NASA SPACE FLIGHT DESIGN CHALLENGE

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***Abstract*— A team of mechanical engineering students at WVU Tech have taken on the challenge of the Space Flight Design Challenge (SFDC). The purpose of this report is to overview the equipment being used for this challenge and how it is being used. When we were given this challenge we received a TubeSat kit which is our starting platform and from there we chose to design our payload based on an accelerometer, gyroscope, magnetometer and IMU. Now we are programming and interpreting the results given, which is included in this paper.**

I. INTRODUCTION

In this Space Flight Design challenge, we have assembled a team of mechanical engineering seniors who are dedicated to take forth this challenge and broaden their knowledge from mechanical engineering to build and program a spacecraft that would take their skill levels to the next stage. Our main goal is to design and integrate a spacecraft from a TubeSat Kit and its payload consisting of battery, solar cells, transceiver (with authorized frequency), microcontroller, antennas and more Mods that would accomplish the mission's requirement set forth by NASA. For this semester, we will be solely focusing on programming and test. The language C++ will be used to control the spacecraft by using simple output and input commands. The payload that we have decided to incorporate in this design is a Satellite Orientation Detection that uses an accelerometer, gyroscope and a magnetometer. Each of these parts will have to be programmed, calibrated, and tested. The knowledge that we will gain from this will extensively aid and promote the understanding that even in space; mechanical engineering can go beyond. Through the collaboration of the Student Partnership in an Advancement of Cosmic Exploration or for short, SPACE club chapter, the team were able to get some of the under classmen to be involved in the project earlier in their studies to understand that engineering is not limited to earth only but also in space. Not only that the team having assistance from these young innovative minds, the team also have the support from the parent engineers from NASA at West Virginia University in Morgantown, West Virginia, and NASA IV&V engineers at hand from Fairmont, West Virginia, to answer any hurdles that may arise.

II. PURPOSE

Our purpose for this space flight design challenge here at WVU Tech is to design a tube satellite that is capable of tracking its location at any given point and time while being in polar low-earth orbit. To do so, we would integrate components like the gyroscope, an accelerometer, and the magnetometer or combinations of any two of the mechanisms to complement each other to get an accurate data calculation and relay it back to earth. A weight limitation has to be-considered; in this case, the payload weight limitation is 70 kg ??. Another major aspect that has to be-considered is the rules for tracking our space vehicle. This tracking is done by the North American Aerospace Defense known as, NORAD; two line Elements (TLEs) through the NASA IV & V operations team.

III. BACKGROUND

The team assembled here at WVU Tech has knowledge from different engineering courses, so each team member is assigned a specific task to do in order to achieve the end goal of this challenge. The team is required to study more on the language of programming the analog devices on the MOD5213. The language that we are using on this design is C++. All calculations are done by using defined variables as an integer (Int). To understand the scope of this design challenge, the team was provided specifications for the TubeSat kit (TubeSat Brochure).

IV. OBJECTIVE

Our over all objective is to build a satellite that incorporates a Satellite Orientation Detection using an accelerometer, gyroscope, magnetometer, and IMU. Once this is done it will be sent in space to do a task of detecting orientation of satellite, measuring the earth magnetic field, and then burn up and fall to earth. We have completed half of the task that needed to be finished before the launch. Our focus now is turning to finishing the project and testing it so it can be ready to launch this summer. Our main goal in finishing the project will be writing the source codes. Once this is done we can begin testing, so that we know that the satellite is ready for flight this summer. When the project is finished, it would show the feasibity for other private entities to have their own personal satellite.

V. PROBLEM STATEMENT

A satellite in space can do a multitude of task. As mechanical engineering students, we have many tools at our disposal along with a wealth of knowledge. Also, we have been given many tools to start this project such as TubeSat Kit; which consist of a MOD-Dev-40 Carrier Board, Setup disc using Netburner for the MOD5213 (referral to figures below provided by the Netburner Development Kit Quick Start Guide and **Figure 7** for specifications).

