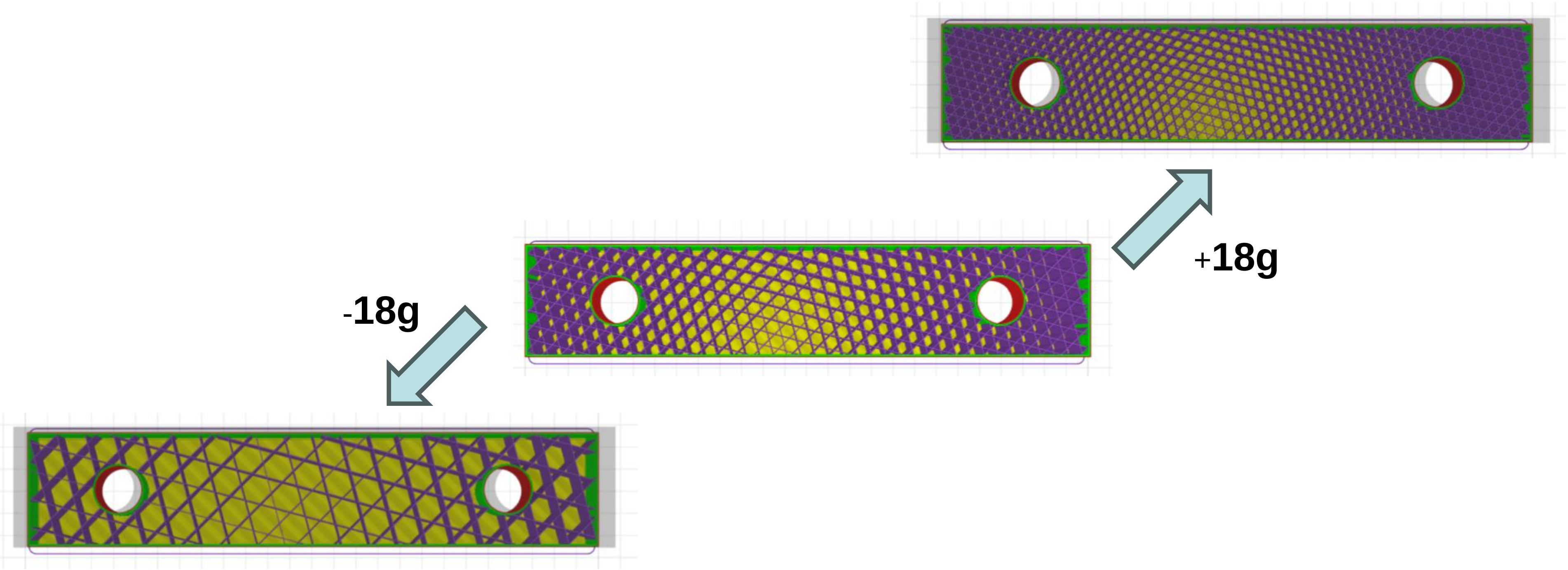
CanSat Mass Budget (1/1)		
Subsystem	**Component**	**Mass (g)**
Electronics	All components	213.3 ± 2.6
Mechanical	Electronics structural	8.4 ± 0.4
	Nose cone	159.5 ± 6.9
	Container	484 ± 21
	Ground Pointing and Orientation Camera	50.4 ± 2.7
	Release module	53.7 ± 2.6
	Auto-gyro	203 ± 5.5
	Fastener	58.56 ± 9.2

Total mass	1230.86 ± 50.9 g
Margin	1410 – 1230.86 ± 50.9 = **128.54g ~ 230.34g**

Correction Method

<u>If the overall weight is larger than the mass requirement</u>

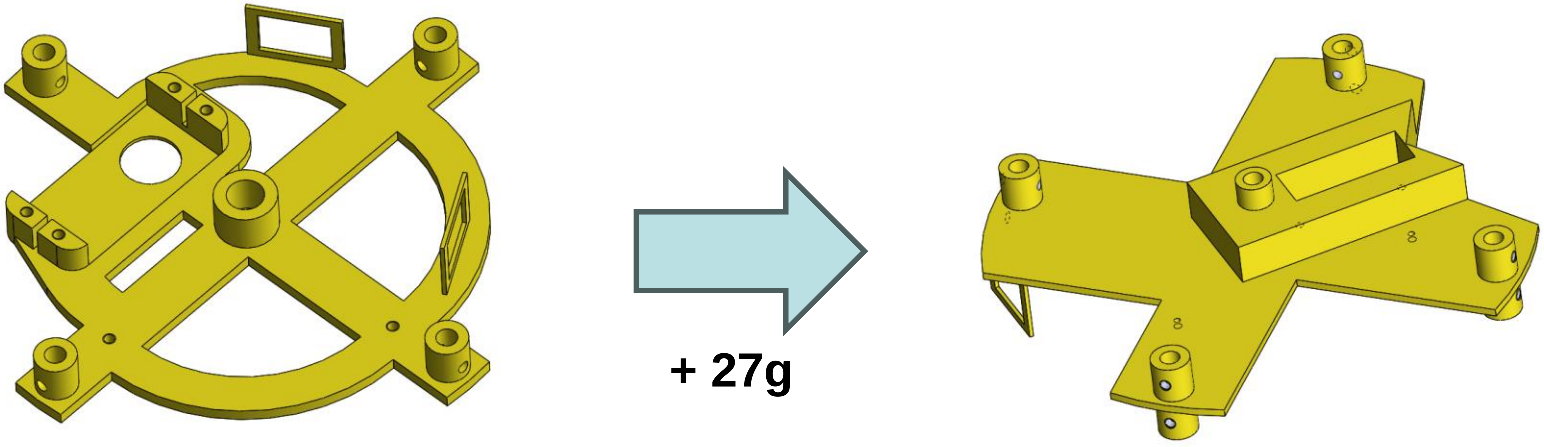
- Decrease the infill percentage on 3D-printed components.
- Replace screws with super glue at components that don’t experience large force.
- Simplify the overall structure by eliminating the reductant structure.



Correction Method

<u>If the overall weight is less than the mass requirement</u>

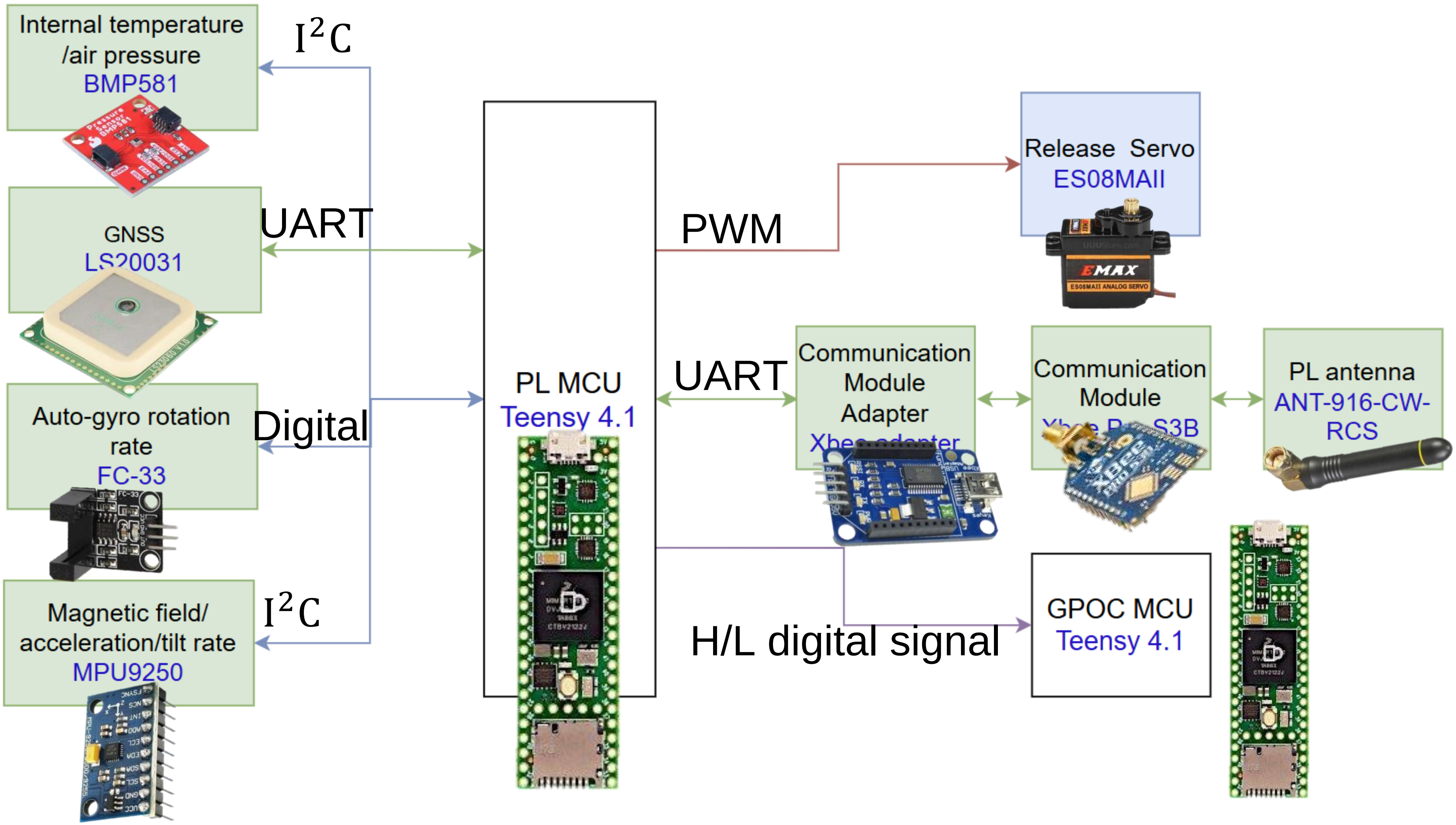
- Increase the infill percentage on 3D-printed components.
- Increase the thickness of 3D-printed components.
- Increase the thickness of paramount structure in CanSat.
- Increase weight into the nose cone (3D-printed parts).



Communication and Data Handling (CDH) Subsystem Design

Guan-Chang Chen

Payload Command Data Handler (CDH) Overview



CDH Changes Since PDR

Changes	PDR	CDR	Rationale
IMU	ICM20948	MPU9250	• Heritage • Better stability • ICM failed frequently during test
GNSS	LS2003E-G	LS20031	• Heritage • 0.1” pitch, easier for soldering

ICM-20948

MPU9250

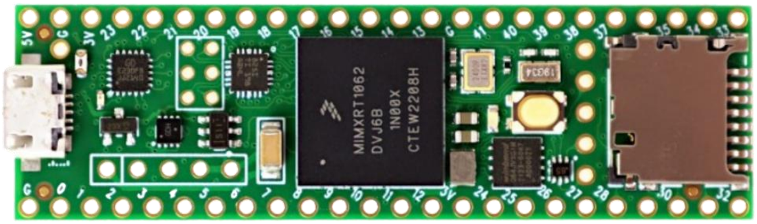
LS2003E-G

LS20031

Payload Processor & Memory 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)**
Teensy 4.1 (Cortex-M7)	4	600	8*UART, 3*SPI, 3*I²C	54	7MB Flash	1023 kB	75×21	40.75

Data Bus Width(bits)	Current (mA)	Voltage (V)	Power Consumption (W)	Reducing CPU speed to 528 MHz or lower reduces power consumption.
64/32	100	3.3	0.33	

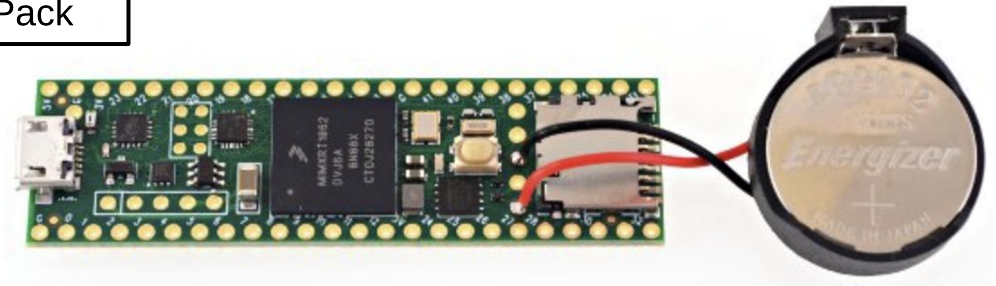


Selected Processor	Rationales
Teensy 4.1	• Heritage • Embedded SD card socket • Most useable ports • Tiny size

Payload Real-Time Clock

Real-Time Clock Trade					
Model	Oscillator (kHz)	Power	Weight(g)	Dimensions (mm)	Cost (USD)
Teensy 4.1embedded	32.768	External battery	4g*	24×7*	1*

*NOTE: Battery Pack



CR2032 Coin Cell connected to VBAT allows Teensy 4.1 to keep date / time while power is off

An external CR2032 coin cell battery is used to provide independent power for RTC operation.

