West Virginia University
Blue Team

“Blue Team aims to measure magnetic field data and atmospheric radiation levels to determine their complicity to accepted models, use Software Defined Radio (SDR) to record L-band Radio frequencies to determine feasibility of an SDR as a positioning system, and implement an Inertial Navigation System to determine the attitude of the rocket.”

Clayton Cobb, Austin Hodges, Connor Kirk, Ethan Rohrbach, Amanda Cathreno, James Stephens, Matthew Russell, Samantha Pittman, Thomas Swiger (left to right)

Dr. Jason Gross
West Virginia University

June 3rd, 2019
1.0 Mission Statement, Requirements, and Expected Results

Our Mission essentially has two parts. We are going to test Software Defined Radio and Inertial navigation as two means of navigation. Secondly, we will be comparing atmospheric phenomena with accepted models.

For the Navigation mission to be successful, we must be able to capture enough data to be compared to the Gold Team’s GPS data. For our atmospheric missions to be successful we must be able to calibrate our instruments to obtain measurements that can be compared to the standard models.

The data we receive from the navigational experiment should give use information such as, velocity, position, and acceleration of the rocket. The atmospheric missions will give use values that can be plotted with altitude data from the GPS to show how data is obtained for the standard models.

2.0 Final Payload Design

Mechanical Design

The Blue team has handled a majority of the mechanical design for the canister. Below is a picture of the lower half of the canister. This is where 2 of the batteries will be housed along with Blue Team’s experiments.
The only blue team experiment to be mounted in the top half of the canister is the SDR. This will go above the GPS splitter, mounted to the lid of the can.

The Netburner will be used to help power the GoPro and the splitter. For the sake of clearance though, it will have to be mounted in the lower half of the canister. Wires will run through the wire channel on the canister. This isn’t really a challenge and if anything, is good as it also powers the IMU.
Here is a view from the observation window (left). The NUC’s battery will sit on the top plate while the NUC itself will be under the midmount. There are also 3 batteries total, each reaches the wire channel no problem (right).
3.0 Testing Results

A. Integrated Subsystem Testing Results

SDR:
The Software Defined Radio was tested in tangent with the Gold Team’s Novatel GPS receiver. The rocket launch data was simulated and passed through the signal splitter. For the SDR, the data was processed and is displayed below. This is a projection of the rockets path as seen from the data of the SDR.
**MAGNETOMETER and Geiger counter**

The Geiger counter and the Magnetometer were also tested together. They were both powered on and connected to the data logger. Then they were powered off and were removed. The data was then analyzed with MATLAB. We also successfully collected data for the Geiger counter.
B. Full Mission Simulation Results

**SDR:**

The SDR is able to collect satellite binary data which can be post processed for position solutions. It was used to record both outdoor (real) satellite data, as well as simulated binary data.

**INS:**

The INS data shown was run for 550 seconds. The INS also was run for a duration test of 30 minutes and the battery lasted the full duration of the test. The data we received had some errors in it, but we have since corrected the errors.
MAGNETOMETER and Geiger Counter:

The MAGNETOMETER and Geiger counter were tested for a duration of 30 minutes and it is working exactly as planned. It is integrated and ready for launch.

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### A. User Guide Compliance

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<td>Connected to can by 4 or 5 bulkheads on top and bottom only</td>
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<tr>
<td>Mass at 20±0.2lbs</td>
<td>16.1 lb (Currently making 3.9lb of ballast)</td>
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<tr>
<td>Shared canister clearance</td>
<td>Yes</td>
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<tr>
<td>No voltage on the can</td>
<td>Complied With</td>
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<tr>
<td>No voltage on multipurpose port</td>
<td>Complied With</td>
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<tr>
<td>Activation wires at least 4 ft</td>
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<td>Activation wire at least 24 gauge</td>
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<tr>
<td>Early Activation: current &lt; 1 A</td>
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<td>T-3 Activation: current &lt; .1 A</td>
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</tr>
<tr>
<td>Battery Type</td>
<td>Lithium Polymer (will not charge at Wallops)</td>
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### B. Integration Plan and Procedure

- **Overall**
  - Charge Batteries
  - Hook up t-3 switch and NUC battery to NUC
  - Hook up t-3 switch and Power Distribution battery to INS Board
  - Assemble canister
- **SDR**
  - Uncomment script so when powered it can record data
  - Delete any data currently on the storage
  - Ensure all connections are tight
  - Ensure signal splitter is set up properly
- **INS Board**
  - Clear SD Card
  - Plug in Netburner
  - Plug in IMU
  - Check connections to board
- **MAGNETOMETER**
  - Clear SD Card
  - Hook up to 5v Power on power distribution board
C. Action Items

● Overall
  ○ Complete Vibration testing
  ○ Make sure there is no voltage on the can anywhere.

● SDR
  ○ Ensure Antenna/splitter work properly and receive satellite signals.
  ○ Ensure power connector works
  ○ Ensure script is properly automated

● INS Board
  ○ Get reliable data from software
    ■ Systematically alter parameters to find solution for bad data
    ■ Contact Netburner support for assistance
    ■ If above fails, procure old IMU that we have used in the past and replace ours with that.