The MOD5213 comes assembled as seen (this was provided to the team from Netburner Development Kit) in the rectangular space are for the payload and other programmable sensors. This can be programed to do a multitude of task, which we will take full advantage of. During this time in space, the data will be collected and recorded by an SD memory card and transmitted back to NASA through an authorized frequency. With these tools we can and will build a satellite that can perform the necessary tasks at hand.

VI. THEORY

The MOD5213 module that came in this TubeSat kit came already assembled and left open is a rectangular area for installations of mechanisms or payload of choice (seen in **Figure 1**), and a SD card recorder for retrieval and transmission of data. The theory of the payload that we have chosen here at WVU Tech is the use of the magnetometer or IMU, which is the default payload that came with this kit. The Honeywell HMC 2003 (refer to **Figure 2**) is a magnetometer that measures low earth magnetic field by using a tri-axis calculation. The variables that are used for such calculations are x, y, z, theta (Θ_x, Θ_y), the voltage (volts) output, avgVolts, sumVolts, accelVoltsX, accelVoltsY, magX, magY, and magZ. The axis of definition defined as X-axis being the direction of travel, Y-axis being the resultant directions, and the Z-axis being the direction of earth (refer to **Figure 4**). These define variables in theory would be calculated and transmitted. The data will enable us to give an estimated position of the space vehicle at a given point in time. We have managed to get readings with the change of parameters on a sample program. The power source that would power the space vehicle for the course of six weeks is the use of a 9 volt battery and a recharging source using solar cells (refer to **Figure 3**).

VII. METHOD

There are three ways of approaching the methods to achieve this. One would be the use of a Gyroscope, which has a mechanism that rotates but yet it spins on an axis of 90^o from rotation. The data would be recorded from the X, Y, and Z axis and compares the data with the earth's magnetic field. The second component that can be use is the 3-axis magnetic sensor hybrid HMC2003 "Magnetometer". The magnetometer would use an output voltage to measure the earth's magnetic field which would be directly sent to the onboard payload. The third mechanism the team would use is an accelerometer in combination with a built in integrated gyroscope. This combination of mechanism is called the IMU ADIS16300 isensor (refer to **Figure 6**). The accelerometer would detect and calculate the tri-axis to sense it's bearings in zero gravity. All these devices are methods that work coincide with each other to compare output and input data and sends it back to the development and operations team on earth.

The needs for this project is to achieve the communication from space to ground, built systems to communicate with each other and deliver the payload to detect ssatellite orientation.

The next step is the conceptualization. In this project, the concept is to have the tube satellite to orbit the earth at an altitude of 310 km above earth after being launched into space.

The production step is to build and assemble the devices that were provided to our team. We will program the magnetometer, accelerometer, and gyroscope. After the programing process, our team would run test and analysis of the device before we finalize our project.

