A Raspberry Pi Powered 1U CubeSat

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Introduction

The goal for of this project is for students to design and build CubeSat prototypes using commercial-off the-shelf (COTS) components and 3D printing techniques. The CubeSat uses a raspberry Pi as the command and data handling center (CDH). The project includes three phases. The first phase is to develop a FlatSat, test components on a flat surface. The second phase is CubeSat developments which includes the design of structures and assembly. The third phase is data collection and analysis. The GPS module, onboard IMU (Inertial Measurement Unit), Camera module and inferred camera module were tested. The experience simulates interacting with a CubeSat for preliminary assembly, integration, & testing (Al&T). Due to its low cost and replicability, this project serves as a model for other students interested in CubeSat design and hardware.

Method

CubeSat is designed using a Computer Aided Design (CAD) software, and CubeSat frames are 3D printed by using PLA (Polylactic acid) plastic. The structure also includes standard M2.5 and M3.0 screws and nuts, as well as heated glue to reinforce frames.

The raspberry pi single board computer is used as the main controller for the CubeSat's subsystems. The Berry-GPS-IMU module is a highly integrated add-on hat for raspberry pi that contains GPS, accelerometer, gyroscope, magnetometer, Barometric/Altitude sensor and temperature sensor.

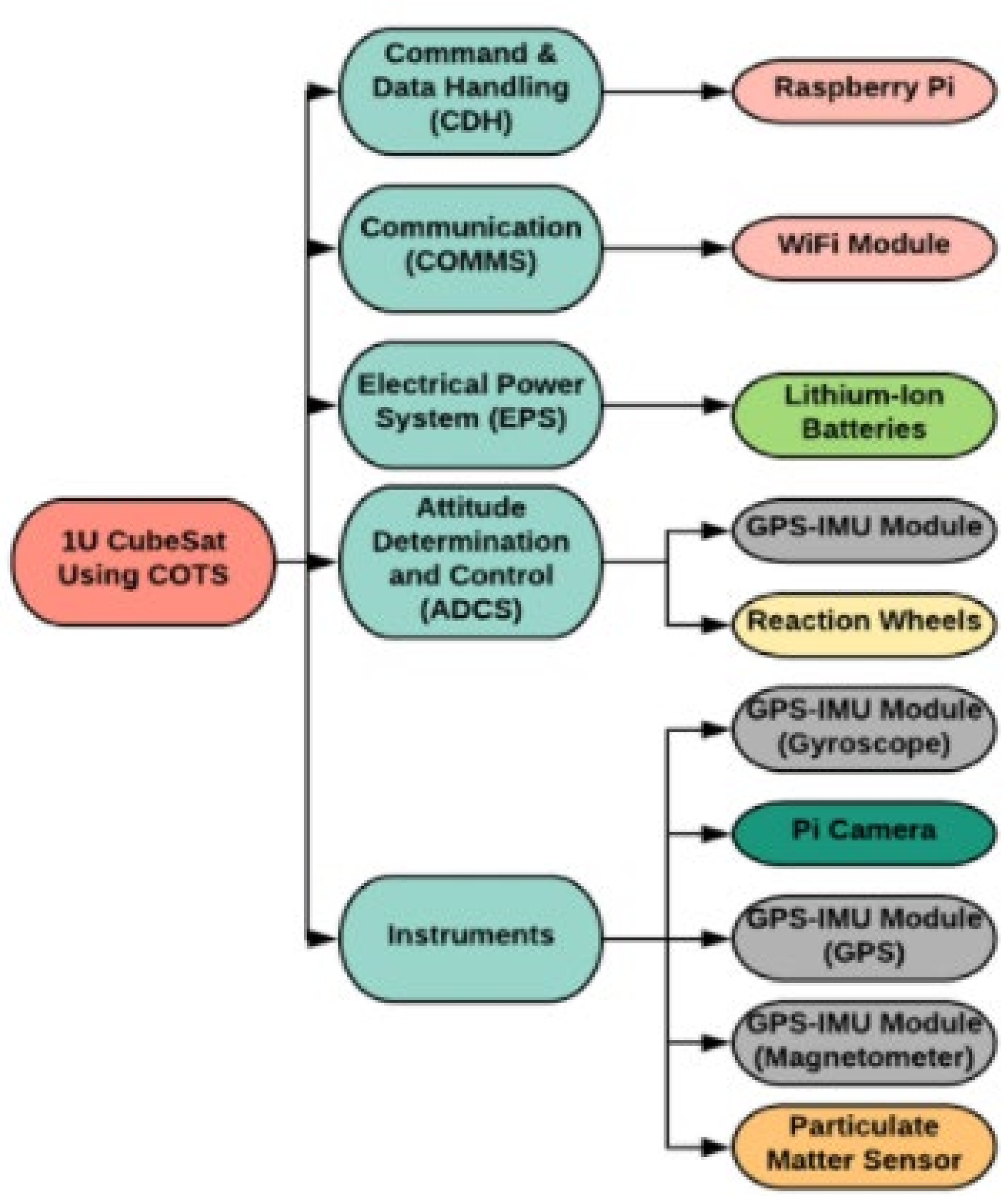

Figure 1: CubeSat Schematic. Gray colored sub-units is GPS-IMU module. Particulate Sensor and Reaction Wheels is the secondary focus of this project.

PHASE 1: FLATSAT ASSEMBLY

The FlatSat assembly (Figure 2) is for testing components on a flat surface before the CubeSat assembly. The layout and the configuration made it is easy to test, diagnose, debug and change components