● MAGNETOMETER
  ○ All Clear

5.0 Conclusions

Blue Team’s mission is to successfully capture navigation data through both conventional instruments as well as by measuring atmospheric phenomena. We feel confident that our experiments will have a successful flight. We have put an incredible amount of effort into each experiment and have triple checked that everything will work. The Software Defined Radio is arguably the most complicated experiment for Blue Team. This experiment had a big learning curve. Not only did we have to learn how to use the HackRF to collect signals but how to interpret them with the intel NUC. We learned a lot from this experiment in particular. All of the other experiments taught us a lot too, each with their own challenge. We have all enjoyed Rocksat-C very much and are very excited for the Launch. All there is really left to do is complete the build-up of the canister and make sure everything survives vibration testing. This has been an incredible experience for all of us and we’re very grateful for the opportunity.
West Virginia University
Gold Team

“The goal of our mission is to use on-board videography to gauge the accuracy of coastal matching by comparing calculated position from collected images to the measured GPS position.”

Shivani Karlapati, Karie Winston, Joe Fisher, Logan Sheridan, Amos Powell, Yusif Razzaq, Adri Persad, Josh Jones, Junaid Karim (left to right)

Dr. Jason Gross
West Virginia University

June 2nd, 2019
1.0 Mission Statement, Requirements, and Expected Results

Our Mission is to use build a GPS system that can be used to compare data from our Coastal Matching navigation experiment. The GPS data will also be used as a reference for the Blue team’s experiments.

To have a successful mission we must capture video that has good enough quality to discern coastal features for matching to a library of images. The GPS system needs to be operational and be able to collect data for the entirety of the flight.

Upon receiving our data, we expect to be able to plot two trajectories of the rocket. One from GPS and one from Coastal Matching. Theses plots should coincide and prove that our Coastal Matching is a viable form of navigation.
2.0 Final Payload Design

*GPS Apparatus*

The GPS Apparatus is straightforward. The receiver is connected to a GPS splitter, connected to the patch antenna in the multipurpose port. The splitter splits the GPS signal to the Novatel Receiver as well as Blue Team’s Software Defined Radio. The SDR is mounted underneath the splitter.

The splitter only requires 3.3 V, like the other experiments in our canister. Therefore, we can supply power through Blue Team’s Netburner as shown.
Camera Apparatus

The Netburner also provides a very short, burst, of power to the Adafruit Relay. This 3.3V, flips the non-latching relay and causes a short inside the camera’s record button. This is similar as if you just pressed the record button on a GoPro.

Mounting the GoPro has been one of our biggest challenges. Lining the GoPro up with the optical port and making sure it can be mounted to a plate has been very difficult. Ultimately what we came up with was a motorcycle helmet mount. The mount has 3 degrees of freedom, uses screws and is small enough to not get in the way of our other experiments. It’s also very important that this mount can withstand the vibration and acceleration of the rocket. This mount is known to withstand 100mph + winds. The screws are also important because each degree of freedom can be secured permanently when it’s time for launch, but we can still adjust the camera as needed.
3.0 Testing Results

A. Integrated Subsystem Testing Results

GPS On-Ground Test Results
- Dual- Frequency Patch Antenna

- Smaller patch Antenna

Test shows the accuracy of the patch antennas. They are accurate enough for our experiment. *Note we did not take the GPS inside a building. Google Earth is just not up to date.
GPS Simulation Test Results

These results show the receiver is officially delimited and can collect data throughout the entire flight.

Camera Coastal filters and detection
**GoPro Integrated with NetBurner integration**

Successfully integrated turn on of GoPro with a small Adafruit relay connected to the Netburner. Turn on testing completed.

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**Block Diagram of entire system integration**

[Diagram of the entire system integration]
B. Full Mission Simulation Results

Coastal Matching comparisons

We are able to compare two different images of the same coastline. The program is able to accurately detect similar features along the coast.

Example Input: Folder contains three reference images for testing
**GPS Integration with Splitter**

We were able to integrate the GPS with a splitter and receiver and receive the exact same data as before.

**GPS integration with Splitter and SDR**

After we tested the GPS with the splitter, we were able to test with both the splitter and the SDR. Both navigation system reported a fix and were able to collect data.
4.0 Launch Readiness
   A. User Guide Compliance

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<td>Yes</td>
</tr>
<tr>
<td>Battery Type</td>
<td>Lithium Polymer, pre-charged</td>
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</tbody>
</table>

B. Integration Plan and Procedure

Procedure:
1) Charge ALL Batteries before arriving to wallops
2) Clear GoPro SD Card, make sure GoPro is clear and operational
3) Turn on GPS at Wallops to sync GPS. This will have to be done before launch, so the GPS finds satellites as easily as possible.
4) For integration we need to make sure the GoPro lines up perfectly with the optical window. We’ll have to do some mounting and adjusting while we’re there. Once it’s lined up, we’ll secure the apparatus and do significant vibration testing.
5) Connect the GPS splitter to multipurpose port.
6) We’ll have to test the Netburner turn on to make sure everything works; first that the GoPro turns on correctly and second that the GPS splitter receives power, letting the GPS and splitter collect data.
C. Action Items
1) Batteries need to be charged
2) Vibration Testing
3) Voltage Check on Cannister
4) Reliably turn on GoPro with Blue Team's NetBurner
5) Collect GPS data with a full system turn on.

5.0 Conclusions

Gold Team’s experiments have been centered around navigation since the beginning. We have faced a lot of hurdles with our experiments, but we have also learned a lot. The camera experiment was by far the most challenging for us. Calibration, collection, turn on, mounting; literally every aspect of this experiment has had a complication. However, with the launch coming up, we have the up most confidence in the both of our experiments. There isn’t much left to do except mounting and vibration testing. Our code all works, and the instruments are running very smoothly. We’ve all enjoyed RockSat-C thoroughly and have learned a lot this past year.