CANSAT 2022-23

CRITICAL DESIGN REVIEW

(CDR)

TEAM ID: 2022ASI-002

TEAM NAME: ASTROPEEP

ASTROPEEP

CANSAT INDIA
Student Competition by IN-SPACe

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Team Description

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Sponsorship to CANSAT

We as Team Astropeep have received the sponsorship from different organisation and institutions, in form of money and in the form of goods.

List of sponsors are as mentioned below:

1. ***Institute of Infrastructure Technology Research and Management, Ahmedabad***
2. ***Centre of Advanced Defence Technologies, IITRAM, Ahmedabad***
3. ***Indian Studytech Services Pvt. Ltd., Dholpur, Rajasthan***
4. ***Rudrabots Pvt. Ltd., Ahmedabad***

List of Acronyms

Acronyms	Meaning
3D	3-Dimensional
A	Analysis
cm	Centimeter
D	Demonstration
dB	Decibel
EPS	Electrical power Subsystem
FRR	Flight Readiness Review
FSW	Flight Software
GCS	Ground Control System
gm	Gram
GPS	Global Positioning System
GS	Ground Station
GUI	Graphical User Interface
Hz	Hertz

I	*Inspection*
I2C	*Inter-Integrated Circuit*
IC	*Integrated Circuits*
LED	*Light Emitting Diode*
PC	*Personal Computer*
QHA	*Quasi Harmonic Function*
RTC	*Real Time Clock*
T	*Test*
VM	*Verification Method*
GHz	*Giga Hertz*
s	*Second*
csv	*Comma separated values*
hrs	*Hours*
PCB	*Printed Circuit Board*
mAh	*Milli ampere hour*
m	*Meter*
V	*Volts*
FSS	*Flight Software State*

System Overview

MISSION SUMMARY

- ***Innovative Mechanical Gyro-control system that shall demonstrate the descent control of the CANSAT.***
- ***CANSAT descent control system that shall open at an altitude of 500 m.***

CANSATs will be launched to an altitude of 800.0 m to 900.0 m from the ground level and above the launch site & deployed near the peak altitude. During the ejection from the rocket orientation of the CANSAT is not controlled. The CANSAT must remain intact during the course of the entire mission and send the data to the ground station through a telemetry link.

Sr.no.	Requirement	Priority	Fulfillment	VM			
				A	I	T	D
1	Total mass of the CANSAT shall be under 0.700 kg (+/- 0.050 kg)	High	Mass of Cansat is within limits.	x			X
2	CANSAT shall fit in a cylindrical body of 0.125 m diameter x 0.310 m height. Tolerances are to be included to facilitate container deployment from the rocket fairing.	High	Cansat is designed with appropriate dimensions.	X			X
3	Any sharp edges on the container body shall be avoided as it can cause interfere during the CANSAT ejection from the rocket.	High	No sharp Edges are present.	X			X

4	*Color of the CANSAT body shall be fluorescent i.e., pink, red or orange, and shall embody the Indian flag.*	*High*	*Color will be fluorescent and will embody Indian Flag.*				*X*
5	*The CANSAT shall consist of necessary sensors to provide the following mandatory Real-time datasets: Position data, altitude, pressure, temperature, orientation data, power data & system status.*	*High*	*Cansat has necessary sensors required for measuring mandatory data.*	*X*			*X*
6	*Each data field shall be displayed in real-time on the ground station user interface/software.*	*High*	*GUI will be developed for displaying Data.*				
7	*CANSAT shall also record the data and save it into an onboard SD card in case of telemetry connection loss.*	*High*	*The data shall be recorded in SD Card.*				
8	*All electronics shall be enclosed and shielded from the environment. No electronics can be exposed except for sensors. There must be a structural enclosure.*	*High*	*No Electronics is exposed.*	*x*			*X*
9	*CANSAT structure shall be built to survive 15 Gs of launch acceleration & 30 Gs of shock.*	*High*	*CANSAT will survive required shock.*				*X*
10	*The CANSAT shall have an external power switch with an indicator light or sound for being turned on or off, in order to avoid the de-assembling of CANSATs on the launch pad.*	*High*	*CANSAT has an external power switch.*	*x*			*X*
11	*The CANSAT shall contain a total of 2 descent control mechanisms, to be used at different stages while descent.*	*High*	*has 2-descent control mechanism.*				*x*

12	***CANSAT shall immediately deploy the first parachute after ejection from the rocket.***	***High***	***1st parachute will be immediately deployed after ejection.***				***X***

Sensor Systems Summary and Test results

Selected Component	Type	Function	Interface
Adafruit BMP 280	Pressure and temperature sensor	Measures air pressure and temperature both in the payload and the container	I2C
Matek SAM M8Q	GPS	Gets payload coordinates (latitude and longitude), GPS time, and GPS satellite	Serial
Voltage divider	Voltage Sensor	Measures voltage of the payload's battery	ADC
MPU6050	Acceleration and Orientation Sensor	Orientation and Acceleration Measurement	ADC

Sensor	Model	Function
Altimeter Sensor	BMP280	Altitude Measurement
Air Pressure and Air Temperature Sensor	BMP280	Pressure and Temperature Measurement
Acceleration and Orientation Sensor	MPU6050	Orientation and Acceleration Measurement
GPS Receiver Sensor	Matek SAM M8Q	Latitude, Longitude, Altitude, Time, Satellites number Measurement

Voltage Sensor	***Voltage Divider , CPU's ADC Converter***	***Power Status***

Payload Air Pressure Sensor Summary (1 of 2)

Sensor-Adafruit BMP 280

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

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

Barometric Equation

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

h = calculated altitude $[m]$

P = sensed pressure $[Pa]$

Po = pressure at ground level $[Pa]$

Sample Output

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

Data Processing

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

kalmanBarometer();

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

Kalman Filter

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

Payload Air Pressure Sensor Summary (2 of 2)

Temperature data will be collected and processed with the help of

Sensor	Adafruit BMP 280

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

Adafruit_BMP3XX library. No further processing is needed as the reading is very stable.

Data Processing

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

Sample Output

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

GPS Sensor Summary

Sensor Matek SAM M8Q + Compass

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

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

Data Processing

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

Sample Output

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

Left to right:

Hour, minute, second, latitude, longitude, altitude, satellite

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

Payload Voltage Sensor Summary

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

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

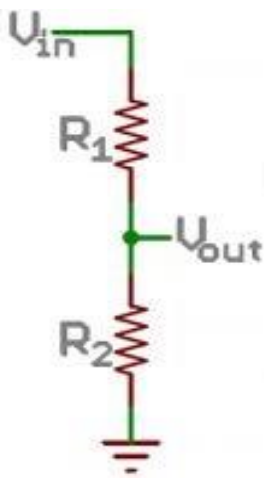
R1 = 1 MΩ

R2 = 100 kΩ

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

Data Processing

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



Sample Output

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

Gyroscope Sensor Selection Summary :

Sensor	Range (°/s)	Resolution (bit)	Accuracy (°/s)	Data Interface	Operating Voltage (V)	Cost (Rs.)	Dimension (mm)	Weight (gm)
MPU6050	±250	16	1.9	I2C/IIC	3-5	120	4 X 4 X 0.9	3

Reason for selecting MPU6050 :

- Light weight, small size and Low Cost.
- Using same sensor for acceleration and orientation measurement will reduce the cost and weight of Cansat.