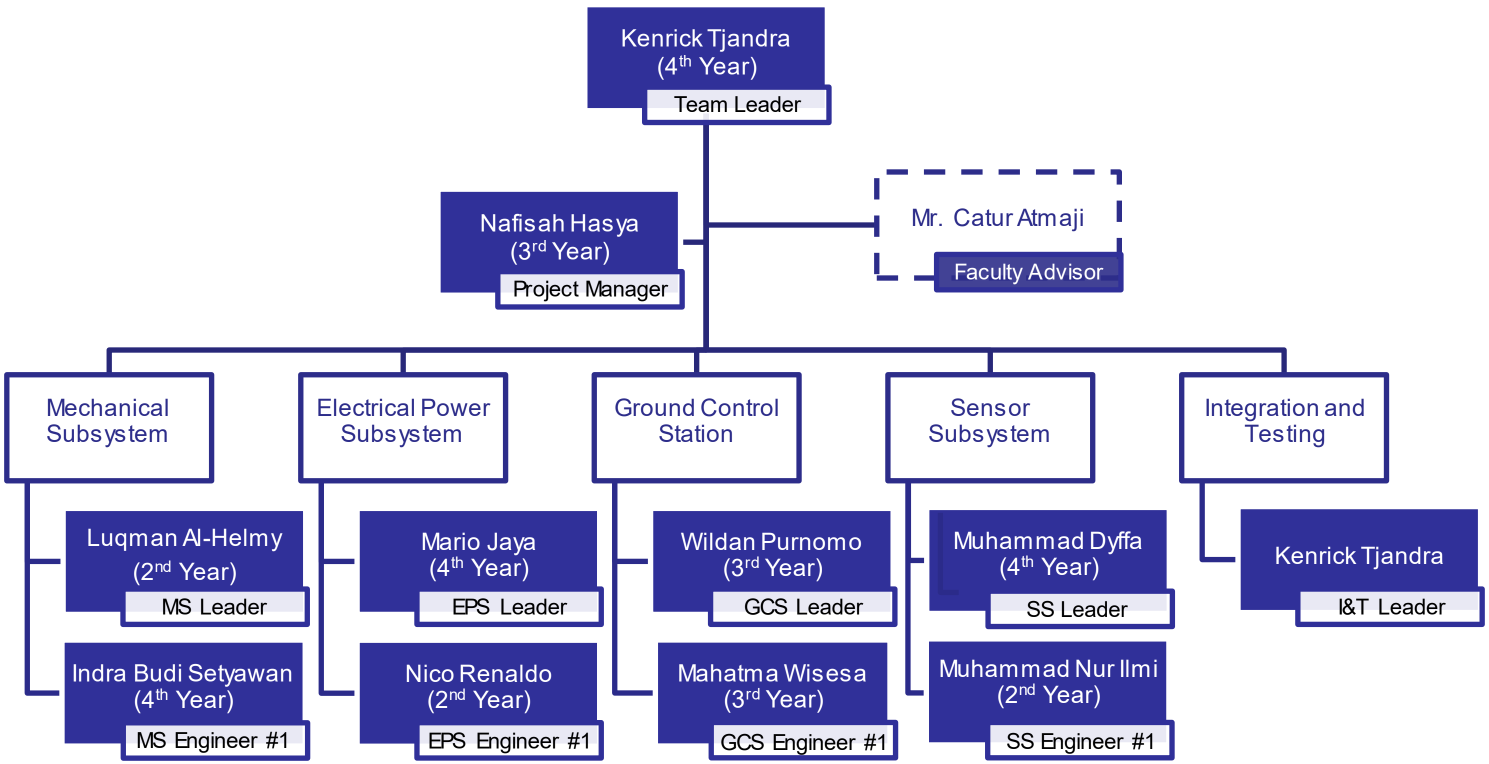
# CanSat 2020
# Preliminary Design Review (PDR)
# *Version 2.0*

**#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 |
| GS | Ground Station |
| 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 reputation in our university, Indonesia, and worldwide

# 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 | | ✓ | ✓ | |
| RN14 | All electronic components shall be enclosed and shielded from the environment with the exception of sensors. | Competition Requirement | Very High | | ✓ | | |
| RN15 | All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives. | Competition Requirement | Very High | ✓ | | ✓ | ✓ |
| RN16 | All mechanisms shall be capable of maintaining their configuration or states under all forces. | Competition Requirement | Very High | ✓ | ✓ | | ✓ |
| RN17 | 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 | | ✓ | | |
| RN18 | The science payload shall measure altitude using an air pressure sensor. | Competition Requirement | Very High | | | ✓ | ✓ |
| RN19 | The science payload shall provide position using GPS. | Competition Requirement | Very High | | | ✓ | ✓ |
| RN20 | The science payload shall measure its battery voltage. | Competition Requirement | Very High | | | ✓ | ✓ |
| RN21 | The science payload shall measure outside temperature. | Competition Requirement | Very High | | | ✓ | ✓ |
| RE22 | The science payload shall measure particulates in the air as it glides. | Competition Requirement | Very High | | | ✓ | ✓ |

# System Requirement Summary (3 of 4)

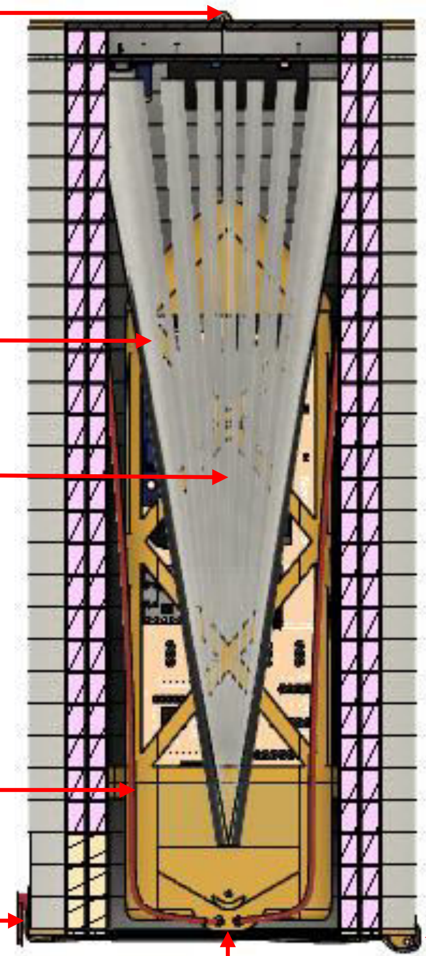
| RN | Requirement | Rationale | Priority | Verification | | | |
|---|---|---|---|---|---|---|---|
| | | | | A | I | T | D |
| RN23 | The science payload shall measure air speed. | Competition Requirement | Very High | | | ✓ | ✓ |
| RN24 | The science payload shall transmit all sensor data in the telemetry. | Competition Requirement | Very High | | | ✓ | ✓ |
| RN25 | Telemetry shall be updated once per second. | Competition Requirement | High | ✓ | | ✓ | |
| RN26 | The Parachutes shall be fluorescent Pink or Orange | Competition Requirement | Very High | | ✓ | | |
| RN27 | 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 | | | ✓ | ✓ |
| RN32 | Both the container and probe shall be labeled with team contact information including email address. | Competition Requirement | Very High | ✓ | ✓ | | |
| RN33 | No lasers allowed. | Competition Requirement | Medium | ✓ | | | |

# System Requirement Summary (4 of 4)

| RN | Requirement | Rationale | Priority | Verification | | | |
|---|---|---|---|---|---|---|---|
| | | | | A | I | T | D |
| RN34 | 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 | | ✓ | | ✓ |
| RN35 | 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 | ✓ | ✓ | | |
| RN36 | An audio beacon is required for the probe. It may be powered after landing or operate continuously. | Competition Requirement | Very High | ✓ | | ✓ | ✓ |
| RN37 | The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed. | Competition Requirement | High | ✓ | ✓ | | |
| RN38 | 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 | | ✓ | | |
| RN39 | 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 | | ✓ | | ✓ |
| RN40 | Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects. | Competition Requirement | High | ✓ | ✓ | | |
| RN41 | Payload/Container shall operate for a minimum of two hours when integrated into rocket. | Competition Requirement | Very High | ✓ | | ✓ | |
| RN42 | 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 | ✓ | ✓ | ✓ | |

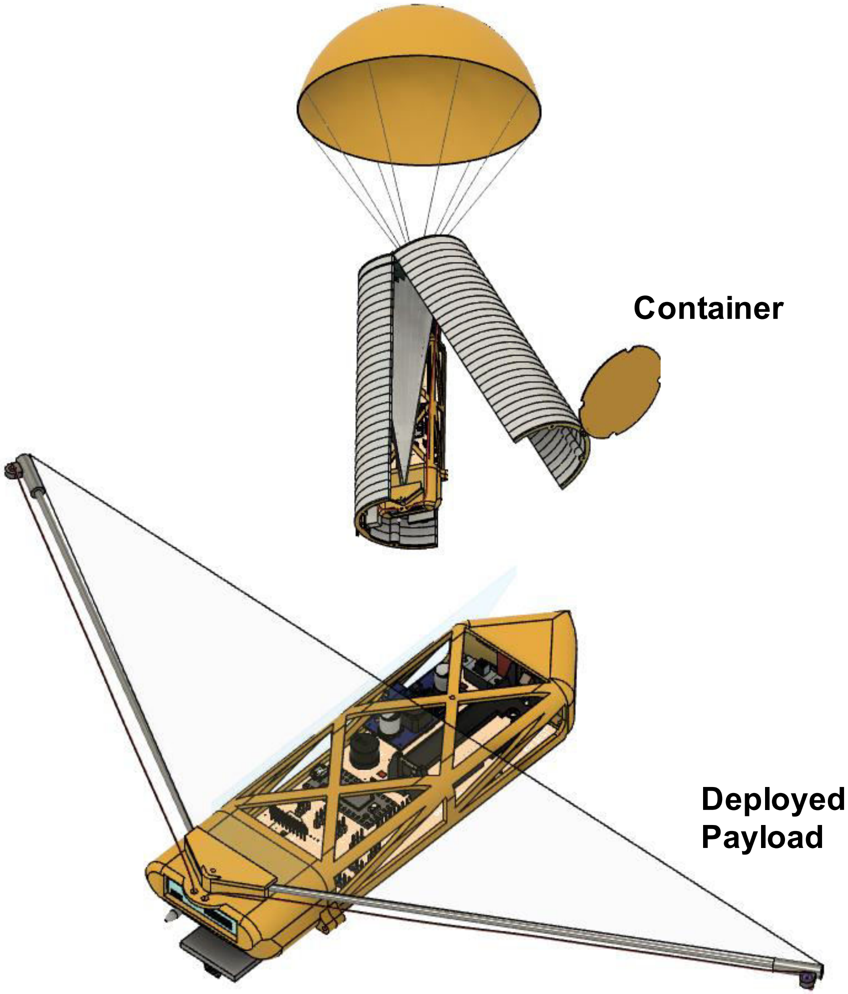
## Design A – Front Wing Support, Passive control Glider

| Main Features |
|---|
| Payload design is more compact |
| Front wing support will be deployed using rubber |
| Container inner side body will stow the payload and wing rods |
| Does not require additional wing stow mechanism |
| Payload will less likely to tumble inside the container |
| During separation, container lock will be released. Enabling the container to open. Releasing the payload inside |



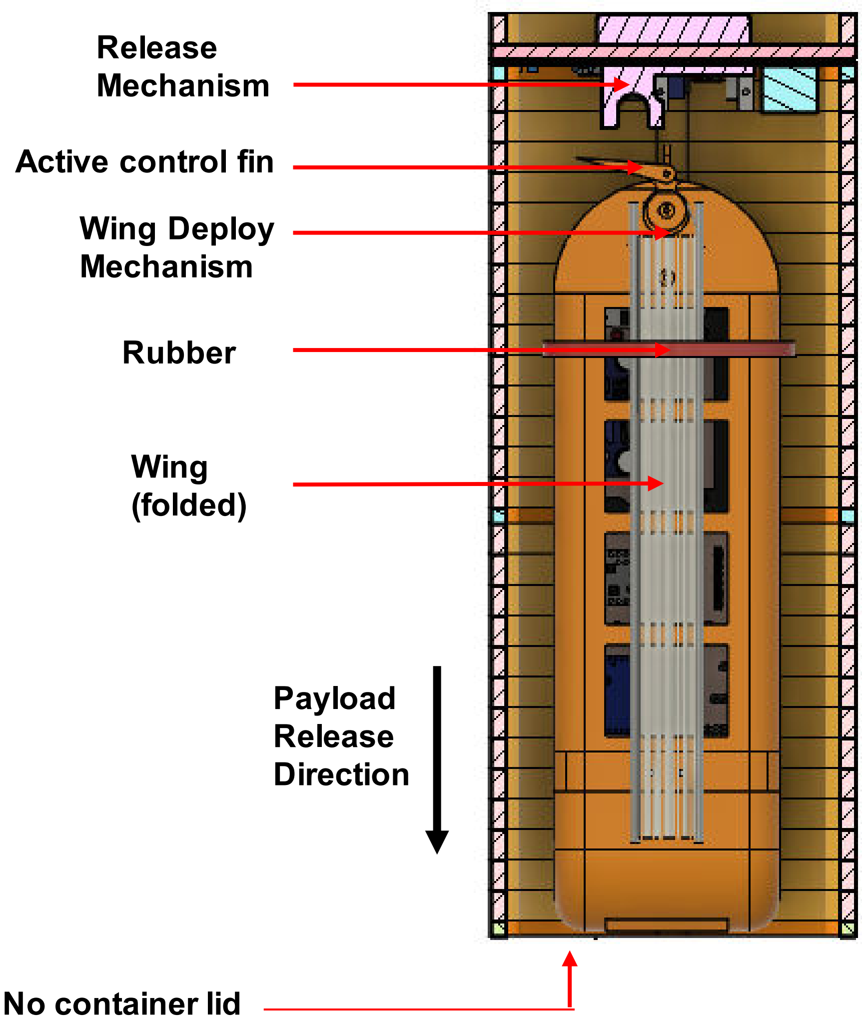
## Design A – Front Wing Support, Passive Control Glider

| Considerations |
|---|
| **Advantages** |
| Less Mass addition |
| Good system durability |
| Simple descent control configuration |
| **Disadvantages** |
| Glide characteristic relies heavily on environment |
| Release direction might be more violent |



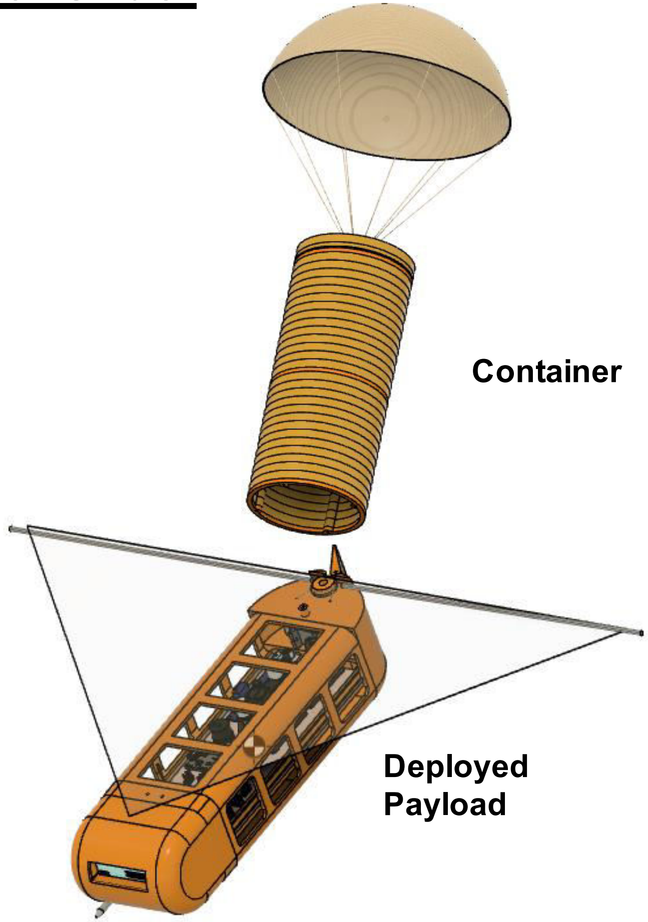
## Design B – Rear Wing Support, Active Control Glider

| Main Features |
|---|
| Torsion spring wing deploy mechanism |
| Wing rods located at the tail part of the payload, ensuring a larger wing surface area |
| Additional rubber is required to stow the wing |
| Payload is stowed using servo with push rod located at the top part of the container |
| The servo will release the payload at 450 m. The bottom part of the container has no lid. Payload can be released easily |
| Active control fin allows controlled payload descent |
| Better clearance between payload and the container as the wing will not contact the inner body of the container |

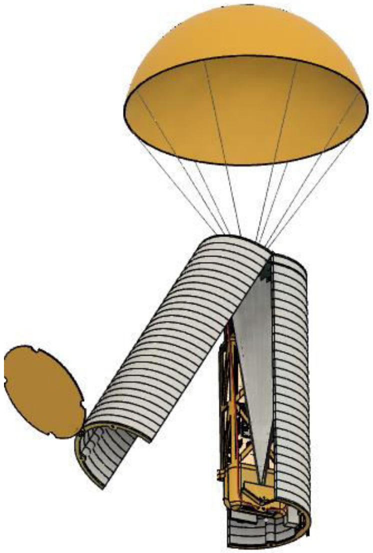


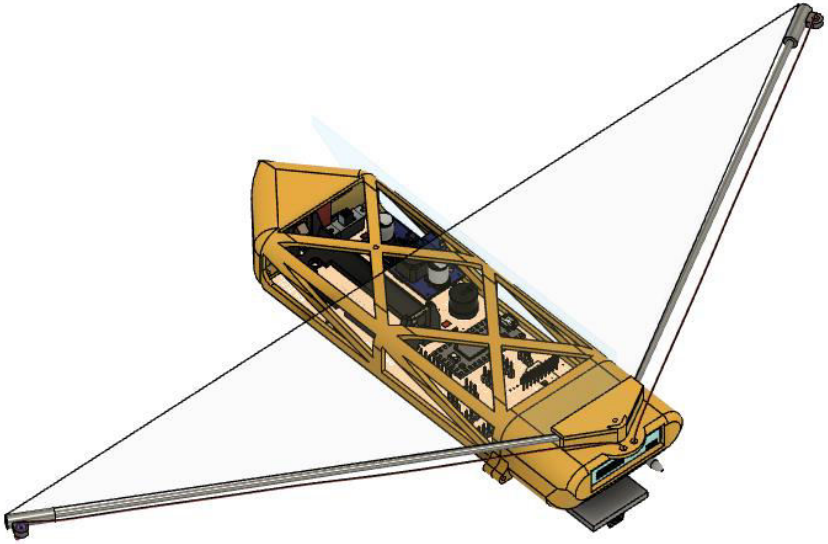
## Design B – Rear Wing Support, Active Control Glider

| Considerations |
|---|
| **Advantages** |
| Less complex separation mechanism |
| Capability to control glide |
| **Disadvantages** |
| Additional servo mass and housing |
| Lesser container durability |
| Added system complexity with active control program |



# System Level Configuration Selection





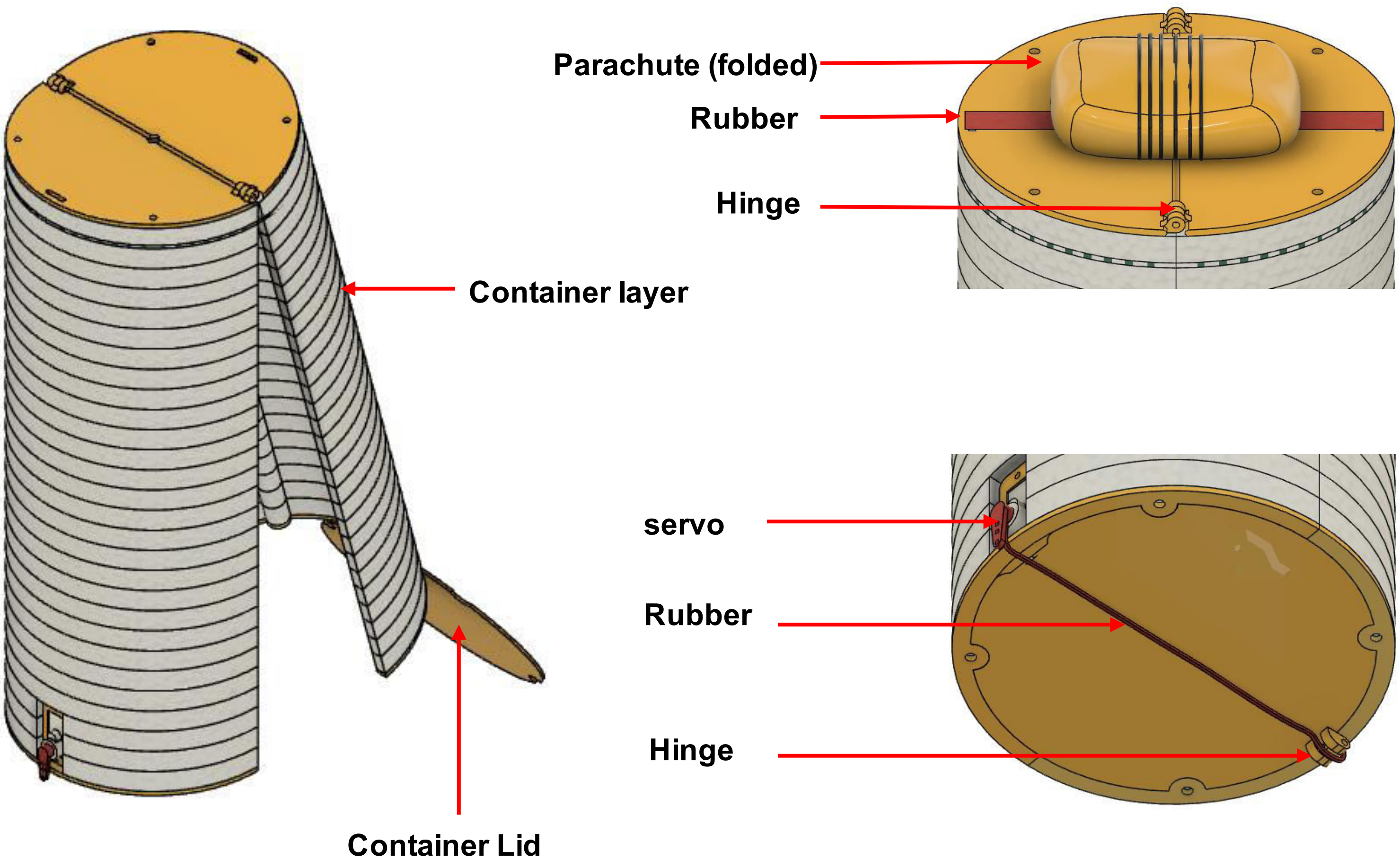
| Chosen System Level Configuration |
| --- |
| Design A |

**Rationale:**

- **Lighter mass to comply with competition requirements**
- **More reliable separation mechanism**
- **More reliable wing deployment mechanism**

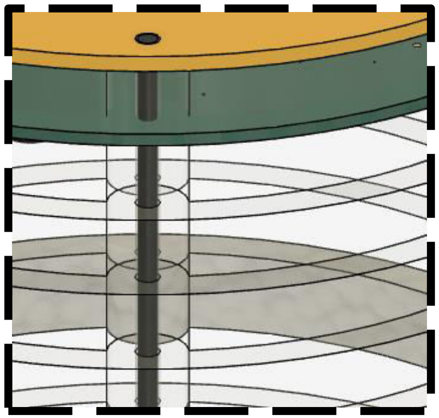
# Physical Layout (1 of 8)

## CONTAINER



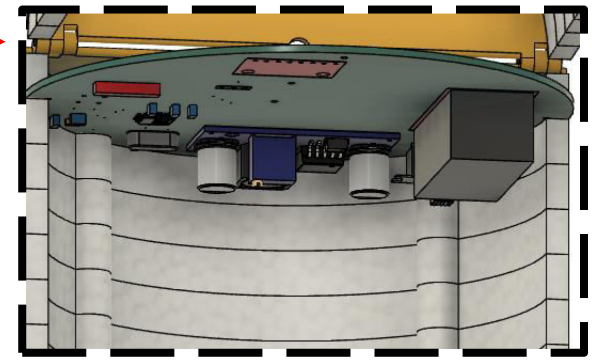
# Physical Layout (2 of 8)

## DETAILED CONTAINER

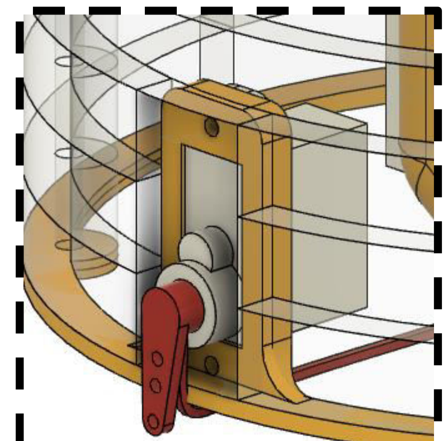


Container structures detail:
- 3D Printed layer
- PCB
- Polyfoam

Constructed with adhesives and carbon support rod

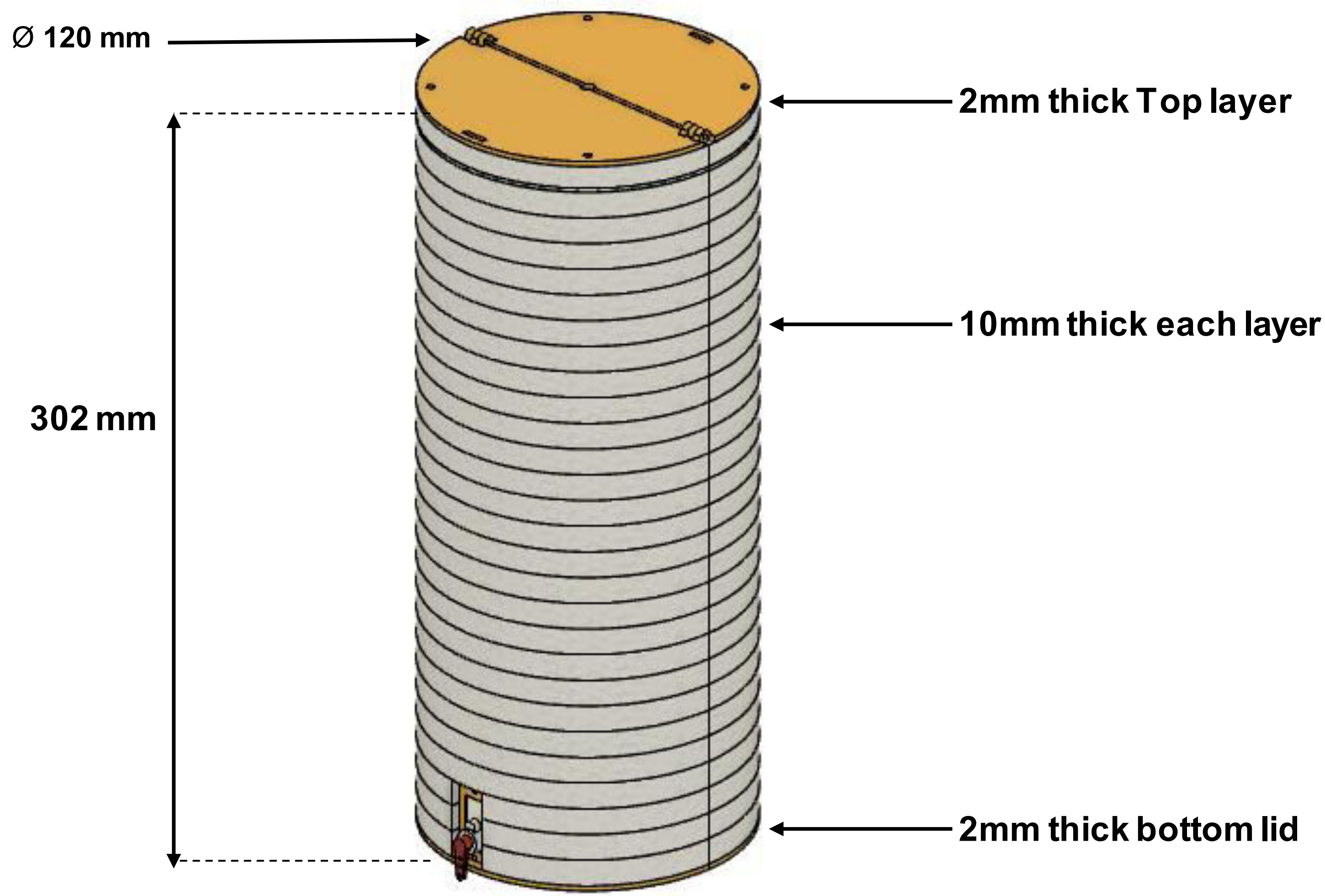


Container electronics detail

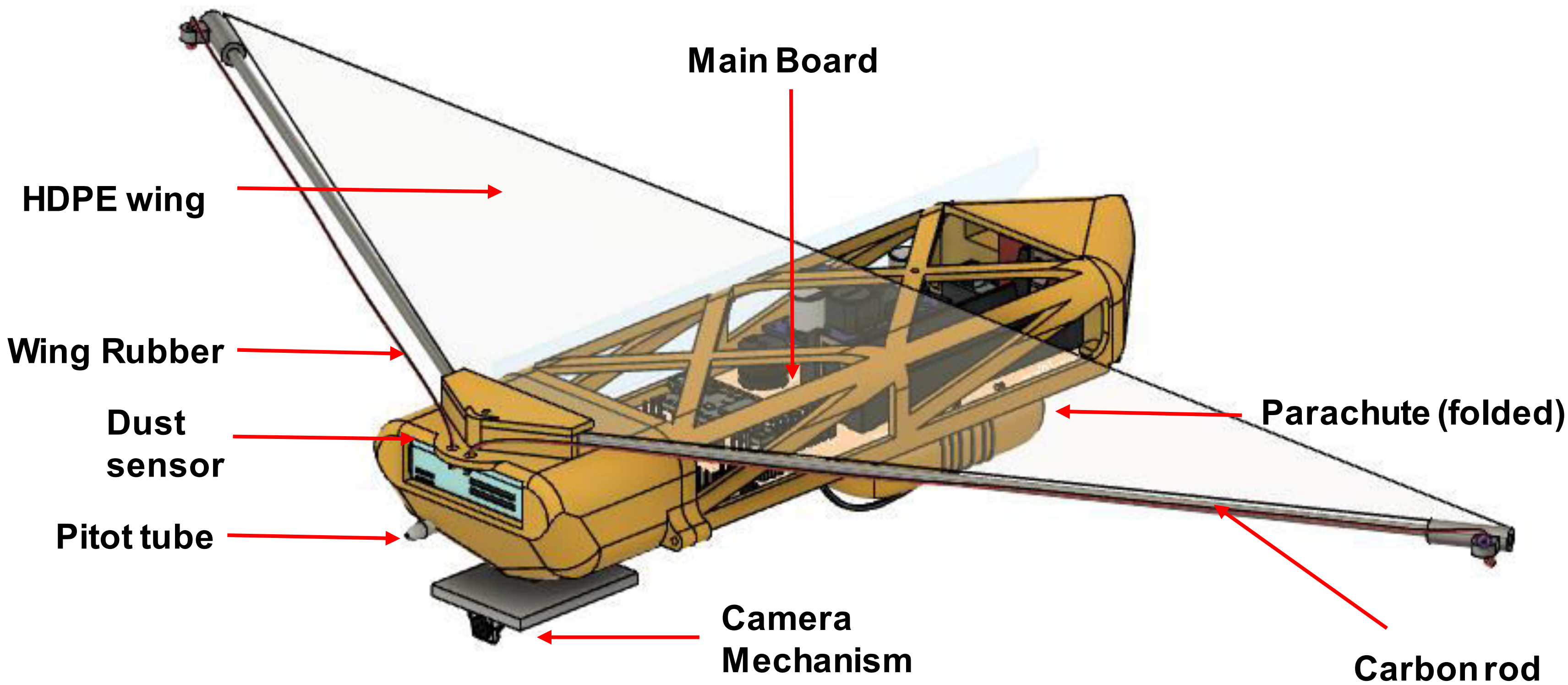


Detail on container servo lock

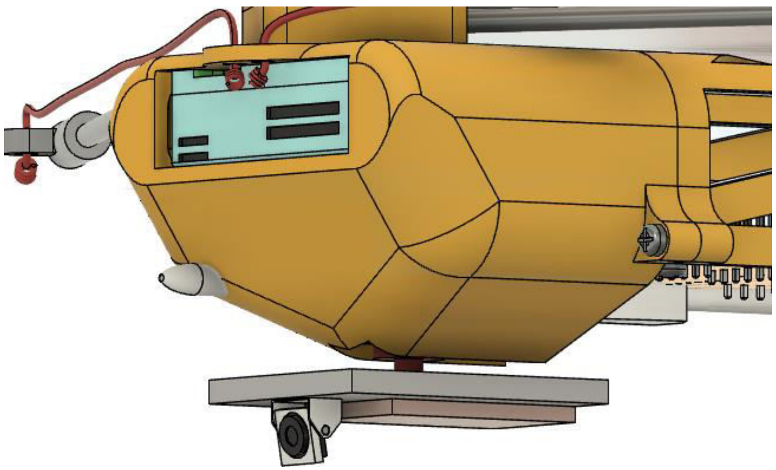
## CONTAINER DIMENSIONS

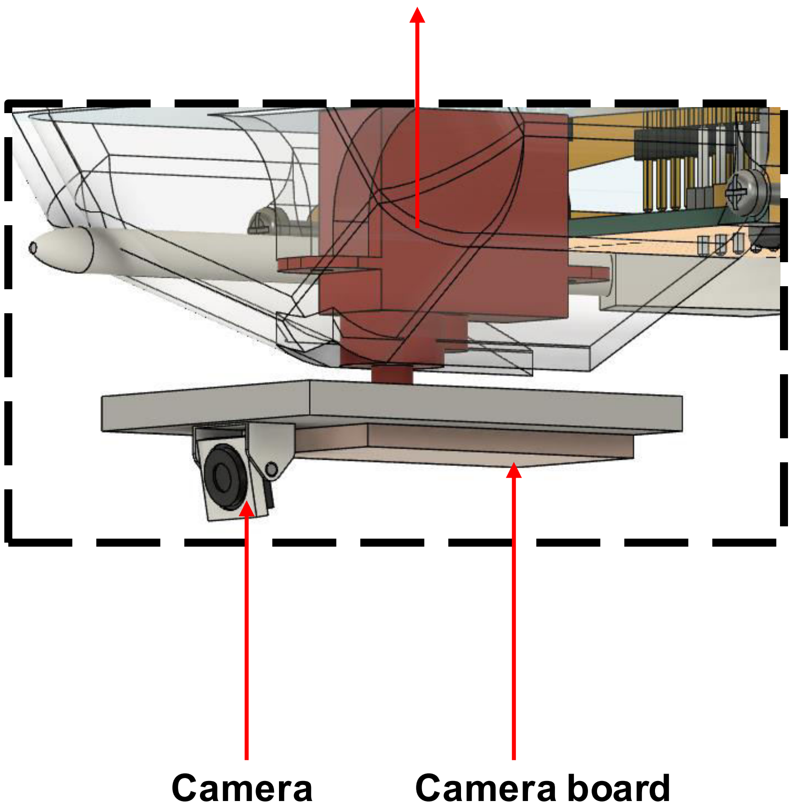


## PAYLOAD


Main Board
HDPE wing
Wing Rubber
Dust sensor
Pitot tube
Parachute (folded)
Camera Mechanism
Carbon rod

