W&J RockSat Team
Critical Design Review

Washington & Jefferson College
J. Angotti, G. French, P. Fullerton,
A. Yamashita, J. Yang, T. Kioussis
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    • Requirements to be verified
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Mission Overview

Garrett French, Akira Yamashita, Julia Angotti
Mission Statement and Objectives

- **Mission statement:** we plan to measure properties of Earth’s ionosphere.
- **Objectives:**
  1. We plan to measure the intensity of electron and ion currents in the ionosphere. From those we will calculate the density and temperature of the plasma. We will use a plasma probe (Langmuir probe) attached to a multipurpose port.
  2. We will measure sodium density in a narrow layer of the atmosphere using an optical port.
  3. We plan to measure these intensities as a function of height of the Terrier-Orion rocket.
- We expect to find a peak of ion/electron density at 115-120 km. There is also a peak of sodium around 90 km.
Mission Requirements

• Here are the major requirements for our mission.
  – The rocket altitude must be at least 120 km.
  – The probe needs to be attached to a multipurpose port to remain in contact with the ions and electrons.
  – We need ~20 V at 30 mA from alkaline batteries (detailed budget below).
  – We need access to an optical ports (1”) to take emission intensity measurements.
  – A Geiger counter will be used to measure high-energy electrons to compare with the plasma data.
  – We need velocity and magnetic-field measurements so appropriate sensors must be installed.
  – The sampling rate should exceed 300 samples/second to overcome the high speed and high angular rate of the rocket.
  – The video frame rate should exceed 60 frames/second for the same reason.
  – We need to obtain the actual rocket trajectory from Wallops.
Mission Overview: Theory and Concepts 1

- Plasmas are collections of electrons and positive ions. There are natural and artificial plasmas.
- Earth and other planets have plasmas at the top of their atmosphere (ionosphere). The density of the electrons is shown in the graph of the right. The RockSat trajectory goes through the E layer.
- We can collect such particles by applying a voltage to an electrode inserted into the plasma. The electrode is called a Langmuir probe.
- The sodium layer is a layer inside of Earth’s atmosphere (mesosphere) that consists of neutral sodium atoms.
- These measurements are important for understanding the ionosphere.
Mission Overview: Theory and Concepts 2

- The understanding of the ionosphere is essential to distant radio communication technology that relies on the reflection of radio wave by the ionosphere.

![Diagram showing ionospheric layers and reflection](image-url)
• Sodium layer comes from ablation of meteors.
• The light emission of sodium comes from the shift between the energy levels of electrons.
• The sodium atoms in the sodium layer are excited.
• Usually the emission is weak so we can’t see from the surface of the earth.
• A laser guide star is an application of the study of the sodium layer.
  – Shine laser of 589nm to the sky in order to excite more sodium atoms so that the sodium layers can provide a preference for reducing the effect waveform distortion due to the atmosphere.
  – This largely increases the resolution power of telescopes on the earth.
The laser guide star at Paranal Observatory

The reason of the position shift is because of the intensity of light from the sun.

Even the laser guide star is usually created during night and our experiment would be during daytime, since the position of the sodium layer would not change dramatically, our measurement would be meaningful.
Concept of Operations

- Power should go on at launch \( (T = 0) \) tripped by the G switch, then turn off at landing. All instruments and microcontrollers should stay on after launch.
- The plasma probe voltage would turn on at \( T = +70 \) s and turn off at \( T = +240 \) s. The main part of data collection would be between those times.
- We plan to take video throughout the flight. The sodium measurements will be taken from 60 to 90 seconds and from 4:00 to 4:20 minutes.
- Sampling rates and frame rates should be constant throughout the flight.
- Power should be turned off at the end of the flight.
ConOps Schematic

