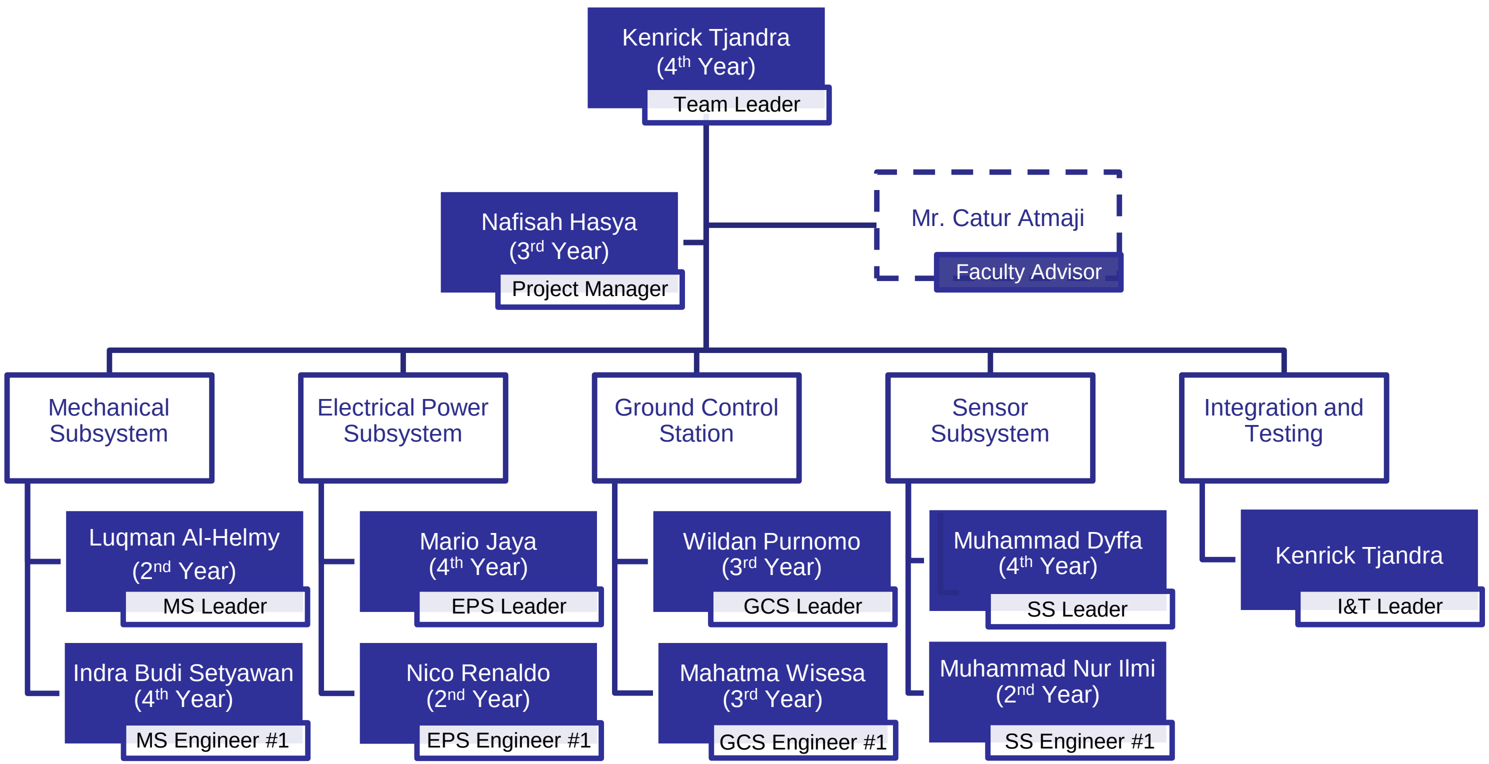
CanSat 2020
Critical Design Review (CDR)
Version 2.0

#1320

Narantaka

Presentation Outline

Team Organization



Acronyms

A	Analysis
ADC	Analog to Digital Converter
CDH	Communication and Data Handling
CONOPS	Concept of Operation
D	Demonstration
DCS	Descent Control Subsystem
EEPROM	Electrical Erasable Programmable Read-only Memory
EPS	Electrical Power Subsystem
FSW	Flight Software
G	G-Force
GCS	Ground Control System
GUI	Graphical User Interface
I	Inspection
I/O	Input/ Output
I2C	Inter-integrated Circuit
I&T	Integration and Testing

ID	Identity
IDE	Integrated Development Environment
IMU	Inertial Measurement Unit
ME	Mechanical Subsystem
MOSFET	Metal-Oxide Semiconductor Field-Effect Transistor
PCB	Printed Circuit Board
RN	Requirement Number
RPM	Revolutions per minute
RP SMA	Reverse Polarity SMA
RTC	Real Time Clock
SS	Sensor Subsystem
SPI	Serial Peripheral Interface
T	Testing
UGM	Universitas Gadjah Mada
USI	Universal Serial Interface

Systems Overview

Kenrick Tjandra

Mission Summary (1 of 2)

Main Objectives:

Build a Can-sized satellite consist of a science payload and a container to protect the payload during launch. The science payload shall be a delta wing glider that will glide in a circular pattern, once released.

- The CanSat shall be launched to an altitude of 670-725 meters and deployed near apogee
- After CanSat is deployed from the rocket, the CanSat shall descent using a parachute at a descent rate of 20 m/s
- At 450 meters, the container shall release The science payload shall glide in a circular pattern collecting sensor data for one minute and remain above 100 meters after being released
- The glider (science payload) shall deploy a parachute to cause the glider to stop gliding and drop to the ground at a rate of 10 meters/second
- The science payload shall monitor altitude, air speed and the science payload shall be a particulate matter/dust sensor to detect particulates in the air while gliding
- All telemetry transmission shall stop, and audio beacon shall active when the Payload land
- The Ground Control Station shall receive and display CanSat data

Bonus Objective:

A video camera shall be integrated into the science payload and point toward the coordinates provided for the duration of the glide time. Video shall be in color with a minimum resolution of 640x480 pixels and 30 frames per second. The video shall be recorded and retrieved when the science payload is retrieved. Points will be awarded only if the camera can maintain pointing at the provided coordinates for 30 seconds uninterrupted. **This mission is being attempted due to high possibility of success**.

Mission Summary (2 of 2)

External Objectives:

- Our team goals for this year is to be among top five in CanSat 2020
- Improving team members skills and experiences
- Promoting Gadjah Mada Aerospace Team to gain International reputation

Summary of Changes Since PDR (1 of 3)

Mechanical

Component	PDR	CDR	Rationale
Container layer thickness	5 mm	15 mm	Provides smaller clearance with the science payload. Thus, reducing excessive payload vibration
Container enclosure material	Polyfoam	Polyfoam with 1 PLA layer on the middle	Improves structural survivability of the container
Payload Wingspan	Consists of 1 stage fold only (439 mm wingspan)	Consists of 2 stage folds (760 mm wingspan)	Larger wing surface area obtained

Summary of Changes Since PDR (2 of 3)

Software

Component	PDR	CDR	Rationale
CSV File Creation	Button click	Automatically logs telemetry data into CSV when receiving from XBEE	More efficient and prevents human error
GCS Client	Consists of two pages : Home and Data Table	Data Table page is removed	Inefficient and prone to human error
GCS Client	Has no serial port connection indicator	Connection indicator added	Detects whether XBEE is connected with Raspberry PI 3B or not
Flight time and Parachute time	No timer	Timer are now added.	Gives more information for post flight analysis

Summary of Changes Since PDR (3 of 3)

Electronics & Hardware

Component	PDR	CDR	Rationale
Payload Processor	Teensy 4.0 breakout boards	ATSAMD51J19 Chip	Smaller form factor of the PCB thus reducing its weight
Container Processor	Arduino Pro Mini	ATMega328P-AU Chip	Smaller form factor of the PCB thus reducing its weight
Sensors	BMP388 and MPU6050 breakout boards	Directly integrate the chip to the PCB	Reduce weight
Payload Battery	Sony VTC6	Turnigy 18650	Better voltage stability
Regulator	One 3.3V regulator	Second 3.3V regulator added	To power the processor and some 3.3V sensors separately from XBEE

System Requirement Summary (1 of 4)

RN	Requirement	Rationale	Priority	Verification			
				A	I	T	D
RN1	Total mass of the CanSat (science payload and container) shall be 600 grams +/- 10 grams.	Competition Requirement	Very High	√		√	
RN2	CanSat shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length. Tolerances are to be included to facilitate container deployment from the rocket fairing.	Competition Requirement	Very High	√	√	√	
RN3	The container shall not have any sharp edges to cause it to get stuck in the rocket payload section which is made of cardboard.	Competition Requirement	Very High	√	√		
RN4	The container shall be a fluorescent color; pink, red or orange.	Competition Requirement	Very High		√		
RN5	The container shall be solid and fully enclose the science payload. Small holes to allow access to turn on the science payload is allowed. The end of the container where the payload deploys may be open.	Competition Requirement	Very High	√	√		
RN6	The rocket airframe shall not be used to restrain any deployable parts of the CanSat	Competition Requirement	Very High	√			√
RN7	The rocket airframe shall not be used as part of the CanSat operations.	Competition Requirement	Very High	√			√
RN8	The container parachute shall not be enclosed in the container structure. It shall be external and attached to the container so that it opens immediately when deployed from the rocket.	Competition Requirement	Very High	√	√		√
RN9	The descent rate of the CanSat (container and science payload) shall be 20 meters/second +/- 5m/s.	Competition Requirement	High	√		√	
RN10	The container shall release the payload at 450 meters +/- 10 meters.	Competition Requirement	Very High	√		√	
RN11	The science payload shall glide in a circular pattern for one minute and stay above 100 meters after release from the container.	Competition Requirement	High	√		√	√

System Requirement Summary (2 of 4)

RN	Requirement	Rationale	Priority	Verification			
				A	I	T	D
RN12	The science payload shall be a delta wing glider.	Competition Requirement	Very High		✓		
RN13	After one minute of gliding, the science payload shall release a parachute to drop the science payload to the ground at 10 meters/second, +/- 5 m/s.	Competition Requirement	Very High		✓	✓	
RN15	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	Competition Requirement	Very High		✓		
RN18	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Competition Requirement	Very High	✓		✓	✓
RN19	All mechanisms shall be capable of maintaining their configuration or states under all forces.	Competition Requirement	Very High	✓	✓		✓
RN21	Mechanisms that use heat (e.g., Nichrome wire) shall not be exposed to the outside environment to reduce potential risk of setting vegetation on fire.	Competition Requirement	High		✓		
RN22	The science payload shall measure altitude using an air pressure sensor.	Competition Requirement	Very High			✓	✓
RN23	The science payload shall provide position using GPS.	Competition Requirement	Very High			✓	✓
RN24	The science payload shall measure its battery voltage.	Competition Requirement	Very High			✓	✓
RN25	The science payload shall measure outside temperature.	Competition Requirement	Very High			✓	✓
RE26	The science payload shall measure particulates in the air as it glides.	Competition Requirement	Very High			✓	✓

System Requirement Summary (3 of 4)

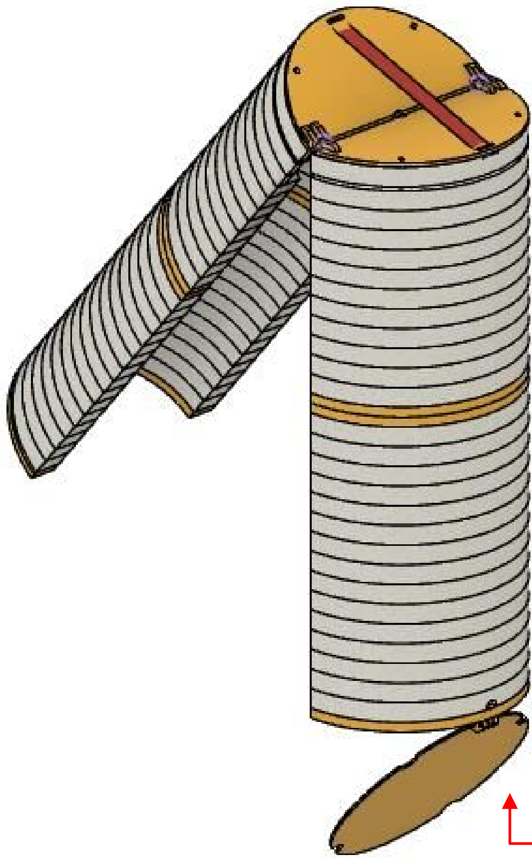
RN	Requirement	Rationale	Priority	Verification			
				A	I	T	D
RN27	The science payload shall measure air speed.	Competition Requirement	Very High			√	√
RN28	The science payload shall transmit all sensor data in the telemetry.	Competition Requirement	Very High			√	√
RN29	Telemetry shall be updated once per second.	Competition Requirement	High	√		√	
RN30	The Parachutes shall be fluorescent Pink or Orange	Competition Requirement	Very High		√		
RN38	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.	Competition Requirement	Very High	√			
RN39	Each team shall develop their own ground station.	Competition Requirement	Very High	√			
RN40	All telemetry shall be displayed in real time during descent.	Competition Requirement	Very High			√	√
RN41	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	Competition Requirement	Very High	√	√		
RN43	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a hand-held antenna.	Competition Requirement	High			√	√
RN45	Both the container and probe shall be labeled with team contact information including email address.	Competition Requirement	Very High	√	√		
RN47	No lasers allowed.	Competition Requirement	Medium	√			

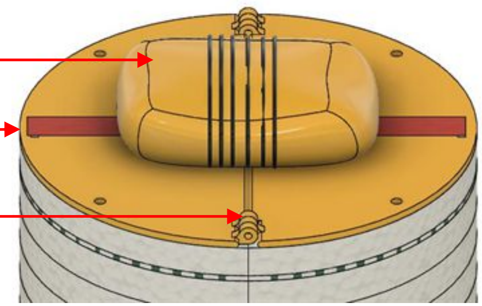
System Requirement Summary (4 of 4)

RN	Requirement	Rationale	Priority	Verification			
				A	I	T	D
RN48	The probe must include an easily accessible power switch that can be accessed without disassembling the cansat and in the stowed configuration.	Competition Requirement	Very High		✓		✓
RN49	The probe must include a power indicator such as an LED or sound generating device that can be easily seen without disassembling the cansat and in the stowed state.	Competition Requirement	Very High	✓	✓		
RN50	An audio beacon is required for the probe. It may be powered after landing or operate continuously.	Competition Requirement	Very High	✓		✓	✓
RN51	The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed.	Competition Requirement	High	✓	✓		
RN52	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.	Competition Requirement	Very High		✓		
RN53	An easily accessible battery compartment must be included allowing batteries to be installed or removed in less than a minute and not require a total disassembly of the CanSat.	Competition Requirement	Very High		✓		✓
RN54	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Competition Requirement	High	✓	✓		
RN56	Payload/Container shall operate for a minimum of two hours when integrated into rocket.	Competition Requirement	Very High	✓		✓	
BM	A video camera shall be integrated into the science payload and point toward the coordinates provided for the duration of the glide time. Video shall be in color with a minimum resolution of 640x480 pixels and 30 frames per second. The video shall be recorded and retrieved when the science payload is retrieved. Points will be awarded only if the camera can maintain pointing at the provided coordinates for 30 seconds uninterrupted.	Bonus Mission	Very High	✓	✓	✓	

Physical Layout (1 of 8)

CONTAINER





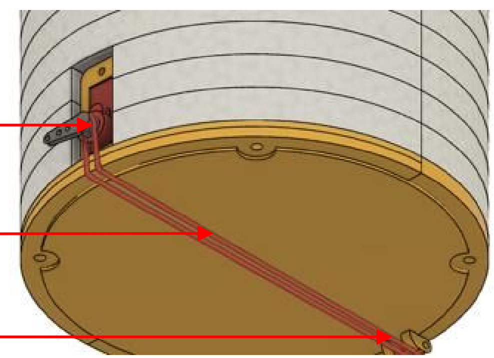
Parachute (folded)

Rubber

Hinge

Container layer (PLA)

Container layer (Polyfoam)



Servo

Rubber

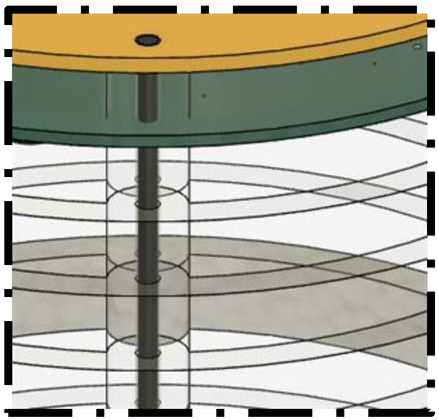
Hinge

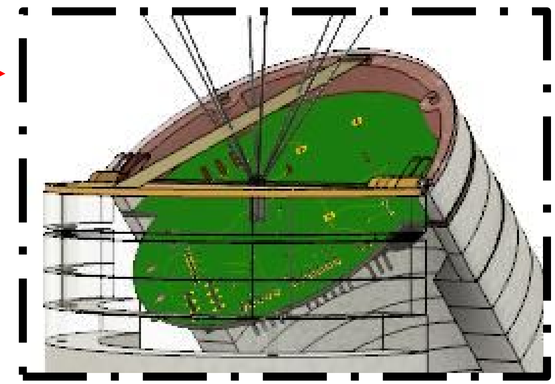
Container Lid

Detailed Technical Drawing Link:
https://drive.google.com/drive/folders/1o9-aatcGgh5FbPMxNwzNsK0NhFsDQE8i?usp=sharing

Physical Layout (2 of 8)

DETAILED CONTAINER



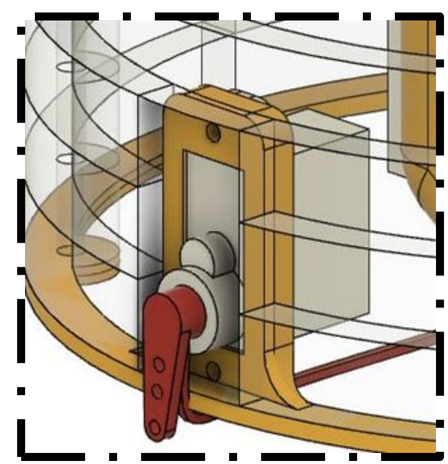


Container electronics detail

Container structures detail:

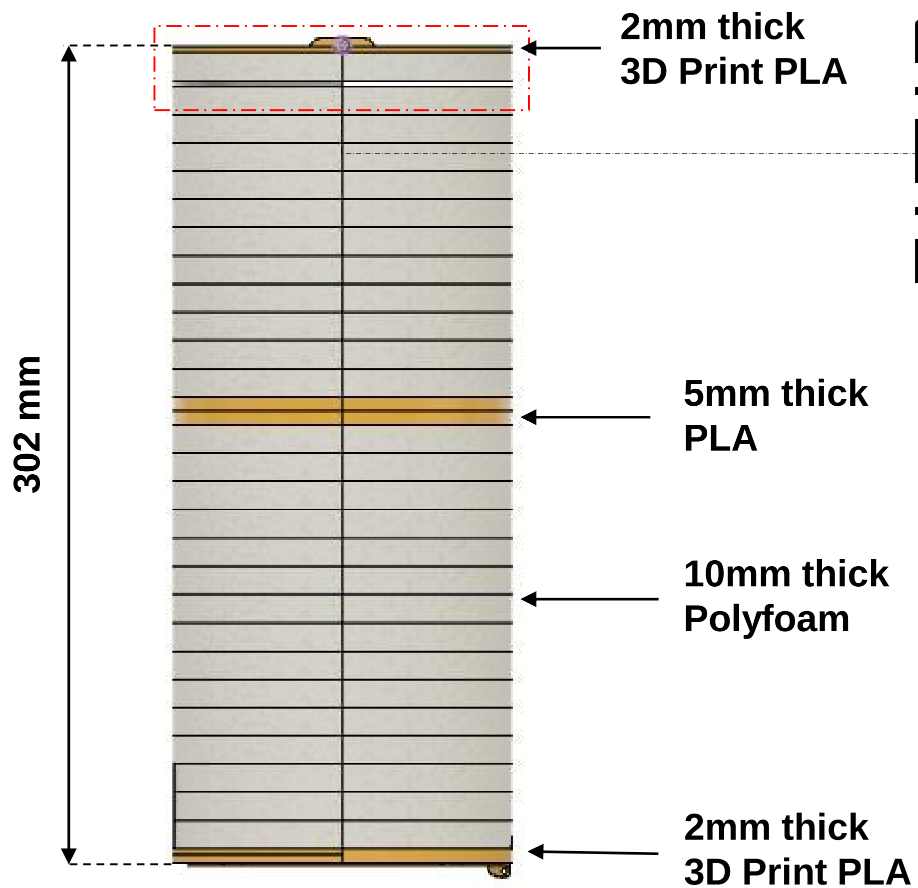
- 3D Printed layer
- PCB
- Polyfoam

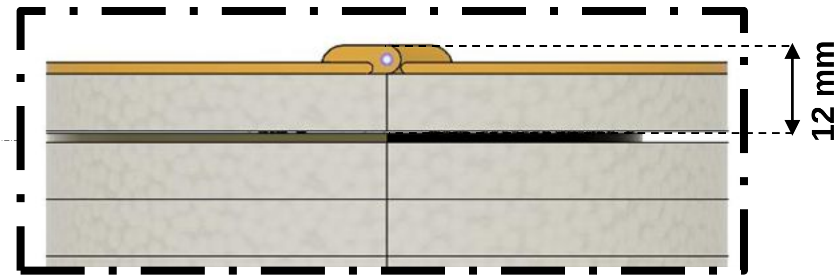
Each layer is stacked up by using epoxy adhesives and supported by 4 carbon rods



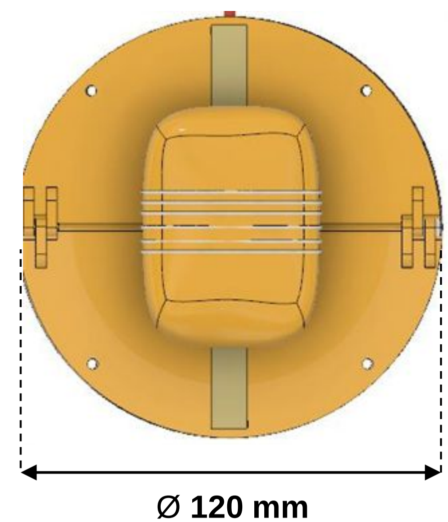
Detail on container servo lock

CONTAINER DIMENSION

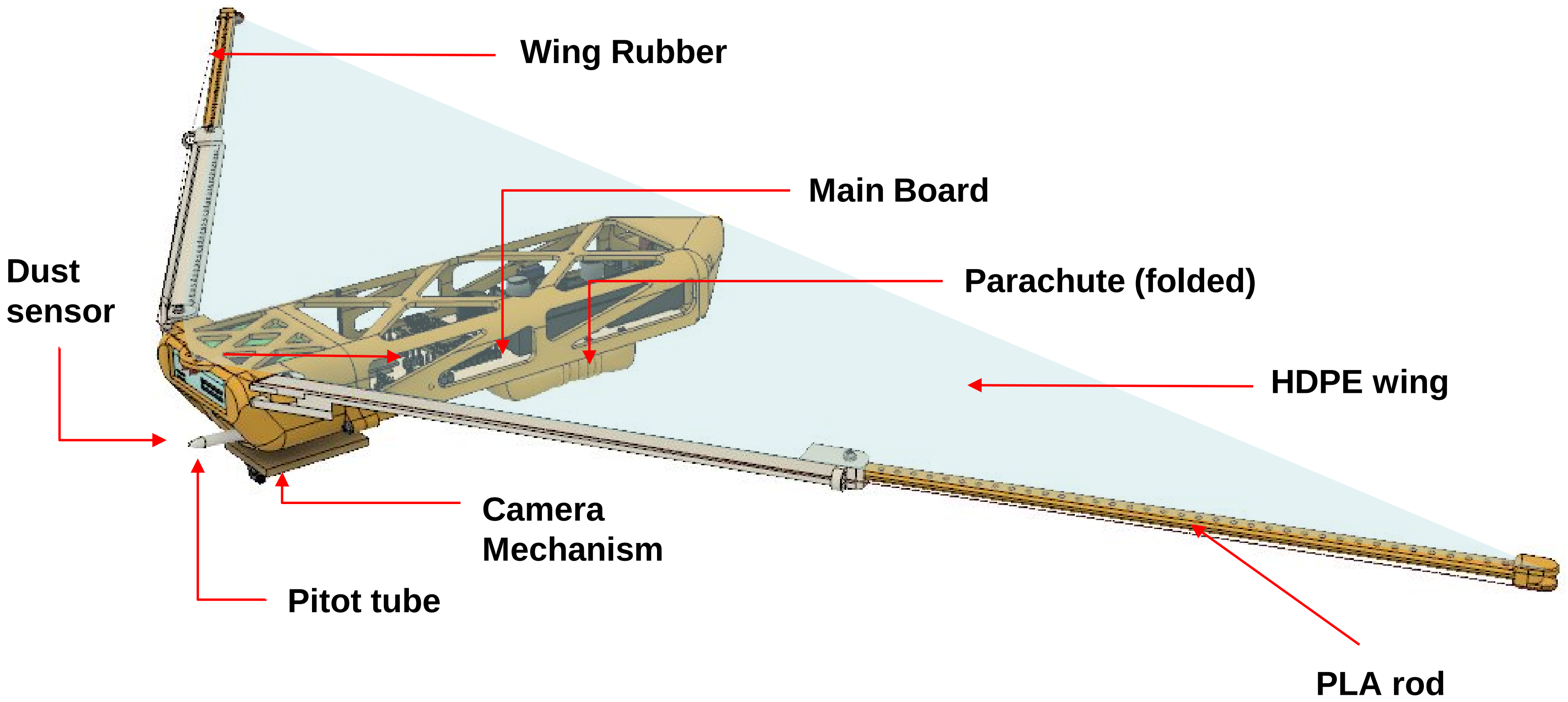




Clearance between container PCB and the top layer

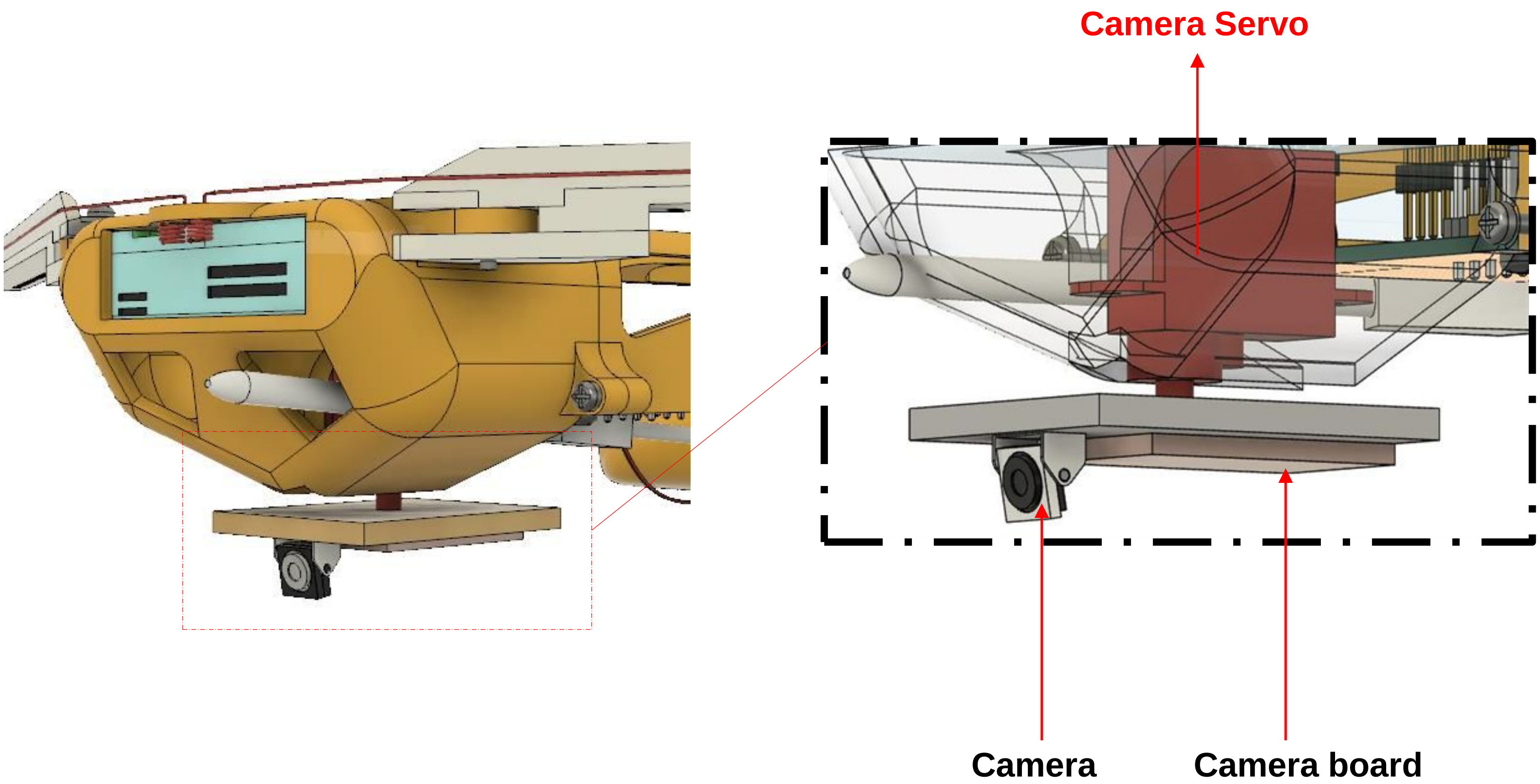


PAYLOAD



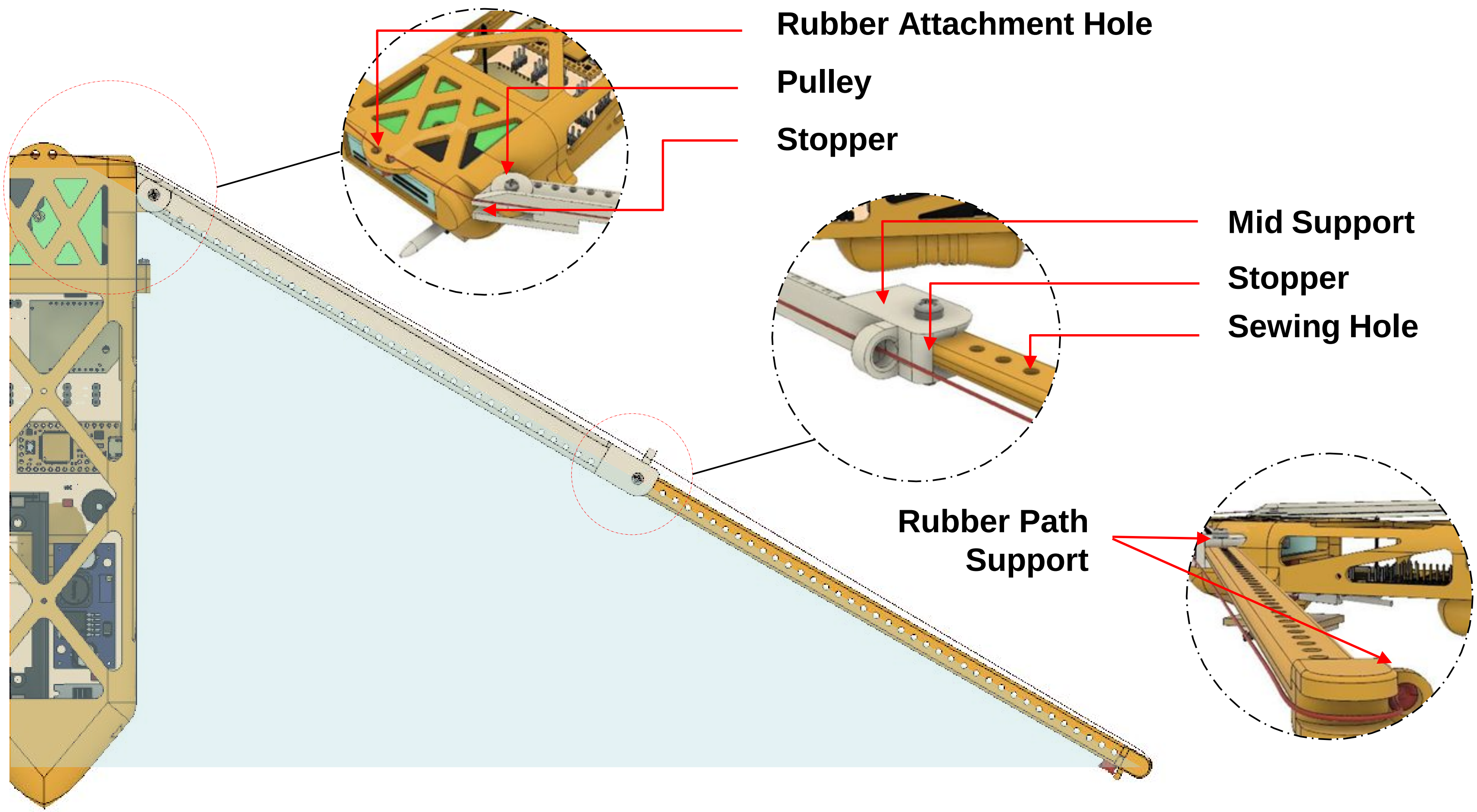
Detailed Technical Drawing Link:
https://drive.google.com/drive/folders/1o9-aatcGgh5FbPMxNwzNsK0NhFsDQE8i?usp=sharing

CAMERA MECHANISM

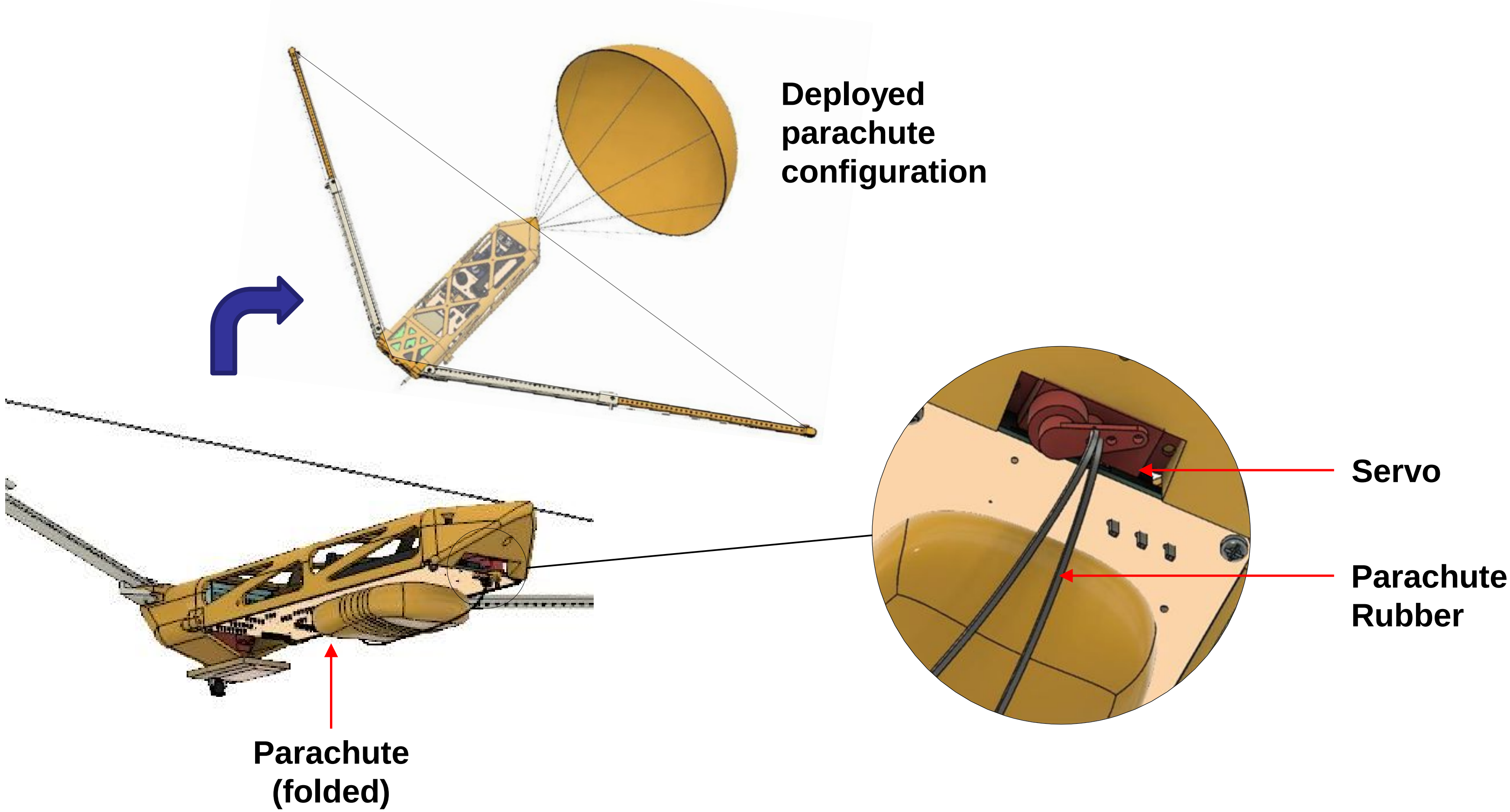


Physical Layout (6 of 8)

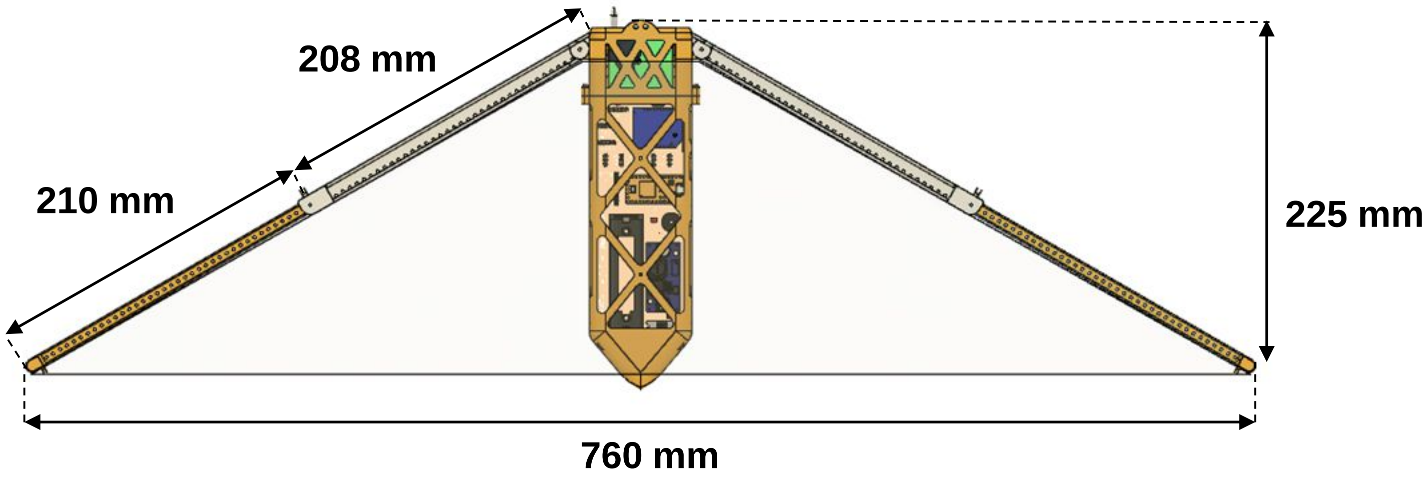
WING DEPLOYMENT MECHANISM

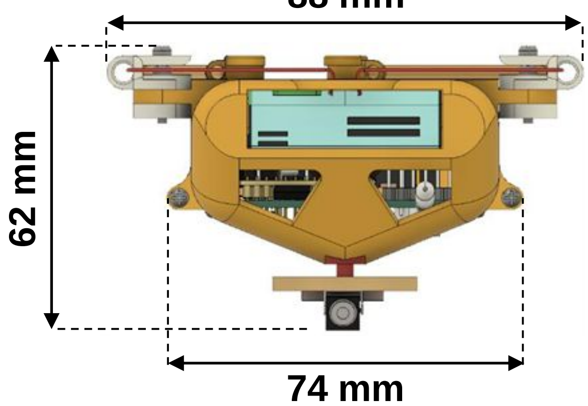


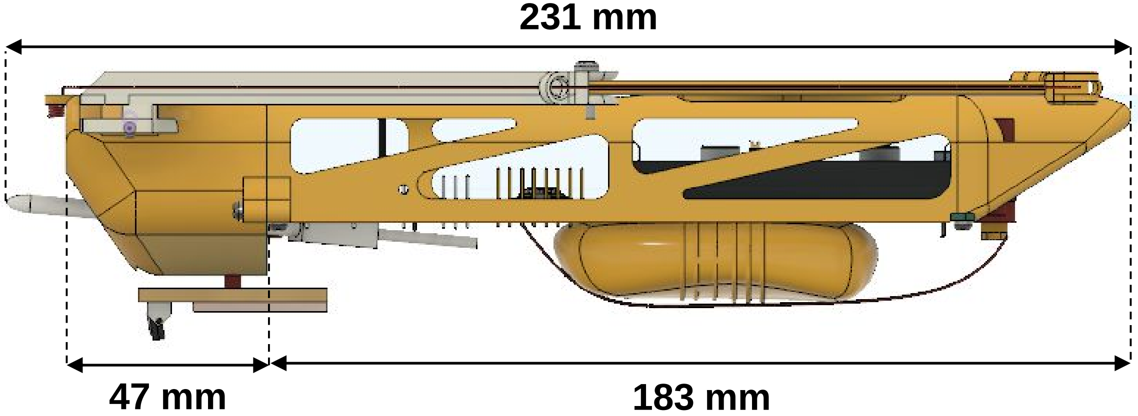
PARACHUTE DEPLOYMENT MECHANISM



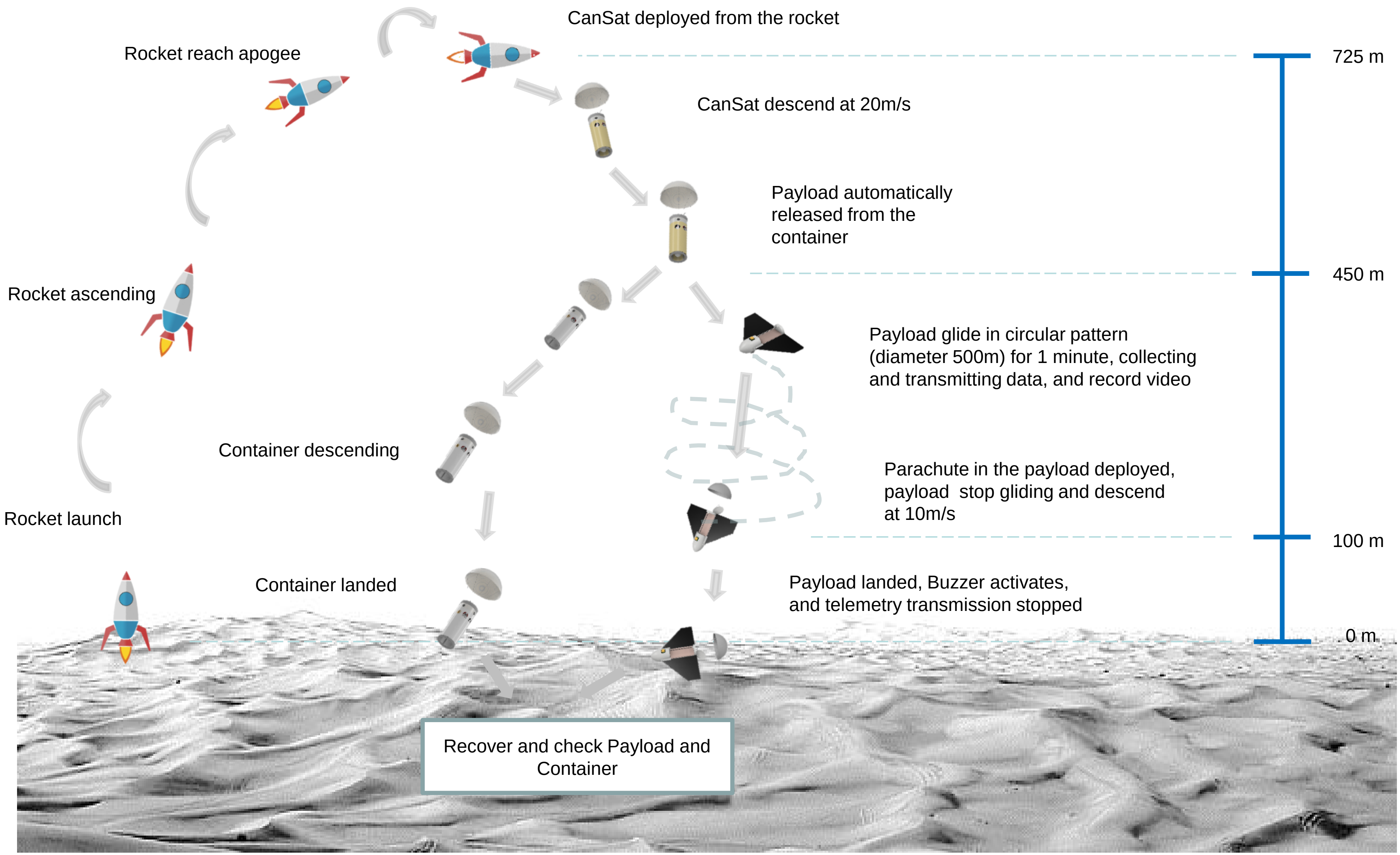
PAYLOAD DIMENSION







System Concept of Operations (1 of 3)