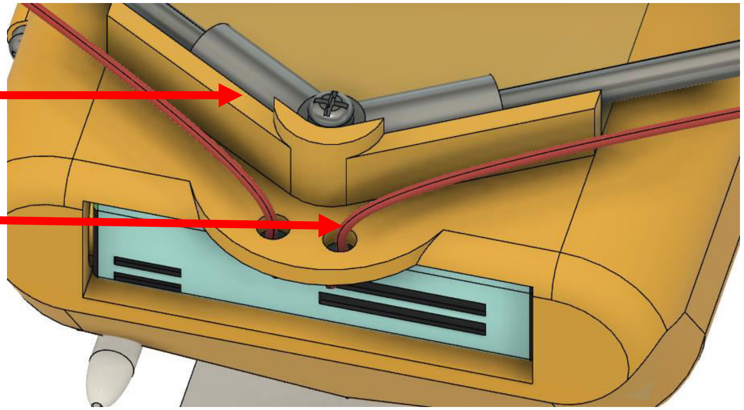
## CAMERA MECHANISM

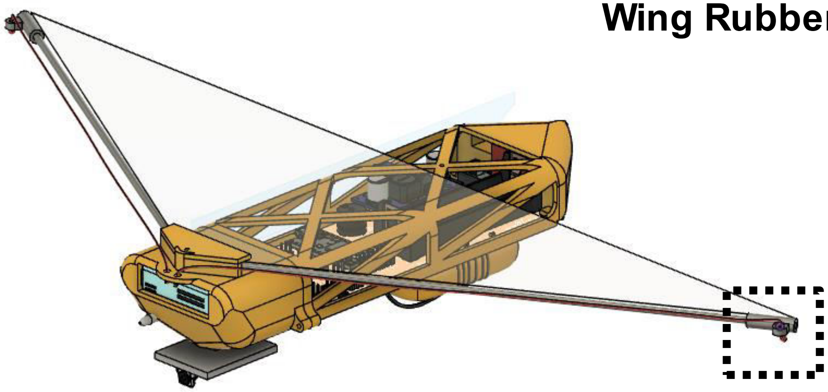


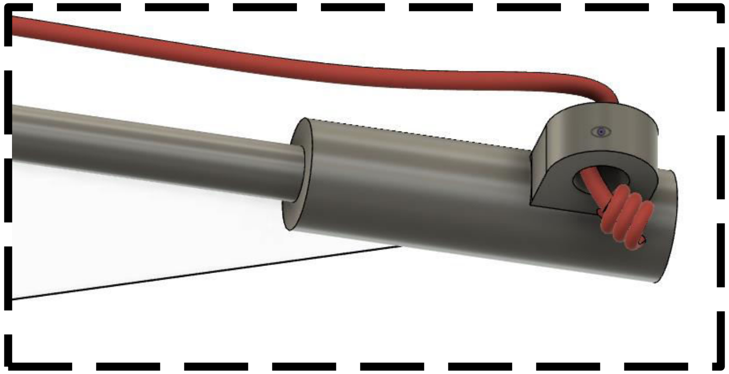


# Physical Layout (6 of 8)

## WING DEPLOYMENT MECHANISM



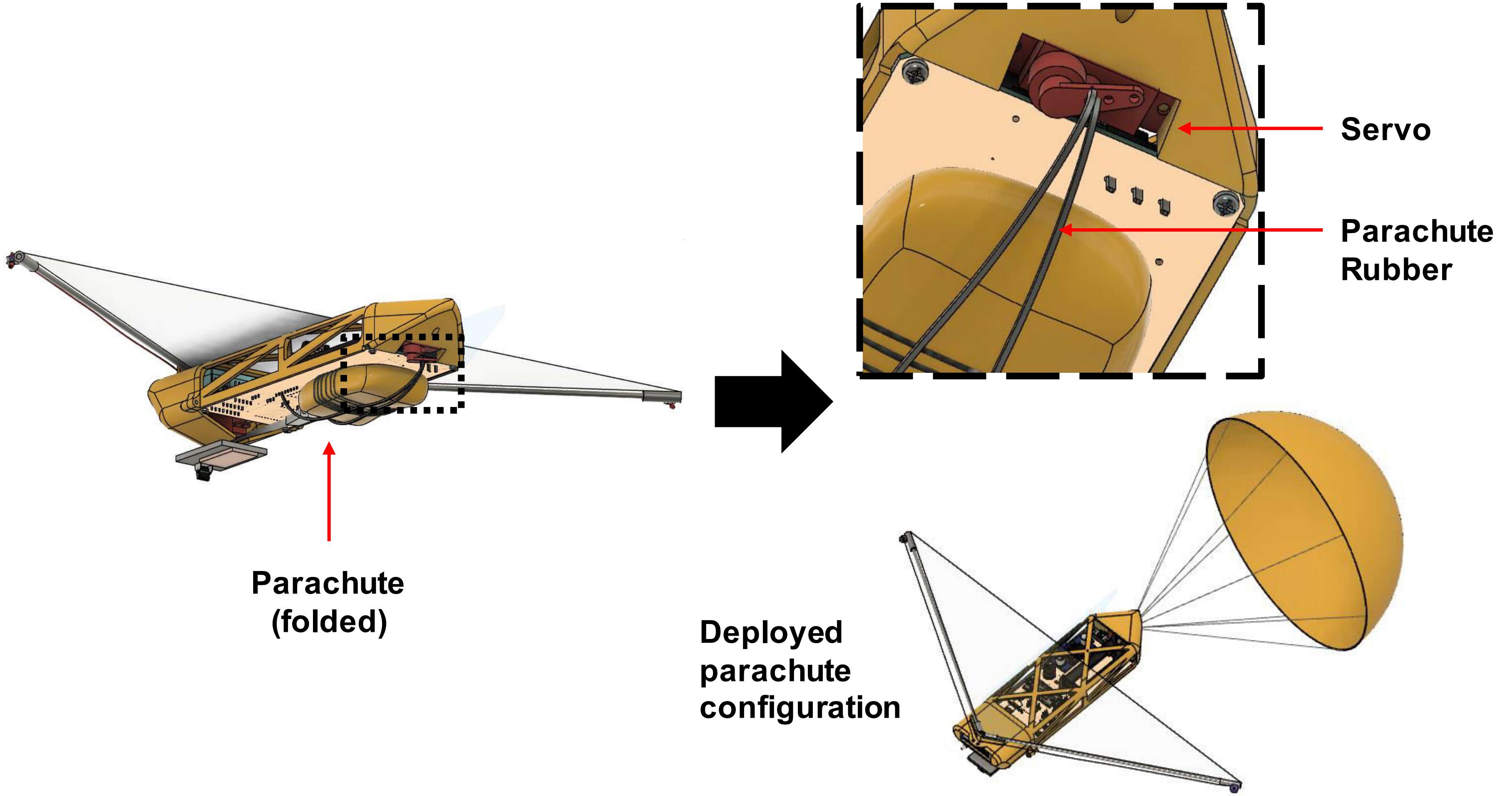





Rubber connection with wing rod

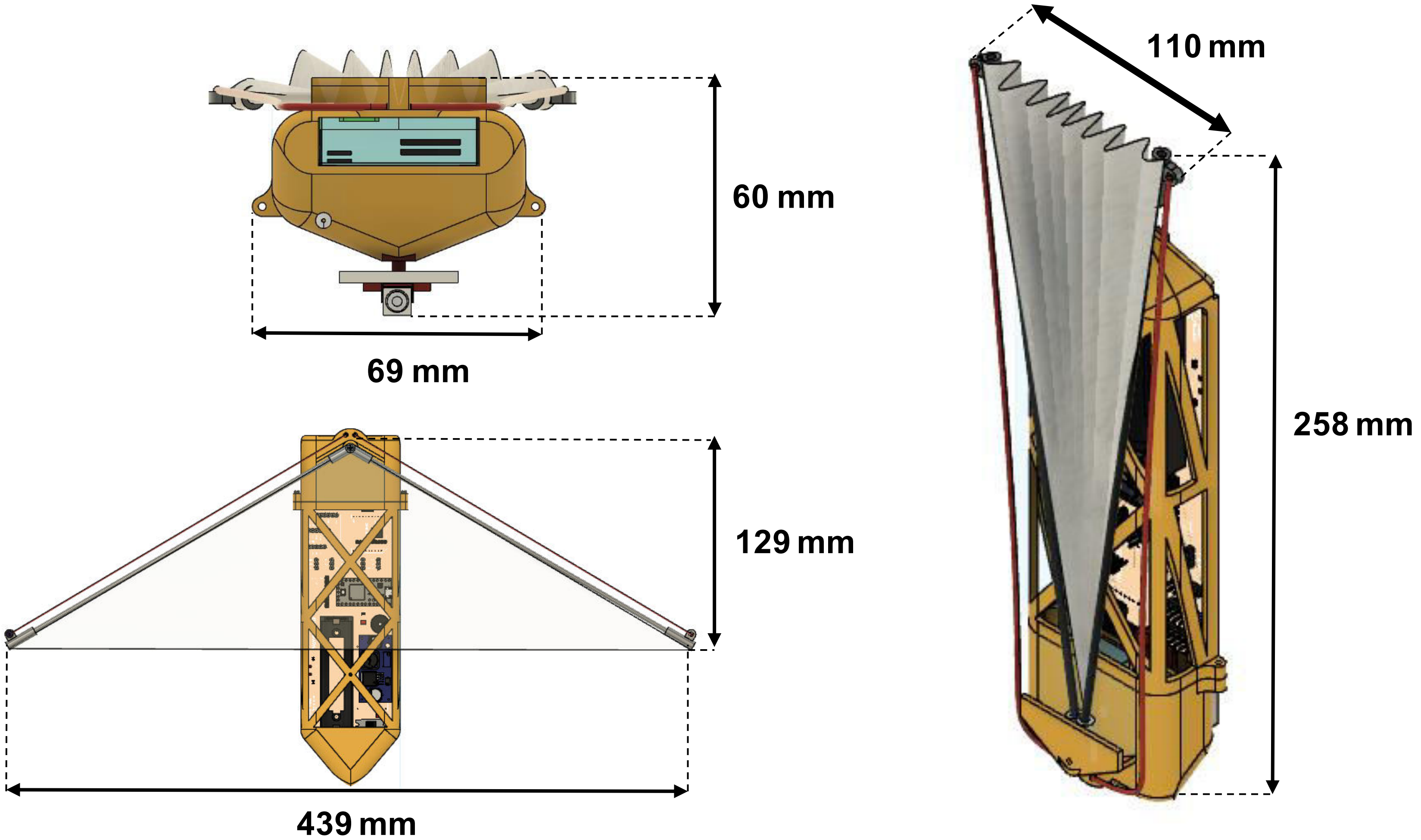
# Physical Layout (7 of 8)

## PARACHUTE DEPLOYMENT MECHANISM

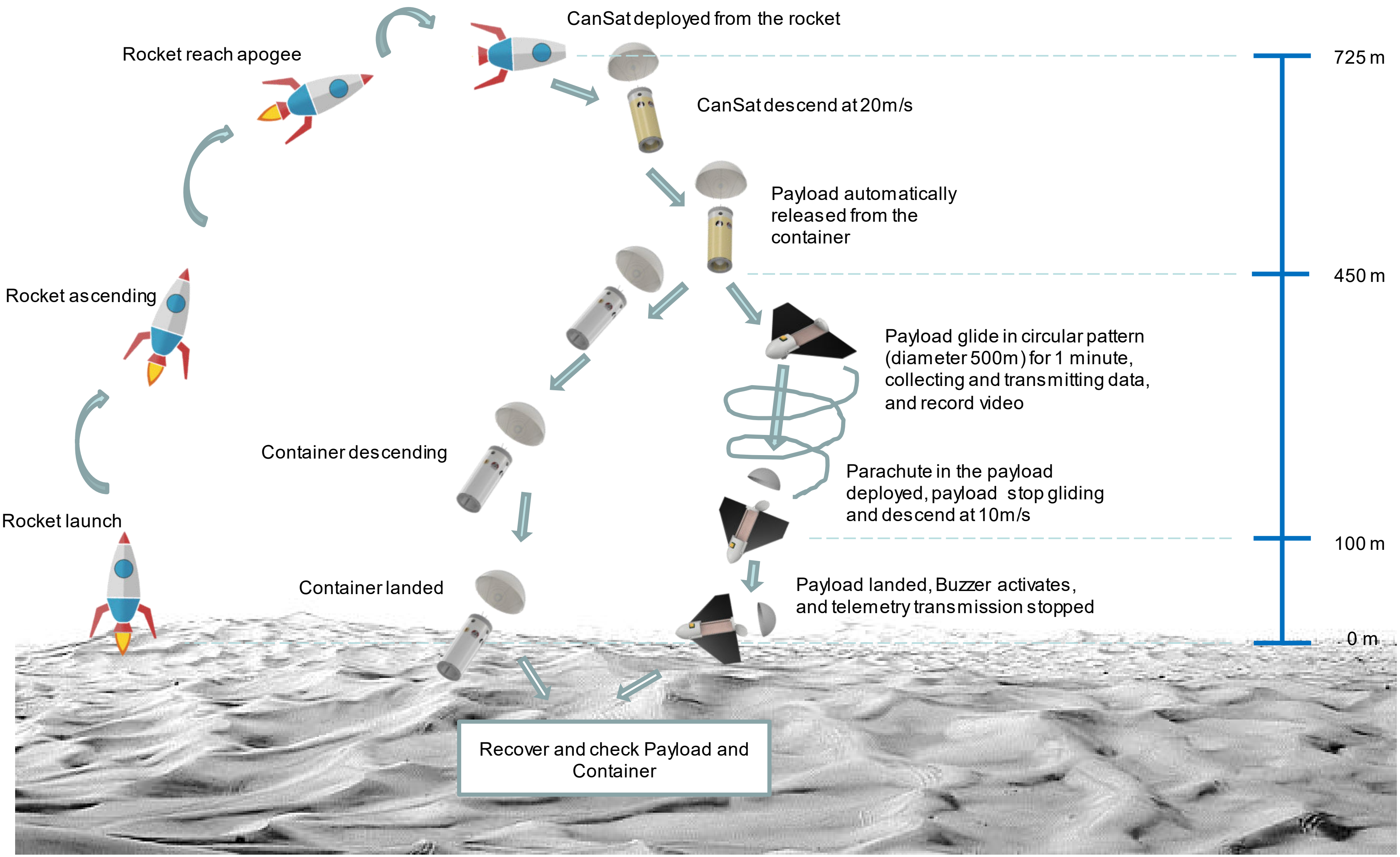


# Physical Layout (8 of 8)

## PAYLOAD DIMENSIONS



# System Concept of Operations (1 of 2)



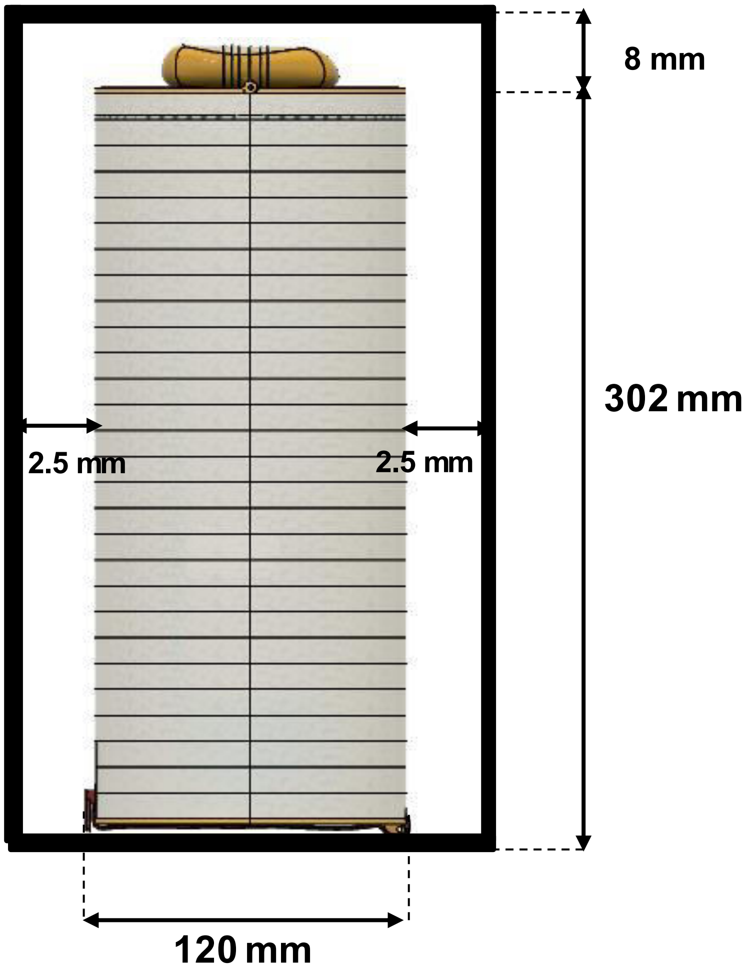
# System Concept of Operations (2 of 2)

| Pre-launch | Launch | Post - Launch |
| --- | --- | --- |
| Team arrival 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 GS 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 | |

# 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 Dyffa**

# Sensor Subsystem Overview

| Selected Component | Type | Function |
|---|---|---|
| Adafruit BMP 388 | Pressure and temperature sensor | Measures air pressure and temperature in payload and in container |
| Ublox SAM M8Q | GPS | Gets payload coordinate (latitude and longitude), GPS time and GPS satellite |
| Voltage divider | Voltage Sensor | Measures voltage of the payload battery |
| MXP7002DP Pitot Tube | Air speed sensor | Measures air speed relative to the payload |
| Sensirion SPS30 | Particle sensor | Counts the particle relative to the payload while gliding |
| Adafruit Mini Spy Camera | Camera | Records a video |

# 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 | ✓ | | ✓ | |
| 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 | ✓ | ✓ | ✓ | |
| 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 | | ✓ | ✓ | |
| RE14 | All electronic components shall be enclosed and shielded from the environment with the exception of sensors. | Competition Requirement | Very High | | ✓ | | |
| RE15 | All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives. | Competition Requirement | Very High | ✓ | | ✓ | ✓ |
| RN18 | The science payload shall measure altitude using an air pressure sensor. | Competition Requirement | Very High | | | ✓ | ✓ |
| RN19 | The science payload shall provide position using GPS. | Competition Requirement | Very High | | | ✓ | ✓ |
| RN20 | The science payload shall measure its battery voltage. | Competition Requirement | Very High | | | ✓ | ✓ |
| RN21 | The science payload shall measure outside temperature. | Competition Requirement | Very High | | | ✓ | ✓ |

# Sensor Subsystem Requirements (2 of 2)

| RN | Requirement | Rationale | Priority | Verification | | | |
|---|---|---|---|---|---|---|---|
| | | | | A | I | T | D |
| RE22 | The science payload shall measure particulates in the air as it glides. | Competition Requirement | Very High | | | ✓ | ✓ |
| RE23 | The science payload shall measure air speed. | Competition Requirement | Very High | | | ✓ | ✓ |
| RN27 | Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost. | Competition Requirement | Very High | ✓ | ✓ | | |
| RN30 | All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.) | Competition Requirement | Very High | ✓ | | | ✓ |
| RN42 | 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 Trade & Selection

| Sensor | Operating Voltage (V) | Weight (g) / Dimension (mm) | Power (uA) | Resolution (Pa) | Accuracy (hPa) | Interface | Cost ($) |
|---|---|---|---|---|---|---|---|
| Adafruit BMP 388 | 1.65 – 3.6 | 1.2<br>21.6 x 16.6 | 3.4 | 0.016 | ±0.08 | I2C, SPI | 9.95 |
| Adafruit BMP 280 | 1.71 – 3.6 | 1.3<br>19.2 x 17.9 | 2.7 | 0.16 | ±0.12 | I2C | 9.95 |
| Adafruit BMP 180 | 1.80 – 3.6 | 1.1<br>16.6 x 16.6 | 2.7 | 1 | ±0.12 | I2C | 9.95 |


| Selected | Rationale |
|---|---|
| Adafruit BMP 388 | • All in one<br>• It has more accuracy and highest resolution compared to other sensors<br>• It provides good pressure data based on our previous experience |

# Payload Air Temperature Sensor Trade & Selection

| Sensor | Operating Voltage (V) | Weight (g) / Dimension (mm) | Power (uA) | Resolution (°C) | Accuracy (°C) | Interface | Cost ($) |
|---|---|---|---|---|---|---|---|
| Adafruit BMP 388 | 1.65-3.6 | 1.2<br>21.6 x 16.6 | 3.4 | 0.005 | ±0.3 | I2C, SPI | 9.95 |
| Adafruit BMP 280 | 1.71-3.6 | 1.3<br>19.2 x 17.9 | 2.7 | 0.01 | ±1 | I2C | 9.95 |
| Adafruit BMP 180 | 1.80 – 3.6 | 1.1<br>16.6 x 16.6 | 2.7 | 0.1 | ±0.5 | I2C | 9.95 |


| Selected | Rationale |
|---|---|
| Adafruit BMP 388 | • All in one<br>• It has more accuracy and highest resolution compared to other sensors<br>• It provides good pressure data based on our previous experience |

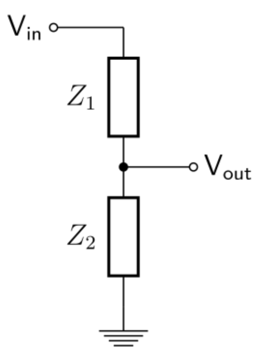
# GPS Sensor Trade & Selection

| Name | Operating Voltage (V) | Weight (g) / Size (mm) | Power (mA) | Channel | Accuracy (m) | Interface | Cost ($) | Update Rate (Hz) |
|---|---|---|---|---|---|---|---|---|
| Matek SAM M8Q + Compass | 4-6 | 7<br>20 x 20 x 10 | 29 | 72 | ~2.5 | UART | 28.99 | 18 |
| Adafruit GPS Ultimate | 3-4.3 | 8.5<br>25.5 x 35 x 6.5 | 20 | 66 | ~3 | UART | 39.95 | 10 |


| Selected | Rationale |
|---|---|
| Matek SAM M8Q + Compass | • It has sufficient channels<br>• Most accurate compared to other GPS<br>• Fast update rate<br>• Lowest cost<br>• Compass sensor included |

# Payload Power Voltage Sensor Trade & Selection

| Name | Range (V) | Error rate (%) | Interface | Cost ($) |
|---|---|---|---|---|
| LTC2945 | 0 / 80 | 0.75 | I2C | 9.95 |
| Microcontroller Analog Pin (Voltage Divider) | 0 / 5 | 0.03 | ADC | ~1 |
| LTC2990 | 2.9 / 5.5 | 0.25 | I2C | 3 |




| Selected | Rationale |
|---|---|
| Microcontroller Analog Pin (Voltage Divider) | • The circuit is simple so it helps reduce payload PCB size<br>• No cost / free |

# Air Speed Sensor Trade & Selection

| Name | Size (in) | Operating Voltage (V) | Operational Environment (°C) | Sensitivity (mV/kPa) | Interface | Cost ($) |
|---|---|---|---|---|---|---|
| MPXV7002DP | 0.7 x 0.75 | 5 | 10 – 60 | 1 | Analog | 16.9 |
| MPX2010DP | 0.7 x 0.75 | 10 - 16 | (-40) – 125 | 2.5 | Analog | 8.99 |

| Selected | Rationale |
|---|---|
| MPXV7002DP | • Available in our country<br>• Higher resolution<br>• The pitot sensor shape fits our payload design |

# Particulate/Dust Sensor Trade & Selection

| Name | Size (mm) | Power (V) | Operational Environment (°C) | Mass Concentration Accuracy (μg/m³) | Interface | Cost ($) | Other |
|---|---|---|---|---|---|---|---|
| Sensirion SPS30 | 41 x 41 x 12 | 5 | -10 to 60 | 1 to 10 | UART, I2C | 46.95 | It has self cleaning procedure |
| Honeywell HPMA115C0-004 | 44 x 36 x 12 | 5 | -20 to 70 | 0 to 1.000 | UART | 63 | Faster response time |
| ZH03 | 50 x 32.4 x 21 | 5 | -10 to 50 | 0.3 | UART, PWM | 30 | - |

| Selected | Rationale |
|---|---|
| Sensirion SPS30 | • Fully calibrated digital output<br>• Able to detect particle up to PM0.5 – PM10<br>• It has self cleaning procedure |

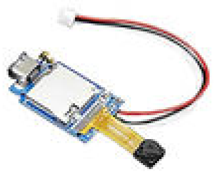
# Container Air Pressure Sensor Trade & Selection

| Sensor | Operating Voltage (V) | Weight (g)/ Size (mm) | Power Consumption (uA) | Resolution (Pa) | Accuracy (hPa) | Interface | Cost ($) |
|---|---|---|---|---|---|---|---|
| Adafruit BMP 388 | 1.65 – 3.6 | 1.2<br>21.6 x 16.6 | 3.4 | 0.016 | ±0.08 | I2C, SPI | 9.95 |
| Adafruit BMP 280 | 1.71 – 3.6 | 1.3<br>19.2 x 17.9 | 2.7 | 0.16 | ±0.12 | I2C | 9.95 |
| Adafruit BMP 180 | 1.80 – 3.6 | 1.1<br>16.6 x 16.6 | 2.7 | 1 | ±0.12 | I2C | 9.95 |


| Selected | Rationale |
|---|---|
| Adafruit BMP 388 | • All in one<br>• It has more accuracy and highest resolution compared to other sensors<br>• It provides good pressure data based on our previous experience |

# Bonus Camera Trade & Selection

| Name | Weight (g) / Size (mm) | Power (V) | Video File Type | Resolution | Interface | Cost ($) | Other |
|---|---|---|---|---|---|---|---|
| SQ 11 | 15<br>22 x 23 x 22 | 5 | AVI | 1280 x 720 | External SD Card | 8.99 | Need some modification for capturing video |
| Adafruit Mini Spy Camera | 2.8<br>28.5 x 17 x 4.2 | 5 | AVI | 640 x 480 | External SD Card | 12.5 | It has a pin to capture photos or video |
| OpenMV M7 | 16<br>44.5 x 35.5 | 3.3 | MJPEG | 640 * 480 | External SD Card | 65 | It has its own processor to process the image frames |



| Selected | Rationale |
|---|---|
| Adafruit Mini Spy Camera | • Small size and lightweight so it helps reduce payload weight and dimension<br>• Easy to trigger video recording with our microcontroller |

# Descent Control Design

Luqman Al Helmy

# Descent Control Overview (1 of 3)

**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 carbon rod and is placed on the front part of the payload
- Wing frame will be held by the inner part of container body during pre deployment
- When deployed, wing frame will create 120 degrees angle, with approximate wing surface area of 286 $cm^2$.

**Payload & Container Descent Control System: Parachute**

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

# Descent Control Overview (2 of 3)

## Descent Control System

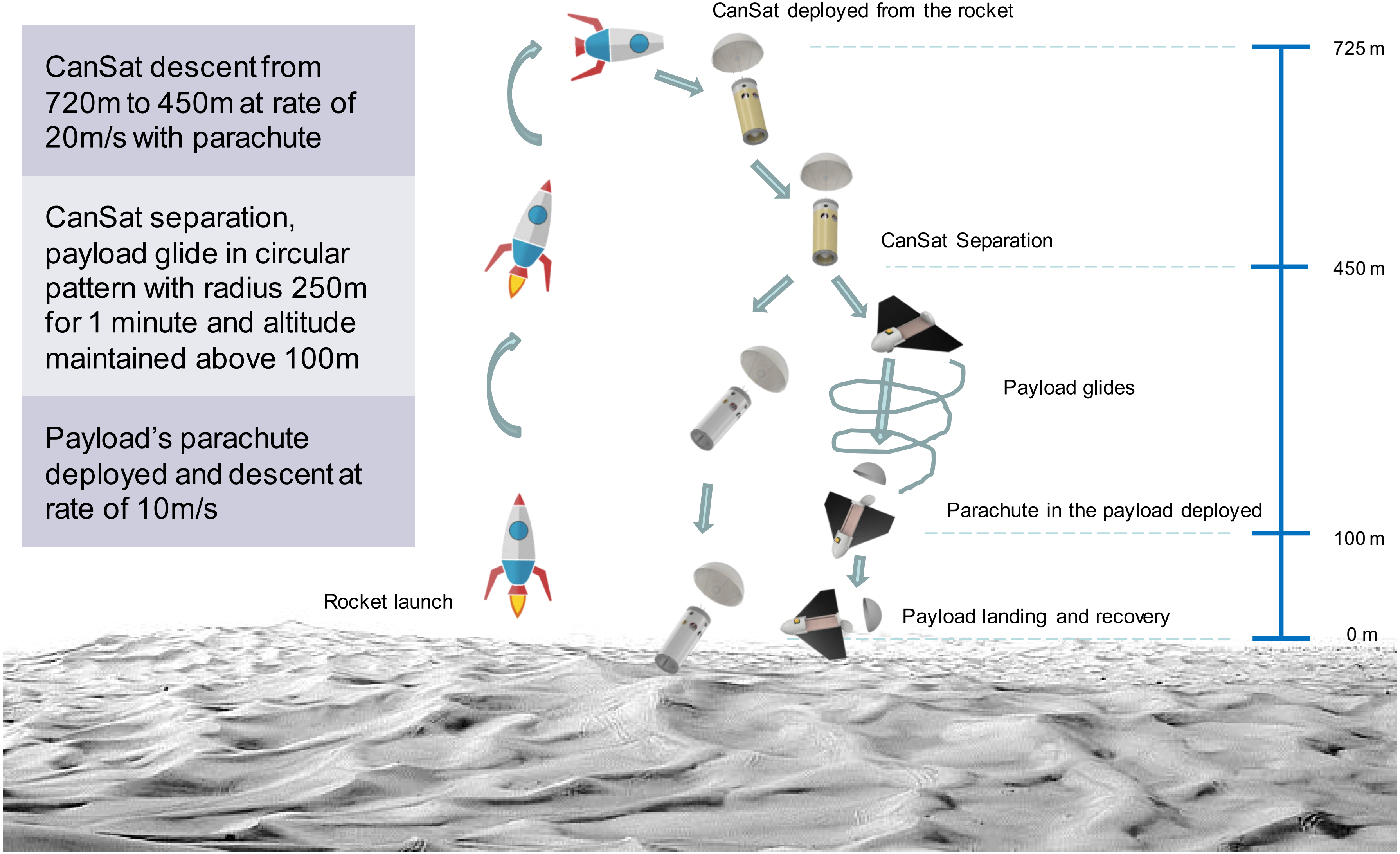
Consist of a Parachute and a deployable delta wing that equipped with secondary parachute

## Descent Order and Deployment

| | |
|---|---|
| Apogee to 450m | • Parachute deployed from the CanSat maintaining descent speed of 20m/s |
| Circular Gliding | • Payload deployed from the container maintaining air time in 500m diameter circular glide trajectory for 1 minute |
| Parachute gliding | • Payload deploys secondary parachute to interrupt the gliding motion and maintaining a descent speed of 10m/s |

# Descent Control Overview (3 of 3)

| |
|---|
| CanSat descent from 720m to 450m at rate of 20m/s with parachute |
| CanSat separation, payload glide in circular pattern with radius 250m for 1 minute and altitude maintained above 100m |
| Payload's parachute deployed and descent at rate of 10m/s |



# Descent Control Requirements (1 of 2)

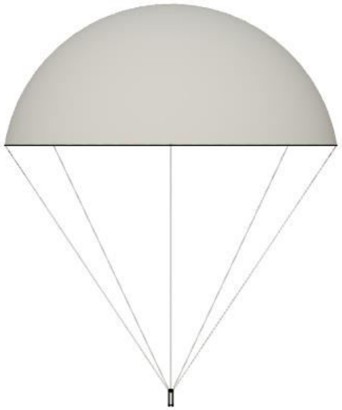
| RN | Requirement | Rationale | Priority | A | I | T | D |
|---|---|---|---|---|---|---|---|
| RN1 | Total mass of the CanSat (science payload and container) shall be 600 grams +/- 10 grams. | Competition Requirement | Very High | ✓ | | ✓ | |
| RN2 | CanSat shall fit in a cylindrical envelope of 125 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 | ✓ | | ✓ | |
| 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 | ✓ | | ✓ | ✓ |

# Descent Control 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 | | ✓ | ✓ | |
| RN26 | The Parachutes shall be fluorescent Pink or Orange | Competition Requirement | Very High | | ✓ | | |

## Pre-Payload Deployment Descent Control Strategies – parachute design

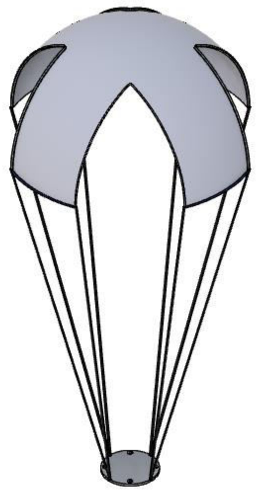
### A. Round Parachute



| Advantages | Disadvantages |
|---|---|
| Higher drag coefficient | Decreased stability in windy environment |
| Easier to deploy | Complex manufacturing process |
| Dimension corresponds to descent rate | - |

# Payload Descent Control Strategy Selection and Trade (2 of 8)

## B. Cruciform Parachute



| Advantages | Disadvantages |
|---|---|
| Easier Manufacturing Process | Lower drag, higher descent rate |
| Steady descent due to lower oscillations | Larger stowing space is required |
| Easier folding procedures | Harder to deploy |

# Payload Descent Control Strategy Selection and Trade (3 of 8)

**Parachute Design Selection**

Scoring with a scale of 1 to 10 (1 is the least and 10 is the most) can be conducted referring to the features of each design. The following table will show the score of each parachute design.

| Option | Ease of Manufacture | Reliability | Durability | Total |
|---|---|---|---|---|
| A | 6 | 9 | 8 | 23 |
| B | 9 | 7 | 6 | 22 |

**Chosen Option :** **Option A**

Round Parachute is preferred due to its high coefficient of drag. Descent rate can be easily modified by modifying the diameter of the parachute.

