An Observation of VLF EM Waves Emitted by Lightning

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Presentation Outline

• Section 1: Mission Overview
• Section 2: Integrated Subsystem Testing Status
• Section 3: Full Mission Simulation Results
• Section 4: Project Management Update
1.0 Mission Overview

Adam
Mission Statement

The objective of our research project is to observe very low frequency (VLF) electromagnetic (EM) waves that come from natural lightning discharges as a function of altitude.

Figure 1: Spectrogram of recorded VLF EM wave data from the University of Greece
Concept of Operations

**Beginning of Ionosphere**
- $t \approx 1.3\ \text{min}$
- Altitude: 75 km

**Data Recording of Reflection Process**
- $t \approx 2.8\ \text{min}$
- Altitude: $\approx 115$ km

**End of Orion Burn – Spin Rate Largest**
- $t \approx 0.6\ \text{min}$
- Altitude: 52 km

**High Tumble Rate**
- $t \approx 4.0\ \text{min}$
- Altitude: 95 km

**Comparative Ground Data**
- $t \approx 5.5\ \text{min}$
- Chute Deploys

**Chute Deploys**
- $t \approx 15\ \text{min}$
- Splash Down

- Early Activation triggered
- All systems on
- Begin data collection

$t = -3\ \text{min}$

$t = 0$
Launch

$100^\circ$
Changes since ISTR

Code for the Magnetometer has been updated since ISTR
A voltage regulator was added to the PCB to support the Xmos since ISTR
2.0 Integrated Subsystem Testing Status

Adam, Nick, Garrett
Integrated Subsystems Testing Status

Analog-Digital
- All 4 ADC channels work and correct outputs recorded
- Adjusted mounts for SD/Xmos/Magnetometer on PCB

Mechanical-All
- Polycarbonate plates incorporated
- Design for mounting PCB to supports incorporated
- Design for mounting circuit boards to PCB to polycarbonate plates incorporated
Integrated Subsystems Testing Status con’t

Mechanical Overview

View of rod/baseplate mount and battery mount

Mechanical-All con’t

- Design for mounting PCB to supports incorporated
- Design for mounting circuit boards to PCB to polycarbonate plates incorporated
Integrated Subsystems Testing Status con’t

Underside of circuit board/PCB

Top of circuit board/PCB

Mechanical-All con’t

- Need to do:
  - Wiring
  - Integrate real PCB instead of dummy
  - More appropriate fasteners for circuit board/PCB
3.0 Full Mission Simulation Results

Name of Presenter(s)
Payload Testing

Simulated payload for flight situation
• Ran for 20 minutes
• Tested all channels and 3 antennas
Had all components to test and verified data will be collected and recorded correctly
• Differed from flight configuration: test performed before it was integrated with mechanical side/mounting structures
Results

- Data was collected and produced expected results
- Equipment worked for full 20 minutes
- Antennas worked and xmos channels functioned properly
Issues

• Xmos, SD holder, Magnetometer wired rather than soldered
  – Solution planned for next PCB revision
• Magnetometer code not functioning
  – Fixed after testing
• Possible issue with powering Xmos discovered through later testing
  – Looking into voltage regulator/wiring connection errors
• Equipment not mounted during test
  – Perform follow up testing while mechanically integrated

Many airwires will be removed in final revision
Remaining Action Items

- Finish securing wires to supports
  - 1 week
- Modifying porthole and testing plate antenna
  - 1-2 weeks
- Order PCB from OSH Park
  - 1 week
- Test data collection with magnetometer running.
  - 1 week
- Run multiple tests on the above items
  - 2 weeks
4.0 Project Management Update

Name of Presenter(s)
<table>
<thead>
<tr>
<th>Requirement</th>
<th>Status/Reason (if needed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center of gravity in 1&quot; mid-can?</td>
<td>Weight is off center; should be corrected with ballast</td>
</tr>
<tr>
<td>Contained in can</td>
<td></td>
</tr>
<tr>
<td>Connected to can by 4/5 bulkheads on top and bottom only</td>
<td></td>
</tr>
<tr>
<td>Mass at 20±0.2lbs</td>
<td>~12 lbs, making ballast</td>
</tr>
<tr>
<td>Shared canister clearance</td>
<td></td>
</tr>
<tr>
<td>No voltage on the can</td>
<td></td>
</tr>
<tr>
<td>No voltage on multipurpose port</td>
<td></td>
</tr>
<tr>
<td>Activation wires at least 4 ft</td>
<td></td>
</tr>
<tr>
<td>Activation wire at least 24 gauge</td>
<td>24 gauge</td>
</tr>
<tr>
<td>Early Activation: current &lt; 1 A</td>
<td></td>
</tr>
<tr>
<td>T-0 Activation: current &lt; .1 A</td>
<td>Not using</td>
</tr>
<tr>
<td>Battery Type</td>
<td>Ni-MH Rechargeable</td>
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</tbody>
</table>
Biggest Worries

• Finishing and testing entire experiment again in flight simulation
• Tests will be conducted next week, and the few remaining problems will be dealt with in the upcoming week
Conclusions

The full mission test was successful and many issues have been dealt with since ISTR. Now, we are focusing on finishing structural integration.