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

Payload Antenna Selection

Antenna Trade						
Model	**Dimension (mm)**	**Gain (dB)**	**Pattern**	**Frequency Range (MHZ)**	**Weight (g)**	**Cost (USD)**
ANT-916-CW-RCS	53.5 x 9.4 x 8	3.3	Omnidirectional	902~930	9	8.81

902 MHZ TO 930 MHZ (915 MHZ)

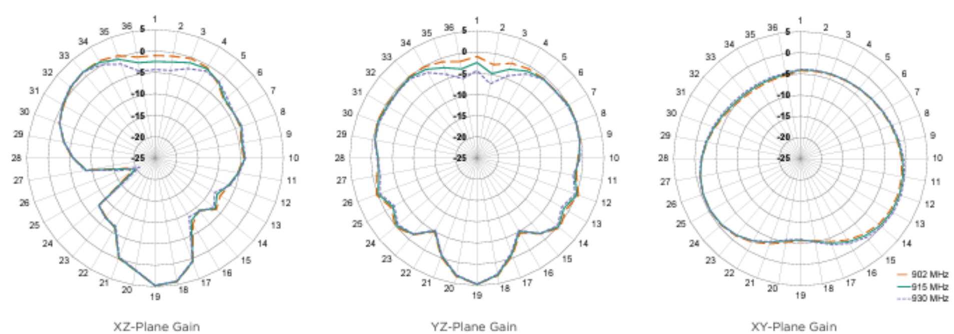


Figure 8. ANT-916-CW-RCS-ccc Radiation Patterns

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

Payload Radio Configuration

Radio Configuration							
Model	**RF Data Rate (kbps)**	**Operating Frequency (MHz)**	**Operating Voltage (V)**	**Operating Current (mA)**	**Sensitivity (dBm)**	**Transmit Power (mW/dBm)**	**Cost (USD)**
XBEE Pro S3B	10/20	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 lands, it stops sending data to the GCS.

The set of XBee modules, including XBee Pro S3B and XBee adapter.

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 mission 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	0.1 gauss
MAG_P	Magnetometer readings in the pitch	gauss	0.1 gauss
MAG_Y	Magnetometer readings in the yaw	gauss	0.1 gauss
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 Design

Fu-Xi Wu

EPS Overview

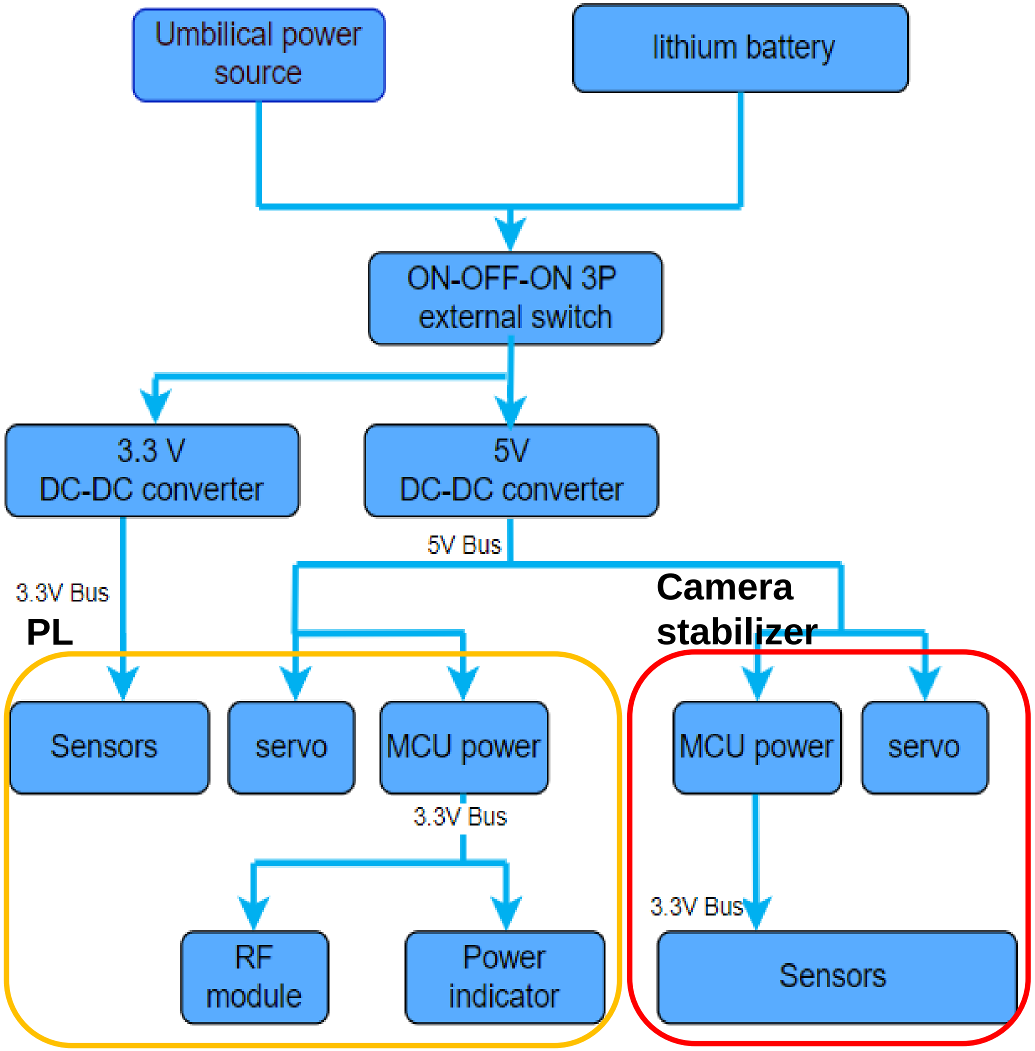
Umbilical power source:
A detachable connector from the batteries that allows the use of an external power source.

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.

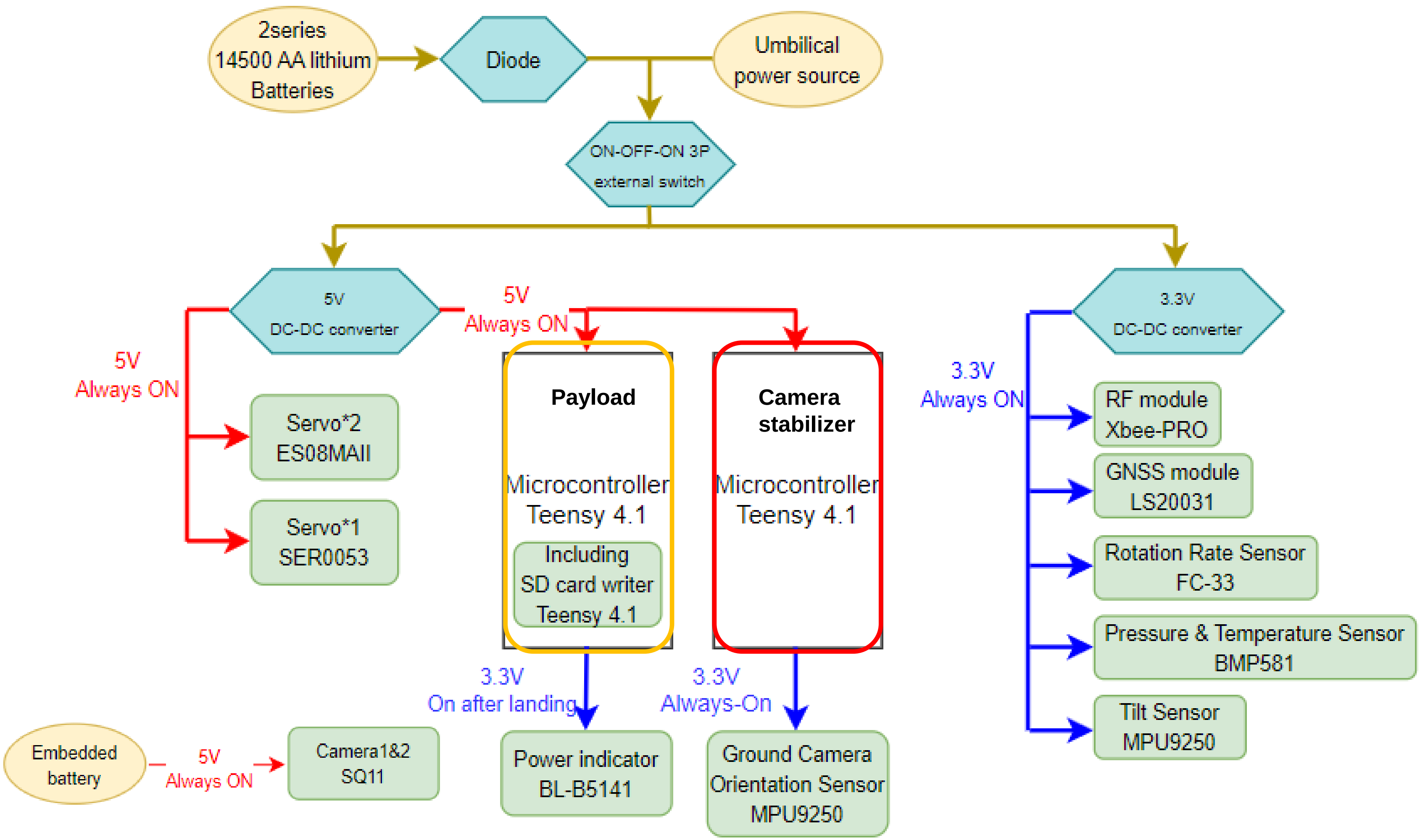
Power indicator:
The power-on indicator



EPS Changes Since PDR

- **The EPS is maintained without change.**
- **Some components are replaced and cause the change in the power budget.**
  - Sensor: ICM20948 → MPU9250
  - Sensor: LS2003E-G → LS20031
  - A servo is reduced.

Payload Electrical Block Diagram

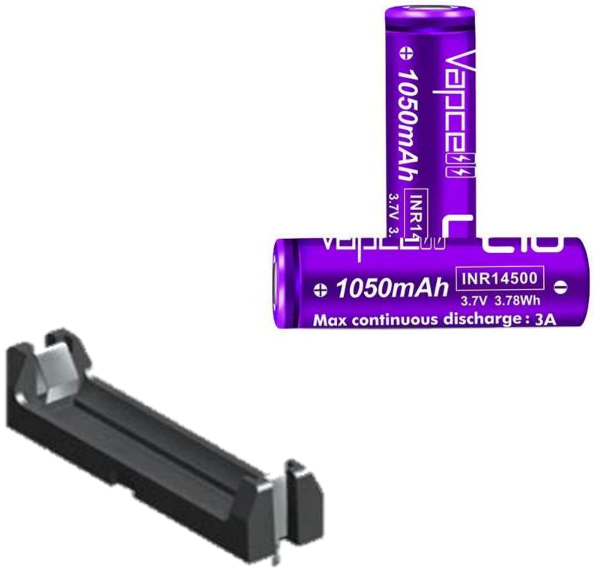


<u>NOTE</u>: The power to all sensors is always-on.

Payload Power Source

Module	Type	Voltage (V)	Capacity (mAh)	Unit Weight (g)	Max Current (A)	Cost (USD)
Vapcell L10 ICR14500	14500 Lithium Battery	3.7	1050	22	3	3.59

ICR14500
Power Source Information: • Batteries supply 7.4 volts • Single battery has a capacity of 1050mAh • The batteries can discharge up to 3A instantly • Batteries are 2 in series (2S1P) • Batteries will be mounted in 14500 battery holders separately 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
MPU9250	3.3	12.21	0.026	2.00	0.00	2	0.048
LS20031	3.3	39.6	0.66	2.00	0.00	1	0.079
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	1	0.09
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)				**3.915**			

- All data come from datasheet, except for ***MPU9250*** 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]	3.915 (-0.207 after PDR)

Margin (%) [(D-E)/D]	19% (+4.2% after PDR)

Flight Software (FSW) Design

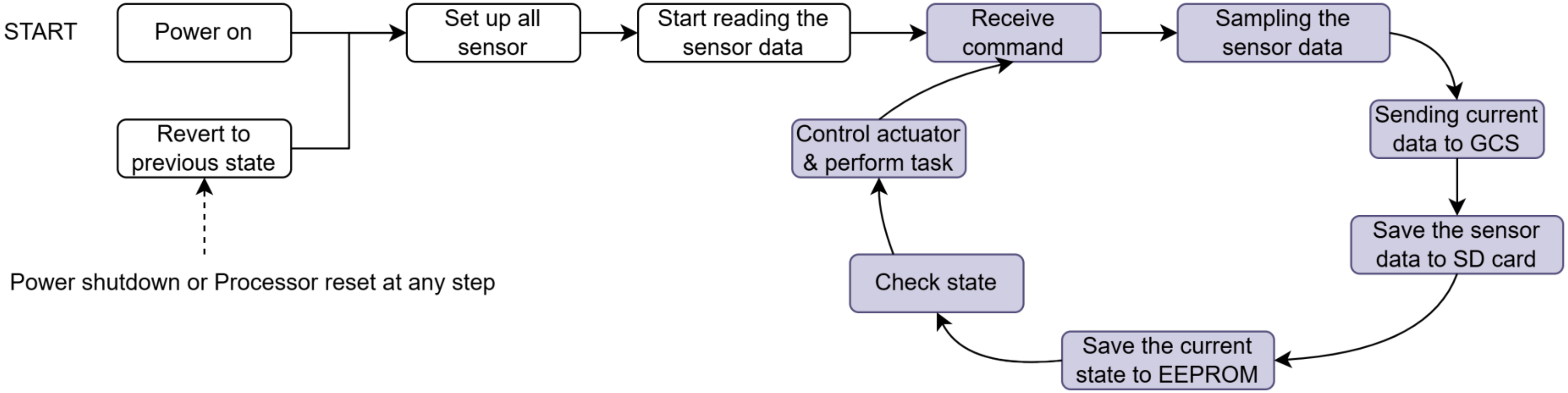
Ting-Tien Cho

FSW Overview (1/3)

- **Functions:**
  - To collect the sensor data
  - To transmit data to the GCS & save in the SD card (on payload)
  - To receive the command from GCS
  - To send signals to actuators according to the command from GCS or sensor data
  - To save the current state in EEPROM to prevent MCU reset or power failure
- **An independent MCU controls the GPOC servo motors.**