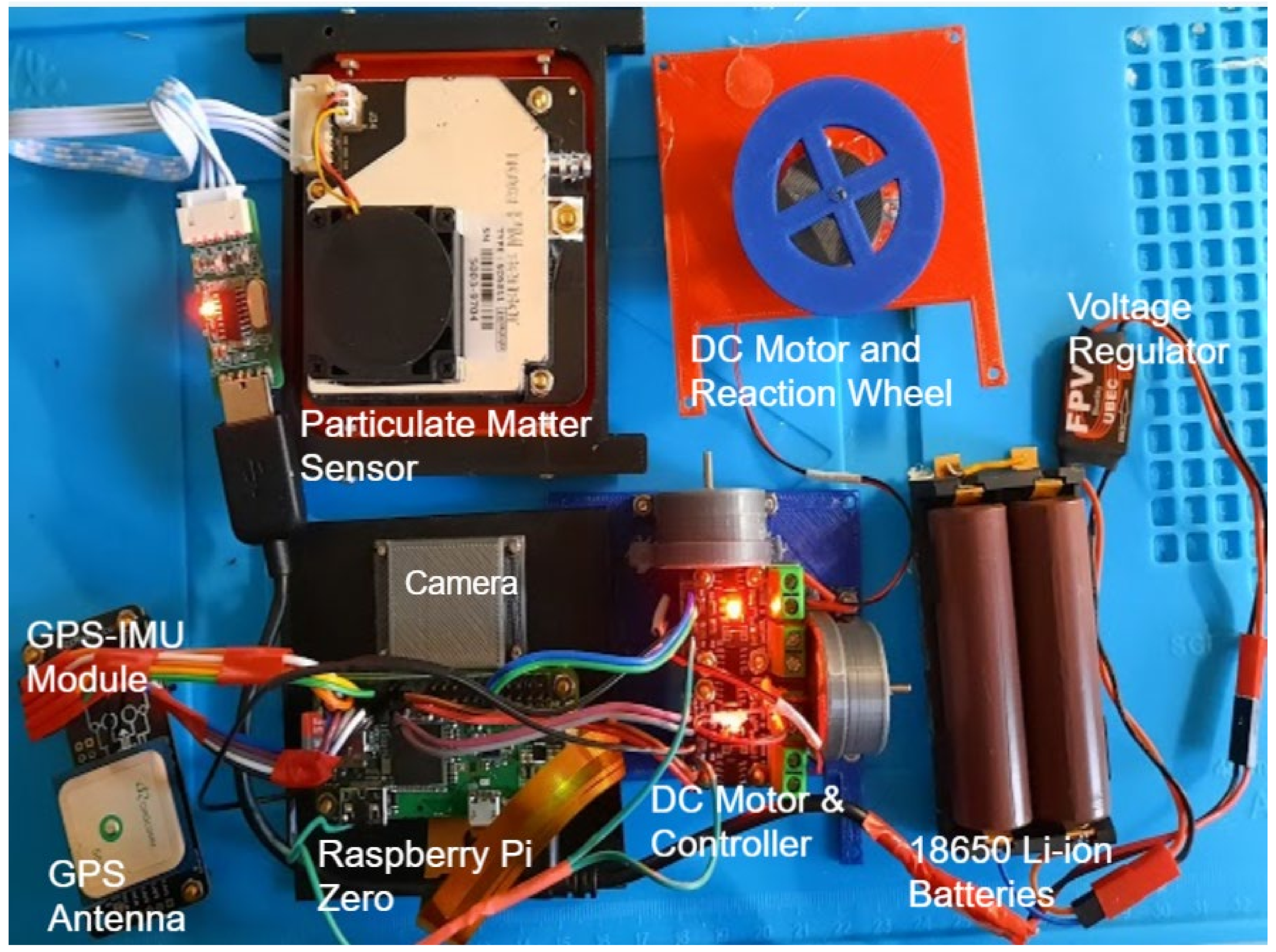

Figure 2: FlatSat Assembly

PHASE 2: CUBESAT ASSEMBLY

The CubeSat design and assembly (Figure 3) followed the following design specifications.

- 1U CubeSat (100mm * 100mm * 113.5mm)
- CubeSat structures designed in Solidworks
- Commercial 3D printer to print frames with polylactic acid (PLA) plastic
- Designs followed CubeSat Design Specification of 1U CubeSat (CalPoly)
- Standardized M2.5 and M3.0 screws and nuts
- Easy to assemble

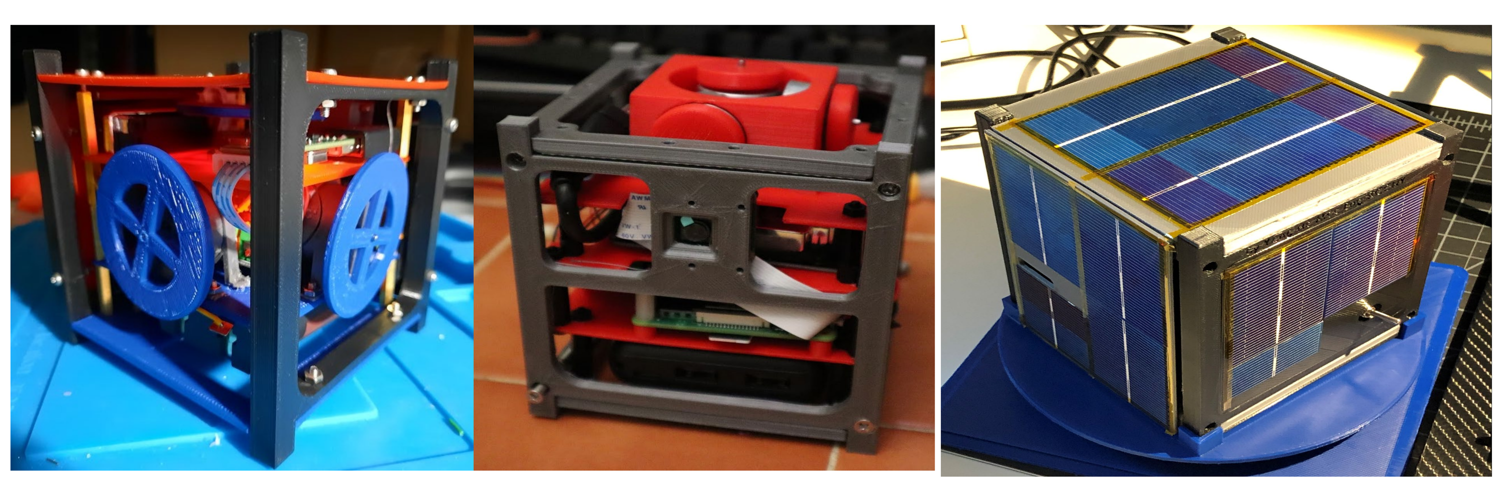

Figure 3:CubeSats Designed by Students

PHASE 3: DATA COLLECTION AND ANALYSIS:

Magnetometer

The data was collection from the sensors that integrated in the CubeSat. The magnetometer is a major sensor for CubeSat's navigation system (NASA), and the calibration of magnetometer is critical for students to learn the fundamental instrument of CubeSats.

The data was collected by using python script and plot via MATLAB. It is a three-dimensional data with respect to x,y and z space axis. The data values only represent its relative strength and does not have a unit.