System Concept of Operations (2 of 3)

Pre-launch	Launch	Post - Launch
Team arrives at Competition Area	Rocket Launch	Recovery of Payload and Container
Pre-Launch Brief	Data Transmission Begin	Inspect Payload and Container damage if any
Set Up GCS	CanSat separated from rocket (670-725m)	Retrieve SD Card that contain flight video recording
System calibration based on GCS Command	Parachute deploy (Descent rate at 20m/s)	Data Analysis
Communication Check	Payload separated from container (450m) and start to glide in circular pattern for 1 minute	PFR Preparation
CanSat Final Check	Video recorded during payload glide	PFR Presentation
CanSat placed into rocket	At 100m, payload's parachute deploy (Descent rate at 10m/s)	
	Buzzer active at 5m height	
	Telemetry transmission stop	

System Concept of Operations (3 of 3)

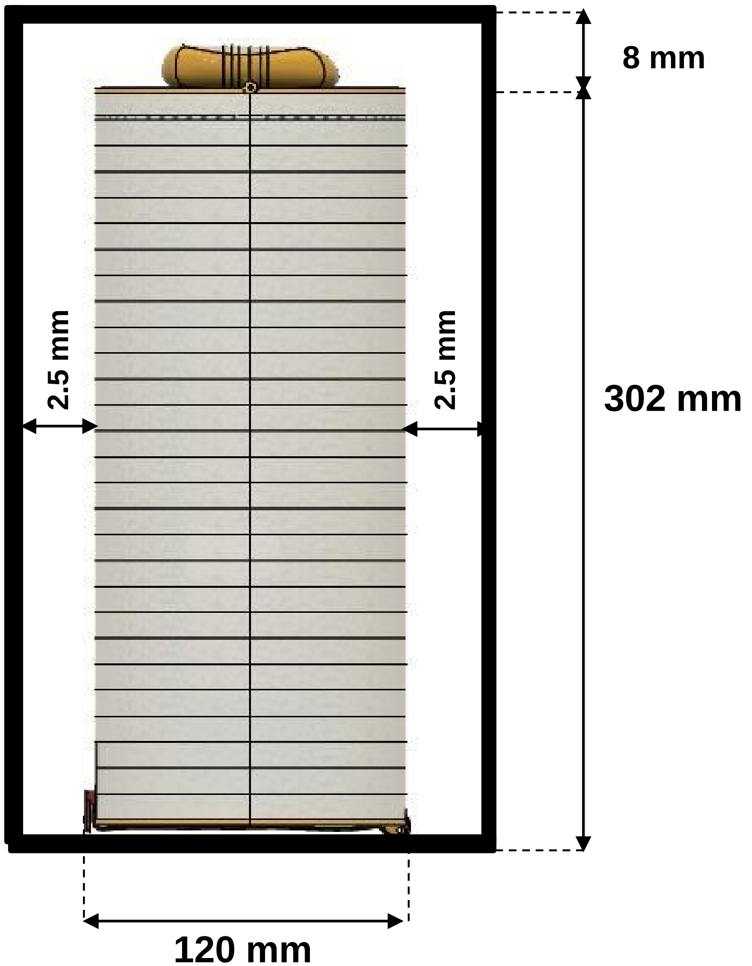
Team Member roles and responsibilities

Roles	Responsibilities	Member Name
Mission Control Officer	Inform flight coordinator when team and CanSat ready for launch	Kenrick Tjandra
CanSat Crew	Prepare CanSat, Integrate CanSat into the rocket, and verify CanSat's status	Indra Budi Setyawan
		Muhammad Dyffa
		Mario Jaya
Ground Station Crew	Monitor GCS for telemetry reception and issue command to the CanSat	Wildan Purnomo
		Mahatma Wisesa
Container Recovery Crew	Track CanSat, recover CanSat, and interact with field judges (make sure all field scores filled in)	Muhammad Nur Ilmi
		Nico Renaldo
Payload Recovery Crew		Luqman Al Helmy
		Nafisah Hasya Sekarini

Launch Vehicle Compatibility

Launch Vehicle Compatibility - Summary

Container clearance with launch vehicle



Payload clearance with container

Top layer to payload
41 mm

Payload side body to container body
16 mm

Wing rods will contact the container inner body

No sharp protrusions

Sensor Subsystem Design

Muhammad Nur Ilmi

Sensor Subsystem Overview

Selected Component	Type	Function	Interface
Adafruit BMP 388	Pressure and temperature sensor	Measures air pressure and temperature both in the payload and the container	I2C
Matek SAM M8Q	GPS	Gets payload coordinates (latitude and longitude), GPS time, and GPS satellite	Serial
Voltage divider	Voltage Sensor	Measures voltage of the payload's battery	ADC
MXP7002DP Pitot Tube	Air speed sensor	Measures air speed relative to the payload	ADC
Sensirion SPS30	Particle sensor	Counts the particle relative to the payload while gliding	I2C
Adafruit Mini Spy Camera	Camera	Records a video	Digital

***NO LASERS**

Sensor Changes Since PDR

- **There are no changes in Sensor Subsystem Design since PDR**

Sensor Subsystem Requirements (1 of 2)

RN	Requirement	Rationale	Priority	Verification			
				A	I	T	D
RN1	Total mass of the CanSat (science payload and container) shall be 600 grams +/- 10 grams.	Competition Requirement	Very High	√		√	
RN10	The container shall release the payload at 450 meters +/- 10 meters.	Competition Requirement	Very High	√		√	
RN11	The science payload shall glide in a circular pattern for one minute and stay above 100 meters after release from the container.	Competition Requirement	High	√		√	√
RE13	After one minute of gliding, the science payload shall release a parachute to drop the science payload to the ground at 10 meters/second, +/- 5 m/s.	Competition Requirement	Very High		√	√	
RE15	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	Competition Requirement	Very High		√		
RE16	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Competition Requirement	Very High	√		√	√
RN22	The science payload shall measure altitude using an air pressure sensor.	Competition Requirement	Very High			√	√
RN23	The science payload shall provide position using GPS.	Competition Requirement	Very High			√	√
RN24	The science payload shall measure its battery voltage.	Competition Requirement	Very High			√	√
RN25	The science payload shall measure outside temperature.	Competition Requirement	Very High			√	√
RE26	The science payload shall measure particulates in the air as it glides.	Competition Requirement	Very High			√	√

Sensor Subsystem Requirements (2 of 2)

RN	Requirement	Rationale	Priority	Verification			
				A	I	T	D
RE27	The science payload shall measure air speed.	Competition Requirement	Very High			✓	✓
RN38	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.	Competition Requirement	Very High	✓	✓		
RN41	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	Competition Requirement	Very High	✓			✓
BM	A video camera shall be integrated into the science payload and point toward the coordinates provided for the duration of the glide time. Video shall be in color with a minimum resolution of 640x480 pixels and 30 frames per second. The video shall be recorded and retrieved when the science payload is retrieved. Points will be awarded only if the camera can maintain pointing at the provided coordinates for 30 seconds uninterrupted.	Bonus Mission	Very High			✓	

Payload Air Pressure Sensor Summary (1 of 2)

Sensor	Adafruit BMP 388

Pressure Range (hPa)	Operating Voltage (V)	Weight (g) / Dimension (mm)	Current Consumption (uA)	Resolution (Pa)	Accuracy (hPa)	Interface	Data Format
300-1250	1.65 – 3.6	1.2 21.6 x 16.6	2.7	0.016	±0.08	I2C, SPI	Float XXXXX.XX (Pa)

Altitude above sea level can be calculated from Barometric Equation below. However, output from sensor is very noisy so that a kalman filter will be used to estimate the pressure value

Barometric Equation

$$h = 44330 \times \left(1 - \left(\frac{P}{P_0}\right)^{\frac{1}{5.255}}\right)$$

h = *calculated altitude* $[m]$
P = *sensed pressure* $[Pa]$
Po = *pressure at ground level* $[Pa]$

Sample Output

```
pressure : 99697.86
pressure : 99698.62
pressure : 99701.95
pressure : 99699.18
pressure : 99698.55
pressure : 99698.00
```

Payload Air Pressure Sensor Summary (2 of 2)

Data Processing

```
bmp.performReading();
press = bmp.pressure;
readAlt = bmp.readAltitude(SEALEVELPRESSURE_HPA);

kalmanBarometer();

if (readAlt != 0 && millis() < 5000) {
  alt0 = readAlt;
}
if(readAlt<alt0){
  alt0=readAlt;
}
altitudeBMP = readAlt - alt0;
```

Kalman Filter

```
void kalmanBarometer() {
  baroKalman[0] = baroKalman[0] + baroKalman[1];
  baroKalman[3] = baroKalman[0] / (baroKalman[0] + baroKalman[2]);
  baroKalman[4] = baroKalman[4] + baroKalman[3] * (readAlt - baroKalman[4]);
  baroKalman[0] = (1 - baroKalman[3]) * baroKalman[0];
  readAlt = baroKalman[4];
}
```

Payload Air Temperature Sensor Summary

Sensor	Adafruit BMP 388						
Temperature Range (°C)	**Operating Voltage (V)**	**Weight (g) / Dimension (mm)**	**Current Consumption (uA)**	**Resolution (Pa)**	**Accuracy (hPa)**	**Interface**	**Data Format**
0 – 65	1.65 – 3.6	1.2 21.6 x 16.6	2,7	0.016	±0.08	I2C, SPI	Float XX.XX (C)

Temperature data will be collected and processed with the help of Adafruit_BMP3XX library. No further processing is needed as the reading is very stable

Data Processing

```
bmp.begin();
bmp.setTemperatureOversampling(BMP3_OVERSAMPLING_2X);
bmp.setPressureOversampling(BMP3_OVERSAMPLING_32X);
bmp.setIIRFilterCoeff(BMP3_IIR_FILTER_DISABLE);
bmp.performReading();
```

Sample Output

```
temp : 27.53
temp : 27.54
temp : 27.56
temp : 27.65
temp : 27.65
temp : 27.65
```

GPS Sensor Summary

Sensor	Matek SAM M8Q + Compass							
Tracking Sensitivity (dBm)	Operating Voltage (V)	Weight (g) / Size (mm)	Current Consumption (mA)	Channel	Accuracy (m)	Interface	Update Rate (Hz)	Data Format
-165	4-6	7 20 x 20 x 10	29	72	~2.5	UART	18	Float and Integer

Longitude, latitude, and the other data will be collected and processed with the help of Tiny GPS Plus library by Mikal Hart. This sensor can lock onto GPS satellite quickly

Data Processing

```
while (gpsSerial.available() > 0) {
  if (gps.encode(gpsSerial.read())) {
    if (gps.location.isValid()) {
      latitude = gps.location.lat();
      longitude = gps.location.lng();
      altitudeGPS = gps.altitude.meters();
    }
    if (gps.time.isValid()) {
      jam = gps.time.hour();
      menit = gps.time.minute();
      detik = gps.time.second();
    }
    satellite = gps.satellites.value();
  }
}
```

Sample Output

```
14,12,13,-7.7711291,110.3733215,144.3,7.00
14,12,14,-7.7711148,110.3732986,141.3,9.00
14,12,15,-7.7710929,110.3733139,142.7,10.00
14,12,16,-7.7711000,110.3733139,138.9,10.00
14,12,17,-7.7711000,110.3733139,138.9,10.00
14,12,18,-7.7711091,110.3733063,145.7,11.00
14,12,18,-7.7711091,110.3733063,145.7,11.00
```

Left to right:
Hour, minute, second, latitude, longitude, altitude, satellite

Source: https://github.com/mikalhart/TinyGPSPlus/blob/master/src/TinyGPS%2B%2B.h

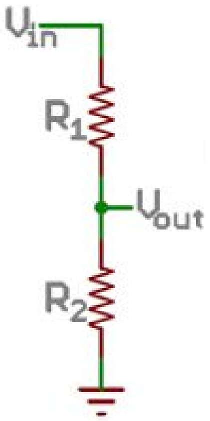
Payload Voltage Sensor Summary

Name	Range (V)	Error rate (%)	Interface	Data Format
Processor Analog Pin (Voltage Divider)	0 - 5	0.03	ADC	Float X.XX (Volt)

Battery voltage is measured using the ADC port trough a voltage divider, the following resistors are used in the circuit

R1 = 1 MΩ (1% error)

R2 = 100 kΩ (1% error)



The ATSAMD Processor ADC has maximum resolution of 32-bit with 3.3 volt analog reference, but the resolution used is 16-bit resolution. So, the maximum accuracy of this on board voltage sensor is 50 uV.

Data Processing

```
static int R1 = 1000000; //1M ohm
static int R2 = 100000; // 100k ohm
analogReadResolution(16);
rawVoltage = (analogRead(voltagePin) * 3.3) / 65535.0;
teganganBaterai = rawVoltage * (R1 + R2) / R2;
```

Sample Output

```
batt : 3.99
batt : 3.99
batt : 3.99
batt : 3.99
batt : 3.99
batt : 3.99
batt : 3.99
batt : 3.99
```

Sensor	MPXV7002DP						
Pressure Range (kPa)	**Size (in)**	**Operating current (mA)**	**Operating Voltage (V)**	**Operational Environment (°C)**	**Sensitivity (V/kPa)**	**Interface**	**Data Format**
(-2) – 2	0.7 x 0.75	10	5	10 – 60	1	Analog	Float XX.X (m/s)

The MPXV7002DP is a sensor that relates the pressure differential between its two inputs. Air speed can be found by applying equation below.

Velocity Equation

$$v = \sqrt{\frac{10000 \cdot \left(\frac{R}{2^{10}-1} - 0.5\right)}{\rho}}$$

R : analog input reading
ρ : air density

Sample Output

```
air speed: 37.79
air speed: 36.41
air speed: 40.28
air speed: 40.50
air speed: 38.43
air speed: 36.27
air speed: 34.98
air speed: 34.86
```

Air Speed Sensor Summary (2 of 2)

Data Processing

```
adc_avg = 0;
veloc = 0.0;
for (int ii = 0; ii < veloc_mean_size; ii++) {
  analogReadResolution(10);
  adc_avg += analogRead(pitotPin) - PITOT_OFFSET;
}
adc_avg /= veloc_mean_size;
if (adc_avg > 512 - zero_span and adc_avg < 512 + zero_span) {
} else {
  if (adc_avg < 512) {
    veloc = -sqrt((-10000.0 * ((adc_avg / 1023.0) - 0.5)) / rho);
  } else {
    veloc = sqrt((10000.0 * ((adc_avg / 1023.0) - 0.5)) / rho);
  }
}
if(veloc<0){
  veloc=0;
}
```

Particulate/ Dust Sensor Summary

Sensor	Sensirion SPS30						
Weight/ Size (g/mm)	Operating Current (mA)	Operating Voltage (V)	Operational Environment (°C)	Mass Concentration Accuracy (µg/m³)	Mass Concentration Range (ug/m³)	Interface	Data Format
0.3 41 x 41 x 12	55	5	-10 to 60	1 to 10	1 to 1000	UART, I2C	Float XXX.XX (mg/m^3)

- This sensor is fully calibrated. Particle mass data will be collected and processed with the help of Sensirion SPS30 library.
- It has self cleaning procedure

Data Processing

```
sps30.begin(I2C_COMMS);
sps30.probe();
sps30.reset();
sps30.start();
ret = sps30.GetValues(&val);
massaPM10 = val.MassPM10;
```

Sample Output

```
Total PM10 mass (mg/m^3): 16.45
Total PM10 mass (mg/m^3): 16.47
Total PM10 mass (mg/m^3): 16.49
Total PM10 mass (mg/m^3): 16.50
Total PM10 mass (mg/m^3): 16.52
Total PM10 mass (mg/m^3): 16.54
```

Bonus Objective Camera Summary (1 of 2)

Sensor	Adafruit Mini Spy Camera			
Weight (g) / Size (mm)	**Voltage (V)**	**Resolution (Pixels)**	**Interface**	**Data Format**
2.8 28.5 x 17 x 4.2	5	640 x 480	External SD Card	.AVI (stored in SD Card)

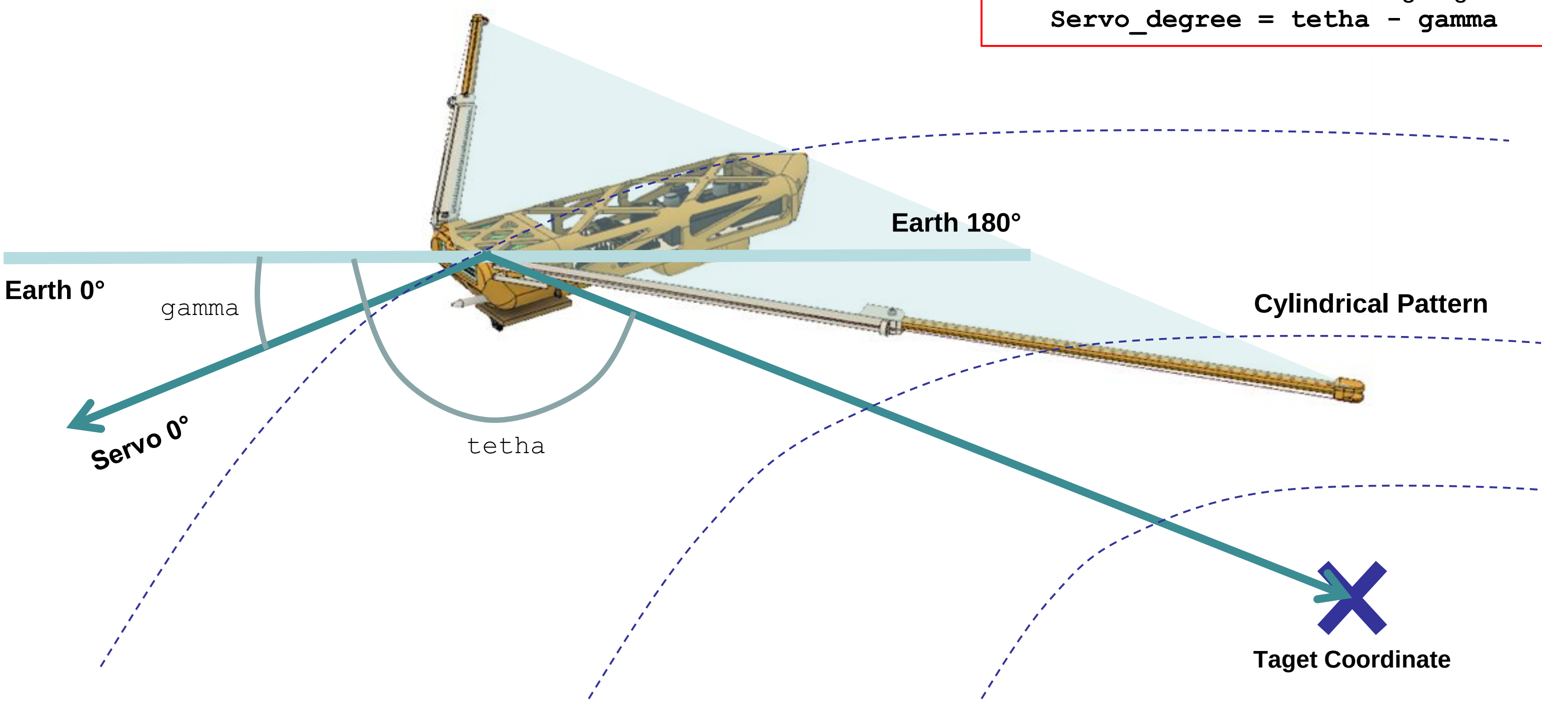
- This camera is very light. It can be easily trigger with digital output pin from processor. We used internal compass QMC588L from GPS module and a servo to maintain our camera, so it point in one direction.
- It has a dedicated pin to capture photos or video

Bonus Objective Camera Summary (2 of 2)

Data Processing

```
double dradianLon = (lon2 - lon1) * DEG_TO_RAD;    //Δλ
double radianLat1 = lat1 * DEG_TO_RAD;             //φ1
double radianLat2 = lat2 * DEG_TO_RAD;             //φ2
double a1 = sin(dradianLon) * cos(radianLat2);
double a2 = cos(radianLat1) * sin(radianLat2) - sin(radianLat1) * cos(radianLat2) * cos(dradianLon);
double tetha = atan2(a1, a2) * RAD_TO_DEG;
tetha = fmod(tetha + 360, 360) ;
```

To maintain the camera's point of view, we need to move it at the following angle:
`Servo_degree = tetha - gamma`



Container Air Pressure Sensor Summary

Sensor	Adafruit BMP 388

Pressure Range (hPa)	Operating Voltage (V)	Weight (g) / Dimension (mm)	Current Consumption (uA)	Resolution (Pa)	Accuracy (hPa)	Interface	Data Format
300-1250	1.65 – 3.6	1.2 21.6 x 16.6	2.7	0.016	±0.08	I2C, SPI	Float XXXXX.XX (Pa)

Altitude above sea level can be calculated from Barometric Equation below. However, output from sensor is very noisy so that a kalman filter will be used to estimate the pressure value

Barometric Equation

$$h = 44330 \times \left(1 - \left(\frac{P}{P_0}\right)^{\frac{1}{5.255}}\right)$$

h = *calculated altitude* $[m]$

P = *sensed pressure* $[Pa]$

Po = *pressure at ground level* $[Pa]$

Sample Output

```
pressure : 99697.86
pressure : 99698.62
pressure : 99701.95
pressure : 99699.18
pressure : 99698.55
pressure : 99698.00
```

Descent Control Design

Luqman Al Helmy

Descent Control System

Consists of a Parachute and a deployable delta wing that equipped with secondary parachute

Payload Descent Control System: Flexible Delta Wing Glider

- Flexible wing is made of HDPE plastic, with elastic rubber deployment system
- Wing frame is made of PLA and attached to the front part of the payload
- Two connected and folded frames will be used to extend wing surface area
- Wing frame will be held by the inner part of container body during pre deployment
- When payload is deployed, wing frame will create 120 degrees angle, with approximate wing surface area of 286 cm^2.

Payload & Container Control System: Parachute

- Parachute is made of HDPE plastic
- Container parachute has 15 cm diameter to ensure descend speed at 20 m/s
- Payload parachute has 20 cm diameter to ensure descend speed at 10 m/s

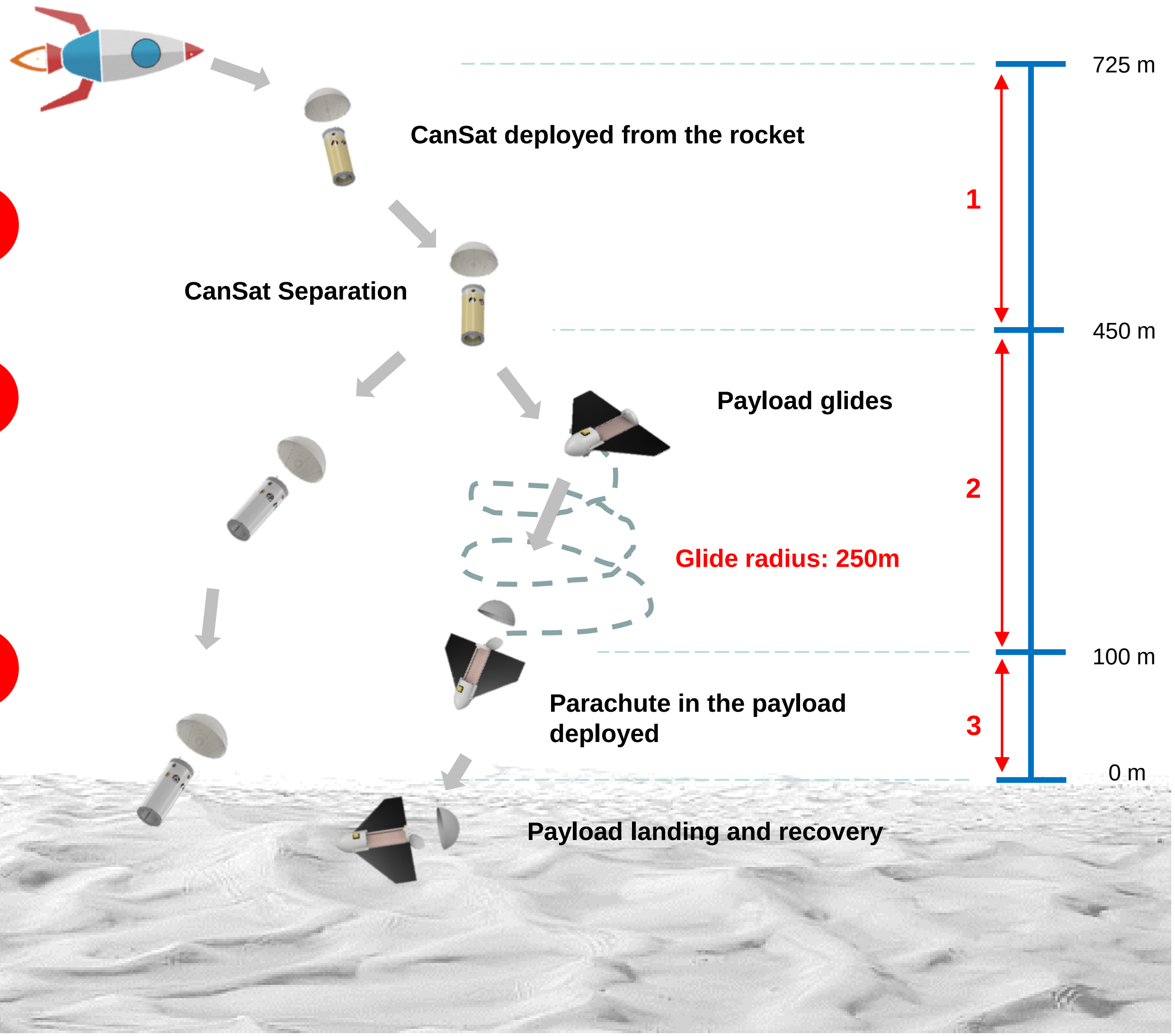
Descent Control Overview (2 of 2)

Deployment and Release Order

1. CanSat descent from 720m to 450m at rate of 20m/s with parachute

2. CanSat separation, payload glide in circular pattern with radius 250m for 1 minute and altitude maintained above 100m

3. Payload's parachute deployed and descent at rate of 10m/s



Descent Control Changes Since PDR (1 of 4)

Changes Since PDR

Components	PDR	CDR	Rationale
Payload descent control hardware: • **Delta Wing Surface Area**	Payload wingspan: $W_s = 0.44\ [m]$ Payload wing root chord: $R_C = 0.13\ [m]$	Payload wingspan: $W_s = 0.76\ [m]$ Payload wing root chord: $R_C = 0.195\ [m]$	Maximizing the surface area of the delta wing will ensure higher lift force induced by the wing

Descent Control Changes Since PDR (2 of 4)

Prototype Testing

Test: CanSat & Payload Parachute Descent

Procedures:

- Parachute prototype was tied to a dummy CanSat (weight: 600 gram & 350 gram)
- The object was then lifted carefully to 40m high by using drone
- A servo was attached to the drone to release the object while ground crew observe and measure the time elapsed for the object to land

Results: CanSat's parachute deployed successfully. Descent speed was in acceptable range (+- 20m/s and 10m/s) and stable

Documentation:

Descent Control Changes Since PDR (3 of 4)

Prototype Testing

Test: Delta Glider Descend

Procedures:

- Delta glider was lifted carefully to 40m high by using drone
- A servo was attached to the drone to release the object while ground crew observe and measure the time elapsed for the object to land

Results: Glider descend at 8 m/s (expected 6 m/s), and form a circular path. Further tests in upcoming weeks will be conducted to improve the delta glider

Documentation:



Payload Delta Wing Prototype Test

- Payload delta wing prototype test has been conducted multiple times . The testing procedures is similar to container parachute testing procedure.
- The first prototype test was using the old wing design (without frame extension). Payload was able to glide when the mass is below the actual mass but fail to glide in actual mass condition.
- The last prototype test was using the extended frame wing. This test was completed successfully although the diameter of glide pattern had not reached 500 m yet


Prototype tested in PDR phase


Prototype tested in CDR phase


Final Prototype

Descent Control Requirements (1 of 2)

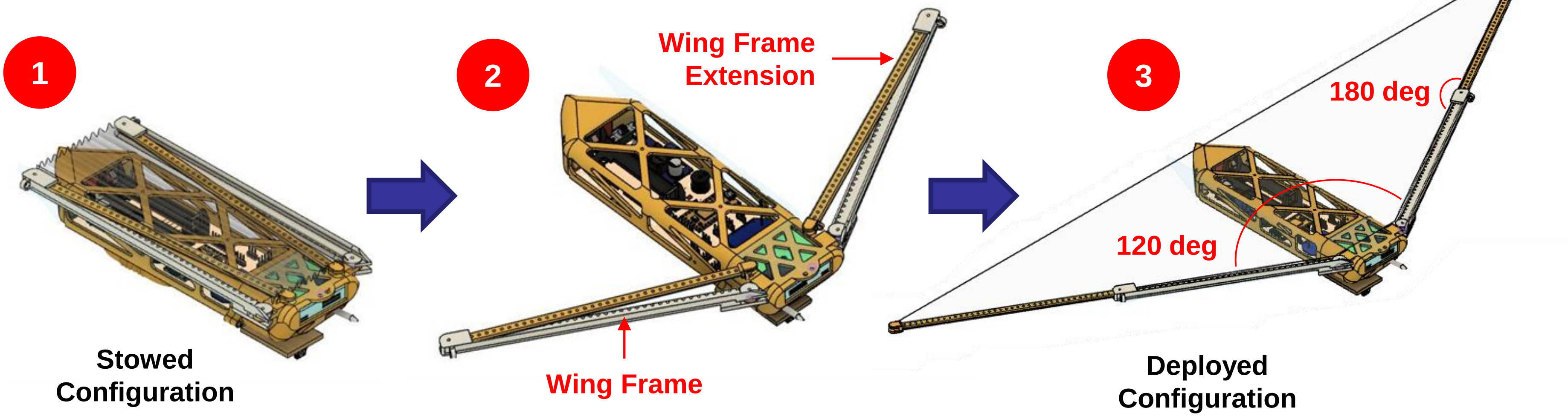
RN	Requirement	Rationale	Priority	A	I	T	D
RN1	Total mass of the CanSat (science payload and container) shall be 600 grams +/- 10 grams.	Competition Requirement	Very High	✓		✓	
RN2	CanSat shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length. Tolerances are to be included to facilitate container deployment from the rocket fairing.	Competition Requirement	Very High	✓	✓	✓	
RN3	The container shall not have any sharp edges to cause it to get stuck in the rocket payload section which is made of cardboard.	Competition Requirement	Very High	✓	✓		
RN4	The container shall be a fluorescent color; pink, red or orange.	Competition Requirement	Very High		✓		
RN5	The container shall be solid and fully enclose the science payload. Small holes to allow access to turn on the science payload is allowed. The end of the container where the payload deploys may be open.	Competition Requirement	Very High	✓	✓		
RN6	The rocket airframe shall not be used to restrain any deployable parts of the CanSat	Competition Requirement	Very High	✓			✓
RN7	The rocket airframe shall not be used as part of the CanSat operations.	Competition Requirement	Very High	✓			✓
RN8	The container parachute shall not be enclosed in the container structure. It shall be external and attached to the container so that it opens immediately when deployed from the rocket.	Competition Requirement	Very High	✓	✓		✓
RN9	The descent rate of the CanSat (container and science payload) shall be 20 meters/second +/- 5m/s.	Competition Requirement	High	✓		✓	
RN10	The container shall release the payload at 450 meters +/- 10 meters.	Competition Requirement	Very High	✓		✓	

Descent Control Requirements (2 of 2)

RN	Requirement	Rationale	Priority	Verification			
				A	I	T	D
RN11	The science payload shall glide in a circular pattern for one minute and stay above 100 meters after release from the container.	Competition Requirement	High	✓		✓	✓
RN12	The science payload shall be a delta wing glider.	Competition Requirement	Very High		✓		
RN13	After one minute of gliding, the science payload shall release a parachute to drop the science payload to the ground at 10 meters/second, +/- 5 m/s.	Competition Requirement	Very High		✓	✓	
RN20	Mechanisms shall not use pyrotechnics or chemicals.	Competition Requirement	High		✓		
RN21	Mechanisms that use heat (e.g., nichrome wire) shall not be exposed to the outside environment to reduce potential risk of setting vegetation on fire.	Competition Requirement	High		✓		
RN22	The science payload shall measure altitude using an air pressure sensor.	Competition Requirement	High			✓	✓
RN26	The Parachutes shall be fluorescent Pink or Orange	Competition Requirement	Very High		✓		
RN38	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.	Competition Requirement	High	✓			

Payload Descent Control Hardware Summary (1 of 5)

Payload DC Hardware Configurations: Delta Wing

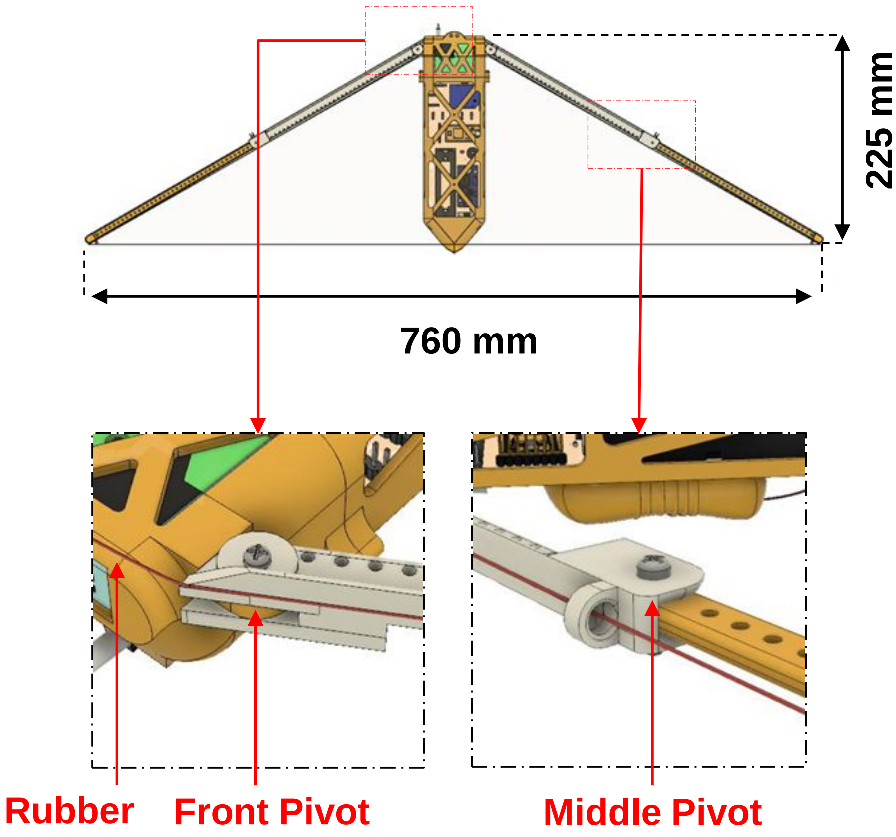


Phase	Height	Deployment Method
1	725-450 (m)	Container Inner body will maintain payload in stowed position
2	450 m	After separation, the wing frame shall deploy to its desired position (120 degree) by using the energy released from the rubber
3	450 m	The wing frame extension shall deploy following the wing frame deployment, enabling the delta wing to be fully deployed. The rubber will apply sufficient moment force to maintain wings' shape

Payload Descent Control Hardware Summary (2 of 5)

Payload DC Hardware Key Features: Delta Wing

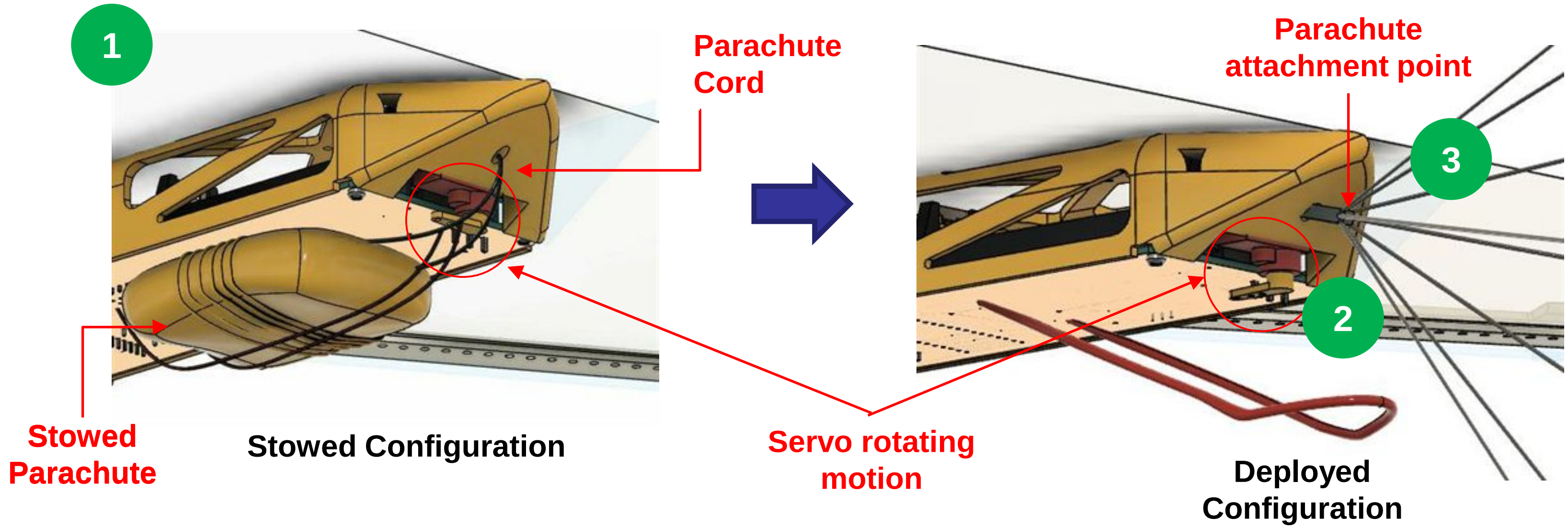
Components Sizing • When fully expanded, the delta wing dimension is as shown in these pictures
Key Design Considerations • Wing frame extension is introduced as an attempt to obtain larger delta wing surface area • Flexible and light wing material will allow less storage space while in stowed position
Color Selection • The payload delta wing color will be **red** • The payload wing frame color is **yellow** (3D printed)



*** DC hardware is passively controlled**

Payload Descent Control Hardware Summary (3 of 5)

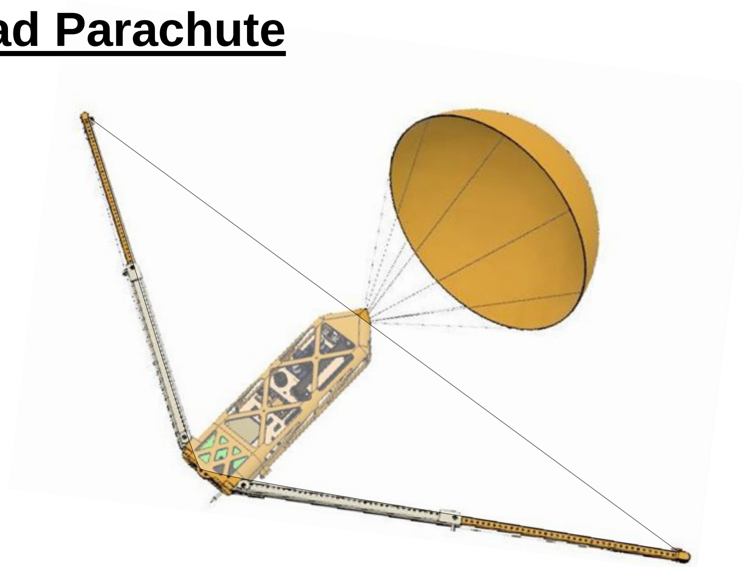
Payload DC Hardware Configurations: Payload Parachute

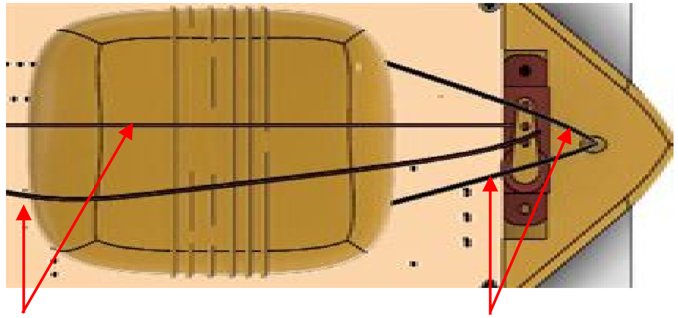


Phase	Height	Deployment Method
1	725-100 (m)	The parachute will be stowed and secured by using rubber. Rubber is attached to payload on one side and servo's horn on the other side
2	100 m	At 100 m, processor send PWM signal (triggered by altitude sensor), the servo will rotate the horn 100 degrees counter-clockwise and release attached rubber
3	100 m	Parachute deployed, air flow and gravity will ensure parachute's deployment. Phase 2 and 3 occur concurrently

Payload DC Hardware Key Features: Payload Parachute

Components Sizing
• Parachute fabric is made from 0,7 m circular shaped HDPE Plastic. Parachute projected surface area is **0.1256 m^2**
Key Design Considerations
• Servo mechanism is used due to its reliability and its compact size • Rubber band is the only tool in securing stowed parachute position. This will minimize potential problem of parachute deployment
Color Selection
• Payload parachute color will be **red** (Chosen color will aid recovery process)

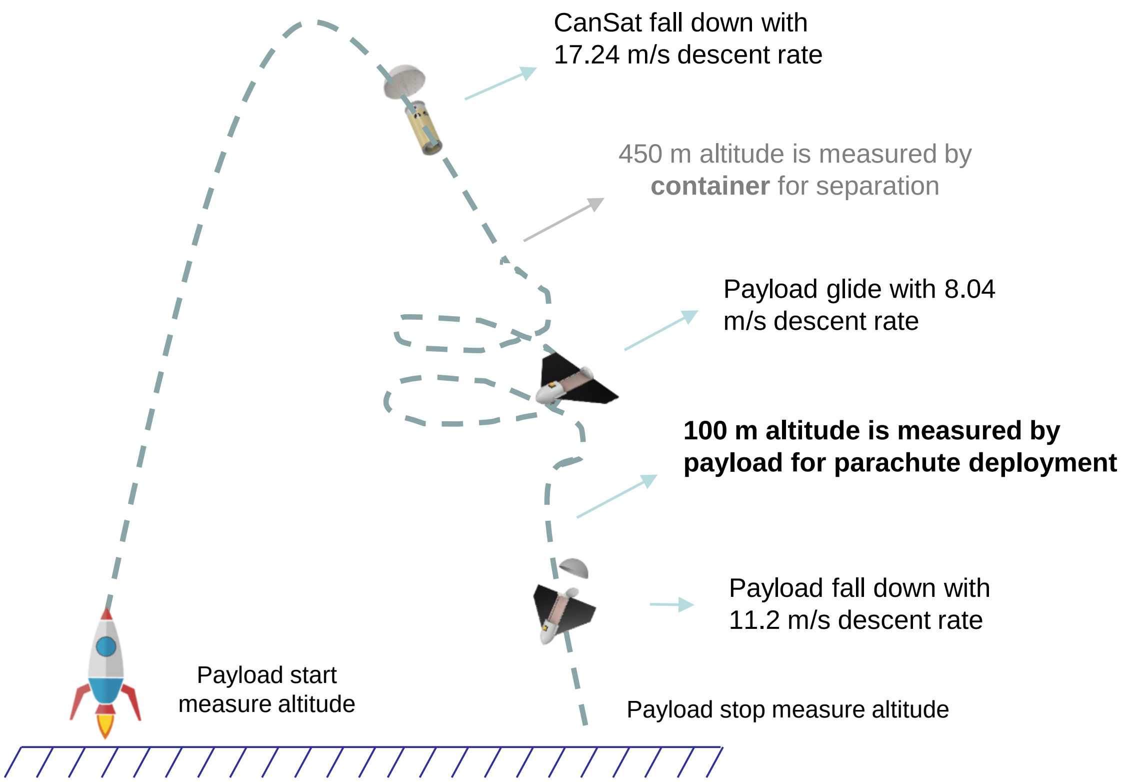




*** DC hardware is passively controlled**

Payload Sensors Operation Sequence

Throughout the entire process, payload **altitude** shall be measured to aid the descent control process. Altitude data is obtained from Adafruit BMP 388 sensor.