# Payload Descent Control Strategy Selection and Trade (4 of 8)

**Post Payload Deployment Descent Control Strategies – Wing Characteristic**

## A. Flexible Wing

Image source: http://caromotors.com/hang-gliders-for-sale.html

| Advantages | Disadvantages |
|---|---|
| Better portability | Lower durability in high wind speeds |
| Easier process of manufacture | Faster descent speed |
| Easier to shape to delta wing configuration | Wing shape can be affected by external force |
| Lighter mass | - |

# Payload Descent Control Strategy Selection and Trade (5 of 8)

## B. Rigid Wing

Image source: http://www.vortex-rc.com/?attachment_id=4879

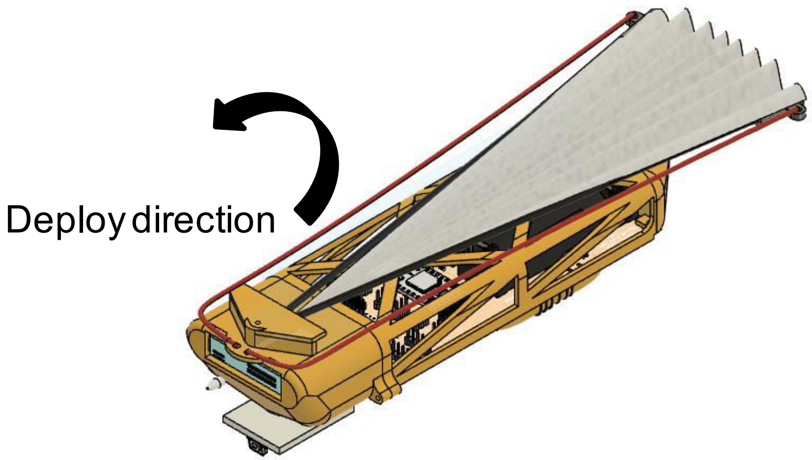
| Advantages | Disadvantages |
| --- | --- |
| Can operate firmly under high speed wind | Complex process of manufacture |
| Ability to modify profile to create airfoil | Requires complex stowing mechanism |
| Structural durability | Ideal dimension is harder to determine |

**Chosen Option : Option A**

Flexible wing is preferred due to its portability. Descent rate can be easily modified by modifying the wingspan

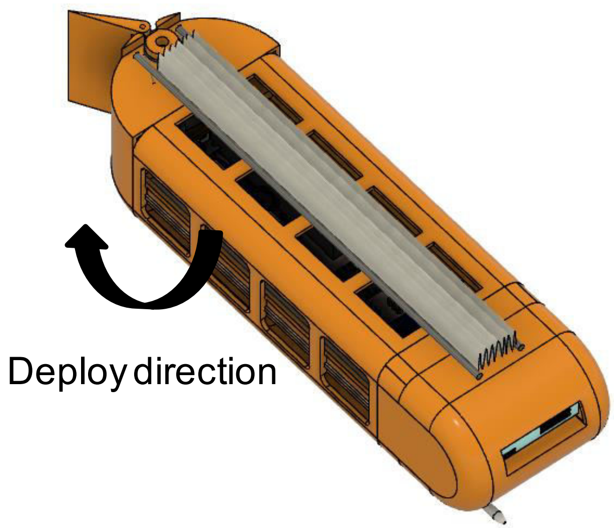
**Post Payload Deployment Descent Control Trade - wing rod placement**

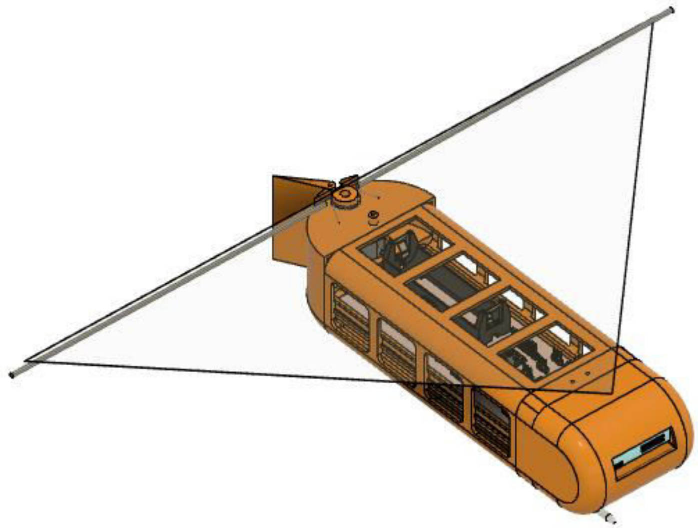
## A. Front Rod placement




| Advantages | Disadvantages |
|---|---|
| Minimize damage to the flexible wing under high wind speed condition | Smaller wing surface area, smaller lift produced by drag |
| Front wing rod act as small airfoil, giving payload slight additional lift | - |

## B. Rear Rod placement



| Advantages | Disadvantages |
|---|---|
| Larger surface area, greater lift produced by drag | Reduced overall wing durability |

# Payload Descent Control Strategy Selection and Trade (8 of 8)

**Rod Placement Position Selection**

Scoring with a scale of 1 to 10 (1 is the least and 10 is the most) can be conducted referring to the features of each position. The following table will show the score of each rod position.

| Option | Ease of Manufacture | Reliability | Durability | Total |
|---|---|---|---|---|
| A | 7 | 7 | 8 | 22 |
| B | 7 | 7 | 6 | 20 |

**Chosen Option : Option A**

Despite minimizing the surface area, front placed wing rod will help increase the durability of the flexible wing. Durability of the wing will help the payload capability to glide

## Post Payload Deployment Descent Stability Strategies – Wing Position

### A. High Wing

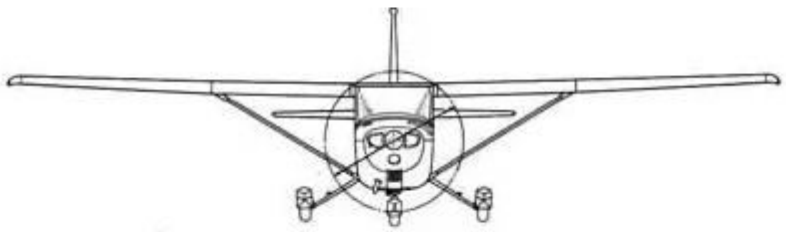


Image source: https://www.quora.com/

| Advantages | Disadvantages |
|---|---|
| Better lateral stability | Higher structural weight |
| More suitable for low speed aircraft | - |
| Better roll stability due to fuselage position | - |
| Higher drag coefficient, better lift | - |

# Payload Descent Stability Control Strategy Selection and Trade (2 of 6)

## B. Low Wing

Image source: https://www.quora.com/

| Advantages | Disadvantages |
| --- | --- |
| High maneuverability | Lower drag coefficient, smaller lift |
| Lower structural weight | Worse lateral stability |
| - | Not suitable for low speed aircraft |

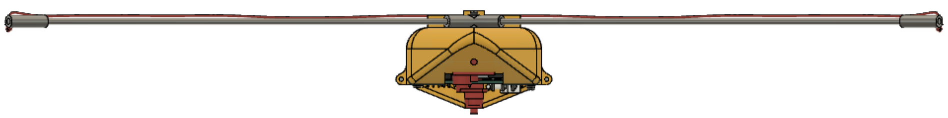
**Chosen Option :** **Option A**

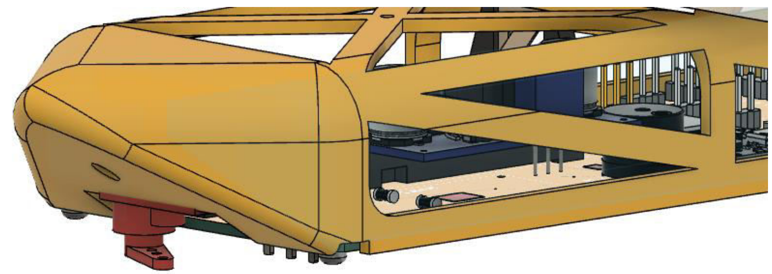
High wing is preferred due to its high drag and high lift. Higher lift can aid the payload to glide better.

# Payload Descent Stability Control Strategy Selection and Trade (3 of 6)

## Post Payload Deployment Descent Stability Strategies – Control type

### A. Passive control

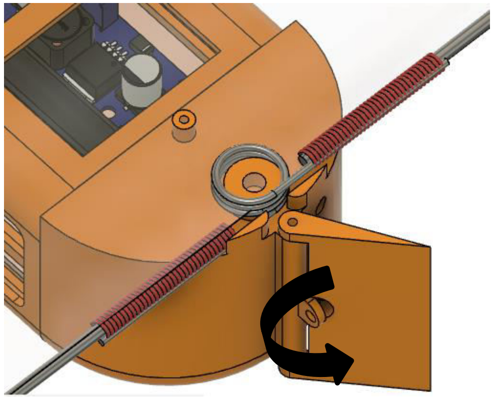


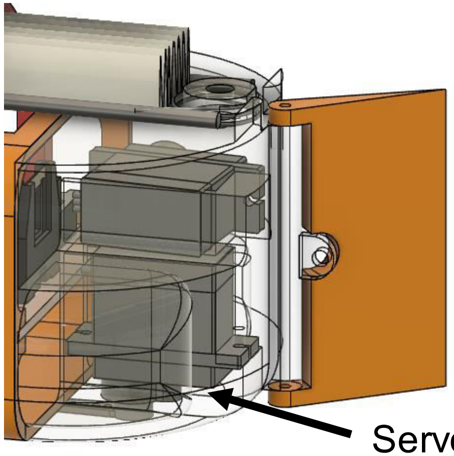


| Advantages | Disadvantages |
|---|---|
| Easier to adjust to find the ideal center of lift | Flight characteristic fully depending on surrounding environment |
| Aerodynamic, pressure, and mass center would align in single axis due to the design | - |
| No additional mechanism | - |

# Payload Descent Stability Control Strategy Selection and Trade (4 of 6)

## B. Active fin control




| Advantages | Disadvantages |
|---|---|
| Adaptive with various flight condition | Heavier system |
| Controllable flight characteristic | Requires complex program to execute |
| - | May reduce glide reliability |

## Control Type Selection

Scoring with a scale of 1 to 10 (1 is the least and 10 is the most) can be conducted referring to the features of each control type. The following table will show the score of each rod position.

| Option | Ease of Manufacture | Reliability | Durability | Total |
|---|---|---|---|---|
| A | 9 | 8 | 8 | 25 |
| B | 5 | 6 | 7 | 18 |

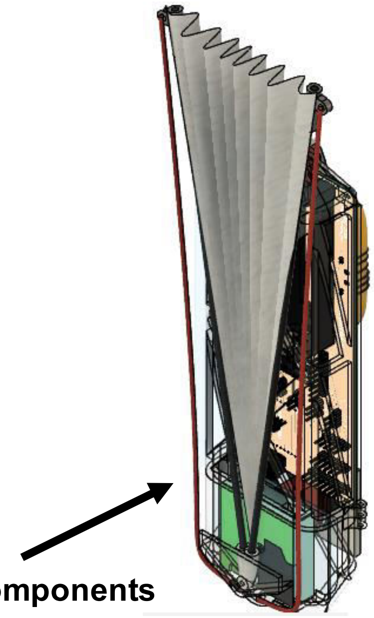
**Chosen Option : Option A (Passive)**

Despite not having the ability to control the payload during descent, easy adjustments can be made to find the ideal center of lift

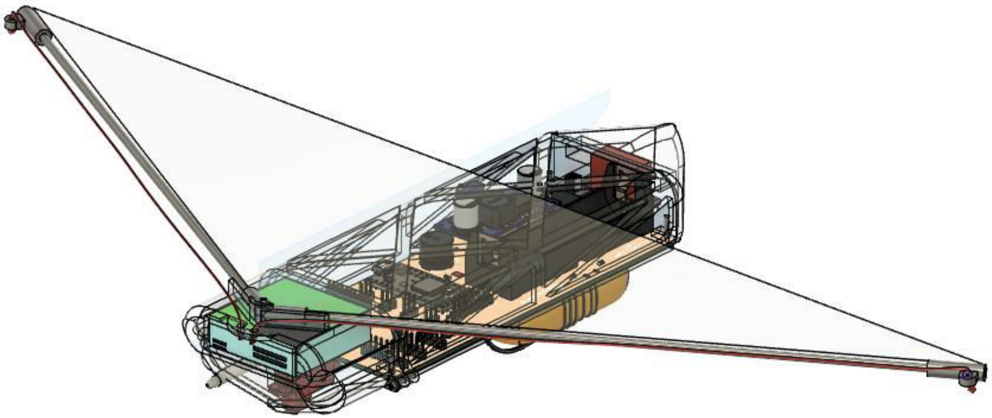
# Payload Descent Stability Control Strategy Selection and Trade (6 of 6)

**Maintaining Nadir Direction**

- 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 low part of the CanSat. Maintaining the nadir direction and preventing the CanSat from tumbling
- Upon deployment, the wing will modify the position of the center of mass. Hence, during the gliding phase, stable gliding can be achieved.



**Major components location**



# 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 $M_P = 0.45\ [kg]$
- Container mass $M_{Co} = 0.15\ [kg]$
- Payload wing root chord $R_C = 0.13\ [m]$
- Payload wingspan $W_s = 0.44\ [m]$
- 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:

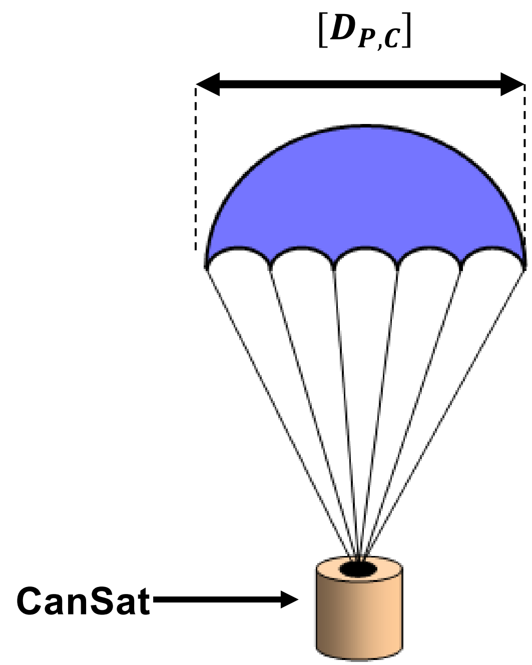
$$A = \frac{1}{4}\pi D_{P,C}^2$$

Hence, D can be obtained by:

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

Where:

$$W_c = M_c\, g$$



# Descent Rate Estimates (4 of 8)

## 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 $[v_1 = 25\, m/s]$

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

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

| 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

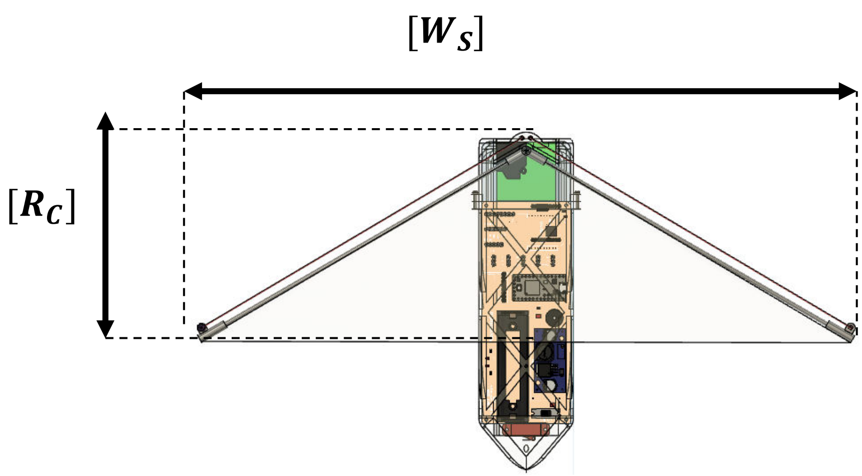
$$\boldsymbol{W_{Co} = M_{Co}\, g}$$

# 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

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

$$W_P = M_P\, g$$

# 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 $[15\ m/s]$

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

$$0.56[-] \leq C_{D,W} \leq 5.05[-]$$

| 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 4.5 N.

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

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

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

$$0.1493[m] \leq D_{P,P} \leq 0.4480\ [m]$$

| Chosen Diameter |
| --- |
| 0.20 m |

To provide adequate resistance and minimize space while stowed

# Descent Rate Estimates (8 of 8)

**Descent Rates Estimation**

1. CanSat Descent Rate estimation (with chosen parachute diameter)

$$v_C = \sqrt{\frac{8W_C}{\rho D_{P,C}^2 \pi C_{D,P}}} = 17.24\ [m/s]$$

2. Container Descent Rate Estimation (with chosen parachute diameter)

$$v_{Co} = \sqrt{\frac{8W_{Co}}{\rho D_{P,C}^2 \pi C_{D,P}}} = 8.62\ [m/s]$$

3. Payload gliding phase Descent Rate Estimation (with chosen drag coefficient)

$$v_{P,G} = \sqrt{\frac{4W_P}{R_C W_S \rho C_{D,W}^2}} = 9.37\ [m/s]$$

4. Payload post gliding phase Descent Rate Estimation (with chosen parachute diameter)

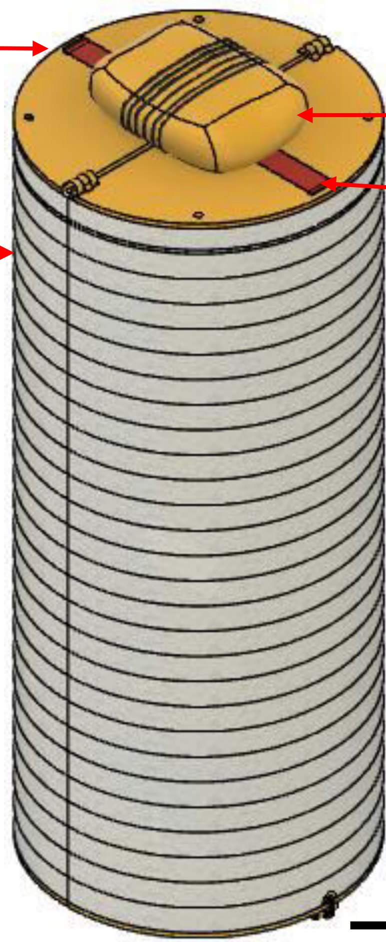
$$v_{P,P} = \sqrt{\frac{8W_P}{\rho D_{P,P}^2 \pi C_{D,P}}} = 11.20\ [m/s]$$

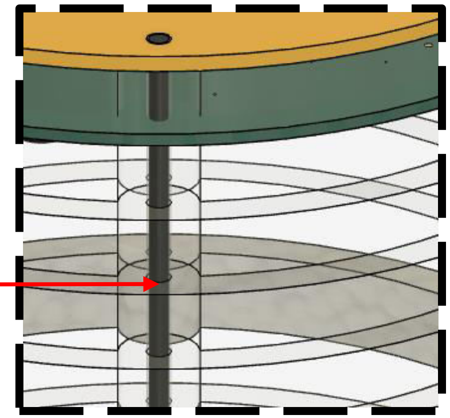
# Mechanical Subsystem Design

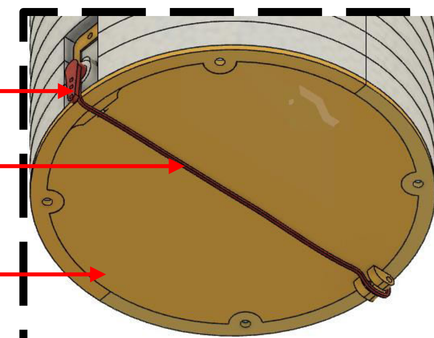
**Luqman Al Helmy**

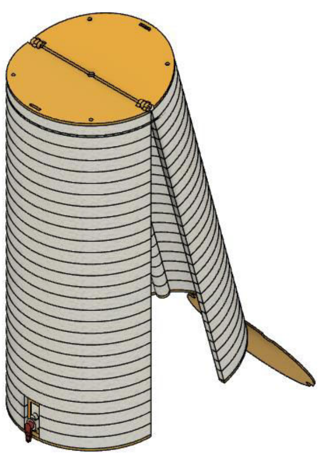
# Mechanical Subsystem Overview (1 of 2)

## CONTAINER DESIGN OVERVIEW



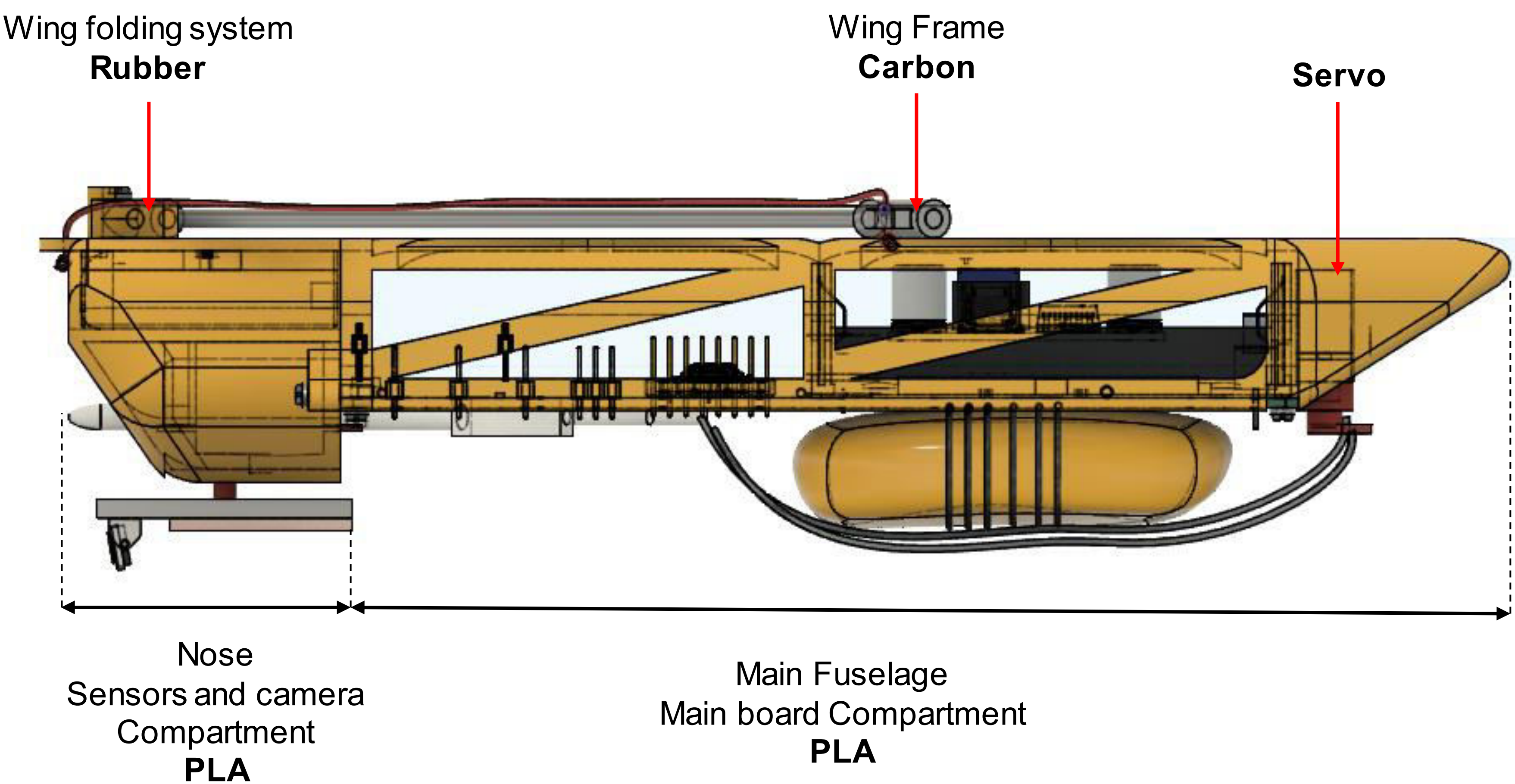



**Deployed configuration**

# Mechanical Subsystem Overview


## PAYLOAD DESIGN OVERVIEW



# 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 | ✓ | | ✓ | |

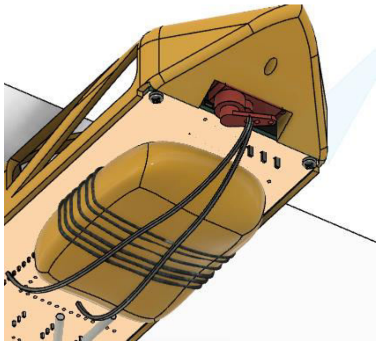
# Mechanical Sub-system Requirements (2 of 2)

| 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 | | ✓ | ✓ | |
| RN14 | All electronic components shall be enclosed and shielded from the environment with the exception of sensors. | | Very High | | ✓ | | |
| RN15 | All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives. | | Very High | ✓ | | ✓ | ✓ |
| RN16 | All mechanisms shall be capable of maintaining their configuration or states under all forces. | Competition Requirement | Very High | ✓ | ✓ | | ✓ |
| RN17 | 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 | | ✓ | | |

# Payload Mechanical Layout of Components Trade & Selection (1 of 12)

## Payload Design A - Overview

**Stowed Configuration View**



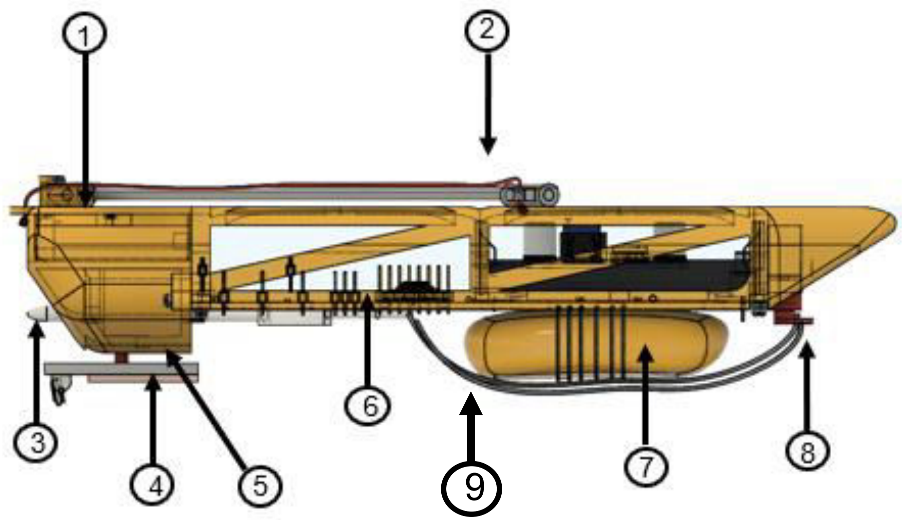
**Parachute mechanism View**

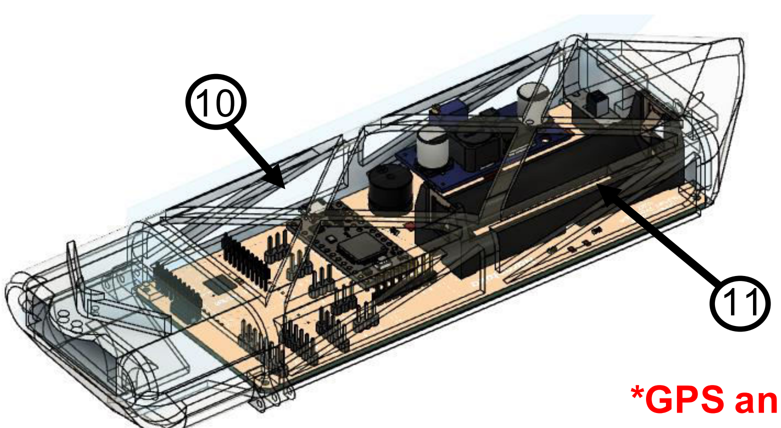
**Deployed Configuration View**

| Payload Layout Key Trade Issues |
| --- |
| Overall Fuselage – Design A<br><br>+ Higher aerodynamic stability<br>+ Smaller size, lighter mass<br>+ Stronger frame<br><br>- Camera is harder to mount<br>- Glide direction can not be controlled |
| Parachute Compartment – Design A<br><br>+ No lid, no additional mass<br>+ Easier to deploy<br><br>- Parachute might accidentally released while gliding |

# Payload Mechanical Layout of Components Trade & Selection (2 of 12)

## Payload Design A – components layout



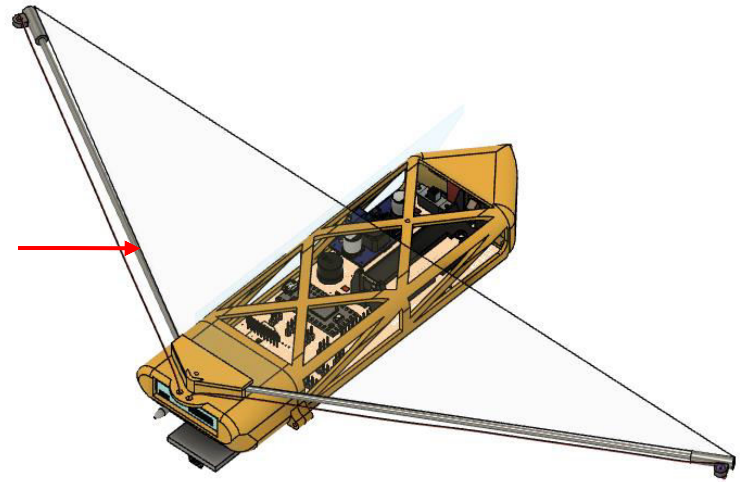

*GPS and XBEE will be mounted on the PCB

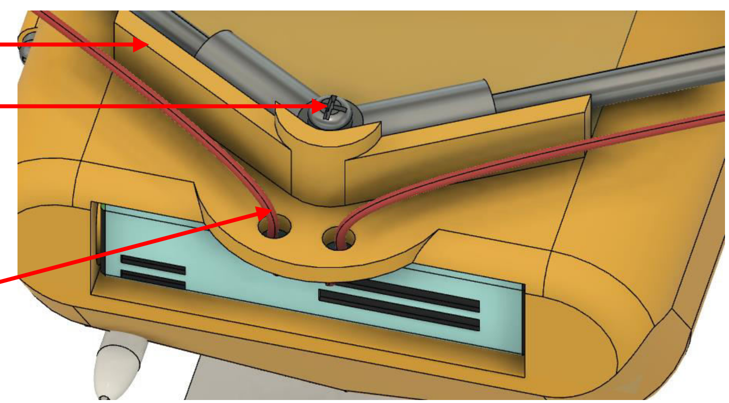
| | Component |
|---|---|
| 1 | Dust particle sensor |
| 2 | Wing Mechanism (rubber + carbon wing rod) |
| 3 | Pitot tube |
| 4 | Camera |
| 5 | Camera servo |
| 6 | Payload main board |
| 7 | Parachute (folded with rubber) |
| 8 | Parachute servo |
| 9 | Parachute rubber |
| 10 | Microcontroller |
| 11 | Battery |

# Payload Mechanical Layout of Components Trade & Selection (3 of 12)

## Payload Design A – Wing Layout

| Key Features |
|---|
| Wing rod joint located at the payload nose |
| Rubber is used to pull open the wing during deployment |
| The barrier is used to maintain the wing angle at 120 degrees when deployed |
| Wing surface is made of foldable HDPE plastic |

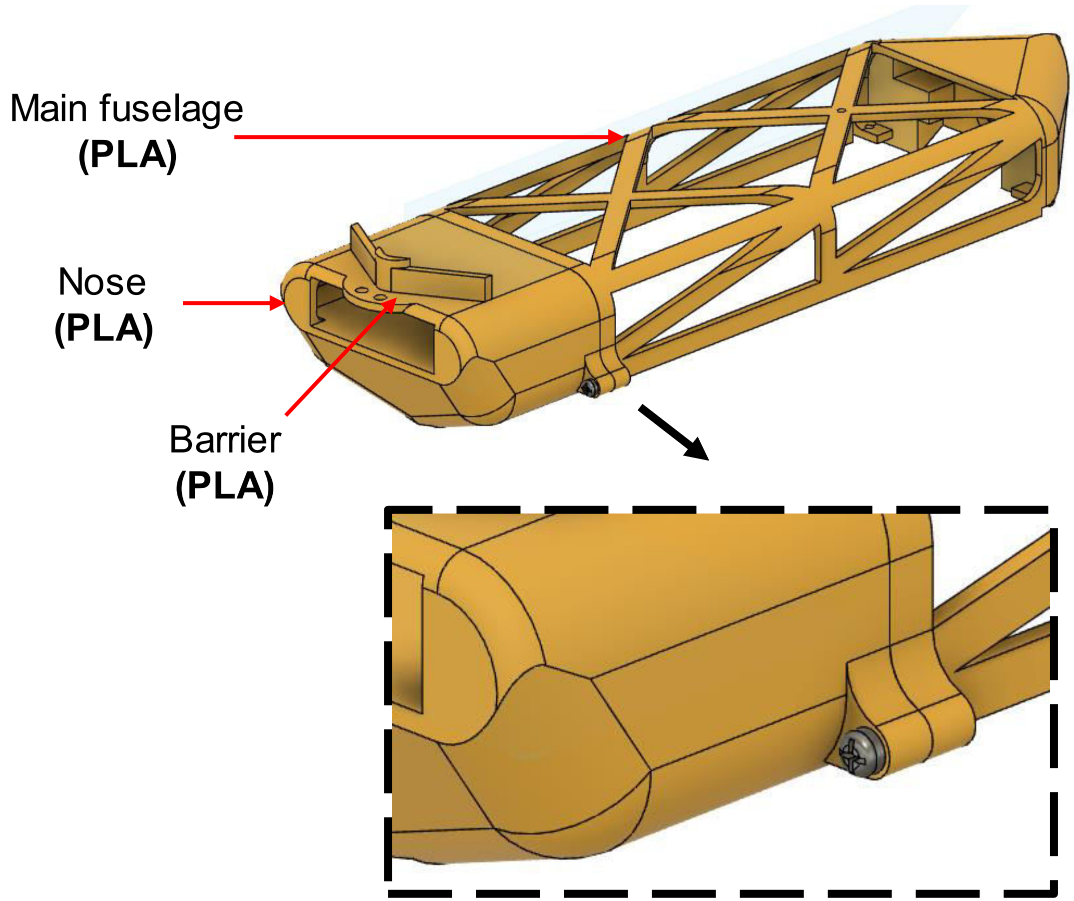


# Payload Mechanical Layout of Components Trade & Selection (4 of 12)

## Payload Design A – Structure

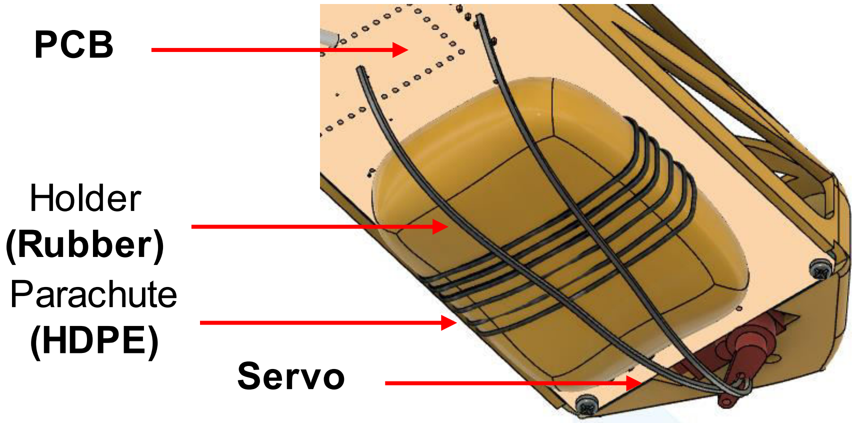
| Key Features |
|---|
| Overall structure is 3D printed, infill density can be modified to alter overall mass |
| Structure consist of nose and main body |
| Structure does not have parachute lid |
| Structure is assembled using 2mm bolt on each side |