Programming languages	Development environments
C	**Arduino IDE**

- **FSW flowchart:**



FSW Overview (3/3)

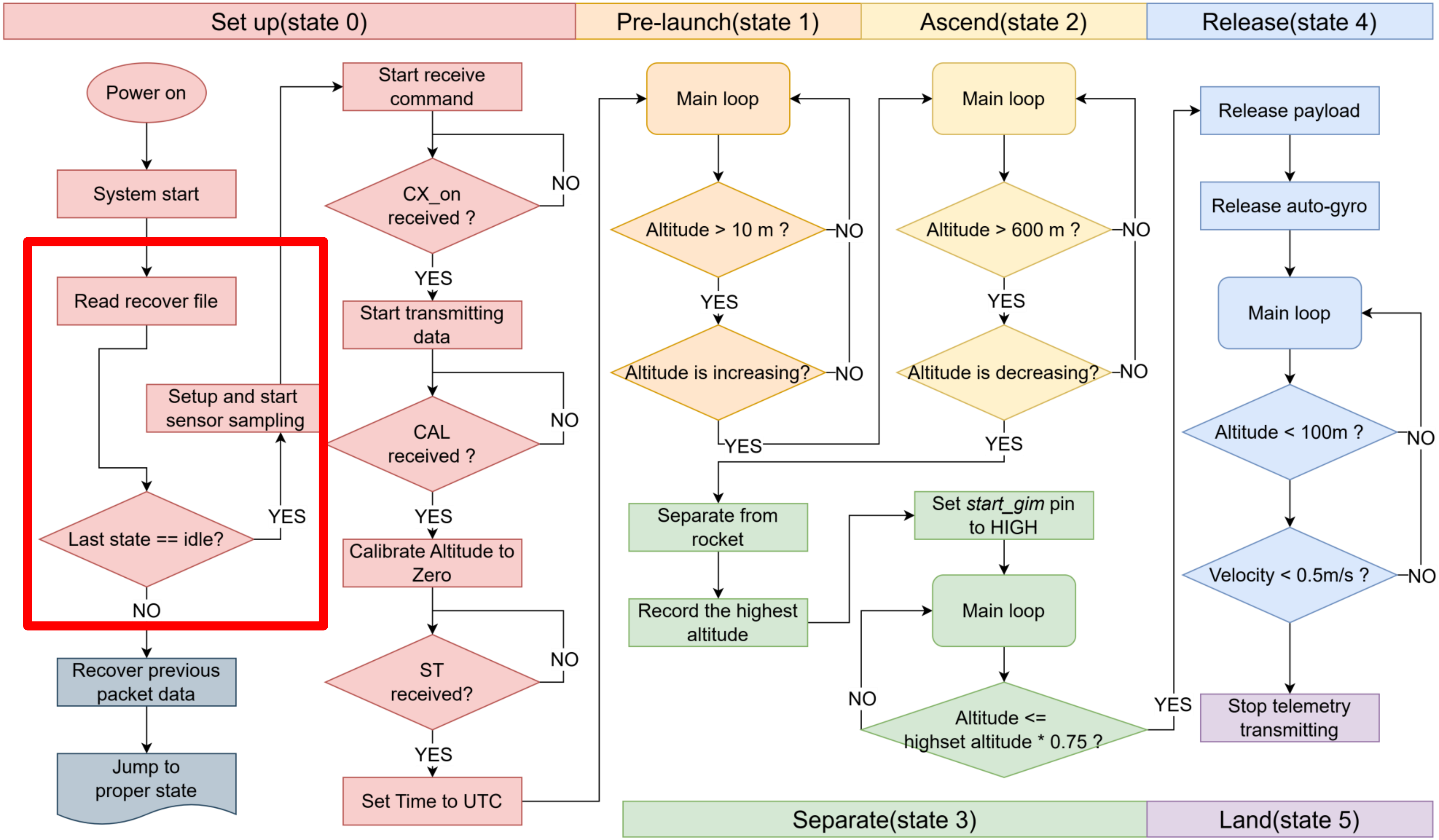
Flight Tasks	
Phase	**Tasks**
Initial	• Read previous saved packet • Boot and configure all sensors • Start transmitting data • Reset reference altitude • Initial MET • Start reading all sensor data
Separate	• Activate the GPOC
Release	• Activate the servo to release PL from container • Release the auto-gyro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

FSW Changes Since PDR

Component	PDR	CDR	Rationale
Software State diagram	First **setup** system states and then read the **recover** data file.	First read the **recover** data file and then **setup** system state.	To correct a flow logic.
GPOC State Diagram	Without **PID** control	Include **PID** control	Using PID control improves the operation and adjustment.
Software Development plan	Gantt chart does not include simulation mode.	Gantt chart **add simulation mode**.	Correction.
Pressure sampling frequency	100 Hz	20 Hz	To reduce MCU load.
Save data frequency	4 Hz	5 Hz	To synchronize all sensors' sampling frequency.

Payload CanSat FSW State Diagram (1/3)

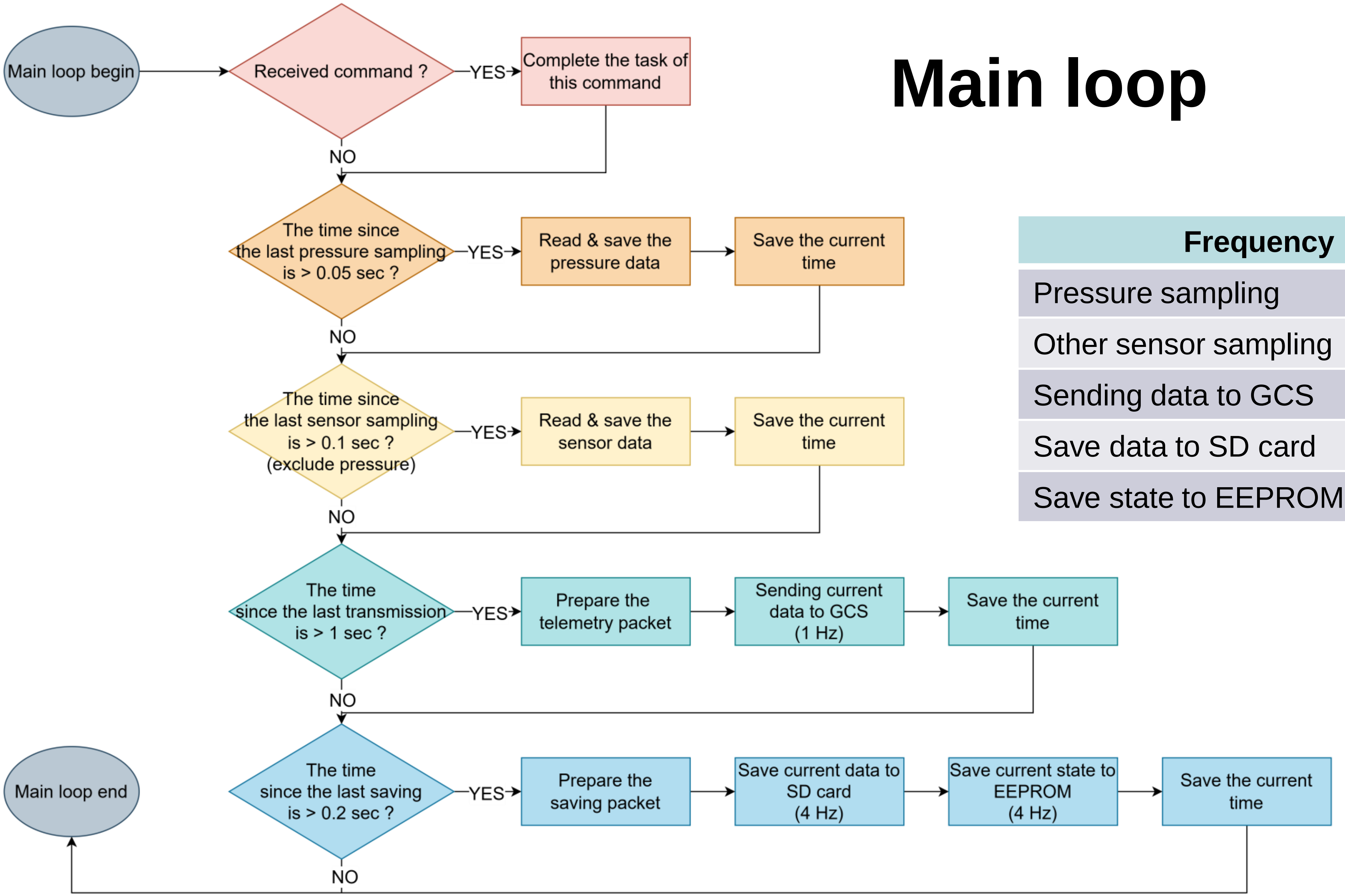
* The red frames indicate the changes since PDR.



Payload CanSat FSW State Diagram (2/3)

* The red frames indicate the changes since PDR.

Main loop



Frequency	
Pressure sampling	20Hz
Other sensor sampling	10Hz
Sending data to GCS	1Hz
Save data to SD card	5Hz
Save state to EEPROM	5Hz

Payload CanSat FSW State Diagram (3/3)

- The FSW stores time, packet counts, and state phase in Teensy 4.1 EEPROM 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 EEPROM as initial values after restarting.**

Simulation Mode Software (1/2)

- In simulation mode, the difference with the Flight mode is that the pressure (altitude) data from the sensor are replaced by the values providing from the artificial data file.

- The GCS is able to read the .txt file containing artificial pressure data, then convert it into radio signals, and then send it to payload by specific commands in the rate of 1 Hz.

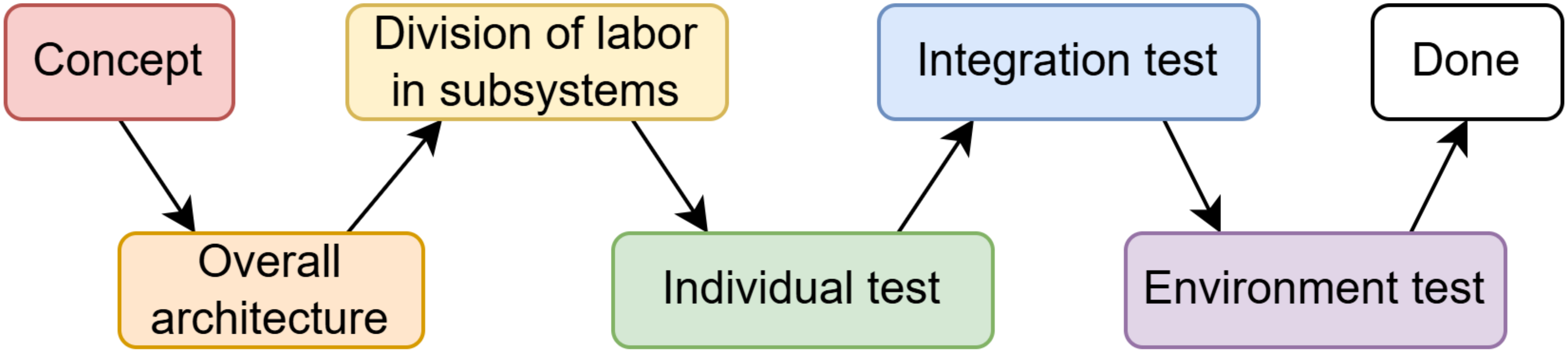
Simulation Mode Software (2/2)

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

- To enter the simulation, first enable it, then activate the simulation mode. Enabling the simulation acts like unlocking a switch; it disables the simulation mode if no activate command is received within 20 seconds.

Software Development plan (1/4)

- Once part of the code is completed, it is tested to ensure it operates as expected.
- If any error is found, the output is analyzed, solved or improved, until the bug(s) is/are fully removed.