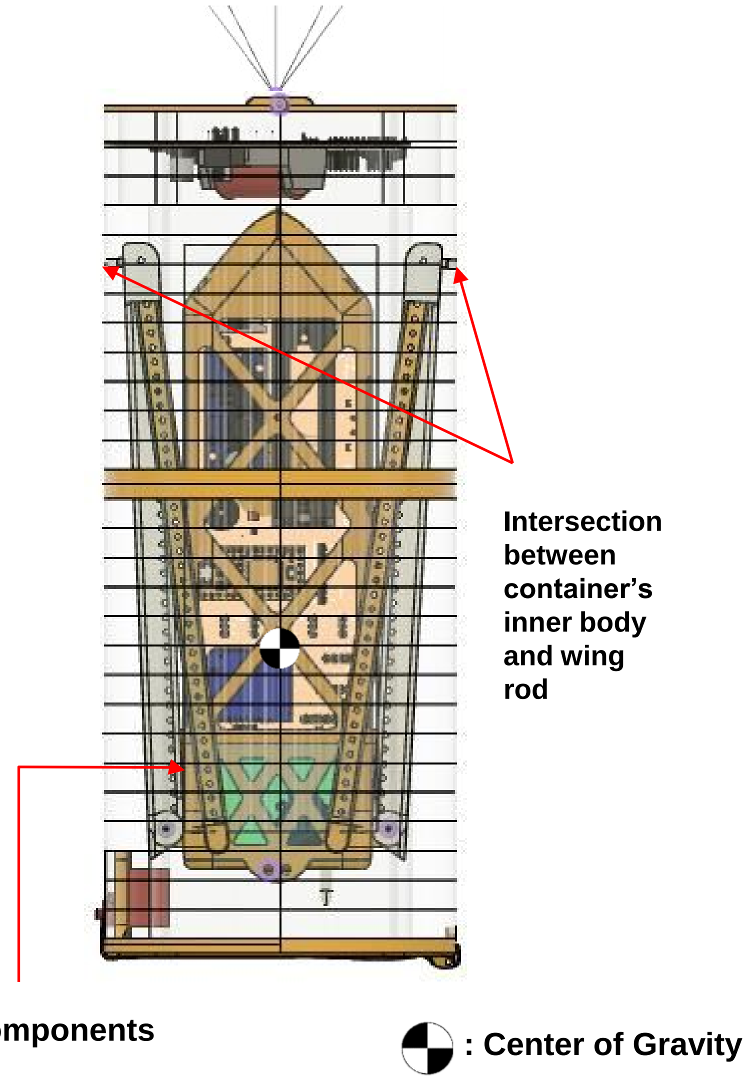


Sample Altitude (xxx.xx m)

```
altitude: 0.50
altitude: 0.55
altitude: 0.72
altitude: 1.13
altitude: 1.78
altitude: 2.12
altitude: 3.11
altitude: 4.56
altitude: 6.09
```

Payload Descent Stability Control Design (1 of 2)

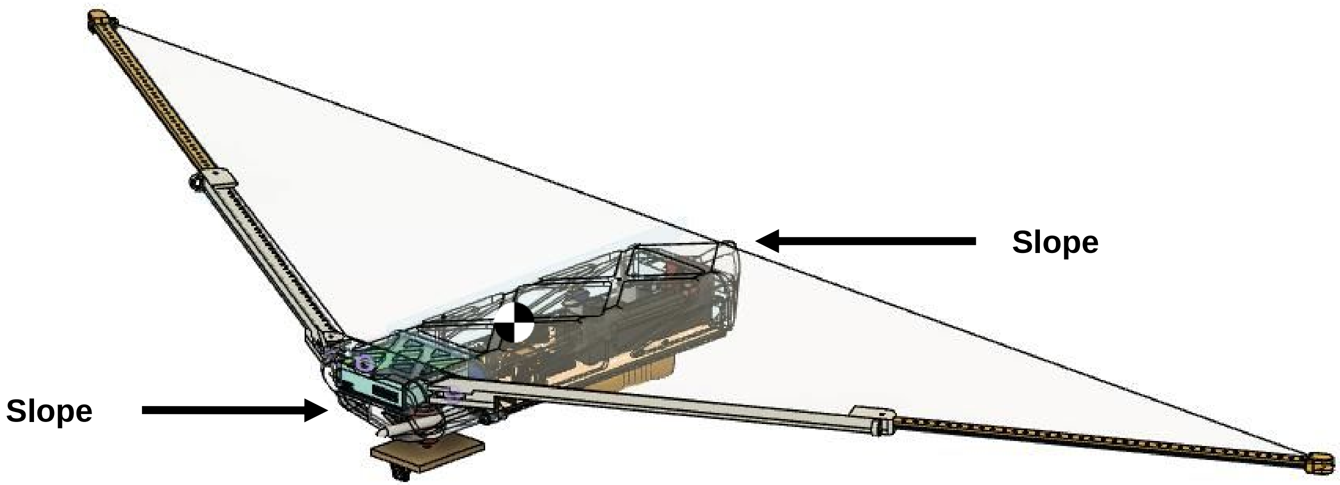
- Major components are positioned in payload nose. The nose will face downward inside the container. Hence, the CanSat center of mass is located at the lower part of the CanSat, maintaining the nadir direction and preventing the CanSat from tumbling
- Container inner body and payload's wing rod will intersect to secure payload's position minimize internal movement during launch
- Upon deployment, the wing will modify the position of the center of mass. Hence, during the gliding phase, stable gliding can be achieved. (illustrated on the next slide)



Payload Descent Stability Control Design (2 of 2)

Design Considerations

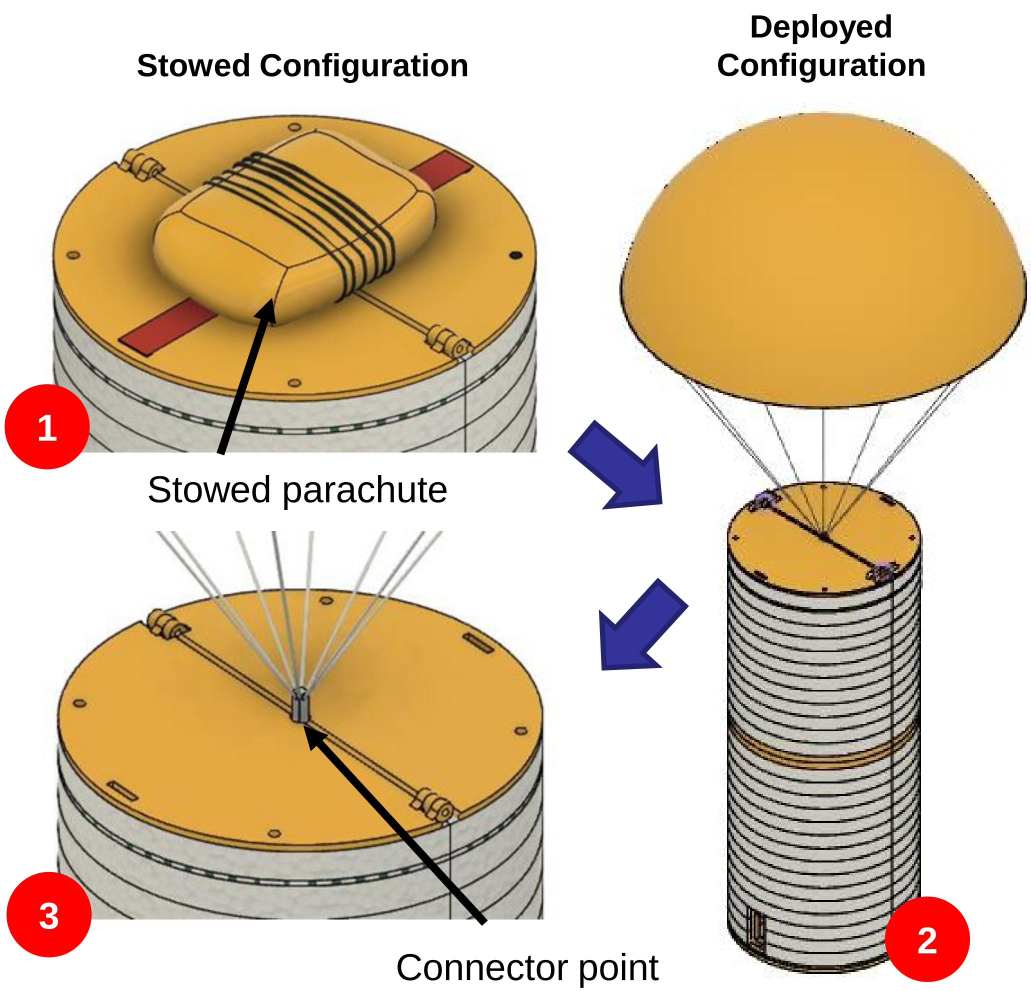
- Slopes will allow the airflow around the payload to remain reasonably laminar, and improve its aerodynamic stability
- Rubber tension is optimized to ensure both wing frames extend to desired angle. When the wings are completely deployed, HDPE plastic will be in fully stretched position to ensure stable glide



Mechanism used: Passive CG adjustment

Container Descent Control Hardware Summary (1 of 4)

Container DC hardware configurations: Parachute



Phase	Deployment Method
1 0 -725 (m)	Parachute is stowed on top of the container, connected to the container
2 450 (m)	Parachute will deploy when exposed to air during separation
3 450 (m)	The expanded parachute will stay intact with the container connector. Phase 2 and 3 occur at the same instant

Container DC Hardware Key Features: Parachute

Components Sizing

- Parachute fabric is made from 0,6 m circular shaped HDPE Plastic. Parachute projected surface area is 0.071 m^2

Key Design Considerations

- Simple stow configuration, no additional compartment needed
- No chance of deployment failure, air and gravity will ensure parachute deployment
- Circular shaped parachute will maximize the wind resistance required for descent

Color Selection

Color chosen below will aid recovery process

- Container parachute color will be **red**
- Container 3D printed parts color is **yellow**
- Container polyfoam parts color will be **red**

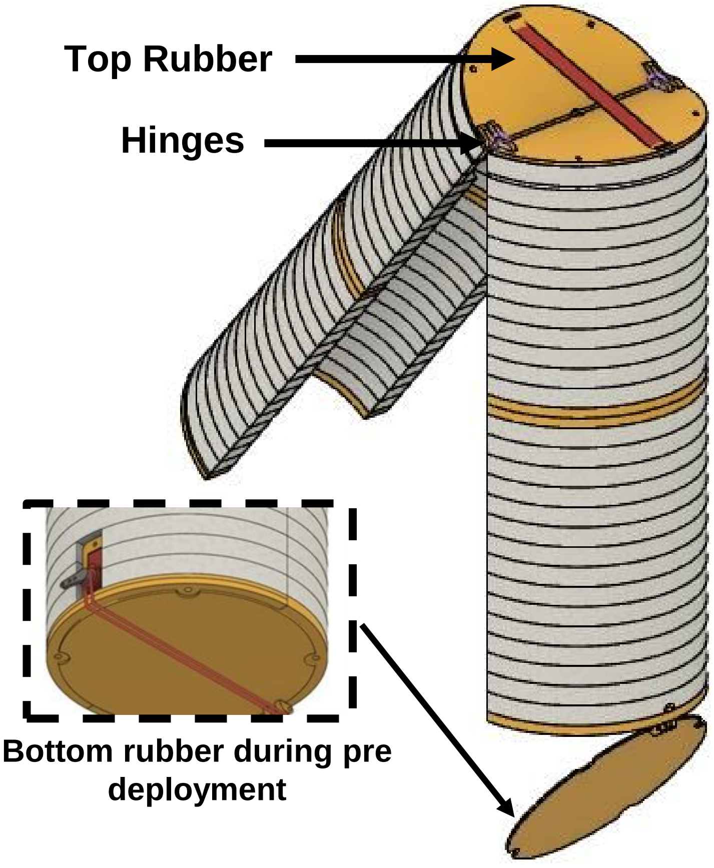
Stowed Parachute Representation

***DC hardware is passive control**

Container Descent Control Hardware Summary (3 of 4)

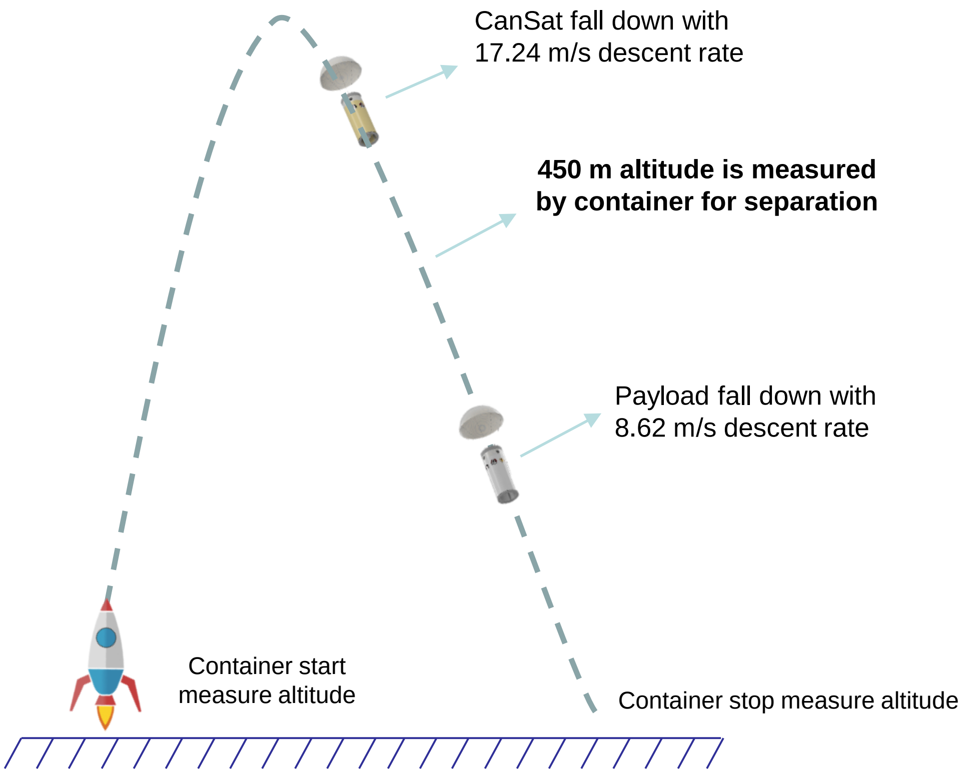
Container Deployment Mechanism

Phase	Sequence of Events
1	Container is **fully enclosed**, Servo hold and stretched the bottom rubber
2	At 450 meters, servo will release the bottom rubber. The top rubber will pull open the container
3	Payload wings expand after the container open. Payload will deploy and start gliding



Container Sensors Operation Sequence

Throughout the entire process, container **altitude** shall be measured to aid the descent control process. Altitude data is obtained from Adafruit BMP 388 sensor.



Sample Altitude (xxx.xx m)

```
altitude: 0.50
altitude: 0.55
altitude: 0.72
altitude: 1.13
altitude: 1.78
altitude: 2.12
altitude: 3.11
altitude: 4.56
altitude: 6.09
```

Descent Rate Estimates (1 of 8)

Descent Rate Estimation Overview

The descent rate of each descent phase will be estimated using different parameters:

CanSat (Container + Payload)

- **Pre-Deployment Phase** → Parameter: CanSat's round parachute diameter $D_{P,C}$
  Requirement: Descent rate of **20 +/- 5 [m/s]**

Container Only

- **Post-Deployment Phase** → Parameter: CanSat's round parachute diameter $D_{P,C}$
  Desired: Descent rate of **20 +/- 5 [m/s]**

Payload Only

- **Gliding Phase** → Parameter: Payload's delta wing coefficient of drag $C_{D,w}$
  Requirements: stay above **100 meters**, **1-minute** glide

Payload Only

- **Post-Gliding Phase** → Parameter: Payload's round parachute diameter $D_{P,P}$
  Requirement: Descent rate of **10 +/- 5 [m/s]**

Descent Rate Estimates (2 of 8)

Descent Rate Estimate – Approximated constants and variables

Approximated constants

- Air Density $\rho = 1.305\ [kg/m^3]$
- Gravity acceleration $g = 10\ [m/s^2]$
- Round type parachute drag coefficient $C_{D,P} = 1.75\ [-]$
- Cansat (Container + Payload) mass $M_C = 0.6\ [kg]$
- Payload mass $M_P = 0.35\ [kg]$
- Container mass $M_{Co} = 0.25\ [kg]$
- Payload wing root chord $R_C = 0.195\ [m]$
- Payload wingspan $W_s = 0.76\ [m]$
- Phi constant approximation $\pi = 3.14\ [-]$

Variables

- Cansat velocity $= v_C\ [m/s]$
- Container velocity $= v_{Co}\ [m/s]$
- Payload glide descent rate $= v_{P,G}\ [m/s]$
- Payload post glide descent rate $= v_{P,P}\ [m/s]$

Pre deployment descent rate estimation – deriving equation

To achieve the required descent rate, we use round parachute with a Diameter of $D_{P,C}$. Which can be derived from the drag force equation

$$F_D = \frac{1}{2}\rho v^2 C_{D,P} A$$

Assume the vertical net force is zero (constant descent velocity)

$$F_D - W_C = 0$$

The projected area of the parachute can be approximated by:

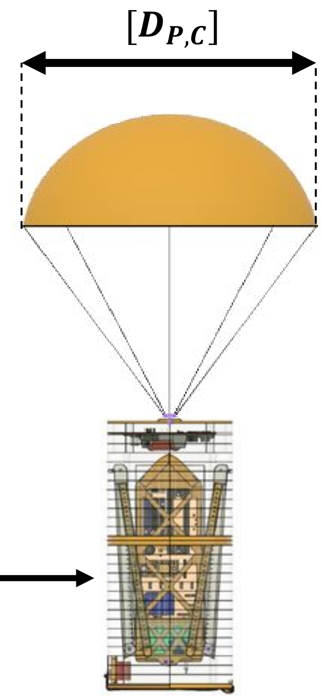
$$A = \frac{1}{4}\pi D_{P,C}^2$$

Hence, D can be obtained by:

$$D_{P,C} = \sqrt{\frac{8W_C}{\rho v^2 \pi C_{D,P}}}$$

Where:

$$W_c = M_c\, g$$



CanSat

Pre deployment descent rate estimation – boundary values calculation

CanSat (Payload + Container)

To determine the allowed parachute diameter $[D_{P,C}]$ we use the minimum allowed descent velocity $[v_0 = 15\ m/s]$ and the maximum allowed descent velocity $[v_1 = 25\ m/s]$

$$\sqrt{\frac{8W_C}{\rho v_0^2 \pi C_{D,P}}} \leq D_{P,C} \leq \sqrt{\frac{8W_C}{\rho v_1^2 \pi C_{D,P}}}$$

$$0.1035[m] \leq D_{P,C} \leq 0.1724\ [m]$$

Chosen Diameter
0.15 m

To provide adequate resistance and minimize space while stowed

Container only

Container will descent using the exact same parachute with the CanSat. Descent rate estimation can be found using the container weight approximation

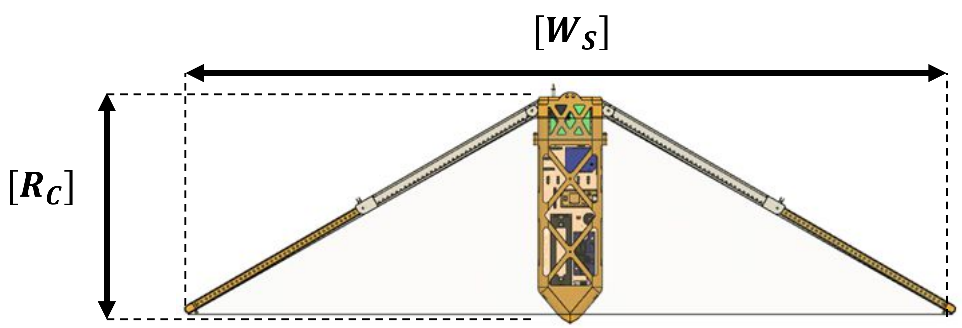
$$W_{Co} = M_{Co}\, g$$

Descent Rate Estimates (5 of 8)

Gliding Phase Descent Rate Estimation – deriving equation

We assume the payload orbits perfectly and only estimate the vertical descent motion. To achieve this, we estimate the vertical descent rate of **10 +/- 5 m/s** and apply delta wing to the payload with drag coefficient $[C_{D,W}]$ Which can be derived from the drag force equation.

$$F_D = \frac{1}{2}\rho v^2 C_{D,W} A$$



Assume the vertical net force is zero (constant descent velocity)

$$F_D - W_P = 0$$

The projected area of the delta wing is approximated with perfect triangle

$$A = \frac{1}{2} Rc\, Ws$$

Where $[R_C]$ is the Root Chord of the wing and $[W_S]$ is the wingspan

$$C_{D,W} = \frac{4W_P}{R_C W_S \rho v^2} \qquad W_P = M_P\, g$$

Descent Rate Estimates (6 of 8)

Gliding Phase Descent Rate Estimation – boundary values calculation

To determine the wing Coefficient of drag [$C_{D,W}$] we use the minimum approximated descent velocity [$5\ m/s$] and the maximum allowed descent velocity [$15\ m/s$]

$$\frac{4W_P}{R_C W_S \rho v^2} \leq C_{D,W} \leq \frac{4W_P}{R_C W_S \rho v^2}$$

$$0.32[-] \leq C_{D,W} \leq 2.89[-]$$

Chosen Drag Coefficient
1.2

To compensate the circular motion of the glider so that the glider will stay above 100 meters after gliding for 1 minute

Descent Rate Estimates (7 of 8)

Post Gliding descent rate estimation – boundary values calculation

To achieve the required descent rate, we use similar parachute design with a diameter of $[D_{P,P}]$. And Glider's weight approximation of 3.5 N.

$[D_{P,P}]$ can be approximated using the previous formula

$$\boxed{D_{P,P} = \sqrt{\frac{8W_C}{\rho v^2 \pi C_{D,P}}}}$$

$$\sqrt{\frac{8W_P}{\rho v^2 \pi C_{D,P}}} \leq D_{P,P} \leq \sqrt{\frac{8W_P}{\rho v^2 \pi C_{D,P}}}$$

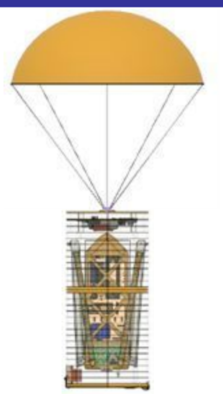
$$0.1317[m] \leq D_{P,P} \leq 0.3952\,[m]$$

Chosen Diameter
0.20 m

To provide adequate resistance and minimize space while stowed

Descent Rate Estimates (8 of 8)

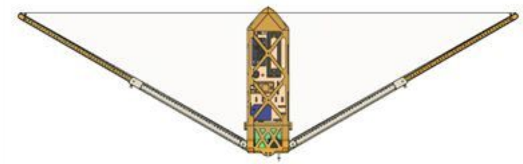
CanSat Descent Rate with Deployed Parachute



$$v_C = \sqrt{\frac{8W_C}{\rho D_{P,C}^2 \pi C_{D,P}}}$$

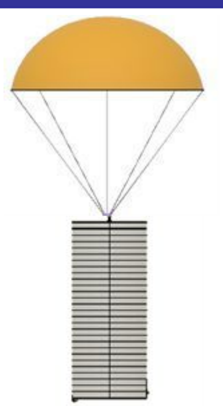
$$v_C = 17.24\ [m/s]$$

Payload Vertical Descent Rate During Glide



$$v_{P,G} = \sqrt{\frac{4W_P}{R_C W_S \rho C_{D,W}^2}} = 8.04 [m/s]$$

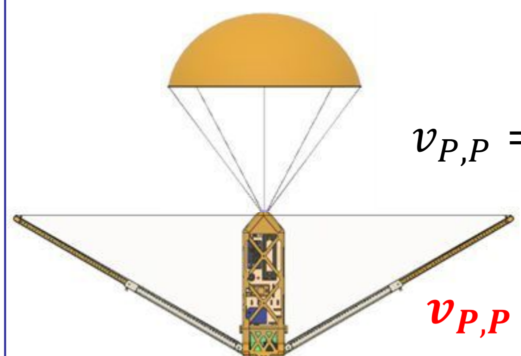
Container Descent Rate After Separation



$$v_{Co} = \sqrt{\frac{8W_{Co}}{\rho D_{P,C}^2 \pi C_{D,P}}}$$

$$v_{Co} = 8.62\ [m/s]$$

Payload Descent Rate with Deployed Parachute



$$v_{P,P} = \sqrt{\frac{8W_P}{\rho D_{P,P}^2 \pi C_{D,P}}}$$

$$v_{P,P} = 11.20\ [m/s]$$

Mechanical Subsystem Design

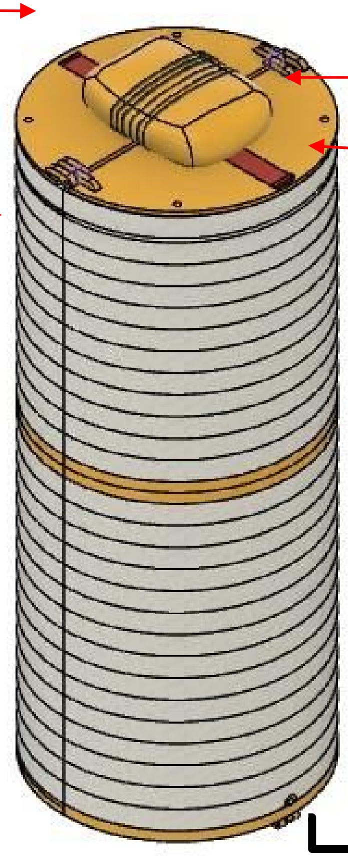
Luqman Al Helmy

Mechanical Subsystem Overview (1 of 2)

CONTAINER DESIGN OVERVIEW

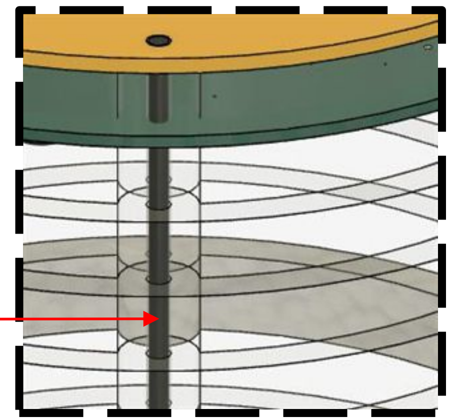
Top Layer
(PLA)

Main Body
Enclosure
(Polyfoam + PLA)

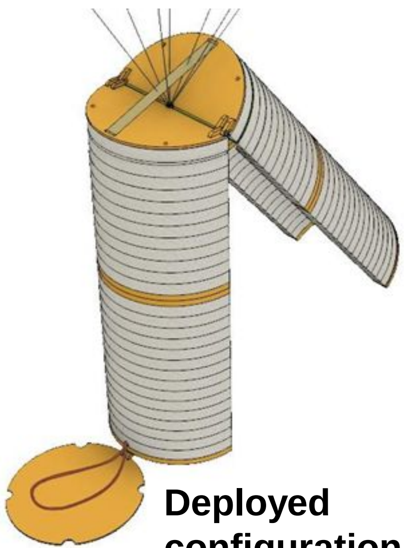


Parachute
(HDPE)

Actuator
(Rubber)



Support Rod
(Carbon)

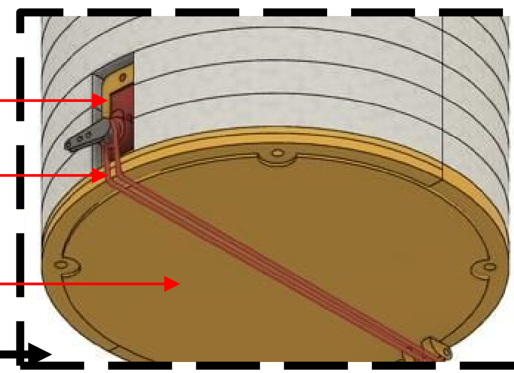


Deployed configuration

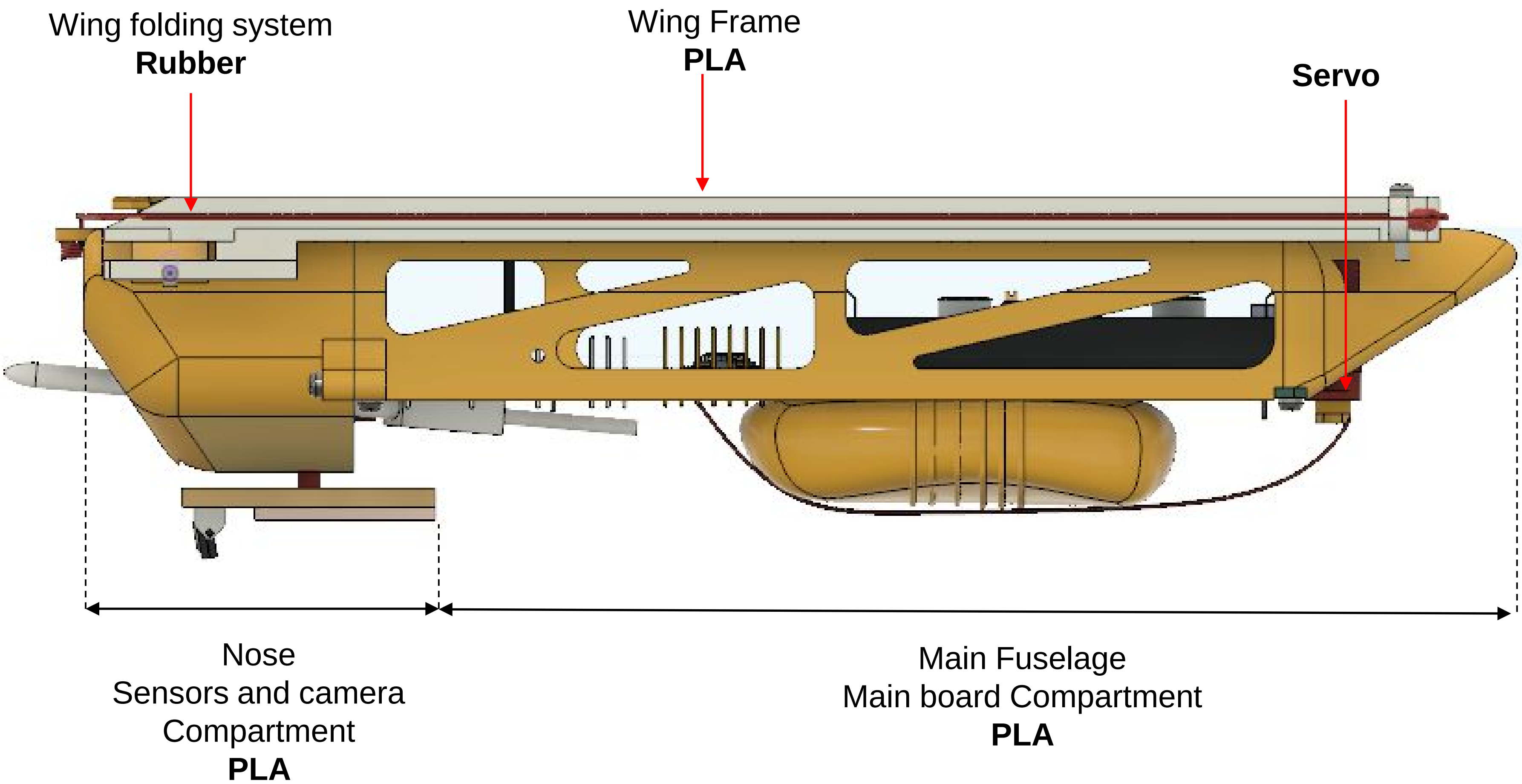
Container lid lock
(Servo)

Lid holder
(Rubber)

Bottom lid
(PLA)



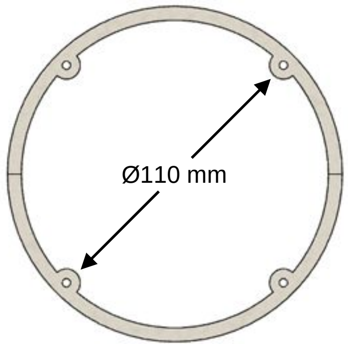
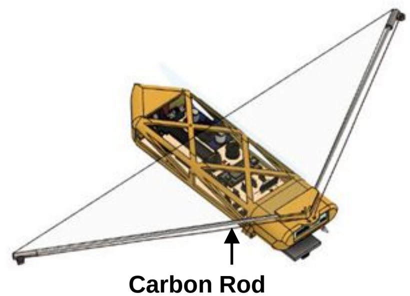
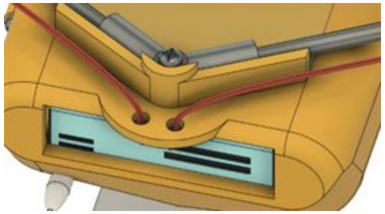
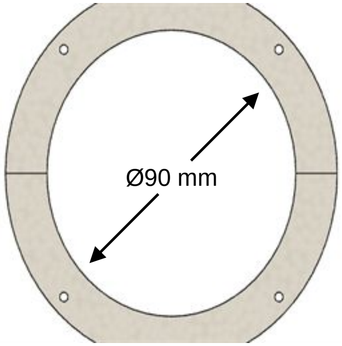
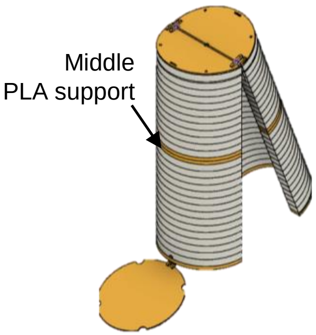
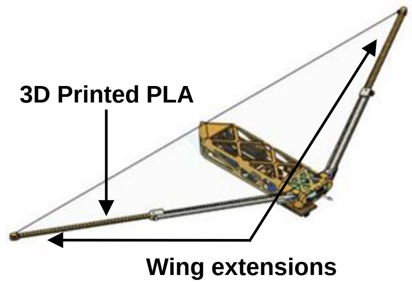
PAYLOAD DESIGN OVERVIEW



Mechanical Subsystem Changes Since PDR (1 of 2)

PDR	CDR	RATIONALE
The container polyfoam layer outer diameter is 120 mm and the inner diameter is 110 mm	The container polyfoam layer outer diameter is 120 mm and the inner diameter is 90 mm	Container with 90 mm inner diameter can provide smaller clearance with the science payload. Thus, reducing excessive payload vibration
The container body enclosure is entirely made of polyfoam	The container body enclosure is made of polyfoam with PLA middle support	Additional PLA support for the enclosure can improve the structural survivability of the container
The folding mechanism of the payload wing consists of 1 stage fold only	The folding mechanism of the payload wing consists of 2 stage folds.	Our attempt to obtain larger wing surface area
Wing frames are made from carbon fiber	Wing frames are made from 3D Printed PLA	Easier to manufacture complex shapes and easier to sew wing fabric
Wing pivot located at the center of payload nose	Wing pivot located at the side of payload nose	Reduce payload height, accomodate larger wing frame, and provide better strength to wing mounting

Mechanical Subsystem Changes Since PDR (2 of 2)

Container (Inner Body)	Container (Middle Support)	Payload (Wing Extension & Material)	Payload (Wing Pivot)
PDR			
			
CDR			
			

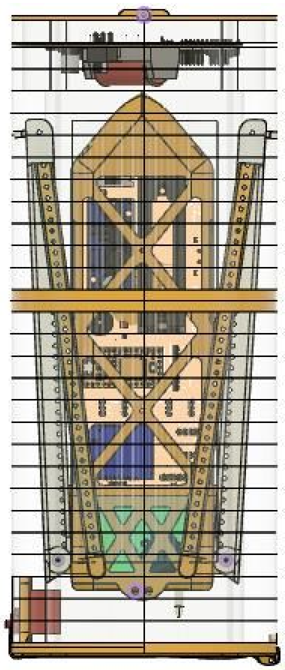
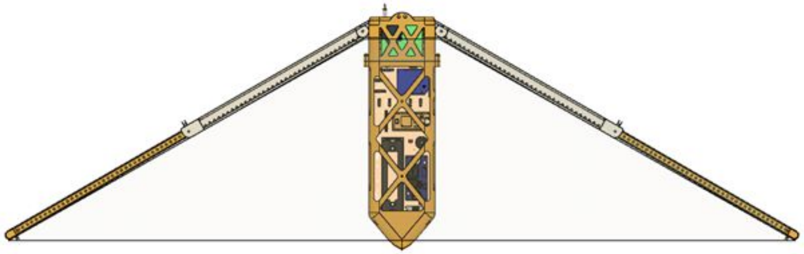
Mechanical Sub-system Requirements (1 of 2)

RN	Requirement	Rationale	Priority	Verification			
				A	I	T	D
RN1	Total mass of the CanSat (science payload and container) shall be 600 grams +/- 10 grams.	Competition Requirement	Very High	✓		✓	
RN2	CanSat shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length. Tolerances are to be included to facilitate container deployment from the rocket fairing.	Competition Requirement	Very High	✓	✓	✓	
RN3	The container shall not have any sharp edges to cause it to get stuck in the rocket payload section which is made of cardboard.	Competition Requirement	Very High	✓	✓		
RN4	The container shall be a fluorescent color; pink, red or orange.	Competition Requirement	Very High		✓		
RN5	The container shall be solid and fully enclose the science payload. Small holes to allow access to turn on the science payload is allowed. The end of the container where the payload deploys may be open.	Competition Requirement	Very High	✓	✓		
RN6	The rocket airframe shall not be used to restrain any deployable parts of the CanSat	Competition Requirement	Very High	✓			✓
RN7	The rocket airframe shall not be used as part of the CanSat operations.	Competition Requirement	Very High	✓			✓
RN8	The container parachute shall not be enclosed in the container structure. It shall be external and attached to the container so that it opens immediately when deployed from the rocket.	Competition Requirement	Very High	✓	✓		✓
RN9	The descent rate of the CanSat (container and science payload) shall be 20 meters/second +/- 5m/s.	Competition Requirement	High	✓		✓	
RN10	The container shall release the payload at 450 meters +/- 10 meters.	Competition Requirement	Very High	✓		✓	