Ideally, data should be like a sphere (Figure 4). The Uncalibrated data (red dots) is off center and became an ellipse. After calibration, data returns correctly (blue dots)

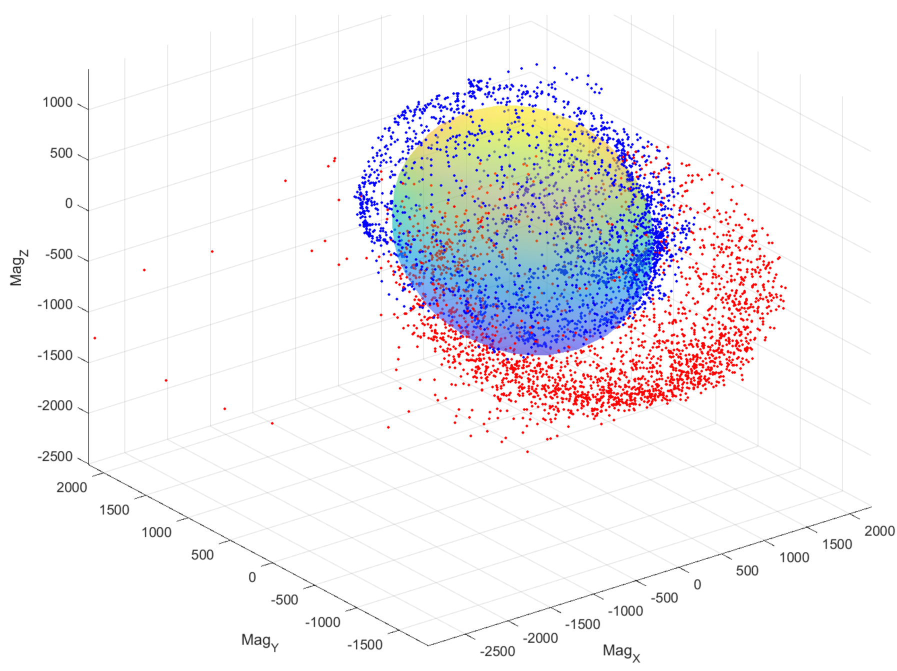

Figure 4: Magnetometer Data

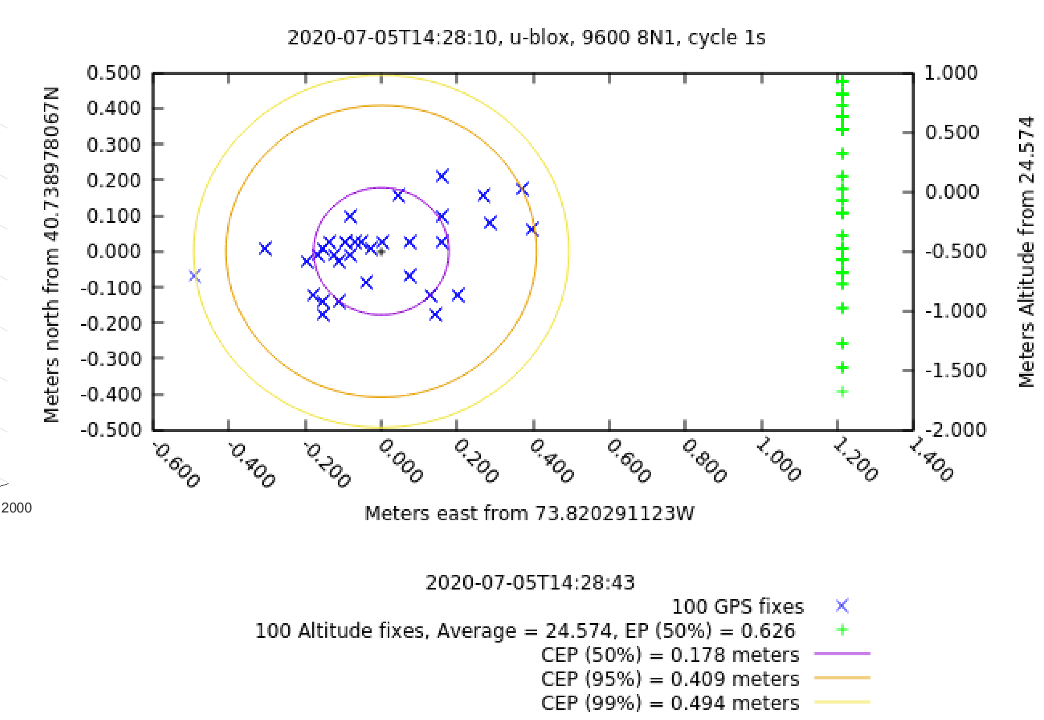

Figure 5: GPS Data

GPS

In order to analyze the accuracy of GPS and its signal, student took 100 data points (fix) from GPS Module and display them on a graph. The graph performs the accuracy profiling on GPS. The results was plotted by *GNUPLOT* and shows that the 99% circular error probable is less than 0.5 meters.

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