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Contents

- Section 1 - Mission Overview
  - Success Criteria
  - Concept of Operation
  - Changes since STR
- Section 2 - Design Overview
  - Design Overview
  - Functional Block Diagram
  - Hazardous Mechanical/Electrical Items
  - Special Requests
- Section 3 - Subsystem Status
  - Subsystem Overview
  - MAG testing Status
  - MUON testing Status
- Section 4 - Integrated Subsystem Testing Status
  - ISTS Overview
  - System Testing Status
- Section 5 - Plan for Full System Testing
  - Canister Integration
  - Vibe test
  - Electrical Testing
  - Software Testing
  - System Level Testing
  - Plan for FMSR
- Section 6 - Project Management Update
  - Schedule Update
  - Summary of Progress
  - User Guide Compliance
  - Shared Can Logistics
  - Budget
  - Conclusions
  - Organizational Chart
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.
Success Conditions

● This mission will be considered successful if:
  ○ The muon detector can accurately measure muon flux at different altitudes
  ○ The magnetometer can gather enough data to model a relationship between altitude and magnetic flux
  ○ We reach a local school to get kids involved with our program

● This mission will be partly successful if:
  ○ At least one of the experiments succeeds
  ○ The local outreach listed above is accomplished
Concept of Operations

**Altitude (km)**

- **t = -3 min**
  - All systems activated
  - Begin data collection

- **End of Orion Burn**
  - $t \approx 0.6$ min
  - Altitude: 52 km

- **Medium Muon Flux and Magnetic Field Strength**
  - $t \approx 1.3$ min
  - Altitude: 75 km

- **Apogee**
  - High Muon Flux
  - Low Magnetic Field Strength
  - $t \approx 2.8$ min
  - Altitude: $\approx 115$ km

- **Medium Muon Flux and Magnetic Field, High Tumble**
  - $t \approx 4.0$ min
  - Altitude: 95 km

- **t \approx 15$ min
  - Splash Down
  - Payload Turns off

- **t = 0.6$ min
  - Altitude: 52 km

- **t \approx 5.5$ min
  - Chute Deploys

- **t \approx 1.3$ min
  - Medium Muon Flux and Magnetic Field

- **t \approx 2.8$ min
  - High Magnetic Field Strength

- **t \approx 4.0$ min
  - Medium Muon Flux

- **t \approx 15$ min
  - Splash Down
  - Payload Turns off
Changes Since STR

- Muon detector is FINALLY soldered together
- The magnetometer code has been changed to avoid potential data loss
Design Overview

Section 2
Mechanical Design - Overall Physical Model

**Half Canister**

1. MUON
2. Aluminum Casing
3. Arduino Nano

- Top Plate
- Bottom Plate
- 9V Power (x2)

Red Board
Arduino Uno

HWS
RockSat-C
2018
Mechanical Design - Top Plate
Mechanical Design - Bottom Plate
Mechanical Design - Payload in Canister

Half Canister

4.25"
MUON Functional Block Diagram

Legend
- Positive Power
- Ground
- Data Request Wire
- Data Wire
- Built in connections
- WFF t-3

Scintillator
SiPM
MUON PCB
ARD
PWR
Hazardous Mechanical/Electrical Elements

- All of the parts of our subsystems are solid state
- Our payload will not exceed the voltage maximum
Subsystem Status

Section 3
Subsystems Overview

MUON

When ionizing radiation (read muons and other non-target particles) hit the scintillating plate within the muon detector, it releases light. This light will be collected by a Silicon Photomultiplier (SiPM) which is powered by and sends data via the gate PCB to an arduino. The gate PCB filters out signals from the SiPM which are too weak to have been caused by particles less energetic than muons. This data is then recorded and time-stamped by the Arduino onto a microSD card.

MAG

The molten iron core of the Earth creates a constant magnetic field that protects us from harmful cosmic radiation. It also provides the us with an excellent navigation system: this field is what enables compasses to point to the north. The MAG system will measure the strength of this field over a range of altitudes, and use this data to try to model how the strength of the field changes. This data will be collected by a fluxgate magnetometer, processed with an Arduino, and saved onto a microSD card.
Subsystem Testing Status: MAG

- The magnetometer is operational, and basic tests have been conducted:
  - Powers on and off with the Arduino (success)
  - Reads data and writes it to an SD card (partial success: SD card writing needs tweaking)
  - The data reflects the strength of the magnetic field that the sensor is in, and the data is numerically accurate (success)

- We have not:
  - Done a test to determine if the housing of the sensor is structurally strong enough to withstand launch/flight conditions
  - Done a test fitting of the subsystem on the mounting plate

- The structural tests will take place within the next two weeks
Testing Status: MUON