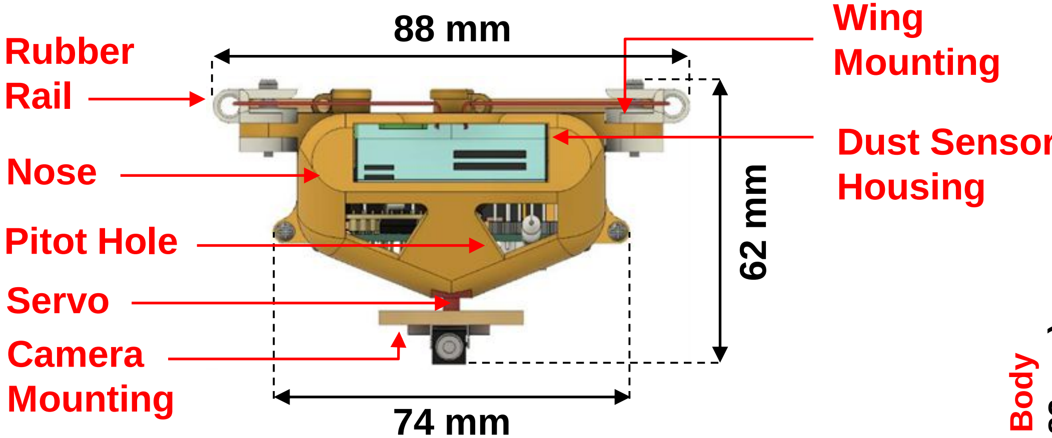
Mechanical Sub-system Requirements (2 of 2)

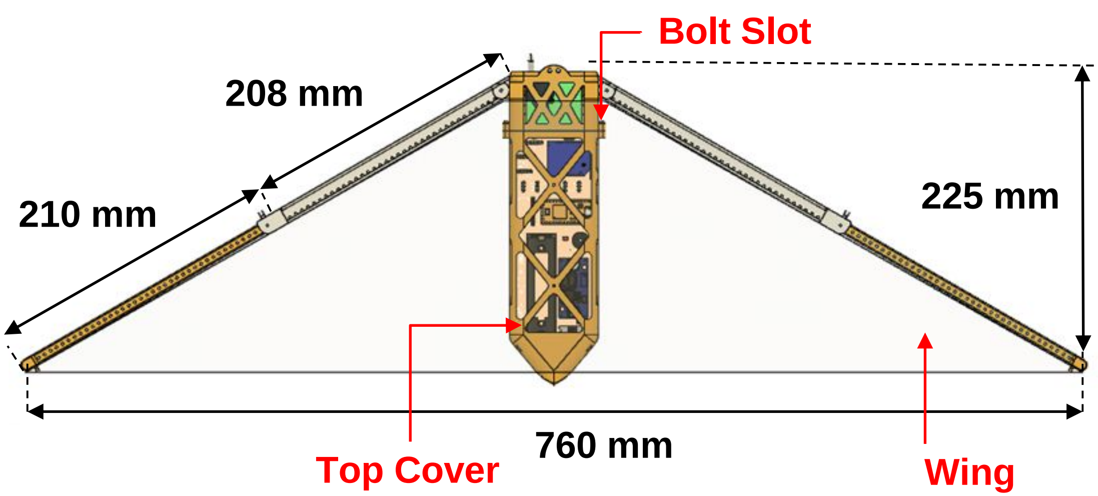
RN	Requirement	Rationale	Priority	Verification			
				A	I	T	D
RN12	The science payload shall be a delta wing glider.	Competition Requirement	Very High		√		
RN13	After one minute of gliding, the science payload shall release a parachute to drop the science payload to the ground at 10 meters/second, +/- 5 m/s.	Competition Requirement	Very High		√	√	
RN15	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	Competition Requirement	Very High		√		
RN18	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Competition Requirement	Very High	√		√	√
RN19	All mechanisms shall be capable of maintaining their configuration or states under all forces.	Competition Requirement	Very High	√	√		√
RN20	Mechanisms shall not use pyrotechnics or chemicals.	Competition Requirement	High		√		
RN21	Mechanisms that use heat (e.g., nichrome wire) shall not be exposed to the outside environment to reduce potential risk of setting vegetation on fire.	Competition Requirement	High		√		
RN38	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.	Competition Requirement	High	√			
RN48	The probe must include an easily accessible power switch that can be accessed without disassembling the cansat and in the stowed configuration.	Competition Requirement	High		√		√
BM	A video camera shall be integrated into the science payload and point toward the coordinates provided for the duration of the glide time. Video shall be in color with a minimum resolution of 640x480 pixels and 30 frames per second. The video shall be recorded and retrieved when the science payload is retrieved. Points will be awarded only if the camera can maintain pointing at the provided coordinates for 30 seconds uninterrupted.	Bonus Mission	Very High			√	

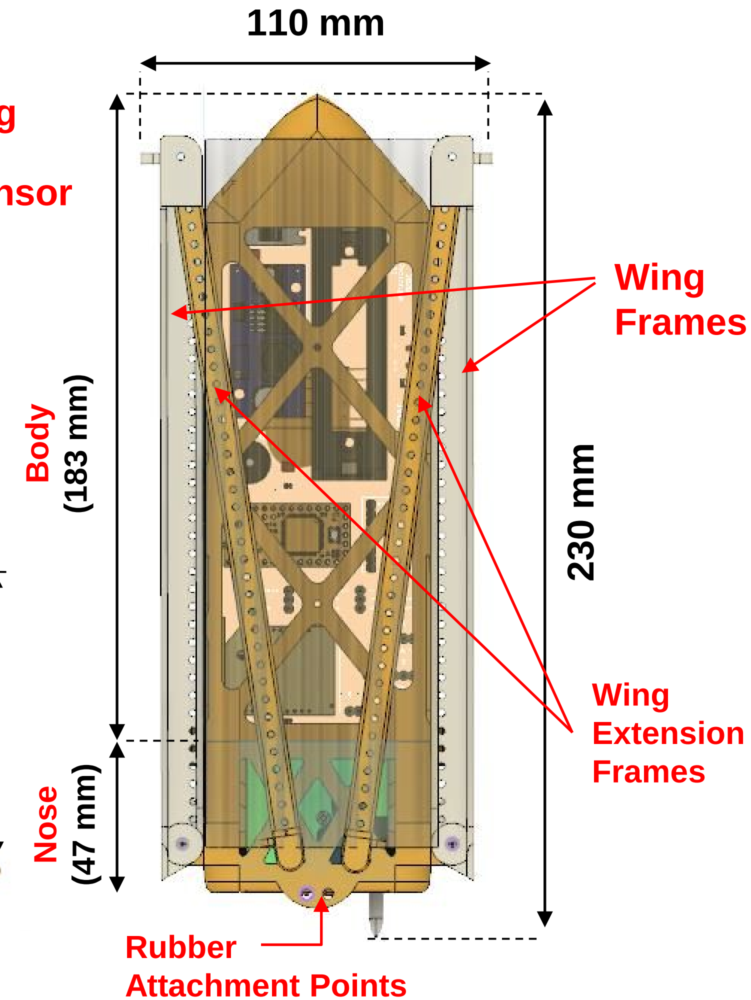
Payload Configurations

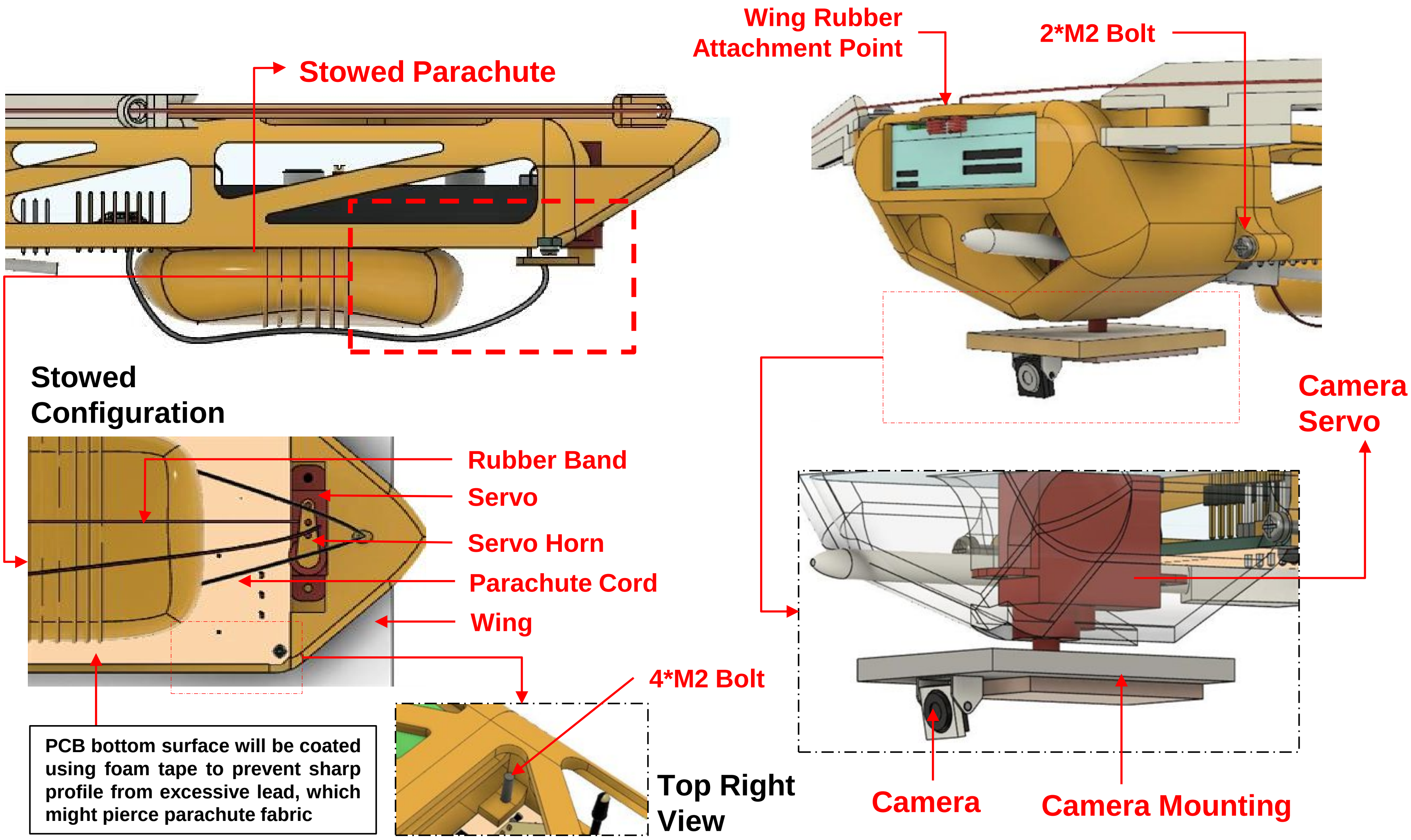
Pre – Deployment	Deployed
 	 

Payload Dimension









PCB bottom surface will be coated using foam tape to prevent sharp profile from excessive lead, which might pierce parachute fabric

Payload Design Key Features

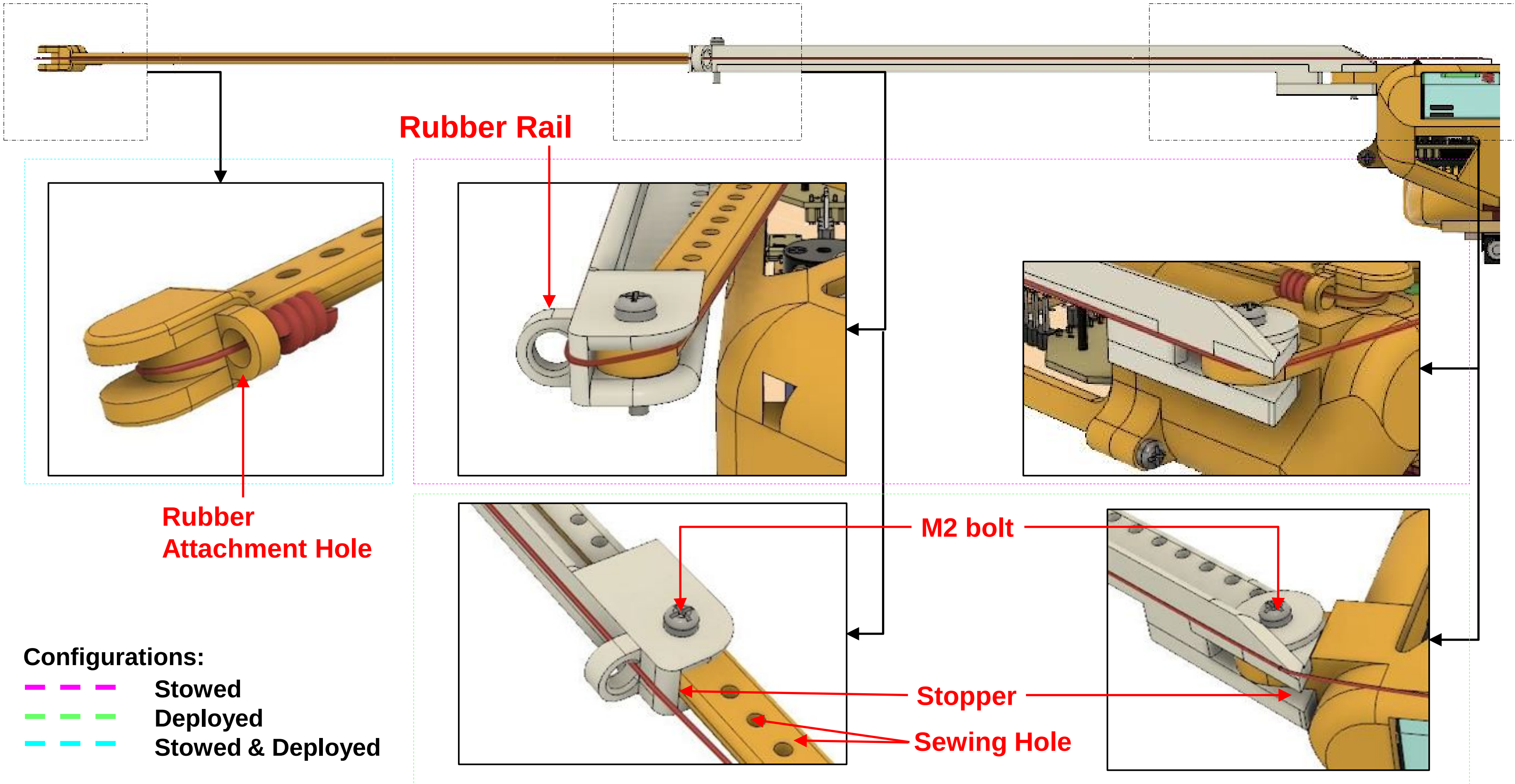
Structure and Material

- 100% of the payload structure material is PLA plastic
- Payload consists of 2 main parts (nose and body). Bolted connection is chosen to join both parts
- Deployable delta wing shall use HDPE plastic material
- The body “X” pattern shall reduce the payload weight while providing sufficient durability

Functional Parts

- Motions of moving parts shall be triggered by rubber mechanism
- Wing frame extensions added to enlarge wing surface area
- Stoppers are used to control the angle of wings opening
- Main electronic board shall be mounted to the body, play a dual role as payload’s bottom cover

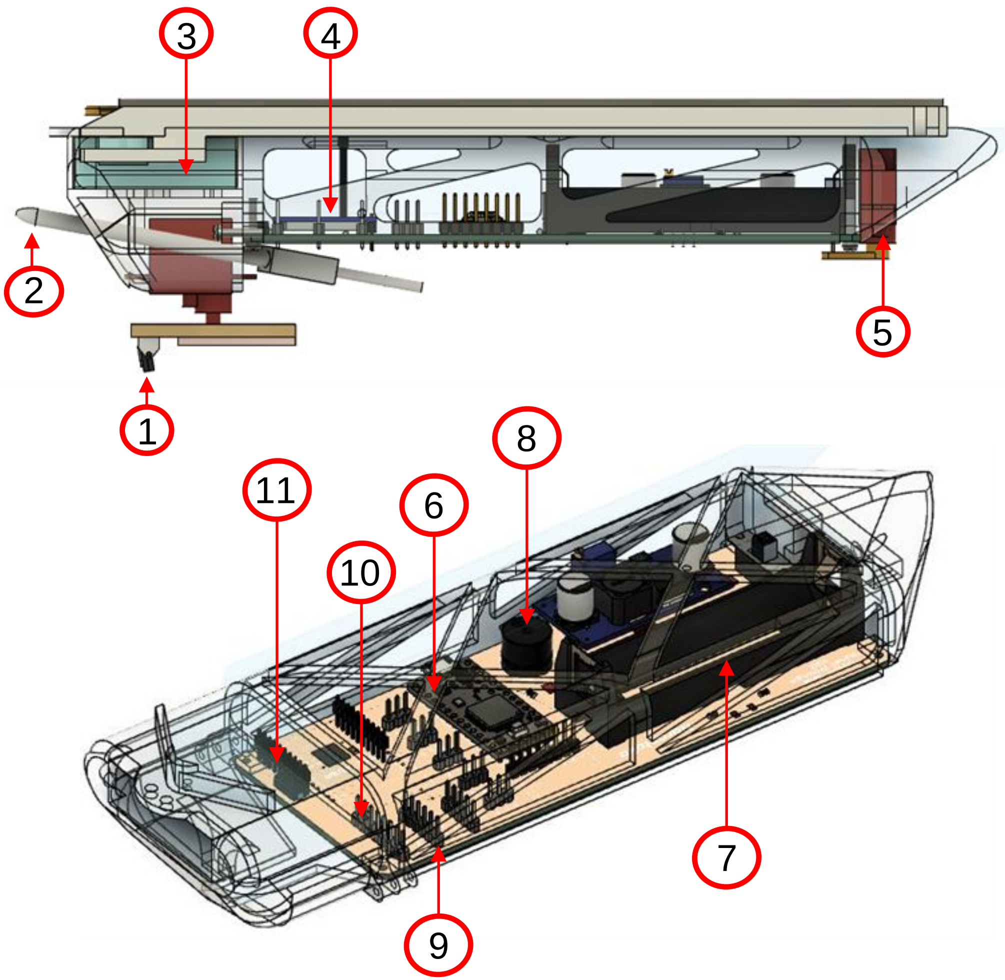
Payload Wing Frame Attachment Point



Configurations:
- Stowed
- Deployed
- Stowed & Deployed

Payload Mechanical Layout of Components (6 of 7)

Position of Major Electrical Components



Part Number	Description
1	Camera – servo mechanism
2	Pitot tube
3	Dust particle sensor
4	Xbee radio module
5	Parachute servo
6	Processor
7	Battery
8	Buzzer
9	GPS
10	Temperature & Pressure Sensor
11	Power Switch

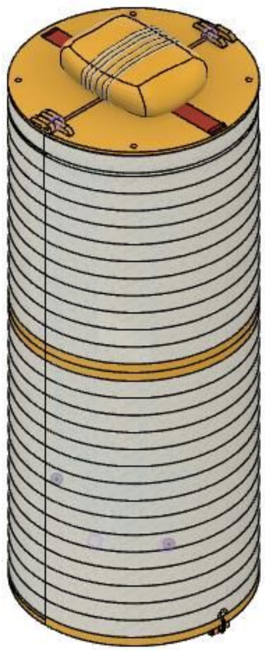
Payload Mechanical Layout of Components (7 of 7)

Payload Material Selection

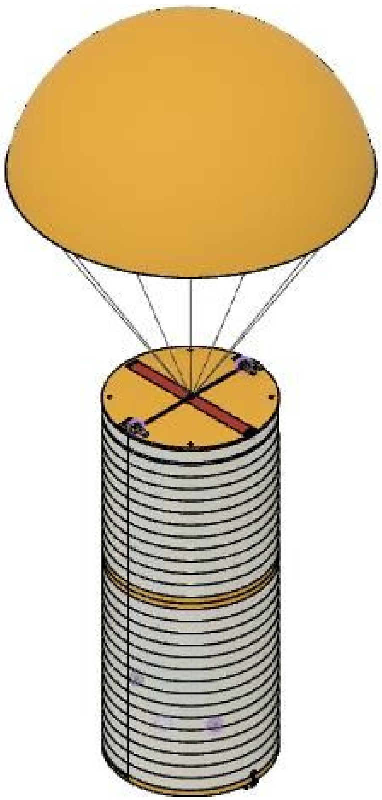
Structure	Selection	Rationale(s)
Main structure	3D Printed PLA	Easy to manufacture, considerable strength
Wing surface	HDPE plastic	Lightweight, ready stock
Wing frames and wing extension frames	3D Printed PLA	Complex shapes easily manufactured
Parachute	HDPE plastic	Lightweight, ready stock

Container Mechanical Layout of Components (1 of 6)

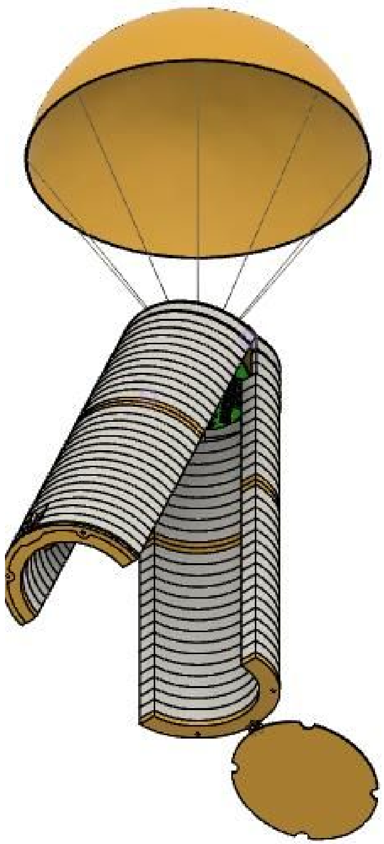
Container Configurations



Stowed Configuration



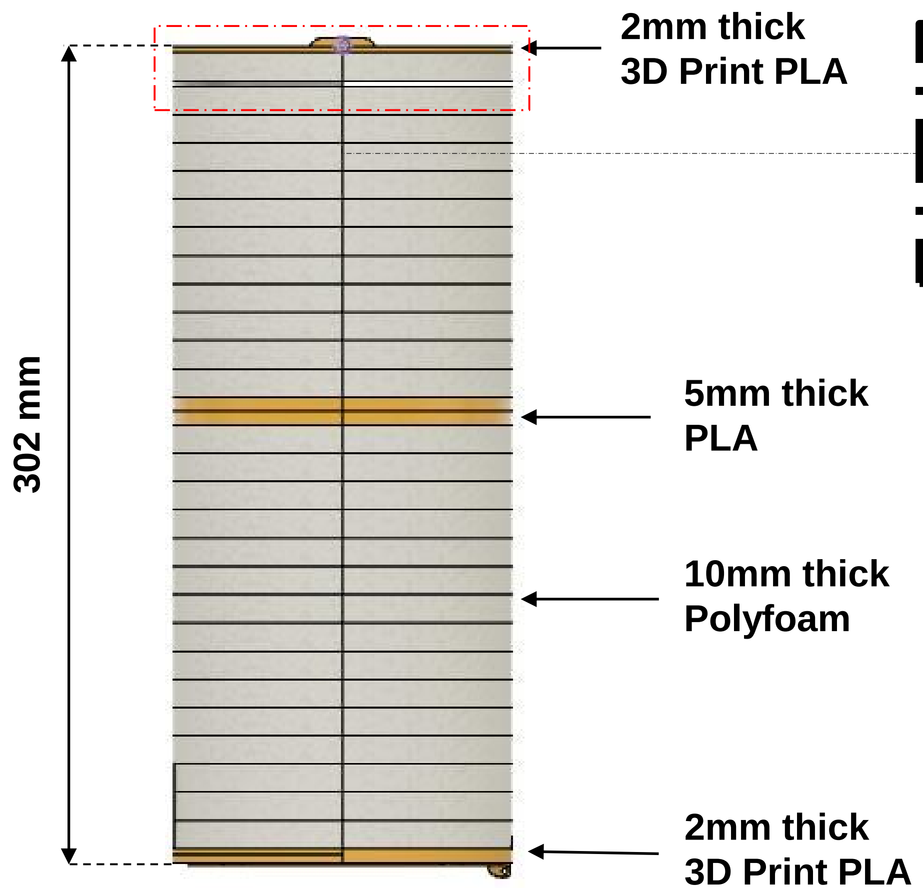
Rocket separation Configuration

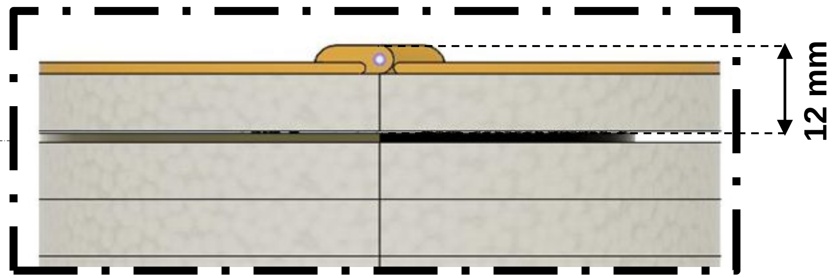


Payload separation Configuration

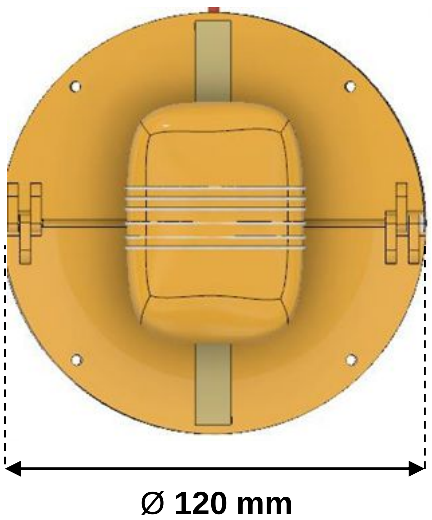
Container Mechanical Layout of Components (2 of 6)

Container Dimension



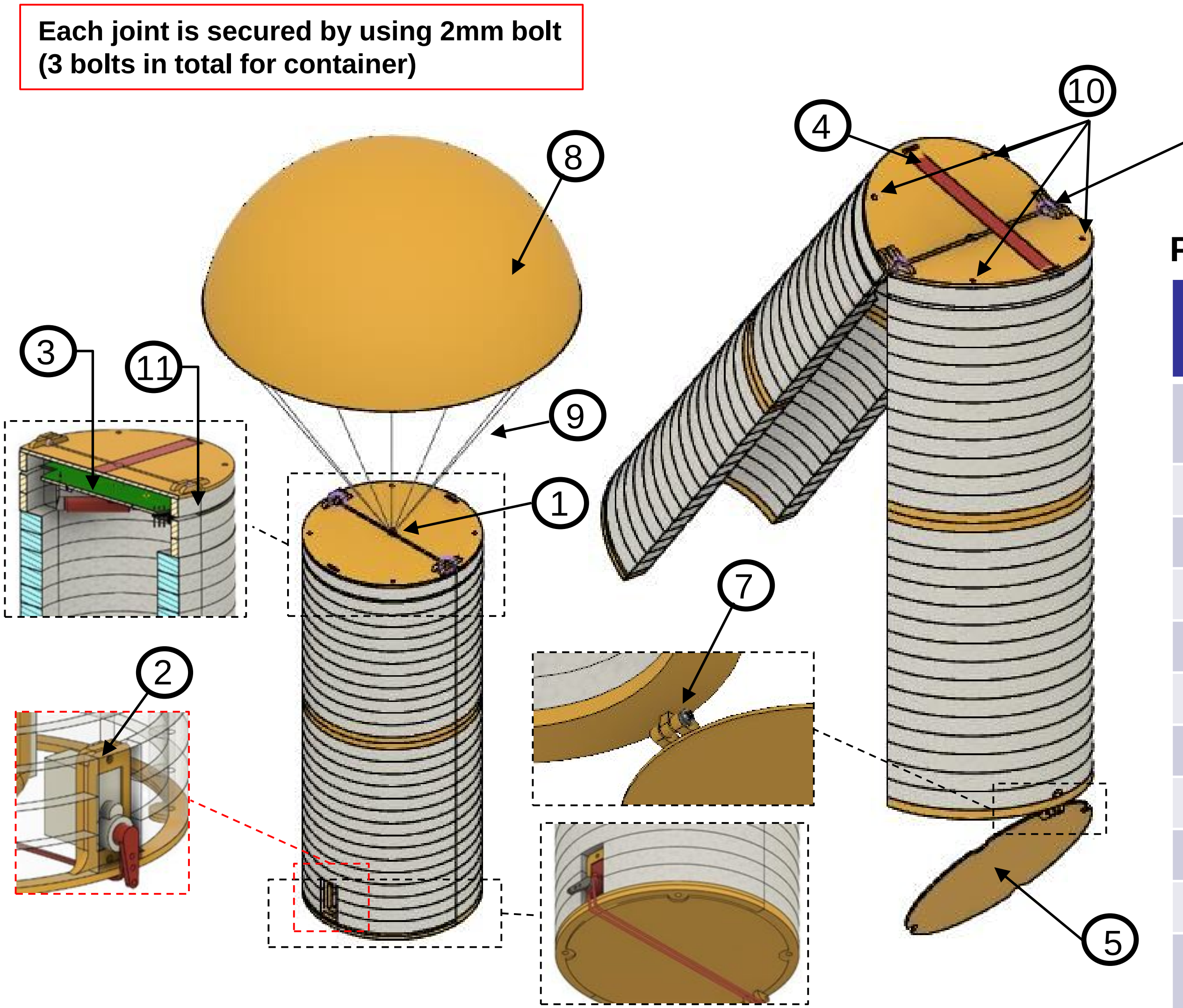


Clearance between container PCB and the top layer



Container Mechanical Layout of Components (3 of 6)

Each joint is secured by using 2mm bolt (3 bolts in total for container)



Part Definitions

Part Number	Description
1	Parachute attachment point
2	Servo housing
3	PCB
4	Rubber
5	Bottom cover
6	Upper Hinge (2)
7	Lower Hinge (1)
8	Parachute
9	Parachute Cord
10	Carbon Rod Slot (4)
11	Power Switch (access hole will be provided)

Container Mechanical Layout of Components (4 of 6)

Container Design Key Features

Structure and Material

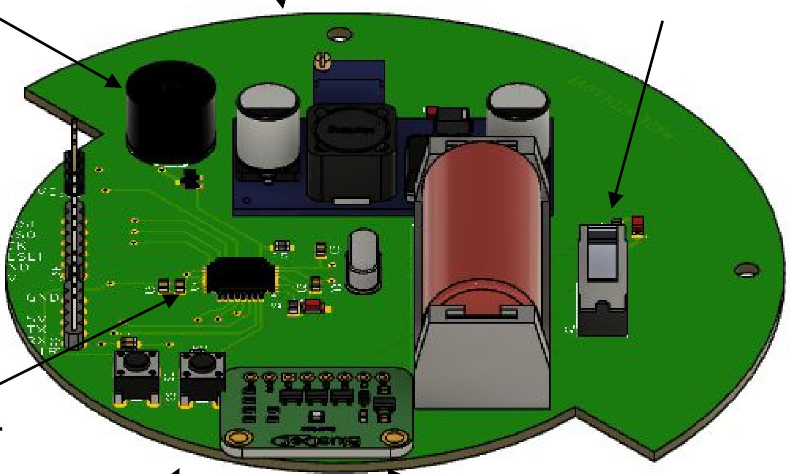
- 90% of the container is made from polyfoam **(fluoroscent red colored)**
- Container structure will be supported by 4 carbon rod columns
- The overall structure is assembled from 29 polyfoam layer (10 mm thick each) and 3 PLA layer placed on top, middle, and bottom of the structure
- 3D printed PLA will be used to support moving parts and provide better strenfth toward the structure
- Rounded edges **(no sharp edges)**
- Container **fully enclose** science payload

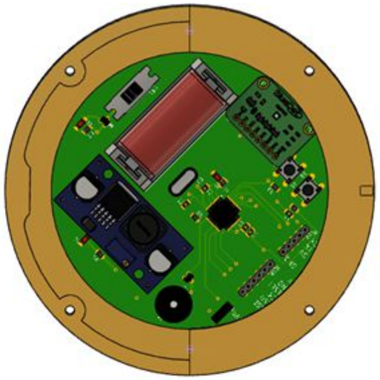
Functional Parts

- Rubbers (top and bottom) is used to trigger movement of moving parts
- Payload release mechanism rely on electronics hardware (servo)
- No additional compartment provided to stow parachute. Folded parachute is placed on top of the container

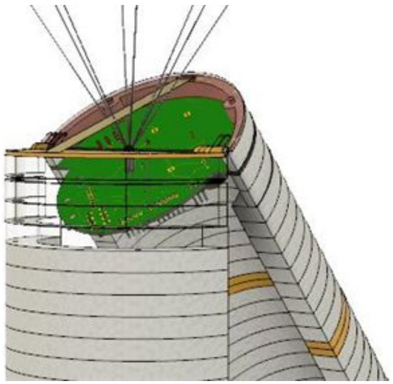
Container Mechanical Layout of Components (5 of 6)

Position of Major Electrical Parts





Bottom View (bottom cover removed)



Side View

Mechanism description

- Container attachment side shall be parallel with the servo lock mechanism to facilitate its connection
- Components side was designed to be smaller to facilitate clearance during separation

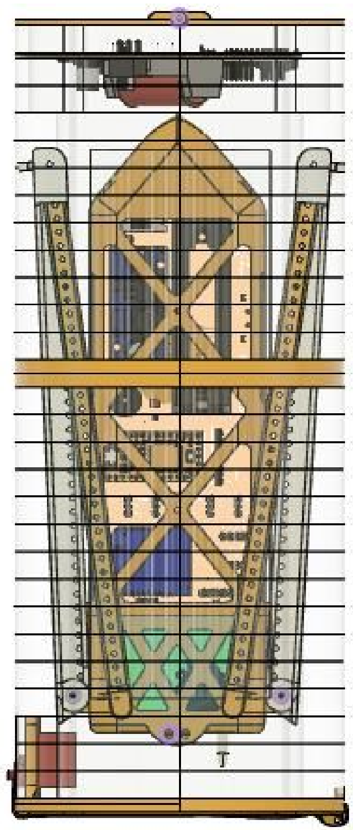
Container Mechanical Layout of Components (6 of 6)

Container Material Selection

Structure	Material	Rationale(s)
Hinged lid	3D print PLA	Provides better strength
Container layer	Polyfoam	Lighter and easier to manufacture
Support Column	Carbon fiber	Lighter and cheaper
Servo housing	3D print PLA	Complex shapes easily manufactured
Middle body support	3D print PLA	Complex shapes easily manufactured

Payload Release Mechanism (1 of 2)

Release Mechanism sequence of operation



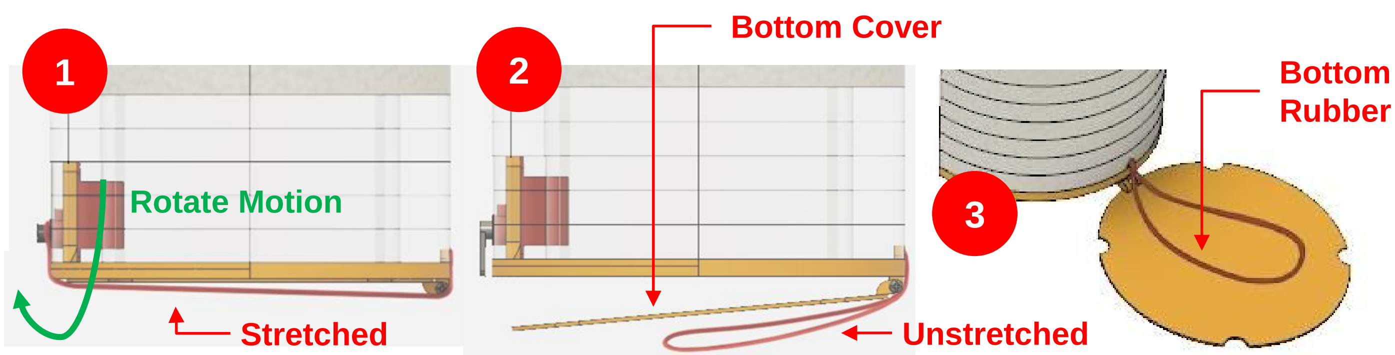
Stowed Configuration

Container body is made from a pair of half-round hollow cylinder, joined by using hinge at the top and rubber band at the bottom. In general, there are two corresponding release mechanisms (top and bottom) to ensure CanSat Separation.

BOTTOM

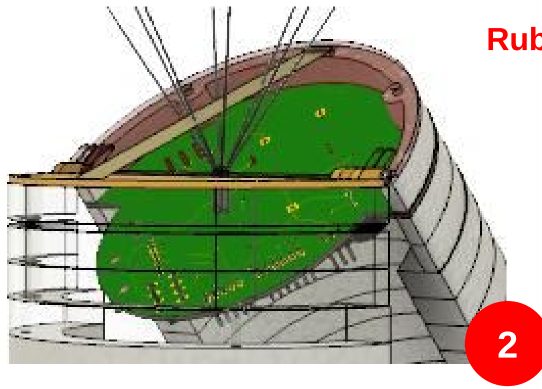
Horn initial position is parallel to container bottom cover. The rotation of horn is controlled by a servo.

- This position allows rubber band to link and stretch, maintaining the container fully closed and preventing bottom cover from opening.
- At 450 m, servo receives a signal and rotate the horn 90 degrees clockwise.
- The motion will release the attachment of rubber band to horn and results in the bottom cover being opened.