Altitude

**Sodium layer**
- $t \approx 1.3-1.5$ min
- Altitude: 80-95 km

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

**Apogee**
- $t \approx 2.8$ min
- Altitude: $\approx 115$ km

**Plasma region**
- $t \approx 1.5-3.5$ min
- Altitude: 90-120 km

**High Tumble Rate**
- $t \approx 4.0$ min
- Altitude: 90-120 km

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

**t = 0 min**
- G switch triggered
- All systems on
- Begin data collection

**t = 15 min**
- Splash Down

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RockSat-C 2018

CDR
Expected Results

- The density of electrons is shown as a function of height. Expected peak density is about $5 \times 10^{11}$ electrons/m$^3$.
- The density figure is for the daytime. Plasma needs sunlight so the density at night is much lower (see graphic).
- In the Geiger counter accompanying the plasma probe, energetic electrons should show a peak around 20-25 km then decrease with height (see plot).
- Sodium layer: the peak intensity should at least triple from the background near 80 km. It is most intense around 80-95 km.
- Wavelength around 589 nm should be observed in the sodium layer.
- The magnetic field decreases with height as a power-law fit
**Success Criteria**

- **Minimum Success Criteria:**
  - Plasma: Several voltage sweeps throughout the flight above 90 km.
  - Sodium: Minimum amount of data: Video from one of the two cameras

- **Comprehensive Success Criteria:**
  - Plasma: ion and electron currents at high sampling rate above 90 km
  - Sodium: continuous video from switch-on until splashdown
  - Electron measurements from the Geiger counter
Functional Requirements

- F.R.1: System shall have measured ion and electron current data.
- F.R.2: System will attempt to measure the plasma potential.
- F.R.3: The data rate needs to be high to compensate for the 5.6-Hz spin rate. This is important for the temperature calculation.
- F.R.4: The camera requires to record a unique sodium emission line at 589 nm.
- F.R.5: The frame rate needs to be high to overcome the 5.6-Hz spin rate.
- F.R.6: The Geiger counter should be calibrated to work with high particle fluxes in space.
# Design Requirements: LPC Subsystem

<table>
<thead>
<tr>
<th>Design Requirement</th>
<th>Verification</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>D.R.1.1: System shall have appropriate voltage bias</td>
<td><strong>Analysis, Test</strong></td>
<td>System will be tested on the ground with a plasma to make sure we get good I/V data</td>
</tr>
<tr>
<td>D.R.1.2: System shall have voltage bias controlled by the Arduino throughout the flight as a function of time.</td>
<td><strong>Analysis, Test</strong></td>
<td></td>
</tr>
<tr>
<td>D.R.1.3: System shall have measured I/V data recorded in the Arduino throughout the flight as a function of time.</td>
<td><strong>Analysis, Test</strong></td>
<td></td>
</tr>
<tr>
<td>D.R.2.1: The velocity of rocket shall be obtained from NASA data.</td>
<td><strong>Analysis, Test</strong></td>
<td>The velocity is obtained from trajectory data. The magnetic field measurements will be compared to a model.</td>
</tr>
<tr>
<td>D.R.2.2: The magnetic field shall be measured by an on-board magnetometer.</td>
<td><strong>Analysis, Test</strong></td>
<td></td>
</tr>
<tr>
<td>D.R.3.1: The Arduino Timer code shall provide time accurate to 1 microseconds based on the speed we varied the voltage of 1 V/s error we have in the ADC.</td>
<td><strong>Analysis, Test</strong></td>
<td>The Arduino System’s timing will be tested with the Langmuir probe to insure that the times correspond to the right voltage.</td>
</tr>
</tbody>
</table>
### Design Requirements: SLM, GCE Subsystems

<table>
<thead>
<tr>
<th>Design Requirement</th>
<th>Verification</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>D.R.4: A filter of $589 \pm 10$ nm will be used to limit the light to sodium wavelength.</td>
<td>Test</td>
<td>Filter system will be tested on the lab with a sodium lamp.</td>
</tr>
<tr>
<td>D.R.5: A camera module operating at 90 fps will be used to measure sodium emissions.</td>
<td>Test</td>
<td>Preliminary testing shows this is feasible.</td>
</tr>
<tr>
<td>D.R.6: The GM tube shall be covered with a high-density metal to reduce high fluxes.</td>
<td>Analysis, Test</td>
<td>The thickness of the metal needs to be calculated, then GC must be tested with a radioactive source.</td>
</tr>
</tbody>
</table>
System Overview