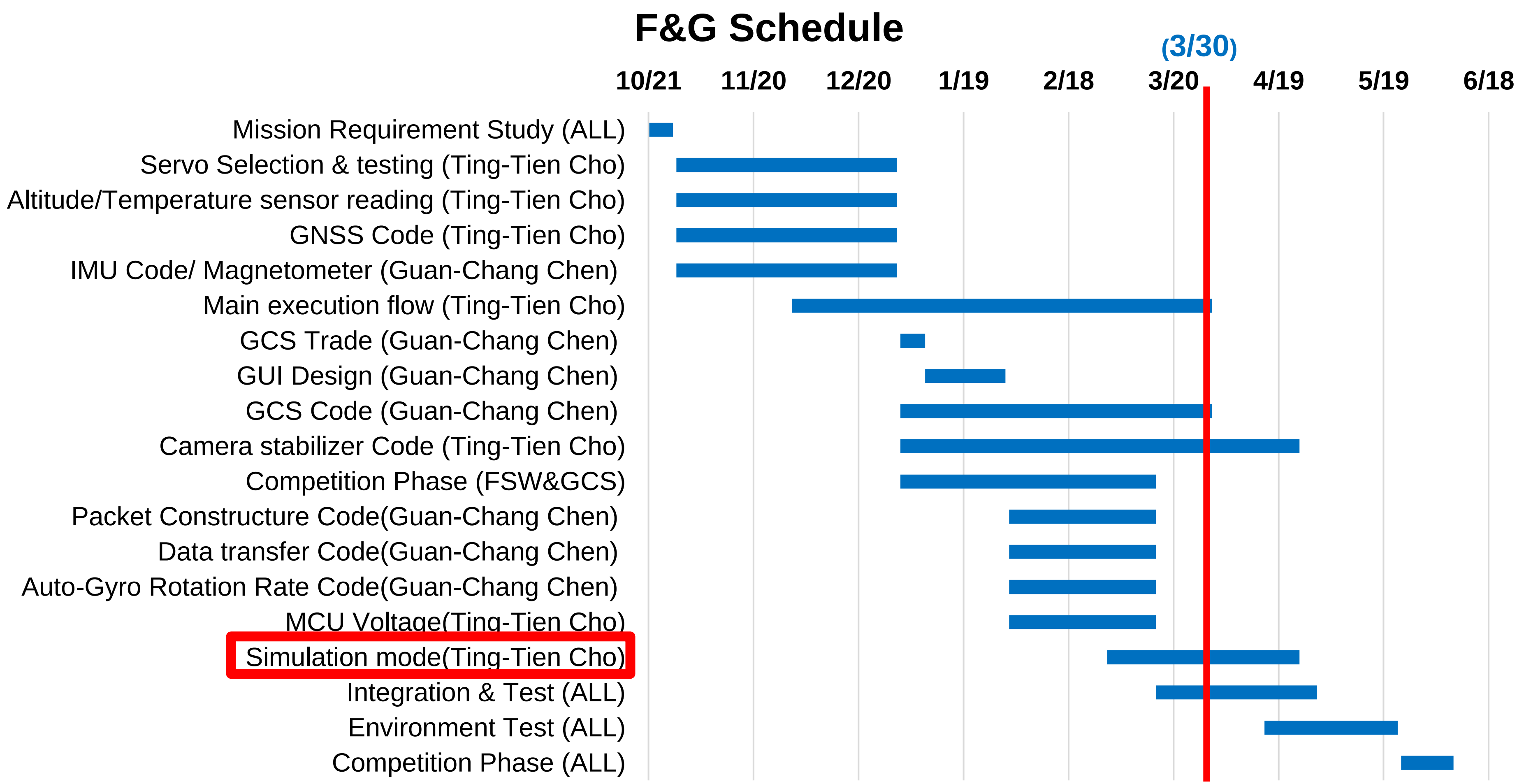


Software Development plan (2/4)

Software development group:

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

Software Development plan (3/4)



* The red frames indicate the changes since PDR.

Software Development plan (4/4)

- **FSW Progress since PDR**

1. All sensor can be read and printed on Arduino IDE.
2. All data can be saved in EEPROM and SD card.
3. Main loop of state diagram is done.
4. Two versions FSW for GPOC are developed, and still under improvement.

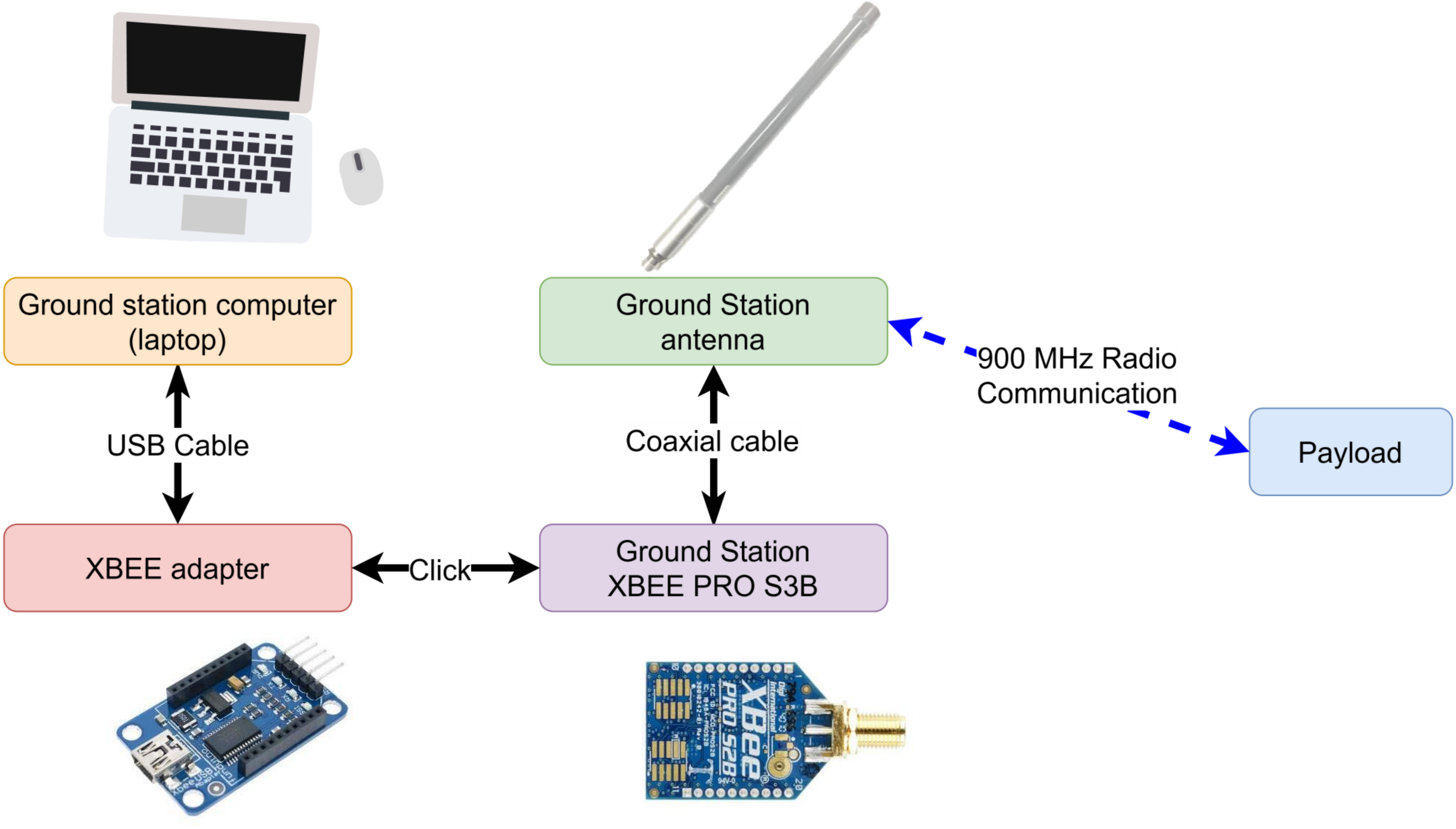
- **FSW future schedule**

1. XBEE communication test and command receiving.
2. Payload and auto-gyro release servo control.
3. Payload and GPOC teensy communication.
4. Completing Simulation mode.
5. Completing GPOC FSW.

Ground Control System (GCS) Design

Guan-Chang Chen

GCS Overview



GCS Changes Since PDR

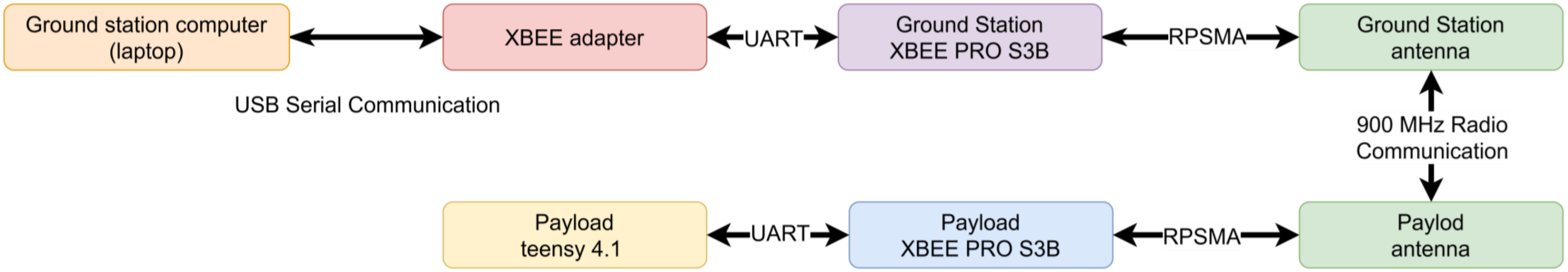
Changes	PDR	CDR	Rationale
Ground Station Antenna	OA-8996M08-NF	OLT-G1-915-05	Transportation for international flight

OA-8996M08-NF (L:1450mm)

OLT-G1-915-05 (L:550mm)

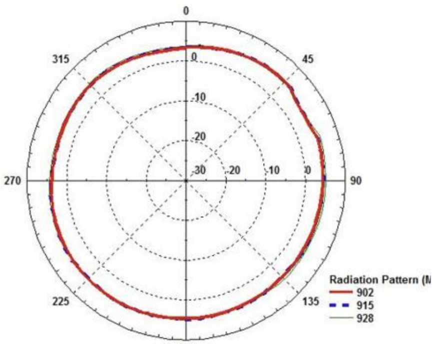
GCS Design

- **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.

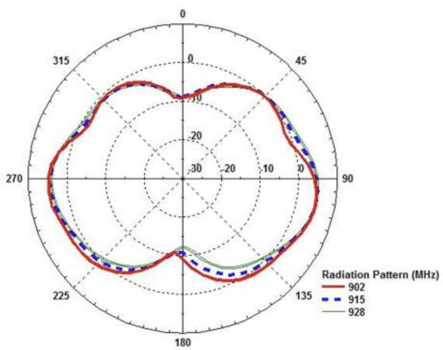


GCS Antenna (1/3)

GCS Antenna Selection					
Model	Frequency Range(MHz)	Polarization	Gain(dB)	Pattern	Mounting Type
OLT-G1-915-05	902~928	Vertical	5	Omni	Handheld



Horizontal



Vertical

GCS Antenna	Rationales
OLT-G1-915-05	• Better Gain • Larger Frequency Range with Omni Direction • RoHS Compliant

GCS Antenna (2/3)

Antenna Length and Weight	0.55 m long and 0.2 kg weight, easily held by hand or stand.
Antenna Construction	OLT-G1-915-05 is a detachable antenna
Antenna Portability	This antenna can be carried by luggage for international flights.

- **Hand-held**

GCS Antenna (3/3)

Link budget and Margin

- **Link budget equation:**

$$(E_b/No) = 10\log P_T G_T - 20\log(4\pi d/\lambda) + 10\log(G_R/T) - 10\log L_A - 10\log R_b - 10\log M$$

(E_b/No)	$10\log P_T G_T$	$20\log(4\pi d/\lambda)$	$10\log(G_R/T)$	$10\log L_A$	$10\log R_b$	$10\log M$
(dB)	EIRP (dBW)	Free Space Loss (dB)	Figure of merit of Rx station (dBK^{-1})	Additional Losses (dB)	Data Rate (dBHz)	Link Margin (dB)

Calculation info:

$EIRP$= **27.3** dBm

FSL= **101.3** dB

G_R/T = **8.3** dBK

L_A = **6** dB

R_b=**1** dB, (10kbps and 8000 bits/cycle)

M=**12** dB

⇒ **E_b/No=-84.7 dB**

$(Eb / N_O) + (R/BT) = SNR$

(dB) (dB) (dB)

E_b/No=-84.7 dB

R_b/BT=0.2 dB

⇒ **SNR=-84.5 dB**

SNR of received signal (dB)	XBee Receiving Sensitivity (dB)	Link Budget Margin (=SNR-Sensitivity, dB)
-84.5	-109	24.5

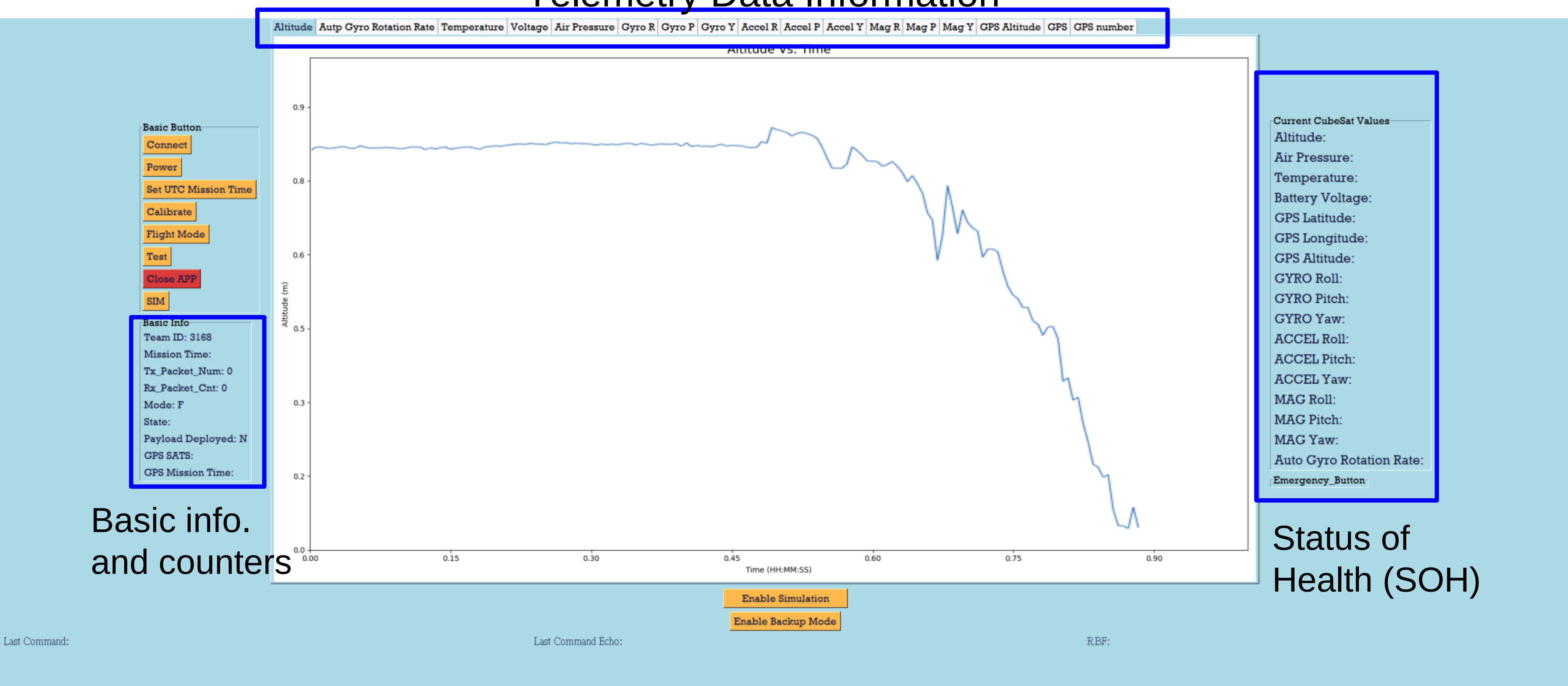
GCS Software (1/3)

Commercial off the shelf (COTS) software packages used	Spyder (Python IDE) and XCTU (XBee Utility) are used as the core tools. No commercial licensed software is used.
Real-time plotting software design	Telemetry data is processed by Python by matplotlib.pyplot package and all received sensors' values are displayed in the status of health (SOH) window and data saved in CSV which is presented to judges in the end.
Command software and interface	A button is placed to read and send artificial air pressure data for simulation mode (SIMP command). All other commands can be sent instantly by pressing the corresponding buttons. Additionally, there's a backup text input window for sending commands manually.
Simulation mode	GCS enters the simulation mode by SIM ENABLE and SIM ACTIVATE commands. After that, the GCS read the .csv file containing the artificial barometric pressure data and send it to the FSW at 1Hz as SIMP command.