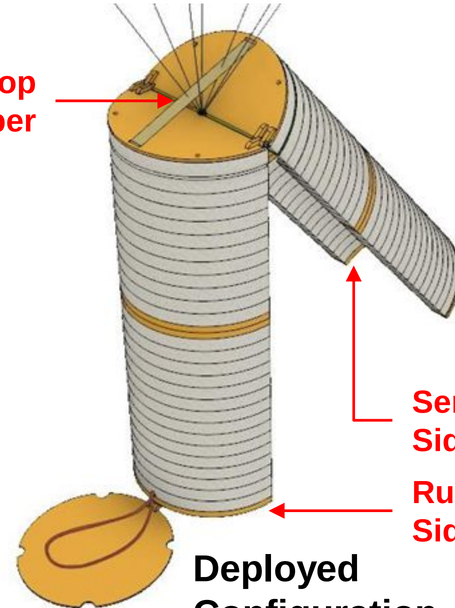


Payload Release Mechanism (2 of 2)

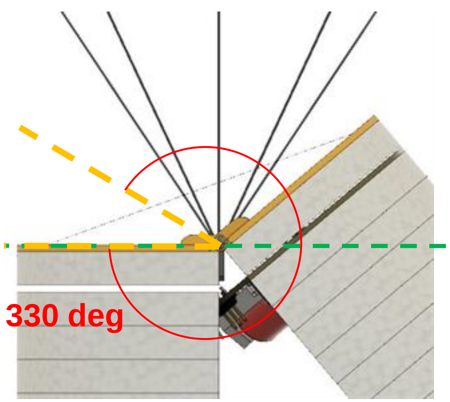
Release Mechanism sequence of operation



PCB mount will be on the servo side of the container only, The illustration show PCB configuration after CanSat separation



Deployed Configuration



Initial Position
Projected Final Position

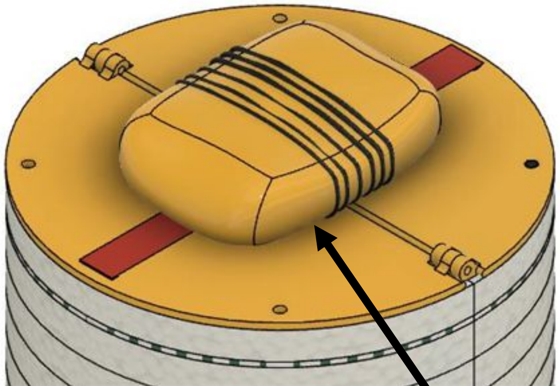
TOP

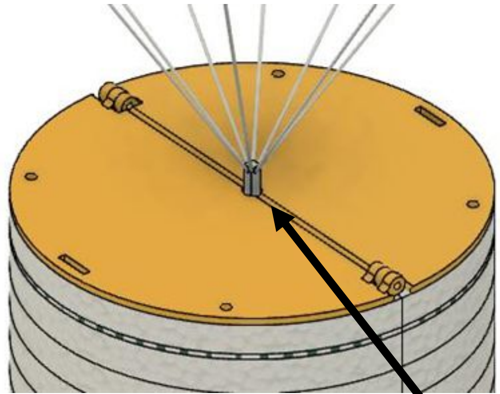
Corresponding to the release of the bottom rubber,

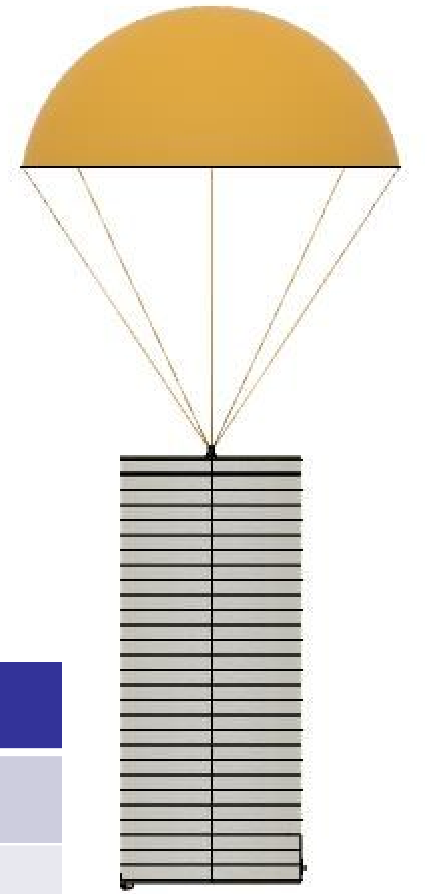
- The top rubber will convert its potential energy to kinetic energy. Since the remaining container attachment point is only at the top cover, Container will be exposed at approximately 330 degrees
- The release system will ensure successful separation, take out any chance of Payload stucked inside the container
- The motion will release the attachment of rubber band to horn and reults in the bottom cover being opened

Container Parachute Release Mechanism

Parachute deployment sequence of operation







Phase	Sequence of Events
1	Parachute is stowed on top of the container, connected to the container
2	After separation, the parachute will open after exposed to the air
3	The expanded parachute will stay intact with the container connector

Payload Parachute Release Mechanism

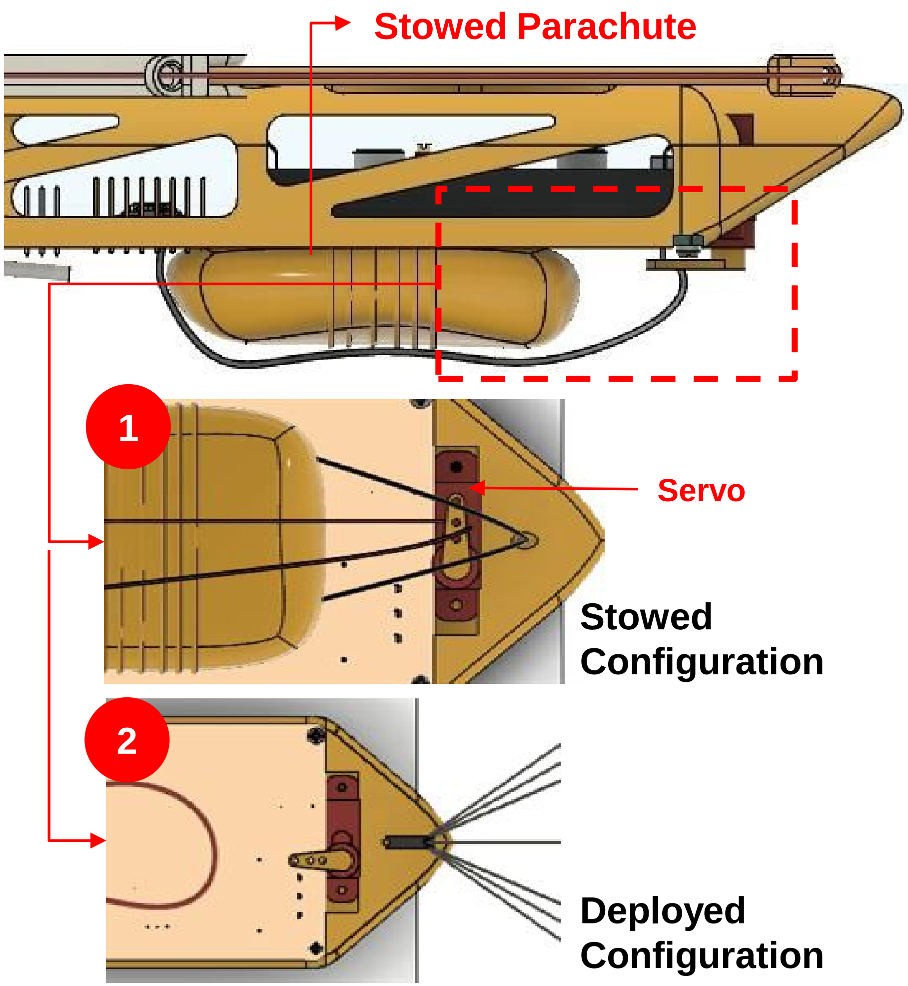
Payload Parachute Deployment Mechanism

Payload Parachute

- At 100 m, the servo receives a signal to rotate the horn 100 deg counter-clockwise, which release rubber's connection to horn
- Following horn rotation, rubber band will detach from the horn and unlock parachute
- Parachute deployed; Parachute cord is attached to an attachment point located at the rear edge of payload.
- Figure 1 and Figure 2 show the configuration before and after parachute deployment

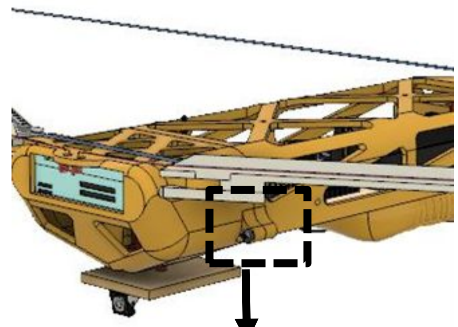
Mounting Method

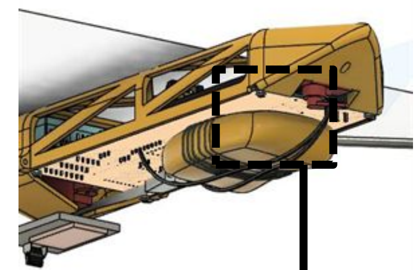
Parachute is locked in position by rubber band attached to servo horn. Horn rotation is controlled by a servo



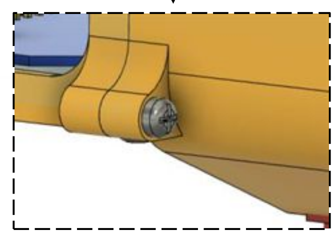
Payload Structure Survivability

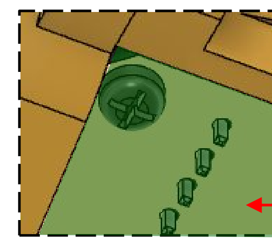
Mounting • Bolted connection is used to mount payload to payload's body • Servos and dust sensor is secured inside designated housings • Other electronics are mounted using double sided tape
Electronic Enclosure • Electronics are enclosed by payload's body and foam tape • Hollow body facilitate any final adjustment before launch and access to payload power switch
Electronics Connection • (Pin and Socket) and soldering provide connection for components directly mounted to the PCB • Cable shall provide connection between sensors and servos
Descent Control attachment • Wing frame mechanism shall be mounted using bolted connection and deployed using rubber mechanism • Wing fabric is sewn to wing structure



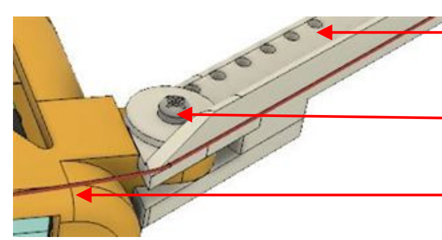


Payload Structure is mounted using 2 x 2mm bolts (1 in each side)





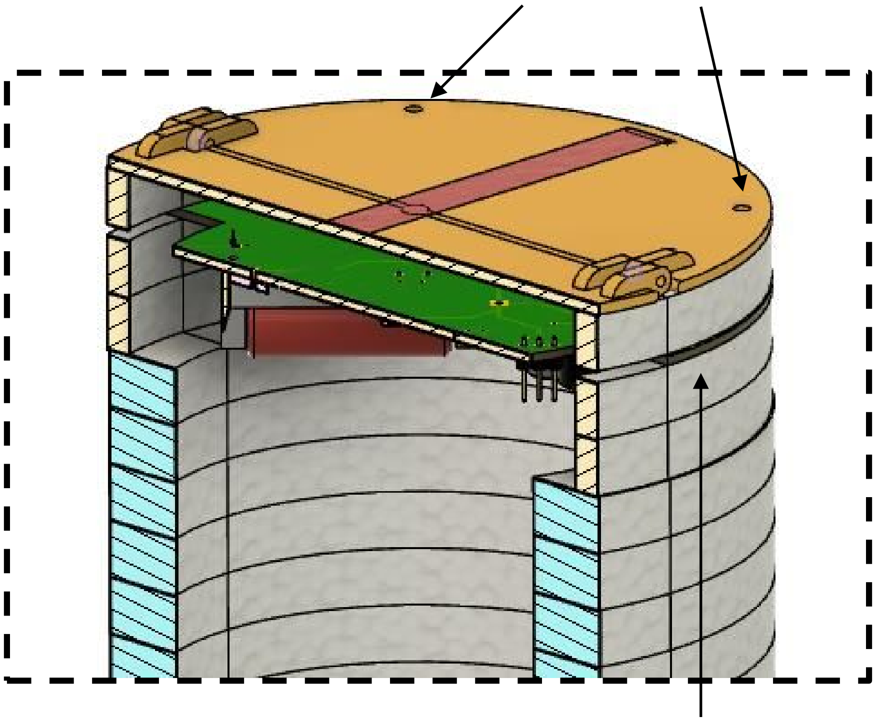
Payload PCB is mounted using 4 x 2mm bolts



Structure Survivability (2 of 2)

Container Structure Survivability

Electronics Mounting • Epoxy adhesive is used to mount PCB in between two polyfoam layer • Cable between PCB and servo is mounted to container inner wall by using tape
Electronics Enclosure • Container body provide full enclosure to container electronics and payload • Carbon rods are used to reinforce the enclosure
Electronics Connection • (Pin and Socket) and soldering provide connection for components directly mounted to the PCB • Cable shall provide connection between sensors and servos
Descent Control attachment • Clearance between PCB and the top layer shall provide space for parachute attachment. Parachute cord shall be tied firmly.



***Shock and acceleration test should be done in the following weeks to ensure structure survivability**

Mass Budget (1 of 3)

Payload Mass Chart

Component name	Mass (g)	Obtain Method	Margins (g)
3D printed structure	74	M	-
PCB	35	E	7
Wings	54	M	-
Rubber (x3)	2	M	-
Servo (x2)	14	M	-
Camera mechanism	7	E	1.4
M2 bolts (x6)	2.1	M	
Foam Tape	3	M	
Battery	47	M	-
Electronics & Sensors	106	E	21.2
Parachute	9.6	E	1.56
XBEE	7	M	-
Antenna	5	M	-
Total Payload Mass	**313.8**	**M, E**	**24.26**

Note:
Due to the complexity of overall system, Mass estimation is derived from the 20% of its estimated value

Legends:
- E = Estimated
- D = Data Sheet
- M = Measured

Measured weight is obtained through 3 separate measurement, and standard of deviation is negligible

Total Payload Mass
363.9 ± 24.26 g

Mass Budget (2 of 3)

Container Mass Chart

Component name	Mass (g)	Obtain Method	Margins (g)
Electronics & Sensors	78	M	15.6
PCB	15		3
Polyfoam Structure	67	M	-
3D Printed Structure	12	M	
3 mm Carbon rod (x4)	7.5	M	-
M2 bolts (x3)	1	M	
Servo motor	7	M	-
Battery	17	M	-
Parachute	9.6	E	1.56
Epoxy Adhesives	17	M	-
Total Container Mass	231.1	M,E	21.16

Note:
Due to the complexity of overall system, Mass estimation is derived from the 20% of its estimated value

Legends:
- E = Estimated
- D = Data Sheet
- M = Measured

Measured weight is obtained through 3 separate measurement, and standard of deviation is negligible

Total Container Mass
231.1 $\pm$ 20.16 g

Mass Budget (3 of 3)

Total CanSat Mass

595 Grams

Total mass margin = | required mass – estimated mass | = | 600 – 595 | g = +5 g

- Competition requirement mass margin: ± 10 g -> **PASSED**

Methods for Mass Margin Correction	
1	If the CanSat mass is **< 590 g,** then some structural parts will be manufactured with higher infill density 3D print filament and higher density foam will be used for container material
2	If the CanSat mass is **> 610 g,** then the 3D printed parts will be printed with less infill density and container thickness will be decreased

Communication and Data Handling (CDH) Subsystem Design

Muhammad Dyffa

CDH Overview

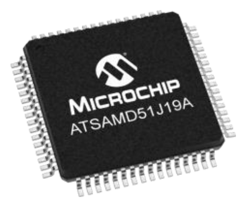
PAYLOAD CDH

ANT-RA57-915:
Antenna for payload communication

GCS

Xbee Pro 900HP S3B:
A RF Module is used to transmit and receive data from payload to GCS

PAYLOAD CAMERA



Sandisk Ultra 16GB:
An external storage device is used to store bonus mission video

ATSAMD51J19:
A processor is used to sample and process data from sensors

Matek SAM M8Q RTC:
A real-time clock is used to know real time clock data

CONTAINER CDH

BMP 388
A BMP388 is used to collect pressure and temperature data

ATMega328P-AU
A processor is used to sample and process altitude data from sensors and command servo for separation

Servo
A servo is used to separate payload from container

CDH Changes Since PDR

PDR	CDR	Rationale
Payload main processor was Teensy 4.0	Payload main processor changed to ATSAMD51J19 Microncontroller Chip	Weight is a huge issue to our payload, we changed the Teensy breakout board to Processor Chip to reduce our CanSat total mass.
Container main processor was Arduino Pro Mini	Container main processor changed to ATMega328P Microncontroller Chip	Weight is a huge issue to our payload, we changed the Arduino Pro Mini breakout board to Processor Chip to reduce our CanSat total mass.

CDH Requirements (1 of 2)

RN	Requirement	Rationale	Priority	Verification			
				A	I	T	D
RN1	Total mass of the CanSat (science payload and container) shall be 600 grams +/- 10 grams.	Competition Requirement	Very High	√		√	
RN10	The container shall release the payload at 450 meters +/- 10 meters.	Competition Requirement	Very High	√		√	
RN11	The science payload shall glide in a circular pattern for one minute and stay above 100 meters after release from the container.	Competition Requirement	High	√		√	√
RE13	After one minute of gliding, the science payload shall release a parachute to drop the science payload to the ground at 10 meters/second, +/- 5 m/s.	Competition Requirement	Very High		√	√	
RE15	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	Competition Requirement	Very High		√		
RE18	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Competition Requirement	Very High	√		√	√
RN21	Mechanisms that use heat (e.g., nichrome wire) shall not be exposed to the outside environment to reduce potential risk of setting vegetation on fire.	Competition Requirement	High		√		
RN28	The science payload shall transmit all sensor data in the telemetry.	Competition Requirement	Very High			√	√
RN29	Telemetry shall be updated once per second.	Competition Requirement	High	√		√	
RN33	Telemetry shall include mission time with one second or better resolution. Mission time shall be maintained in the event of a processor reset during the launch and mission.	Competition Requirement	High	√		√	
RN34	Configuration states such as if commanded to transmit telemetry shall be maintained in the event of a processor reset during launch and mission.	Competition Requirement	High	√			√
RN35	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE Pro radios are also allowed.	Competition Requirement	High	√			√

CDH Requirements (2 of 2)

RN	Requirement	Rationale	Priority	Verification			
				A	I	T	D
RN36	XBEE radios shall have their NETID/PANID set to their team number.	Competition Requirement	High		√		
RN37	XBEE radios shall not use broadcast mode.	Competition Requirement	High		√		
RN38	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.	Competition Requirement	Very High	√	√		
RN28	Each team shall develop their own ground station.	Competition Requirement	Very High	√			
RN29	All telemetry shall be displayed in real time during descent.	Competition Requirement	Very High			√	√
RN30	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	Competition Requirement	Very High	√	√		
RN31	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a hand-held antenna.	Competition Requirement	High			√	√
RN41	Payload/Container shall operate for a minimum of two hours when integrated into rocket.	Competition Requirement	Very High	√		√	
RN42	Teams shall plot each telemetry data field in real time during flight.	Competition Requirement	High			√	√
BM	A video camera shall be integrated into the science payload and point toward the coordinates provided for the duration of the glide time. Video shall be in color with a minimum resolution of 640x480 pixels and 30 frames per second. The video shall be recorded and retrieved when the science payload is retrieved. Points will be awarded only if the camera can maintain pointing at the provided coordinates for 30 seconds uninterrupted.	Bonus Mission	Very High			√	

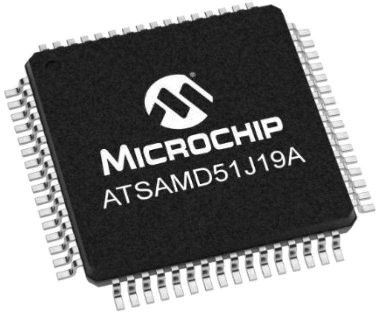
Payload Processor & Memory Selection (1 of 2)

Processor	Processor Speed (MHz)	Data Bus Width	Boot Time	I/O Pin	Interfaces	Operating Voltage (V)	Memory
ATSAMD51J19	120	32-bit	5 ms	25 Digital 6 Analog in 22 PWM	6 SPI 6 I2C 3 UART	1.71 – 3.6	Flash (1 MB) SRAM (192 KB)

Selected Component : ATSAMD51J19

Considerations:

- Programmable with Arduino IDE
- Fast CPU clock which sufficient for sampling – processing – sending sensor data and calculate bearing for servo as camera actuator
- Uses small amount of power
- EEPROM storage size is sufficient for storing states and packet count
- Smaller size compared to board version



Payload Processor & Memory Selection (2 of 2)

We don’t use external memory storage in our payload. Micro SD card is used to store bonus mission video, not CanSat flight data.

SD Card Model	Memory (GB)	Interface	Data transfer rate
Sandisk Ultra Micro SD Card	16	Mounted directly to micro SD slot in camera board	Up to 98 MB/s

Selected Component : **SanDisk Ultra Micro SD Card**

Considerations
- Good in transfer rate
- Affordable price
- Fits in our camera module

Payload Real-Time Clock

RTC Model	Types	Power Source	Reset Tolerance	Accuracy (Time Drift)
Matek SAM M8Q RTC	Hardware	Coin cell battery	In reset condition, external clock continues keeping time	5-30 ppm

Selected Component : Internal Matek GPS Module RTC

Considerations

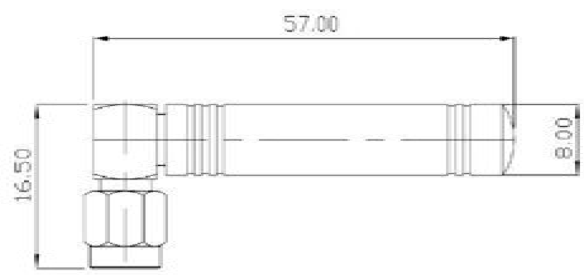
- All in one. It doesn't need external weight and spending since it's integrated on Matek SAM M8Q module
- Backup battery (on GPS module board) maintains time through processor reset
- Simple serial query
- The RTC keeps ticking while the processors reset, providing accurate and real time clock data, and can be accessed anytime

Payload Antenna Selection (1 of 2)

Antenna	Connection Type	Frequency (MHz)	Direction	Gain (dBi)	VSWR	Mass (g)	Size (cm)	Polarization	Price ($)
ANT-RA57-915	RP-SMA	890-960	Omni-directional	2	<= 1.5 : 1	2	5.7 x 1.65 x 0.8	Vertical	4.95

Selected Antenna : **ANT-RA57-915**

Considerations
- ¼ wavelength antenna
- 900 MHz which is better in open air condition
- Fits in the payload
- Tested



Payload Antenna Selection (2 of 2)

Performance:

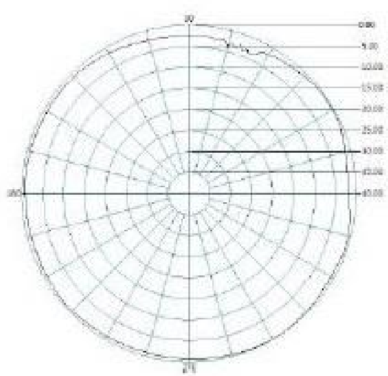
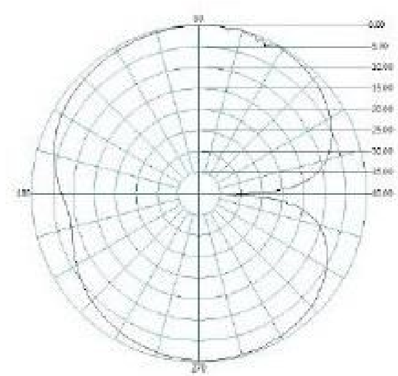
- Up to 700 m in medium density traffic.
- Has stable Voltage Standing Wave Ratio around 1.5:1. This value indicates very good transmission power, that 4% of power is reflected and 96% is transmitted from the antenna (VSWR formula shown below).
- ANT-RA57-915 also has isotropic gain antenna as shown in radiation pattern below.

Voltage Standing Wave Ratio:

$$\mathrm{SWR} = \left({1 + \sqrt{\frac{P_r}{P_f}}} \Big/ {1 - \sqrt{\frac{P_r}{P_f}}} \right)$$

Where
P_r=reflected power, P_f=Forward Power

Radiation Pattern of ANT-RA57-915 :

H-PLANE	E-PLANE
	

Payload Radio Configuration (1 of 2)

XBEE Pro S3B 900HP:

- We can use low data rate (1 Hz sample rate)
- Better sensitivity
- Team member experience
- Already available

XBEE Pro900HP S3B is selected as transmitter for payload and receiver for GCS. It has **900 MHz** operating frequency.

NETID/PANID numbers are set to our team number **1320** for both XBEEs.

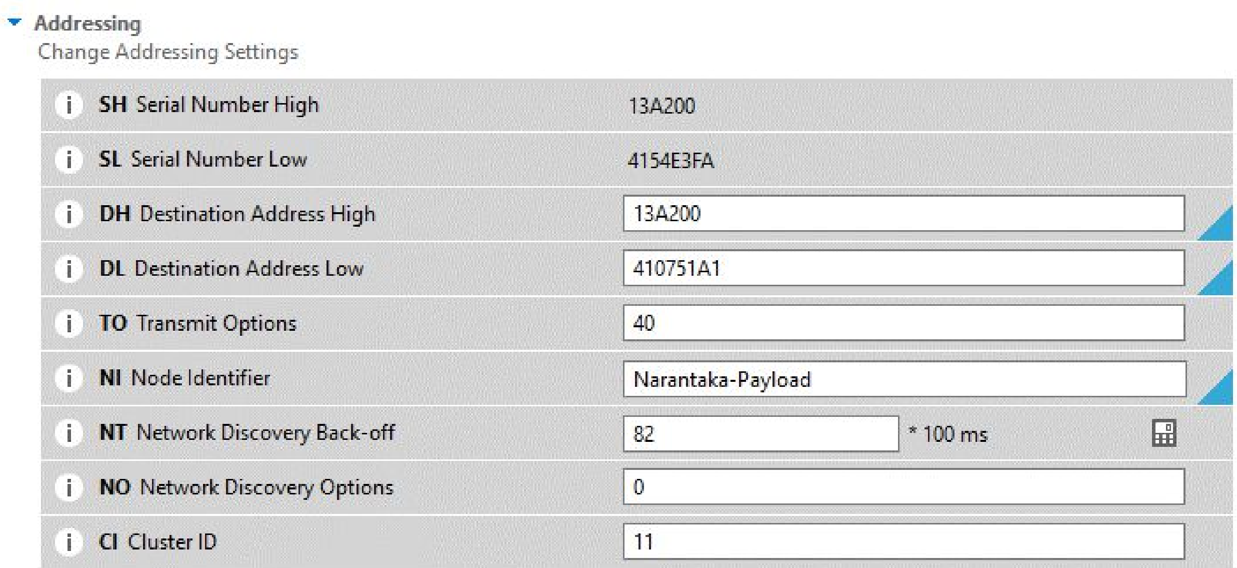
XBEE is set to send the packet to GCS at **1Hz** transmission rate.

Both XBEEs communicate in **unicast** mode, not in broadcast mode.

Payload Radio Configuration (2 of 2)

Transmission Control

The XBEE in the payload is set as endpoint transmitter while the XBEE at GCS is set as coordinator receiver. In every mission phase, the endpoint transmitter sends telemetry packet to the coordinator receiver in GCS. Before launch the coordinator sends a command for calibration.



Payload Telemetry Format (1 of 2)

Data Format	Example	Description
<TEAM ID>	1320	Assigned team identification
<MISSION TIME>	112	Time since initial power up in seconds
<PACKET COUNT>	112	Count of transmitted packets, which is to be maintained through processor reset
<ALTITUDE>	100	Altitude with 0.1 meters resolution
<PRESSURE>	99506.98	Atmospheric pressure in units of pascals. The resolution must be 1 pascals
<TEMP>	32	Sensed temperature in degrees C with one tenth of a degree resolution
<VOLTAGE>	3.9	Voltage of the CanSat power bus wih 0.01 volts resolution
<GPS TIME>	13.21	Time generated by the GPS receiver, reported in UTC and have a resolution of a second
<GPS LATITUDE>	-7.7645543	Latitude generated by the GPS receiver degrees with a resolution of 0.000001 degrees
<GPS LONGITUDE>	110.3767432	Longitude generated by the GPS receiver with a resolution of 0.000001 degrees
<GPS ALTITUDE>	166	Altitude generated by the GPS receiver in meters with a resolution of 0.1 meters
<GPS SATS>	6	Number of GPS satellites being tracked by the GPS receiver
<AIR SPEED>	30	Rate of air speed relative to the payload in m/s
<SOFTWARE STATE>	3	State of the software (boot, idle, launch, deploy, gliding, parachute, landed)
<PARTICLE COUNT>	400	Measured particle count in mg/m^3

Payload Telemetry Format (2 of 2)

Data **packet** will be transmitted at a rate if **1 Hz** in **burst**

The telemetry data shall be transmitted with ASCII comma separated fields followed by a carriage return in the following format:

```
<TEAM ID>, <MISSION TIME>, <PACKET COUNT>, <ALTITUDE>,
<PRESSURE>, <TEMP>, <VOLTAGE>, <GPS TIME>, <GPS LATITUDE>,
<GPS LONGITUDE>, <GPS ALTITUDE>, <GPS SATS>, <AIR SPEED>,
<SOFTWARE STATE>, <PARTICLE COUNT>
```

Example telemetry packet:

```
1320,112,112,100,99506.98,32,3.9,13,12,21,-7.7645543, 110.3767432,166,6,30,3,400
```

The example telemetry packet match with the competition guide requirements.

The telemetry data file will be saved as: **Flight_1320.csv**

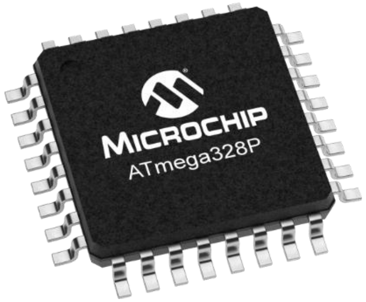
Container Processor & Memory Selection

Processor	Processor Speed (MHz)	Data Bus Width	Boot Time	I/O Pin	Interfaces	Operating Voltage (V)	Memory
ATMega328P-AU	16	8-bit	6.6 s	20 Digital 6 Analog in 6 PWM	2 SPI 1 I2C 1 UART	1.8-5.5	EEPROM (1 KB) Flash (32 KB) SRAM (2 KB)

Selected Component : ATMega328P-AU

Considerations

- Affordable price
- Processor in container only maintains altitude data, servo, and state so using 16 MHz processor is enough for our application
- It works very well in our testing



We don't use external memory storage in our container

Altitude data from BMP stored in volatile memory so that when the altitude is below 450m, ATMega328P will give a signal to move the servo

Electrical Power Subsystem Design

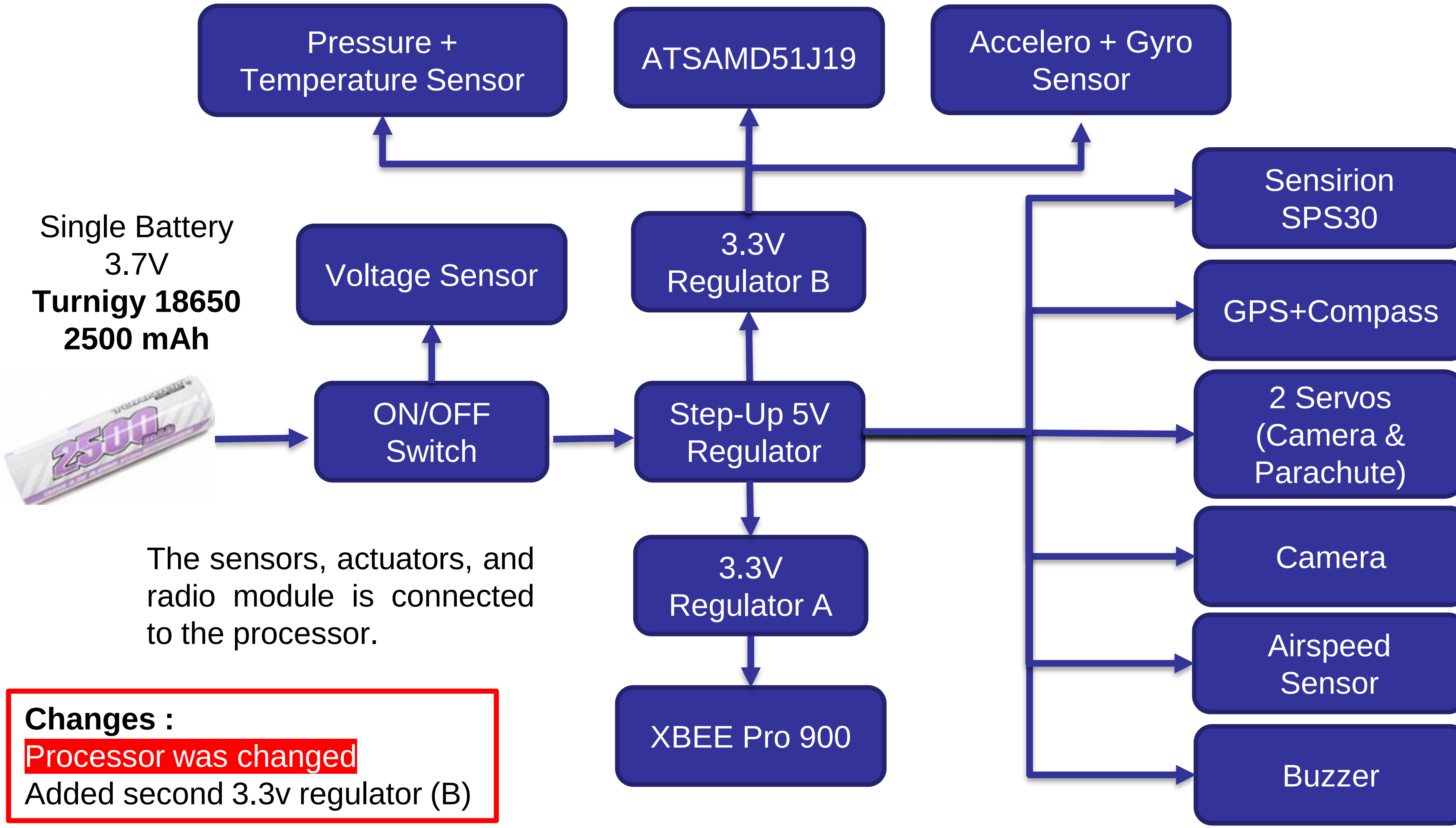
Nico Renaldo

EPS Overview (1 of 3)

Component Type	Purpose
Battery	Supplies power to the components
Switch	Connect and disconnect the battery from the circuit
Voltage Regulator	Adjusts the voltage to the appropriate level that the sensors and processor need
Processor	Receive and process data obtained from sensor and to control the actuator
Sensor	Provides environment measurement to the payload
Radio Communication	Sends payload data using RF signal to GCS
Buzzer	Assist recovery team by making a loud sound after landing
MOSFET	Works as a switch controlled by digital signal from microprocessor
Servo	Actuator to control the position of the (1) camera, (2) parachute deployment, and (3) separation mechanism

EPS Overview (2 of 3)

Payload EPS Overview

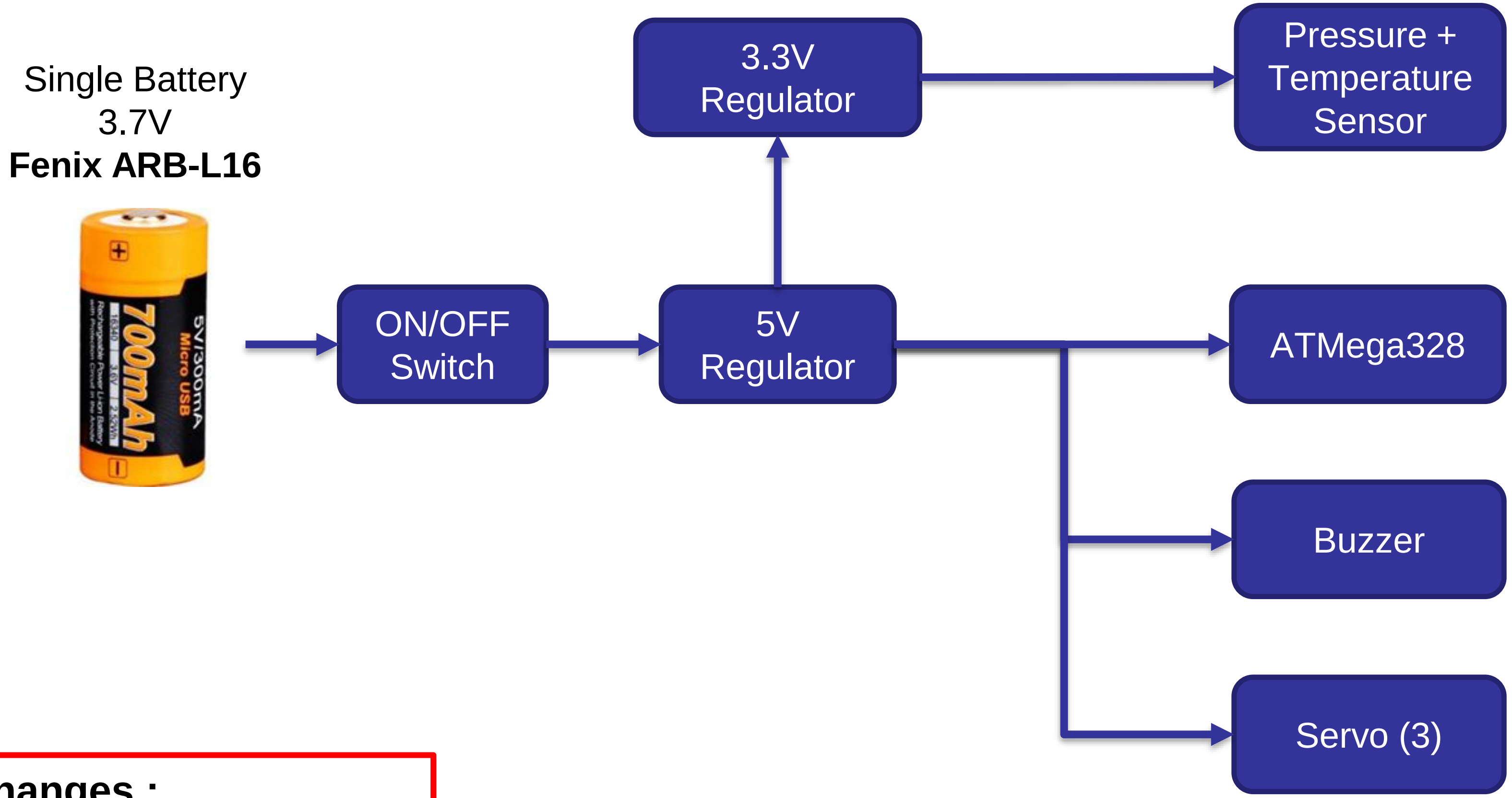


The sensors, actuators, and radio module is connected to the processor.

Changes :
Processor was changed
Added second 3.3v regulator (B)

EPS Overiew (3 of 3)

Container EPS Overview



Changes :
Processor was changed

EPS Changes Since PDR

Changes in Design and Components :

Component	PDR	CDR	Rationale
Payload Processor	Teensy 4.0 breakout boards	ATSAMD51J19 Chip	Smaller form factor of the PCB thus reducing its weight
Container Processor	Arduino Pro Mini	ATMega328P-AU Chip	Smaller form factor of the PCB thus reducing its weight
Sensors	BMP388 and MPU6050 breakout boards	Directly integrate the chip to the PCB	Reduce weight
Payload Battery	Sony VTC6	Turnigy 18650	Better voltage stability
Regulator	Has one 3.3V regulator	Second 3.3V regulator added	To power the processor and some 3.3V sensors separately from XBEE

Changes in Presentation :

- We recalculated the Power Budget
- We changed the block diagram

EPS Requirements (1 of 2)

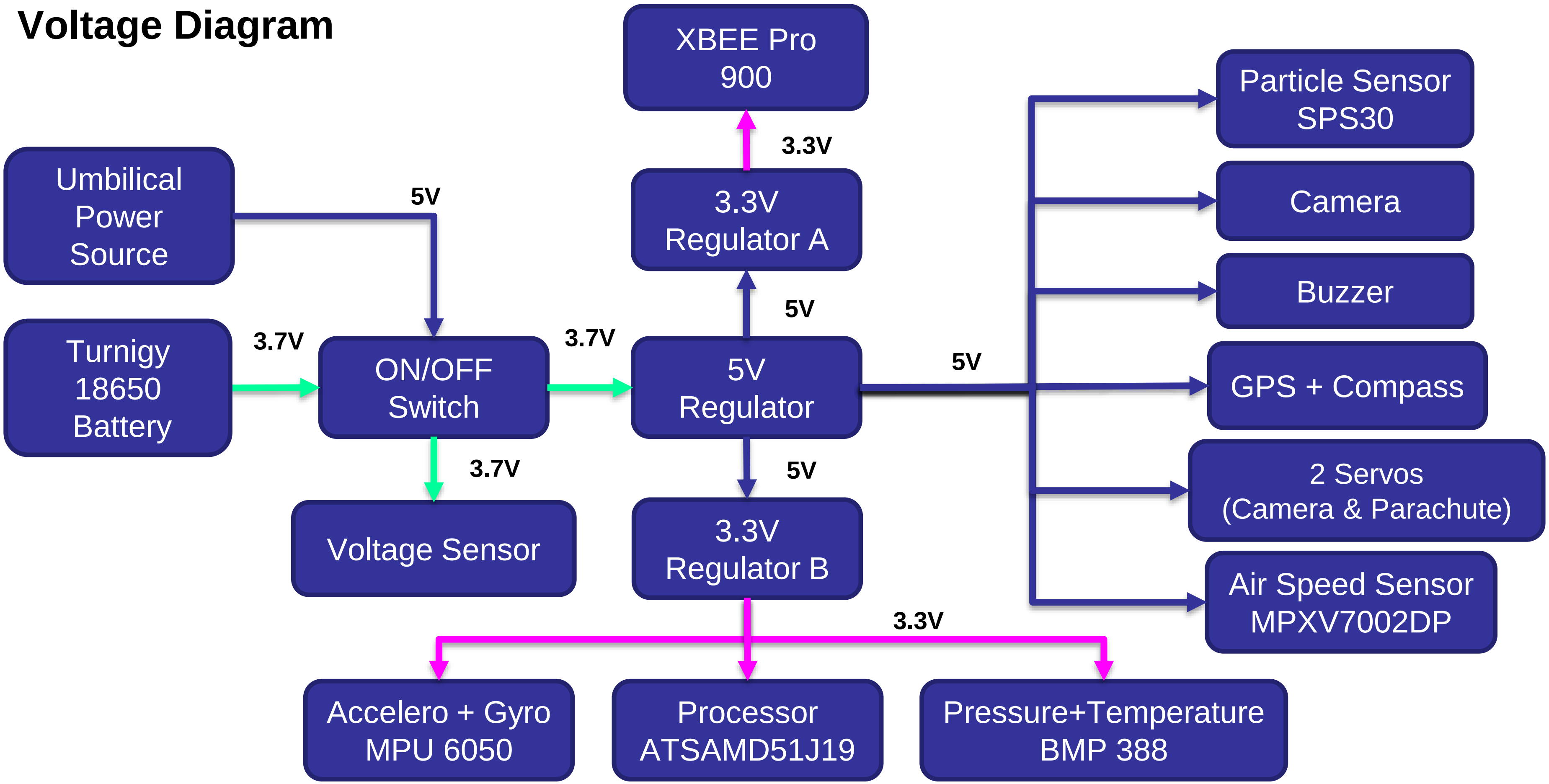
RN	Requirement	Rationale	Priority	Verification			
				A	I	T	D
RN22	The science payload shall measure altitude using an air pressure sensor.	Competition Requirement	Very High			✓	✓
RN23	The science payload shall provide position using GPS.	Competition Requirement	Very High			✓	✓
RN24	The science payload shall measure its battery voltage.	Competition Requirement	Very High			✓	✓
RN25	The science payload shall measure outside temperature.	Competition Requirement	Very High			✓	✓
RE26	The science payload shall measure particulates in the air as it glides.	Competition Requirement	Very High			✓	✓
RN27	The science payload shall measure air speed.	Competition Requirement	Very High			✓	✓
RN28	The science payload shall transmit all sensor data in the telemetry.	Competition Requirement	Very High			✓	✓
RN47	No lasers allowed.	Competition Requirement	Medium	✓			
RN48	The probe must include an easily accessible power switch that can be accessed without disassembling the cansat and in the stowed configuration.	Competition Requirement	Very High		✓		✓
RN49	The probe must include a power indicator such as an LED or sound generating device that can be easily seen without disassembling the cansat and in the stowed state.	Competition Requirement	Very High	✓	✓		
RN50	An audio beacon is required for the probe. It may be powered after landing or operate continuously.	Competition Requirement	Very High	✓		✓	✓

EPS Requirements (2 of 2)

RN	Requirement	Rationale	Priority	Verification			
				A	I	T	D
RN51	The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed.	Competition Requirement	High	√	√		
RN52	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.	Competition Requirement	Very High		√		
RN53	An easily accessible battery compartment must be included allowing batteries to be installed or removed in less than a minute and not require a total disassembly of the CanSat.	Competition Requirement	Very High		√		√
RN54	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Competition Requirement	High	√	√		
RN56	Payload/Container shall operate for a minimum of two hours when integrated into rocket.	Competition Requirement	Very High	√		√	
BM	A video camera shall be integrated into the science payload and point toward the coordinates provided for the duration of the glide time. Video shall be in color with a minimum resolution of 640x480 pixels and 30 frames per second. The video shall be recorded and retrieved when the science payload is retrieved. Points will be awarded only if the camera can maintain pointing at the provided coordinates for 30 seconds uninterrupted.	Bonus Mission	Very High	√	√	√	

Payload Electrical Block Diagram

Voltage Diagram

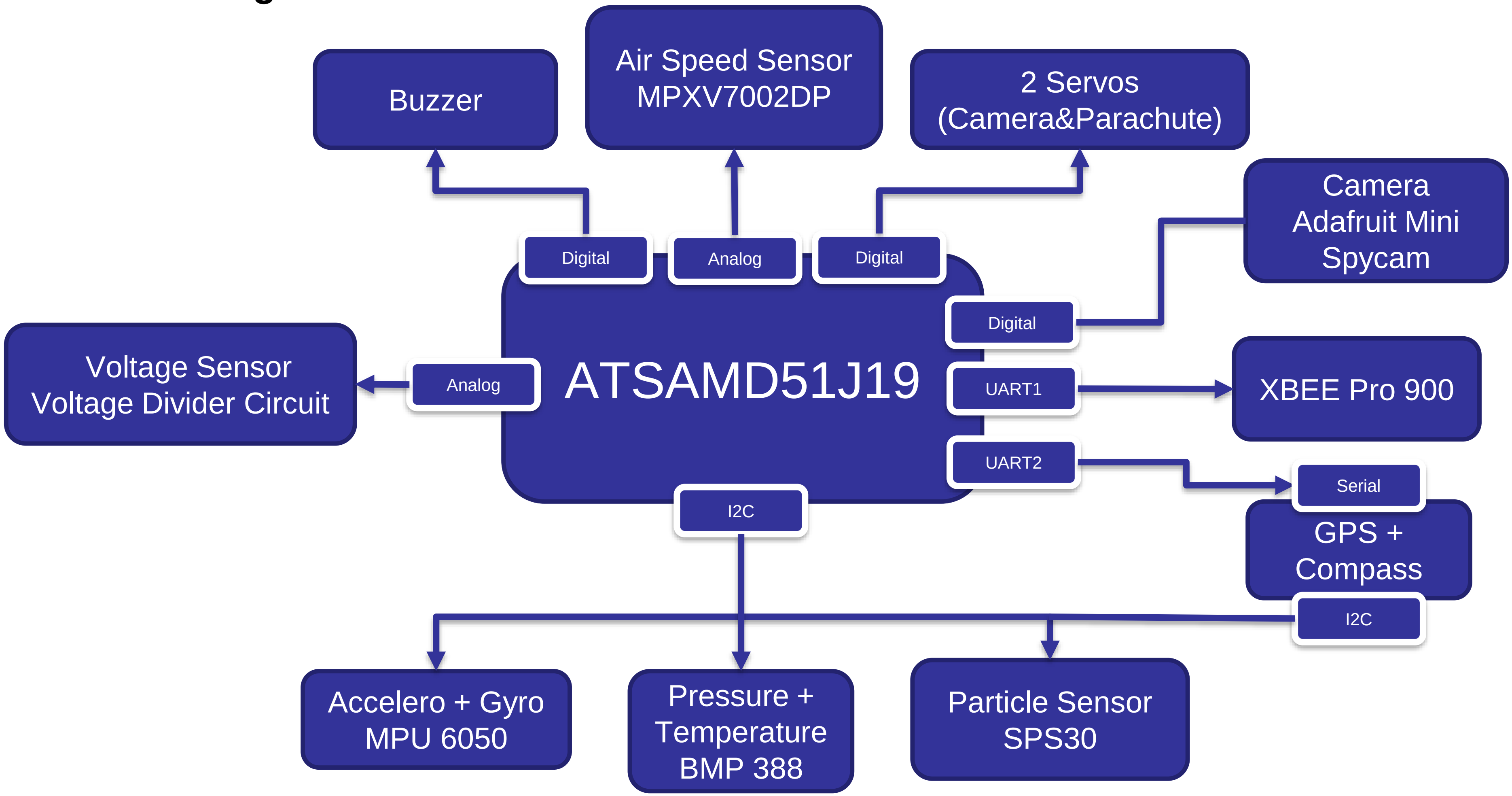


The power will be controlled by a switch placed in accessible place from outside.

