Subsystem Testing Review

Hobart and William Smith Colleges

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Mission Overview

Section 1
Mission Overview

- Our mission is to get more data on where muons occur in the upper atmosphere and create a model of a slice of the earth's magnetic field.
- Our mission has two parts:
  - Muon Detector
  - Magnetometer
- Additionally, we plan to reach out to a local high school/middle school to promote interest in STEM fields.
Concept of Operations

Altitude (km)

Medium Muon Flux and Magnetic Field Strength
\[ t \approx 1.3 \text{ min} \]
Altitude: 75 km

End of Orion Burn
\[ t \approx 0.6 \text{ min} \]
Altitude: 52 km

- All systems activated
- Begin data collection

Apogee
High Muon Flux
Low Magnetic Field Strength
\[ t \approx 2.8 \text{ min} \]
Altitude: \( \approx 115 \) km

Medium Muon Flux and Magnetic Field,
High Tumble
\[ t \approx 4.0 \text{ min} \]
Altitude: 95 km

t \approx 15 \text{ min}
Splash Down
Payload Turns off

Altitude (km)

End of Orion Burn
Altitude: 52 km

- All systems activated
- Begin data collection

Apogee
High Muon Flux
Low Magnetic Field Strength
Altitude: \( \approx 115 \) km

Splash Down
Payload Turns off

Altitude: 75 km

Medium Muon Flux
\[ t \approx 1.3 \text{ min} \]

Chute Deploys
\[ t = -3 \text{ min} \]

Altitude: 75 km

Medium Muon Flux
and Magnetic Field Strength
\[ t \approx 1.3 \text{ min} \]
Altitude: 75 km

Chute Deploys
\[ t = -3 \text{ min} \]

Medium Muon Flux
and Magnetic Field Strength
\[ t \approx 1.3 \text{ min} \]
Altitude: 75 km

Chute Deploys
\[ t = -3 \text{ min} \]
Final Design Description

Section 2
Changes Since CDR

- We have almost finished the soldering required for the MUON subsystem.
- We have secured complete funds for our project from the President’s Office of HWS, so we can fully focus on the construction of the payload, without worrying about funding
MUON Functional Block Diagram

Legend
- Positive Power
- Ground
- Data Request Wire
- Data Wire
- Built in connections
- WFF t-3
- Power Switch
MAG Functional Block Diagram

Legend
- Positive Power
- Ground
- Data Request Wire
- Data Wire
- Built in connections
- Faraday Cage
- WFF t-3 Power Switch
Mechanical Design - Overall Physical Model

**Half Canister**

1. MUON
2. Aluminum Casing
3. Arduino Nano

Top Plate

Bottom Plate

1. MAG
2. FAR

Red Board

Arduino Uno

9V Power (x2)

HWS
RockSat-C
2018
Mechanical Design - Top Plate

Top Plate

D 0.89"
1.03"
2.17"
1.89"
3.54"
6.57"
D 9.1"

HWS
RockSat-C
2018
Mechanical Design - Bottom Plate

Bottom Plate

R 4.1"
R 3.5"

Middle Support Holes
Base Support Holes

9.1"
2.05"
1.125"

HWS
RockSat-C
2018
Mechanical Design - Payload in Canister

Half Canister

4.25"
Electrical Design
Hazardous Mechanical and Electrical Elements

- All of the parts of our subsystems are solid state
- Our payload will not exceed the voltage maximum
## Detailed Mass Budget

### Overall Weight Budget

<table>
<thead>
<tr>
<th>Component</th>
<th>Total Mass (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAG</td>
<td>0.118</td>
</tr>
<tr>
<td>MUON</td>
<td>0.953</td>
</tr>
<tr>
<td>Mounting Plates</td>
<td>0.576</td>
</tr>
<tr>
<td>4 9v Batteries</td>
<td>0.4</td>
</tr>
<tr>
<td>Half Canister</td>
<td>3.45</td>
</tr>
<tr>
<td>Current Ballast Estimate</td>
<td>0.503</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>6</strong></td>
</tr>
</tbody>
</table>
# Updated Power Budget

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Voltage (V)</th>
<th>Max Current (A)</th>
<th>Time On (min)</th>
<th>Watts</th>
<th>Ah</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muon</td>
<td>21.0</td>
<td>0.30</td>
<td>18</td>
<td>6.20</td>
<td>0.09</td>
</tr>
<tr>
<td>Magnetometer</td>
<td>9.0</td>
<td>0.05</td>
<td>18</td>
<td>0.41</td>
<td>0.01</td>
</tr>
</tbody>
</table>
Software Design Elements

- Both subsystems work the same on separate arduinos.
- They read the data given by their respective sensor and write the numerical data and a timestamp to a file on a microSD card.
Software Elements - MAG

- Code for the MAG has been written by the manufacturer for the arduino.
- This code is already functional and we are able to view results on a computer.
- Code for saving the data to an SD card needs to be written.
Code has been written for a detector utilizing the same electrical components as our detector by a professor at MIT. The code has already been modified to eliminate elements that we are not using. The code is ready for testing the detector although not ready for saving data.
De-Scopes & Off-Ramps

- We have extra PCD’s for the muon detector, so if we destroy one of them it isn’t a problem.
Mechanical Elements

Has been manufactured/purchased:

- Scintillator & SiPM
- Arduino Nano (not mounted)
- PCBs (Components still being soldered)
- All parts for the magnetometer

Has not been manufactured/purchased:

- Aluminum Casing
- Subsystem plate mounts
Electrical Elements

MAG

- The MAG 3110 has been soldered and is working.
- The SD card shield is attached.
- The real time clock arrived this week.