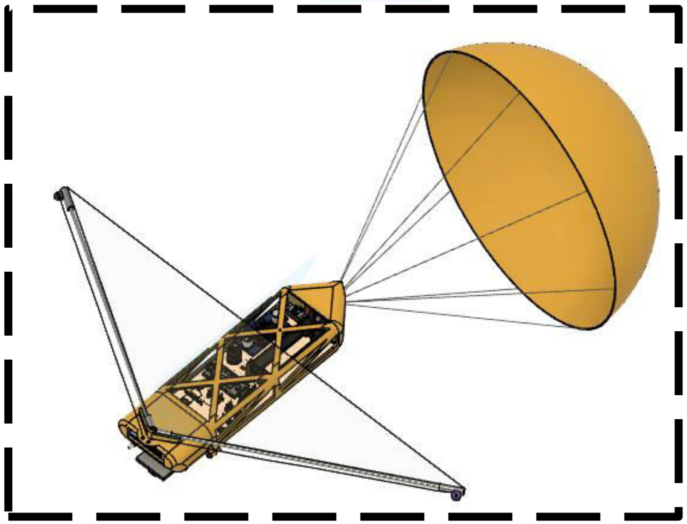



**Parts are connected by 2mm bolt on each side (2 in total)**

## Payload Design A – Parachute Mechanism

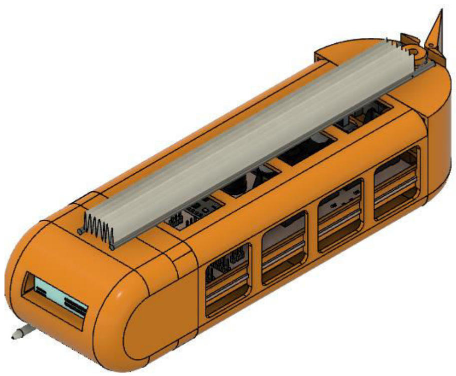
| Key Features |
| --- |
| Parachute is stowed using rubber that connects to a servo |
| Servo will release the rubber after gliding phase is completed |
| No additional lid, lighter mass |



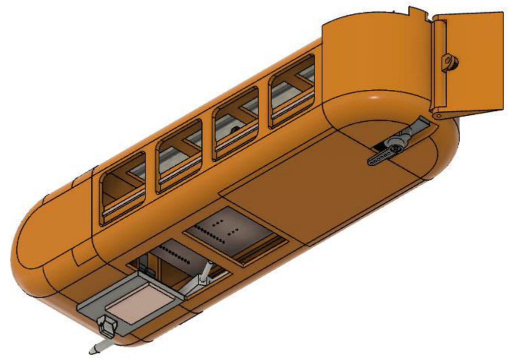



# Payload Mechanical Layout of Components Trade & Selection (6 of 12)

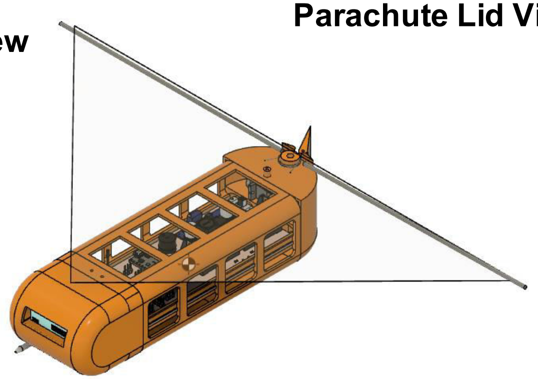
## Payload Design B - Overview



**Stowed Configuration View**



**Parachute Lid View**

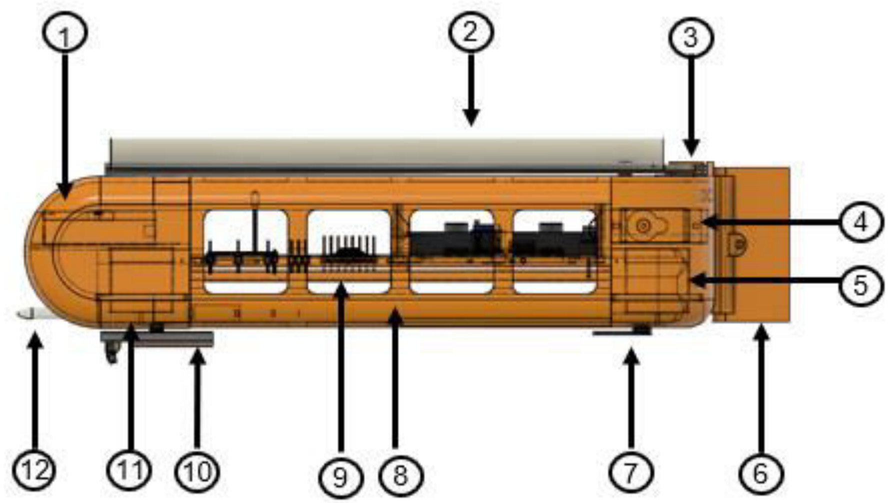


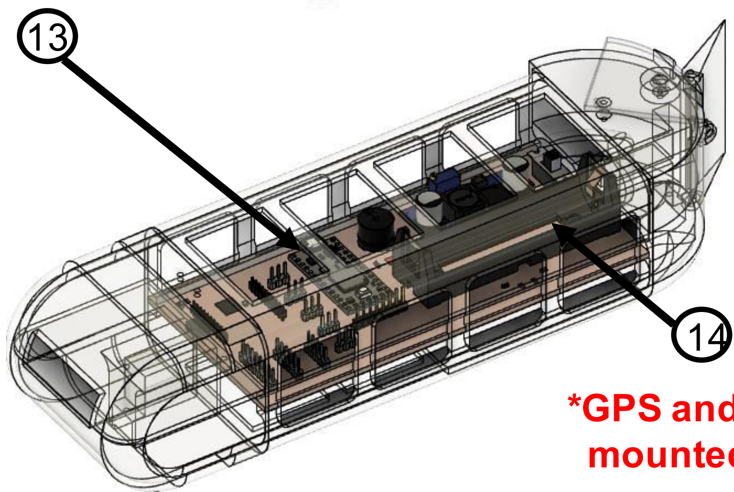
**Deployed configuration view**

| Payload Layout Key Trade Issues |
|---|
| Overall Fuselage – Design B<br><br>+ Greater protection for electronics<br>+ Larger size, can facilitate active control<br><br>- High horizontal drag due to its size<br>- Larger size, higher mass |
| Parachute Compartment – Design B<br><br>+ Parachute lid prevents the parachute from opening while gliding<br><br>- Need to introduce additional lid mass |

# Payload Mechanical Layout of Components Trade & Selection (7 of 12)

## Payload Design B – components layout



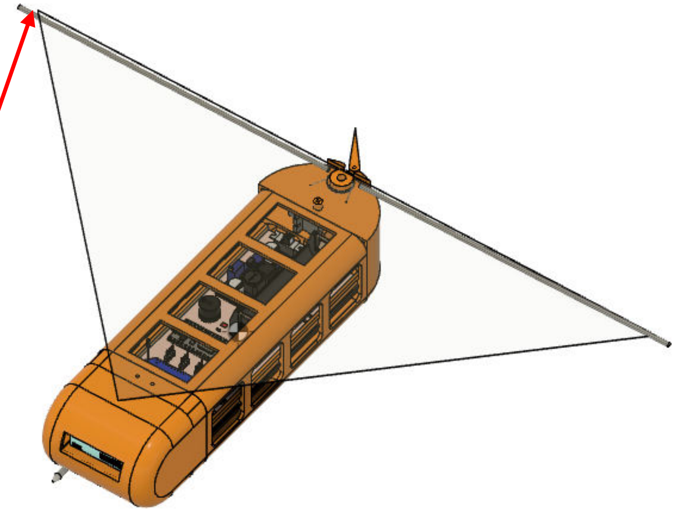



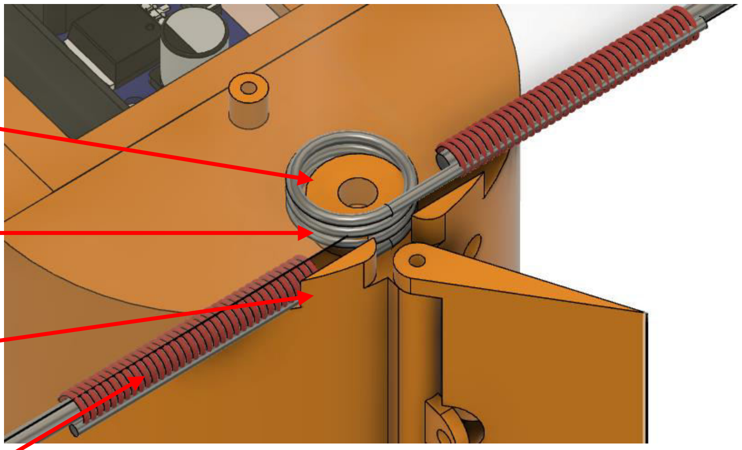

*GPS and XBEE will be mounted on the PCB

| | Component |
|---|---|
| 1 | Dust particle sensor |
| 2 | Wing (folded) |
| 3 | Wing mechanism |
| 4 | Fin servo |
| 5 | Parachute lid servo |
| 6 | Fin |
| 7 | Parachute lid |
| 8 | Parachute (folded) |
| 9 | Payload main board |
| 10 | Camera mechanism |
| 11 | Camera servo |
| 12 | Pitot tube |
| 13 | Microcontroller |
| 14 | Battery |

## Payload Design B – wing layout

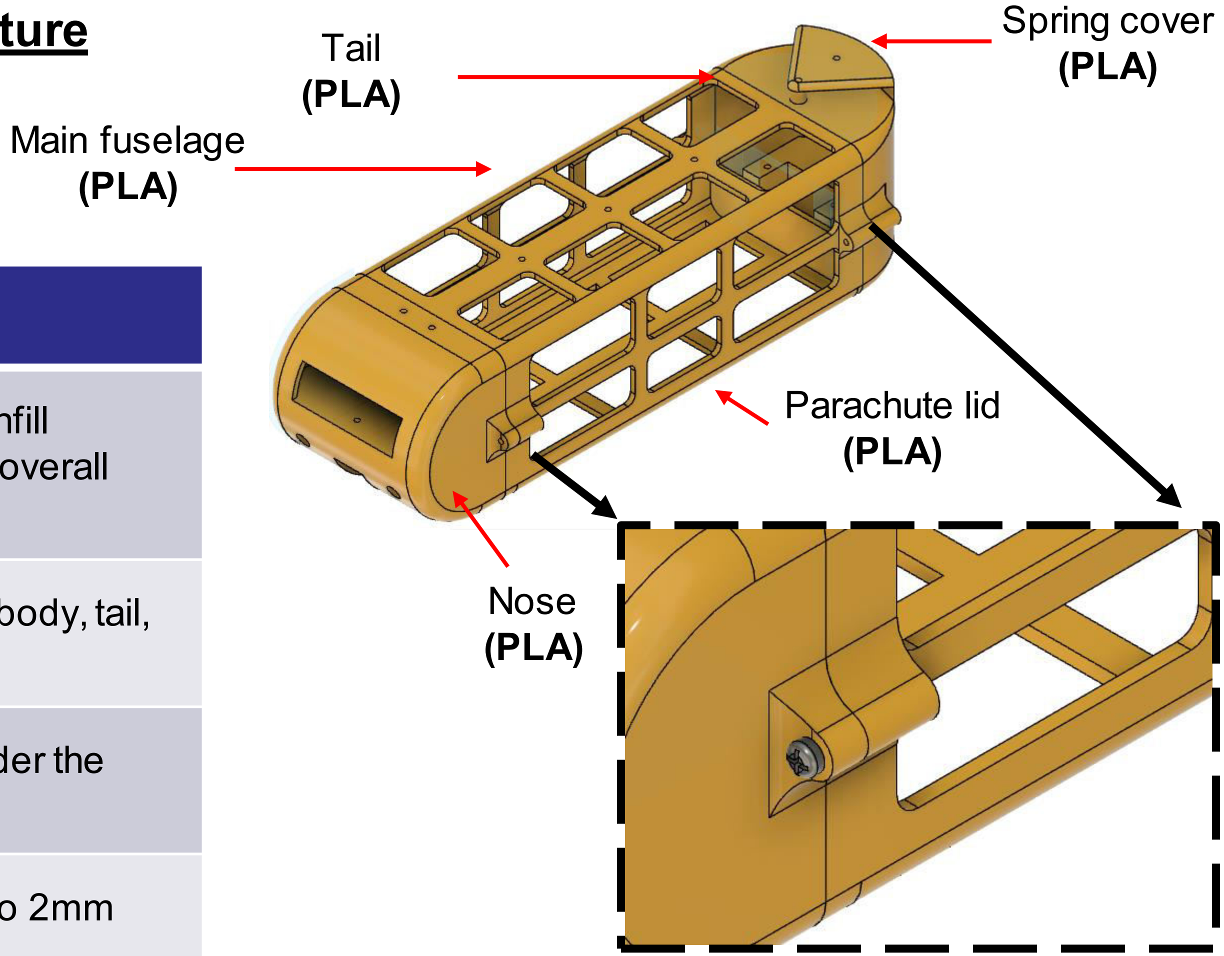
| Key Features |
|---|
| Wing rod joint located at the payload tail |
| Torsion spring is used to pull open the wing during deployment |
| The barrier is used to maintain the wing angle at 180 degrees when deployed. Ensuring larger wing surface area |
| Wing surface is made of foldable HDPE plastic |
| Connection between spring and the rod is made by sewing thread |



# Payload Mechanical Layout of Components Trade & Selection (9 of 12)

## Payload Design B – Structure



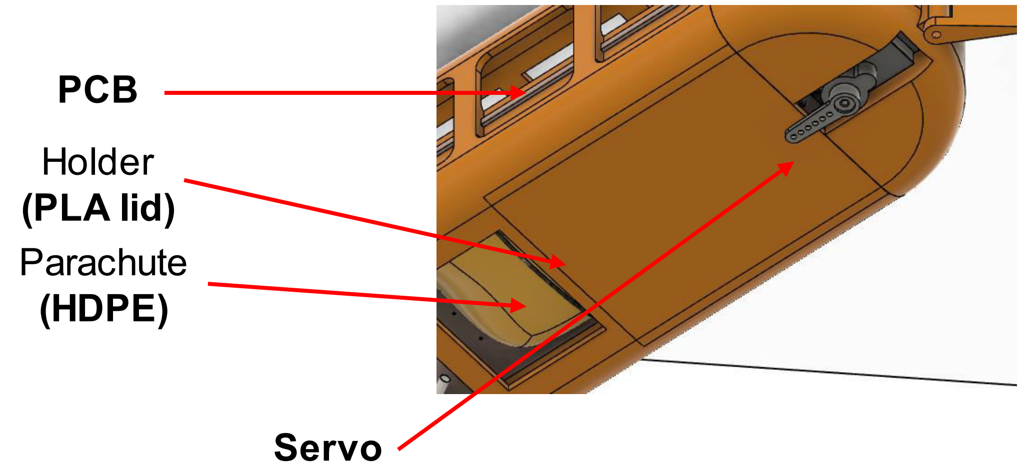

Parts are connected by 2 2mm bolts on each side (4 in total)

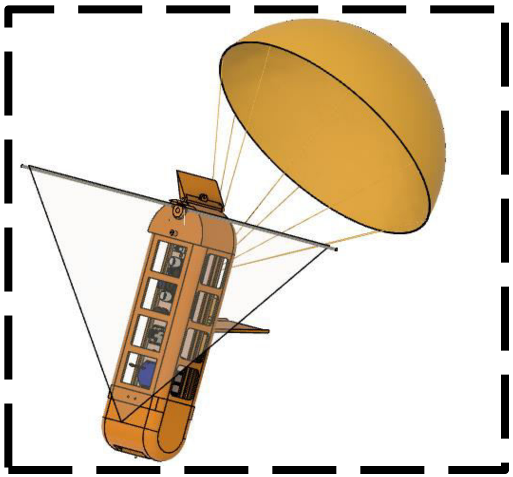
| Key Features |
|---|
| Overall structure is 3D printed, infill density can be modified to alter overall mass |
| Structure consist of nose, main body, tail, and spring cover |
| Structure have parachute lid under the main body |
| Structure is assembled using two 2mm bolts on each side |

# Payload Mechanical Layout of Components Trade & Selection (10 of 12)

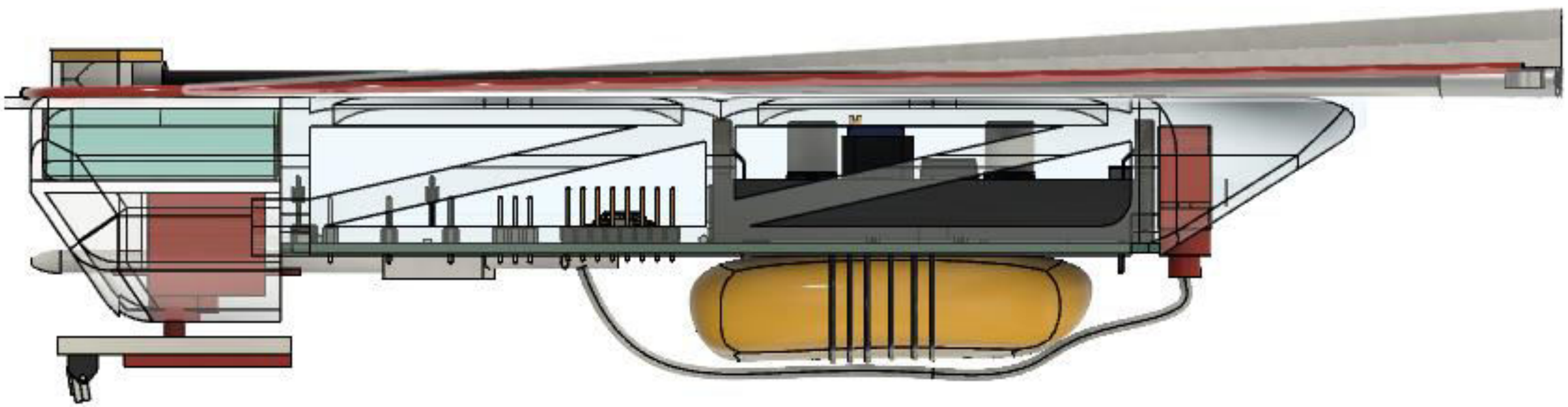
## Payload Design B – Parachute mechanism

| Key Features |
|---|
| Parachute is stowed using parachute lid and servo |
| Servo will open the parachute lid after gliding phase is complete |
| Additional lid ensures the parachute stowed while gliding |



## Payload Design Trade Selection



**Chosen Design :** **Design A**

Overall design have simpler mechanisms and design A allows the front facing wing rod placement to better support the flexible wing

# Payload Mechanical Layout of Components Trade & Selection (12 of 12)

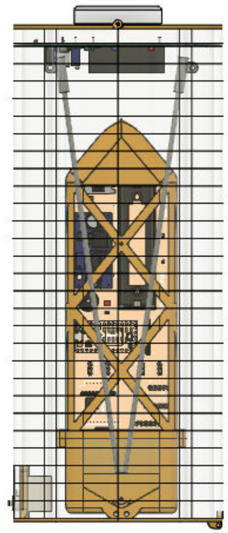
## Payload Structure Material Trade Selection

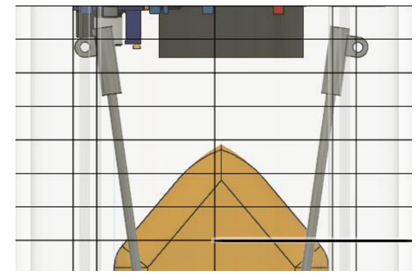
| Structure | Options | Selection | Rationale(s) |
|---|---|---|---|
| Main structure | • Polyfoam<br>• 3D Printed ABS<br>• EPP foam<br>• 3D Printed PLA | 3D Printed PLA | Easy manufacture, considerable strength |
| Deployable Wing and parachute | • Nylon trilobal<br>• Kevlar<br>• Polyfoam<br>• HDPE plastic | HDPE plastic | Lightweight, obtainable |
| Wing frame | • Aluminum<br>• Carbon Fiber | Carbon fiber | Lightweight yet durable |

# Payload Pre-Deployment Configuration Trade & Selection (1 of 3)

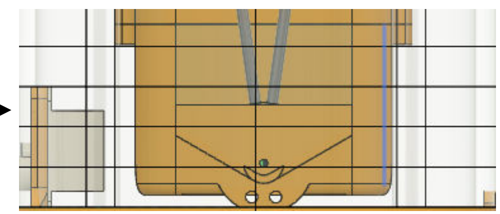
## Payload Pre-Deployment Configuration – Wing stow mechanism

### A. Container Aided Wing Stow Mechanism





Wing frame held by container body

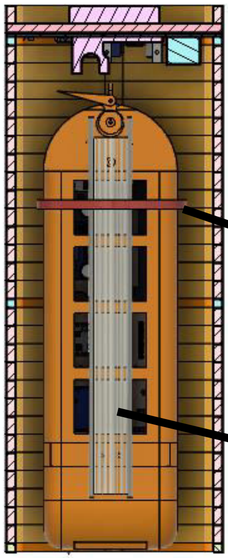


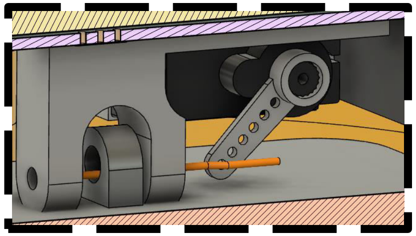
Payload resting point

| Advantages | Disadvantages |
|---|---|
| Higher chance of successful release | Container electronics is harder to access |
| Payload can be firmly placed inside the container | More complex overall mechanism |
| Better structural durability | - |
| Payload does not need additional mechanism to hold the wing | - |

# Payload Pre-Deployment Configuration Trade & Selection (2 of 3)

## B. Rubber aided wing stow mechanism





Detail on Servo Mechanism

Approximate rubber position during payload pre deployment. The rubber will be released during separation

Approximate wing rod position during stowed position

| Advantages | Disadvantages |
|---|---|
| Stow mechanism is easier to manufacture | Require additional mechanism to hold the wing |
| Predictable release direction | Payload is not firmly placed inside the container |
| Precise release time | - |

# Payload Pre-Deployment Configuration Trade & Selection (3 of 3)

**Stow Mechanism Selection**

Scoring with a scale of 1 to 10 (1 is the least and 10 is the most) can be conducted referring to the features of each mechanism. The following table will show the score of each mechanism.

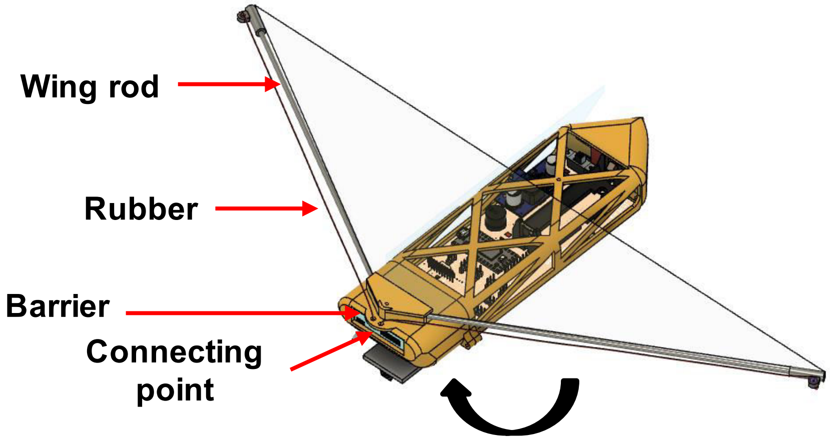
| Mechanism | Ease of Manufacture | Reliability | Durability | Total |
|---|---|---|---|---|
| A | 6 | 8 | 7 | 21 |
| B | 8 | 6 | 6 | 20 |

**Chosen Mechanism : Mechanism A**

Mechanism A will ensure the payload to have higher chance of release success

## Payload Deployment Configuration – wing release mechanism

### A. Rubber wing release mechanism

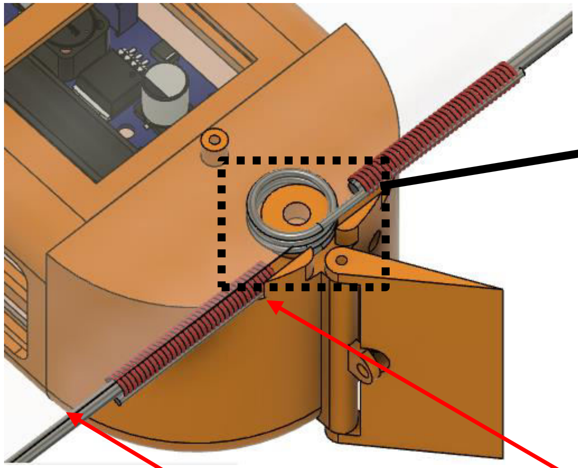


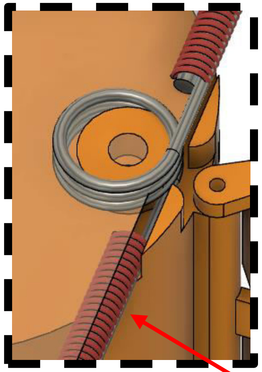

**The rubber connected to the wing rod, will pull the rod to the connecting point. As a result, the wing will open until the rod reaches the barrier**

| Advantages | Disadvantages |
|---|---|
| Better mechanism durability | Needs to find the rubber with ideal elasticity |
| Better chance of success | More complex manufacture process |
| Slightly smaller mass | Rubber needs to be checked before flight to ensure desired elasticity |
| Mechanism can be easily adjusted | |

# Payload Deployment Configuration Trade & Selection (2 of 3)

## B. Torsion Spring wing release mechanism




**The torsion spring will push the wing rod until it reaches the barrier**

| Advantages | Disadvantages |
|---|---|
| Prebuilt mechanism, no need to find ideal elasticity | Low durability and reliability |
| Easier manufacture process | Small adjustment is harder to make |

# Payload Deployment Configuration Trade & Selection (3 of 3)

**Wing Deployment Mechanism Selection**

Scoring with a scale of 1 to 10 (1 is the least and 10 is the most) can be conducted referring to the features of each mechanism. The following table will show the score of each mechanism.

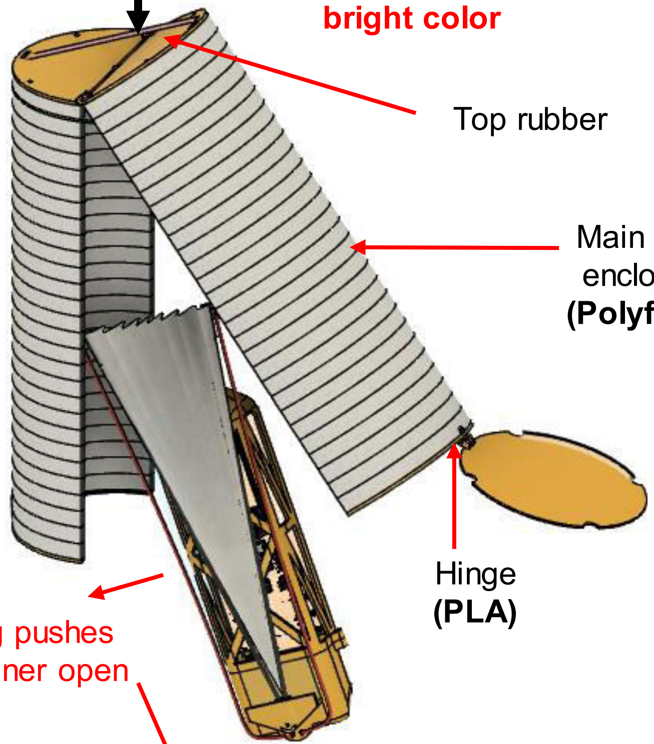
| Mechanism | Ease of Manufacture | Reliability | Durability | Total |
|---|---|---|---|---|
| A | 7 | 7 | 8 | 22 |
| B | 8 | 5 | 6 | 19 |

**Chosen Mechanism : Mechanism A**

Rubber mechanism is preferred, rubber mechanism offers ease of adjustments that can be made. This will benefit during system testing

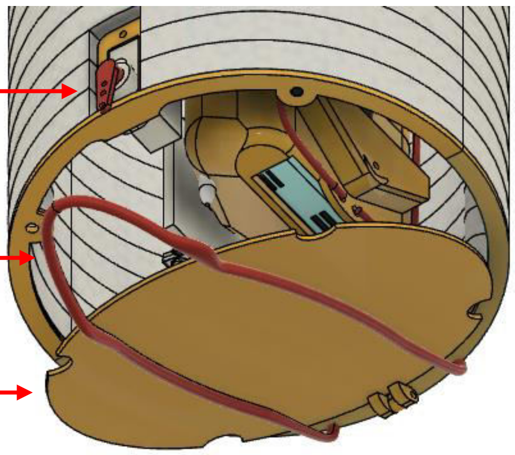
# Container Mechanical Layout of Components Trade & Selection (1 of 4)

## Design A overview

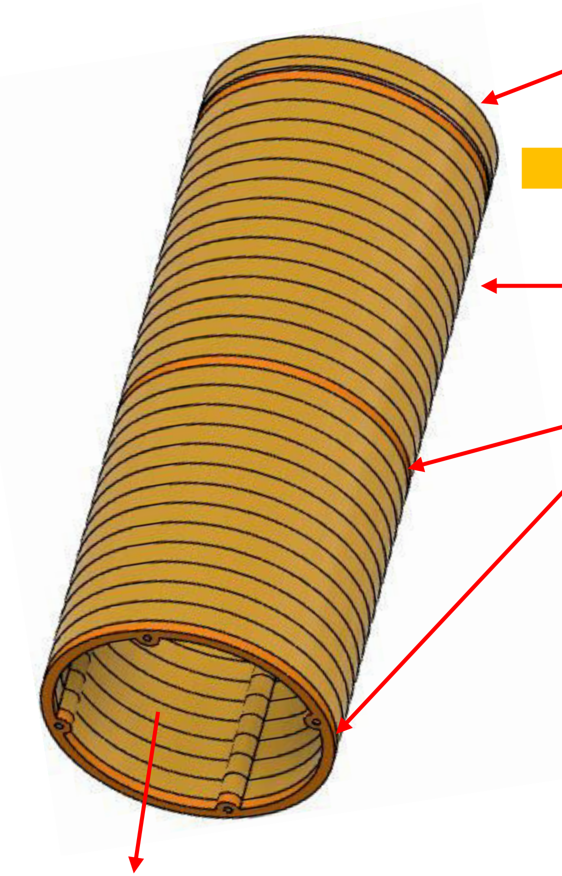


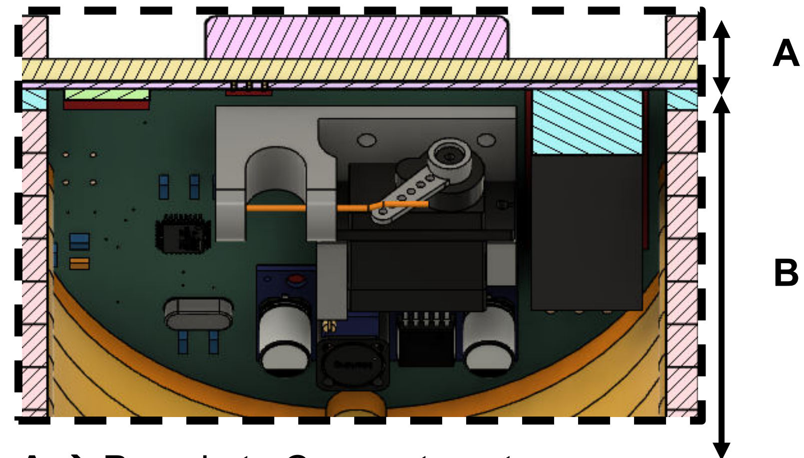

| Key Features |
|---|
| Container have two hinges located on top layer and on the bottom lid |
| Top rubber will help the container to open during separation |
| Bottom rubber will help the container lid to lock the container and maintain the payload inside. |
| Electronics components located near the top layer, used to drive the bottom servo locking system |

**Detailed view on Servo lock system**



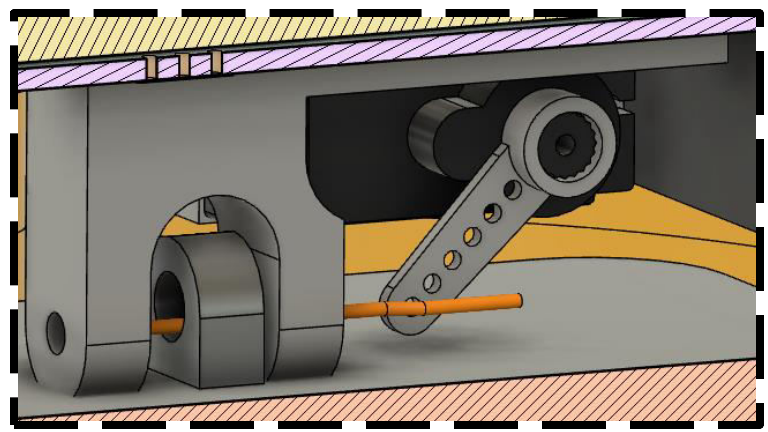
## Design B - Overview




A → Parachute Compartment
B → Container Electronics Compartment

| Key Features |
| --- |
| No major moving container parts |
| Durable and lightweight enclosures |
| Servo aided release system |
| Release system stowed on PCB directly |