The system will activate the audio beacon and LED for a second during its initialization.

Payload Electrical Block Diagram (2 of 2)

Interface Diagram



Payload Power Source

Power Source Selection

Selected Battery :	**Turnigy 18650 3.7V 2500mAh**

The battery will be locked on a battery socket and secured with tape

Description
We use a single cell Lithium-Ion battery to power the main system.
The battery has a nominal voltage of 3.7V and maximum capacity of 2500mAh.
Allows up to 2 hours of constant 1.25A current drainage, and more than 25 hours of 100mA.
The battery could discharge up to 20A stable output.
Well known battery manufacturer.

Payload Power Budget (1 of 3)

No	Name	Voltage (V)	Duty Cycle (%)	Power (W)	Power Consumption (Wh)	Source
1	ATSAMD51J19	5	100	0.111*	0.222	Datasheet/ Estimate
2	Servo Camera (1)	5	12.5	1.388**	0.34722	Datasheet/ Estimate
3	Servo Parachute (2)	5	1	1.388**	0.02776	Datasheet/ Estimate
4	MPU 6050	3.3	100	0,029971*	0.059942	Datasheet
5	MPXV7002DP	3.3	100	0.0367**	0.734	Datasheet
6	BMP 388	3.3	100	0,000017*	0.000034	Datasheet
7	GPS + Compass	5	100	0,138**	0.277	Datasheet

Payload Power Budget (2 of 3)

No	Name	Voltage (V)	Duty Cycle (%)	Power (W)	Power Consumption (Wh)	Source
8	XBEE Pro 900	3.3	100	1.075*	2.15	Datasheet
8	Sensirion SPS 30	5	100	0.444**	0.888	Datasheet
9	Adafruit Spycam	5	12.5	0.611**	0.1527	Datasheet
10	Audio Beacon	5	25	0.555**	0.277	Datasheet

*Power of components powered by buck (3.3v) regulator is recalculated by the following equation :
[Power+current*drop voltage(5-3.3)]

**Power of components powered by boost (5v) regulator is recalculated by the following:
Estimating 90% efficiency of our boost regulator -> Power/0.9

Total Power Consumed	5.125 Wh

Payload Power Budget (3 of 3)

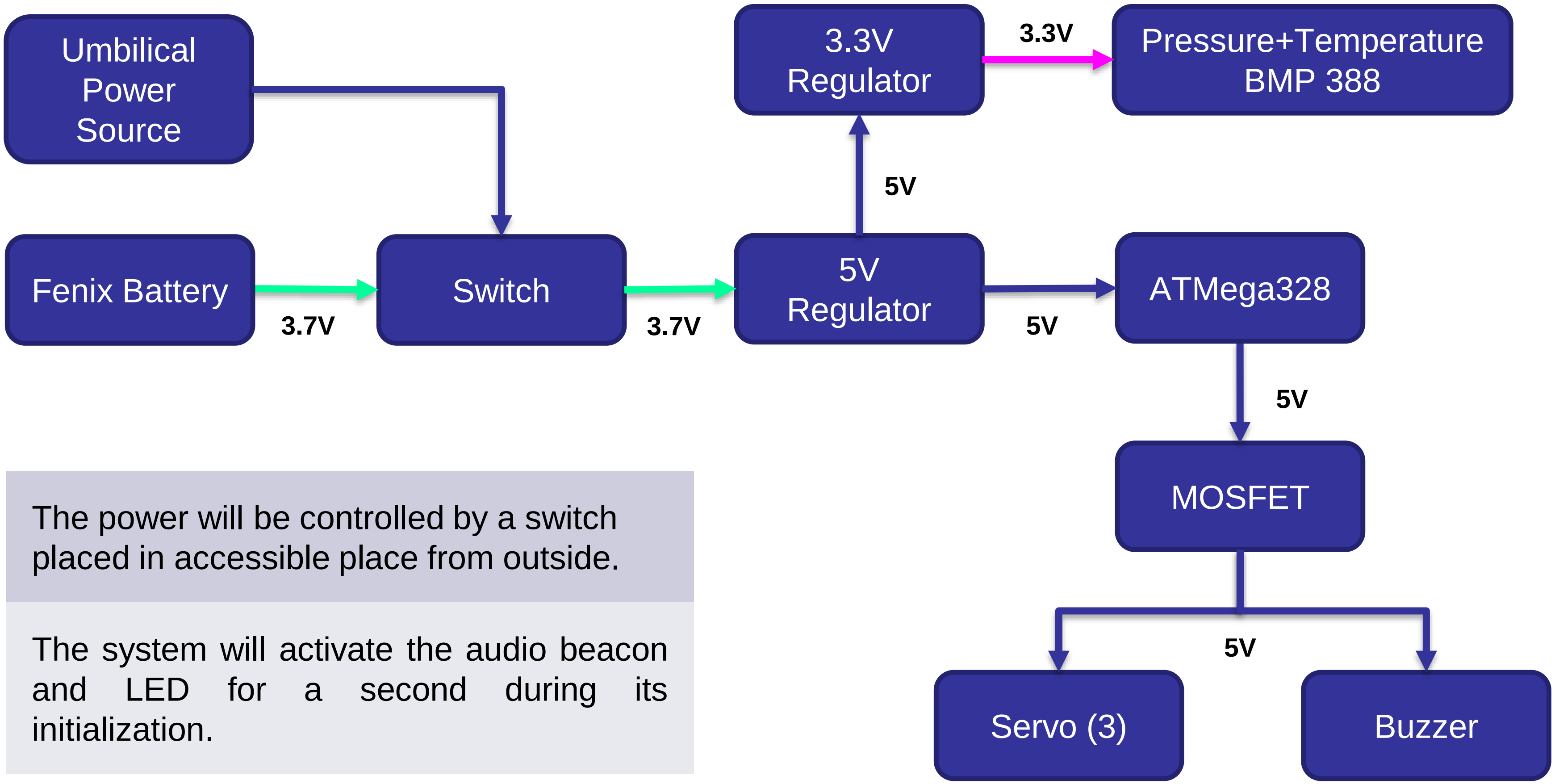
Available Total Current Capacity (for two hours)	Available Total Power Capacity (for two hours)
2500 mAh	9.25 Wh

Margin of Power Consumption
9.25 Wh - 5.125 Wh = 4.125 Wh (44.5% Margin)

Conclusion :

Our battery is sufficient to power all the components throughout the flight.

Voltage Diagram

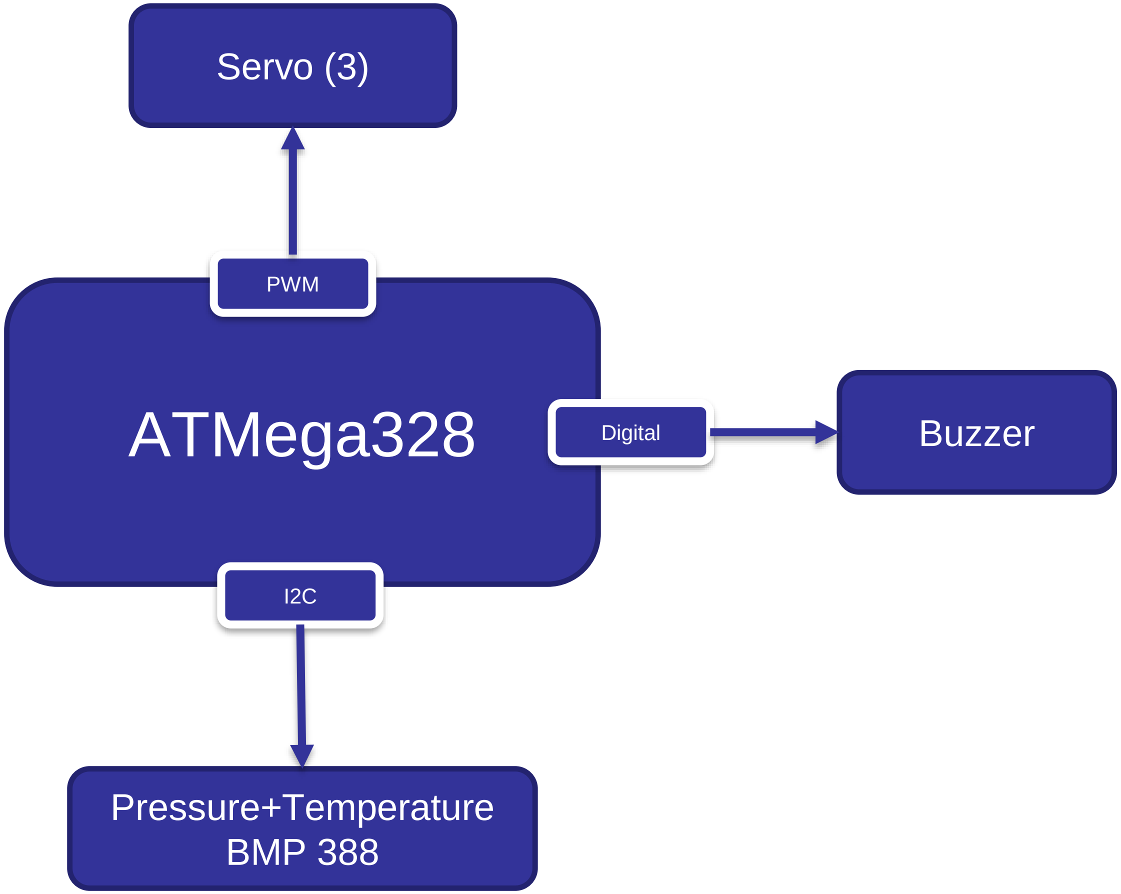


The power will be controlled by a switch placed in accessible place from outside.

The system will activate the audio beacon and LED for a second during its initialization.

Interface Diagram

- Servo is used as separation mechanism between payload (glider) and container.
- BMP 388 is used as altitude measurement device.
- Buzzer is used to help the tracker find the container after the separation.



Container Power Source

Power Source Selection

Selected Battery : **Fenix ARB-L16**

Description
We use a single cell Lithium-Ion battery to power the separation mechanism by servo.
The battery has a nominal voltage of 3.7V and maximum capacity of 700mAh.
Allows up to 2 hours of constant 350mA current drainage, and more than 30 hours of 50mA.
The battery could discharge up to 2.5A stable output.

The battery will be locked on a battery socket, and secured with a tape later.

Container Power Budget (1 of 2)

No	Name	Voltage (V)	Duty Cycle (%)	Power (W)	Power Consumption (Wh)	Source
1	ATMega328	5	100	0.18	0.36	Estimate
2	Adafruit BMP388	3.3	100	0.00134	0.002673	Datasheet
3	Servo	5	5	1.125	0.1125	Estimate
4	LED x 2	2	100	0.036	0.072	Estimate
5	Buzzer	5	15	0.675	0.2025	Datasheet

***All components power is recalculated by estimating the efficiency of the boost regulator (90%) by the following equation : Actual Power = Estimated Power / 0.9**

Total Power Consumed
0.749673 Wh

Container Power Budget (2 of 2)

Available Total Current Capacity (for two hours)	Available Total Power Capacity (for two hours)
700 mAh	2.590 Wh

Margin of Power Consumption (for two hours)
2.590 Wh – 0.749673 Wh = 1.840327 Wh (71.05% Margin)

Conclusion :

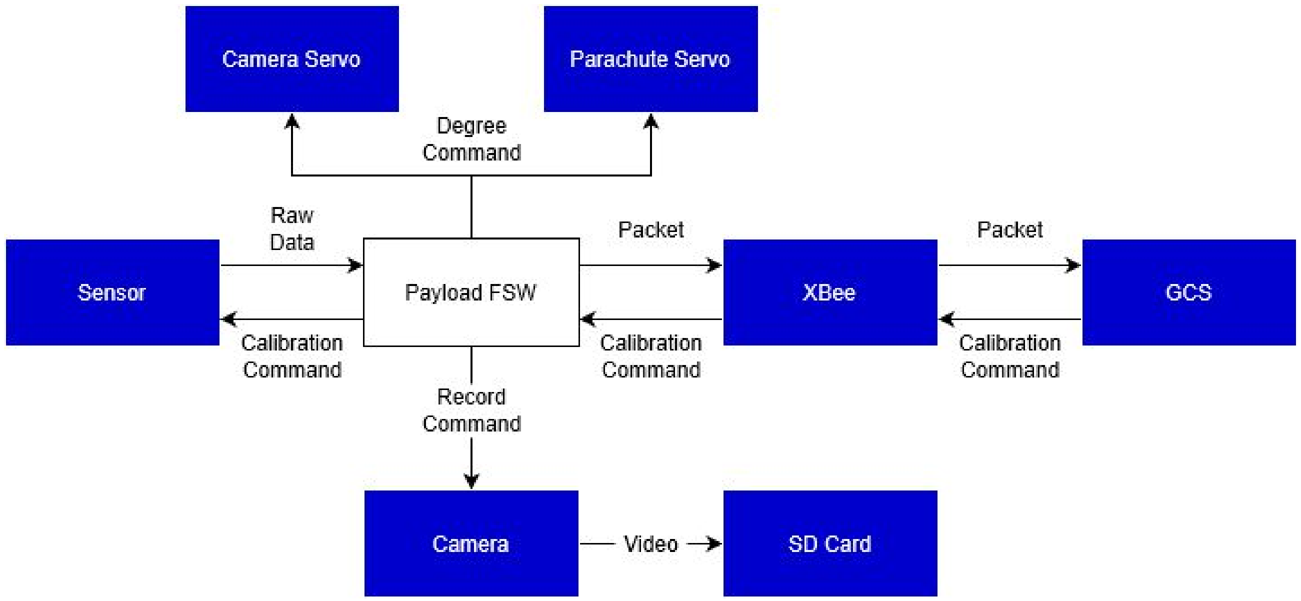
Our battery is sufficient to power all the components throughout the flight.

Flight Software (FSW) Design

Muhammad Dyffa

FSW Overview (1 of 3)

PAYLOAD FSW



CONTAINER FSW

Narantaka

FSW Overview (2 of 3)

CanSat FSW task

Payload FSW tasks
Checks when sensor fails
Samples each sensor
Calibrates the sensors
Handles data processing
Sends data to GCS
Decides the software state
Stores system data to EEPROM for recovery
Command camera to record a video
Command servo to point the camera and parachute

Container FSW tasks
Measures altitude
Stores system data to EEPROM for recovery
Commands EPS to move the servo

Programming languages	C/C++
Development environments	Arduino IDE Dev C++

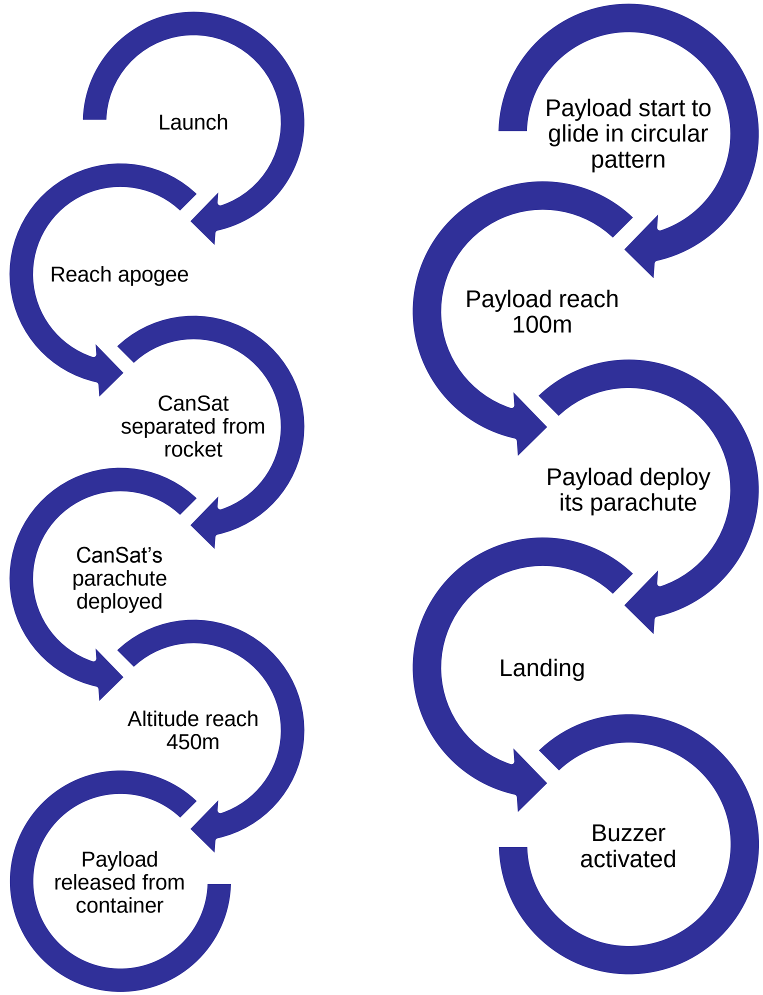
FSW Overview (3 of 3)

CanSat FSW architecture

Payload measures atmospheric data and send the data to GCS

Container measures altitude

Container rules the EPS to move the servo



Payload released to glide with mechanical mechanisms

Payload measures atmospheric data and send the data to GCS

Payload reaches the ground and activates the buzzer

FSW Changes Since PDR

- **We changed one person in our software development team**

FSW Requirements (1 of 2)

RN	Requirement	Rationale	Priority	Verification			
				A	I	T	D
RN10	The container shall release the payload at 450 meters +/- 10 meters.	Competition Requirement	Very High	✓		✓	
RN11	The science payload shall glide in a circular pattern for one minute and stay above 100 meters after release from the container.	Competition Requirement	High	✓		✓	✓
RE13	After one minute of gliding, the science payload shall release a parachute to drop the science payload to the ground at 10 meters/second, +/- 5 m/s.	Competition Requirement	Very High		✓	✓	
RN22	The science payload shall measure altitude using an air pressure sensor.	Competition Requirement	Very High			✓	✓
RN23	The science payload shall provide position using GPS.	Competition Requirement	Very High			✓	✓
RN24	The science payload shall measure its battery voltage.	Competition Requirement	Very High			✓	✓
RN25	The science payload shall measure outside temperature.	Competition Requirement	Very High			✓	✓
RE26	The science payload shall measure particulates in the air as it glides.	Competition Requirement	Very High			✓	✓
RN27	The science payload shall measure air speed.	Competition Requirement	Very High			✓	✓
RN33	Telemetry shall include mission time with one second or better resolution. Mission time shall be maintained in the event of a processor reset during the launch and mission.	Competition Requirement	High	✓		✓	
RN34	Configuration states such as if commanded to transmit telemetry shall be maintained in the event of a processor reset during launch and mission.	Competition Requirement	High	✓			✓
RN41	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	Competition Requirement	Very High	✓			✓

FSW Requirements (2 of 2)

RN	Requirement	Rationale	Priority	Verification			
				A	I	T	D
RN46	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.	Competition Requirement	High	✓			✓
BM	A video camera shall be integrated into the science payload and point toward the coordinates provided for the duration of the glide time. Video shall be in color with a minimum resolution of 640x480 pixels and 30 frames per second. The video shall be recorded and retrieved when the science payload is retrieved. Points will be awarded only if the camera can maintain pointing at the provided coordinates for 30 seconds uninterrupted.	Bonus Mission	Very High	✓	✓	✓	

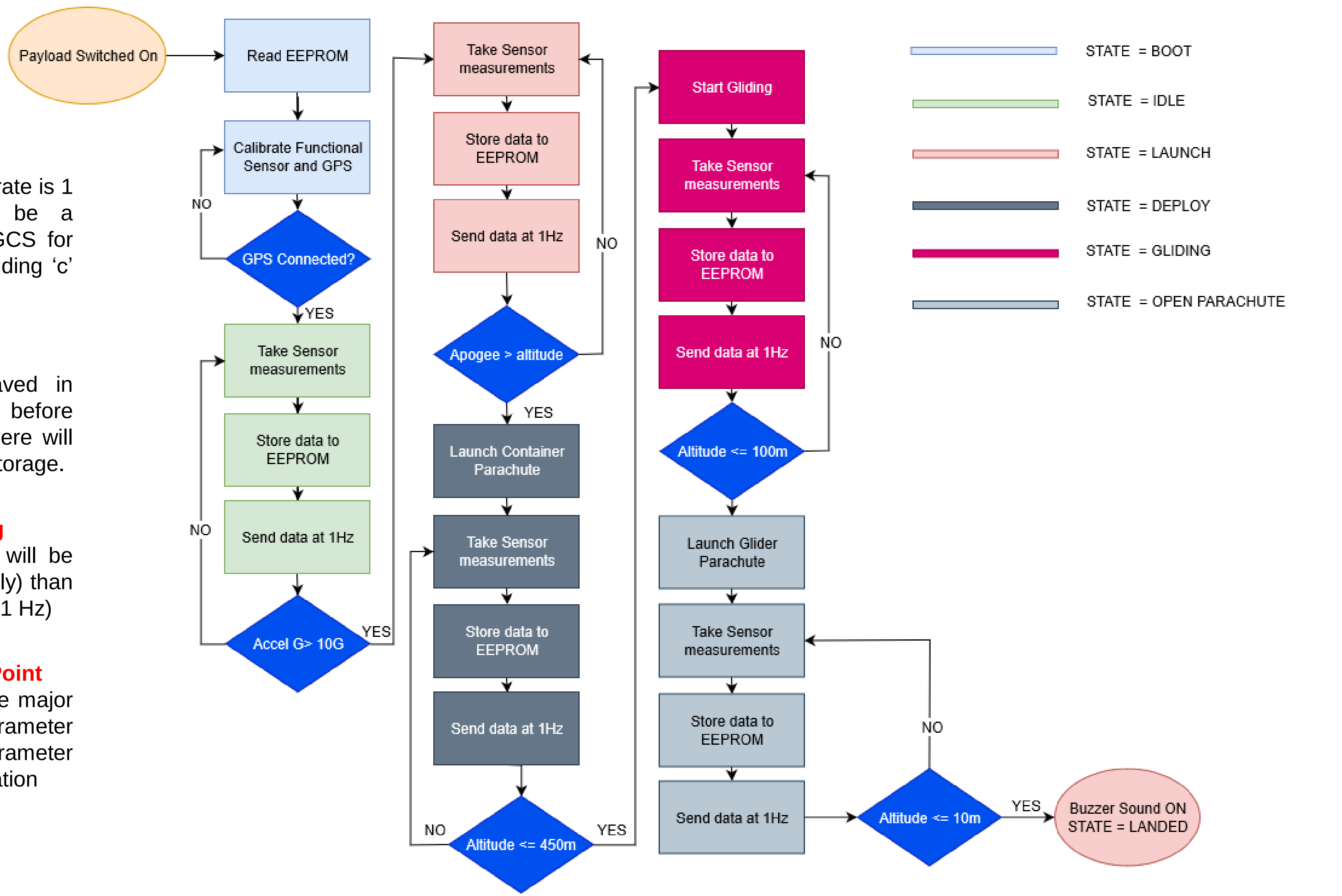
Payload CanSat FSW State Diagram (1 of 2)

Communication
The packet send rate is 1 Hz. There will be a command from GCS for calibration by sending ‘c’ to payload.

Data Storage
Data will be saved in volatile memory before send to GCS. There will be no additional storage.

Sensor Sampling
Sensor sampling will be faster (continuously) than packet send rate (1 Hz)

Major Decision Point
Altitude will be the major decision parameter among other parameter used as consideration



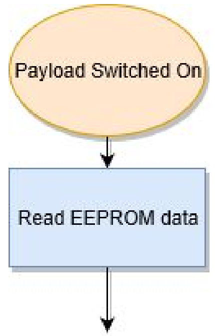
Processor Reset Control

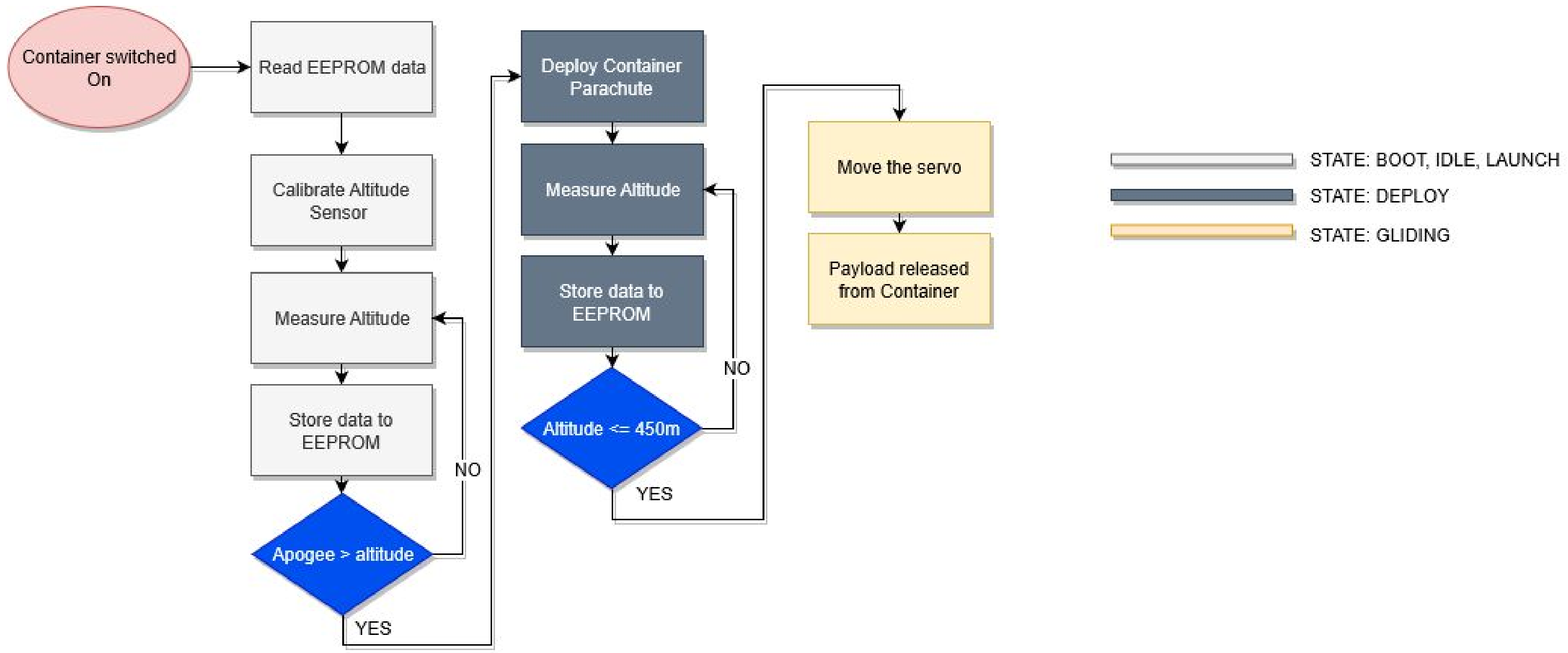
The processor reset can be caused by a program crash (memory buffer or array is being written beyond the size of the array or buffer size) or it could be a power or electrical noise problem

Data saved to EEPROM are last altitude data, state, and packet count

Data Storage	Power Management	State Recovery
- All sensor data will be sent to GCS (not stored in payload) - Camera video will be saved directly to SD card	- Measure the battery voltage and send it to GCS - The battery capacity is more than enough to flight within 2 hours	- State and packet count will be saved to EEPROM - Real time clock data will be saved to EEPROM - If the processor reset, the data will retrieved from the EEPROM

Processor reset diagram from payload FSW state diagram





Communication
Container is independent. There is no device to communicate with.

Data Storage
Data will be saved in volatile memory. There will be no additional storage.

Sensor Sampling
BMP will continuously do sampling to get altitude data. Sampling every 75 ms

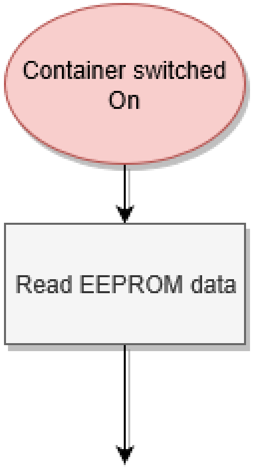
Major Decision Point
Altitude will be the major decision point and the only parameter used

Processor Reset Control

The processor reset can be caused by a program crash (memory buffer or array is being written beyond the size of the array or buffer size) or it could be a power or electrical noise problem

State Recovery	Power Management
- Last altitude data and state will be saved to EEPROM - If the processor reset, the data will be retrieved from the EEPROM	- There will be no power management in container - The battery is able to move the servo and get altitude data during mission

The following diagram is processor reset diagram from container FSW state diagram

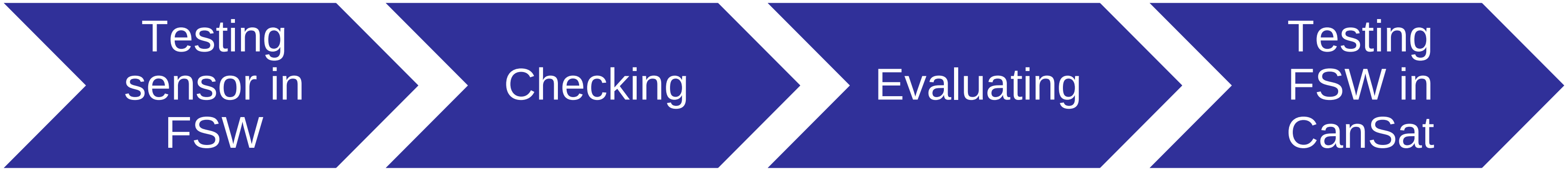


Software Development Plan (1 of 6)

Prototyping and prototyping environments

Subject	Prototyping Environment	Prototyping Procedure
Sensor	Breadboard and PCB	Each sensor was tested separately on breadboard and PCB designed after prototyping
Processor	Arduino IDE	Programming and debugging are done in Arduino IDE and data stream is monitored via Arduino IDE serial monitor.

Test Methodology



Software Development Plan (2 of 6)

Payload Software Development Sequence

Task List	Compliance	Deadline
List of sensors and electrical detail for comparation	Completed	Mid September
Selection of sensors	Completed	Early October
Testing of each sensors with modified library	Completed	Late October
Calibration of each sensor according to test	Completed	Early November
Test all sensors in prototype board	Completed	Mid November
Analyze algorithm to find bearing of two coordinates for bonus mission	Completed	Late November
Create algorithm to control servo for camera stabilizer	Completed	Early December
Wired serial communication test with prototype GCS	Completed	Mid December
Recording video and saving it on external storage	Completed	Late December
Testing 1-axis stabilizer for camera	Completed	Early January
Test all component and sensor in prototype board	Completed	Mid January
Wireless communication test with prototype GCS	Completed	Early February
Evaluation for troubleshooting and problem	Completed	Early February

Software Development Plan (3 of 6)

Container Software Development Sequence

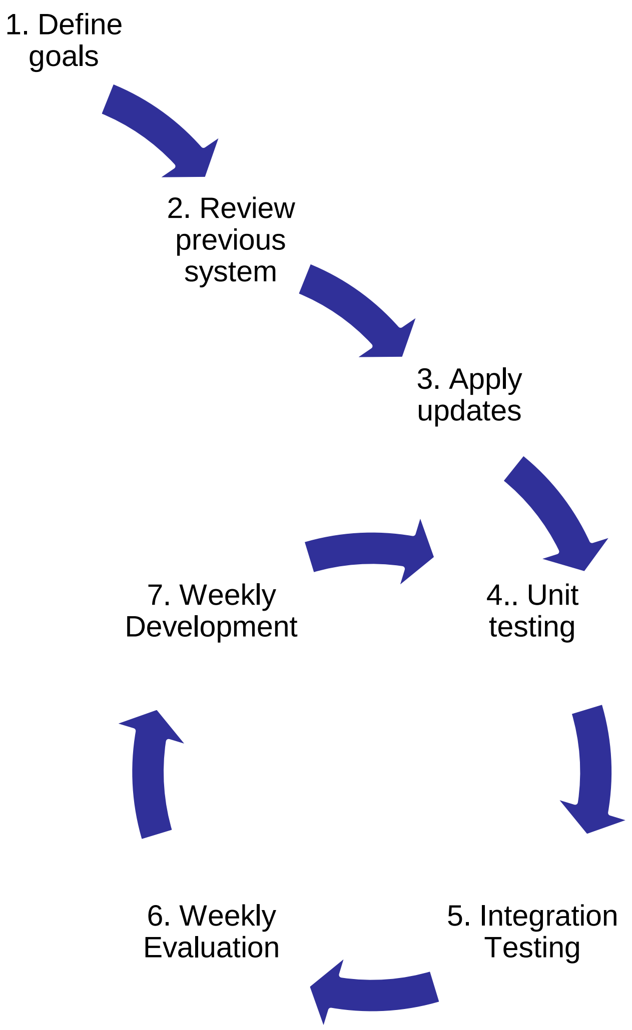
Task List	Compliance	Deadline
List of barometer sensor and its electrical detail for comparation	Completed	Mid September
Selection of sensors	Completed	Early October
Testing of barometer sensors with modified library	Completed	Late October
Calibration of barometer sensor according to test	Completed	Early November
Test barometer sensors in prototype board	Completed	Mid November
Analyze algorithm to determine separation conditions	Completed	Late November
Create algorithm to control servo for separation	Completed	Early December
Test sensor and servo in prototype board	Completed	Early February
Evaluation for troubleshooting and problem	Completed	Late February

To do List : Periodically testing and evaluating

Software Development Plan (4 of 6)

Development Processes

No.	Process
1	Defining objectives of software system by thoroughly review the mission guide.
2	Reviewing software system used for CanSat 2019.
3	Applying changes and updates into software system based on requirements.
4	Performing unit test for updated software system.
5	Performing integration test to assess overall systems.
6	Weekly evaluation of software.
7	Weekly revision of software



Software Development Plan (5 of 6)

- **Software Development Team**
  - Muhammad Dyffa
  - Wildan Fajar Purnomo
  - Muhammad Nur Ilmi
- **Source Code Management**
  - We're using **Gogs**, a self-hosted Git service, for **storing codes** as well as **tracking their changes.**
  - Gogs allows us to **return** anytime to any **checkpoint** of change.
- **Deployment**
  - Payload and container FSW are uploaded to processor with **Arduino IDE**.
  - We're using **Docker**, a tool for deploying software as package into Raspberry PI 3B.
  - Docker allows us to perform a **loosely coupled development**.
  - Useful for **web development** as our GCS is web based.
- **Late Development Prevention**
  - Since we have developed software that is functionally similar to the needs of the competition, we are confident that the software development for CanSat from the previous software will be completed on time.

Software Development Plan (6 of 6)

PROGRESS SINCE PDR

Payload Development Update

- Payload software development plan was completed with no delay
- We still need to test the state sequences in real condition
- GCS is able to send calibration command to payload
- Sensors were tested multiple time to get the best result

Container Development Update

- Container software development plan is completed with no delay
- The container is set to move the servo after separated with rocket in 450m
- There is no delay after processor give command to servo

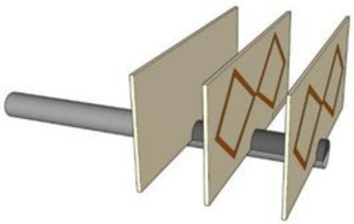
Ground Control System (GCS) Design

Mahatma Ageng Wisesa
&
Wildan Fajar Purnomo

GCS Overview

Science
payload data

XBEE



DIY Antenna

XBEE

Raspberry PI 3B
(GCS Server)

PC
(GCS Client)

GCS Changes Since PDR

Component	PDR	CDR	Rationale
CSV File Creation	Button click	Automatically logs telemetry data into CSV when receiving from XBEE	More efficient and prevents human error
GCS Client	Consists of two pages : Home and Data Table	Data Table page is removed	Inefficient and prone to human error
GCS Client	Has no serial port connection indicator	Connection indicator added	Detects whether XBEE is connected with Raspberry PI 3B or not
Flight time and Parachute time	No time counters	Time counters are now added.	Gives more information for post flight analysis

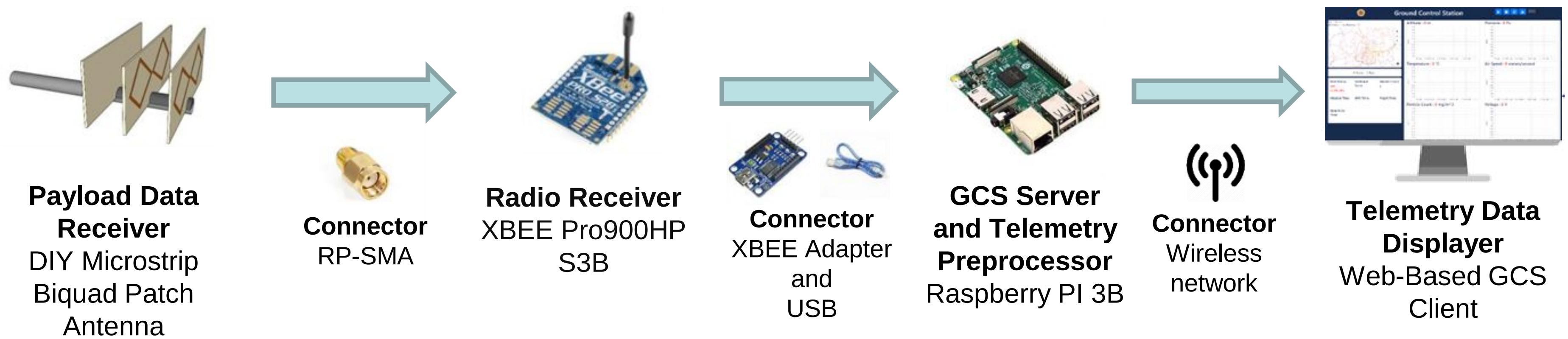
GCS Requirements (1 of 2)

RN	Requirement	Rationale	Priority	Verification			
				A	I	T	D
RN22	The science payload shall measure altitude using an air pressure sensor.	Competition Requirement	Very High			✓	✓
RN23	The science payload shall provide position using GPS.	Competition Requirement	Very High			✓	✓
RN24	The science payload shall measure its battery voltage.	Competition Requirement	Very High			✓	✓
RN25	The science payload shall measure outside temperature.	Competition Requirement	Very High			✓	✓
RE26	The science payload shall measure particulates in the air as it glides.	Competition Requirement	Very High			✓	✓
RN27	The science payload shall measure air speed.	Competition Requirement	Very High			✓	✓
RN28	The science payload shall transmit all sensor data in the telemetry.	Competition Requirement	Very High			✓	✓
RN29	Telemetry shall be updated once per second.	Competition Requirement	High	✓		✓	
RN31	The ground system shall command the science vehicle to start transmitting telemetry prior to launch.	Competition Requirement	High	✓		✓	
RN32	The ground station shall generate a csv file of all sensor data as specified in the telemetry section.	Competition Requirement	High	✓	✓	✓	
RN33	Telemetry shall include mission time with one second or better resolution. Mission time shall be maintained in the event of a processor reset during the launch and mission.	Competition Requirement	High	✓		✓	
RN34	Configuration states such as if commanded to transmit telemetry shall be maintained in the event of a processor reset during launch and mission.	Competition Requirement	High	✓			✓

GCS Requirements (2 of 2)

RN	Requirement	Rationale	Priority	Verification			
				A	I	T	D
RN38	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.	Competition Requirement	Very High	√			
RN39	Each team shall develop their own ground station.	Competition Requirement	Very High	√			
RN40	All telemetry shall be displayed in real time during descent.	Competition Requirement	Very High			√	√
RN41	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	Competition Requirement	Very High	√	√		
RN42	Teams shall plot each telemetry data field in real time during flight.	Competition Requirement	High			√	√
RN43	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a hand-held antenna.	Competition Requirement	High			√	√

GCS Design

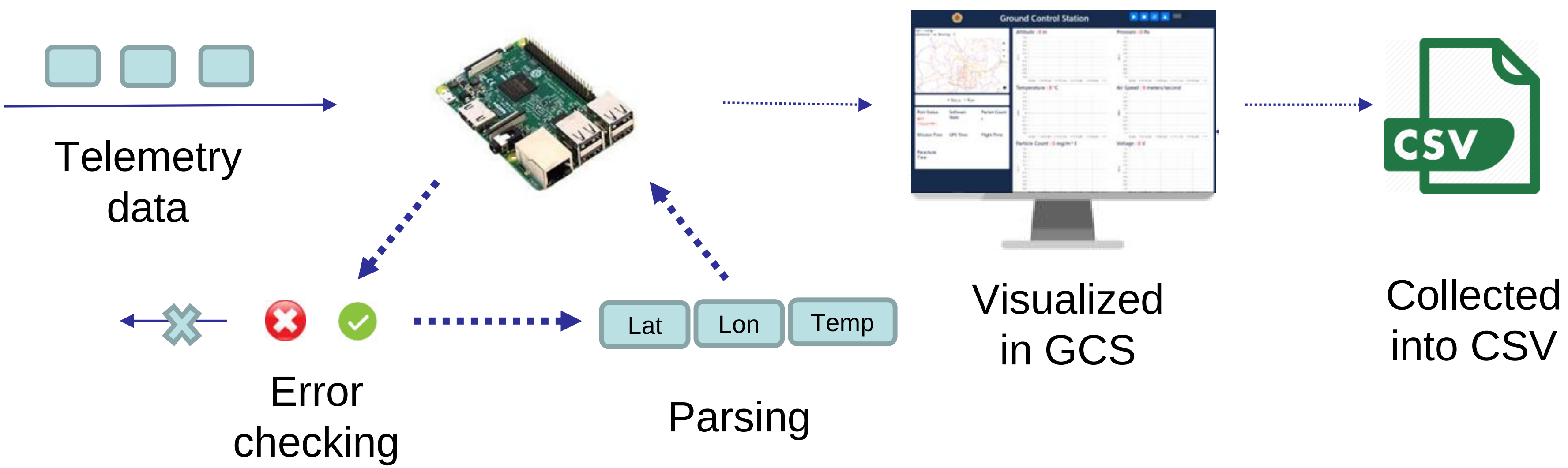


Specification	
Battery	PC can operate for approximately 2.5 hours with current battery. As mitigation we will use fresh genuine battery at competition.
Overheating mitigation	Cooling fan for PC and umbrella.
Computer auto update mitigation	- Disable the Auto Update feature. - Prevent Raspberry PI 3B from accessing WiFi.