- Detector is soldered although we are unable to run at this time due to not having an enclosure for the SiPM
- Additional tests are still being considered for how to best verify the detector is working.
Integrated Subsystem Testing Status

Section 4
Integrated Subsystem Testing Status

Order that the subsystems will be tested:
- Magnetometer (testing ongoing)
- Muon (construction ongoing, testing will commence ASAP)
- Mechanical construction of entire payload

Order that the subsystems will be integrated:
- Magnetometer (can be mounted as soon as CoM is calculated with respect to MUON)
- Muon (as soon as construction is complete)
- Peripheries (e.g. WFF switch, batteries, etc.)
Integrated Subsystem Testing Status

MAG

- SD card writing
  - Demonstrate that the detector can write data to the SD card when power is turned on, and the data is preserved even if power is cut to the system unexpectedly
- Accuracy of Data:
  - Demonstrate that the detector senses magnets in a numerically significant way, e.g. that the same magnet being moved the same distance away returns the same result with multiple trials
  - Determine the range of errors that we can expect to encounter with our data
- Structural Stability
  - Demonstrate that the detector will hold up to launch conditions

MUON

- The detector is assembled but not tested
Plan for Full System Integration

Section 5
Canister Integration

We intend to allow the payload to run until the batteries die, as well as our mock vibration test (detailed on next slide). These tests should give us an idea of how our payload will hold up under launch conditions.
Vibe Test

To prepare for the vibration testing, we will go to Wegmans and roll the payload around in a grocery cart (a highly sophisticated grocery transportation device known for its lack of shock absorption). This has worked for our team in the past. To prepare, we use string and hot glue to make sure that everything from SD cards to screws are secured in place.
Electrical Testing

MAG

- The magnetometer has no high voltage components
- The only electrical element that needs to be tested are the connecting wires, to make sure that all connections are secure, there are no shorts, and that the wiring will withstand launch
- Battery life has been tested: we powered the subsystem from a 9 volt battery for somewhere between 48 and 72 hours. The battery ran out of charge somewhere in this range
  - This range is acceptable for us

MUON

- We have tested the PDB solder joints and none have shown signs of being faulty
Software Testing

MAG

- The software is mostly completed:
  - Sensor is automatically initialized on subsystem startup
  - Data is read from the sensor
  - Data is formatted into a .csv type structure
  - Data is saved to an SD card
- The electrical and mechanical tests can proceed with the code where it is
- These tests will occur within the next week

MUON

- We have software from the source of our detector design, but we can’t test until we get the detector running
System Level Testing

- **Battery drain test - April 14th**
  - Allow the payload to run and collect data until the batteries die

- **Vibration test - April 16th**
  - Put the payload into a grocery cart and roll it around the Wegmans parking lot for a bit

- **Mission Simulation - 23rd**
  - Let payload run for the time it will theoretically be running the day of launch after repeating vibration test
Plan for FSMR

- Finish muon detector: April 9
- Completely finish building payload: April 16-23
- Payload structural integrity/software testing: April 16-30
- Solve any remaining software problems: May 4
- Solve any remaining physical problems: June 2-4
- Any last things we didn’t finish by the end of school: June 2-4
Project Management Update

Section 6
- No changes since STR
Schedule Update

- **April 12**: Final Payment Due
- **April 16-20**: Progress Update Teleconference
- **April 30-May 4**: Progress Update Teleconference
- **May 21-25**: FMSTR Teleconference
- **May 30**: Possible Progress Update Teleconference
- **June 4**: Drive to Wallops!
Progress Summary

We intend to have our payload finished and tested before our finals week. We have scheduled to allow extra time to fix things over the summer as needed.
### User’s Guide Compliance

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Specification</th>
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</thead>
<tbody>
<tr>
<td>Mass within $6\pm.1$ 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 $9.1&quot; \times 9.1&quot; \times 4.25&quot;$</td>
<td>$9.1&quot; \times 9.1&quot; \times 4.25&quot;$</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. We sent them a CAD model of our payload.
## 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>
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<tbody>
<tr>
<td>Half Canister Space</td>
<td>NASA</td>
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<td>$7,000.00</td>
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<td>Copper Pipe</td>
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<td>Outreach Materials</td>
<td>Jameco, Scrap bins</td>
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<td></td>
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<td><strong>$7,686.76</strong></td>
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</tbody>
</table>
Conclusion

- We are nearly finished with the muon detector and should be testing this weekend
- The magnetometer needs to be tested physically now that software bugs have been fixed
- The outreach program is underway
Questions

- How much do extra meals and extra t-shirts cost per person?
- Will you be requiring posters again? (11 by 14)