**Detailed view on release mechanism**

# Container Mechanical Layout of Components Trade & Selection (3 of 4)

## Container Design Trade Selection

| Design | Advantages | Disadvantages |
|---|---|---|
| Design A | • Has a greater chance of separation success<br>• No additional wing stow mechanism<br>• Payload will not move freely when stowed | • Need to configure ideal rubber for the hinges<br>• Container body will constantly be pushed by the payload wing during pre deployment |
| Design B | • Simpler release mechanism<br>• Easier manufacturing process | • Additional servo increases mass<br>• Smaller space for parachute<br>• Container PCB holds entire payload mass when stowed |

**Chosen Design : Design A**

Rationale:

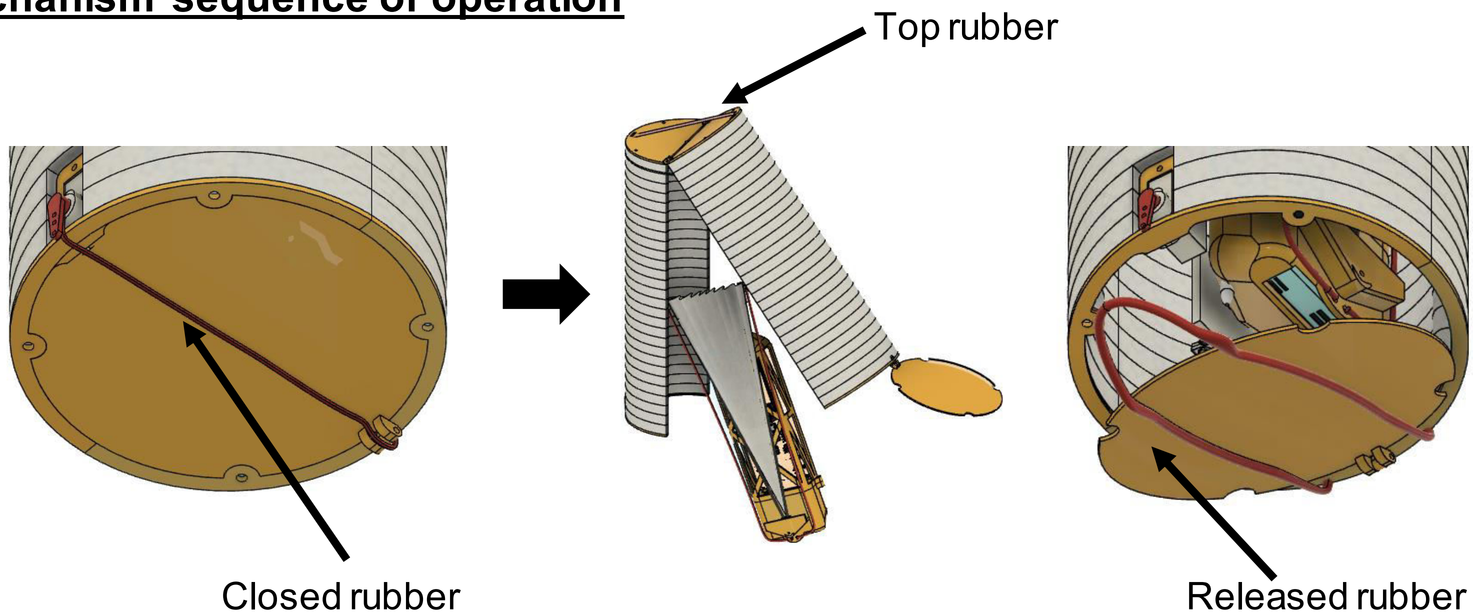
- Much reliable stow – release system
- Minor adjustment can be quickly made
- Greater chance of success

# Container Mechanical Layout of Components Trade & Selection (4 of 4)

**Container Structure Material Trade Selection**

| Structure | Options | Selected | Rationale(s) |
|---|---|---|---|
| Hinged lid | • Polyfoam<br>• 3D print PLA + | 3D print PLA | Provide better strength |
| Container layer | • 3D print PLA +<br>• Polyfoam<br>• Mica paper | Polyfoam | Lighter and easier to manufacture |
| Support Column | • Carbon fiber<br>• nylon<br>• PVC | Carbon fiber | Lighter and cheaper |
| Servo housing | • 3D print PLA +<br>• Plastic molding | 3D print PLA | Easier to manufacture |

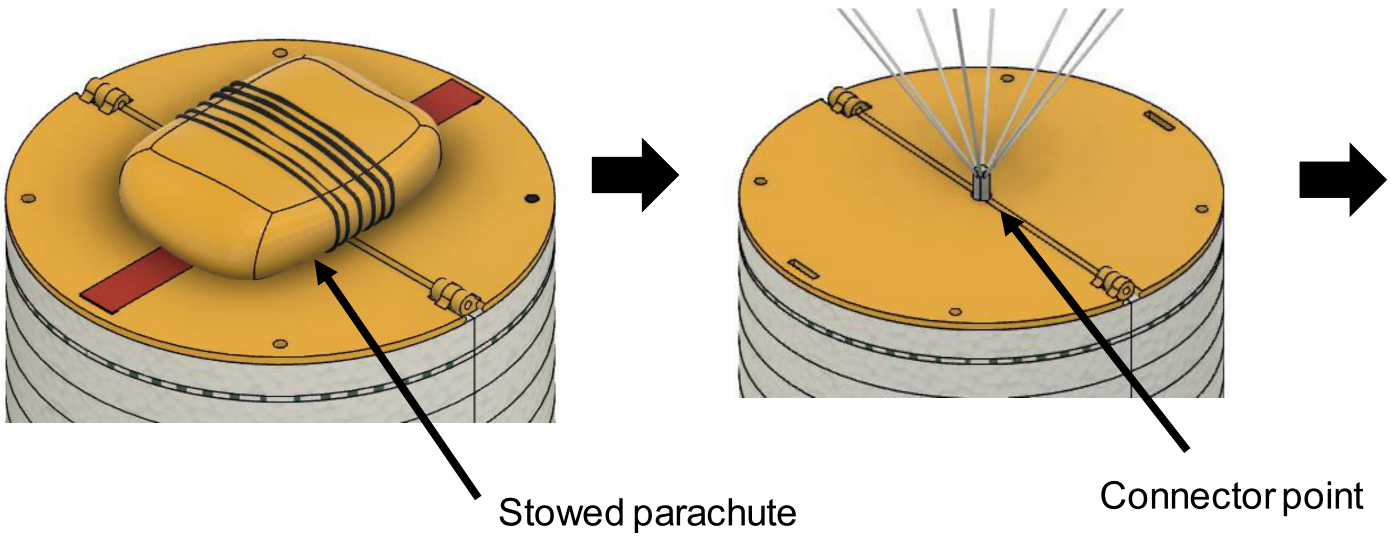
**Release Mechanism sequence of operation**




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

# 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 |

# Electronics Structural Integrity (1 of 2)

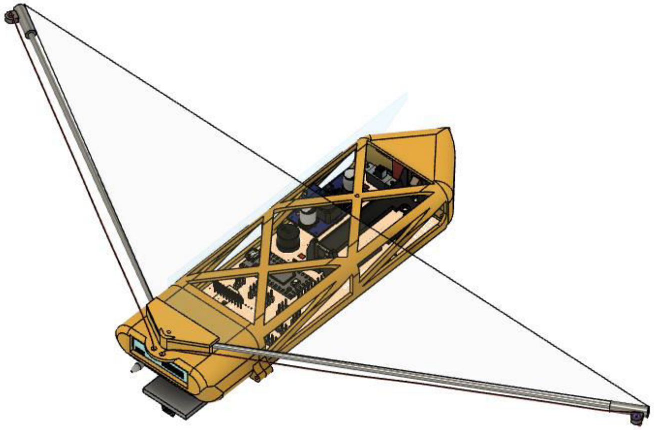
**PCB and major electronics mounting methods**

- Payload PCB size is 60 mm x 150 mm and will be mounted with bolted connection to the payload main structure
- Container PCB diameter is 125 mm and will be mounted directly on the container body layer by adhesives
- Servos will be mounted inside the payload by using bolted connection and glue
- Sensors located at payload nose, such as particle sensor will be mounted by using double tape (foam)
- Camera module will be mounted using double tape (foam)

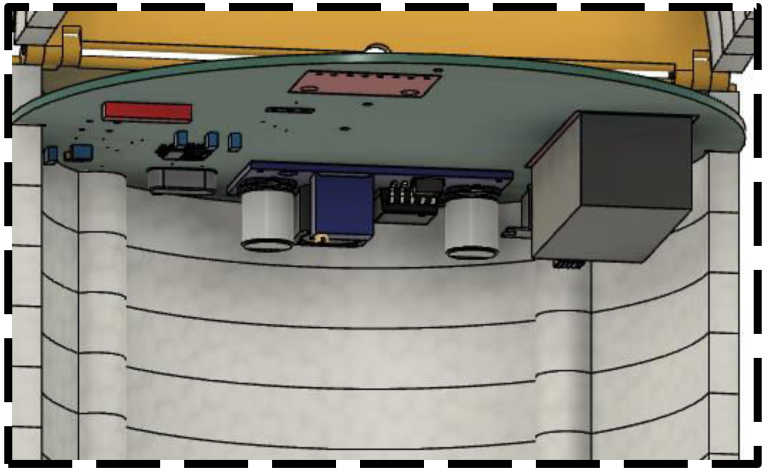
**PCB and electronics enclosures**

- Container electronics and payload will be enclosed by polyfoam layers of the container. Access to power switch will be made
- Sensors mounted in payload nose will be enclosed by PLA
- Camera module will not be enclosed

# Electronics Structural Integrity (2 of 2)

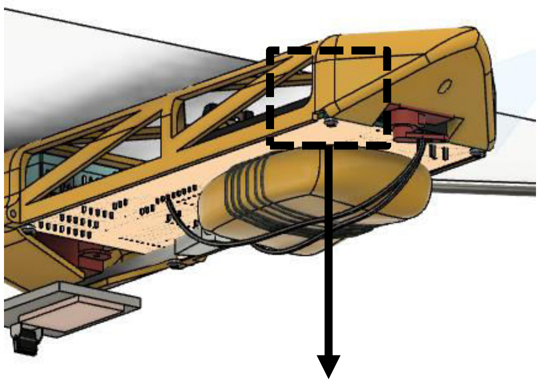


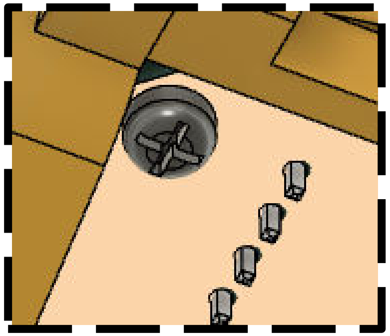
Payload PCB view



Container PCB is directly mounted using adhesives

PCB Connection detail





Payload PCB is mounted using 4 x 2mm bolts

# Mass Budget (1 of 3)

## Payload Mass Chart

| Component name | Mass (g) | Obtain Method | Margins (g) |
|---|---|---|---|
| Payload structure | 74 | M | - |
| PCB | 35 | E | 7 |
| Wing Frame | 4 | M | - |
| Torsion Spring | 3 | M | - |
| Servo motor | 36 | M | - |
| 360 camera mechanism | 7 | E | 1.4 |
| Battery | 47 | M | - |
| Electronics and Sensors | 106 | E | 21.2 |
| Parachute | 7.8 | E | 1.56 |
| XBEE module | 7 | M | - |
| Antenna | 5 | M | - |
| Total Payload Mass | 331.8 | 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

| Total Payload Mass |
|---|
| $331.8 \pm 24.26$ g |

# Mass Budget (2 of 3)

## Container Mass Chart

| Component name | Mass (g) | Obtain Method | Margins (g) |
|---|---|---|---|
| Parachute compartment | 5 | E | 1 |
| Electronics and Sensors | 93 | E | 18.6 |
| Body layer | 54 | M | - |
| 3mm Carbon rod | 7.5 | M | - |
| Servo motor | 9 | D | - |
| Battery | 17 | M | - |
| Parachute | 7.8 | E | 1.56 |
| Epoxy Adhesives | 17 | M | - |
| Total Container Mass | 210,3 | M,E,D | 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

| Total Container Mass |
|---|
| 210,3 $\pm$ 21.16 g |

# Mass Budget (3 of 3)

**Total CanSat Mass**

**541.8 Grams**

**Total mass margin = | required mass – estimated mass | = | 600 – 541.8 | g = 58.2 g**

- Competition requirement mass margin: ± 10 g

| 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 the container material will be reconsidered to use higher density foam or different material. |
| 2 | If the CanSat mass is **> 610 g,** then the 3D printed parts will be printed with less infill density. |

# Communication and Data Handling (CDH) Subsystem Design

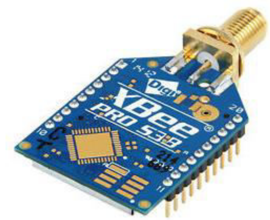
**Muhammad Dyffa**

# Payload CDH Overview

**PAYLOAD CAMERA**


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

**Teensy 4.0:**
A processor is used to sample and process data from sensors




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

**GCS**


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

# Payload 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 | | ✓ | ✓ | |
| RE14 | All electronic components shall be enclosed and shielded from the environment with the exception of sensors. | | Very High | | ✓ | | |
| RE15 | All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives. | | Very High | ✓ | | ✓ | ✓ |
| RN17 | 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 | | ✓ | | |
| RN24 | The science payload shall transmit all sensor data in the telemetry. | Competition Requirement | Very High | | | ✓ | ✓ |
| RN25 | Telemetry shall be updated once per second. | Competition Requirement | High | ✓ | | ✓ | |
| RN27 | 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 | | | ✓ | ✓ |

# Payload CDH Requirements (2 of 2)

| RN | Requirement | Rationale | Priority | Verification | | | |
|---|---|---|---|---|---|---|---|
| | | | | A | I | T | D |
| 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 | ✓ | | ✓ | |

# Payload Processor & Memory Trade & Selection (1 of 2)

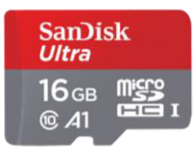
| Micrcontroller Board | Processor Speed (MHz) | Boot Time | I/O Pin | Interfaces | Operating Voltage (V) | Memory | Cost ($) |
|---|---|---|---|---|---|---|---|
| Teensy 3.2 Microcontroller | 72 | 5 ms | 34 Digital<br>14 Analog in<br>12 PWM | 1 SPI<br>2 I2C<br>3 UART | 3.7 – 5.5 | EEPROM (2 KB)<br>Flash (256 KB)<br>SRAM (64 KB) | 19.8 |
| Arduino Nano | 16 | 4.84 s | 22 Digital<br>8 Analog in<br>6 PWM | 1 SPI<br>1 I2C<br>2 UART | 5 | EEPROM (1 KB)<br>Flash (32 KB)<br>SRAM (2 KB) | 22 |
| Teensy 4.0 Microcontroller | 600 | 3 ms | 40 Digital<br>14 Analog in<br>31 PWM | 3 SPI<br>3 I2C<br>7 UART | 3.6 – 5 | EEPROM (64 KB)<br>Flash (2 MB)<br>SRAM (1 MB) | 19.9 |

| Selected | Rationale |
|---|---|
| Teensy 4.0 | • Super fast CPU clock which sufficient for sampling – processing – sending sensor data and calculate bearing for servo as camera actuator<br>• Serial baud rates can adapt in changes of CPU speed<br>• EEPROM storage size is sufficient for storing states and packet count<br>• Teensy 4.0 can execute 2 instructions per clock with its ARM Cortex M7 |

# Payload Processor & Memory Trade & 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 | Cost ($) |
|---|---|---|---|---|
| Sandisk Ultra Micro SD Card | 16 | Mounted directly to micro SD slot in camera board | Up to 98 MB/s | 5.79 |
| Toshiba Exceria Micro SD Card | 16 | Mounted directly to micro SD slot in camera board | 90 MB/s | 8.9 |




| Selected | Rationale |
|---|---|
| Sandisk Ultra Micro SD Card | • Affordable price<br>• Better in transfer rate |

# Payload Real-Time Clock

| RTC Model | Types | Power Source | Reset Tolerance | Accuracy (Time Drift) | Cost |
|---|---|---|---|---|---|
| Built-in Teensy RTC | Software | Teensy Vin | In reset condition, software reads the last data from the memory | ±5-20 ppm | Free |
| Matek SAM M8Q RTC | Hardware | Coin cell battery | In reset condition, external clock continues keeping time | 5-30 ppm | Free |
| DS1307 RTC Module | Hardware | Coin cell battery | In reset condition, external clock continues keeping time | ± 23 ppm | $2 |


| Selected | Rationale |
|---|---|
| Internal Matek SAM M8Q clock | • All in one. It doesn't need external weight and spending since it's integrated on Matek SAM M8Q module<br>• Backup battery (on GPS module board) maintains time through processor reset<br>• Simple serial query |

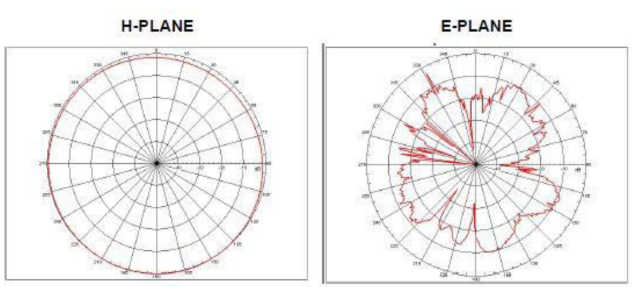
# Payload Antenna Trade & Selection

| Antenna | Connection Type | Frequency (MHz) | Range | Direction | Gain (dBi) | VSWR | Mass (g) | Size (cm) | Polarization | Price ($) |
|---|---|---|---|---|---|---|---|---|---|---|
| ANT-RA57-915 | RP-SMA | 890-960 | ≥ 1km | Omni-directional | 2 | ≤ 1.5 : 1 | 2 | 5.7 x 1.65 x 0.8 | Vertical | 4.95 |
| Dual Frequency Duck Antenna | RP-SMA | 900/1800 | ≥ 1km | Omni-directional | 2 | 1.8 : 1 | 11 | 10.5 x 1 x 1 | Vertical | 7.95 |

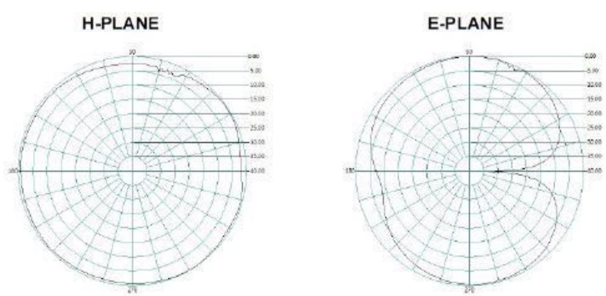
**Selected Antenna: ANT-RA57-915**

| Device | Rationale |
|---|---|
| ANT-RA57-915 | • ¼ wavelength antenna (shorter)<br>• Lighter |

**Radiation Pattern of Dual Frequency Duck Antenna :**




**Radiation Pattern of ANT-RA57-915 :**



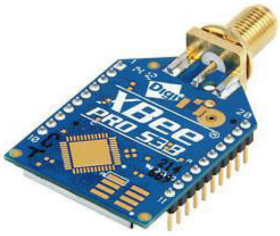
# Payload Radio Configuration

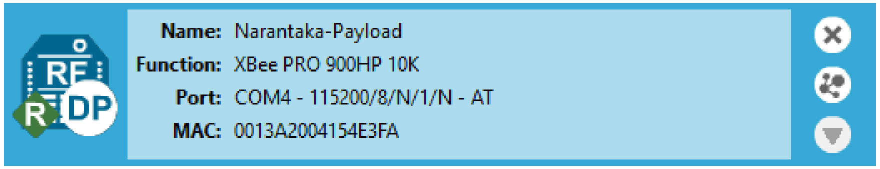
**XBEE Pro900HP S3B** is selected as transmitter for payload and receiver for GCS.

NETID/PANID numbers are set to our team number 1320 for both XBEEs. Both XBEEs communicate in unicast mode, not in broadcast mode.

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.

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






**Addressing**
Change Addressing Settings

| | |
|---|---|
| **SH** Serial Number High | 13A200 |
| **SL** Serial Number Low | 4154E3FA |
| **DH** Destination Address High | 13A200 |
| **DL** Destination Address Low | 410751A1 |
| **TO** Transmit Options | 40 |
| **NI** Node Identifier | Narantaka-Payload |
| **NT** Network Discovery Back-off | 82 * 100 ms |
| **NO** Network Discovery Options | 0 |
| **CI** Cluster ID | 11 |

# 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> | 1152 | 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> | 6.2 | 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> | -7.7645 | Latitude generated by the GPS receiver degrees with a resolution of 0.0001 degrees |
| <GPS LONGITUDE> | 110.3767 | Longitude generated by the GPS receiver with a resolution of 0.0001 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:

**1320,112,112,100,1152,32,6.2,13:21,-7.7645,110.3767,166,6,30,3,400**

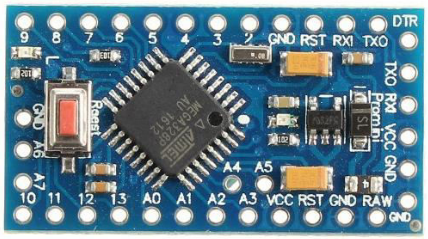
The example telemetry packet match with the competition guide requirements.

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

# Container CDH Overview

**BMP 388**

A BMP388 is used to collect pressure and temperature data.



**Arduino Pro Mini 8MHz**

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

**No external memory storage**

**Servo**

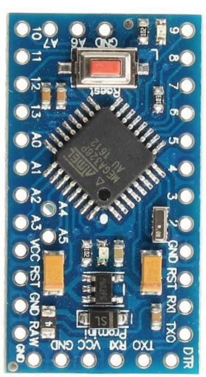
A servo is used to separate payload from container

# Container CDH Requirements

| 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 | | ✓ | ✓ | |
| RE14 | All electronic components shall be enclosed and shielded from the environment with the exception of sensors. | | Very High | | ✓ | | |
| RE15 | All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives. | | Very High | ✓ | | ✓ | ✓ |
| RN17 | 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 | | ✓ | | |
| RN27 | Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost. | Competition Requirement | Very High | ✓ | ✓ | | |
| RN41 | Payload/Container shall operate for a minimum of two hours when integrated into rocket. | Competition Requirement | Very High | ✓ | | | ✓ |

# Container Processor & Memory Trade & Selection

| Micrcontroller Board | Processor Speed (MHz) | Boot Time | I/O Pin | Interfaces | Operating Voltage (V) | Memory | Cost ($) |
|---|---|---|---|---|---|---|---|
| Teensy 3.2 Microcontroller | 72 | 5 ms | 34 Digital<br>21 Analog in<br>12 PWM | 1 SPI<br>2 I2C<br>3 UART | 3.7 – 5.5 | EEPROM (2 KB)<br>Flash (256 KB)<br>SRAM (64 KB) | 19.8 |
| Arduino Nano | 16 | 4.84 s | 22 Digital<br>6 Analog in<br>2 Analog out | 1 SPI<br>1 I2C<br>2 UART | 5 | EEPROM (1 KB)<br>Flash (32 KB)<br>SRAM (2 KB) | 4.3 |
| Arduino Pro Mini | 8 | 6.6 s | 14 Digital<br>14 Analog in<br>4 Analog out | 1 SPI<br>1 I2C<br>1 UART | 3.3 | EEPROM (1 KB)<br>Flash (32 KB)<br>SRAM (2 KB) | 2.5 |



| Selected | Rationale |
|---|---|
| Arduino Pro Mini 8MHz | • Affordable price and cheapest among others<br>• Processor in container only maintains altitude data, servo, and state so using 8 MHz microcontroller is enough for our applications |

**We don't use external memory storage in our container**

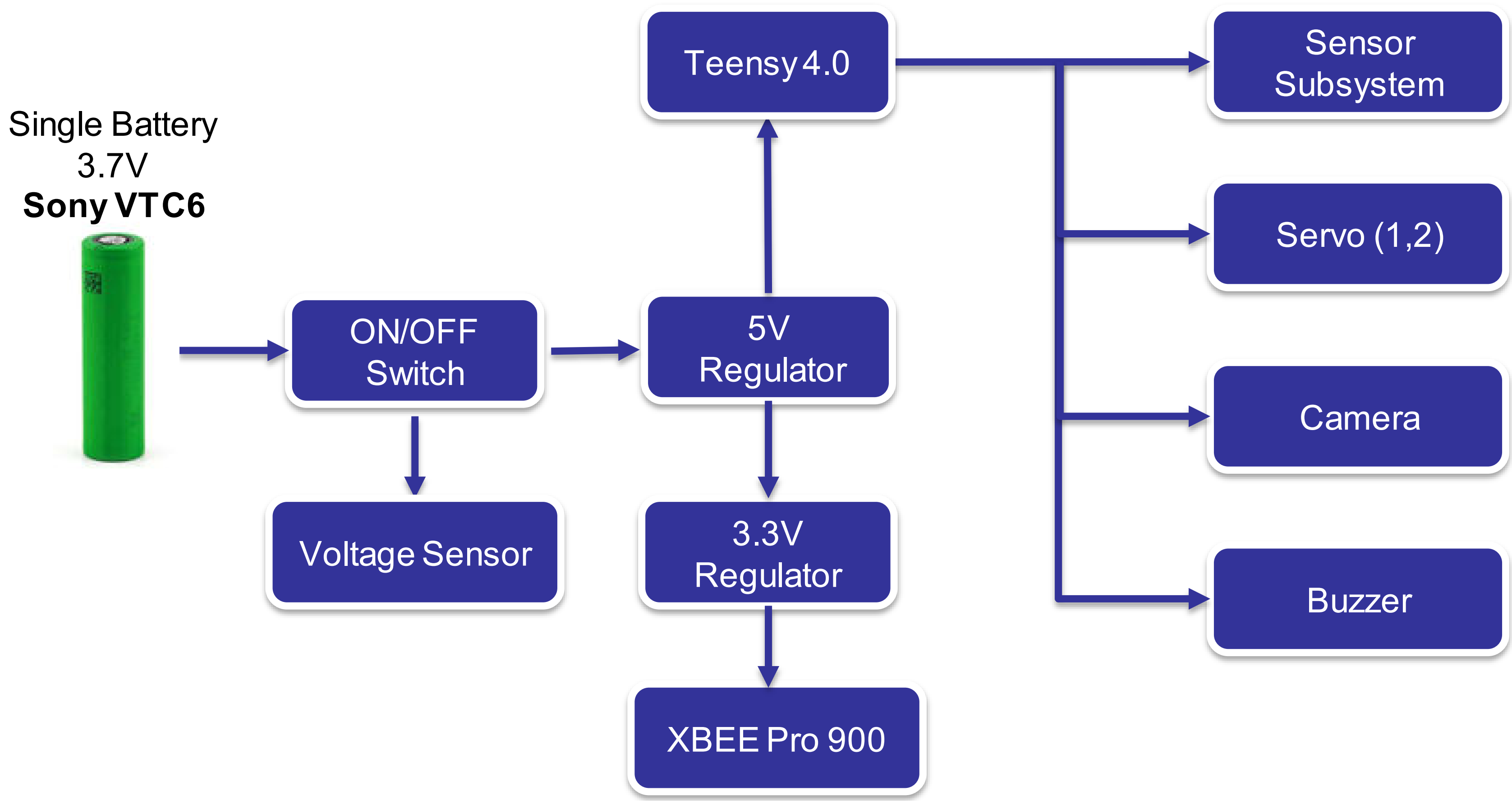
# Electrical Power Subsystem Design

Nico Renaldo

# EPS Overview (1 of 3)

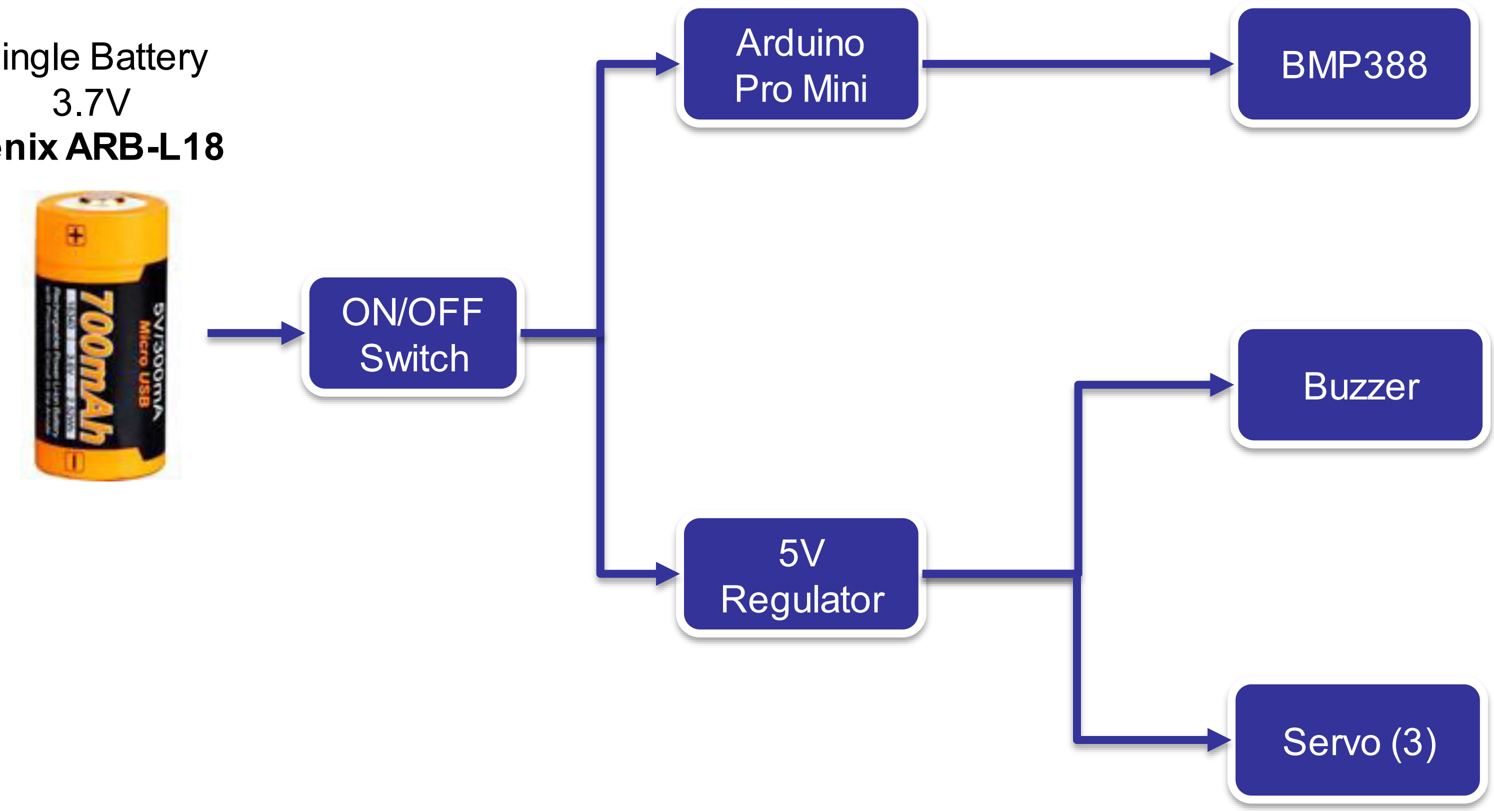
| Component Type | Purpose |
|---|---|
| Battery | Supplies power to the components |
| Switch | Connect and disconnect the battery from the circuit |
| Voltage Regulator | Adjusts the voltage to the appropriate level that the sensors and processor need |
| Microcontroller | Receive and process data 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 |

## Payload EPS Overview



## Container EPS Overview

Single Battery
3.7V
**Fenix ARB-L18**



# EPS Requirements (1 of 2)

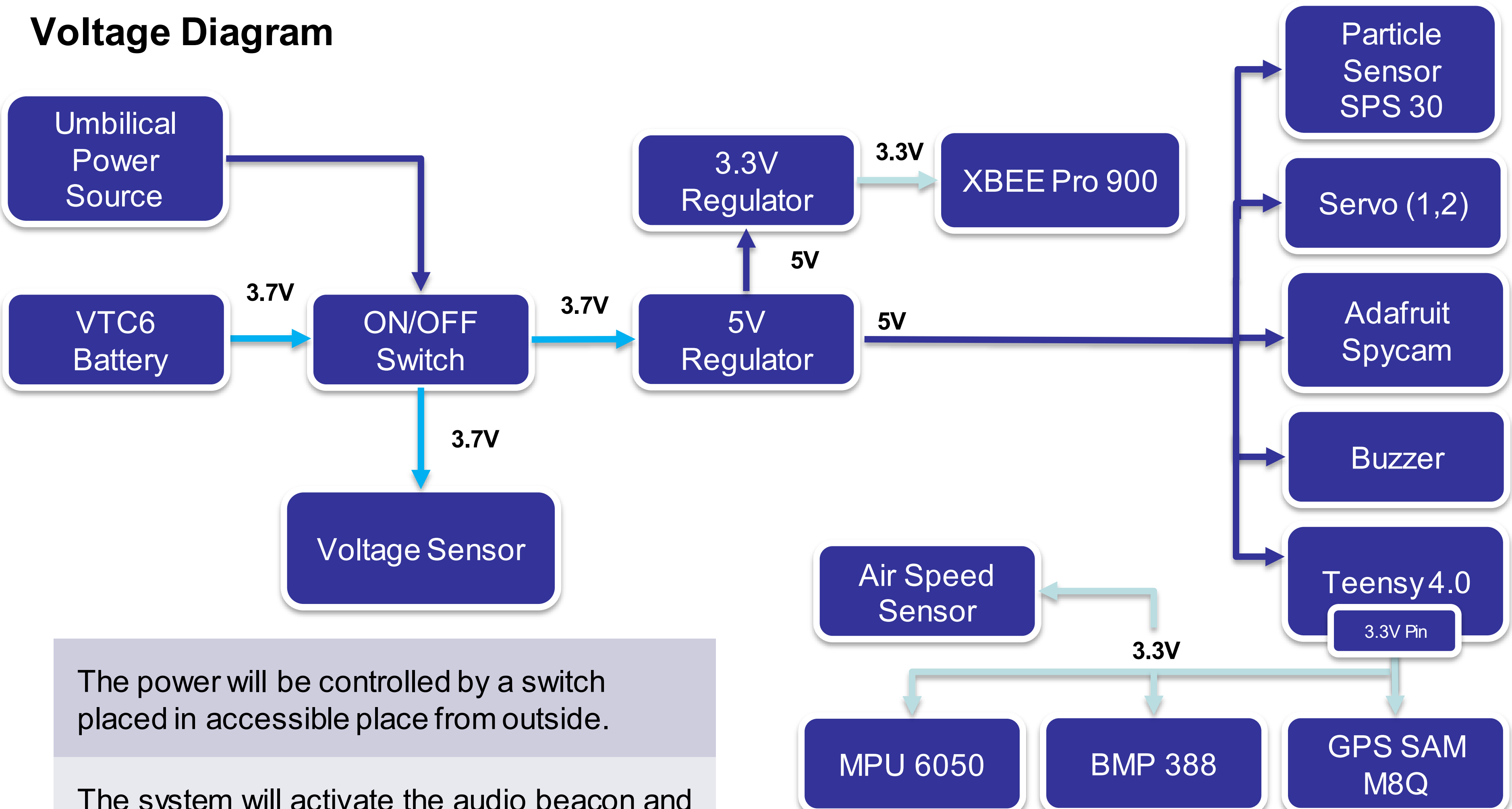
| RN | Requirement | Rationale | Priority | Verification | | | |
|---|---|---|---|---|---|---|---|
| | | | | A | I | T | D |
| RN18 | The science payload shall measure altitude using an air pressure sensor. | Competition Requirement | Very High | | | ✓ | ✓ |
| RN19 | The science payload shall provide position using GPS. | Competition Requirement | Very High | | | ✓ | ✓ |
| RN20 | The science payload shall measure its battery voltage. | Competition Requirement | Very High | | | ✓ | ✓ |
| RN21 | The science payload shall measure outside temperature. | Competition Requirement | Very High | | | ✓ | ✓ |
| RE22 | The science payload shall measure particulates in the air as it glides. | Competition Requirement | Very High | | | ✓ | ✓ |
| RN23 | The science payload shall measure air speed. | Competition Requirement | Very High | | | ✓ | ✓ |
| RN24 | The science payload shall transmit all sensor data in the telemetry. | Competition Requirement | Very High | | | ✓ | ✓ |
| RN33 | No lasers allowed. | Competition Requirement | Medium | ✓ | | | |
| RN34 | 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 | | ✓ | | ✓ |
| RN35 | 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 | ✓ | ✓ | | |