GCS Software (1 of 7)

- **COTS Software Packages and Tools**
  - Node.js v10.14.1
  - serialport npm package: real-time RF transceiver access through USB serial port
  - Chart.js and Moment.js : real-time telemetry data plotting
  - Leaflet.js and Tileserver GL – map display
- **Software Commands and Interface**
  - Calibration command, telemetry data transmission command → Button click which will trigger backend service to write a character to XBEE via serial port. Then, XBEE will transmit command signal to payload.
  - CSV retrieval → Button click which will retrieve CSV from File Manager within Raspberry PI 3B into user's PC.
- **Telemetry Data Recording**
  - Received data at Raspberry PI 3B will be pre processed (checked for errors and parsed), then sent to GCS to be plotted into respective charts.
  - Received data at Raspberry PI 3B will asynchronously written into CSV file.
- **CSV File Creation**
  - CSV file is automatically created when data being received at Raspberry PI 3B. It is stored into a File Manager within Raspberry PI 3B.

- **Realtime Plotting Design**



GCS Software (3 of 7)

- **Changes Since PDR**
  - In PDR, we designed GCS to have data table page to display recorded data before converted into CSV. This was inefficient and prone to human error as data table will be cleared upon browser page refresh. Therefore we redesigned backend service to automatically logs telemetry data into Raspberry PI 3B's File Manager as CSV file.
  - We added serial connection indicator so operator will be aware if XBEE is disconnected from Raspberry PI 3B.
  - We added flight time and parachute time counters to give more historical information for post flight analysis.

- **Progress Since PDR**
  - We've already conducted tests to assess telemetry data transmission, software command transmission and antenna effective horizontal distance.
  - Tests result :
    - GCS is able to receive and visualize all telemetry data.
    - GCS is able to send all commands to FSW (start transmission, auto-calibration and stop transmission).
    - GCS Antenna effective horizontal distance is approximately 800 meters.

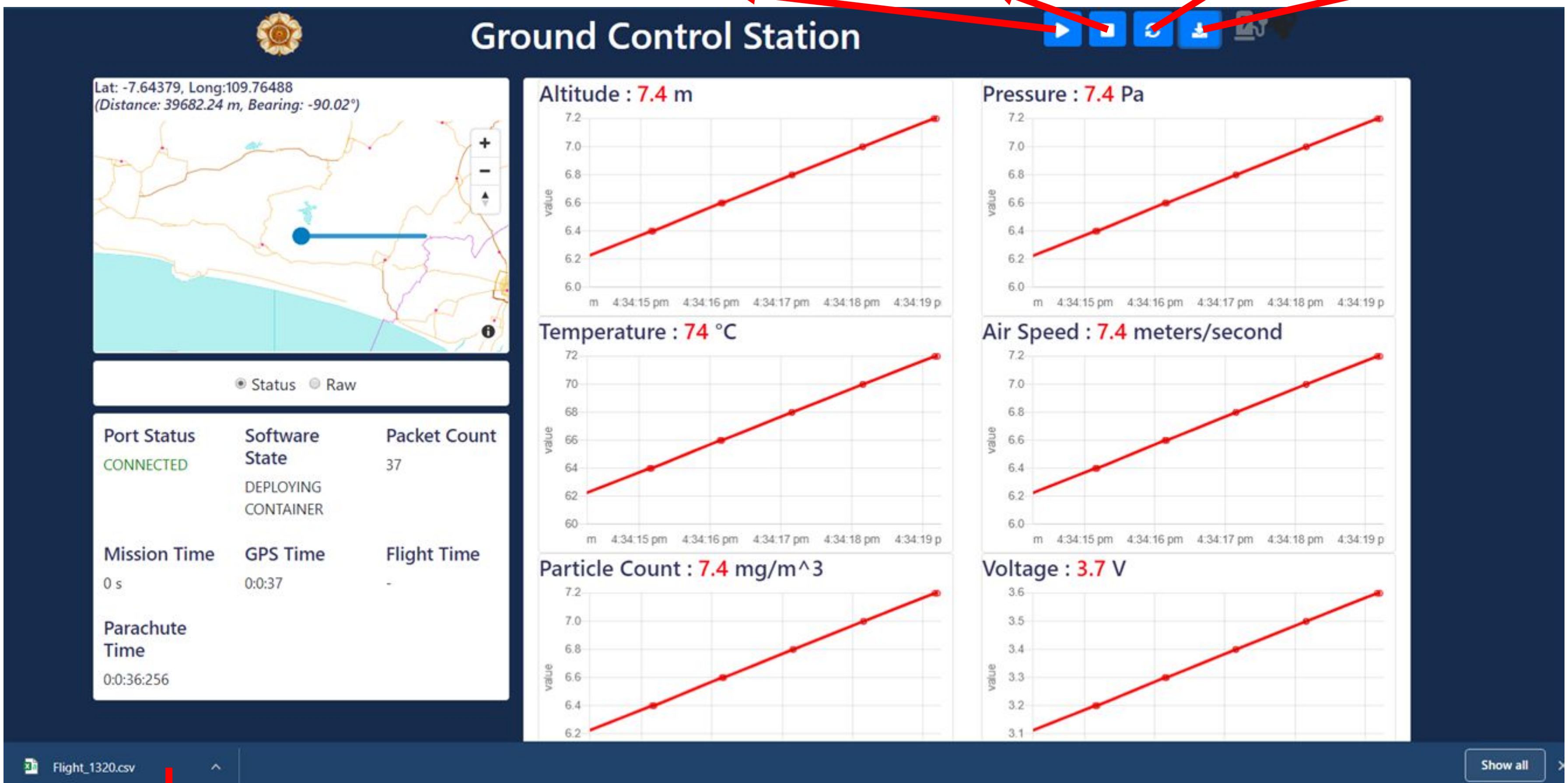
Screenshot (Dummy Data)

Start transmission

Stop transmission

Calibration

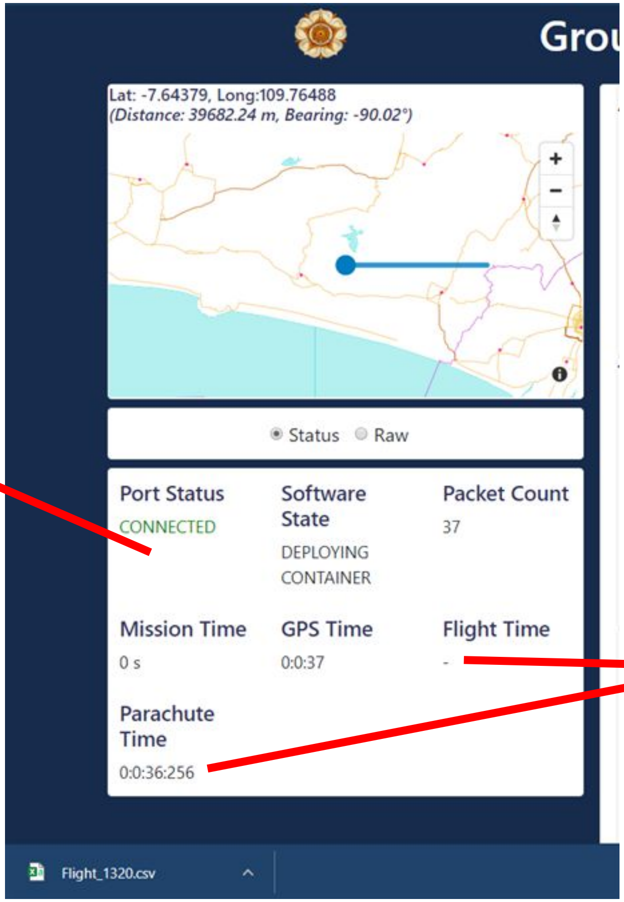
Download CSV



Downloaded CSV

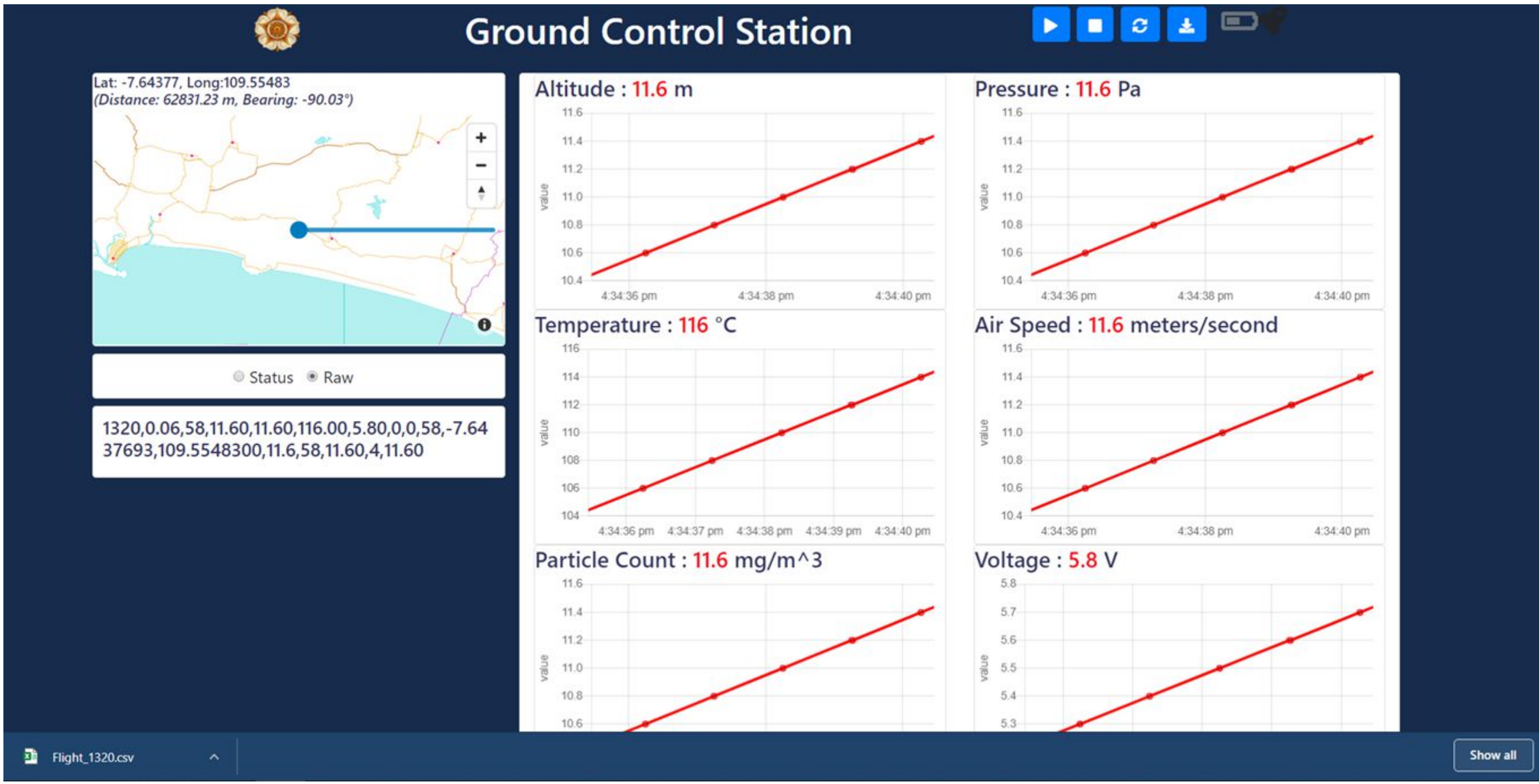
Applied Changes (Serial Connection Status & Time Counters)

Serial Connection Status



Time counters

Screenshot of Raw Data Display



GCS Software (7 of 7)

Example of generated CSV file

	A
1	TIME,PACKET NUMBER,ALTITUDE,PRESSURE,TEMPERATURE,VOLTAGE,GPS TIME,GPS LAT,GPS LONG,GPS ALTITUDE,GPS SATS,AIR SPEED,STATE,PARTICLE COUNT
2	
3	29,25,0.24,99479.45,29.15,3.8,14:46:48,0,0,0,0,113.58,1,23.33
4	30,26,0.7,99476.85,29.16,3.8,14:46:49,0,0,0,0,113.62,1,23.3
5	31,27,0.68,99478.12,29.17,3.82,14:46:50,0,0,0,0,113.59,1,23.25
6	32,28,0.62,99477.98,29.18,3.8,14:46:51,0,0,0,0,113.6,1,23.17
7	33,29,0.68,99477.66,29.18,3.82,14:46:52,0,0,0,0,113.57,1,23.14
8	34,30,0.72,99478.17,29.18,3.79,14:46:53,0,0,0,0,113.65,1,23.13
9	35,31,0.77,99479.41,29.18,3.81,14:46:54,0,0,0,0,113.57,1,23.12
10	36,32,0.6,99480.11,29.19,3.8,14:46:55,0,0,0,0,113.59,1,23.15
11	37,33,0.55,99480.56,29.19,3.82,14:46:56,0,0,0,0,113.59,1,23.19
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13	39,35,0.73,99481.01,29.19,3.81,14:46:58,0,0,0,0,113.62,1,23.26
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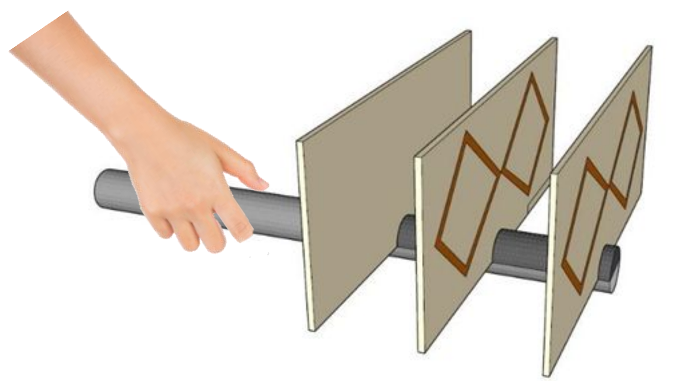
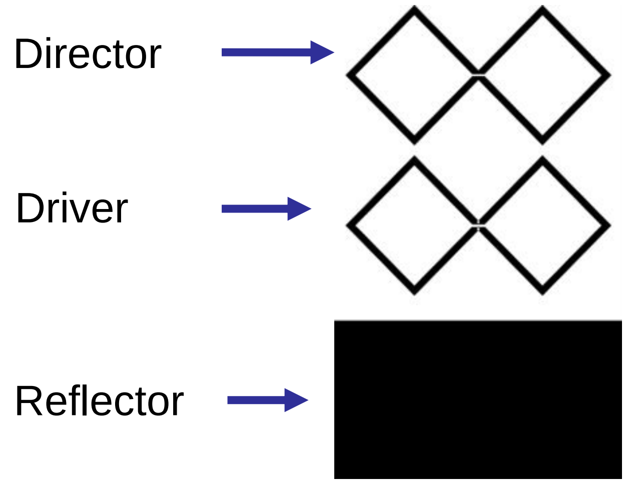
20	47,42,0.64,99480.98,29.23,3.8,14:47:6,0,0,0,0,113.64,1,23.62
21	48,43,0.57,99481.63,29.23,3.86,14:47:7,0,0,0,0,113.53,1,23.62
22	49,44,0.72,99479.52,29.24,3.8,14:47:8,0,0,0,0,113.54,1,23.65
23	50,45,0.9,99477.57,29.23,3.8,14:47:9,0,0,0,0,113.54,1,23.67
24	51,46,0.51,99480.58,29.3,3.82,14:47:10,0,0,0,0,113.51,1,48.64
25	52,47,1.09,99481.11,29.34,3.79,14:47:11,0,0,0,0,113.43,1,48.69
26	53,48,1.25,99478.52,29.4,3.8,14:47:12,0,0,0,0,113.47,1,43.56
27	54,49,1.42,99478.7,29.44,3.8,14:47:13,0,0,0,0,113.38,1,37.9
28	55,50,1.45,99479.39,29.48,3.81,14:47:14,0,0,0,0,113.44,1,32.28
29	56,51,1.43,99478.21,29.52,3.8,14:47:15,0,0,0,0,113.46,1,28.08
30	57,53,1.58,99476.75,29.56,3.81,14:47:16,0,0,0,0,113.45,1,27.22

Flight_1320

GCS Antenna Trade & Selection (1 of 5)





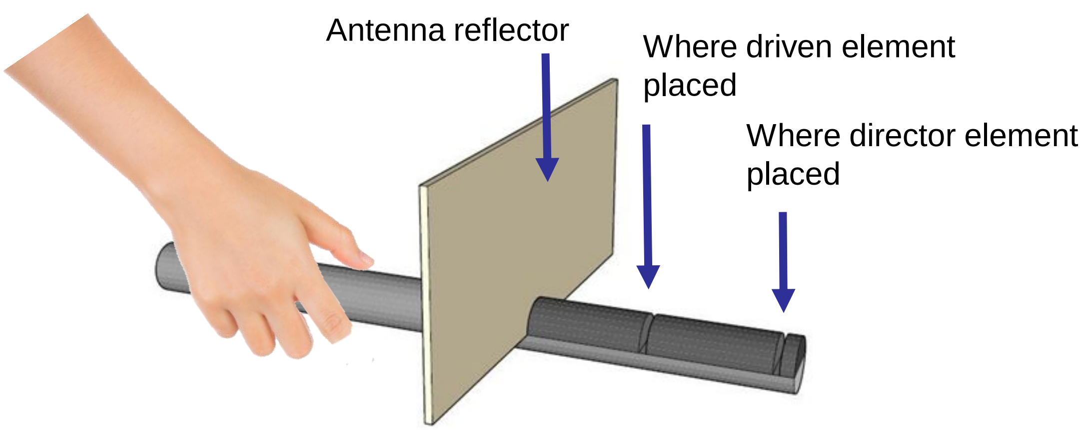
(PCB Design)

Selected Antenna:	DIY Microstrip Biquad Patch Antenna

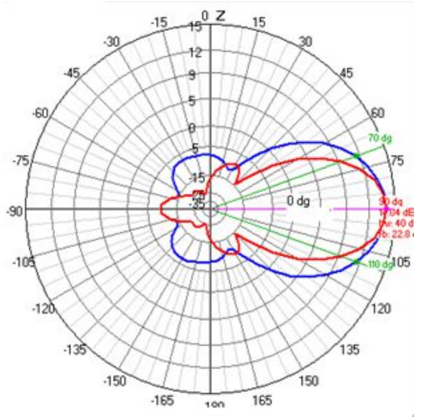
Gain (dBi)	Beamwidth		Connector	Polarization
	Vertical	Horizontal		
11.71	47.7	47,3	RP-SMA	Vertical, Horizontal

Rationale
Large horizontal and vertical beam width to compensate pointing error
Less directors needed in comparison to Yagi Antennas (saves space for packaging)
Easily handheld by team member
Team member experience
Tested

Antenna Mounting Design Selection :

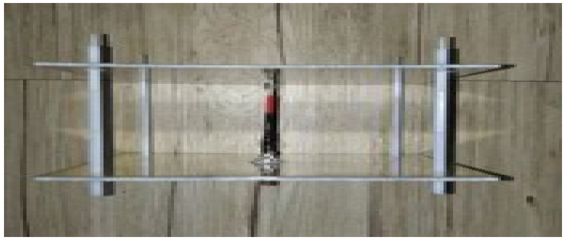


Far field (elevation & azimuth plot) :



GCS Antenna Trade & Selection (3 of 5)




Antenna Design
(holder in progress)

Coaxial Cable &
SMA Connector

Total Mass (g)	Holder Material	Price ($)
254	PVC Pipe	0.71

GCS Antenna Trade & Selection (4 of 5)

Voltage Standing Wave Ratio :

$$\mathrm{SWR} = \left(\left. 1 + \sqrt{\frac{P_r}{P_f}} \right/ 1 - \sqrt{\frac{P_r}{P_f}} \right)$$

Where
P_r=reflected power, P_f=Forward Power

Perfomance :
Tested in medium traffic density, up to 1 km.
Has stable Voltage Standing Ratio approximately 1.9:1 (tested with Rig Expert). This value indicates that 91.216 % power is transmitted and 8.784 % power is reflected.
Has horizontal and vetical beamwidth 47.7° and 47.3° (tested)

GCS Antenna Trade & Selection (5 of 5)

Narantaka

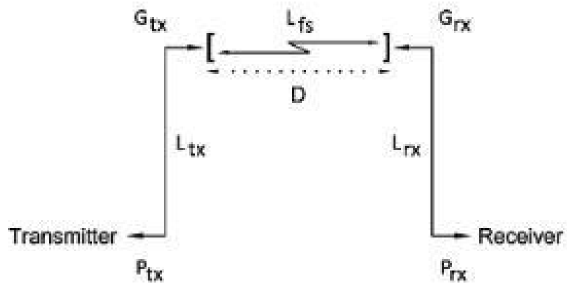
Radio Link Budget Formula:

$$P_{RX} = P_{TX} + G_{TX} + G_{RX} - L_{TX} - L_{FS} - L_{P} - L_{RX}$$

Where,

P_{RX} = Received Power (dBm)
P_{TX} = Transmitter Power Output (dBm)
G_{TX} = Transmitter Antenna Gain (dBi)
G_{RX} = Received Atenna Gain (dBi)

L_{TX} = Losses Associated with Transmitter (cable, connector, etc.) (dB)
L_{FS} = Free-Space Losses (dB)
L_{P} = Miscellaneous Signal Propagation Losses (dB)
L_{RX} = Losses Associated with Receiver (cable, connector, etc.) (dB)



Free Space Path Loss Formula:

$$\text{FSPL} = 20\log(D) + 20\log(f) + 32.44$$

Where, D = Distance
f = frequency

- Transmitter Output Power : 50 mW (12 dBm)
- Transmitter Antenna Gain : 11.71 dBi
- Receiver Antenna Gain : 2 dBi
- Xbee Receiver Sensitivity : -101 dBm
- Miscellaneous Power Loss : 5 dBi (estimated)
- Predicted link distance : 5 km

Margins:

- Calculated FSPL : 105.5 dB
- Calculated Pout : -83.81 dBm

-83.81 dBm > -101 dB
so approximate margins is **17.19 dBm**
which is **very sufficient for this requirement**

CanSat Integration and Test

Kenrick Tjandra

CanSat Integration and Test Overview (1 of 3)

Preparation → Test each component of each subsystem → Test all component of each subsystem → Integrate all subsystem and match requirementsm → Test CanSat on appropriate environment level

Subsystem Level
- Sensors
- CDH
- EPS
- FSW
- Mechanical
- Descent control

Integrated Level
- Mechanisms
- Communication
- Deployment
- Descent testing

Environmental
- Drop test
- Thermal test
- Vibration test
- Fit check

CanSat Integration and Test Overview (2 of 3)

Subsystem Level Testing Plans
Sensors were installed and tested on the breadboard, filter algorithm was then applied to the received data
The communication and data transmission were tested on PCB to determine if any error occurred
Multimeter was used to measure voltage and LED indicator will turn on if voltage was sufficient.
Two-way communications (command transmission and data retrieval) were tested
Wing folding mechanism and release mechanism of the delta wing glider were analyzed
Parachutes were dropped from higher floors to test folding effectiveness and parachutes survivability were tested by attaching similar weigh stone to the parachute

Integrated Level Functional Testing Plans
Stowed parachute was attached to CanSat and released from 100m via drone. CanSat descend behavior and parachute’s rope were analyzed
Servo release mechanism was tested to determine delay time in CanSat separation
Payload glide characteristics was analyzed by releasing it from 100m height via drone and conducted in similar environment to launch location
Camera movement and pointing direction were tested in different coordinates

CanSat Integration and Test Overview (3 of 3)

Integrated Level Functional Testing Plans (Continued)
Stowed parachute was attached to payload and released from 100m via drone. Parachute deployment via servo, payload descend behavior, and parachute's rope were analyzed
Communications were tested between the receiver and transmitter by using XCTU Program and telemetry data format was checked
Antenna range and data transmission were tested to minimize data loss
Camera movement and pointing direction will be tested in different coordinates

Environmental Testing Plans
61 cm fishing cord will connect CanSat and 2m height fixed bar. Drop test will then be conducted and CanSat power, components, and mountings will be observed
Thermal test will be carried out by placing CanSat inside DIY insulated thermal box. Heat will be generated from hair dryer and maintained between 55-60 for 2 hours
Wing folding mechanism and release mechanism of the delta wing glider were analyzed
Vibration test will be performed by using orbit sander. CanSat power, components, accelerometer data, and mountings will be observed
Fit check will be done by placing CanSat on a container with diameter of 125mm and 310mm height.

Subsystem Level Testing Plan (1 of 3)

Sensors	• Test all sensors on the breadboard by ensuring data come into processor • Calibrate each sensor until accuracy rate is high • Repeat testing
CDH	• Test CDH on dummy PCB and breadboard • Ensure each sensor communicates with processor and the raw data is processed by processor correctly • Ensure accuracy and speed of the data sent to ground station is correct
EPS	• Using multimeter to ensure each voltage configuration match the needed conversion • Ensure each LED indicator turned on in each voltage level • Using multimeter to ensure no short circuit occur between PCB traces • Ensure installed processor, sensors, and radio module work properly
Radio Communications	• Antenna is tested by rotating it half cycle in front of payload with 1km minimum distance • If signal loss occurs, SWR and cable reactance will then tuned until it passed the test

Subsystem Level Testing Plan (2 of 3)

FSW

- Time keeping algorithm (with EEPROM) needs to be tested in case of processor resets
- Testing with dummy payload and ensure program satisfies the requirement
- Ensuring two-way transmission between GCS & Payload is successful within distance
- Simulating the minimum 2 hours performance of GCS by conducting trial at open space
- Ensure the CanSat state logic is correct and do all the task correctly
- Testing the camera, ensure the video is saved on SD Card

Descent Control

- Ensure the payload stability in different stages
- Ensure the payload can glide and orbit a point of 250m radius
- Drop test the payload in different altitude

Mechanical

- Ensure wings deployment mechanism worked properly, including force generated by rubber
- Ensure the payload can exit container easily during separation
- Ensure CanSat survivability during rocket launch
- Ensure the servos could handle torque applied

Wing Deployment Mechanism: Rubber Mechanism Check

Integrated Level Functional Test Plan (1 of 2)

Descent testing
Payload will be released at 100m height to observe glide characteristics (flyability and circular flight path pattern) and descend speed.
Parachutes (payload and CanSat) will also be released at 100 m height carrying full CanSat load for CanSat parachutes and full payload load for payload parachutes. Parachutes descend speed will be recorded.

Using drone, the payload will be taken to 100m height to simulate its glide capability

Mechanisms
This test is designed to verify that the servo can release the rubber with allocated power to activate the container opening mechanism unlock payload's parachute, and camera pointed at correct angle
Functional test of wing deployment and payload survivability inside container during launch will also be observed

Integrated Level Functional Test Plan (2 of 2)

Communications
This test is aimed to measure the quality of 2-way communications between GCS and installed FSW program
Communication from GCS to FSW includes command transmission. The test will include verification of transmitted commands by looking at it's response, measurement of transmission delay in various environments (crowded and open space) and measurement of effective horizontal and vertical distance.
Communication from FSW to GCS includes telemetry data transmission. The test will include verification of data value between transmitted value and value displayed in GCS, measurement of transmission delay in various environments (crowded and open space) and measurement of effective horizontal and vertical distance.

Deployment
CanSat's whole system will be dropped from 100m height by using drone
CanSat's parachute will be deployed at 100m and descend to 60m altitude
Payload will then separate from container, deploy it's wings and glide in circular pattern
At 30m altitude, payload's parachute deploy and descend until it reaches the ground
Payload and parachutes ability to deploy seamlessly will then be observed and analyzed

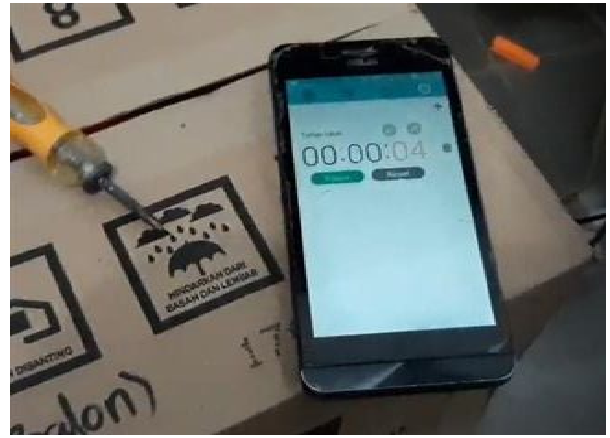
Environmental Test Plan (1 of 4)

DROP TEST	
I	Power on CanSat
Ii	Verify telemetry is being received
Iii	Raise CanSat by the attached cord, so that the attachment points of the cord, on the eye bolt and the parachute, are at the same height
iv	Release the CanSat
v	Verify the CanSat did not lose power
vi	Inspect for any damage, or detached parts
vii	Verify telemetry is being received

*adapted from 2020 CanSat Mission Guide

We plan to drop the CanSat from 60cm height with a cord attached to parachute attachment point (tools created in 2019)

Environmental Test Plan (2 of 4)



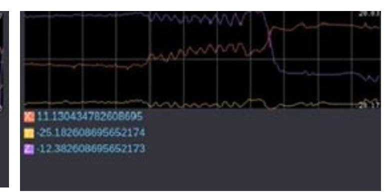
THERMAL TEST	
i	Place CanSat inside DIY thermal box
ii	Power on CanSat
iii	Close and seal the thermal box
Iv	Power on hair dryer (blow direction opposite the CanSat)
v	Monitor the temperature and turn off hair dryer when the internal temperature reaches 60ºC and turn on the heat source when the temperature drops to 55ºC
vi	Maintain the test conditions for 2 hours
vii	Turn off hair dryer
viii	Conduct visual inspection and any functional tests to verify the CanSat survived the thermal exposure and can operate as expected
ix	While CanSat temperature still hot, test any mechanisms and structures to make sure the integrity has not been compromised
x	Verify if epoxy joints still maintain their strengths

VIBRATION TEST	
i	Power on CanSat
ii	Verify accelerometer data is being collected
iii	Power up the sander
iv	Once the sander is up to full speed, wait 5 seconds
v	Power down the sander to a full stop
vi	Repeat steps iii to v four more times
vii	Inspect the CanSat for damage and functionality
viii	Verify accelerometer data is being collected
ix	Power off CanSat

*adapted from 2020 CanSat Mission Guide

Accelerometer

Gyrometer

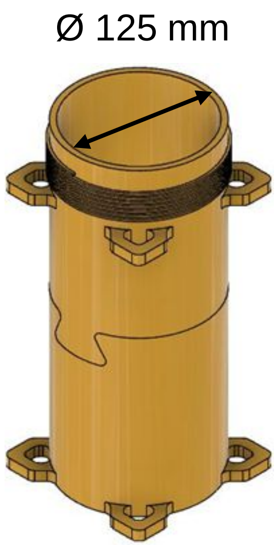


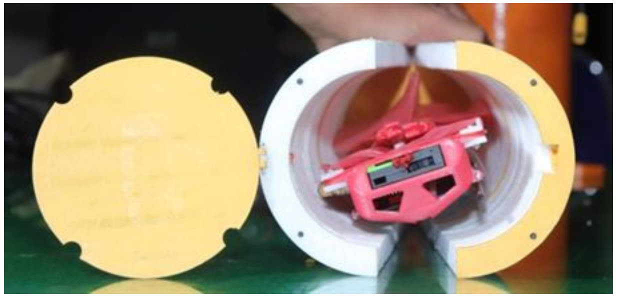
This is the sensor measurement from vibration test

Environmental Test Plan (4 of 4)

Dimensions Verification

This test is to verify if the CanSat can fit inside rocket's compartment. This will ensure volume clearance and no protrusions applied and minimalize the possibility of deployment failure





We have manufactured a container which has 125mm diameter to simulate launch vehicle fit test.

Test Procedures Descriptions

Subject/ Object	Test Descriptions	Requirements	Pass/ Fail Criteria	Status
Air Pressure Sensor	Each sensors are installed on the bread-board to check the accuracy and stability of sensor readings (+ ability to record video on 640*480 resolution for camera)	22	Altitude data based on sensor reading stable and equal to actual established altitude	**Passed**
Air Temperature Sensor		25	Temperature data equal to actual temperature	**Passed**
GPS		23	GPS data show correct location and time data	**Passed**
Voltage Divider		24		**Passed**
Air Speed Sensor		27	Sensor data equal to actual temperature	**Passed**
Particulate Sensor		26	Sensor able to count particle in (ug/m^3 of particle <=10ug) relative to the payload	**Passed**
Camera		Bonus Mission	Video output must be 640*480 pixels	**Passed**

Test Procedures Descriptions (2 of 5)

Subject/ Object	Test Descriptions	Requirements	Pass/ Fail Criteria	Status
Communication Test (CDH)	Processor and XBEE baud rate is fixed at 115200. All data is sent in a formatted packet data	28, 29	Formatted packet data sent successfully every 1 seconds	**Passed**
RTC Test (CDH)	System reset condition is tested continuously to check the validity of RTC	40	Time data continuous-ly recorded and valid while system in reset condition	**Passed**
Release Mechanism Algorithm Test (FSW)	CanSat is dropped from certain altitude (e.g. 20m)	10, 11, 13, 22	Servos on payload and container is activated at determined altitude	**Passed**
(FSW) State Determination Algorithm Test			State variable on payload matches the state based on altitude	**Passed**
Wireless Communication Test	Validity of data transmission is checked & payload is kept away from antenna in certain distance	40, 41	Packet count variable shows valid data without any interruption	**Passed**

Test Procedures Descriptions (3 of 5)

Subject/ Object	Test Descriptions	Require ments	Pass/ Fail Criteria	Status
Servo Motor Test	Rotation of servo motor is calibrated with algorithm	10, 13, Bonus Mission	Formatted packet data sent successfully every 1 seconds	**Passed**
Voltage Test	Battery is connected to PCB and voltage sensor is connected in parallel with LED Indicator	57	Battery voltage reads 3.7V and all LED indicators are turned on	**Passed**
GCS PC Battery Test	PC is used in outdoor area for 2 hours and 30 minutes	44	PC is still working after 2 hours of usage	**Passed**
GCS data Inspection (measurements, instr-uments, or sensors)	Verify that data has been correctly displayed in engineering units	41	Displayed value should be rational and match sensors	**Passed**
Interval data changing in GCS display	Verify real time data display with interval update of one second	33, 40	GCS displays data in real time every one second	**Passed (certain distance)**
Whole data inspection in GCS display	Verify that data is complete and not broken	22, 23, 24, 25, 26, 27, 28	GCS plots all telemetry data	**Passed**

Test Procedures Descriptions (4 of 5)

Subject/ Object	Test Descriptions	Requirements	Pass/ Fail Criteria	Status
CanSat Separation Test	Payload is placed inside container and servo is programmed to unlock the container	10	Payload seamlessly exits the container	**Passed**
Wing Deployment Test	Payload with stowed wings is placed inside container, then container opens	11, 12	Wings automatically deploy after leaving the container	**Passed**
CanSat's Parachute Deployment Test	Stowed parachute is exposed to fan that blows the CanSat directly	8, 9, 30	Parachute successfully deployed	**Passed**
Payload's Parachute Deployment Test	Servo is programmed to unlock stowed parachute	13, 30	Parachute successfully deployed	**Passed**
Antenna Range Test	Dummy data is used to measure antenna range while receiver and antenna transmitter connecting	35, 39, 40	Packet data is still received every 1s from 800m distance	**Passed**

Test Procedures Descriptions (5 of 5)

Subject/ Object	Test Descriptions	Requirements	Pass/ Fail Criteria	Status
Drop Test	CanSat will be connected to 61cm cord and released from 2 meters	8, 14, 56	No damage found on CanSat	**Passed**
Thermal Test	CanSat placed inside insulated thermal box with temperature maintained at 55ºC to 60ºC	56	CanSat performs well and maintains its structure	**Passed**
Vibration Test	Orbital sander vibrate CanSat at 14000 opm	16, 17, 18, 19, 56	CanSat survives in one piece, no damage found	**Passed**
Mass Test	Whole CanSat system mass is measured	1	Total mass must be 600 g +/- 10g	**Not tested yet**
Visual Inspection	Visually inspect CanSat to ensure manufactured CanSat comply requirements	4, 5, 12, 15, 20, 21, 30	CanSat complies all the requirements (color, enclosure, etc) visually	**Not tested yet**
Fit Test	CanSat placed inside envelope of 125mm diameter x 310mm length	2, 3, 6, 7	CanSat dimension fits inside envelope easily	**Not tested yet**

Mission Operations & Analysis

Kenrick Tjandra

Overview of Mission Sequence of Events (1 of 5)

Flowchart of Events

1 Arrival	2 Pre-Launch	3 CanSat Assembly/ Launch Preparation
Team arrival at the launch site	GCS on site deployment	Assembly of CanSat major components
CanSat condition inspection	Electronics replacement and re – adjustments (if necessary)	Mechanism inspection
CanSat weight and dimension check	CanSat damage reparation	Ensure payload has stowed firmly
GCS and antenna preparation	Field score sheet review and checklist	Ensure CanSat structural integrity
	Communication inspection	Final inspection before launch

Overview of Mission Sequence of Events (2 of 5)

4 Mission	5 Recovery	6 Analysis
Launch initiation	Recovery initiation	Data analysis and acquisition
CanSat launch and descent monitoring	Search for CanSat with the buzzer and GPS aid	Delivery of telemetry data file to line judges for scoring
GCS display to the judges		Launch day team evaluation
Recovery crew preparation		Mission assessment
Landing zone observation		PFR development preparation
Securing data received from the payload		

Overview of Mission Sequence of Events (3 of 5)

Team Member roles and responsibilities

Roles	Responsibilities	Member Name
Mission Control Officer	Inform flight coordinator when team and CanSat ready for launch	Kenrick Tjandra
CanSat Crew	Prepare CanSat, Integrate CanSat into the rocket, and verify CanSat's status	Indra Budi Setyawan
		Muhammad Dyffa
		Mario Jaya
Ground Station Crew	Monitor GCS for telemetry reception and issue command to the CanSat	Wildan Purnomo
		Mahatma Wisesa
Container Recovery Crew	Track CanSat, recover CanSat, and interact with field judges (make sure all field scores filled in)	Muhammad Nur Ilmi
		Nico Renaldo
Payload Recovery Crew		Luqman Al Helmy
		Nafisah Hasya Sekarini

Overview of Mission Sequence of Events (4 of 5)

Antenna Construction & Ground System Setup

1. Connecting Antenna to XBEE
2. Turn on Raspberry PI 3B to start GCS Server
3. Connect XBEE to Raspberry PI 3B
4. Turn PC on and connect to Raspberry PI's network
5. Accessing GCS Client page and perform small test
6. Antenna held by team member, Raspberry PI is not connected to Internet

CanSat Assembly

1. Assemble electrical components
2. Mount each components
3. Fold Parachutes
4. Stow deployable CanSat components
5. Power on CanSat

Overview of Mission Sequence of Events (5 of 5)

CanSat Tests

1. CanSat Drop Test
2. Structure Check (integrity, color, sharp protusion, label, enclosure)
3. Separation Mechanism Check
4. CanSat Mass Check
5. CanSat Fit Check

Telemetry Data File Delivery

1. GCS Server receives telemetry data from XBEE
2. GCS server records received data into CSV File
3. CSV File stored in file manager within Raspberry PI 3B
4. Retrieve CSV from file manager into PC by button click
5. GCS Operator delivers CSV File using USB Drive

CanSat MoM Development & Content

Ground Station Configuration
- Antenna Preparation
- Communication Check

CanSat Preparation
- CanSat assembly
- Battery voltage check
- CanSat structural integrity check

CanSat integration to the rocket
- CanSat fit check
- CanSat weight check

Launch Preparation Procedure
- Final communication check
- Sensor calibration if necessary

Launch Procedure
- Launch and descend monitoring
- Real time GCS data display

Removal Procedure
- Recover CanSat after recovery permission granted by LCO
- GCS data submitted via thumb drive
- Video file retrieved from SD Card

Development Status

- Two (2) copies of Mission operations manual will be assembled into a **three ring binder**, consists of 6 operations procedures, printed with **each section start on its own page**
- Final version of Mission operations manual will be ready **by the end of May**, after launch rehearsal to inspect its efficiency and to make sure no step is missed. Mission operations manual will be presented to judges during Flight Readiness Review
- Mission operations manual **draft has been created** and improved as further research and tests are conducted

CanSat Location and Recovery

Container Recovery
Outer Structure will be orange colored to aid recovery search
Address and contact person of the team representative will be inserted on the outer structure of the container

Payload Recovery
Payload overall structure will be orange colored to aid recovery search
Buzzer high pitch sound signal will aid recovery search
Last logged GPS position will aid recovery search
Address and contact person of the team representative will be inserted on the payload

Label attached on container and probe:

Property of Team:
#1320, Narantaka, Indonesia

Kindly please contact us if founded:
aerospace@ugm.ac.id

Mission Rehearsal Activities (1 of 2)

Rehearsed on March, 27th

Ground System Radio Link Check

- Allowing GCS to receive data from XBEE to make sure data transmission is working as desired
- Testing command transmission by pressing GCS button to make sure command transmission is working as desired

Rehearsed on March, 27th

Powering On/ Off CanSat

- CanSat is powered on by using an external switch
- Ensure serial sent to ground station is correct