Pat Fullerton, Jiaoyi Yang
System Definitions

• The following are the main subsystems of the payload:
  • LPC: Langmuir Probe Circuit
  • ADA: Arduino Data Acquisition
  • SLM: Sodium Layer Measurement
  • GCE: Geiger Counter Experiment
Changes Since PDR

• The ADA subsystem was merged with the LPC.
• The Geiger counter was added as a subsystem so it could be comparable to the plasma experiment, but with a more precise role.
• The change should make the mission objectives and functional requirements clearer.
System-Level Functional Block Diagram (from CoDR)

- Makrolon plate (top)
  - Arduino and plasma electronics - storing data (mounted to plate)
  - Small sensors
  - Power
  - Connected to each other with standoffs

- Makrolon plate (bottom)
  - Cameras
  - Raspberry Pi and electronics – controlling cams (mounted to plate)

- Placed above center of canister for viewing (attached to top plate)
- Mounts to top of canister
Mechanical Design Elements

- The top plate contains the LPC while the bottom holds the SLM and GCE.
- Standoffs, small electronics (switches), and wires not shown.
- We will test the mechanical properties of the system to ensure it survives the flight.
Mechanical Design Elements (continued)

• Additional views of the 3D design.

Height: 9.5”

Diameter: 9.3”
Port Design Elements

• The LPC requires access to electrons and ions so we are requesting a multipurpose port. We are planning to use the dual SMA connector type.

• We will need to modify the pocket cover by adding an electrode (the plasma probe).

• Interface between port and payload:
  – Electrical: 3 wires of sufficient length (0.25-1 m) to connect port to canister above/below.
  – Mechanical: at this point we do not need a mechanical connection.

• The SLM requires optical access and we have requested an optical port.
Port Design Elements

- WFF Door Piece
- Mounting Flange (optional)
- Pocket Cover
- Electrode
Electrical Design Elements

• Block diagrams are shown in the next two slides.

• Breadboards:
  – Plasma experiment (LPC): 2
  – Sodium layer experiment (SLM): 2
  – Geiger counter experiment (GCE): 2

• Sensors:
  – LPC: 1
  – SLM: 2
  – GCE: 1

• Schematics: we are revising the schematics in a new software (Multisim) and they are not ready yet. However we are attaching sample schematics for LPC and GCE.
LPC: FBD (from PDR)

- **Power**
- **2 G-Switches In parallel**
- **RBF switch (Wallops)**

**Arduino Microcontroller (Arduino Uno)**

- **ADC**
- **Flash Memory**

**Plasma Probe**

**Op amp circuit (AD8231)**

Data flow:
- Red: Power
- Blue: Data
SLM: FBD (from CoDR)
Schematic for plasma board

- Microcomputer not shown.
- We are revising this schematic in a new software.
Schematic for Geiger counter board

- Arduino board not shown.
Software Design Elements

- Flow diagrams for LPC and SLM are below.
- The LPC will generate a voltage sweep and at the same time record I/V data.
- The SLM is responsible for video output.
De-Scopes and Off-Ramps

• LPC: If the op amps cannot be combined into a small number, we will use a greater number of components even if that means spreading them out over multiple PCBs.
• SLM: we should not need any de-scopes
• GCE: We can simplify the data acquisition if needed (reduce the sampling rate).
Special Requests

• LPC’s multipurpose port: it would be useful to have the pocket in our lab by the end of February.
• SLM: no requests.
• GCE: no requests. This is a high voltage subsystem (>500 V) so it will be self-contained and we will apply conformal coating.
Subsystem Design: LPC

Garrett French, Pat Fullerton
LPC Design

- We designed this subsystem based on the Arduino voltage outputs so that the probe measures the electron and ion currents. We will code the Arduino to output a triangle wave from -5V to 5V. The differential amplifier will then measure the difference between V-probe and the input voltage.
- We are using the Arduino Uno R3 based on its PWM functions, and its GPIO and analog ports.
- Power: 3.3 W
- Data (I/V measurements at a minimum of 300 Hz): 0.9 MB
- Mechanical interfaces:
  - Main boards attached to plate
  - Probe and cover attached to multipurpose port
- Electrical interfaces:
  - Wires to its power supply
  - RBF and G switches to line to Wallops
  - Wires to probe
- Mass: 0.4 kg (estimated)
- Design:
  - Mechanical: Not final. Needs design of probe, cover; arrangement of main boards
  - Electrical: Not final. Needs revision of schematics and testing.
LPC: FBD (from PDR)