MUON

- Most of the parts have been soldered.
- The parts that have not been soldered have arrived recently.
Software Elements

MAG

- Code for the MAG 3110 has been tested and works.

Muon

- Code has been written by the designers of the detector.

Both subsystems do not yet have code for writing to SD cards yet, but progress has been made towards writing to SD cards.
Subsystem Test Results

Section 4
Magnetometer

- We have gotten code to work for measuring magnetic fields with the MAG3110.
- The faraday cage is not operating as we had hoped, but its failure has given us some useful information:
  - The fields that we are trying to block with the cage are not easy to make, and unless they are intentionally created within a very small radius of the sensor, won’t be an issue.
MAG: Status

- The magnetometer is operational
- We have tested the magnetometer in different orientations, and have tested it for handling interference from nearby sources
  - Permanent magnets
  - Electromagnets
  - Current running through wires
- These tests have given us good results: the magnetometer will be unlikely to be heavily affected by interference from the rocket
MAG: Initial Tests

- The graph below shows a crude electromagnet being held close to the magnetometer. While the data isn’t numerically significant, it demonstrates that:
  - The magnetometer responds to changing magnetic fields
  - The magnitude of that change can be measured
  - The strength of the field returns to what it was prior to the magnets introduction, showing that the detector is not permanently affected by the field
MAG: Data

- We have completed some initial testing at this time to confirm that the code and magnetometer are working properly.
- We are currently working on devising a way to test the sensor with magnets of known strength, to check to see that the sensor is reading correct values.
Muon Detector

- We have obtained the final prints of the PCBs and have soldered all but a few components onto two copies.
- We cannot test the functionality of the Muon detector due to some of the components only arriving recently, but we have been using a digital multimeter to test the resistance each resistor soldered component on the board.
MUON: Status

- The detector is almost complete and we have recently received the parts that are needed to complete the soldering on the PCB.
MUON: Tests/Data

- No tests of detecting muons has been done yet.
- We have used a digital multimeter to check our soldering and no issues have been found.
Plan for Integrated Subsystem Testing

Section 5
Plan For Integrated Subsystem Testing

We are much farther behind with the muon detector than the magnetometer. We should be able to get everything tested and integrated by the end of March.
Project Management Update

Section 6
Management and Team Updates

- Team member Marshall Ireland has found that he no longer had the time to participate and has left the team.
- We have started the process of recruiting middle schoolers for our G-Sat program.
- We are currently working with the HWS administration and the middle school’s administration to handle the insurance/liability forms in order to bring students on campus
User’s Guide Compliance

Section 7
<table>
<thead>
<tr>
<th>Requirement</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass within 6±.1 lb</td>
<td>Currently under 5 lbs (only experiment, not canister). Ballast will be added once the payload is complete</td>
</tr>
<tr>
<td>Center of Gravity</td>
<td>The center of gravity currently lies within the given constraints in the z direction, but will need to be balanced with ballast to fit the x and y constraints</td>
</tr>
<tr>
<td>Volume within 9.1” x 9.1” x 4.25”</td>
<td>9.1” x 9.1” x 4.25”</td>
</tr>
<tr>
<td>Activation</td>
<td>The payload will need to be activated around 3 minutes prior to launch</td>
</tr>
<tr>
<td>Neutrally Charged Payload</td>
<td>The payload is mounted on an insulative plate, and will not have any electrical potential between it and ground</td>
</tr>
<tr>
<td>Thermal Control</td>
<td>The payload will not generate enough heat to necessitate an active heating component</td>
</tr>
<tr>
<td>Entire Team are US Citizens</td>
<td>NO, but all those who are not have previously been allowed into WFF</td>
</tr>
</tbody>
</table>
Sharing Logistics

We are sharing our canister with Stevens Institute of Technology. We have established contact with them and will work with them to ensure the success of both of our payloads.
## Project Budget

<table>
<thead>
<tr>
<th>Item/Event</th>
<th>Merchant/Source</th>
<th>Unit Price</th>
<th>Quantity</th>
<th>Items Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Half Canister Space</td>
<td>NASA</td>
<td>$7,000.00</td>
<td>1</td>
<td>$7,000.00</td>
</tr>
<tr>
<td>Scintillator Plate Material</td>
<td>recycled</td>
<td>$0.00</td>
<td>1</td>
<td>$0.00</td>
</tr>
<tr>
<td>Muon Detector Components</td>
<td>Digikey/Sparkfun</td>
<td>$63.31</td>
<td>1</td>
<td>$63.31</td>
</tr>
<tr>
<td>Copper Pipe</td>
<td>recycled</td>
<td>$0.00</td>
<td>1</td>
<td>$0.00</td>
</tr>
<tr>
<td>Magnetometer Components</td>
<td></td>
<td>$74.25</td>
<td>1</td>
<td>$74.25</td>
</tr>
<tr>
<td>Batteries</td>
<td>9V</td>
<td>$3.41</td>
<td>2</td>
<td>$6.82</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>$7,144.38</strong></td>
</tr>
</tbody>
</table>
Conclusion

- We are preparing to integrate the magnetometer subsystem.
- The muon detector is coming together now that we have all the parts.
- We are starting the outreach program within the month.
Questions

- Is there an “official” mid-mounting plate? We plan to make our own, but the powerpoint given as a model for this presentation listed the weight of the mid-mounting plate.