Rehearsed on late April, 19th

Launch Configuration Preparations

- All CanSat components are placed and integrated into operating configuration
- Wing deployment and separation mechanism are checked
- Initiate data transmission by sending command from GCS

Mission Rehearsal Activities (2 of 2)

Rehearsed on April, 19th

CanSat Loading in Launch Vehicle

- CanSat is placed inside DIY rocket envelope with the exact dimension as used in the competition
- CanSat is placed upside down with bottom lid facing upwards to simulate launch condition

Rehearsed on April, 26th

Telemetry processing, archiving, and analysis

- Inspecting GCS display while it is active to verify if the processing at backend service (Raspberry PI) is correct
- Inspecting the file manager within Raspberry PI and check if the CSV file is there to make sure that backend service is actually outputting CSV
- Crosschecking CSV file with history logs of backend service to make sure content of CSV file is correct

Will be rehearsed on late May

Recovery

- Recovery crew will wait until CanSat fully landed and clear for recovery
- GPS is used to track and recover payload, with buzzer to assist the recovery process
- Buzzer is used to track and recover container if possible

Requirements Compliance

Kenrick Tjandra

Requirements Compliance Overview

- Our CanSat is designed to met the requirements of CanSat 2020 mission.
- The design must be tested to make sure that it is able to comply to the requirement, there are 3 condition to met: comply, partial, and not comply

IMPROVEMENTS
CanSat mass and dimension are measured
Wing deployment and parachutes deployment are tested. Servos, rubbers, and other supporting components' capability and lifetime have been satisfying
Descend speed in each state have met the requirement
Communications between GCS & installed FSW program has been successfully tested

THINGS TO DO
Payload glide characteristics need to be improved, further flight test will be conducted
More tests to make sure every components work properly during launch

Requirements Compliance (1 of 6)

RN	Requirement	Compliance	Ref. Slides	Comments
1	Total mass of the CanSat (science payload and container) shall be 600 grams +/- 10 grams.		97-99	OK
2	CanSat shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length. Tolerances are to be included to facilitate container deployment from the rocket fairing.		26	OK
3	The container shall not have any sharp edges to cause it to get stuck in the rocket payload section which is made of cardboard.		88	OK
4	The container shall be a fluorescent color; pink, red or orange.		88	OK
5	The container shall be solid and fully enclose the science payload. Small holes to allow access to turn on the science payload is allowed. The end of the container where the payload deploys may be open.		88	OK
6	The rocket airframe shall not be used to restrain any deployable parts of the CanSat		91-92	OK
7	The rocket airframe shall not be used as part of the CanSat operations.		91-92	OK
8	The container parachute shall not be enclosed in the container structure. It shall be external and attached to the container so that it opens immediately when deployed from the rocket.		93	OK
9	The descent rate of the CanSat (container and science payload) shall be 20 meters/second +/- 5m/s.		70	OK
10	The container shall release the payload at 450 meters +/- 10 meters.		60, 70, 142	OK
11	The science payload shall glide in a circular pattern for one minute and stay above 100 meters after release from the container.		67-68	Require further improvement

Requirements Compliance (2 of 6)

RN	Requirement	Compliance	Ref. Slides	Comments
12	The science payload shall be a delta wing glider.		79, 81	OK
13	After one minute of gliding, the science payload shall release a parachute to drop the science payload to the ground at 10 meters/second, +/- 5 m/s.		69, 70, 140	OK
14	All descent control device attachment components shall survive 30 Gs of shock.		95-96	OK
15	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.		79, 83, 87, 88	OK
16	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.		95-96	OK
17	All structures shall be built to survive 15 Gs of launch acceleration.		95-96	OK
18	All structures shall be built to survive 30 Gs of shock.		95-96	OK
19	All mechanisms shall be capable of maintaining their configuration or states under all forces.		95-96	OK
20	Mechanisms shall not use pyrotechnics or chemicals.		73, 91-96	OK
21	Mechanisms that use heat (e.g., nichrome wire) shall not be exposed to the outside environment to reduce potential risk of setting vegetation on fire.		73, 91-96	OK
22	The science payload shall measure altitude using an air pressure sensor.		32, 123	OK
23	The science payload shall provide position using GPS.		35, 123	OK
24	The science payload shall measure its battery voltage.		122, 123	OK

Requirements Compliance (3 of 6)

RN	Requirement	Compliance	Ref. Slides	Comments
25	The science payload shall measure outside temperature.		34, 123	OK
26	The science payload shall measure particulates in the air as it glides.		39, 123	OK
27	The science payload shall measure air speed.		37, 123	OK
28	The science payload shall transmit all sensor data in the telemetry.		112, 113	OK
29	Telemetry shall be updated once per second.		113	OK
30	The Parachutes shall be fluorescent Pink or Orange		55,58	OK
31	The ground system shall command the science vehicle to start transmitting telemetry prior to launch.		156	OK
32	The ground station shall generate a csv file of all sensor data as specified in the telemetry section.		112, 113, 156	OK
33	Telemetry shall include mission time with one second or better resolution. Mission time shall be maintained in the event of a processor reset during the launch and mission.		113	OK
34	Configuration states such as if commanded to transmit telemetry shall be maintained in the event of a processor reset during launch and mission.		141	OK
35	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE Pro radios are also allowed.		108	OK

Requirements Compliance (4 of 6)

RN	Requirement	Compliance	Ref. Slides	Comments
36	XBEE radios shall have their NETID/PANID set to their team number.		110	OK
37	XBEE radios shall not use broadcast mode.		110	OK
38	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.		211	OK
39	Each team shall develop their own ground station.		155, 161	OK
40	All telemetry shall be displayed in real time during descent.		157, 159, 161	OK
41	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)		159, 161	OK
42	Teams shall plot each telemetry data field in real time during flight.		157, 159, 161	OK
43	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a hand-held antenna.		155, 163-165	OK
44	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.		155	OK
45	Both the container and probe shall be labeled with team contact information including email address.		194	OK
46	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.		141	OK
47	No lasers allowed.		28	OK

Requirements Compliance (5 of 6)

RN	Requirement	Compliance	Ref. Slides	Comments
48	The probe must include an easily accessible power switch that can be accessed without disassembling the cansat and in the stowed configuration.		87	OK
49	The probe must include a power indicator such as an LED or sound generating device that can be easily seen without disassembling the CanSat and in the stowed state.		83,89	OK
50	An audio beacon is required for the probe. It may be powered after landing or operate continuously.		116, 122, 123	OK
51	The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed.		117, 118	OK
52	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.		124, 130	OK
53	An easily accessible battery compartment must be included allowing batteries to be installed or removed in less than a minute and not require a total disassembly of the CanSat.		72-73	OK
54	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.		95-96	OK
55	The CANSAT must operate during the environmental tests laid out in Section 3.5.		177-179	OK
56	Payload/Container shall operate for a minimum of two hours when integrated into rocket.		127, 132	OK

Requirements Compliance (6 of 6)

RN	Requirement	Compliance	Ref. Slides	Comments
57	A video camera shall be integrated into the science payload and point toward the coordinates provided for the duration of the glide time. Video shall be in color with a minimum resolution of 640x480 pixels and 30 frames per second. The video shall be recorded and retrieved when the science payload is retrieved. Points will be awarded only if the camera can maintain pointing at the provided coordinates for 30 seconds uninterrupted.		22, 41	OK

Management

Nafisah Hasya S

Status of Procurements (1 of 3)

Mechanical Components				
Components	**Quantity**	**Ordered Date**	**Received Date**	**Status**
PLA Filament	1	23/10/2019	27/10/2019	Received
Polyfoam (100cm x 50cm x 1cm)	1	23/10/2019	27/10/2019	Received
HDPE Plastic	1	23/10/2019	27/10/2019	Received
Ropes	1	23/10/2019	27/10/2019	Received
Yarn	1	23/10/2019	27/10/2019	Received
Carbon Rod	2	23/10/2019	27/10/2019	Received
Rubber	1	12/01/2020	17/01/2020	Received
Bolt	12	12/01/2020	17/01/2020	Received
Epoxy Adhesives	1	23/10/2019	27/10/2019	Received

Note:
Rubber is bought later due to change of plan for our wing deployment mechanism. Prior to rubber, we use torsion spring.

Legend			
Estimated	XX	Actual	XX

Additional Information
1 USD = 16683 IDR

Status of Procurements (2 of 3)

Electrical Components				
Components	**Quantity**	**Ordered Date**	**Received Date**	**Status**
BMP388	2	23/10/2019	27/10/2019	Received
Pololu U1V10F5	1	28/02/2020	03/03/2020	Received
Pololu U3V70F5	1	28/02/2020	03/03/2020	Received
AP2112K-3.3TRG1	1	28/02/2020	03/03/2020	Received
LM1117 SMD	2	23/10/2019	27/10/2019	Received
ATMEGA328P-AU	1	23/10/2019	27/10/2019	Received
ATSAMD51J19	1	28/02/2020	03/03/2020	Received
Fenix ARB-L16	1	23/10/2019	27/10/2019	Received
Turnigy 18650	1	23/10/2019	27/10/2019	Received
Buzzer	2	23/10/2019	27/10/2019	Received
Micro Servo FS90R	3	23/10/2019	27/10/2019	Received
XBEE Pro S3b	1	23/10/2019	27/10/2019	Received
Adafruit Mini Spy Camera	1	28/02/2020	03/03/2020	Received

Legend			
Estimated	XX	Actual	XX

Additional Information
1 USD = 16683 IDR

Status of Procurements (3 of 3)

Electrical Components				
Components	**Quantity**	**Ordered Date**	**Received Date**	**Status**
MPXV7002DP	1	23/10/2019	27/10/2019	Received
Matek M8Q GPS + QMC5883l Compass	1	23/10/2019	27/10/2019	Received
Sensirion Air Quality Sensor	1	23/10/2019	30/01/2020	Received
MPU-6050	1	23/10/2019	27/10/2019	Received

Note:
- Camera is received later due to stock unavailability at store so we need to pre order it
- All the items needed for the competition have been received in good condition

Legend			
Estimated	XX	Actual	XX

Additional Information
1 USD = 16683 IDR

CanSat Budget – Hardware (1 of 3)

Mechanical Components				
Components	**Quantity**	**Unit**	**Unit Price**	**Total Cost ($)**
PLA Filament	1	Kilogram	10.79	10.79
Polyfoam (100cm x 50cm x 1cm)	1	Sheet	1.80	1.80
HDPE Plastic	1	Roll	3.90	3.90
Ropes	1	Roll	0.12	0.12
Yarn	1	Roll	0.12	0.12
Carbon Rod	2	Stick	1.20	2.40
Rubber	1	Pack	0.72	0.72
Bolt	12	Pairs	0.06	0.72
Epoxy Adhesives	1	Tube	1.80	1.80
			Total	**22.37**

Legend			
Estimated	XX	Actual	XX

Additional Information
1 USD = 16683 IDR

CanSat Budget – Hardware (2 of 3)

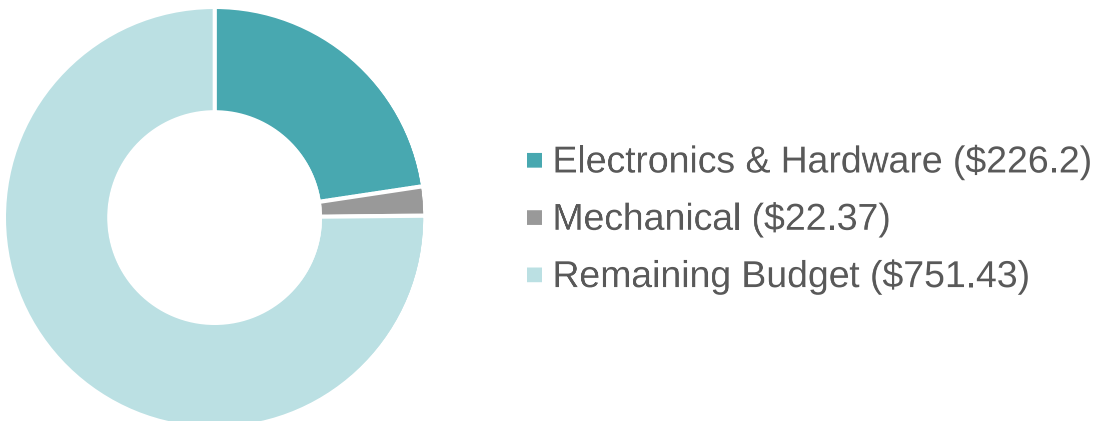
Electrical Components				
Components	**Quantity**	**Unit**	**Unit Price**	**Total Cost ($)**
BMP388	2	Pcs	3.20	6.40
Pololu U1V10F5	1	Pcs	4.49	4.49
Pololu U3V70F5	1	Pcs	12.95	12.95
AP2112K-3.3TRG1	1	Pcs	0.47	0.47
LM1117 SMD	2	Pcs	1.10	2.20
ATMEGA328P-AU	1	Pcs	2.01	2.01
ATSAMD51J19	1	Pcs	4.60	4.60
Fenix ARB-L16	1	Pcs	6.45	6.45
Turnigy 18650	1	Pcs	5.21	5.21
Buzzer	2	Pcs	3.33	6.66
Micro Servo FS90R	3	Pcs	4.95	14.85
XBEE Pro S3b	1	Pcs	50.00	50.00
Adafruit Mini Spy Camera	1	Pcs	12.5	12.5

Legend			
Estimated	XX	Actual	XX

Additional Information
1 USD = 16683 IDR

CanSat Budget – Hardware (3 of 3)

Electrical Components				
Components	**Quantity**	**Unit**	**Unit Price**	**Total Cost ($)**
MPXV7002DP	1	Pcs	12.2	12.2
Matek M8Q GPS + QMC5883l Compass	1	Pcs	30	30
Sensirion Air Quality Sensor	1	Pcs	46.9	46.9
MPU-6050	1	Pcs	8.31	8.31
			Total	226.2



Legend			
Estimated	XX	Actual	XX

Additional Information
1 USD = 16683 IDR

CanSat Budget – Other Costs (1 of 3)

Electrical Components				
Components	**Quantity**	**Unit**	**Unit Price**	**Total Cost ($)**
RP SMA Female Connector	3	Pcs	1.51	3.53
RG58 Coaxial Cable	1	Meter	1.81	1.81
PCB Board	6	Pcs	3.80	22.80
Raspberry PI 3B	1	Pcs	35.00	35.00
XBEE Pro S3b	1	Pcs	50.00	50.00
ASUS X550VX PC	1	Pcs	0.00 (Personal Property)	
			Total	112.34

Legend			
Estimated	XX	Actual	XX

Additional Information
1 USD = 16683 IDR

CanSat Budget – Other Costs (2 of 3)

Detail	Quantity	Unit Cost ($)	Unit(s)	Total Cost ($)
Airfare	10	850	Pax	8,500
Train Fare	10	70	Pax	700
Shipping	1	107	Packet	107
Accomodation & Food	10	325	Pax	3,250
Team Shirts	10	3.5	Pcs	35
Visa	10	160	Pax	1600
Competition Entry Fee	1	200	Pax	200
			Total	**14,392**
			Margins (10%)	**1,245**

Legend			
Estimated	XX	Actual	XX

Additional Information
1 USD = 16000 IDR

CanSat Budget – Other Costs (3 of 3)

INCOME

Source	Amount
Grants (Universitas Gadjah Mada)	8000
Sponsors (Companies & Government Institutions)*	9000
Total	**17000**

*Sponsorship amount is updated on 4/1, additional income source is still possible

EXPENDITURE

Source	Amount
Mechanical & Electrical	248.57
Ground Station	112.34
Non-Technical & Others	14,392.00
Total	**14,752.91**
Margins (10%)	1,245.00

EXPENDITURE	MARGIN

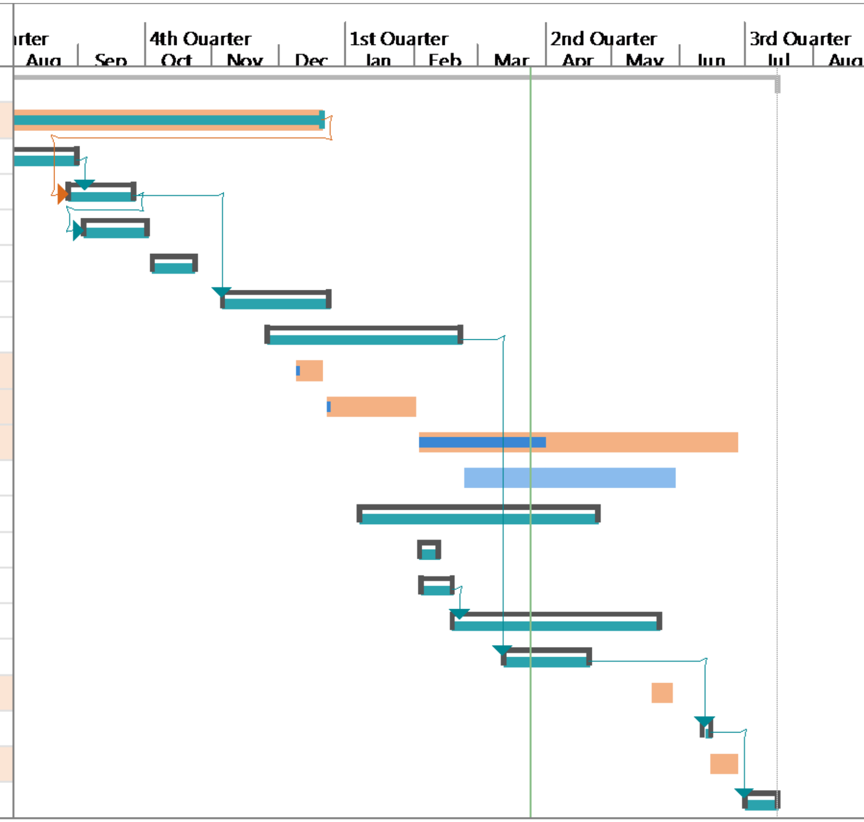
Income - Expenditure ($)	415.42

Legend			
Estimated	XX	Actual	XX

Additional Information
1 USD = 14300 IDR

Program Schedule Overview

ID	Task Name	Duration	Start	Finish
0	CanSat 2020	253 days	Thu 01-08-19	Wed 15-07-20
1	Fall Semester	102 days	Thu 01-08-19	Fri 20-12-19
2	Project Initiation	22 days	Thu 01-08-19	Fri 30-08-19
5	Project Analysis	22 days	Tue 27-08-19	Wed 25-09-19
11	Requirement Analysis	21 days	Tue 03-09-19	Tue 01-10-19
15	Procurement of Facilities, Equipment, & Materials	14 days	Fri 04-10-19	Wed 23-10-19
19	System Integration	35 days	Tue 05-11-19	Mon 23-12-19
24	PDR Development	64 days	Tue 26-11-19	Fri 21-02-20
32	Fall Semester Exam	10 days	Mon 09-12-19	Fri 20-12-19
33	Winter Break	30 days	Mon 23-12-19	Fri 31-01-20
34	Spring Semester	108 days	Mon 03-02-20	Fri 26-06-20
35	Travel Preparations	70 days	Mon 24-02-20	Fri 29-05-20
36	Resource Procurement: Finances	80 days	Tue 07-01-20	Fri 24-04-20
40	Procurement of Equipment & Materials	7 days	Mon 03-02-20	Tue 11-02-20
43	Manufacture & Build	10 days	Tue 04-02-20	Mon 17-02-20
47	Testing & Design Reiteration	70 days	Tue 18-02-20	Fri 22-05-20
56	CDR Development	27 days	Fri 13-03-20	Mon 20-04-20
64	Eid Al Fitr	6 days	Wed 20-05-20	Wed 27-05-20
65	Competition Final	4 days	Thu 11-06-20	Sun 14-06-20
68	Spring Semester Exam	10 days	Mon 15-06-20	Fri 26-06-20
69	Post Event	11 days	Wed 01-07-20	Wed 15-07-20



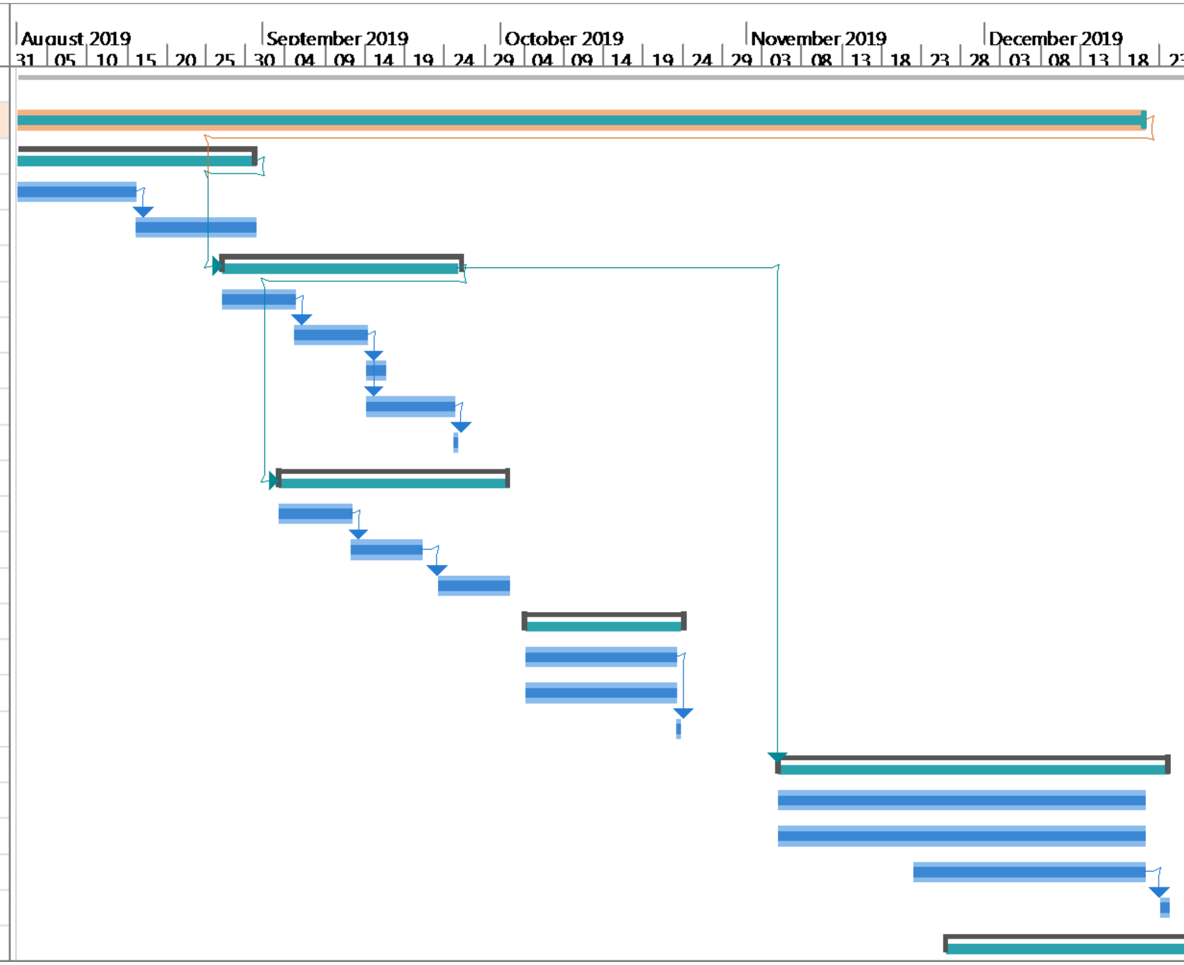
Legend

Academic milestones and holidays		Competition Task

Narantaka

Detailed Program Schedule (1 of 6)

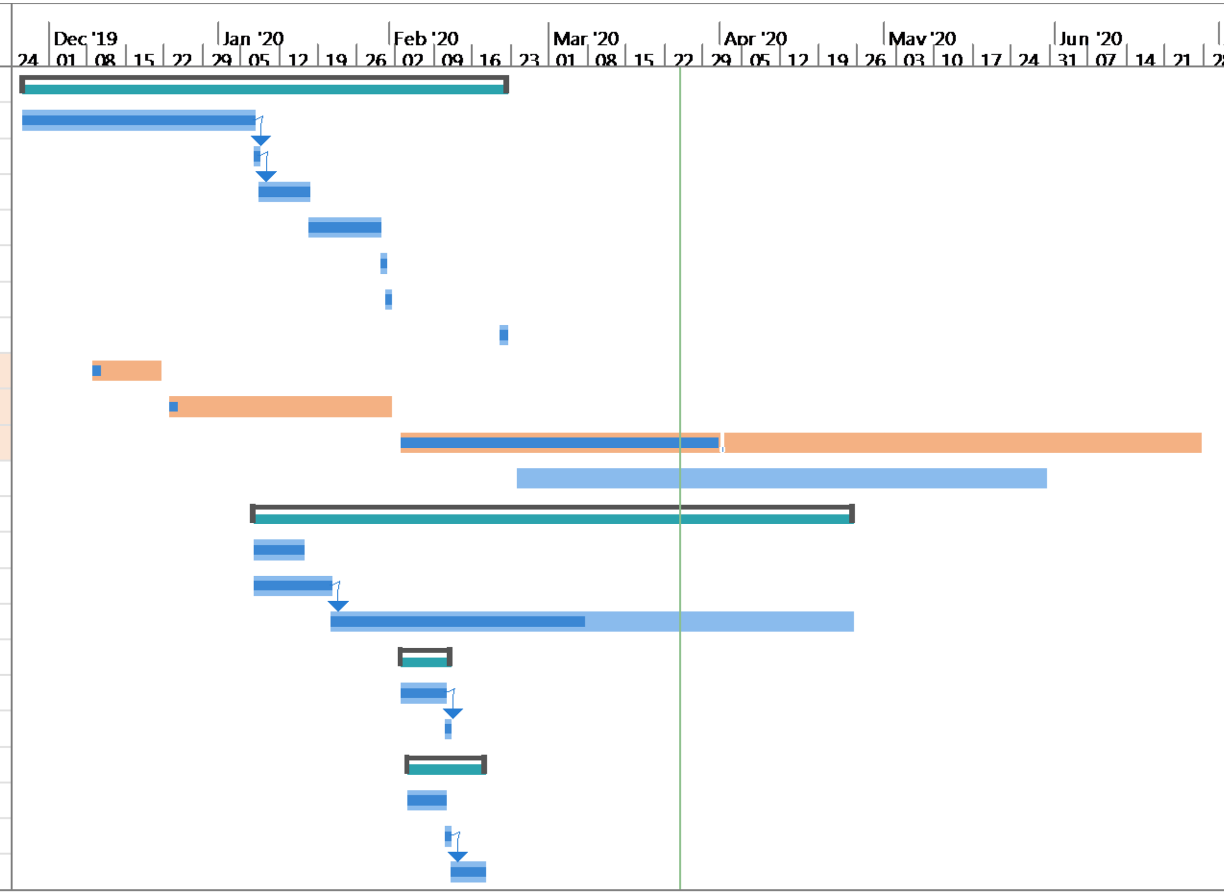
ID	Task Name
0	**CanSat 2020**
1	Fall Semester
2	**Project Initiation**
3	Starting Operations
4	Determine Team Memberships
5	**Project Analysis**
6	Read & Understand Project Brief
7	Team Discussions
8	Allocation of Project Team Positions
9	Establishing Goals & Objectives
10	Project Scheduled & Planned
11	**Requirement Analysis**
12	Read & Understand Requirements
13	Categorize and Split Requirements
14	Requirements Breakdown
15	**Procurement of Facilities, Equipment, & Materials**
16	List Facilities, Equipment, & Materials Needed
17	Arrange Testing Facilities and Required Permissions
18	Place Order
19	**System Integration**
20	Testing & Validation Planning
21	Check Sub System Design Compliance With Requirements
22	Develop Complete System Design
23	Finalize Design
24	**PDR Development**



Legend		
Academic milestones and holidays		Competition Task

Detailed Program Schedule (2 of 6)

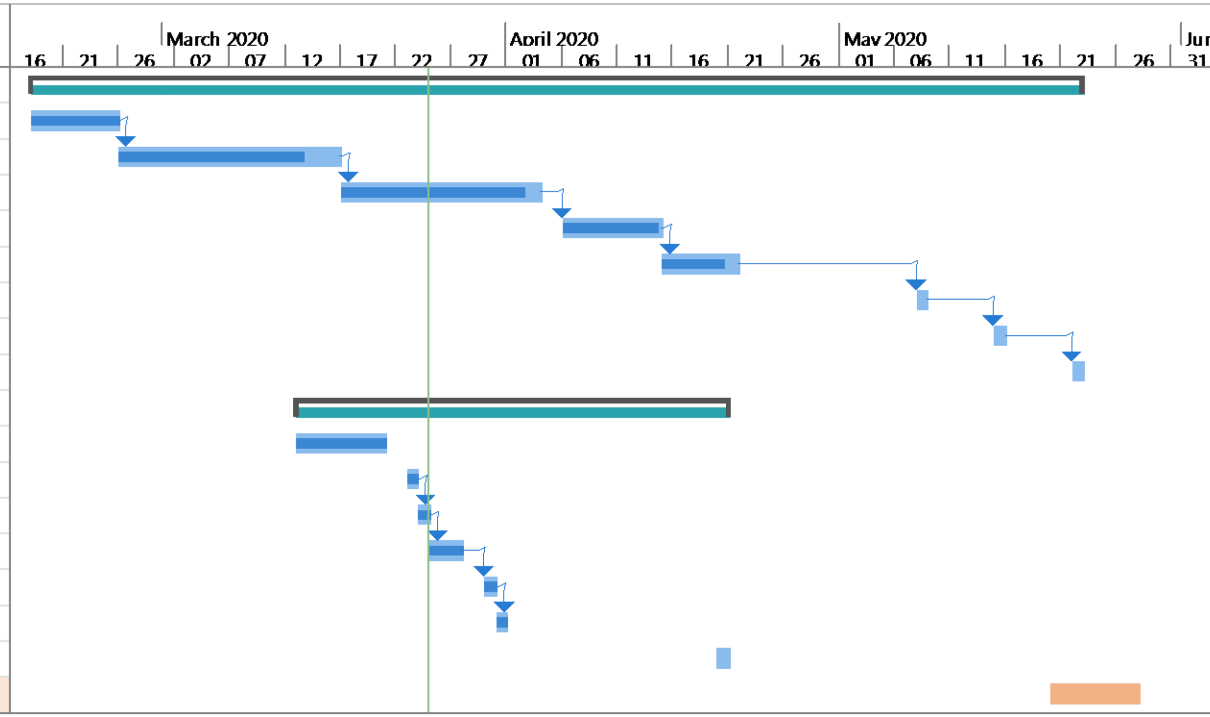
ID	Task Name
24	**PDR Development**
25	Develop Individual Sub System Slides
26	Submission of Individual Sub System Slides
27	Assimilation and Formatting Slides
28	Finalizing PDR Content & Format
29	Proofreading
30	PDR Submissions
31	Present PDR
32	Fall Semester Exam
33	Winter Break
34	Spring Semester
35	Travel Preparations
36	**Resource Procurement: Finances**
37	List Potential Sponsors, Donors, and Partners
38	Draft Proposal
39	Approach Targetted Sponsors
40	**Procurement of Equipment & Materials**
41	List Equipment and Materials Needed
42	Place Order
43	**Manufacture & Build**
44	Prepare Required Plans & Drawings
45	Submit for Manufacturing
46	Assembly & Build



Legend		
Academic milestones and holidays		Competition Task

Detailed Program Schedule (3 of 6)

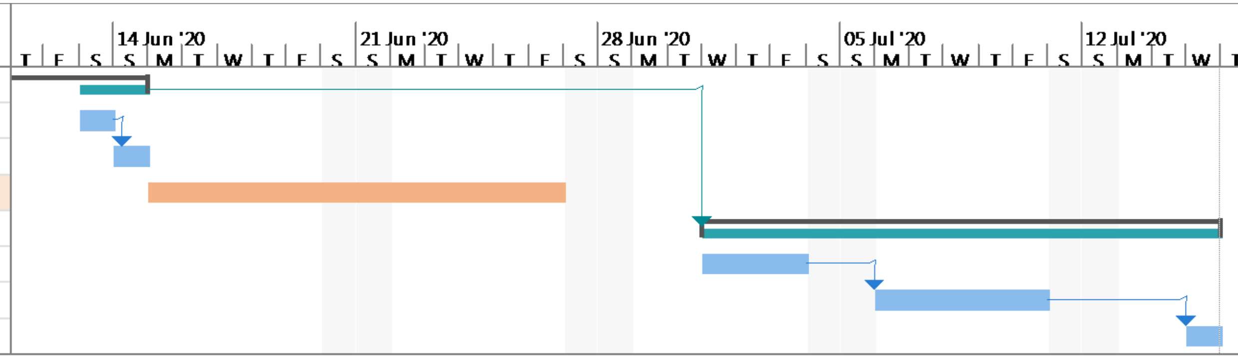
ID	Task Name
47	**Testing & Design Reiteration**
48	Testing Individual Subsystem
49	Testing Complete System
50	Requirement Compliance
51	Finalize Design
52	Run Final Tests
53	Test Launch 1
54	Test Launch 2
55	Test Launch 3
56	**CDR Development**
57	Develop Individual Sub System Slides
58	Submission of Individual Sub System Slides
59	Assimilation and Formatting Slides
60	Finalizing CDR Contents & Format
61	Proofreading
62	CDR Submission
63	CDR Presentation
64	Eid Al Fitr



Legend		
Academic milestones and holidays		Competition Task

Detailed Program Schedule (4 of 6)

ID	Task Name
65	**Competition Final**
66	Competition: Test, Flight & Data Submission
67	Competition: PFR
68	Spring Semester Exam
69	**Post Event**
70	Project Evaluation
71	Draft Report
72	Report Submission



Legend	
Main Task	
Sub - Task	
Exams & Vacations	
Progress	Inner Bar
Followed Task	
Task Length	

Detailed Program Schedule (5 of 6)

Task Name	Duration	Start	Finish	% Complete
CanSat 2020	**253 days**	**Thu 01-08-19**	**Wed 15-07-20**	**76%**
Fall Semester	102 days	Thu 01-08-19	Fri 20-12-19	100%
Project Initiation	**22 days**	**Thu 01-08-19**	**Fri 30-08-19**	**100%**
Starting Operations	11 days	Thu 01-08-19	Thu 15-08-19	100%
Determine Team Memberships	11 days	Fri 16-08-19	Fri 30-08-19	100%
Project Analysis	**22 days**	**Tue 27-08-19**	**Wed 25-09-19**	**100%**
Read & Understand Project Brief	7 days	Tue 27-08-19	Wed 04-09-19	100%
Team Discussions	7 days	Thu 05-09-19	Fri 13-09-19	100%
Allocation of Project Team Positions	0.1 days	Sat 14-09-19	Mon 16-09-19	100%
Establishing Goals & Objectives	7 days	Sat 14-09-19	Tue 24-09-19	100%
Project Scheduled & Planned	0.1 days	Wed 25-09-19	Wed 25-09-19	100%
Requirement Analysis	**21 days**	**Tue 03-09-19**	**Tue 01-10-19**	**100%**
Read & Understand Requirements	7 days	Tue 03-09-19	Wed 11-09-19	100%
Categorize and Split Requirements	7 days	Thu 12-09-19	Fri 20-09-19	100%
Requirements Breakdown	7 days	Mon 23-09-19	Tue 01-10-19	100%
Procurement of Facilities, Equipment, & Materials	**14 days**	**Fri 04-10-19**	**Wed 23-10-19**	**100%**
List Facilities, Equipment, & Materials Needed	13 days	Fri 04-10-19	Tue 22-10-19	100%
Arrange Testing Facilities and Required Permissions	13 days	Fri 04-10-19	Tue 22-10-19	100%
Place Order	0.1 days	Wed 23-10-19	Wed 23-10-19	100%

Task Name	Duration	Start	Finish	% Complete
System Integration	**35 days**	**Tue 05-11-19**	**Mon 23-12-19**	**100%**
Testing & Validation Planning	34 days	Tue 05-11-19	Fri 20-12-19	100%
Check Sub System Design Compliance With Requirements	34 days	Tue 05-11-19	Fri 20-12-19	100%
Develop Complete System Design	21 days	Fri 22-11-19	Fri 20-12-19	100%
Finalize Design	1 day	Mon 23-12-19	Mon 23-12-19	100%
PDR Development	**64 days**	**Tue 26-11-19**	**Fri 21-02-20**	**100%**
Develop Individual Sub System Slides	30 days	Tue 26-11-19	Mon 06-01-20	100%
Submission of Individual Sub System Slides	1 day	Tue 07-01-20	Tue 07-01-20	100%
Assimilation and Formatting Slides	7 days	Wed 08-01-20	Thu 16-01-20	100%
Finalizing PDR Content & Format	9 days	Fri 17-01-20	Wed 29-01-20	100%
Proofreading	1 day	Thu 30-01-20	Thu 30-01-20	100%
PDR Submissions	1 day	Fri 31-01-20	Fri 31-01-20	100%
Present PDR	1 day	Fri 21-02-20	Fri 21-02-20	100%
Fall Semester Exam	10 days	Mon 09-12-19	Fri 20-12-19	100%
Winter Break	30 days	Mon 23-12-19	Fri 31-01-20	100%
Spring Semester	108 days	Mon 03-02-20	Fri 26-06-20	40%
Travel Preparations	70 days	Mon 24-02-20	Fri 29-05-20	40%
Resource Procurement: Finances	**80 days**	**Tue 07-01-20**	**Fri 24-04-20**	**60%**

Detailed Program Schedule (6 of 6)

Task Name	Duration	Start	Finish	% Complete
List Potential Sponsors, Donors, and Partners	7 days	Tue 07-01-20	Wed 15-01-20	100%
Draft Proposal	10 days	Tue 07-01-20	Mon 20-01-20	100%
Approach Targetted Sponsors	70 days	Tue 21-01-20	Fri 24-04-20	50%
Procurement of Equipment & Materials	**7 days**	**Mon 03-02-20**	**Tue 11-02-20**	**100%**
List Equipment and Materials Needed	6 days	Mon 03-02-20	Mon 10-02-20	100%
Place Order	1 day	Tue 11-02-20	Tue 11-02-20	100%
Manufacture & Build	**10 days**	**Tue 04-02-20**	**Mon 17-02-20**	**100%**
Prepare Required Plans & Drawings	5 days	Tue 04-02-20	Mon 10-02-20	100%
Submit for Manufacturing	1 day	Tue 11-02-20	Tue 11-02-20	100%
Assembly & Build	4 days	Wed 12-02-20	Mon 17-02-20	100%
Testing & Design Reiteration	**70 days**	**Tue 18-02-20**	**Fri 22-05-20**	**85%**
Testing Individual Subsystem	7 days	Tue 18-02-20	Tue 25-02-20	100%
Testing Complete System	14 days	Wed 26-02-20	Mon 16-03-20	90%
Requirement Compliance	14 days	Tue 17-03-20	Fri 03-04-20	90%
Finalize Design	7 days	Mon 06-04-20	Tue 14-04-20	95%
Run Final Tests	5 days	Wed 15-04-20	Tue 21-04-20	70%
Test Launch 1	1 day	Fri 08-05-20	Fri 08-05-20	0%
Test Launch 2	1 day	Fri 15-05-20	Fri 15-05-20	0%

Task Name	Duration	Start	Finish	% Complete
Test Launch 3	1 day	Fri 22-05-20	Fri 22-05-20	0%
CDR Development	**27 days**	**Fri 13-03-20**	**Mon 20-04-20**	**93%**
Develop Individual Sub System Slides	6 days	Fri 13-03-20	Fri 20-03-20	100%
Submission of Individual Sub System Slides	1 day	Mon 23-03-20	Mon 23-03-20	100%
Assimilation and Formatting Slides	1 day	Tue 24-03-20	Tue 24-03-20	100%
Finalizing CDR Contents & Format	3 days	Wed 25-03-20	Fri 27-03-20	100%
Proofreading	1 day	Mon 30-03-20	Mon 30-03-20	100%
CDR Submission	1 day	Tue 31-03-20	Tue 31-03-20	100%
CDR Presentation	1 day	Mon 20-04-20	Mon 20-04-20	0%
Eid Al Fitr	6 days	Wed 20-05-20	Wed 27-05-20	0%
Competition Final	**4 days**	**Thu 11-06-20**	**Sun 14-06-20**	**0%**
Competition: Test, Flight & Data Submission	1 day	Sat 13-06-20	Sat 13-06-20	0%
Competition: PFR	1 day	Sun 14-06-20	Sun 14-06-20	0%
Spring Semester Exam	10 days	Mon 15-06-20	Fri 26-06-20	0%
Post Event	**11 days**	**Wed 01-07-20**	**Wed 15-07-20**	**0%**
Project Evaluation	3 days	Wed 01-07-20	Fri 03-07-20	0%
Draft Report	5 days	Mon 06-07-20	Fri 10-07-20	0%
Report Submission	1 day	Wed 15-07-20	Wed 15-07-20	0%

Shipping and Transportation

Person:

Yogyakarta – Jakarta: Overnight Train
Jakarta – Blacksburg: Plane (Turkish Airlines)

CanSat and Tools:

Yogyakarta – Blacksburg: Cargo (DHL)
Shipping Address 1: Committee Office
Shipping Address 2: Indonesian Embassy in DC

Precaution:

In order to minimize trouble for transporting the tools and CanSat, we will send one set of the CanSat and tools using cargo service and another set carried along with us aboard.

Social Media & Publicity (1 of 2)

Website

Our website, aerospace.ugm.ac.id has been active since 2013.

Instagram

Our Instagram account, @gmatugm latest post reach 786 people and we have made 2,129 impressions this week

Social Media & Publicity (2 of 2)


TribunJogja.com Sabtu, 23 Maret 2019 Cari

Balon Udara

Menakjubkan! Ini Foto Pulau Jawa dari Ketinggian 11 Kilometer

Rabu, 25 April 2018 21:56

Dok Gadjah Mada Aerospace

Pemandangan dataran Pulau Jawa dari ketinggian 30 km, diabadikan dari kamera tersemat di balon cuaca.

E-Newspaper

Our activity is published in one of Indonesia's local newspaper agency, Tribun Jogja.


detiknews

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Kamis 06 Agustus 2015, 15:29 WIB

UGM Raih Emas dan Perak dalam Kompetisi Muatan Roket dan Roket Indonesia 2015

Bagus Kurniawan - detikNews

E-Newspaper

One of our achievement in national competition is published on another local newspaper agency, Detik.com.

Conclusions

Major accomplishments

- The CanSat weight and production below the weight limit
- Program design is 100% finalized
- Indonesian authority in Washington DC have been contacted
- Our progresses match designated timeline

Major unfinished work

- Team members’ visas have not been applied
- No bookings have been made due to uncertainty of COVID-19 Pandemics

Why we are READY

- We will catch up our non-technical progress as soon as condition gets better
- We have performed our best, we hope that we will get the best results