Power

2 G-Switches
In parallel

RBF switch
(Wallops)

Arduino
Microcontroller
(Arduino Uno)

ADC

Flash Memory

Plasma Probe

Op amp circuit
(AD8231)

ADC

ADC

Power

Data
The following table shows a trade study for a differential amplifier used in the Langmuir probe circuit.

<table>
<thead>
<tr>
<th>Differential Amp</th>
<th>AD8231</th>
<th>AD8230</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>$7</td>
<td>$7</td>
</tr>
<tr>
<td>Variable Gain</td>
<td>1,2,4,8,16,32,64,128 V</td>
<td>10-1000 V</td>
</tr>
<tr>
<td>Drift</td>
<td>50 nV/c</td>
<td>50 nV/c</td>
</tr>
<tr>
<td>Slew Rate</td>
<td>2 V/μs</td>
<td>1.1 V/μs</td>
</tr>
<tr>
<td><strong>Average:</strong></td>
<td><strong>9</strong></td>
<td><strong>8.4</strong></td>
</tr>
</tbody>
</table>
LPC: Trade Studies (from PDR)

- The following table shows a trade study for the LPC processor.

<table>
<thead>
<tr>
<th></th>
<th>Arduino</th>
<th>Raspberry Pi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>$29.95</td>
<td>$35.00</td>
</tr>
<tr>
<td>Availability</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Clock Speed</td>
<td>16MHz</td>
<td>700MHz</td>
</tr>
<tr>
<td>A/D Converters</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Programming Language</td>
<td>9</td>
<td>7</td>
</tr>
</tbody>
</table>
LPC: Risk Matrix

1: Arduino doesn’t work: no data
2: Batteries run out of power: limited data
3: Probe damaged on liftoff.
4: Excess static on an Arduino IO port.
Subsystem Design:
SLM

Akira Yamashita, Jiaoyi Yang
SLM Design

- We designed this subsystem based on the high frame rate and small size of the RP camera module.
- There are two modules with an RP for each one.
- The first module is equipped with a sodium (589-nm) filter. The second one produces a reference signal so it is equipped with a filter centered in a nearby wavelength range.
- We program using Unix scripts to obtain a fast response from the modules.
- Power: 22.5 W due to RPs and modules.
- Data (640x480 over 12 min): 39.9 MB. A large flash memory card is required.
- Mechanical interfaces:
  - RP boards and camera mounts attached to plate
- Electrical interfaces:
  - Wires to power supply
  - Wires to LPC’s G-switch line
- Mass: 0.8 kg (estimated)
- Design:
  - Mechanical: not final. Camera mounts need to be redesigned.
  - Electrical and programming: close to FINAL.
SLM: FBD (from CoDR)
## SLM: Trade Studies (from PDR)

<table>
<thead>
<tr>
<th></th>
<th>Raspberry Pi</th>
<th>Nano Pi</th>
<th>ODROID-XU4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memory</td>
<td>1G RAM</td>
<td>1G RAM</td>
<td>2G RAM</td>
</tr>
<tr>
<td>CPU</td>
<td>1.2 GHz</td>
<td>1.4 GHz</td>
<td>2 GHz</td>
</tr>
<tr>
<td>Cost</td>
<td>29 $</td>
<td>33$</td>
<td>59$</td>
</tr>
</tbody>
</table>
### SLM: Trade Studies (from PDR)