# EPS Requirements (2 of 2)

| RN | Requirement | Rationale | Priority | Verification | | | |
|---|---|---|---|---|---|---|---|
| | | | | A | I | T | D |
| RN36 | An audio beacon is required for the probe. It may be powered after landing or operate continuously. | Competition Requirement | Very High | ✓ | | ✓ | ✓ |
| RN37 | The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed. | Competition Requirement | High | ✓ | ✓ | | |
| RN38 | 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 | | ✓ | | |
| RN39 | 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 | | ✓ | | ✓ |
| RN40 | Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects. | Competition Requirement | High | ✓ | ✓ | | |
| RN41 | Payload/Container shall operate for a minimum of two hours when integrated into rocket. | Competition Requirement | Very High | ✓ | | ✓ | |
| RN42 | 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 (1 of 2)

## Voltage Diagram

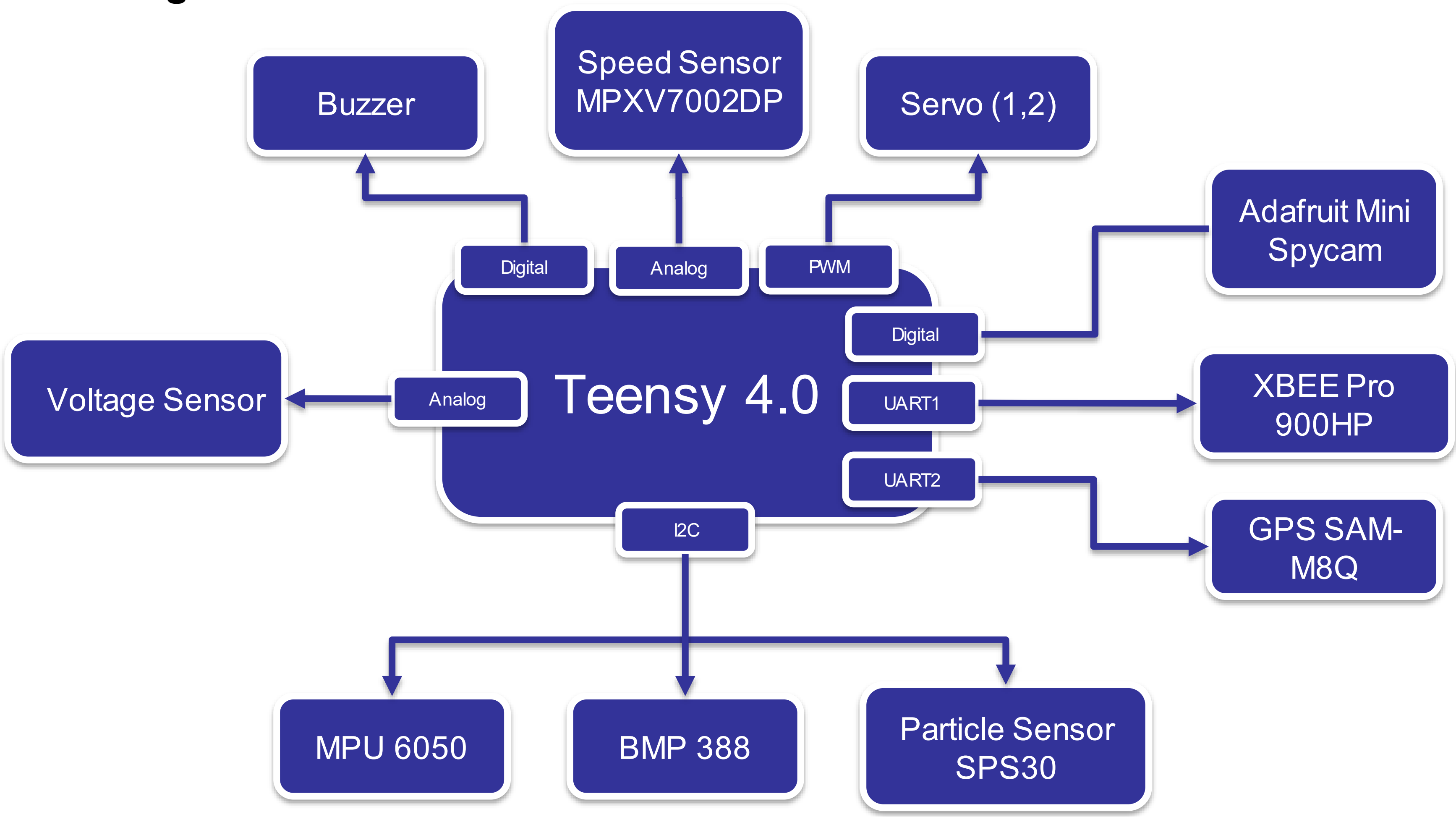



The power will be controlled by a switch placed in accessible place from outside.

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 Trade & Selection (1 of 3)

## Payload Power Source

| No | Model Name | Type | Nominal Voltage (V) | Capacity (mAh) | Weight (g) | Max Continuous Discharge Rate (A) | Price ($) |
|---|---|---|---|---|---|---|---|
| 1 | Sony VTC6 18650 | Lithium Ion | 3.7 | 3000 | 46.6 | 30 | 5.99 |
| 2 | Samsung INR18650-25R | Lithium Ion | 3.7 | 2500 | 45 | 20 | 3.79 |
| 3 | Eneloop Pro Black | Nickel – Metal Hydride | 1.2 | 2550 | 30 | 5 | 18.49 (pack of 4) |
| 4 | Duracell Ultra DL 223 CR-P2 | Lithium – Ion (MnO2) | 6 | 1400 | 38 | 1 | 6 |

1

2

3

4

# Payload Power Trade & Selection (2 of 3)

## Power Source Pros & Cons

| No | Battery Name | Pros | Cons |
|---|---|---|---|
| 1 | Sony VTC6 | • Rechargeable<br>• Largest Capacity<br>• High discharge rate | • Relatively Heavy |
| 2 | Samsung INR18650-25R | • Rechargeable<br>• Large Capacity<br>• High discharge rate | • Relatively Heavy |
| 3 | Eneloop Pro Black | • Large Capacity<br>• Rechargeable | • Low Voltage Level<br>• Need to arrange more cells in series in order to reach higher voltage<br>• Expensive |
| 4 | Duracell Ultra DL 223 CR-P2 | • High Voltage Level<br>• Relatively Cheap<br>• Lightweight | • Smallest capacity<br>• Low discharge rate |

# Payload Power Trade & Selection (3 of 3)

## Power Source Selection

| | |
|---|---|
| **Selected Battery :** | **Sony VTC6** |


| Reasons: |
|---|
| Higher capacity |
| Available in our country |
| Relatively cheap |
| Capable to deliver enough current to power all electronic components simultaneously |
| Better reviews from users |

- **Single Sony VTC6 battery will be used as a power source (no configuration).**
- **Battery will be mounted on PCB using battery socket.**

# Payload Power Budget (1 of 3)

| No | Name | Voltage (V) | Duty Cycle (%) | Power (W) | Power Consumption (Wh) | Source |
|---|---|---|---|---|---|---|
| 1 | Teensy 4.0 | 5 | 100 | 0.555** | 1.111 | 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 | ADXL345 | 3.3 | 100 | 0.000132 | 0.000264 | Datasheet |
| 5 | MPXV7002DP | 3.3 | 100 | 0.033 | 0.066 | Datasheet |
| 6 | BMP 388 | 3.3 | 100 | 0.00001122 | 0.00002244 | Datasheet |
| 7 | MATEK SAM-M8Q2 | 3.3 | 100 | 0.066 | 0.132 | 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 regulator is recalculated by the following equation : Power+current*drop voltage(5-3.3)**

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

| Total Power Consumed |
|---|
| 5.15 Wh |

# Payload Power Budget (3 of 3)

| Available Total Current Capacity (for two hours) | Available Total Power Capacity (for two hours) |
|---|---|
| 3000 mAh | 11.1 Wh |

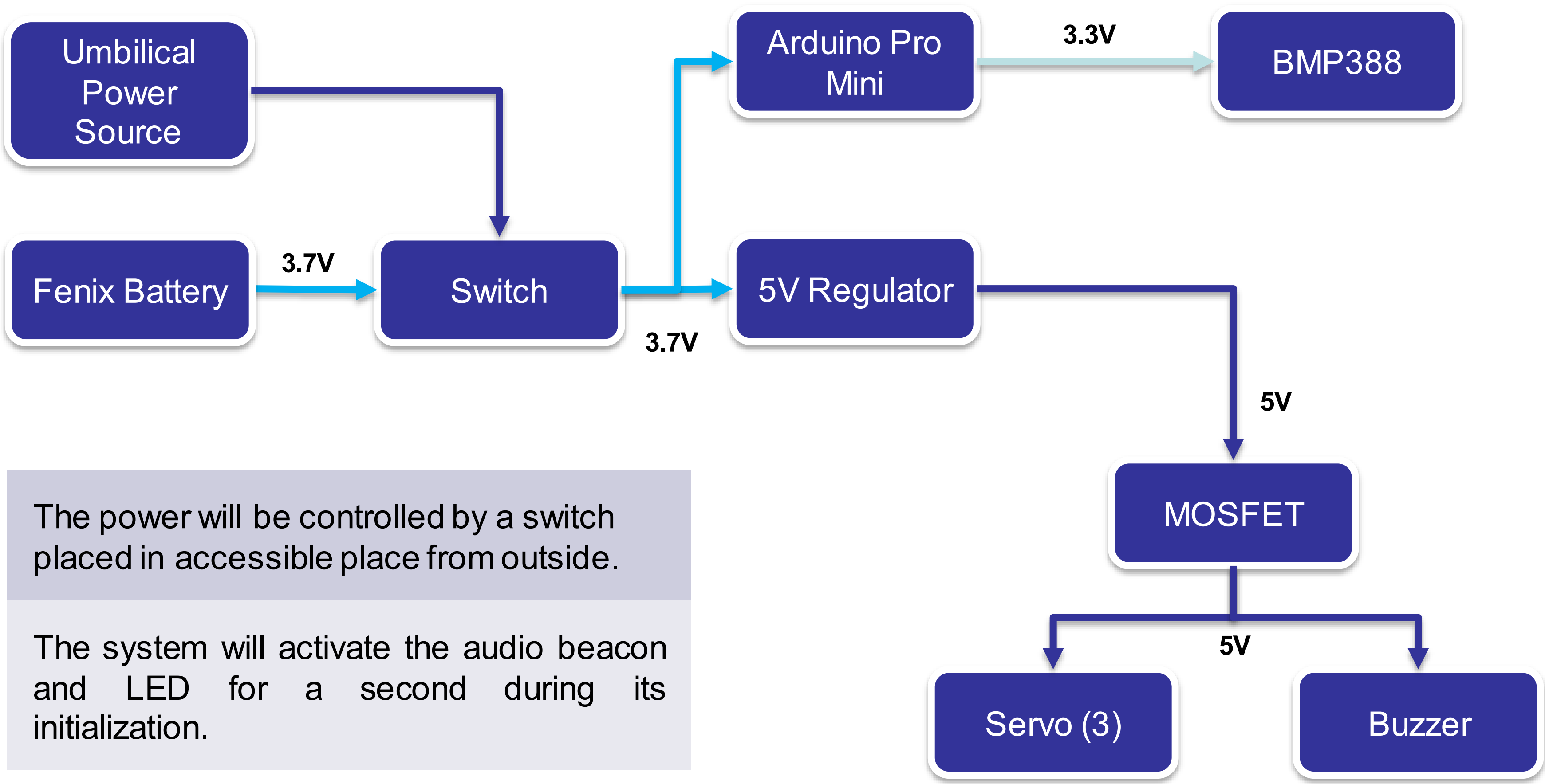
| Margin of Power Consumption |
|---|
| 11.1 Wh - 5.15 Wh<br>= 5.95 Wh (53.6% Margin) |

**Conclusion :**

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

# Container Electrical Block Diagram (1 of 2)

## Voltage Diagram



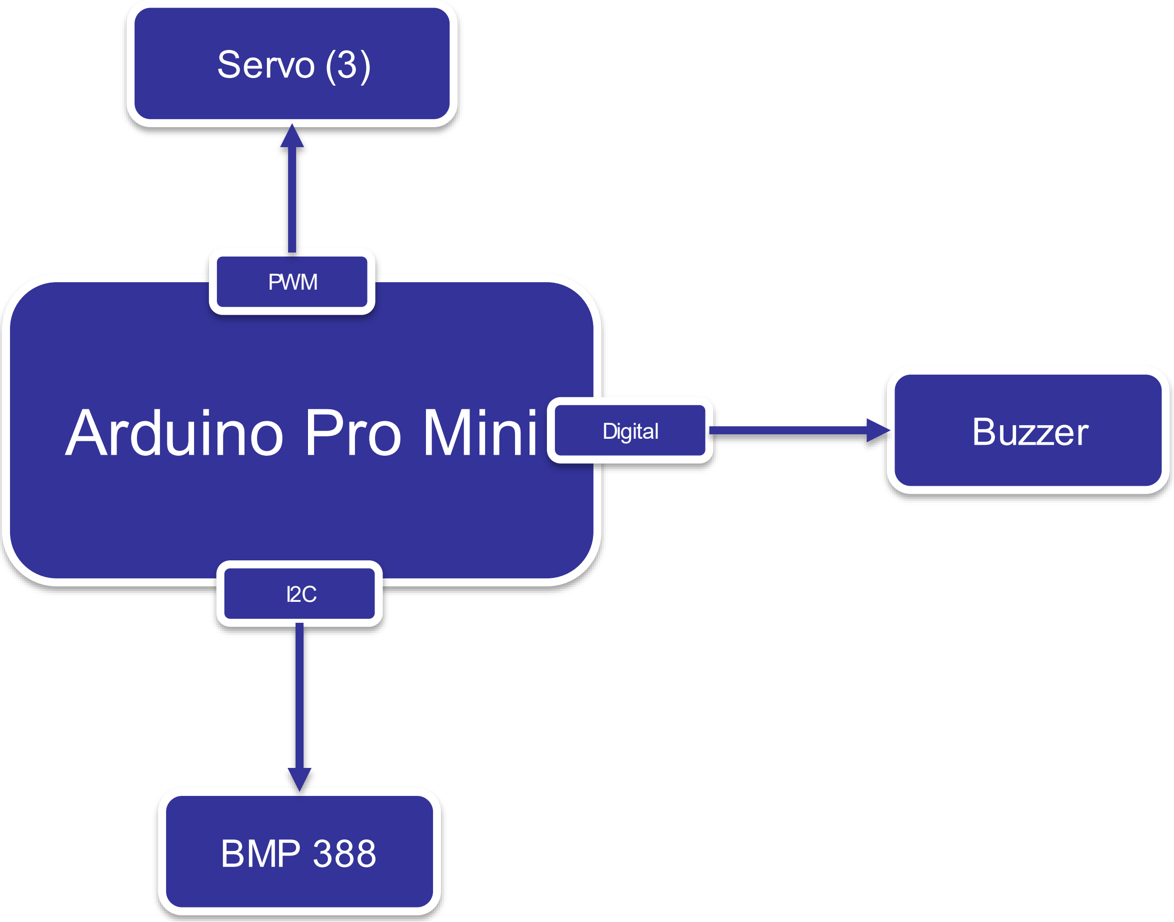

The power will be controlled by a switch placed in accessible place from outside.

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

# Container Electrical Block Diagram (2 of 2)

## 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 Trade & Selection (1 of 3)

## Payload Power Source

| No | Name/Model | Type | Nominal Voltage (V) | Capacity (mAh) | Weight (g) | Max Continuous Discharge Rate (A) | Price ($) |
|---|---|---|---|---|---|---|---|
| 1 | Sony VTC6 18650 | Lithium Ion | 3.7 | 3000 | 46.6 | 30 | 5.99 |
| 2 | Fenix ARB-L16 | Lithium Ion | 3.7 | 700 | 17.4 | 2.5 | 8.49 |
| 3 | Olight IMR 16340 | Lithium Ion | 3.7 | 550 | 18 | 2.75 | 5.50 |
| 4 | Olight 14500 | Lithium Ion | 3.7 | 750 | 21.5 | 1.5 | 4.95 |


1


2


3


4

# Container Power Trade & Selection (2 of 3)

## Power Source Pros & Cons

| No | Battery Name | Pros | Cons |
|---|---|---|---|
| 1 | Sony VTC6 | • Rechargeable<br>• Largest Capacity<br>• High discharge rate | • Relatively Heavy<br>• Big form factor |
| 2 | Fenix ARB-L16 | • In-Build Charging Port<br>• Smallest form factor<br>• Lightweight | • Relatively Expensive<br>• Small Capacity<br>• Low Discharge Rate |
| 3 | Olight IMR 16340 | • Rechargeable<br>• Smallest form factor<br>• Lightweight<br>• High discharge rate | • Small Capacity<br>• Relatively expensive |
| 4 | Olight 14500 | • Rechargeable<br>• Lightweight<br>• Small form factor | • Small Capacity<br>• Relatively Expensive<br>• Low Discharge Rate |

# Container Power Trade & Selection (3 of 3)

## Power Source Selection

**Selected Battery :** **Fenix ARB-L16**


| Reasons: |
|---|
| Available in our country |
| It has PCB holder for convenience |
| Relatively Light |
| Built-in charging Port |
| It has capability to deliver enough current and power for the container |

- **Fenix ARB-L16 battery will be used as a single power source (no configuration).**
- **Single Fenix ARB-L16 battery will be mounted on PCB using battery socket.**

# Container Power Budget (1 of 2)

| No | Name | Voltage (V) | Duty Cycle (%) | Power (W) | Power Consumption (Wh) | Source |
|---|---|---|---|---|---|---|
| 1 | Arduino Pro Mini | 3.3 | 100 | 0.146* | 0.293 | Estimate |
| 2 | Adafruit BMP388 | 3.3 | 100 | 0.00183* | 0.0036 | Datasheet |
| 3 | Servo | 5 | 5 | 1.3889* | 0.13889 | Estimate |
| 4 | LED x 2 | 2 | 100 | 0.0445* | 0.0889 | Estimate |
| 5 | Audio Beacon | 5 | 15 | 0.833* | 0.25 | 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 |
|---|
| 0.66569 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 – 0.6657 Wh<br>= 1.92431 Wh ( 74.3% 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)

## CanSat FSW design

- **Payload FSW design**

  **Teensy 4.0** will take atmospheric data from the sensors and send the data to the GCS with radio frequency module. **Teensy** will trigger the camera to record video while the payload glide. When the glider reach 100m, the payload will release a parachute to make the payload stop gliding. Audio beacon activated after the payload reach the ground

- **Container FSW design**

  **Arduino nano** stores the altitude data from altitude sensor, and if the CanSat reach 450m it will release the glider by moving the servo.

| | |
|---|---|
| **Programming languages** | C/C++ |
| **Development environments** | Arduino IDE<br>Dev C++ |

# 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 |

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

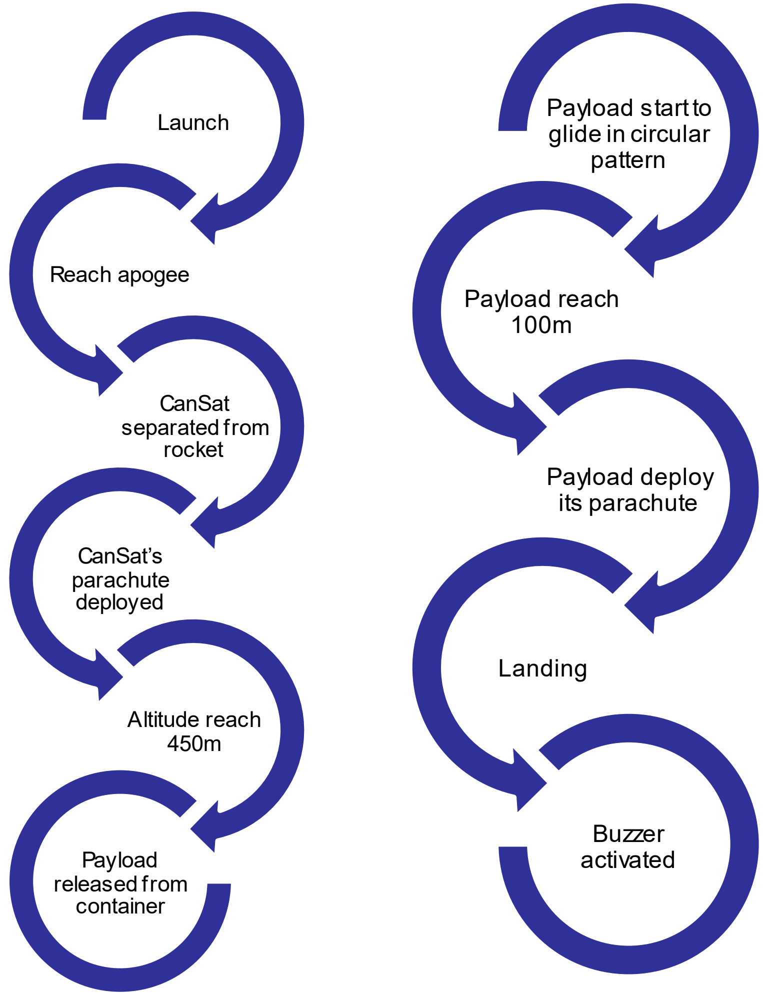
# FSW Overview (3 of 3)

## 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

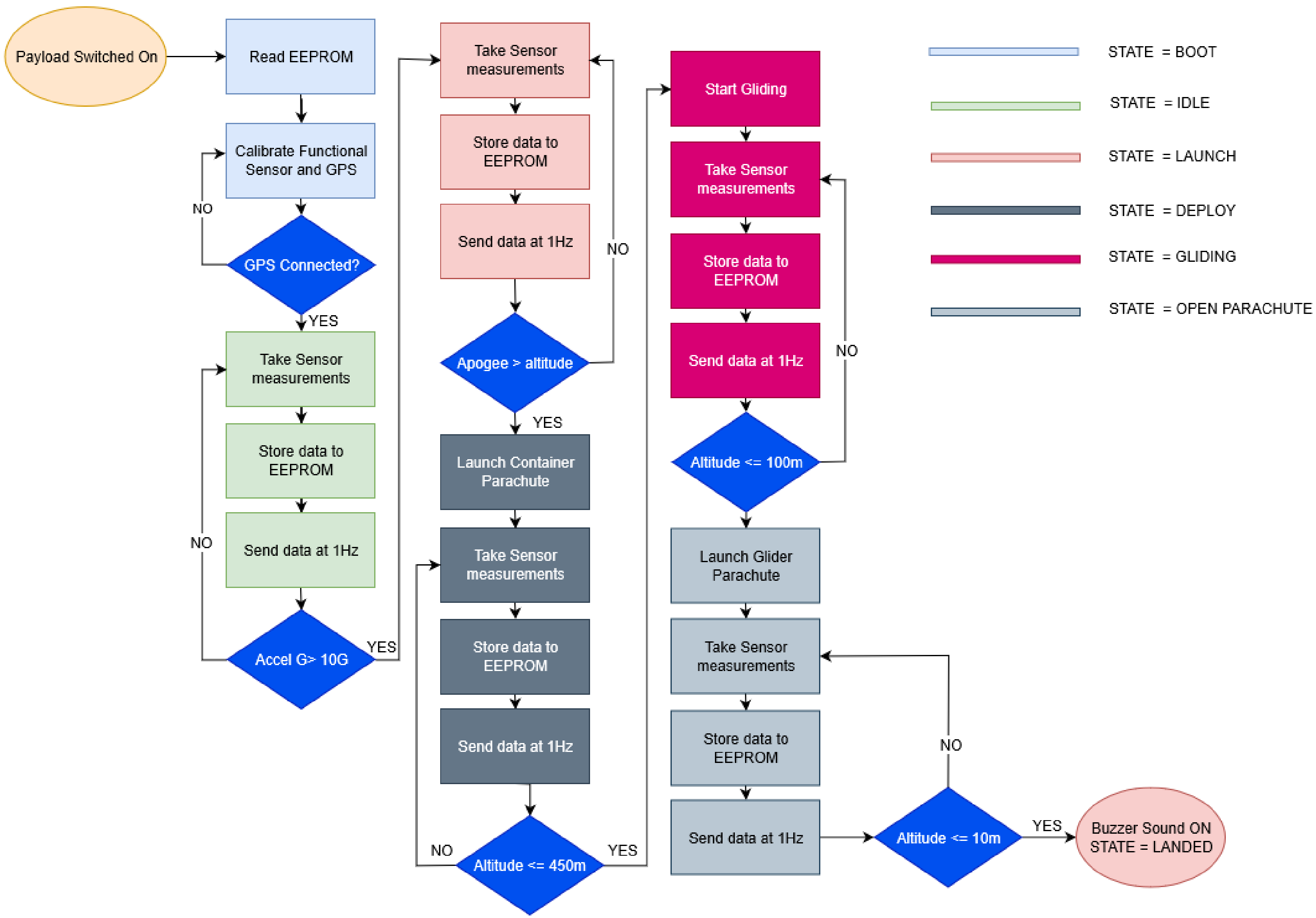
# FSW Requirements (1 of 2)

| 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 | | ✓ | ✓ | |
| RN18 | The science payload shall measure altitude using an air pressure sensor. | Competition Requirement | Very High | | | ✓ | ✓ |
| RN19 | The science payload shall provide position using GPS. | Competition Requirement | Very High | | | ✓ | ✓ |
| RN20 | The science payload shall measure its battery voltage. | Competition Requirement | Very High | | | ✓ | ✓ |
| RN21 | The science payload shall measure outside temperature. | Competition Requirement | Very High | | | ✓ | ✓ |
| RE22 | The science payload shall measure particulates in the air as it glides. | Competition Requirement | Very High | | | ✓ | ✓ |
| RE23 | The science payload shall measure air speed. | Competition Requirement | Very High | | | ✓ | ✓ |
| RN30 | 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 |
| RN42 | 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 FSW State Diagram (1 of 2)



# Payload FSW State Diagram (2 of 2)

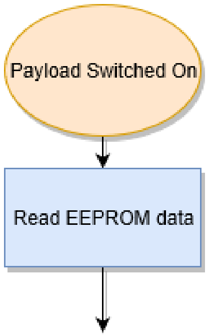
**Processor Reset Control**

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

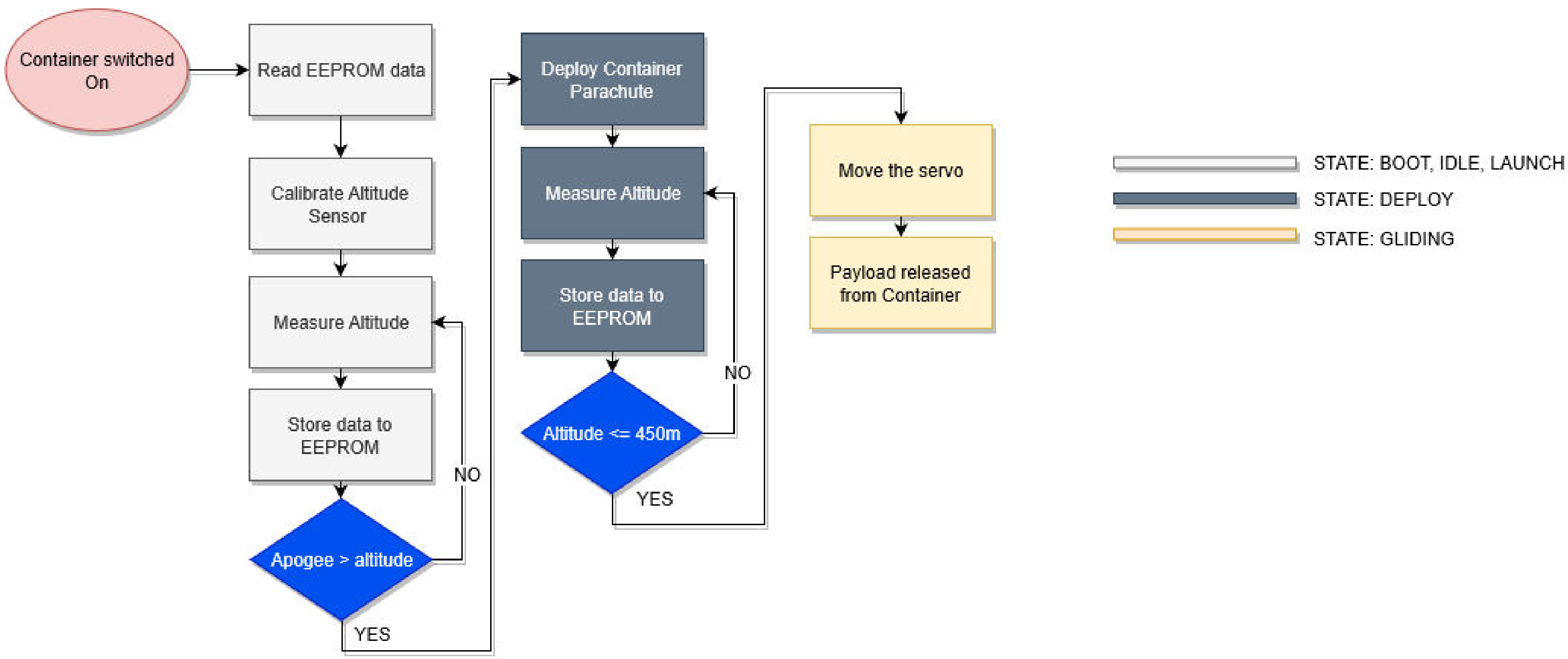
**Data saved to EEPROM** are last altitude data, state, and packet count

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

Processor reset diagram from payload FSW state diagram



# Container FSW State Diagram (1 of 2)

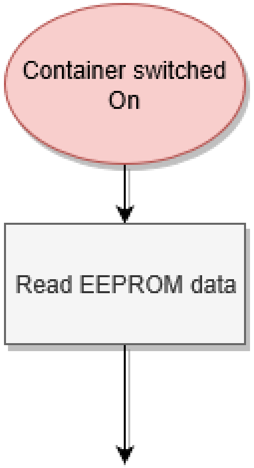


## Processor Reset Control

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 |
| --- |
| - Last altitude data and state will be saved to EEPROM<br>- If the processor reset, the data will be retrieved from the EEPROM |

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



# Software Development Plan (1 of 5)

## Prototyping and prototyping environments

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

## Test Methodology

Testing sensor in FSW → Checking → Evaluating → Testing FSW in CanSat

# Software Development Plan (2 of 5)

## 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 | In progress | Mid January |
| Wireless communication test with prototype GCS | In Progress | Early February |
| Evaluation for troubleshooting and problem | - | Early February |

# Software Development Plan (3 of 5)

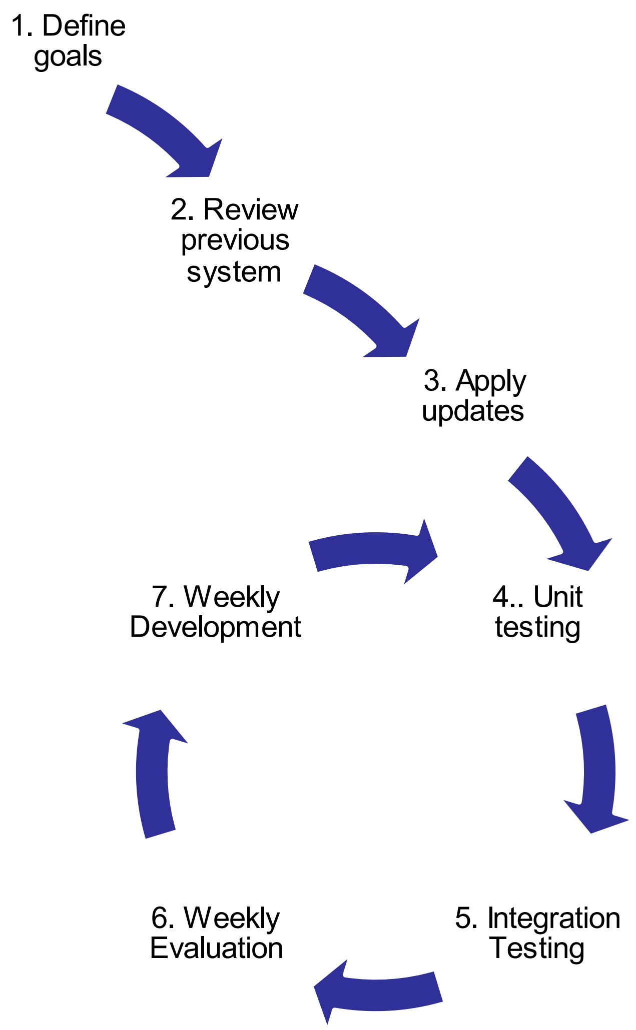
## Container Software Development Sequence

| 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 | In progress | Early February |
| Evaluation for troubleshooting and problem | - | Late February |

# Software Development Plan (4 of 5)

## 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 |



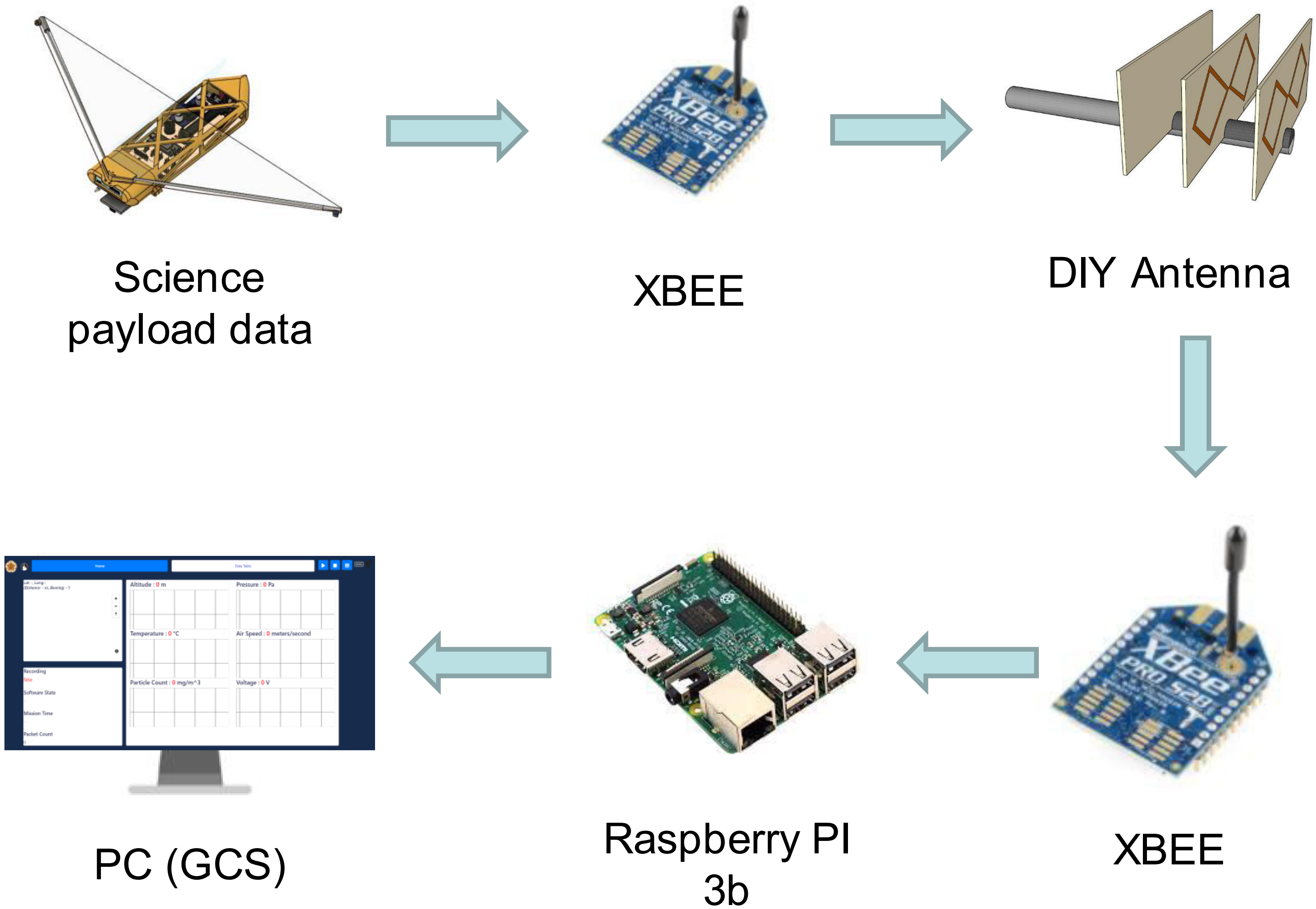
# Software Development Plan (5 of 5)

- **Software Development Team**
  - Muhammad Dyffa
  - Wildan Fajar Purnomo
  - Mahetma Ageng Wisesa
- **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**
  - 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.