GCS Software (2/3)

- **GUI window**

Telemetry Data Information



GCS Software (3/3)

- **GCS Progress since PDR**

1. All components of GCS are received and tested.
2. The function of the data saving is done and the format of the .csv files is verified.
3. The function of the real-time plot is done.

- **GCS future schedule**

1. The functions of the command sending and telemetry receiving.
2. The implementation of the simulation mode
3. The Long-distance communication field test

CanSat Integration and Test

Chan-Hao Tao

CanSat Integration and Test Overview

CanSat Integration and Test	Description	Remark
Subsystem Level Test	Each individual subsystem is tested respectively. Identify problems that need to be solved before integration.	Subsystems: Sensors CDH EPS FSW ME
Function Test in the Integration Level	Integrate all components and subsystems and verify their functionality step by step.	Modules: Parachute Auto-Gyro Communications Deployment
Environmental Test	After the full integration, the CanSat is tested by using the suggested methods listed in the mission guide. Additionally, the CanSat is tested by the appropriate facilities in the campus.	Test items: Drop test Thermal test Vibration test Fit Check Vacuum test
Simulation Test	Under simulation mode, the CanSat receives simulated pressure data from the ground station to demonstrate functionality of the FSW.	FSW logic

Subsystem Level Testing Plan (1/3)

<table>
<tr><th>Subsystem</th><th>Component</th><th>Test plan</th><th>Pass Requirement</th></tr>
<tr><td rowspan="5">Sensors</td><td>MPU9250</td><td rowspan="5">• Test sensors respectively
• Writing simple codes and run with Teensy 4.1 MCU
• Sensor calibration
• Sensor accuracy test</td><td rowspan="5">• Sensors function properly.
• Sensor outputs satisfy requirements</td></tr>
<tr><td>BMP581</td></tr>
<tr><td>LS20031</td></tr>
<tr><td>FC-33</td></tr>
<tr><td>SQ11</td></tr>
<tr><td rowspan="2">EPS</td><td>Vapcell
L10 ICR14500
&
CR2032</td><td rowspan="2">• Battery endurance test by the electric load
• Test output voltages and current</td><td rowspan="2">• System remains powered on during the endurance test.
• The power status is clearly shown.</td></tr>
<tr><td>DC-DC converter</td></tr>
</table>

Subsystem Level Testing Plan (2/3)

Subsystem	Component	Test Plan	Pass Requirement
CDH	Teensy 4.1 CanSat XBee	• Power on and Initialization • Communication test • Sensor calibration and data acquisition • Data storage	• The CanSat and GCS can communicate bidirectionally and data are saved properly.
Radio Communications	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="6">ME</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>GPOC</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 mechanisms</td><td>• Input signals to the release mechanisms.</td><td>• The release mechanisms functioned properly.</td></tr>
<tr><td rowspan="2">Descent Control</td><td>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>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 (1/3)

- **Payload Release from Container**

Items	Test Plan	Pass Requirement
Release trigger	• Power on Cansat. • Enter SIMULATION Mode • Send the simulation pressure data • Check if the release module is activated at the pressure of 450m (release altitude) is sent.	• The release module successfully activated at the designated pressure/altitude.
Mechanism	• Place the CanSat in a horizontal position. • Activate the release module. • Pull the payload out from the container.	• The release module activated successfully. • The payload can be smoothly pulled out from the container.
	• Hang the CanSat vertically.	• The payload does not slide out of the container when the CanSat is suspended vertically.
Payload rotor release	• Set up cushioning measures beneath the CanSat. • Hang the CanSat vertically. • Enter SIMULATION Mode • Send the simulation pressure data • Check if the release module is activated at the pressure of 450m (release altitude) is sent. • Check if the parachute is damaged as a result of the release module activation.	• The release module successfully activated at the designated pressure/altitude. • The payload can smoothly slide out from the container. • Parachute stay attached with container

Integrated Level Functional Test Plan (2/3)

- **Communication Test Plan**

Item	Test Plan	Pass Requirement
GCS software	• Power on CanSat in outdoor. • Collect telemetry for 5 minutes at first location. • Check the display to verify the functionality of GCS software. • Close GCS software • Measure the radio strength by XCTU to verify the functionality of antenna. • Repeat the above steps at different distances. (as far as 2km) • Check the lost rate of the received telemetry packets by timestamps after outdoor tests.	• CSV files are saved properly. • GCS shows the plot and all telemetry values correctly.
Telemetry		• By checking CSV files, packets lost rate should be less than 2% within 2km distance.
Antennas		• The measured strength of the radio signal should comply with the calculation of the link budget.

Integrated Level Functional Test Plan (3/3)

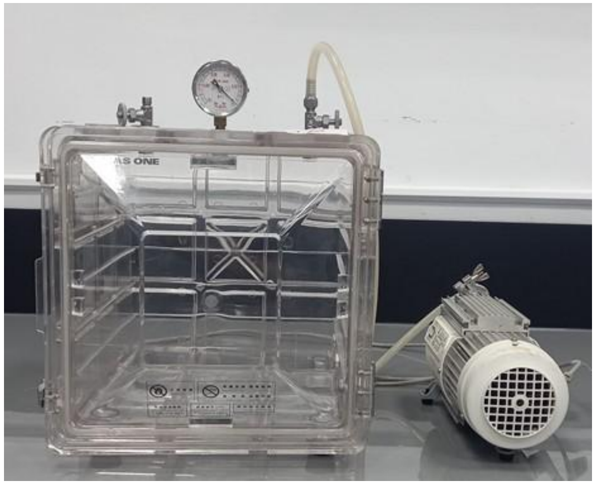
Item	Test Plan	Pass Requirement
Deployment	• Hang the payload in stowed position • Activate the servo to deploy the auto-gyro blades by GCS command.	• The release mechanism and hinges of auto-gyro operate appropriately. • The auto-gyro blades must open after released.
Descent Control	**Descent by auto-gyro** 1) A cardboard test tube with only auto-gyro and PCB (including MCU, pressure sensor, SD card and battery) is built. 2) Auto-gyro is configured in the operation position (fully opened). 3) Power on PCB. 4) The test tube is dropped from the roof of Dept. of ME, NCKU. (a 12-story building with ~45m height). (see P.49) 5) Recover the test tube and read the saved pressure data. 6) Calculate the height by pressure data and corresponding decent rate. **Decent by parachute** 1) Replace the auto-gyro in the test tube with a parachute. 2) Keep parachute untangled. 3) Repeat above step 3) to 6).	• The test tube descends at a rate of 17~23 m/s with the parachute open. • The test tube descends at a rate of 2~8 m/s with the auto-gyro fully opened.
Simulation	• Send **SIMULATION ENABLE** and **SIMULATION ACTIVE** commands to enter simulation mode • Send simulation pressure data by GCS software. • Check the received telemetry packets stored in CSV files. • The save data is compared with the simulation file.	• The pressure data in the CSV file is identical to the simulation pressure.

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 attach1/8-inch-thickckd 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 maintains power on after test. • No interior or exterior damage is identified. • Telemetry are received continuously, and no error is identified.
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. • Telemetry are received continuously, and no error is identified. • No anomaly is found in the accelerometer data.

Environmental Test Plan (2/2)

Test	Test Plan	Pass Requirement
Fit Check (Dimensional verification)	The CanSat is placed into a cardboard or PVC tube with dimensions provided in the mission guidebook.	The CanSat can move in and out of the tube easily without impediment.
Vacuum test	The CanSat is 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 continuously during the test. • No anomaly is found in the pressure data.



Subsystem Level Test Description (1/8)

Subsystem	Test Proc	Test Description	Rqmts	Pass/Fail Criteria	Status
Sensors	1	Use a breadboard to connect the BMP581, power supply, and Teensy 4.1. Link the BMP581 to Teensy's I^2C line. Upload example code from the SparkFun_BMP581_Arduino _Library.h using Arduino. Check if BMP581 communicates properly and outputs data.	SN1, SN2	Measures ambient pressure with a resolution of 0.016 Pa, altitude with a resolution of 0.1m, and temperature with resolution of 0.01°C	Done & Pass
	2	Use a breadboard to connect the LS20031, power supply, and Teensy 4.1. Connect LS20031 to Teensy's UART line. Upload example code from the TinyGPSPlus.h library using Arduino. Check if LS20031 communicates properly and outputs data.	SN4	Measures time within 1 second of UTC, altitude to a resolution to 0.1 m, latitude and longitude with a resolution of 0.0001°, and reports the number of acquired satellites	Done & Pass

Test Procedures Descriptions (2/14)

Subsystem Level Test Description (2/8)

Subsystem	Test Proc	Test Description	Rqmts	Pass/Fail Criteria	Status
Sensors	3	Create a temporary circuit using a breadboard, power supply, and Teensy 4.1. Connect the power supply to the ADC pin of the Teensy 4.1, and push example code. Confirm that Teensy 4.1 can read the analog signal and display voltage values.	SN3	Measures voltage accurately to a resolution of 0.1 volt	Done & Pass
	4	Connect the FC-33, power supply ,and Teensy 4.1 using a breadboard. Connect the FC-33 to the Digital of Teensy 4.1, and push example code with .Confirm that the FC-33 measure the accurate auto-gyro rotation rate.	SN6	Measures total pressure and static pressure difference and convert it into flight speed	Done & Pass

Test Procedures Descriptions (3/14)

Subsystem Level Test Description (3/8)

Subsystem	Test Proc	Test Description	Rqmts	Pass/Fail Criteria	Status
Sensors	5	Using the SQ11 for recording, and saving the photos to the built-in memory card.	SN10	The resolution exceeds 640x480, and the frame rate reaches 30 frames per second.	Done & Pass
	6	Connect the MPU9250, power supply ,and Teensy 4.1 using a breadboard. Connect the MPU9250 to the I^2C communication line of Teensy 4.1, and push example code with Arduino from the "MPU9250_WE.h" Library to Teensy 4.1. Confirm that the MPU9250 has good communication with Teensy and read the output data.	SN5, SN11	Measures tilt in the X and Y axis accurately to a resolution of 0.01° and the rotation rate of Z axis to a resolution of 0.1 dps .	Done & Pass

Test Procedures Descriptions (4/14)

Subsystem Level Test Description (4/8)

Subsystem	Test Proc	Test Description	Rqmts	Pass/Fail Criteria	Status
ME	7	Use air compressor to blow to see the auto-gyro system is working.	C7	The blades need to auto-rotate when the air compressor air gun blows.	Done & Pass
	8	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.	S16	The CanSat should slide out of the container smoothly when tilted.	Ongoing

Test Procedures Descriptions (5/14)

Subsystem Level Test Description (5/8)

Subsystem	Test Proc	Test Description	Rqmts	Pass/Fail Criteria	Status
ME	9	Drop the test prototype(=1.4kg) with a parachute, Teensy, and IMU from the building's top and collect the data from it.	C4	Terminal velocity in 20 m/s with a parachute that automatically deploys. Error is +/- 3 m/s.	Ongoing
	10	Drop the test prototype(=1.4kg) with the auto-gyro subsystem, Teensy, and IMU from the building's top and collect its data.	C7	Terminal velocity in 5 m/s with a parachute that automatically deploys. Error is +/- 3 m/s.	Ongoing
	11	The release module stowing mechanism is ensured that the blades remain securely fastened during descent.	C7	The gripper can securely fasten the blades without any external force.	Under preparation
	12	When the payload exits the container, the auto-gyro blades will immediately deploy.	C7	Once the gripper of the release mechanism releases, the auto-gyro blades immediately open.	Under preparation

Test Procedures Descriptions (6/14)

Subsystem Level Test Description (6/8)