<table>
<thead>
<tr>
<th></th>
<th>Arducam OV5647</th>
<th>Arducam Sony IMX219</th>
<th>Raspberry Pi Module</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frame Rate</strong></td>
<td>30-90 fps</td>
<td>60 fps</td>
<td>30 fps</td>
</tr>
<tr>
<td><strong>Resolution</strong></td>
<td>1080P</td>
<td>1280 x 720P</td>
<td>1080P</td>
</tr>
<tr>
<td><strong>Sensor</strong></td>
<td>5M Pixel</td>
<td>8M Pixel</td>
<td>5M Pixel</td>
</tr>
<tr>
<td><strong>Size</strong></td>
<td>25 x 24.5 mm</td>
<td>36 x 36 mm</td>
<td>25 x 24 mm</td>
</tr>
<tr>
<td><strong>Wide Angle</strong></td>
<td>54°</td>
<td>91°</td>
<td>75.7°</td>
</tr>
<tr>
<td><strong>Cost</strong></td>
<td>14.99$</td>
<td>64.99$</td>
<td>21.99$</td>
</tr>
</tbody>
</table>
SLM: Risks

Risk 1: Raspberry Pi doesn’t work
  • have 2 G switches in parallel
Risk 2: Run out of power
  • test the power source before the launch
  • save the video minute by minute
Risk 3: Dust on camera
Risk 4: Camera shift caused by vibration
Risk 5: Filter break so we lose reference video
Risk 6: Not enough memory for video
Risk 7: Rocket doesn’t launch
# SLM: Risk Matrix

<table>
<thead>
<tr>
<th>Possibility</th>
<th>1, 7</th>
<th>3, 4</th>
<th>2, 6</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: Raspberry Pi doesn’t work: no video</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2: Batteries run out of power: video ends</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3: Dust/debris on camera: blurry image</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4: Camera shift caused by vibration: limited field of view</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5: Filter breaks: we lose comparison</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6: Not enough memory for video</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7: Rocket doesn’t launch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Subsystem Design: GCE

Julia Angotti, Patrick Fullerton
GCE Design

- We designed this subsystem based on a reliable Geiger counter board we have used before and an Arduino-based data acquisition.
- The Geiger counter measures beta and gamma radiation but the contribution will be due to electrons. The threshold energy is 50 keV.
- The board produces an operating voltage of 500 V.
- The data acquisition is written in Arduino and reads one of the processor’s analog ports.
- Power: 1.6 W on Arduino.
- Data (3 channels over 5 min): 60 kB.
- Mechanical interfaces:
  - Boards attached to plate
- Electrical interfaces:
  - Wires to power supply
  - Wires to LPC’s G-switch line
- Mass: 0.1 kg (estimated)
- Design is FINAL.
## GCE: Trade Studies

<table>
<thead>
<tr>
<th></th>
<th>GMT-01</th>
<th>GMT-02</th>
<th>GMT-03</th>
<th>GMT-04</th>
<th>GMT-05</th>
<th>GMT-06</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiation type</td>
<td>α, β, γ</td>
<td>β, γ</td>
<td>β, γ</td>
<td>β, γ</td>
<td>β, γ</td>
<td>β, γ</td>
</tr>
<tr>
<td>Fragile</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Energy threshold (keV)</td>
<td>3000, 50, 7</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>250, 1100</td>
<td>350, 350</td>
</tr>
<tr>
<td>Cost ($)</td>
<td>75</td>
<td>45-60</td>
<td>40</td>
<td>50</td>
<td>75</td>
<td>60</td>
</tr>
<tr>
<td>Signal*</td>
<td>Strong</td>
<td>Strong</td>
<td>Weak</td>
<td>Weak</td>
<td>Weak</td>
<td>Mod.</td>
</tr>
</tbody>
</table>

* Depends on size and material
GCE: Risk Matrix

<table>
<thead>
<tr>
<th>Possibility</th>
<th>1, 3</th>
<th>1: Arduino does not work. No data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>2: Battery runs out of power: limited data.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3: Rocket doesn’t launch: no data</td>
</tr>
</tbody>
</table>
Subsystem Design – Mass Budget

- The mass budget is shown on the right.
- The maximum limit for the full payload in the canister is $20 \pm 0.2$ lbs and the canister weighs $6.7$ lbs.
- So the two-payload limit is $20 - 6.7 = 13.3$ lbs.
- If the two payloads have equal mass specs, that spec is $6.65$ lbs or $3.01$ kg.
- We will need to add mass to reach the spec.