# Ground Control System (GCS) Design

**Wildan Fajar Purnomo**

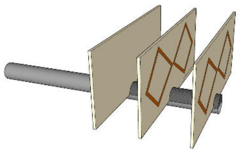
# GCS Overview



# GCS Requirements

| RN | Requirement | Rationale | Priority | Verification | | | |
|---|---|---|---|---|---|---|---|
| | | | | A | I | T | D |
| RN18 | The science payload shall measure altitude using an air pressure sensor. | Competition Requirement | Very High | | | ✓ | ✓ |
| RN19 | The science payload shall provide position using GPS. | Competition Requirement | Very High | | | ✓ | ✓ |
| RN20 | The science payload shall measure its battery voltage. | Competition Requirement | Very High | | | ✓ | ✓ |
| RN21 | The science payload shall measure outside temperature. | Competition Requirement | Very High | | | ✓ | ✓ |
| RE22 | The science payload shall measure particulates in the air as it glides. | Competition Requirement | Very High | | | ✓ | ✓ |
| RN23 | The science payload shall measure air speed. | Competition Requirement | Very High | | | ✓ | ✓ |
| RN24 | The science payload shall transmit all sensor data in the telemetry. | Competition Requirement | Very High | | | ✓ | ✓ |
| RN25 | Telemetry shall be updated once per second. | Competition Requirement | High | ✓ | | ✓ | |
| RN27 | 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 | | | ✓ | ✓ |

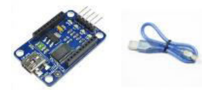
# GCS Design



**Payload Data Receiver**
DIY Microstrip Biquad Patch Antenna

**Connector**
RP-SMA

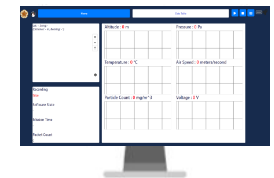
**Radio Receiver**
XBEE Pro900HP S3B



**Connector**
XBEE Adapter and USB

**Telemetry Data Preprocessor**
Raspberry PI 3B

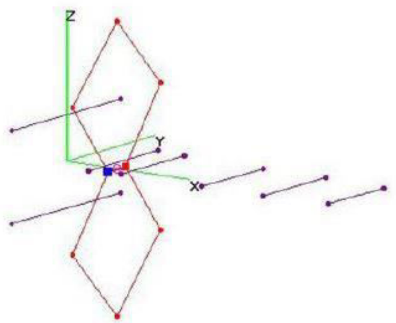
**Connector**
Wireless network



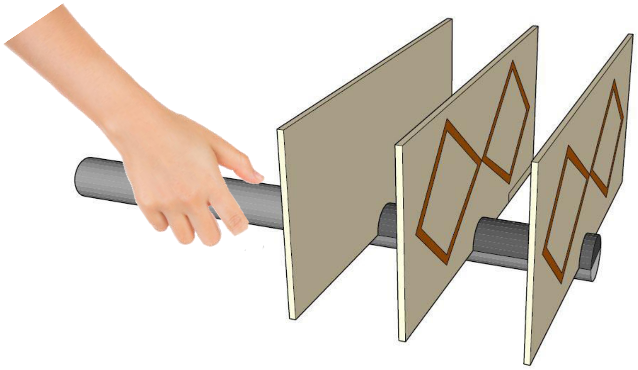
**Telemetry Data Displayer**
Web-Based GCS

| 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.<br>- Prevent Raspberry PI 3B from accessing WiFi. |

# GCS Antenna Trade & Selection (1 of 3)




DIY Biquad Antenna



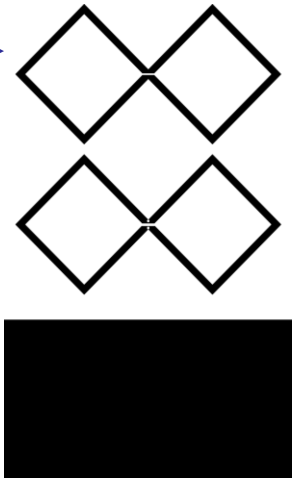
DIY Microstrip biquad patch antenna

| Antenna | Gain (dBi) | Beamwidth (Vertical/Horizontal) | Connector | Polarization |
|---|---|---|---|---|
| Microstrip biquad patch antenna | 11.71 | 47.7/47.3 | RP-SMA | Vertical, Horizontal |
| DIY Biquad Antenna (copper wire) | 9.83 | 62.1/94.1 | RP-SMA | Vertical, Horizontal |

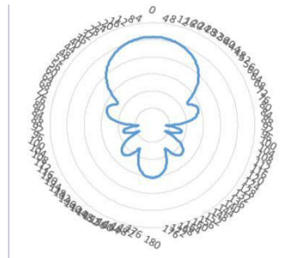
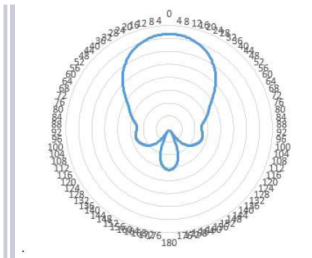
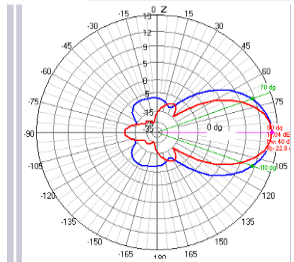
Director

Driver

Reflector



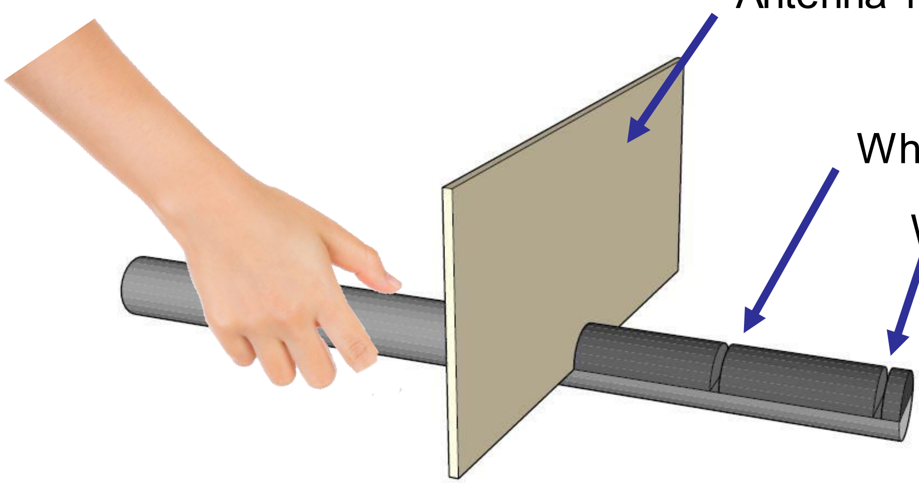
DIY Microstrip biquad patch antenna (PCB Design)

| DIY Microstrip Biquad Patch Antenna | | DIY Biquad Antenna |
|---|---|---|
|  |  |  |
| Far field (elevation plot) | Far field (azimuth plot) | Far field (elevation & azimuth plot) |

| Device Selected | Rationale |
|---|---|
| Microstrip biquad patch antenna | • Large horizontal and vertical beamwidth to compensate the pointing error<br>• Less directors needed compared to Yagi Antennas (saves space for packaging)<br>• Easily hold by team member<br>• Team member experience |

## Antenna Mounting Design Selection

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

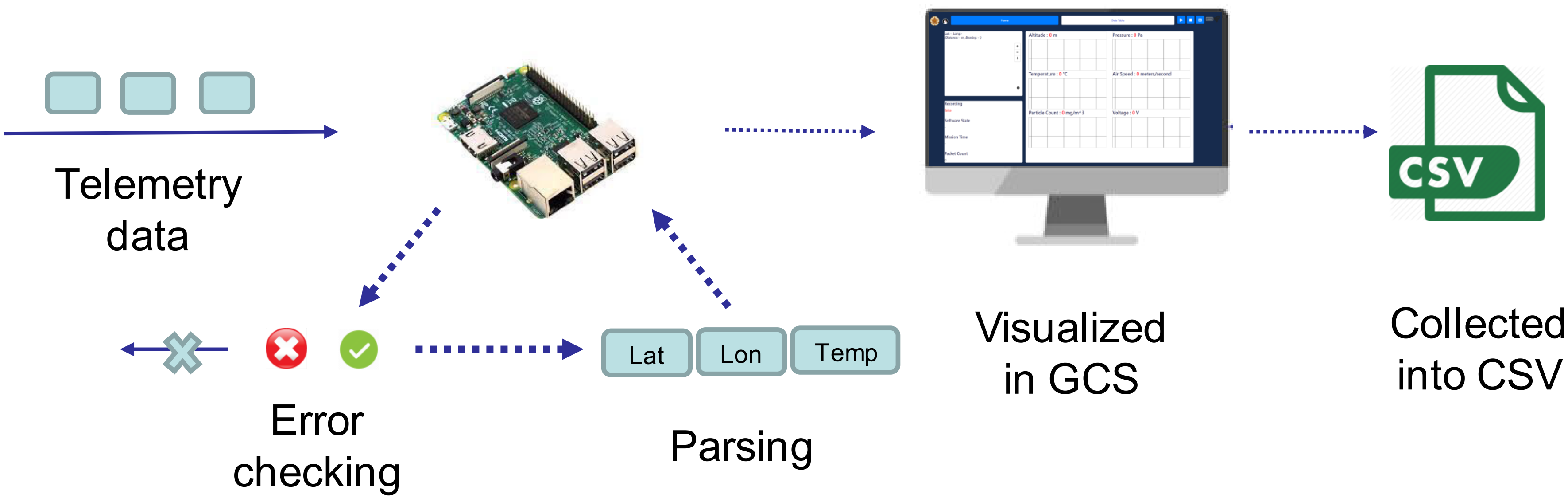



Antenna will be handheld by one of team member. The reason of this is the payload altitude will be changing over time.

# GCS Software (1 of 5)

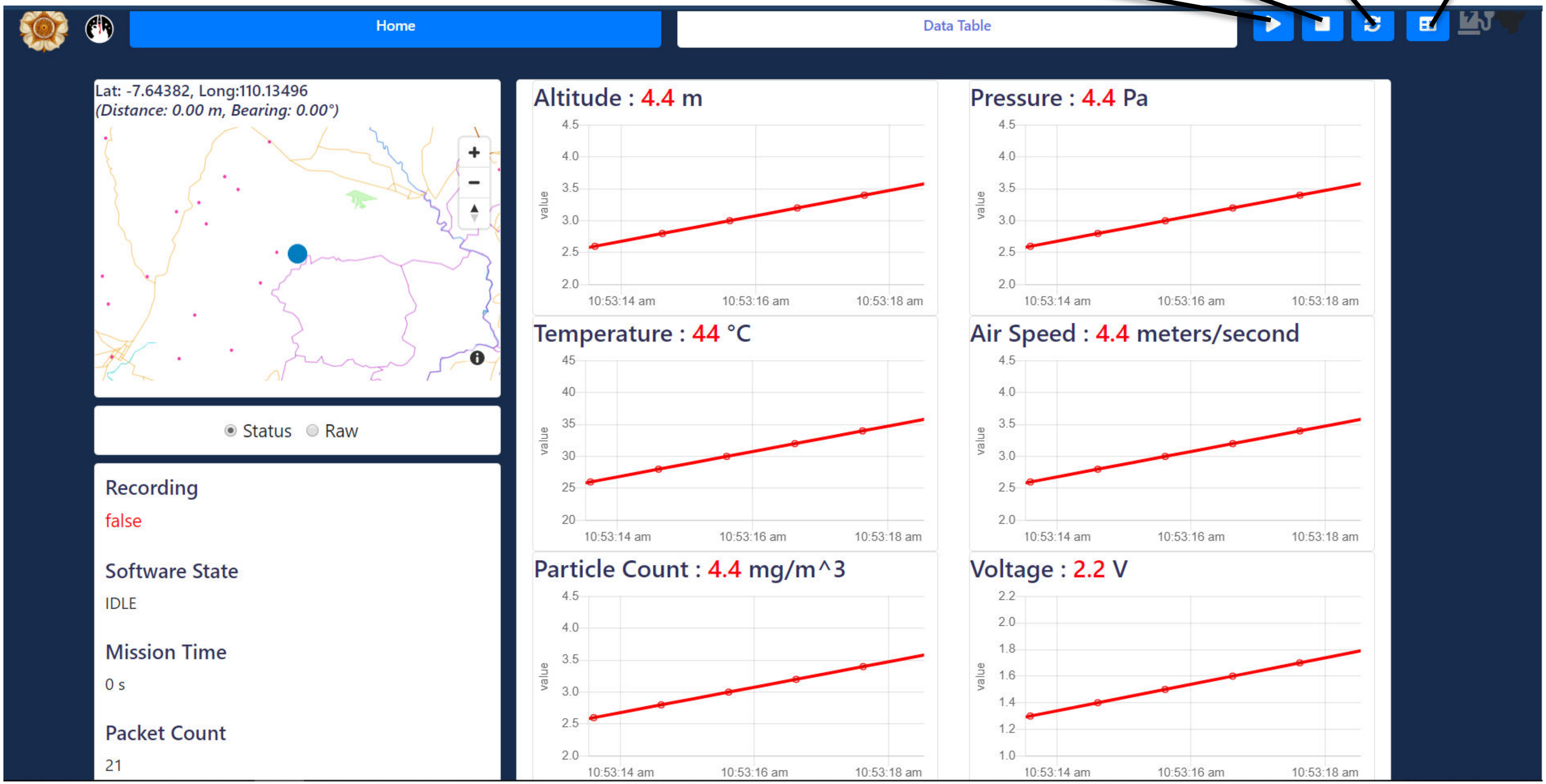
- **COTS Software Packages and Tools**
  - Node.js v10.14.1
  - serialport npm package: real-time RF transceiver access through USB serial port
  - Chart.js and Moment.js : real-time telemetry data plotting
- **Software Commands and Interface**
  - Calibration command, telemetry data transmission command, and data recording command → Button click which will trigger backend service to write a character to XBEE serial port. Then, XBEE will transmit command signal to payload.
  - Data table creation and .CSV retrieval → button click.
- **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.
  - GCS has recording session. Received data at this session will be saved into array before converted later into table by button click.
- **CSV File Creation**
  - First, recorded data should be converted into table using **Save to data table** button. Then, data in table can be retrieved in CSV using **Retrieve .CSV** button.

- **Realtime Plotting Design**

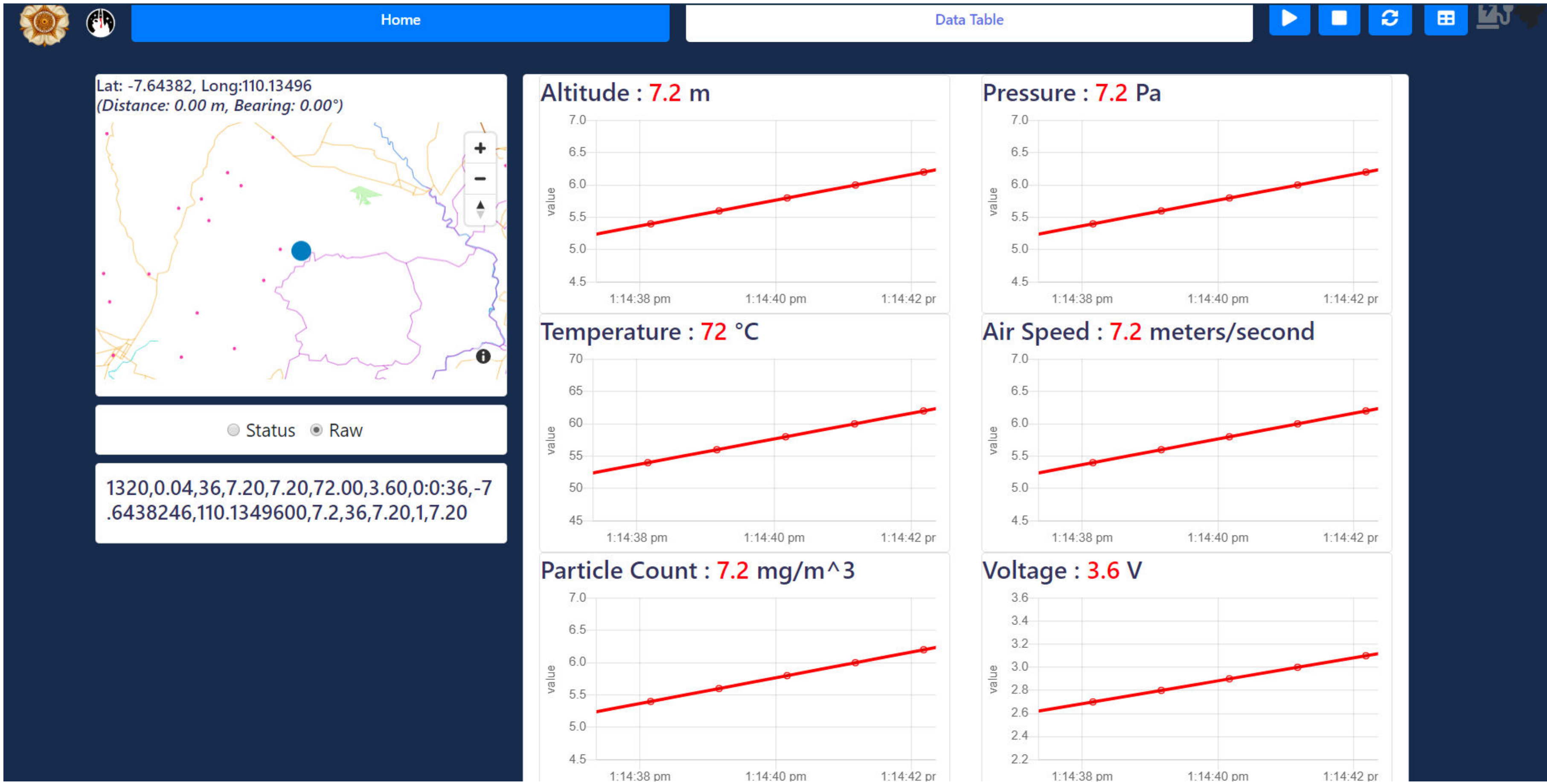


# GCS Homepage

Start transmission
Stop transmission
Calibration
Save to data table



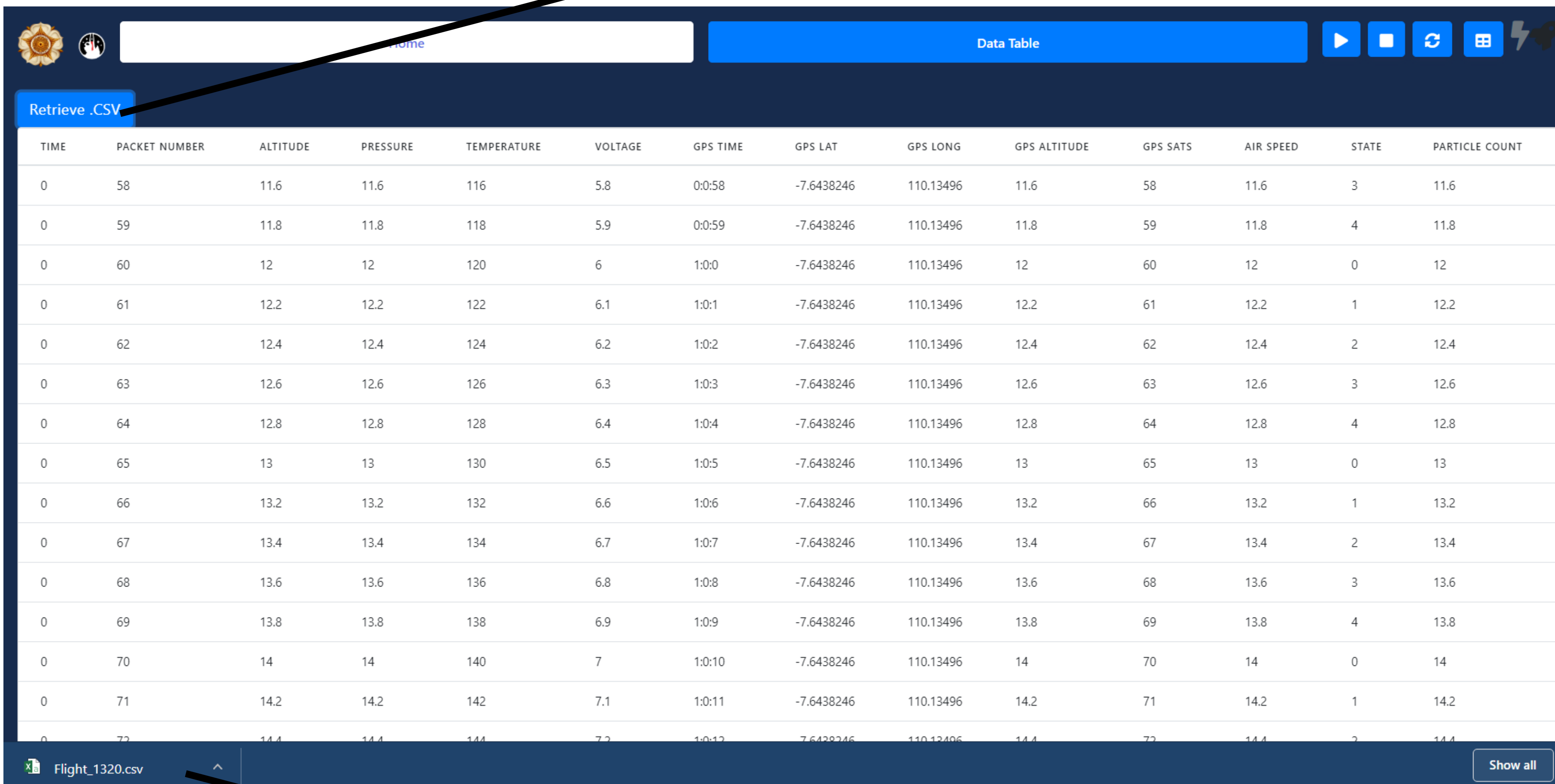
## GCS Homepage with Raw Data



# GCS Software (5 of 5)

## GCS Data Table Page

Retrieve CSV Button




| TIME | PACKET NUMBER | ALTITUDE | PRESSURE | TEMPERATURE | VOLTAGE | GPS TIME | GPS LAT | GPS LONG | GPS ALTITUDE | GPS SATS | AIR SPEED | STATE | PARTICLE COUNT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 58 | 11.6 | 11.6 | 116 | 5.8 | 0:0:58 | -7.6438246 | 110.13496 | 11.6 | 58 | 11.6 | 3 | 11.6 |
| 0 | 59 | 11.8 | 11.8 | 118 | 5.9 | 0:0:59 | -7.6438246 | 110.13496 | 11.8 | 59 | 11.8 | 4 | 11.8 |
| 0 | 60 | 12 | 12 | 120 | 6 | 1:0:0 | -7.6438246 | 110.13496 | 12 | 60 | 12 | 0 | 12 |
| 0 | 61 | 12.2 | 12.2 | 122 | 6.1 | 1:0:1 | -7.6438246 | 110.13496 | 12.2 | 61 | 12.2 | 1 | 12.2 |
| 0 | 62 | 12.4 | 12.4 | 124 | 6.2 | 1:0:2 | -7.6438246 | 110.13496 | 12.4 | 62 | 12.4 | 2 | 12.4 |
| 0 | 63 | 12.6 | 12.6 | 126 | 6.3 | 1:0:3 | -7.6438246 | 110.13496 | 12.6 | 63 | 12.6 | 3 | 12.6 |
| 0 | 64 | 12.8 | 12.8 | 128 | 6.4 | 1:0:4 | -7.6438246 | 110.13496 | 12.8 | 64 | 12.8 | 4 | 12.8 |
| 0 | 65 | 13 | 13 | 130 | 6.5 | 1:0:5 | -7.6438246 | 110.13496 | 13 | 65 | 13 | 0 | 13 |
| 0 | 66 | 13.2 | 13.2 | 132 | 6.6 | 1:0:6 | -7.6438246 | 110.13496 | 13.2 | 66 | 13.2 | 1 | 13.2 |
| 0 | 67 | 13.4 | 13.4 | 134 | 6.7 | 1:0:7 | -7.6438246 | 110.13496 | 13.4 | 67 | 13.4 | 2 | 13.4 |
| 0 | 68 | 13.6 | 13.6 | 136 | 6.8 | 1:0:8 | -7.6438246 | 110.13496 | 13.6 | 68 | 13.6 | 3 | 13.6 |
| 0 | 69 | 13.8 | 13.8 | 138 | 6.9 | 1:0:9 | -7.6438246 | 110.13496 | 13.8 | 69 | 13.8 | 4 | 13.8 |
| 0 | 70 | 14 | 14 | 140 | 7 | 1:0:10 | -7.6438246 | 110.13496 | 14 | 70 | 14 | 0 | 14 |
| 0 | 71 | 14.2 | 14.2 | 142 | 7.1 | 1:0:11 | -7.6438246 | 110.13496 | 14.2 | 71 | 14.2 | 1 | 14.2 |

Retrieved CSV file

# CanSat Integration and Test

**Kenrick Tjandra**

# CanSat Integration and Test Overview

Preparation

Test each component of each subsystem

Test all component of each subsystem level

Integrate all subsystem and match requirements

Test CanSat on appropriate environment

**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

# Subsystem Level Testing Plan (1 of 2)

| | |
|---|---|
| **Sensors** | • Test all sensors on the breadboard<br>• Calibrate until accuracy rate is high<br>• Repeat testing |
| **CDH** | • Test CDH on PCB and breadboard<br>• Ensure serial communication of each sensor is correct<br>• Data storage tested with SD Card<br>• Ensure accuracy and speed of the data sent to ground station is correct |
| **EPS** | • Ensure there are no current leakage<br>• Ensure each sensors power demands are fulfilled<br>• Ensure total power sufficient<br>• Ensure each components functioned properly |
| **Radio Communications** | • Range test<br>• Beam accuracy test<br>• SWR stability test<br>• Repeat testing |

# Subsystem Level Testing Plan (2 of 2)

**FSW**

- Time keeping algorithm is to be tested in case of microcontroller 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
- Testing the camera

**Mechanical**

- Ensure wings deployment mechanism worked properly
- Ensure the payload can separate from container
- Ensure the CanSat structure can survive when rocket is launched
- Ensure the servo in gimbal mechanism could handle torque applied

**Descent Control**

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

# Integrated Level Functional Test Plan (1 of 2)

**Mechanisms**

- This test is designed to verify that the servo can release the payload with allocated power and the parachute deployment mechanisms is working properly
- Functional test of wing deployment system
- Test the time required to release the payload

**Deployment**

- Payload deployment is tested in various altitude
- Parachute deployment is tested in various altitude
- Integration between sensors and servo deployment system is tested in various conditions

**Communications**

- This test is designed to verify that the communication system run smoothly when installed in the CanSat and other XBEEs are active.
- Test in LOS and crowded urban city
- Measure effective vertical and horizontal communication distance with 1 Hz rate and installed FSW program. The data shall appear in GCS monitor

**Descent testing**

This test is designed to verify that the payload can glide in circular orbit

With payload mass approximately 450g, we plan to drop the payload from various height and observe the flight characteristic and measure the flight time of the payload

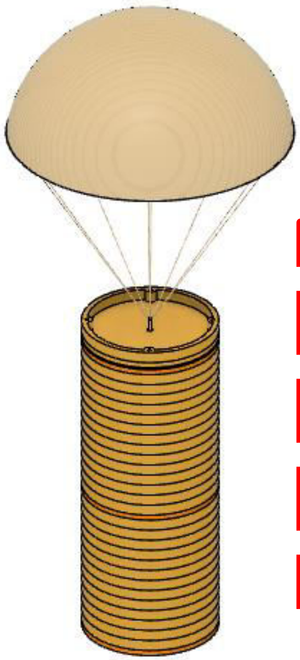
We also plan to test the parachute of the payload in future testing

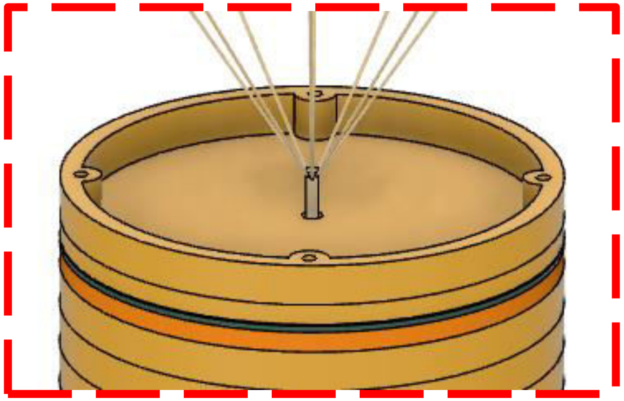
Using drone, the payload will be taken to various height to simulate its glide capability

**Drop test**

This test is designed to verify that the container parachute and attachment point will survive the deployment from the rocket payload section which can be very violent.

The release mechanism will also be tested to verify it can hold the science vehicle in the container. Component mounts and battery mount will also be tested. The drop test generates approximately 30 Gs of shock to the system. (CanSat guidebook)





We plan to drop the cansat from 60cm height with a cord attached to parachute attachment point

# Environmental Test Plan (2 of 4)

**Thermal test**

This test is to verify the CanSat and container can operate in a hot environment.

When the CanSat is integrated into the rocket and sit on the launch pad, the sun can heat up the payload section of the rocket from mid to upper 30ºC temperatures. This test will determine if any warp materials, weaken, characteristics change, or fail to function at up to 35ºC temperature. (CanSat guidebook)


We plan to do the thermal test by using Heat gun. The heat gun and the CanSat will be sealed inside a chamber to maximize heat transfer

Heat gun will heat up the chamber until it reaches 60ºC, then CanSat is placed inside the chamber. Heat gun will be turned on if temperature drop to 55ºC and repeated for 2 hours

# Environmental Test Plan (3 of 4)

**Vibration test**

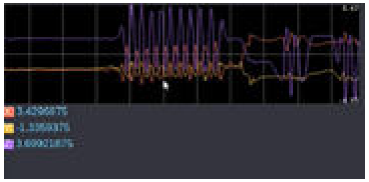
This test is designed to verify the mounting integrity of all components, connections mounting, structural integrity, and battery connections.

The test uses an orbit sander. The sander is a handheld power tool where the sand head moves in a circular pattern.