Subsystem	Test No.	Test Description	Rqmt Num	Pass criteria	Status
CDH	13	Data saved in backup registers survives resets and power downs	F2	Variables are consistently available.	Under preparation
	14	Programming a code that makes data, including time, and NETID, transit through XBee by unicast per second, and the other XBee receives the data packet per second.	X2 X3 X4	Verify the data is correct and receive the packet in 1 Hz. And the NETID corresponds to the team number.	Under preparation
	15	Real-Time Clock measures time by code and connects to the computer by USB.	G6 G8	Time of CanSat and Computer in-sync during the tests	Under preparation
	16	Test multiple positions of the GCS antenna to determine which yields the strongest signal. All sensor data will be transmitted back to the GNS and recorded onto the SD card. Commands from the GNS will be transmitted to observe changes in the CanSat	G9	The telemetry package can successfully be received without error.	Under preparation

Test Procedures Descriptions (7/14)

Subsystem Level Test Description (7/8)

Subsystem	Test Proc	Test Description	Rqmts	Pass/Fail Criteria	Status
EPS	17	Connect the power supply and Teensy 4.1 to a breadboard. Use a multimeter to measure the voltage between the 3.3V output pin and ground to verify whether the 3.3V DC-DC converter on the Teensy 4.1 is functioning correctly.	-	The measure voltage of 3.3V output pin is 3.3±0.1V.	Done & Pass
	18	Discharge and charge the batteries in holders using an electrical load and power supply for two hours, repeating the process twice. Set the current based on the power budget. Check if the batteries can operate for two hours and if both batteries and holders can properly work under high current conditions.	E5	After two hours of discharge, the depth of discharge remains below 80%. After two cycles of discharge and charge, the graph of discharge for each cycle is consistent.	Done & Pass
	19	Install the 5V DC-DC converter onto the PCB. Check its functionality using the umbilical power source.	-	The output voltage of 5V DC-DC converter is 5±0.1V.	Ongoing

Test Procedures Descriptions (8/14)

Subsystem Level Test Description (8/8)

Subsystem	Test Proc	Test Description	Rqmts	Pass/Fail Criteria	Status
EPS	20	Install 14500 AA lithium batteries onto the PCB. Check the functionality of the battery power source lines.	E1, E2	The voltage of the batteries is correct, and the output voltage of 5V DC-DC converter is 5±0.1V.	Ongoing
	21	Install teensy4.1, power indicator onto the PCB. Check their functionality using both power sources.	E3, E4	Power Indicator can be easily observed during daytime.	Under preparation
	22	Connect all electrical components. Install two full charged 14500 AA lithium batteries. Turn on all the components and communicate with ground station. Monitor battery voltage for two hours to check if the system can operate for two hours.	E5	Entire system can operate without error, and the ground station can collect the data for 2 hours.	Under preparation
FSW	23	Rotate the GPOC system independently on the plate and record video by SQ11 during rotation. Afterward, watching the video saved in the SD card, ensure it is stable recording.	C10, C11, C12, SN8, SN9	The video in the SD card is stable , in the end GPOC still points nadir 45° downward.	Under preparation

Test Procedures Descriptions (9/14)

Integrated Functional Level Testing Description (1/4)

Subsystem	Test Proc	Test Description	Rqmts	Pass criteria	Status
Communications	24	Reading the data from XBee, and process and plot the data in real-time.	G6	1. The data is shown in real time. 2. The shown plot is consistent with the data stored in the SD card.	Under preparation
	25	Test different distances between the GCS and CanSat. All sensor data are transmitted to the GCS and recorded onto the onboard SD card. Commands from the GCS are transmitted to check the response of the CanSat.	G6	The GCS can successfully receive data at different distances.	Under preparation
	26	• Boot the FSW • Collect the sensor data and form data packets • Save data packets in the onboard SD card and transmit the data packets to GCS for 5 minutes at least.	X5	Check the consistency of the received and stored data.	Ongoing

Test Procedures Descriptions (10/14)

Integrated Functional Level Testing Description (2/4)

Subsystem	Test Proc	Test Description	Rqmts	Pass criteria	Status
ME	27	Power on the Cansat, enter SIMULATION mode, send simulated pressure data, and check if the release module activates at the simulated 450 m altitude.	-	The release module was successfully activated when the designated pressure corresponding to the target altitude was reached.	Ongoing
	28	Place the CanSat in a horizontal position. Then, activate the release module. Once it is activated, pull the payload out from the container.	-	The release module activated successfully, allowing the payload to be smoothly pulled out from the container without any obstruction.	Under preparation
	29	Hang the CanSat vertically to confirm release module deployment.	-	When the CanSat is suspended vertically, the payload does not slide out of the container on its own.	Under preparation

Integrated Functional Level Testing Description (3/4)

Subsystem	Test Proc	Test Description	Rqmts	Pass criteria	Status
ME	30	Deploy cushioning beneath the CanSat and secure it in a vertical position. Enter SIMULATION mode and transmit pressure data corresponding to an altitude of 450 meters to verify release module activation. Conclude by inspecting the parachute for potential damage post-deployment.	-	The release module successfully activated at the designated pressure and altitude. The payload was able to smoothly slide out from the container, and the parachute remained securely attached to the container.	Under preparation
	31	Hang the payload in stowed position	-	The release mechanism and hinges of auto-gyro operate appropriately.	Under preparation

Test Procedures Descriptions (12/14)

Integrated Functional Level Testing Description (4/4)

Subsystem	Test Proc	Test Description	Rqmts	Pass criteria	Status
ME	32	The parachute descent control A cardboard test tube with a PCB (MCU, pressure sensor, SD card, and battery) is tested for descent. It descends with a parachute. Dropped from the 45m-high NCKU ME building (see P.49), pressure data is recorded to calculate descent height and rate for comparison.	-	The parachute can effectively decelerate the CanSat to a speed of 17–23 m/s.	Ongoing
	33	The auto-gyro descent control A cardboard test tube with a PCB (MCU, pressure sensor, SD card, and battery) is tested for descent. It descends with a fully opened auto-gyro. Dropped from the 45m-high NCKU ME building (see P.49), pressure data is recorded to calculate descent height and rate for comparison.	-	The test tube descends at a rate of 2~8 m/s with the auto-gyro fully opened.	Ongoing

Environmental Test Description (1/2)

Test	Test Proc	Test Description	Rqmts	Pass/Fail Criteria	Status
Vibration Test	25	The CanSat would be placed on an orbital sander, which vibrates at a frequency between 0 and 233 Hz and generate around 20 to 29G for a minute.	S8 S9 S21 M2	The structural integrity of the CanSat is maintained and all sensors can function normally. The data from the accelerometer can be received.	Under preparation
Vacuum Test	26	The CanSat will be placed in a vacuum chamber fully figured and powered. The telemetry will be monitored throughout the test until the vacuum chamber reaches its lowest pressure at 0.8 atm.	-	The CanSat should transmit and record the telemetry throughout the test and the data will be provided to the judges.	Under preparation
Thermal Test	27	The CanSat is placed inside a thermal chamber, where the air temperature is raised to 60°C for 2 hours.	M2	All sensors can function normally and the telemetry isn’t lost. The structural integrity of the CanSat should remain intact after the test.	Under preparation

Test Procedures Descriptions (14/14)

Environmental Test Description (2/2)

Test	Test Proc	Test Description	Rqmts	Pass/Fail Criteria	Status
Drop Test	28	The CanSat relates to a 61 cm non-stretching cord and dropped without hitting anything.	M3	The power and structural integrity of the CanSat is maintained. No anomaly is found in the telemetry.	Under preparation
Mass Test	29	Total mass of the CanSat is measured.	S1	Total mass falls in the range of 1400 +/- 10 g.	Under preparation
Dimensions verification	30	The CanSat is inserted into a tube with dimensions listed in the mission guidebook.	S16 C2	The CanSat can move in and out of the tube easily without impediment.	Under preparation

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 receives 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 GCS 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 (GCS 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 (GCS Crew)
- Analyze data and video recording
- Deliver to judges after CanSat touch-down

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

Field Safety Rules Compliance (1/2)

Section	Description
Team Rosters	• Overview of the roles of each team and the responsibilities for each role.
Ground Station Configuration	• Setup laptop and antenna • Check baud rate • Connect with ground station antenna
CanSat Preparation	• Check the charge level of the battery • Check all components with the overall checklist • Assemble the CanSat step by step • Turn on the CanSat • Check all communication with ground station is stable • Verify all mechanisms are in start position
CanSat Integration	• Visually check CanSat again • Mount CanSat into the rocket • Check free movement of CanSat
Launch Preparation	• Final communication check • The rest contents are already published in MOM template
Launch Procedure	• The plan is already published in MOM template

Field Safety Rules Compliance (2/2)

Development Status
1. MOM template is referred from the version published in 2024 (Gemini Space, #2038) 2. The team are preparing our own MOM on schedule. 3. The final version MOM is scheduled to be done before FRR. 4. The MOM is assembled into three-ring binder. 5. All team members will receive a copy of MOM and study thoroughly before launch.

CanSat Location and Recovery

Recovery Strategy	Description
Fluorescent color	The container is equipped with a gold outward and brilliant-colors parachute to improve its visibility for recovery.
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 improve recovery.
AirTag	With a paired iPhone, the container can be located by an installed AirTag.

Exterior label template →

CanSat competition 2025
Team: Gemini Supernova #3168
Address: No. 1 University Road, Tainan City, 70101, Taiwan, R.O.C
Team Lead: Guan-Chang Chen
E-mail: f44101070@gs.ncku.edu.tw
+886-985990990

Mission Rehearsal Activities (1/2)

Section	Plan
Powering on/off the CanSat (Rehearsal date: 4/10)	1. Insert batteries into electronics sector of the CanSat 2. Turn on the CanSat 3. Check power indicator is activated 4. Turn off the CanSat 5. Check power indicator is disactivated
Ground system radio communication (Rehearsal date: 4/15)	1. Attach and connect antenna to ground station 2. Power on the CanSat 3. Adjust antenna position 4. Check ground station for good connection 5. Send CX,ON command 6. Assure ground station receive telemetry data
Launch configuration preparations (Rehearsal date: 4/30)	1. Ensure all connection points and linkages are Strong 2. Ensure all component are fixed and secured 3. Fold and pack CanSat parachute. 4. Ensure all servos are in starting position.

Mission Rehearsal Activities (2/2)

Section	Plan
Telemetry processing (Rehearsal date: 5/10)	1. Turn on the CanSat 2. Ensure connection 3. If connection success, command CXON to turn on telemetry 4. Ensure ground station receive telemetry data successfully.
Loading the CanSat in the launch vehicle (Rehearsal date: 5/15)	1. Final CanSat inspection 2. Turn on the CanSat 3. Ensure communication 4. Place CanSat into the tube. 5. Rotate CanSat and check its smoothness 6. Check communication again
Recovery (Rehearsal date: 5/20)	1. Visually track CanSat 2. Check last GPS data for approximate location. 3. Recovery the CanSat by audio and visual beacon.

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.
- 2 requirements are partially complied with.
  - -These requirements are not serious issues; only have to be validated by further analysis or environmental tests.
- There are 0 requirements that are not complied with in the current phase.

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	P24,71	
2	The CanSat container shall be mounted on top of the rocket with the shoulder section inserted into the airframe.	Comply	P24,33	
3	The CanSat payload and container shall be deployed from the rocket when the rocket motor ejection charge fires.	Comply	P24,33	
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	P59	
5	At 75% flight peak altitude, the payload shall be released from the container.	Comply	P132	
6	At 75% peak altitude, the payload shall deploy an auto-gyro descent control system.	Comply	P132	

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	P60	
8	The sensor telemetry shall be transmitted at a 1 Hz rate.	Comply	P133	
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	P26,32,45,78	
10	A second video camera shall point in the north direction during descent.	Comply	P44, 73, 77, 90, 91	
11	The second camera shall be pointed 45 degrees from the CanSat nadir direction during descent.	Comply	P44, 73, 77, 90, 91	
12	The second video camera shall be spin stabilize so the ground view is not rotating in the video.	Comply	P44, 73, 77, 90, 91	

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	P28,71	
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	P207~P216	
15	The CanSat and container mass shall be 1400 grams +/- 10 grams.	Comply	P94~P103	
16	Nose cone shall be symmetrical along the thrust axis.	Comply	P27	
17	Nose cone radius shall be exactly 72.2 mm	Comply	P71	
18	Nose cone shoulder length shall be a minimum of 50 mm	Comply	P71	

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	P71	
20	The nose cone shall not have any openings allowing air flow to enter	Comply	P71	
21	The nose cone height shall be a minimum of 76 mm.	Comply	P71	
22	CanSat structure must survive 15 Gs vibration	Partial Comply	P173	Confirmed by vibration test
23	CanSat shall survive 30 G shock	Partial Comply	P159	Confirmed by drop test
24	The container shoulder length shall be 90 to 120 mm.	Comply	P69	
25	The container shoulder diameter shall be 136 mm.	Comply	P81	
26	Above the shoulder, the container diameter shall be 144.4 mm	Comply	P33	

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	P81	
28	The container length above the shoulder shall be 250 mm +/- 5%.	Comply	P81	
29	The CanSat shall perform the function of the nose cone during rocket ascent.	Comply	P69,70	
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	P82,83	
31	All electronics and mechanical components shall be hard mounted using proper mounts such as standoffs, screws, or high-performance adhesives.	Comply	P92,93	
32	The CanSat container shall meet all dimensions in section F	Comply	P81	

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	P81	
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	P70	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	P70	Nose cone does not separate.
36	No pyrotechnical or chemical actuators are allowed.	Comply	P70	Do not use pyrotechnical or chemical actuators
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	P70	Do not use nichrome wire