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Total Mass (lbf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPC</td>
<td>0.88</td>
</tr>
<tr>
<td>SLM</td>
<td>1.76</td>
</tr>
<tr>
<td>GCE</td>
<td>0.22</td>
</tr>
<tr>
<td>Plates</td>
<td>0.66</td>
</tr>
<tr>
<td>Standoffs, brackets</td>
<td>0.44</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3.97</strong></td>
</tr>
<tr>
<td><strong>Over/Under</strong></td>
<td><strong>(2.68)</strong></td>
</tr>
</tbody>
</table>
Subsystem Design – Detailed Power Budget

• Attached is a screenshot of the power budget (sent separately).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>Power budget</td>
<td></td>
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<td>Power (mW)</td>
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<td>Power (mW)</td>
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<tr>
<td>14</td>
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<td>Camera (2)</td>
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<td>Power (mW)</td>
</tr>
<tr>
<td>18</td>
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<td>1600</td>
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<td></td>
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</table>
Prototyping/Analysis

Patrick Fullerton
Analysis Results/Plans

• Analysis for SLM: We wrote a basic program which records video at 90 fps with the RP camera and convert the raw video in a user-friendly format. This will be the core of the image acquisition and analysis programs.

• Plans for GCE: Trade studies for the board and tube.
Prototyping Results/Plan

• LPC: Since PDR we tested the plasma system to take I/V data.
  – Results: we are still having problems getting the right range of voltages and currents.
  – Relevance: When finished, we will automate the data taking using the Arduino.
Manufacturing Plan

Akira Yamashita
Mechanical Elements

• **Structures**: we need to buy and cut the polycarbonate sheets, and attach them to the canister using standoffs.

• **We need to re-build mounts for the camera modules.** We 3D-printed a design, but when testing some pins broke.
Electrical Elements

• The boards need to be designed and ordered. We will need 4 or more versions of the LPC electronics, and about 2 for each of the SLM and GCE.
Software Elements

• LPC: code needs to be expanded, revised.
• SLM: basic elements of code are simple and were tested. They need to be run over a realistic timescale (duration of the flight). The analysis program in Matlab will need minor revisions.
• GCM: the code is available from a previous experiment and is ready to be uploaded.
Testing Plan

Jiaoyi Yang
Testing

• Mechanical: We are looking for a provider for vibration, structural, and thermal testing. The nearest provider is about 2 hours away, but we should be able to find someone closer.

• Electrical: We will make voltage and current measurements of the boards when they are ordered and received from the manufacturer.
Software Testing

- **LPC**: the software is dependent on the electrical design so they will be tested together.

- **SLM**: the main parts of the code have been developed and testing will begin after the winter break.

- **GCE**: the code has been tested in earlier experiments and testing will begin as soon as the board is built.
System Level Testing

• There is a fair amount of integration that needs to be done once the LPC system is ready.
• We will perform the system-level testing on campus. It will be a simulation of the entire flight lasting approximately the same time.
User Guide Compliance

Akira Yamashita
## RockSat-C 2018 User’s Guide Compliance

<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>Not estimated yet</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>Based on 3D design only</td>
</tr>
<tr>
<td>Mass at $20 \pm 0.2\text{lbs}$</td>
<td>2.68 lb under; will use ballast</td>
</tr>
<tr>
<td>Shared canister clearance</td>
<td>Is not expected to interfere with partner payload</td>
</tr>
<tr>
<td>No voltage on the can</td>
<td>Not checked</td>
</tr>
<tr>
<td>Activation wires at least 4 ft</td>
<td>N/A</td>
</tr>
<tr>
<td>Activation wire at least 24 gauge</td>
<td>N/A</td>
</tr>
<tr>
<td>Early Activation: current &lt; 1 A</td>
<td>N/A</td>
</tr>
<tr>
<td>T-0 Activation: current &lt; .1 A</td>
<td>Not measured yet</td>
</tr>
<tr>
<td>Battery Type</td>
<td>Alkaline</td>
</tr>
</tbody>
</table>
Design Overview: Shared Can Logistics (if you already have one)

- We were assigned University of Wisconsin/Milwaukee, but we have not been able to contact them yet; we plan to do so by tomorrow.
- The volume of our payload should have sufficient clearance from theirs.
- The mass of the payload is lower than needed so we can adjust it as needed for a combined 13.3 lb.
Project Management Plan