A. *Figures and Tables*

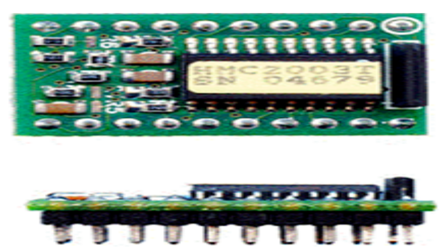


Figure 1: HMC2003 Magnetometer

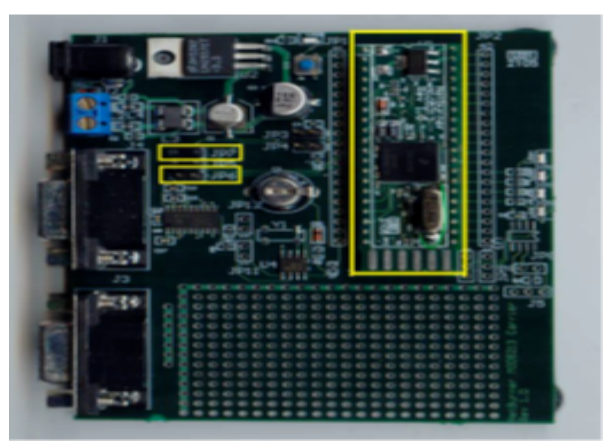


Figure 2: MOD5213 Circuit Board

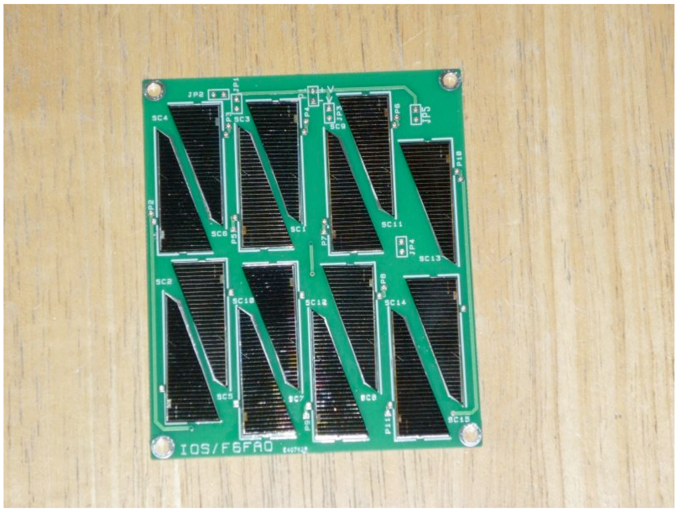


Figure 3: TubeSat Solar Panel

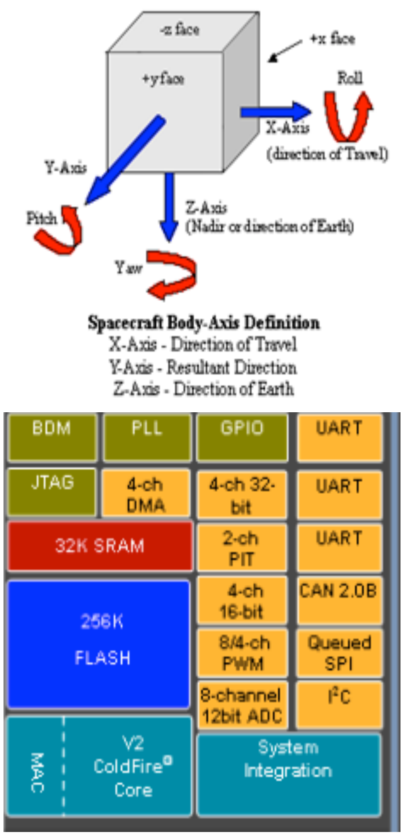


Figure 4: Axis Definition/Block Diagram

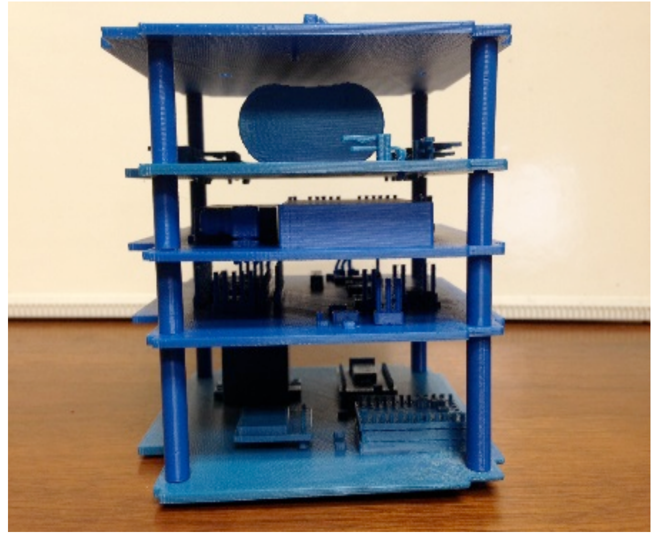


Figure 5: 3D Printed Model of TubeSat

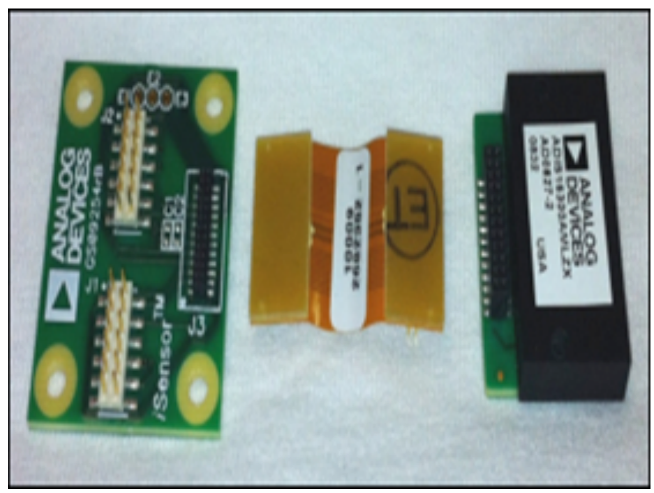
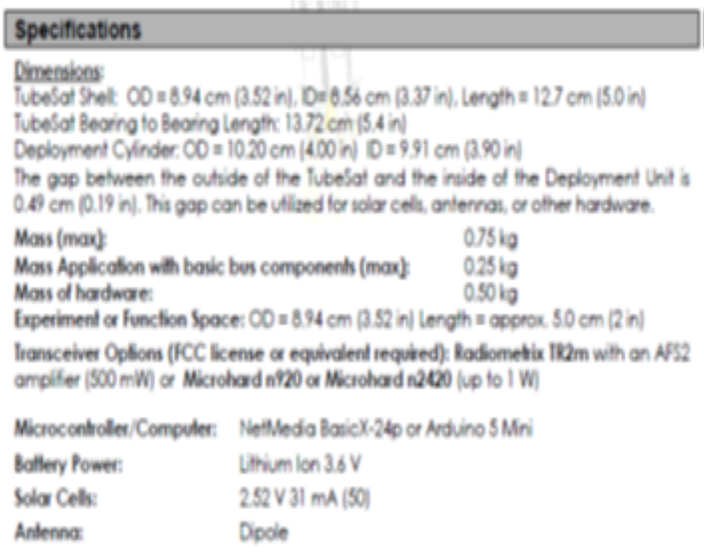


Figure 6: IMU ADIS16300



Specifications

Dimensions:
TubeSat Shell: OD = 8.94 cm (3.52 in), ID= 8.56 cm (3.37 in), Length = 12.7 cm (5.0 in)
TubeSat Bearing to Bearing Length: 13.72 cm (5.4 in)
Deployment Cylinder: OD = 10.20 cm (4.00 in) ID = 9.91 cm (3.90 in)
The gap between the outside of the TubeSat and the inside of the Deployment Unit is 0.49 cm (0.19 in). This gap can be utilized for solar cells, antennas, or other hardware.

Mass (max):	0.75 kg
Mass Application with basic bus components (max):	0.25 kg
Mass of hardware:	0.50 kg

Experiment or Function Space: OD = 8.94 cm (3.52 in) Length = approx. 5.0 cm (2 in)
Transceiver Options (FCC license or equivalent required): Radiometrix TR2m with an AFS2 amplifier (500 mW) or **Microhard n920 or Microhard n2420** (up to 1 W)

Microcontroller/Computer:	NetMedia BasicX-24p or Arduino 5 Mini
Battery Power:	Lithium Ion 3.6 V
Solar Cells:	2.52 V 31 mA (50)
Antenna:	Dipole

Figure 7: Specifications

VIII. Results

The results that the team have achieve just from simple manipulation on some simple commends, e.g. cout, cin, and int(), gives us a reading from the default HMC2003 magnetic sensor that was accomplished by Wes Gosselink. There will be more results as more understanding of the language C++. The team has assembled the satellite components managed to wire all mechanisms according to each components manufactured schematic diagram. Doing so allows us to start the recalibration, test and analysis phase of the design. At this point there are more steps needed to be completed before final analysis.

IX. Conclusion

In conclusion, the procedure for understanding the program that came along with the TubeSat kit is a slow but steady state of getting a good firm ground on how the program works from importing files and retrieving the project and executing the project using the MOD5213 Module with ultimate goal of detecting the satellite orientation. The team is also working with many under classmen to involve them into the project through the introduction of our SPACE (Student Partnership in an Advancement of Cosmic Exploration) club chapter. The finished TubeSat can be referred to **Figure 5**.

Acknowledgment

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