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	P92, 93	
39	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Comply	P92, 124	
40	Lithium polymer batteries are not allowed.	Comply	P124	
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	P124	
42	Easily accessible power switch is required.	Comply	P30,81,73	
43	Power indicator is required.	Comply	P29, 76	

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	P28, 71	
46	The audio beacon shall have an easily accessible power switch.	Comply	P28, 30, 71	
47	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE radios are also allowed.	Comply	P111, 112	
48	XBEE radios shall have their NETID/PANID set to their team number.	Comply	P112	
49	XBEE radios shall not use broadcast mode.	Comply	P144, 148	
50	The CanSat shall transmit telemetry once per second.	Comply	P133	
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	P113~117	

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	P37	
53	CanSat payload shall measure its internal temperature.	Comply	P38	
54	CanSat payload shall measure its battery voltage.	Comply	P39	
55	CanSat payload shall track its position using GPS.	Comply	P40	
56	CanSat payload shall measure its acceleration and rotation rates.	Comply	P42	
57	CanSat payload shall measure auto-gyro rotation rate.	Comply	P41	
58	CanSat payload shall video record deployment of the auto-gyro at 75% peak altitude	Comply	P44, 45	

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	P43, 44, 90	
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	P43, 44, 90	
61	The video cameras shall record video in color and with a minimum resolution of 640x480.	Comply	P44, 45	
62	The CanSat shall measure the magnetic field.	Comply	P42, 43	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	P118, 132, 133, 148, 149	
64	The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section.	Comply	P148, 149	

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	P113~117, P132~134	
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	P132~134	
67	Each team shall develop their own ground station.	Comply	P141~150	
68	All telemetry shall be displayed in real time during ascent and descent on the ground station.	Comply	P113~117, 148, 149	
69	All telemetry shall be displayed in the International System of Units (SI) and the units shall be indicated on the displays.	Comply	P113~117, 148, 149	
70	Teams shall plot each telemetry data field in real time during flight.	Comply	P148, 149	

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	P142~146	
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	P142~146	
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	P148, 149	
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	P148	

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	P142, 143, 145, 146	
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	P148, 149	
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	P148, 149	
78	The ground station shall be able to activate all mechanisms on command.	Comply	P148, 149	

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	P128, 133, 134	
80	The CanSat shall maintain mission time throughout the entire mission even in the event of a processor resets or momentary power loss.	Comply	P128, 133, 134	
81	The CanSat shall have its time set by ground command to within one second UTC time prior to launch.	Comply	P130, 132	
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	P135, 136, 148	

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	P135, 136, 148	
84	The flight software shall only enter simulation mode after it receives the SIMULATION ENABLE and SIMULATION ACTIVATE commands.	Comply	P118, 119, 136	
85	The flight shall include commands to activate all mechanisms. These commands shall be documented in the mission manual.	Comply	P119, 129, 130	

Management

Kuan-Yu Lai

Status of Procurements (1/5)

Electrical Components			
Components	**Quantity**	**Status**	**Date Received**
Teensy 4.1	2	Received	Feb. 21, 2025
BMP581	2		Dec. 7, 2024
LS20031	1		Dec. 26, 2024
MPU9250	1		Feb. 21, 2025
SQ11	2		Mar. 21, 2025
Servo	4		Dec. 7, 2024
XBee Pro S3B	2		
14500 battery holder	4		Feb. 21, 2025
FC-33	3		Dec. 16, 2024

Status of Procurements (2/5)

Electrical Components			
Components	**Quantity**	**Status**	**Date Received**
32GB microSD Card	2	Received	Nov.24, 2024
CR2032 Coin Cell	1		Oct. 31, 2024
CR2032 battery holder	1		
LED	5		Dec. 7, 2024
Buzzer	1		
3-pin Rocker Switch	2		Jan. 31, 2025

Status of Procurements (3/5)

Mechanical Component			
Components	**Quantity**	**Status**	**Date Received**
Parachute	1	Received	Feb. 9, 2025
Socket Head Screw M3x100	3		Jan. 10, 2025
Socket Head Screw M3x8	3		
Socket Head Screw M2x16	12		
Lock Nut M2	11		
Lock Nut M3	22		
Flat Head Screw M3x10	43		
Flat Head Screw M3x6	9		
Hinge	3		Dec. 20, 2024

Status of Procurements (4/5)

Mechanical Component			
Components	**Quantity**	**Status**	**Date Received**
Button Head Socket Screw M3x30	7	Received	Mar. 3, 2025
Compress Spring 1.2x40x53	1		Jan. 10, 2025
Button Head Socket Screw M3x20	6		
Self Tapping Screw M2x6	2		
Socket Head Screw M2x8	3		
Flat Head Screw M3x14	1		
PETG	3		Mar. 20, 2025

Status of Procurements (5/5)

Ground Station Component			
Components	**Quantity**	**Status**	**Date Received**
XBee adapter	2	Received	Dec. 20, 2024
Indoor testing antenna	2		
Coaxial cable	2		

All components including backup parts are received, and no pending parts.

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		
IMU	MPU9250	2	12.5	25		
GNSS	LS20031	1	49	49		
SD card	SanDisk Ultra Micro SDHC UHS-I C10 32GB	1	7	7		
SD card writer	Teensy 4.1	1	0	0		
Camera	SQ11	2	12	24		
Audio Beacon	CMI-1210-5-95T	2	0.15	0.3		

CanSat Budget – Electronics (2/3)

Component	Model	Quantity (pic)	Unit Price (USD/pic)	Total (USD)	Reusing	Actual/Estimated /Budgeted
Step motor	ES08MAII	2	6	12	NO	Actual
Servo motor	SER0053	1	10	10		
Voltmeter	Teensy 4.1 on board ADC	1	0	0		
Battery	Vapcell L10 ICR14500	2	3.59	7.18		
Battery basket	14500 battery box	2	0.3	0.6		
CanSat antenna	ANT-916-CW-RCS	1	8.81	8.81		
Coin cell battery	CR2032	1	1.5	1.5		
XBee	XBEE Pro S3B	1	61.11	61.11		

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		
PCB	Custom	2	20	40		
Rotary Connector	SRM-12U2A-085	1	21	21		
Tracker	AirTag	1	30.27	30.27		
Electronics Total : $378.6						

CanSat Budget – Hardware (1/7)

Component	Model	Quantity (pic)	Unit Price (USD/pic)	Total (USD)	Reusing	Actual/Estimated /Budgeted
Nose cone	Carbon fiber bar	4	2.5	10	NO	Actual
Container	Plywood disk	1	1	1		
	Eyebolt	1	6.25	6.25		
GPOC	Rotary connector	1	25	25		
Auto-gyro	fixmainshaft	2	2.99	5.98		
	mainshaft	1	6.21	6.21		
	Ball bearing	1	4.18	4.18		
	blade	4	13.76	55.04		
	Hinge pin	4	0.82	3.28		
	Torsion spring	4	9.11	36.44		

CanSat Budget – Hardware (4/7)

Component	Model	Total Mass (g)	Quantity (spool)	Unit Price (USD/spool)	Total (USD)	Reusing	Actual/ Estimated/ Budgeted
ME	PLA+	441.7	1	12.6	12.6	NO	Actual
	PETG	287.4	1	12.7	12.7		

- The weights of all 3D-printed parts are summarized in the table above. Since each spool of 3D printing material is 1 kg, any weight less than 1 kg is automatically rounded up and charged as one full spool.

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		
Screw	M2 × 5mm	8	0.051	0.41		
Screw	M2 × 10mm	8	0.051	0.41		
Screw	M2 × 12mm	23	0.051	1.17		
Screw	M2 × 20mm	3	0.051	0.15		
Screw	M3 × 6mm	8	0.020	0.16		
Screw	M3 × 8mm	1	0.020	0.02		

CanSat Budget – Hardware (6/7)

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

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 : $218.37						

Electronics Total (USD)	Hardware Total (USD)	CanSat Overall Total (USD)
378.6	218.37	**596.97**

The overall cost of our CanSat satisfies the requirement of C14.

* The cost of the CanSat components is sponsored by NCKU HMH Space Science & Technology Center.

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		
GCS antenna	OLT-G1-915-05	1	96	96		
GCS laptop	ASUS Zenbook	1	400	400		
Total : $565						

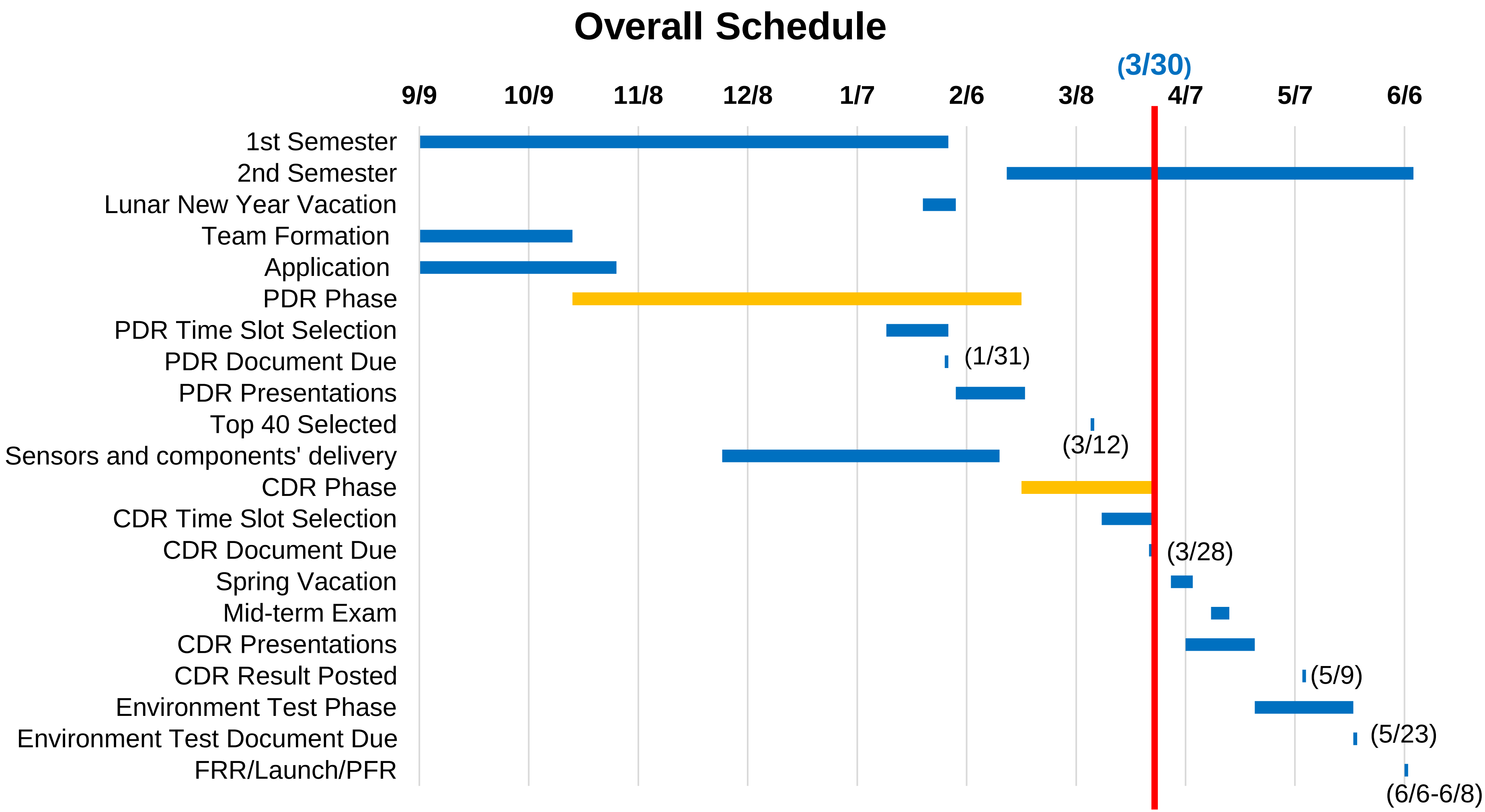
* The GCS cost is sponsored by NCKU HMH Space Science & Technology Center.