Julia Angotti, Patrick Fullerton
Organizational Chart

Team Leader
Garrett French

Faculty Advisor:
Prof. Dimitris Vassiliadis

Plasma Experiment
Patrick Fullerton, Garrett French

Camera:
Akira Yamashita, Jiaoyi Yang

Communications Coordinator
Julia Angotti
Schedule Information

• Fall 2017: Design phase
  – Weekly team meetings; working meetings
• Monthly reviews (CoDR, PDR, CDR)
• January 2017: Downselection
• Spring 2018: Development and testing
  – Team and working meetings
• Reviews and regular telecons
• June 21, 2018: Launch
• End of June 2018: Final report.
Budget

• Our budget covers purchases for the payload and testing.
  – The largest item is the travel expense to Wallops Flight Facility in June 2018.
  – The budget includes a margin of ~13%.

• Our sources of funding are the Pennsylvania Space Grant Consortium and the Department of Physics – to whom we are very grateful!

<table>
<thead>
<tr>
<th>Subsystem/Activity</th>
<th>Aggregate Cost</th>
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<tr>
<td>LPC</td>
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</tr>
<tr>
<td>SLM</td>
<td>400</td>
</tr>
<tr>
<td>GCE</td>
<td>200</td>
</tr>
<tr>
<td>Testing</td>
<td>400</td>
</tr>
<tr>
<td>Travel to Wallops</td>
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</tr>
<tr>
<td>Margin</td>
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<td><strong>Total</strong></td>
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Team Contact Matrix

- Contact matrix shown below:

<table>
<thead>
<tr>
<th>Team Member</th>
<th>Role/Position</th>
<th>Email Address</th>
<th>Phone Number</th>
<th>US Person? (Y/N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Julia Angotti</td>
<td>Communications</td>
<td><a href="mailto:angottijm@jay.washjeff.edu">angottijm@jay.washjeff.edu</a></td>
<td>412-807-1458</td>
<td>Y</td>
</tr>
<tr>
<td>Patrick Fullerton</td>
<td>Physicist</td>
<td><a href="mailto:fullertonpa@jay.washjeff.edu">fullertonpa@jay.washjeff.edu</a></td>
<td>(724) 256-1396</td>
<td>Y</td>
</tr>
<tr>
<td>Garrett French</td>
<td>Physicist</td>
<td><a href="mailto:Frenchgk@jay.washjeff.edu">Frenchgk@jay.washjeff.edu</a></td>
<td>(484) 866-2477</td>
<td>Y</td>
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<tr>
<td>Akira Yamashita</td>
<td>Physicist</td>
<td><a href="mailto:yamashitaa@jay.washjeff.edu">yamashitaa@jay.washjeff.edu</a></td>
<td>(412)-923-6731</td>
<td>N</td>
</tr>
<tr>
<td>Jiaoyo Yang</td>
<td>Physicist</td>
<td><a href="mailto:yangj@jay.washjeff.edu">yangj@jay.washjeff.edu</a></td>
<td>(724)-263-6631</td>
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<tr>
<td>Dimitris Vassiliadis</td>
<td>Advisor</td>
<td><a href="mailto:dvassiliadis@washjeff.edu">dvassiliadis@washjeff.edu</a></td>
<td>202-315-6976</td>
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</tbody>
</table>

- We have used GoogleDrive to store and exchange documents.
## Team Availability Matrix - Spring 2018

<table>
<thead>
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Project Summary

• Remaining issues:
  – We still have work to do on the LPC.
  – The other two subsystems are being finalized.

• Areas of concern:
  – Testing of the LPC boards.
Worries

• Although the design of the LPC is straightforward, there are several implementation issues that will keep us busy for several weeks in January and February.
Conclusion

• Our mission is to measure electric currents and sodium density in the top part of the atmosphere.
• We have a good mechanical model at this point.
• However we need to revise the schematics and build the circuit boards. Several of these tasks will be done over the winter break.
• The SLM and GCE subsystems are getting finalized and should be integrated without problems.