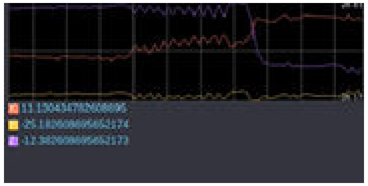
The payload will be plastered to the sander and the sander will be set to its higher power. The sander will be turned off for 2 seconds and repeated for one minute


Orbital Sander

Accelerometer



Gyrometer

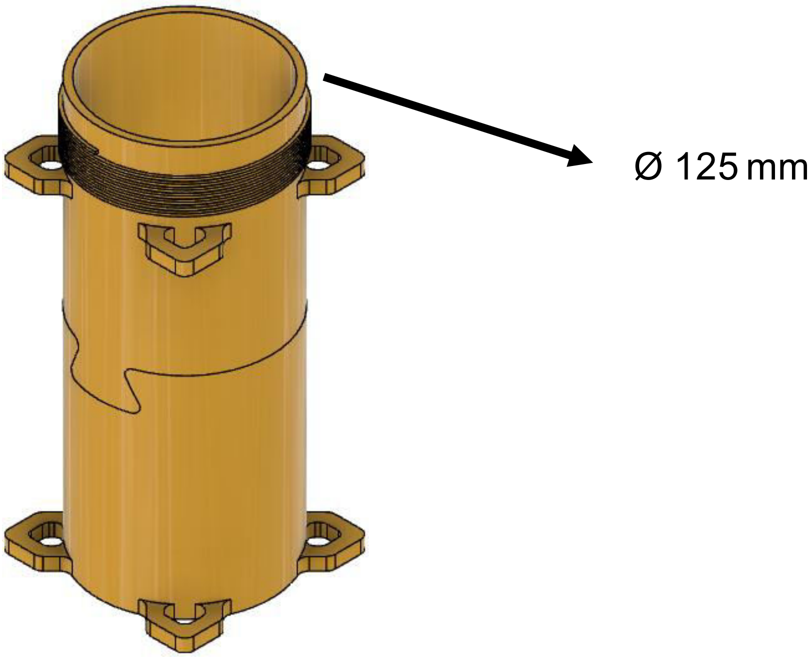


This is the sensor measurement from vibration test

# Environmental Test Plan (4 of 4)

**Fit check**

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




We planned to manufacture a container which has 125mm diameter to simulate launch vehicle fit test.

# Mission Operations & Analysis

**Kenrick Tjandra**

# Overview of Mission Sequence of Events (1 of 3)

| 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 3)

| 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 3)

| Team Member roles and responsibilities | |
|---|---|
| **Roles** | **Member Name** |
| Mission Control Officer | Kenrick Tjandra |
| CanSat Crew | Indra Budi Setyawan |
| | Muhammad Dyffa |
| | Mario Jaya |
| Ground Station Crew | Wildan Purnomo |
| | Mahatma Wisesa |
| Container Recovery Crew | Nico Renaldo |
| Payload Recovery Crew | Luqman Al Helmy |
| | Nafisah Hasya Sekarini |

# Mission Operations Manual Development Plan

**Mission Operation Manual Outline:**

- **GCS Configuration**

  System setup and communication test, antenna communication test

- **CanSat Assembly**

  CanSat major components assembly and general inspection, major mechanism inspection

- **CanSat Integration with Rocket**

  CanSat clearance inspection and final inspection before launch

- **Launch Procedure**
- **Removal Procedure**

  Recovery, Data acquisition

- **Overall Mission Operations Manual objectives**

  Ensure every team member understands every competition rules and procedures during the competition, Ensure the team is able to complete the competition safely

# CanSat Location and Recovery

| Container Recovery | Payload Recovery |
|---|---|
| Outer Structure will be orange colored to aid recovery search | Payload overall 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 | 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 |

# 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

| | |
|---|---|
| | Majority of the requirements has been successfully completed (39/57) |
| | There are few requirements that will need further tests, and are projected to be done In the following weeks. In order to fully comply, we will perform further tests on delta wing opening mechanism, payload separation by using servo mechanism, parachute deploying mechanism on payload, survivability against certain amount of shock and acceleration, and integration and communication of electronic system and sensors. |
| | We have not encounter any serious problem yet, all the requirements have been taken into our considerations and designed according to the rules. |

# 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. | | 99-101 | 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. | | 27 | 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. | | 91 | OK |
| 4 | The container shall be a fluorescent color; pink, red or orange. | | 91 | 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. | | 91 | OK |
| 6 | The rocket airframe shall not be used to restrain any deployable parts of the CanSat | | 95 | OK |
| 7 | The rocket airframe shall not be used as part of the CanSat operations. | | 95 | 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. | | 96 | OK |
| 9 | The descent rate of the CanSat (container and science payload) shall be 20 meters/second +/- 5m/s. | | 67 | Theoretically complies |
| 10 | The container shall release the payload at 450 meters +/- 10 meters. | | 143, 145 | Theoretically complies |
| 11 | The science payload shall glide in a circular pattern for one minute and stay above 100 meters after release from the container. | | 64, 65 | Theoretically complies |

# Requirements Compliance (2 of 6)

| RN | Requirement | Compliance | Ref. Slides | Comments |
|---|---|---|---|---|
| 12 | The science payload shall be a delta wing glider. | | 73, 75 | 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. | | 66, 67, 143 | Theoretically complies |
| 14 | All descent control device attachment components shall survive 30 Gs of shock. | | - | Theoretically complies |
| 15 | All electronic components shall be enclosed and shielded from the environment with the exception of sensors. | | 73, 74, 95 | OK |
| 16 | All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives. | | 97-98 | OK |
| 17 | All structures shall be built to survive 15 Gs of launch acceleration. | | - | Theoretically complies |
| 18 | All structures shall be built to survive 30 Gs of shock. | | - | Theoretically complies |
| 19 | All mechanisms shall be capable of maintaining their configuration or states under all forces. | | - | Theoretically complies |
| 20 | Mechanisms shall not use pyrotechnics or chemicals. | | 73, 95 | 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. | | 95 | OK |
| 22 | The science payload shall measure altitude using an air pressure sensor. | | 32, 123 | Theoretically complies |

# Requirements Compliance (3 of 6)

| RN | Requirement | Compliance | Ref. Slides | Comments |
|---|---|---|---|---|
| 23 | The science payload shall provide position using GPS. | | 34, 123 | Theoretically complies |
| 24 | The science payload shall measure its battery voltage. | | 122, 123 | Theoretically complies |
| 25 | The science payload shall measure outside temperature. | | 33, 123 | Theoretically complies |
| 26 | The science payload shall measure particulates in the air as it glides. | | 37, 123 | Theoretically complies |
| 27 | The science payload shall measure air speed. | | 36, 123 | Theoretically complies |
| 28 | The science payload shall transmit all sensor data in the telemetry. | | 111 | Theoretically complies |
| 29 | Telemetry shall be updated once per second. | | 112 | Theoretically complies |
| 30 | The Parachutes shall be fluorescent Pink or Orange | | 77 | OK |
| 31 | The ground system shall command the science vehicle to start transmitting telemetry prior to launch. | | 159, 161 | Theoretically complies |
| 32 | The ground station shall generate a csv file of all sensor data as specified in the telemetry section. | | 111, 112, 159 | 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. | | 110 | OK |

# Requirements Compliance (4 of 6)

| RN | Requirement | Compliance | Ref. Slides | Comments |
|---|---|---|---|---|
| 34 | Configuration states such as if commanded to transmit telemetry shall be maintained in the event of a processor reset during launch and mission. | | 110 | OK |
| 35 | XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE Pro radios are also allowed. | | 111 | OK |
| 36 | XBEE radios shall have their NETID/PANID set to their team number. | | 111 | OK |
| 37 | XBEE radios shall not use broadcast mode. | | 111 | OK |
| 38 | Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost. | | 190. 191. 195 | OK |
| 39 | Each team shall develop their own ground station. | | 155 | OK |
| 40 | All telemetry shall be displayed in real time during descent. | | 159-163 | OK |
| 41 | All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.) | | 159-163 | OK |
| 42 | Teams shall plot each telemetry data field in real time during flight. | | 159-163 | 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. | | 155-158 | 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. | | 179 | OK |

# Requirements Compliance (5 of 6)

| RN | Requirement | Compliance | Ref. Slides | Comments |
|---|---|---|---|---|
| 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. | | 144 | OK |
| 47 | No lasers allowed. | | - | OK |
| 48 | The probe must include an easily accessible power switch that can be accessed without disassembling the cansat and in the stowed configuration. | | 20 | 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. | | 127, 128 | OK |
| 50 | An audio beacon is required for the probe. It may be powered after landing or operate continuously. | | 117, 122, 123 | OK |
| 51 | The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed. | | - | 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, 132 | 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. | | 18, 20 | OK |
| 54 | Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects. | | 97 | OK |
| 55 | The CANSAT must operate during the environmental tests laid out in Section 3.5. | | 170-173 | OK |

# Requirements Compliance (6 of 6)

| RN | Requirement | Compliance | Ref. Slides | Comments |
|---|---|---|---|---|
| 56 | Payload/Container shall operate for a minimum of two hours when integrated into rocket. | | 124, 132 | OK |
| 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. | | 21, 38 | Theoretically complies |

# Management

**Nafisah Hasya Sekarini**

# CanSat Budget – Hardware (1 of 3)

| Electronics Components | | | | | |
|---|---|---|---|---|---|
| **Component** | **Part Name** | **Quantity** | **Unit Cost ($)** | **Total Cost ($)** | **Consideration** |
| Boost Converter | U3V70F5 | 1 | 11.91 | 11.91 | Actual |
| Buzzer | CMT-8540S | 1 | 2.64 | 2.64 | Actual |
| Heat Sink | Small Heatsink | 1 | 1.95 | 1.95 | Actual |
| GPS | Matek SAM M8Q | 1 | 37.06 | 37.06 | Actual |
| Buck Converter | MIC5219 | 1 | 9.03 | 9.03 | Actual |
| Pitot | MPXV7002DP | 1 | 16.56 | 16.56 | Actual |
| Pitot | Pitot Tube | 1 | 6.41 | 6.41 | Actual |
| Slide Switch 6A | MS12ANW03 | 1 | 3.13 | 3.13 | Actual |
| RF | XBEE Pro S3B | 1 | 53.76 | 53.76 | Actual |
| RF adapter GCS | XBEE Adapter | 1 | 6.05 | 6.05 | Actual |
| Particle Sensor | SPS30 | 1 | 46.71 | 46.71 | Actual |

# CanSat Budget – Hardware (2 of 3)

| Electrical Components | | | | | |
|---|---|---|---|---|---|
| **Component** | **Part Name** | **Quantity** | **Unit Cost ($)** | **Total Cost ($)** | **Consideration** |
| Pressure and Temperature Sensor | BMP388 | 2 | 9.95 | 19.90 | Actual |
| SBC | Raspberry Pi 3B | 1 | 35.00 | 35.00 | Actual |
| Payload Battery | Fenix ARB-L18 | 1 | 12.35 | 12.35 | Actual |
| Container Battery | Fenix ARB-L16-700UP | 1 | 11.00 | 11.00 | Actual |
| Servo | EMAX ES08 | 3 | 5.33 | 15.99 | Actual |
| Camera | Mini Spy Camera | 1 | 12.50 | 12.50 | Actual |
| Antenna | XBEE Antenna 900Mhz RP SMA Male Digi A09-HASM-675 | 1 | 35.50 | 35.50 | Actual |
| | | | Total | 337.45 | |

# CanSat Budget – Hardware (3 of 3)

| Mechanical Components | | | | | |
|---|---|---|---|---|---|
| **Component** | **Part Name** | **Quantity** | **Unit Cost ($)** | **Total Cost ($)** | **Consideration** |
| Deployment Mechanism | Rubber | 1 | 0.07 | 0.07 | Estimated |
| Container Structure | Polyfoam 5mm | 1 | 2.78 | 2.78 | Estimated |
| Container Structure | Polyfoam 10mm | 1 | 6.22 | 6.22 | Estimated |
| Payload Structure | PLA filament | 1 | 21.95 | 21.95 | Estimated |
| Structure Rod | Carbon Rod | 1 | 3.66 | 3.66 | Estimated |
| Wing Structure | Carbon Rod | 1 | 3.66 | 3.66 | Estimated |
| Parachute | HDPE Plastic | 2 | 1.22 | 2.44 | Estimated |
| Adhesives | Araldite Epoxy Glue | 1 | 1.10 | 1.10 | Estimated |
| Payload Wing | HDPE Plastic | 1 | 1.20 | 1.20 | Estimated |
| | | | Total | **43.08** | |
| | | | Margin | **4.31** | |

# Cansat Budget – Other Costs (1 of 4)

## Income

| Source | Amount ($) |
|---|---|
| Department Of Electrical Engineering and Information Technology, UGM | 2000 |
| Department of Mechanical and Industrial Engineering, UGM | 2000 |
| Faculty of Mathematics and Natural Sciences, UGM | 2000 |
| Department Computer Science and Electronics, UGM | 2000 |
| Directorate of Student Affairs, UGM | 5000 |
| Other sponsors | 7000 |
| Total | **20000** |

# Cansat Budget – Other Costs (2 of 4)



## Ground Station

| Component | Part Name | Quantity | Unit Cost ($) | Total Cost ($) | Consideration |
|---|---|---|---|---|---|
| Raspberry Pi | Raspberry Pi 3b | 1 | 46.19 | 46.19 | Actual |
| XBEE | Xbee Pro S3B 900HP | 1 | 56.85 | 56.85 | Actual |
| XBEE Adapter + Cable | XBEE Explorer | 1 | 7.11 | 7.11 | Actual |
| Power Bank | Xiaomi Power Bank 2S 10000mAh | 1 | 13.50 | 13.50 | Actual |
| Antenna | Self-made | 1 | 17.27 | 17.27 | Estimated |
| Antenna Holder | Self-made | 1 | 3.55 | 3.55 | Estimated |
| Computer | Asus ROG Strix GL502VT | 1 | Private | Private | Private |
| | | | Total | 144.47 | |
| | | | Margin | **14.45** | |

# Cansat Budget - Other Costs (3 of 4)

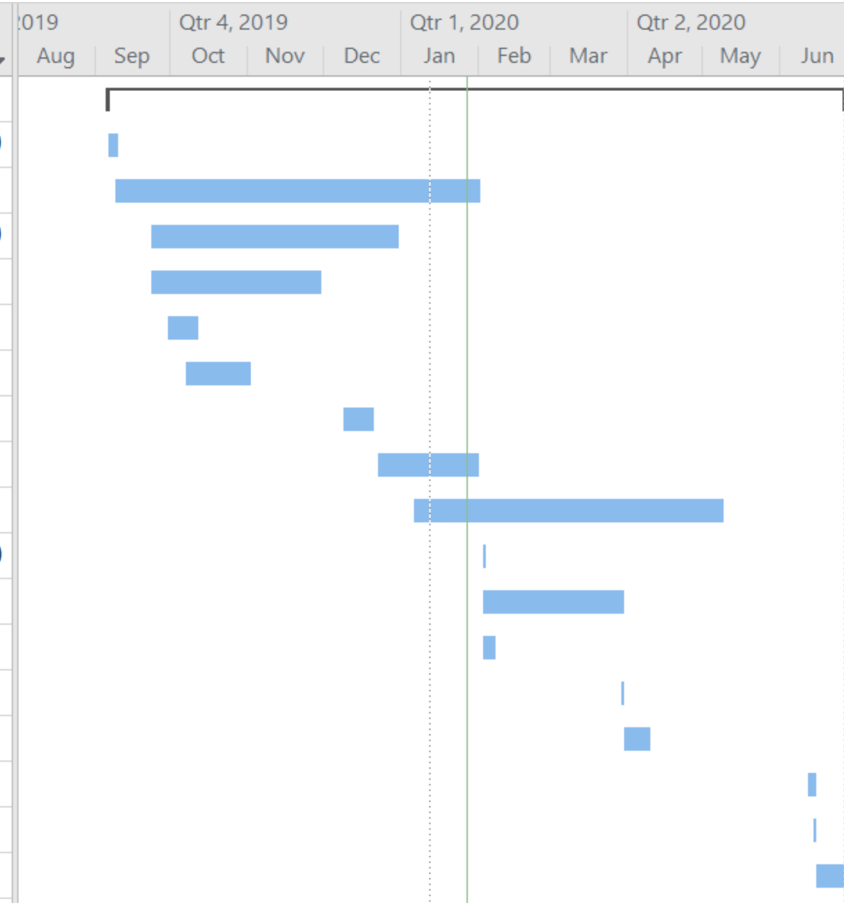
| Other Costs | Quantity | Unit Cost ($) | Total Cost ($) | Consideration |
|---|---|---|---|---|
| Prototyping | 2 | 319.78 | 639.56 | Estimated |
| Test Facilities and Equipment | Provided by University | Provided by University | Provided by University | Provided by University |
| Cooling Fan | 1 | 18.30 | 18.30 | Estimated |
| Umbrella | 1 | 5.85 | 5.85 | Estimated |
| Airfare | 10 | 853.54 | 8535.40 | Estimated |
| Hotel and Expenses | 10 | 550.00 | 5500.00 | Estimated |
| Food | 10 | 300.00 | 1036.46 | Estimated |
| Visa | 10 | 160.00 | 1600.00 | Actual |
| Team Shirts | 10 | 10.00 | 100.00 | Estimated |
| Competition Entry Fee | 1 | 200.00 | 200.00 | Actual |
| | | Total | **17635.57** | |
| | | Margin | **1763.56** | |

# Cansat Budget - Other Costs (4 of 4)

| Categories | Cost ($) |
|---|---:|
| Mechanical & Electrical | 380.53 |
| Ground Station | 144.47 |
| Other Costs | 17635.57 |
| Total | 18160.57 |
| Margin (10%) | 1782.32 |
| Income | 20000.00 |

# Program Schedule Overview

| Task Name | Duration | Start | Finish |
|---|---|---|---|
| **Summary** | **213 days** | **Fri 06/09/19** | **Fri 26/06/20** |
| Team Member Recruitment | 2 days | Fri 06/09/19 | Mon 09/09/19 |
| PDR Preparation | 105 days | Mon 09/09/19 | Sat 01/02/20 |
| Creating Design for the 1st Prototype | 71 days | Mon 23/09/19 | Mon 30/12/19 |
| Order the Components | 50 days | Mon 23/09/19 | Fri 29/11/19 |
| University Mid 1st Semester Exam | 10 days | Mon 30/09/19 | Fri 11/10/19 |
| Prototype Construction | 20 days | Mon 07/10/19 | Fri 01/11/19 |
| University Final 1st Semester Exam | 10 days | Mon 09/12/19 | Fri 20/12/19 |
| Holiday | 30 days | Mon 23/12/19 | Fri 31/01/20 |
| Sponsors | 91 days | Mon 06/01/20 | Fri 08/05/20 |
| PDR Submit | 1 day | Mon 03/02/20 | Mon 03/02/20 |
| CDR Preparation | 41 days | Mon 03/02/20 | Sun 29/03/20 |
| System Integration | 5 days | Mon 03/02/20 | Fri 07/02/20 |
| CDR Submit | 1 day | Sun 29/03/20 | Sun 29/03/20 |
| University Mid 2nd Semester Exam | 9 days | Mon 30/03/20 | Thu 09/04/20 |
| Competition | 2 days | Fri 12/06/20 | Sun 14/06/20 |
| PFR Presentation | 1 day | Sun 14/06/20 | Sun 14/06/20 |
| University Final 2nd Semester Exam | 10 days | Mon 15/06/20 | Fri 26/06/20 |

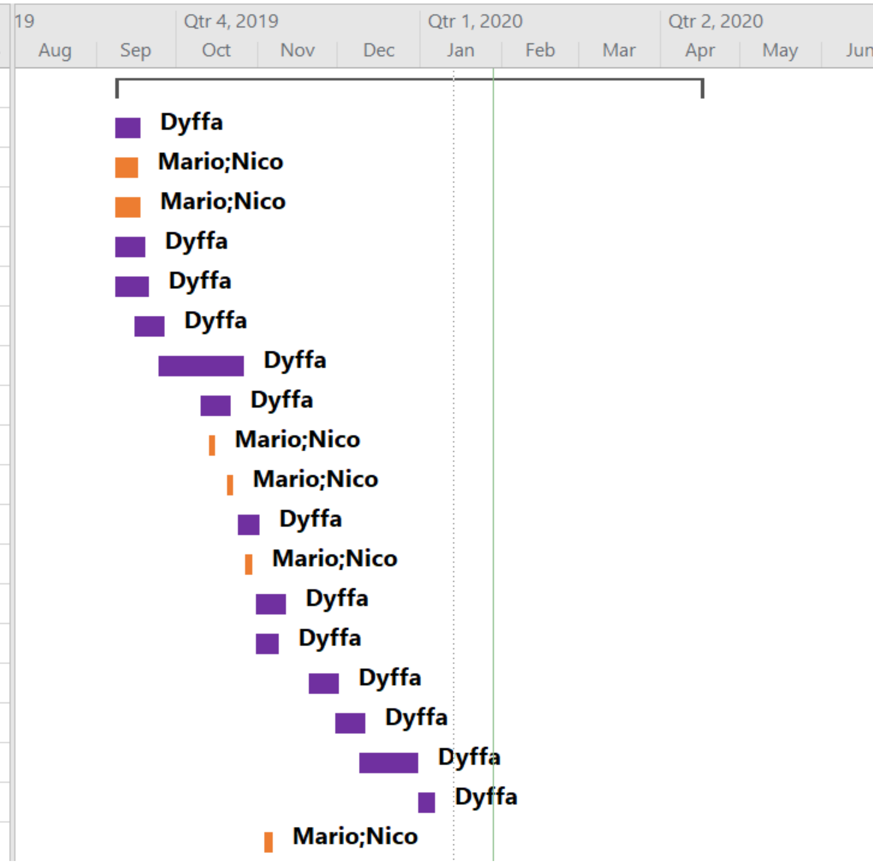


# Detailed Program Schedule (1 of 4)

| Task Name | Duration | Start | Finish |
|---|---|---|---|
| **Administration** | **213 days** | **Fri 06/09/19** | **Fri 26/06/20** |
| Team Member Recruitment | 2 days | Fri 06/09/19 | Mon 09/09/19 |
| First Meeting Of the Team | 1 day | Mon 09/09/19 | Mon 09/09/19 |
| Reviewing the Mission Guide | 5 days | Mon 09/09/19 | Fri 13/09/19 |
| Order The Components | 51 days | Mon 23/09/19 | Fri 29/11/19 |
| Mid 1st Semester Exam | 11 days | Sat 28/09/19 | Fri 11/10/19 |
| Preparing For the Sponsorship Proposal | 59 days | Mon 14/10/19 | Tue 31/12/19 |
| Final 1st Semester Exam | 10 days | Mon 09/12/19 | Fri 20/12/19 |
| Holiday | 30 days | Mon 23/12/19 | Fri 31/01/20 |
| Looking for the Sponsors | 90 days | Mon 06/01/20 | Fri 08/05/20 |
| Looking for Internal Funding (University) | 91 days | Mon 20/01/20 | Sat 23/05/20 |
| Get The Sponsors | 65 days | Mon 02/03/20 | Fri 29/05/20 |
| PDR Submit | 1 day | Sat 01/02/20 | Sat 01/02/20 |
| Preparing CDR | 41 days | Mon 03/02/20 | Sun 29/03/20 |
| Submit CDR | 1 day | Sun 29/03/20 | Sun 29/03/20 |
| Mid 2nd Semester Exam | 9 days | Mon 30/03/20 | Thu 09/04/20 |
| PFR Presentation | 1 day | Sun 14/06/20 | Sun 14/06/20 |
| Final 2nd Semester Exam | 10 days | Mon 15/06/20 | Fri 26/06/20 |

# Detailed Program Schedule (2 of 4)

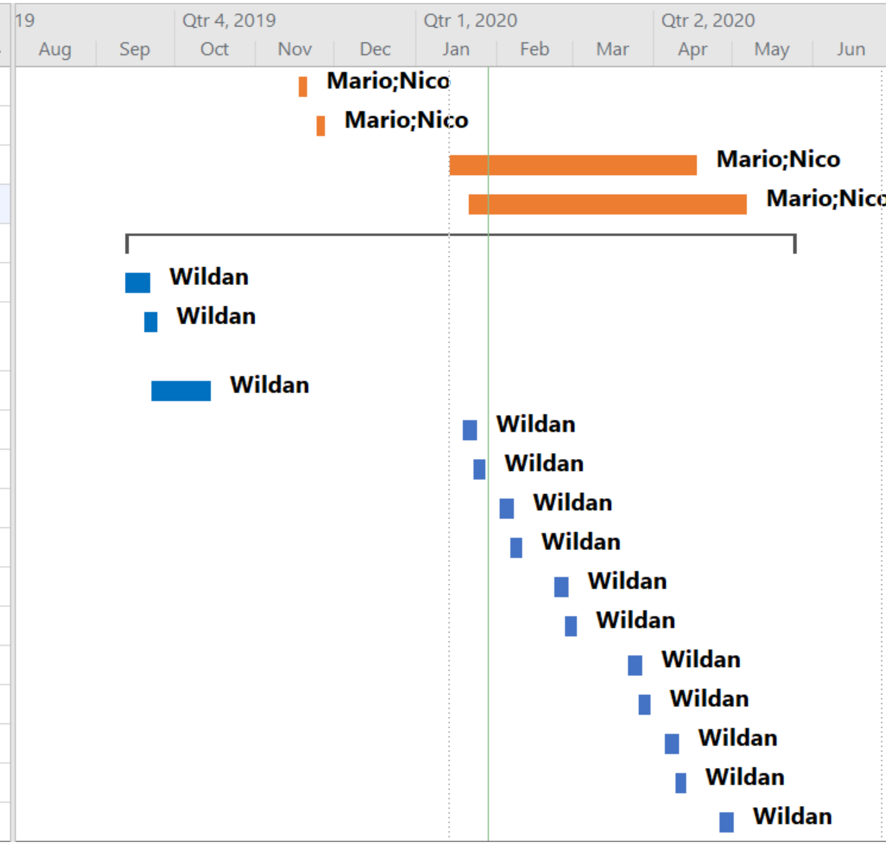
| Task Name | Duration | Start | Finish |
|---|---|---|---|
| **Electronics** | **161 days** | **Mon 09/09/19** | **Thu 16/04/20** |
| Research for The Sensor | 6 days | Mon 09/09/19 | Mon 16/09/19 |
| Research for The Battery | 6 days | Mon 09/09/19 | Sun 15/09/19 |
| Select The Battery | 6 days | Mon 09/09/19 | Mon 16/09/19 |
| Research For The Microcontroller | 8 days | Mon 09/09/19 | Wed 18/09/19 |
| Select The Microcontroller | 9 days | Mon 09/09/19 | Thu 19/09/19 |
| Select The Sensor | 8 days | Mon 16/09/19 | Wed 25/09/19 |
| Prepare The Algorithm | 23 days | Wed 25/09/19 | Fri 25/10/19 |
| Test The Sensor | 7 days | Fri 11/10/19 | Sun 20/10/19 |
| Design for the 1st PCB | 1 day | Mon 14/10/19 | Mon 14/10/19 |
| Evaluate Design of the 1st PCB | 1 day | Mon 21/10/19 | Mon 21/10/19 |
| Testing The Algorithm | 5 days | Fri 25/10/19 | Thu 31/10/19 |
| 1st Version Of PCB Created | 1 day | Mon 28/10/19 | Mon 28/10/19 |
| Calibrating The Sensor | 8 days | Fri 01/11/19 | Sun 10/11/19 |
| Programming The Microcontroller | 6 days | Fri 01/11/19 | Thu 07/11/19 |
| Test Xbee Communication | 8 days | Thu 21/11/19 | Sat 30/11/19 |
| Test The Deploy | 9 days | Sun 01/12/19 | Tue 10/12/19 |
| Calibrate The Camera Tracking | 15 days | Tue 10/12/19 | Mon 30/12/19 |
| Test for Camera Tracking | 4 days | Wed 01/01/20 | Sun 05/01/20 |
| Design for the 2nd PCB | 2 days | Mon 04/11/19 | Tue 05/11/19 |



# Detailed Program Schedule (3 of 4)

Narantaka

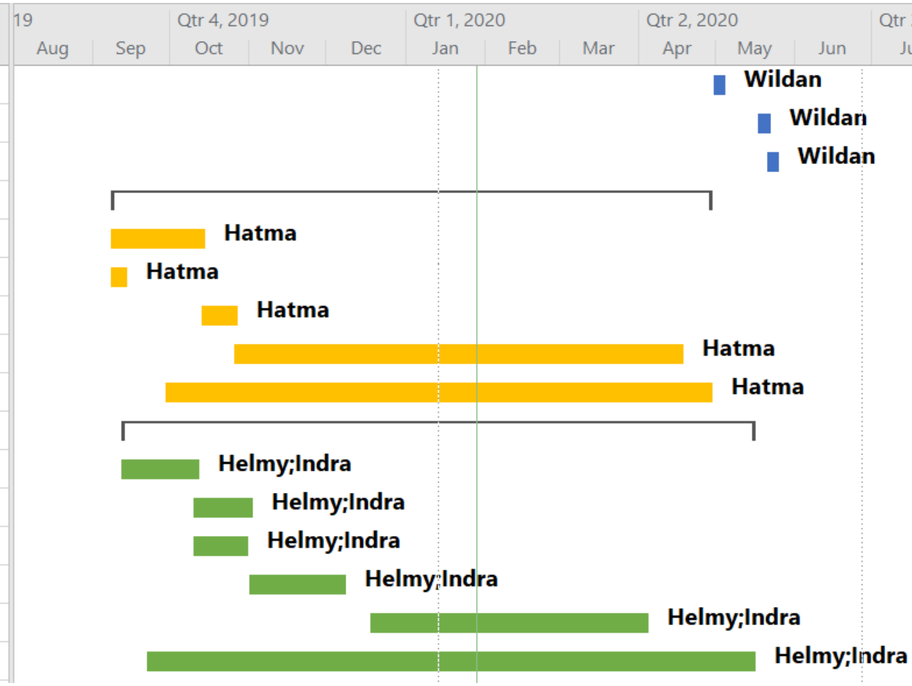
| Task Name | Duration | Start | Finish |
|---|---|---|---|
| Evaluate Design of 2nd PCB | 2 days | Mon 18/11/19 | Tue 19/11/19 |
| 2nd PCB Created | 2 days | Mon 25/11/19 | Tue 26/11/19 |
| Make a design and Evaluate The PCB | 67 days | Wed 15/01/20 | Thu 16/04/20 |
| Test new Version of PCB | 75 days | Wed 22/01/20 | Tue 05/05/20 |
| **Software** | **183 days** | **Fri 13/09/19** | **Sun 24/05/20** |
| Reviewing GCS Used For CanSat 2019 | 6 days | Fri 13/09/19 | Fri 20/09/19 |
| Planning and Designing GCS For CanSat 2020 | 2 days | Fri 20/09/19 | Mon 23/09/19 |
| Applying Changes and Updates Into GCS | 16 days | Mon 23/09/19 | Sun 13/10/19 |
| 1st Integration and Subsystem Test | 4 days | Mon 20/01/20 | Thu 23/01/20 |
| 1st Evaluation | 2 days | Fri 24/01/20 | Sun 26/01/20 |
| 2nd Integration and Subsystem Test | 4 days | Mon 03/02/20 | Thu 06/02/20 |
| 2nd Evaluation | 2 days | Fri 07/02/20 | Sun 09/02/20 |
| 3rd Integration and Subsystem Test | 4 days | Mon 24/02/20 | Thu 27/02/20 |
| 3rd Evaluation | 2 days | Fri 28/02/20 | Sun 01/03/20 |
| 4th Integration and Subsystem Test | 4 days | Mon 23/03/20 | Thu 26/03/20 |
| 4th Evaluation | 2 days | Fri 27/03/20 | Sun 29/03/20 |
| 5th Integration and Subsystem Test | 4 days | Mon 06/04/20 | Thu 09/04/20 |
| 5th Evaluation | 2 days | Fri 10/04/20 | Sun 12/04/20 |
| 6th Integration and Subsystem Test | 4 days | Mon 27/04/20 | Thu 30/04/20 |



Narantaka

# Detailed Program Schedule (4 of 4)

| Task Name | Duration | Start | Finish |
|---|---|---|---|
| 6th Evaluation | 2 days | Fri 01/05/20 | Sun 03/05/20 |
| 7th Integration and Subsytem Test | 4 days | Mon 18/05/20 | Thu 21/05/20 |
| 7th Evaluation | 2 days | Fri 22/05/20 | Sun 24/05/20 |
| **Telemetry** | **169 days** | **Mon 09/09/19** | **Tue 28/04/20** |
| Research For The Antenna | 26 days | Mon 09/09/19 | Sun 13/10/19 |
| Select The Antenna | 5 days | Mon 09/09/19 | Fri 13/09/19 |
| Make The 1st Antenna | 11 days | Mon 14/10/19 | Sat 26/10/19 |
| Improve Design for The Antenna | 128 days | Sun 27/10/19 | Fri 17/04/20 |
| Test The Antenna | 154 days | Mon 30/09/19 | Tue 28/04/20 |
| **Mechanics** | **178 days** | **Fri 13/09/19** | **Fri 15/05/20** |
| 1st Design Creation In Fusion | 21 days | Fri 13/09/19 | Fri 11/10/19 |
| 2nd Design Creation In Fusion | 16 days | Fri 11/10/19 | Fri 01/11/19 |
| Material Trade, Mass Budget Estimate | 14 days | Fri 11/10/19 | Wed 30/10/19 |
| Design Protyping, Feasibility Study | 27 days | Sat 02/11/19 | Sat 07/12/19 |
| Improve Design for The Prototype | 77 days | Thu 19/12/19 | Fri 03/04/20 |
| Test The Prototype | 172 days | Mon 23/09/19 | Fri 15/05/20 |



# Conclusion (1 of 2)

## Administration and Finance

| Major Accomplishments | Major Unfinished Work |
| --- | --- |
| Sponsorship proposal was completed | Waiting confirmation for the sponsors |

## Electronics and Programming

| Major Accomplishments | Major Unfinished Work |
| --- | --- |
| Already put some changes and updates to the software system | Software system hasn’t tested yet to the hardware |
| All sensors has been tested | Require to do unit testing and integration test for the updated software system |

# Conclusion (2 of 2)

| Mechanics | |
|---|---|
| **Major Accomplishments** | **Major Unfinished Work** |
| Prototype of CanSat has been finished and tested | Design improvement of CanSat based on testing results and evaluation |

**Why we are ready for the next stage:**

- We have experiences on joining aerospace related competitions
- So far, we have completed our schedules on time

**Narantaka is ready for the next phase of 2020 CanSat Competition!**