Travel

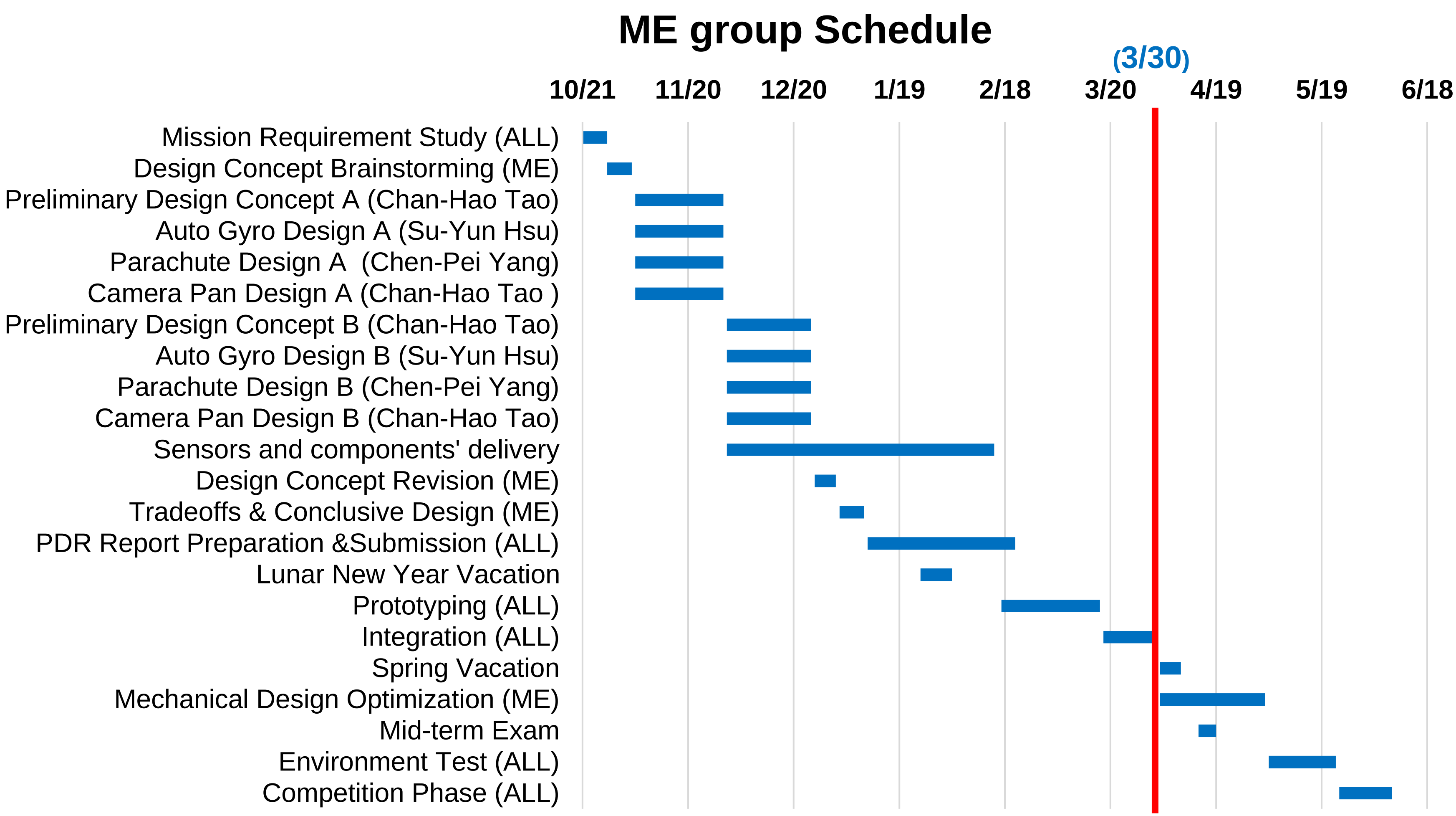
Component	Quantity	Unit Price (USD)	Total (USD)	Actual/Estimated/Budgeted
Round Trip flight (TPE-IAD) Including insurance	7	2,000	14,000	Estimated
Car rental + fuel	2	600	1,200	
Accommodation	7	300	2,100	
Meals	7	250	1,750	
Domestic transportation	7	100	700	
Total: $19,750				

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

Program Schedule Overview

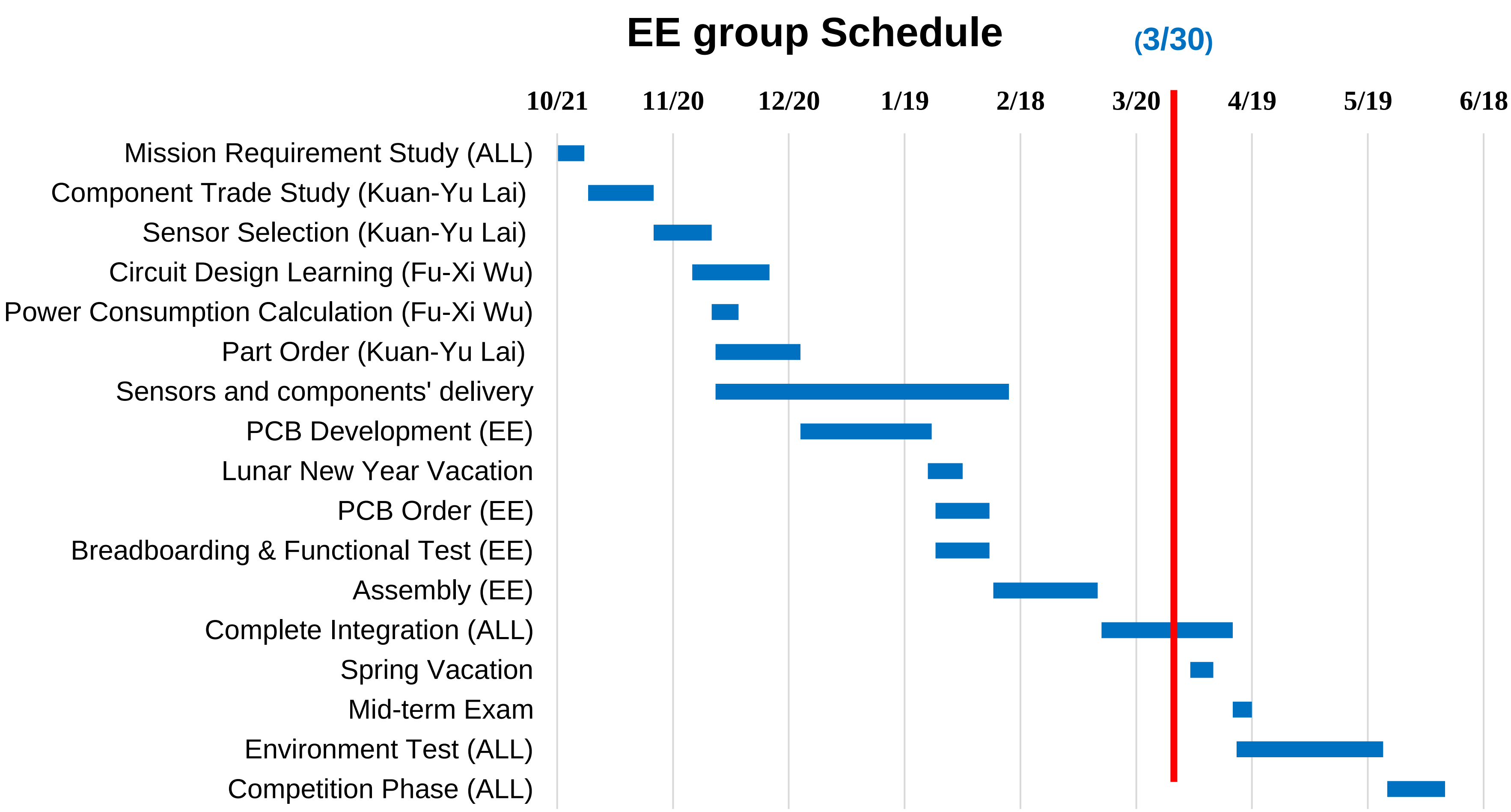


Detailed Program Schedule (1/4)



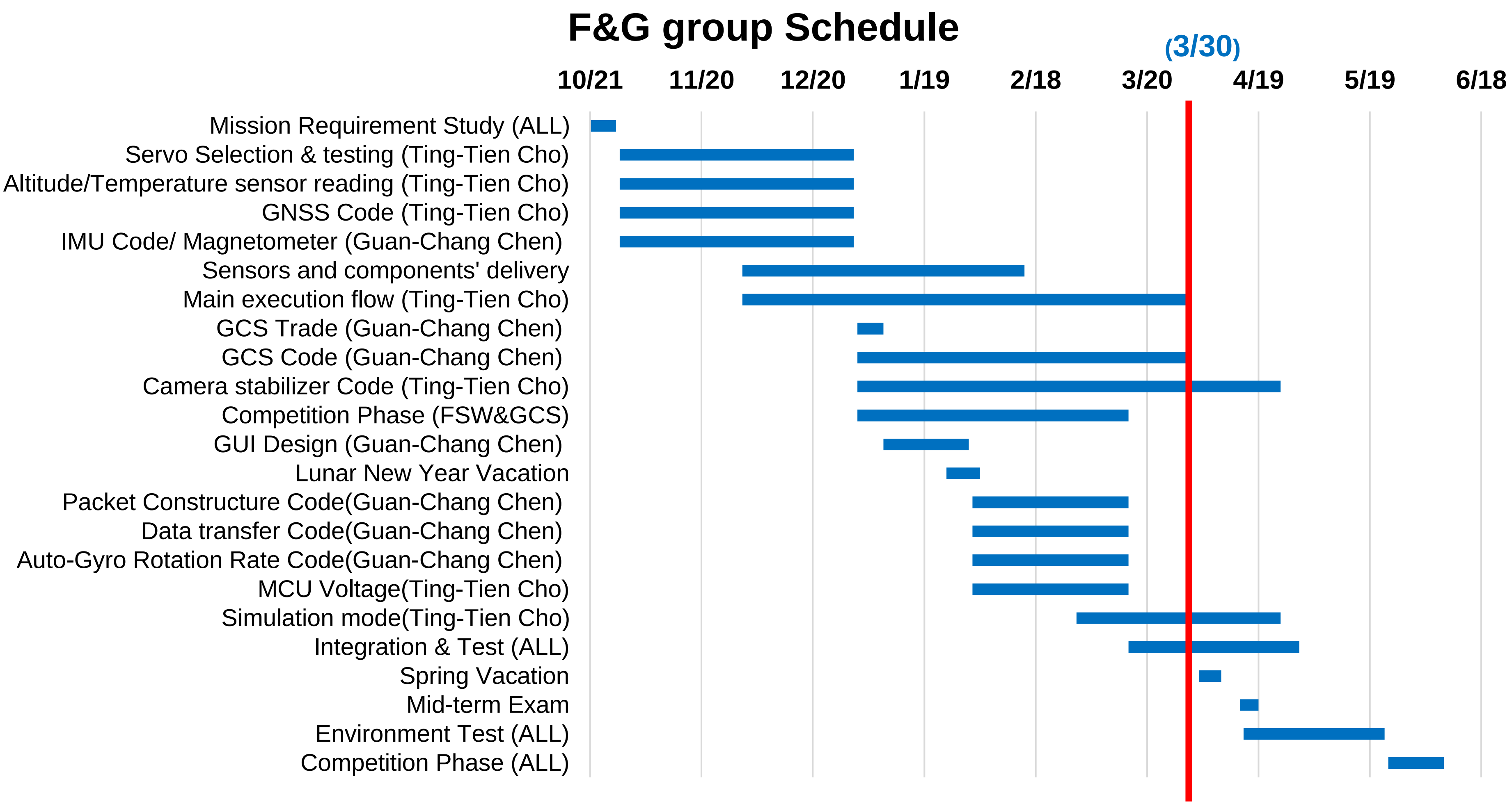
- Responsible member : Chan-Hao Tao

Detailed Program Schedule (2/4)



- Responsible member : Fu-Xi Wu

Detailed Program Schedule (3/4)



- Responsible member : Ting-Tien Cho

Detailed Program Schedule (4/4)

- To effectively assess our overall progress, the mission is organized into four units: Electronics, Mechanics, FSW & GCS , Integration & Testing.
- The progress is calculated based on the Gantt chart of each unit, using the ratio of the completed task duration to the total task duration.

Unit	Estimated progress
EE	67%
ME	82%
F&G	84%
Integration & Testing	35%

The overall progress: 67%

Shipping and Transportation

- Gemini Supernova's CanSat will be transported in a waterproof protective case and taken as a **carry-on luggage**.
- The GSC antenna, tools, and supporting equipment will be appropriately packed and transported as checked baggage.
- The parts of CanSat will be transported to the launch site by our rental car together with the team and be integrated after arrival.

Conclusions (1/4)

Group of electronics and electricals	
Major Accomplishments	1. All sensors and actuators are purchased and received. 2. All sensors and actuators are tested and work perfectly. 3. Built our own flatsat testing board 4. Working with final PCB
Major Unfinished Work	1. Finalize PCB board and produce 2. Batteries testing 3. Fully integrate testing with others subsystem. 4. Environmental test
Testing to complete	We are currently using self-build flatsat to test electrical system. We are now in the process of commanding and input data handling.

Conclusions (2/4)

Group of mechanicals	
Major Accomplishments	1. Critical design has been finished. 2. The first engineering qualification model has been made. 3. The parachute and auto-gyro has already been purchased and tested.
Major Unfinished Work	1. 3D printing of the modified components 2. Full mechanical subsystem integration
Testing to complete	1. Drop test 2. Thermal test 3. Vibration test 4. Fit Check 5. Vacuum test

Conclusions (3/4)

Group of FSW and GCS	
Major Accomplishments	1. Code libraries for all sensors are created and tested 2. Calibration code has been built 3. GCS code has been built 4. Radio testing are done (XCTU) 5. Reset mode (EEPROM)
Major Unfinished Work	1. Validate the State machine 2. Simulation mode code 3. Back up data save to SD card 4. GCS GUI finalization 5. Command code 6. Integrate with others subsystem 7. Telemetry packet has been built according to requirement and successfully sent through xbee.
Testing to complete	1. GCS function test 2. Flight software test 3. Simulation test 4. Long-distance communication test
Flight Software Status	1. FSW code has been collected and built but needs further integration. 2. The FSW system will be tested in April and finished at the beginning of May.

Conclusions (4/4)

Whole Team	
Major Accomplishments	1. PDR and CDR are done 2. Start to integrate all subsystem 3. Travel and shipment plan is almost done.
Major Unfinished Work	1. Still seeking the external sponsors 2. Integrated tests 3. Environmental tests
Tests to complete	The major testing will start at the Mid-April. We will have a practice launch to simulate the entire mission procedure.

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

We completed the critical design of the CanSat, including mechanical, software, and electronics systems as well as the ground station systems, then start to manufacture the flight model shortly.

We are still seeking possible financial support from the university and external sponsors.